UNIVERSITÀ DEGLI STUDI DI URBINO CARLO BO

Department of Economics, Society, Politics (DESP)

PhD in Global Studies. Economy, Society and Law

Thematic area: International Economic Policy, Business and Governance

Cycle XXXIII

Transportation Infrastructures, Location and Productivity. A micro-geography approach

SSD: SECS-P/ 06

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Academic Year 2019/2020

“You take delight not in a city's seven or seventy wonders, but in the answer it gives to a question of yours.” — Italo Calvino, Invisible Cities

Acknowledgements

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Thesis Abstract

This dissertation collects three empirical studies aiming at investigating the relationship between urban transportation infrastructures and (i) the foreign location choices made by multinational enterprises (MNEs), and (ii) the productivity of firms embedded in the location where these transport networks work, at a very fine-grained geographical level. By building upon past research we argue that the efficiency and the extension of transport infrastructures generate on one hand positive productivity gains for firms, and on the other hand, a change in location's attractiveness. Chapter 1 of this thesis explores the relationship between FDIs location patterns along the value chain and the mobility within urban boundaries. Here we conceptualise the *intracity connectivity*, which reflects both the efficiency, e.g. travel times, and the extension of available within-city connections, i.e. the capacity of infrastructures connecting both the core and the suburbs. Here findings from 21.888 FDIs located in 69 cities all over the world, reveal that firms engaged in capital-intensive activities, less amenable to telework, exhibit higher sensitiveness to the quality of intracity connections, whilst service-related activities show higher sensitiveness to international connections.

While In the first chapter we test our assumptions across all activities in the value chain, in Chapter 2 we focus on the location determinants of a business function largely disregarded in the literature, namely logistics activities of MNEs, being aware that firms supplying intermediate inputs, e.g. logistics, may be sensitive not only to the transport infrastructures investing in the territory where they are located, but also to the degree of existing intersectoral demand generated by the firms' typical users, e.g. retailers. Here we aim to fill a gap in the literature which investigated logistics' location decision as merely determined by the location of production activities. We assume that as other business services, logistics providers are characterised by strong supplier-user interactions and therefore they might be sensitive to the magnitude of existing intersectoral demand from other industries, and particularly so with the retail trade industry. Our findings based on 1777 FDIs across 380 NUTS3 open avenue on future insights about the logistics industry, and particularly MNEs by showing that logistics MNEs are more attracted by the inter-sectoral demand generated by the retail and wholesale sector in NUTS3 regions. This result is consistent with the current debate in the literature arguing the shifting towards a demand- driven economy, in which consumers' preferences for quicker deliveries are paving the way to a more customer-based supply chain. In the third chapter of this dissertation, we explore whether the so far

considered location determinants might as well affect firms' productivity at a remarkably fine spatial level, i.e. the sub-city dimension. Particularly, we evaluate the role played by location in proximity of sources of talent, where proximity reflects inter alia travel times to gain *access* to skilled human capital. The general idea is that better urban networks enhance economic productivity by (i) allowing a better matching between the firm and a specialized labour pool, (ii) and by favouring knowledge spillovers, highly localized in space. We focus on the accessibility to *talents,* i.e. the resident population having at least a bachelor's degree, as we deem it most likely to positively impact on firms' productivity. In order to test our assumptions, we develop an accessibility indicator in which we consider the volume of talents in each firm-own location and talents in other areas within London, weighted by real travel times. Our analysis is based on an unbalanced panel of 4090 firms over the period 2012-2019, located in 1,051 Super Output Areas (SOAs) i.e. sub-city areas with an average population of 300 residents. Our findings open avenue for future insights on the determinants of firms' productivity, acknowledging that indeed it is important to account for strong spatial decay effects, and that firms may be more productive if they tap into a pool of talents, who reside in a sufficiently close area of influence.

Abstract Tesi (ITA)

Questo elaborato di tesi raccoglie tre studi empirici che mirano ad indagare come le caratteristiche delle reti e dei servizi di trasporto influiscono su (i) le scelte di localizzazione all'estero effettuate dalle imprese multinazionali (MNEs), e (ii) la produttività delle imprese, In particolare, questa tesi esamina come l'efficienza e l'estensione delle infrastrutture di trasporto generino da un lato un aumento della produttività delle imprese, e dall'altro un cambiamento nell'attrattiva della localizzazione. Il capitolo 1 di questa tesi esplora la relazione tra i modelli di localizzazione degli Investimenti Diretti Esteri (IDE) lungo la catena del valore e la mobilità all'interno dei confini urbani. Qui concettualizziamo la connettività intra-città, che riflette sia l'efficienza, ad esempio i tempi di viaggio, sia l'estensione delle connessioni disponibili all'interno della città, cioè la capacità delle infrastrutture che collegano sia il nucleo centrale che le periferie. I risultati ottenuti dall'analisi di 21.888 IDE situati in 69 città di tutto il mondo rivelano che le imprese impegnate in attività ad alta intensità di capitale, con minori opportunità di telelavoro, mostrano una maggiore sensibilità alla qualità delle connessioni intra cittadine, mentre le attività legate ai servizi mostrano una maggiore sensibilità alle connessioni internazionali. Mentre nel primo capitolo testiamo le nostre ipotesi su tutte le attività della catena del valore, nel capitolo 2 poniamo l'attenzione sui fattori determinanti della localizzazione delle imprese multinazionali nella logistica. Dato il fatto che forniscono input intermedi, le multinazionali della logistica, possono essere sensibili non solo alle infrastrutture di trasporto che investono nel territorio in cui sono situate, ma anche al grado di domanda intersettoriale esistente generata dagli utenti tipici delle imprese logistiche, ad esempio i *retailers*. Qui si vuole colmare una lacuna nella letteratura che ha indagato le decisioni di localizzazione della logistica come semplicemente determinata dalla localizzazione delle attività produttive. Partiamo dal presupposto che, come altri servizi alle imprese, i fornitori di servizi logistici sono caratterizzati da forti interazioni fornitore-utente e quindi potrebbero essere sensibili all'entità della domanda intersettoriale esistente proveniente da altri settori industriali, e in particolare dal settore del commercio al dettaglio. I nostri risultati basati su 1777 IDE in 380 NUTS3 aprono la strada a future intuizioni sull'industria della logistica, e in particolare sulle multinazionali, mostrando che le multinazionali della logistica sono maggiormente attratte dalla domanda intersettoriale generata dal settore del commercio al dettaglio e all'ingrosso nelle regioni NUTS3. Questo risultato è coerente con l'attuale dibattito in letteratura che sostiene lo spostamento verso un'economia basata sulla

domanda, in cui le preferenze dei consumatori per consegne più rapide stanno spianando la strada a una catena di fornitura (supply chain) più basata sul cliente. Nel terzo capitolo di questa tesi, esaminiamo se i fattori determinanti della localizzazione finora considerati possano influenzare la produttività delle imprese ad un livello spaziale molto fine, cioè a livello sub-urbano. In particolare, valutiamo il ruolo giocato dalla localizzazione in prossimità delle fonti di talento, dove la vicinanza è mediata dai tempi di viaggio lungo la rete stradale che facilitano l'accesso al capitale umano qualificato. L'idea generale è che migliori reti urbane favoriscano la produttività (i) permettendo un migliore abbinamento tra l'impresa e un bacino di lavoro specializzato, (ii) e favorendo la diffusione della conoscenza, altamente localizzata nello spazio. Ci concentriamo sull'accessibilità ai talenti, cioè alla popolazione residente con almeno un diploma di laurea, in quanto la dimensione dell'accessibilità può avere un impatto positivo sulla produttività delle imprese. Per testare le nostre ipotesi, sviluppiamo un indicatore di accessibilità in cui consideriamo il volume dei talenti localizzati laddove è localizzata l'impresa, e dei talenti in altre aree di Londra, ponderato in base ai reali tempi di spostamento. La nostra analisi si basa su un panel sbilanciato di 4090 aziende nel periodo 2012-2019, situate in 1.051 Super Output Area (SOA), ovvero in aree suburbane di Londra con meno di 300 residenti. I nostri risultati aprono la strada a future intuizioni sulle determinanti della produttività delle aziende, riconoscendo che in effetti è importante tenere conto dei forti effetti di *spatial decay* (tasso di decadimento spaziale, tale per cui maggiore la distanza, minore è l'effetto positivo che l'accesso ai talenti ha sulla produttività delle imprese), e che le aziende possono essere più produttive se attingono ad un *pool* di talenti, che risiedono in un'area di influenza sufficientemente vicina.

Introduction

This dissertation collects three empirical studies aiming at investigating the relationship between urban transportation infrastructures and (i) the foreign location choices made by multinational enterprises (MNEs), and (ii) the productivity of firms. The overarching empirical frameworks leading this work concern the Theory of Location as developed in the International Business literature (IB), Accessibility Theory, a product of Transportation Economics (TE), and New Economic Geography (NEG). The general belief shaping this dissertation work reflects the increasing importance of the spatial interactions between the presence and efficiency of transport networks and firms' strategic choices and productivity at a micro geography level. Accordingly, we draw from TE the fundamental concepts of *accessibility*, i.e. the physical *access* to goods, services, and destinations (Geurs et al., 2001), and *connectivity*, i.e. the ease with which goods, people and knowledge *flow* across space (Belderbos et al., 2017). The former has a strong urban feature, and it reflects inter-alia the efficiency with which within-city connections for specific networks (e.g. road) ease the spatial interactions between the volume of economic activity (market size) and economic agents (e.g. firms), in a narrow geographical setting. Accessibility is a suitable concept when comparing the easiness with which markets and resources can be reached by agents along a specific network (as it is the outcome of transport networks). The latter is a more fluid dimension instead, and particularly emphasizes the extension of the existing transport networks (e.g. number of buses, number of international flights) either internationally or locally. A key aspect of connectivity is that it may include a soft dimension when the nature of connections is made being possible by online communication channels. Generally, as past research pointed, connectivity is a more appropriate concept when focusing on commuting flows and/or the extension of multiple transport networks. Despite the wording, these two terms stress the critical role that transport networks have in shaping spatial interaction between economic agents and the location in which they operate. Here, we position our research along the empirical literature (Graham 2007a; Graham et al., 2010; Gibbons et al., 2019; Proost & Thisse, 2019) and we apply either connectivity or accessibility, emphasizing the one most suitable to the empirical context at hand.

Past empirical research has documented the positive effects of transport infrastructures on economic growth, although some controversy still exists as regards the magnitude of these

effects with respect to the geographical unit at which such interactions occur and to which extent firms' characteristics (e.g. activity in the value chain) play a role in such interactions (Melo et al., 2013; Martin- Barroso et al., 2015). The general argument is that improvements in infrastructures generate on one hand a reduction in firms' costs likely to increase profitability, and on the other hand, a change in location's attractiveness. In the first Chapter of this thesis we explore the relationship between FDIs location patterns and *connectivity* as one of the main spatial features determining the locations' attractiveness. FDI locational patterns reflect inter alia the tendency of MNEs to slice their activities along the value chain in a worldwide network of operations, with decreasing transportation costs playing a key facilitating role in this process (Kano et al., 2020), even more so at a fine grained geographical level (Cook et al., 2018). From this perspective, it clearly appears that the extensions and quality of connections, by lowering transportation costs, may be a fundamental attractor for FDIs (Goerzen et al., 2013; Goerzen et al., 2017; Belderbos et al., 2017). However, in addressing the links between MNEs' strategic decision and spatial characteristics the bulk of literature mostly focused on the role of *international connectivity* – i.e. getting there - made possible by the presence of transportation infrastructures and services that enable or facilitate cross-border mobility (Bel and Fageda, 2008; Belderbos et al., 2017), while largely overlooking the role that urban networks might play as attracting factors in cities. This is a major drawback, because the mobility within urban, suburban and metropolitan areas represents a large fraction of the mobility of workers (Chatterjee et al., 2017). Accordingly, we conceptualise the mobility within urban boundaries as *intracity connectivity* – i.e. getting around -, which reflects both the efficiency - e.g. travel times-, and the extension of available connections - i.e. the capacity of infrastructures, connecting both the suburbs and the core. Here, we particularly stress the notion of commuting times, upon which we build our arguments. Commuting time is the time spent in travelling from the place of living to the place of work. An efficient urban transportation system has important implications on location decisions as it may imply a reduction of commuting time within cities, thus lowering transportation costs sustained by workers and firms. Moreover, the efficiency and extension of transport networks, i.e. intracity connectivity, impacts the interplay between workers and jobs' characteristics. Specifically, empirical evidence shows how a better matching between workers and firms' requirements is attained from cities that facilitate the physical proximity between them by reducing commuting costs. To address this largely unexplored issue, we draw insights from geography and transport studies to conceptually and empirically define the role of intracity connectivity

in MNEs' location choice in cities. The first chapter of this dissertation will fill a gap in the IB literature, by focussing on urban transportation infrastructures, as factors impacting the location of MNEs in cities (whereby the city comprises both its core and suburbs) emphasizing those that affect the efficiency of *getting around* the city, i.e. intracity connectivity. We will argue that - due to workers' and activities characteristics – location decision across the value chain may exhibit different sensitivity to the efficiency of transport infrastructure allowing intracity connectivity. Building on research concerning the sensitiveness of individuals to commuting times at the urban level (Chatterjee et al., 2017; Martin-Barroso et al., 2017; Clark et al., 2019), we identify how location decisions vary across business activities according to the likelihood characteristics of workers employed in such activities that are more (less) sensitive to intracity connectivity. More precisely, previous studies have shown that (i) the workers' perceived costs of commuting are negatively associated with educational levels and positive associated with the age of individuals, and (ii) older and less educated workers are relatively more sensitive to commuting times. We therefore expect that production and logistics activities -where these types of workers account for a larger share of employment- should locate in cities with more efficient urban mobility systems. On the contrary, advanced producer services and headquarter activities, where workers tend to be relatively younger and/or more educated, less sensitive to commuting and with higher chances to telework (Andres et al., 2013; White et al.,2016; Chatterjee et al., 2017; Martin-Barroso et al., 2017) are actually less influenced to how efficient intra-city connectivity works. Additionally, we observe that R&D exhibits an intermediate profile, since workers are generally young and well educated, which are normally less sensitive to commuting, but their activities need the lab facilities, hence less amenable to telework. To test the role of intracity connectivity on MNEs' location choices, we estimate a location choice model, using a conditional logit model. Empirical findings are based on a sample of 21.888 cross-border investment projects over the period 2011 – 2015 in 69 cities around the world. Our results show that intracity connections and lower commuting times are key driving factors for MNEs engaged in production activities, whereas a better level of intercity and international connections influences the location of HQs. We consider this as evidence of the heterogeneous role of connectivity as a determinant of location decisions across different value chain activities.

The first chapter aimes to fill a gap in the IB literature by considering urban mobility as a crucial factor in MNEs' strategic decisions across the value chain. We test our assumptions across all

activities in the value chain, openly accounting for the logistics activities, largely overlooked in the business literature. From chapter 1 we observe that logistics is affected by the same connectivity factors affecting manufacturing's location choices. However, we wonder whether findings in chapter 1 implies that logistics and production necessarily proceed "hand in hand", as the extant literature seems to suggest. As a matter of fact, there is a considerable gap in the empirical literature concerning the location determinants of logistics firms, even more so in the case of multinationals. Whilst in the first chapter we emphasize the role of different transport-related dimensions of connectivity, in the second we recognize the role of intersectoral demand and forward linkages which are a particularly suitable lens of analysis in the case of firms providing intermediate inputs, as it is the case of logistics firms.

Up to recently, scholars have started to recognize the pivotal role that logistics operators have nowadays. In 2014 Philip McCann argues that logistics and distribution activities "*are the lifeblood of the economy, keeping all other sectors (quite literally) moving. […] Understanding the modern role played by these activities therefore calls for a renewed efforts at building the research base in these arenas […] and until recently in fields such as economic geography and regional science there has been insufficient interest… even though the movement of goods and people is so central"*. As a matter of fact, very little has been in said in the economic and business literature in terms of locational behaviour of firms engaged in this industry, even more so in the case of multinational firms. Much attention has been paid to business services surrounding production activities (Defever, 2006; Meliciani et al., 2012, 2016) while considering location decisions in logistics as merely determined by production. In other words, logistics is assumed to "follow" manufacturing activities wherever these take place. However, this latter argument might not reflect the complexity with which logistics services are provided, by (literally) moving the goods from the *different loci* of production to the *different loci* of consumption, either domestically or internationally. We recognize that the complexity of the logistics activities may stem from their twofold nature: one devoted to serve production activities, B2B; and one devoted to serve the final market. We aim to emphasize the latter, whilst controlling for the former by building upon past empirical research investigating knowledge-intensive business services location choices as determined by the magnitude of pre-existing forward linkages at the regional level (Guerrieri et al., 2004; Meliciani et al., 2015,2016). Moreover, we argue that to derive location decisions of logistics MNEs from the ones of producers may be not sufficient to explain their locational behaviour. Logistics services

nowadays are experiencing outstanding growth in demand in advanced economies, boosted by increasing time-sensitiveness deliveries, generating higher demand for these services independently from the pre-existing manufacturing base (Bonacich & Wilson, 2008; McKinnon, 2009; Mariotti, 2014; Holl & Mariotti, 2018b). The general argument is that, given the intermediary nature of logistics services, considering the sole production sector may leave out those firms engaged in the downstream part of the supply chain such as retailers and wholesalers, which are the closest points to the end market, and as such suitable actors to capture consumers' increasing demand for quicker distribution services. Scholars reckon this phenomenon as the gradual shifting from a "*supply-push*" to a "*demand-pull*" economy (Bowen, 2008; McKinnon, 2009; Fernie et al., 2010; Holl & Mariotti, 2018b; Mangan, 2019). Bowen (2008) argues that in a "supply-push" economy, firms ''pushed" their output into distribution channels based on demand forecasts. In the latter, i.e. "demand pull" firms gear their production in response to real-time information about what consumers are buying. We assume that as other business services, logistics providers are characterised by strong supplier-user interactions (Meliciani et al., 2012) and therefore they might be sensitive to the intersectoral demand they experience from other industries, i.e. vertical linkages, and particularly so with the retail trade industry. To assess whether vertical linkages exert a positive effect on the location decisions of multinational firms engaged in logistics, we draw from past economic geography literature addressing firms' location choices, arguing that in the case of the logistics industry, higher sectoral interdependencies with retailers and wholesalers, is a crucial factor in attracting logistics MNEs at the NUTS3 level. The empirical analysis is based on 1777 FDIs over the period 2011-2018 located in 380 NUTS3 regions. Similarly to Chapter 1, to test whether vertical linkages with retailers lure logistics MNEs in NUTS3 regions, we estimate a conditional logit model. In our empirical setting we focus on vertical linkages with retail trade as a main explanatory variable, we then control for vertical linkages with manufacturers, agglomeration economies, market potential and its lagged effect in neighbouring regions. Our findings open new research avenues about the logistics, and particularly about MNEs' activities in this industry, by showing that logistics MNEs vertical linkages with the retail and wholesale sector exert a stronger effect in luring logistics operators in NUTS3 regions than other attractors, hence demand pull factors appear to play a stronger role than interdependencies with upstream suppliers. This result is consistent with the current debate in the literature arguing the shifting towards a *demand- driven* economy, in which

consumers' preferences for quicker deliveries are paving the way to a more customer-based supply chain.

In chapter 1 and 2 we explored different aspects (e.g. intracity connectivity, intersectoral demand) affecting MNEs' location decisions. In the third and final chapter of this dissertation we aim to zoom in further in the urban dimension and investigate whether locational factors affect firms' performance, exploiting the sub-city dimension, i.e. the Super Output Area (areas with an average population of 300 residents). Particularly, we evaluate the role played by location in proximity of sources of talent, where proximity is mediated by the quality of connections along the road network - in terms of travel time -, that facilitates the *access* to skilled human capital. The general idea is that transport infrastructures affect the extent to which firms can *access* key resources, e.g. specialized workers. Several studies in this line of research have looked at the relationship between firms' productivity and different dimensions of accessibility, most often accessibility to markets (Rice et al., 2006; Graham 2007a; Holl, 2012), and very recently to specialized workers (Martin-Barroso et al., 2015;2017) or workers - regardless their skills- (Gibbons et al., 2019), as a function of accessibility levels along the road network between large municipalities or regions. In the first chapter of this dissertation, we found that firms prefer to locate in cities where they can enjoy more efficient intracity connections depending on the interplay between intrinsic workers' and jobs' characteristics. In fact, a central tenet of modern theories of labour markets is that enjoying better urban connections enhances economic productivity by (i) allowing a better matching between the firm and a specialized labour pool, (ii) by favouring knowledge spillovers, which tend to be highly localized in space. Particularly, extensive empirical literature agreed on a fundamental observation that worker mobility and the knowledge they embody and spill-over tends to be highly localized in space. Yet, the bulk of the empirical work considers much broader spatial units, -e.g. municipalities, functional areas (Azoulay et al., 2017; Gibbons et al., 2010; 2019; Faggio et al., 2020; Verginer & Riccaboni, 2021), and the work at a micro geographical level is still in its infancy, except for a few pioneering contributions (Gagliardi & Percoco, 2017; Andersson et al., 2016, 2019). The underlying mechanisms that might bring productivity gains to firms for being remarkably closer to talents may act upon the idea that to some extent labour markets are segmented (e.g., in terms of qualification obtained), and workers/firms are restricted by certain geographical boundaries, make it possible that across micro (segmented) labour markets, talents compete for jobs and firms compete for talents (Martin-Barroso et al.,

2017). Therefore, by having greater access to talents within-city, firms may gain higher productivity benefits, that stem from being closer to the pool of workers they wish to hire. Similarly, these mechanisms may bank on knowledge spillovers. e.g. knowledge-intensive workers, such as consultants in services, move from one organization to the other but are relatively immobile in space (Breschi & Lissoni, 2009), confirming that knowledge is transferred and used within a close distance (Torre, 2008). Although scholars argued that knowledge spillovers from competitors are much more localized phenomena, we may also argue that they may also be very sensitive to minor differences in travel times and likely to impact firms' productivity (Eriksson, 2011; Proost & Thisse, 2019). We focus on the access to *talents* as this is likely to positively impact firms' productivity the most. We define *talents*, as the number of residents having at least a bachelor's degree, as in Florida (2005), at a very micro geographical level, i.e. within – city areas, taking the Greater London area (UK) as case study. Although there is a general agreement about the geography of talent being a highly concentrated phenomenon, it is still to be assessed the extent to which higher access to specialized workers is geographically defined in a within-city perspective, thus zooming in the urban dimension of productivity. Accordingly, here we investigate the relationship between firms' productivity and access to talents at a very fine spatial level, building on the assumption that accessibility to talents may unravel that firms may be more productive if they tap into a pool of talents, who reside in a sufficiently close area of influence, by considering the concrete firm- neighbourhood pairs (full-digit postcode of workers' residence). In order to test whether there is a positive relationship between access to talents and firms' productivity, we build an accessibility indicator in which we consider the volume of talents in each firm-own location and talents in other areas within London, weighted by real travel times. The disaggregated geographical unit of analysis may as well allow to identify which sources of productivity may be confined in narrow geographical spaces. This might be the case of knowledge spillovers. Using this fine spatial level of analysis may shed some light on the spatial extent to which access to specialized workers and knowledge spillover accrue to firms yielding productivity improvements. The novelty in our approach relies particularly on the very micro geographical level, the Super Output Areas (SOAs), i.e. sub-city areas with an average population of 300 residents. Our final dataset is unbalanced panel of 4090 firms for which we have data over the period 2012-2019, located in 1,051 SOAs across 33 districts. Although we are aware of the limitation of this measure, we use *turnover per employee* as indicator of firms' productivity. We provide further geographical disaggregated evidence that accessibility to pools of talents

and the knowledge externalities they may spill over, are very much localized phenomena and may be very sensitive to minor differences in travel times and likely to impact firm productivity. Our findings contribute to the current debate on accessibility, via the real transport network, as a key dimension in firms' productivity, by precisely estimating the role of specialized workers and the spatial interaction between firm and talents zooming within the concrete firm- neighbourhood pair. Moreover, the results open avenue for future research on the determinants of firms' productivity, by showing that firms' productivity increases the lower the distance to talents. Here we argue that localising in a city with many talented workers may not be enough to generate productivity advantages if you locate where such talents cannot be effectively accessed. Poor connectivity within the city may not only increase to costs of accessing them, but also impede the ease of interaction that favours knowledge spillovers.

Overall, this dissertation contributes to shed light on the spatial determinants of MNEs' location choices and firms' productivity at different levels of geographical disaggregation, particularly focussing on the role of transport infrastructures and forward linkages. On the one hand, the three chapters provide empirical evidence on the importance of accounting for the urban dimension of connectivity and accessibility when investigating both MNEs' location decisions and firms' productivity. In this vein, we contribute to the empirical business literature, traditionally more focussed on the international nature of connections, by showing that unpacking further aspects of connectivity can lead to interesting insights on the importance of hard infrastructures within and across cities. On the other hand, we reckon that stressing the role of transport networks may not be sufficient to explain the location determinants of firms providing intermediate inputs, as it is the case of firms in the logistics industry. We show that the location choices of firms across and within cities may be driven by the opportunity to enjoy (i) demand-pull factors, as it is the case of logistics firms; (ii) specialized supply factors, such as talents, whose accessibility may accrue positive productivity gains.

Chapter 1

Getting there and around.
The role of transportation infrastructures in MNEs' location choices at the city-level[1]

Abstract

This paper aims to isolate the role of connectivity between and within cities in location decisions of multinational enterprises (MNEs) across the value chain. Empirical findings are based on a sample of 21.888 cross-border investment projects over the period 2012 – 2015 in 69 cities around the world. Our analysis reveals that intracity connections and lower commuting times are key driving factors for MNEs engaged in production, logistics activities and R&D activities, whereas they do not necessarily attract Headquarters (HQs) and Advanced Producer Services (APS). As previous studies have shown the perceived costs of commuting are negatively associated with educational levels and positively with the age of individuals. On top of this, production activities and advanced producer service activities allow very different opportunities for working from home. R&D activities, employing a higher share of young and well-educated workers, but allowing less opportunities for working from home than APS, show patterns in between production/logistics and APS/HQ. Moreover, the presence of high capacity port infrastructure affects the location of logistics and production activities while discouraging the location of business-related services.

Keywords: MNEs' Location choices, Foreign Direct Investments, Transportation Infrastructures, connectivity, urban mobility

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This paper is part of the PhD dissertation project undertaken by the author under the supervision of Prof. Davide Castellani and Prof. Antonello Zanfei and relies on work conducted in collaboration with them during research activities carried out at the University of Urbino, Italy, and at the Henley Business School at Reading, UK. This paper has been presented at the NECTAR Transport Lab Workshop in 2019 (Rome) iBEGIN Conference in 2019 (Copenhagen) and at SIEPI Workshop in 2020, Venice, as a co-authored paper.

Introduction

The location choices of Multinational Enterprises (MNEs) and Foreign Direct Investments (FDIs) have long drawn the attention of scholars and policy makers (Goerzen et al., 2013; Asmussen et al., 2020). FDI locational patterns reflect inter alia the tendency of MNEs to slice their activities along the value chain in a worldwide network of operations, with decreasing transportation costs playing a key facilitating role in this process (Kano et al., 2020). Regions and cities increasingly compete to make themselves attractive for MNEs' investments, promoting corporate-friendly policies, investing in major infrastructures, fostering knowledge intensive activities (Crescenzi et al., 2014). Accordingly, spatial features shaping a place's attractiveness are increasingly the focus of research. Several scholars have also encouraged a more fine-grained analysis of firms' location decision, highlighting the role that cities have in attracting foreign investments (Belderbos et al., 2017; Lorenzen & Mudambi, 2013; Mudambi et al., 2018; Cook et al., 2018). Among the spatial characteristics that play a role in attracting MNEs in cities, scholars have increasingly emphasized the role of *connectivity* – which can be defined as "*the intensity with which people, goods, capital, and knowledge flow across space*" (Belderbos et al., 2017, Bournakis et al.2019) - as a key factor in firms' decision making. From this perspective, it clearly appears that connectivity may well be a fundamental attractor for FDIs and is at the same time fostered by firms in pursuing transnational location strategies (Goerzen et al., 2013; Goerzen et al., 2017; Belderbos et al., 2017).

In addressing location decisions, international business (IB) scholars have focused on the role of *international connectivity* made possible by the presence of transportation infrastructures and services that enable or facilitate cross-border mobility, as proxied by the number of international airports or the number of international flights, for instance (Bel and Fageda, 2008; Belderbos et al., 2017). International connectivity can be considered as part of the wider notion of the connectivity of a place (e.g. a city) with other places. We will refer to this as *intercity* connectivity. Instead, IB scholars have paid virtually no attention to the role of mobility within urban areas (intracity connectivity) in affecting FDI location decisions. This is a major drawback, because the mobility within urban, suburban and metropolitan areas represents a large fraction of the mobility of workers (Chatterjee et al., 2017) and the efficiency of local transportation infrastructures and services is most likely to affect the cost and incentive structures of firms active on the territory, including MNEs. In this vein, we conceptualise the *intracity connectivity,* which reflects the efficiency and the extension of

urban mobility systems providing within-city connections, whereby the city comprises both its core and suburbs. An efficient urban transportation system has important implications on location decisions as it may imply a reduction of commuting time within cities and metropolitan areas. In turn, this contributes to lower transportation costs sustained by workers and firms. A recent research estimates that a 20 minutes increase in commuting time is perceived to be equivalent to a 19% pay cut in terms of job satisfaction (Chatterjee et al. 2017). Other studies show that longer journeys to work badly affect wellbeing by taking out free time, and by increasing strain and mental distress (St. Louis et al., 2014; Titheridge et al., 2017; Chatterjee et al. 2017; White et al., 2016).

Scholars in geography studies, have started to look at the issue of how intracity connectivity may affect firms' access to specialized and skilled labour markets[2] (Martin-Barroso et al., 2017). Firms often necessitate workers with specific qualifications that are not necessarily available across all possible locations. Empirical evidence shows how a better matching between worker's abilities and firms' requirements is attained from more agglomerated cities, characterised by physical proximity between firms and workers thus reducing commuting costs (hence, reservation wages[3]). As a result, the travel time to work or in the course of work has productive value to employers but also to workers: commuting enables workers to access high productivity locations without having to pay the high cost of living in those locations. Therefore, an increase in commuting times reduces the opportunity set available to firms and workers, decreasing welfare (Monte et al., 2015).

Despite commuting long over distances has become a quite accepted fact of modern life in cities (Monte et al., 2015), very little research has analysed its implications on MNEs location choices, and very few studies analysed the role of urban transportation network in affecting such decisions. To address this largely unexplored issue, we draw insights from geography and

[2] The role that intra-city connectivity has in affecting access to talents and hence firm performance will be dealt with in chapter 3 of this dissertation work.

[3] Economics theory would assume that long journey time commuters must be compensated for by an intrinsically or financially rewarding job or by the benefits of living in a preferred residential environment. Therefore, it would be expected that subjective well- being would be the same regardless of an individual's commuting time. However, Stutzer and Frey (2004) identify the 'commuting paradox' - people with longer commuting times report systematically lower subjective well-being, measured in terms of satisfaction with life. These findings of low satisfaction with long commutes support the notion that a long commute may be accepted as a short term resolution but that changes are likely to be sought in the longer term to home, job or travel arrangements to arrive at a more agreeable state.

transport studies to conceptually and empirically define the role of intracity connectivity in MNEs location choice.

This paper will fill a gap in the IB literature by focussing on urban transportation infrastructures as factors impacting the location of MNEs in cities (whereby the city comprises both its core and suburb), disentangling the role of factors that allow to *get to* a city (intercity connectivity) and those that affect the efficiency of *getting around* the city (intracity connectivity) in shaping MNEs' location decision making. We will argue that - due to workers' and activities characteristics – location decisions across the value chain may exhibit different sensitivity to the efficiency of transport infrastructure allowing intracity connectivity. Building on research concerning the sensitiveness of individuals to commuting times at the urban level (Chatterjee et al., 2017; Martin-Barroso et al., 2017; Clark et al., 2019), we identify how location decisions vary across business activities according to the likelihood characteristics of workers employed in such activities that are more sensitive to intracity connectivity. More precisely, as previous studies have shown, the perceived costs of commuting are negatively associated with educational levels and positively with the age of individuals (White et al., 2016; Chatterjee et al., 2017), we predict that production and logistics activities -in which relatively young and unskilled workers account for a larger share of employment[4]- should locate in cities with more efficient urban mobility systems. On the contrary, advanced producer services[5] (henceforth, APS) and headquarter activities (henceforth, HQs), where workers tend to be relatively younger and/or more educated, should be less sensitive to how efficient intracity connectivity works. On top of this, production activities and advanced producer service activities allow very different opportunities for working from home, thus reinforcing the above prediction. R&D activities, employing a higher share of young and well-educated workers, but allowing less opportunities for working from home than APS, are expected to show patterns in between production/logistics and APS/HQ.

To address these issues, the paper will be organized as follows. The first section discusses how connectivity is likely to affect each function of the value chain considered in this research work. The subsequent section will illustrate the methodology applied to analyse the impact of

[4] There is evidence showing that on average production activities employ unskilled workers, whilst services, HQs and R&D tend to employ young and highly educated workers. More details will be given in next sections, Eurostat survey data supporting this evidence may be found in Appendix.

[5] We create our aggregate of APS, relying on past literature according to which APS involves a variety of activities (Finance, Insurance, Accountancy, Real Estate- i.e. FIRE[5]- law and advertising, professional and media services) – (Sassen, 1991; Taylor, 2004)

physical infrastructures on MNE's location decisions. Then we present the data used in our empirical analysis. The last two sections are devoted to the discussion of results and conclusions.

Background Literature

1.1 International connectivity and MNEs' location choices

Among the factors, that have been gaining importance as attracting factors for MNEs, scholars in IB have highlighted the role of *international connectivity* (Goerzen et al., 2013; Goerzen et al., 2017; Belderbos et al, 2017). The standard definition that we have reported in the introduction - "*intensity with which people, goods, capital, and knowledge flow across space*" (Belderbos et al. 2017) - reflects the fact that international connectivity is a multifaceted concept (Asmussen et al., 2020 Belderbos et al., 2017; Castellani et al., 2020), of which physical *infrastructure* is a key aspect. More specifically, infrastructures have been highlighted as a crucial aspect of connectivity as they allow the movement of people and goods between cities, as in the case of airports, railways and harbors. What emerges from the empirical literature is that cities with well-connected networks of physical links and relations gain a privileged position in the global economy, and are likely to attract MNEs, which need to coordinate globally dispersed resources in a geographically fragmented network of resources and operations. Goerzen et al. (2013), using data on the locational choices of Japanese MNEs subsidiaries in a large set of cities, found that the higher the connectivity of each city, the lower the uncertainty and the liability of foreignness. Also, Belderbos et al., (2017) investigated the location of regional HQs (RHQs) by looking in which global city the MNE decide to locate its RHQ. Results show that distance effects disappear when the city is highly connected. Therefore, those firms located in cities involved in a well-connected network of physical connections[6], may exploit an advantaged position, in which the physical infrastructures ease the flows of goods and people, reduces costs (Redding & Turner, 2014), and uncertainty. Bel & Fageda (2008) find that the availability of direct non-stop flights has a large influence on firm headquarters' location in European urban areas. Anderson (2020)

[6] Cities in which different places within the metropolitan area are connected to each other using the transport system. For instance, considering how frequent/reliable services are in each area of the city – e.g. the London department for transport divide the city in 100x100 grids and accounts for each grid the number/frequency and reliability of the public transport available in that area. Further information is available elsewhere (Transport for London, 2010).

investigated the determinants of MNEs investments in the US, finding that FDIs are attracted to US Metropolitan Areas (MSAs) that have airlines connections but not necessarily to those located in the vicinity of a port. Castellani & Lavoratori (2020) qualify this finding by showing that airline connections are particularly important for investments in HQs and manufacturing activities, but not for R&D.

What emerges from the literature investigating MNE's locational strategies is that while intercity connectivity has been addressed and emphasized, the role of intracity connectivity has been hitherto understudied. To the best of our knowledge, there is no evidence on the role of intracity connectivity, hence within city connections, on MNEs location choices. To shed light on the urban dimension of connectivity, we rely also on geography and transport literature, which have extensively investigated the impact of within city connections on employment, productivity and residential location choices, among others. However, although IB disregards intracity mobility, TE gives no special attention to the heterogeneity of firms' activities attracted by the infrastructural endowment, underplaying specificities of MNEs as orchestrators of different activities across the value chain with distinctive needs for connectivity. Therefore, we highlight the need of integrating the two approaches.

1.2 Intracity Connectivity and Commuting Times

While IB literature has devoted most of the attention towards the role of international connectivity, other streams of economic literature have extensively studied a wider variety of connectivity issues, also at the urban level. In particular the geography and transport literatures shed some light on the role that intracity connectivity has in firms' location choices. Specifically, scholars pointed the capacity and the structure of transport infrastructures as crucial elements in the determination of a place's degree of connectivity. According to the World Bank (2019), an intrinsic characteristic of *connectivity* is that it relies on the development of *networks*, i.e. a set of interconnected nodes. A node may be a person, a firm, a city or a country or whatever spatial entity. In transport and economic geography, this refers mostly to connectivity[7] between locations and it is assessed within relatively small spatial

[7] As pointed in the introduction of this dissertation work, the geography literature most often applies the term 'accessibility' which is a measure of the quality of connections and it is countable as the measure with which a place can be reached by or reach other places over time (Geurs et al.,2001, 2004), while connectivity might stay the same regardless of temporality aspects (e.g. the physical network does not change, but road improvements might increase accessibility). However, in the analysis of commuting it is most common use the word 'connectivity' (Graham et al., 2010). Overall, what it stands out is that these two terms might be used as

units, such as a city; in IB it primarily refers to connections between places across countries, thus having a set of larger spatial units to be compared. Overall, the key insight stands on the necessary emphasis on the function that transportation infrastructures within cities may assume. Notably, on the role that travel times assume in the context of appraising the place's overall degree of connectivity, or in other words, the advantage of a location compared to another because a more efficient urban mobility system (Graham, 2007a; Graham et al., 2008; Melo et al., 2013; Holl, 2012; La Nechet et al., 2012; Mavoa et al., 2012; Biosca and Stepniak, 2013).

The impact of connectivity on multinational firms' location decisions is of a major concern in our study. We address it by separating the analysis of intercity connectivity and intracity connectivity, i.e. the efficiency and extension of urban networks allowing within-city connections, whereby the city comprises both its core and its suburb. Typically, empirical literature appraises intracity connections through *commuting times*. The worthiness of considering commuting time is threefold: first, it is a key element when it comes to evaluate the efficiency of a new transport infrastructure investments in Cost and Benefit Analysis, since it accounts for 80% of social benefits (Institute for Transport Studies, University of Leeds, 2003). That is, improvements because of a new infrastructure are detected by decreasing travel times (Heuermann et al., 2019). Secondly, the commute time has value for firms because it is an output lost to the employer, hence to firms[8], while the employee is travelling. Thirdly, journey time to work is also an output lost to the employee: assuming an eight-hour workday, on average workers spend 8%[9] of their working day commuting, thus facing a daily opportunity cost between residence (e.g. residential areas and amenities) and workplace (e.g. the wage they get) (Redding et al., 2014; Monte et al., 2015). As a result, longer commuting

synonymous and interchangeably while describing how physical infrastructures affect economic agents. We use the generic word 'connectivity' throughout since we make no judgment on whether the effects work through transport improvements over time.

[8] The wage rate or cost saving approach, based on classical economic theory of marginal productivity, states that reductions in labour costs due to shorter journeys will result in more units of labour being hired to increase production.

[9] The estimate draws back to the work of Schafer (2000) who summarized 26 national household travel surveys from countries all over the world. Redding & Turner (2014) note that this estimate is problematic for at least two reasons. First, it assigns the time cost of an average worker to an average traveller, when many travellers are likely to have a lower value of time. Second, it assigns the time cost of an average worker to an average commuter, when wages probably vary systematically with commute distance. Basing upon these surveys, a rough guess would be that the aggregate time cost of household travel is somewhere between 3.5% and 8% of the aggregate value of labour in an economy.

times may require higher reservation wages (Graham, 2007; Holl, 2012; Martin-Barroso et al., 2015; Chatterjee et al., 2017).

1.3 Commuting Times and Firms' Location Choices

Scholars in geography and transport studies, have started to look at accessibility as an attractive factor for firms, enhancing productivity and favouring the match between workers and firms (Martin-Barroso et al., 2015, 2017). Firms need workers with a specific set of skills that are not automatically available across all possible locations – assuming that each firm defines its area of influence for hiring and compete with other firms for that labour pool (Cheng et al., 2013). Empirical evidence shows how a better matching between worker's abilities and firms' requirements is attained from agglomerated cities, which increases physical proximity between firms and workers reducing commuting costs, thus reservation wages. The latter aspect is not trivial; if worker's propensity to change his/her residence hinge on wage differentials, ultimately linked with firm's performance, a simultaneity problem might arise between workers' accessibility and productivity as shown in Holl (2012) and Graham (2010), who found out that increasing in firm's productivity derives from a better location's accessibility[10] (Melo et al., 2013; Martin-Barroso et al., 2015). The relationship between accessibility and labour market, thus the interaction between firms and workers, mainly focused on the supply side, i.e. the accessibility of workers to jobs (Graham, 2007a; Geurs et al., 2004, 2013; Holl, 2012, 2016).

Recently, Monte et al. (2015), provided evidence and theory that elasticity of local employment depends on the commuting openness of the local labour market. Using data on location decisions drawn from *million-dollar plants* dataset, they found out that reductions in commuting costs generate welfare gains of around 3%. Workers spend about 8% of their working day commuting to and from work (Redding & Turner, 2015), this means that there is a significant daily investment to live and work in different locations to balance their living costs, residential amenities and the wage they get. Therefore, the ability of firms in a location to attract workers depends on the ability to attract local residents and commuters from other locations. Therefore, migration and commuting determine the local employment elasticity as in Bartik (1991). Here Monte et al., (2015) used county-level data for the U.S. to develop a

[10] For an extensive review on the relationship between firms' productivity and accessibility, please refer to Chapter 3 of this dissertation.

general equilibrium model that incorporates spatial linkages between locations in good markets (trade) and factor markets (commuting and migration). They show that the resulting commuting flows between locations exhibit a gravity equation relationship with a much higher distance elasticity than for goods flows, suggesting that moving people is costlier than moving goods across geographic space. In their research work, commuting is modelled as a gravity equation in which flows of commuting are calculated by using the share of commuters who work and live in their residence county with respect to commuters who live in a different county and commuting to their workplace (i.e. there are counties which import commuters, and counties which export commuters). The results presented by the authors are coherent with past literature studying commuting times-labour markets relationship, by confirming that commuting enables workers to access high productivity locations without having to pay the high cost of living in those locations. Therefore, increases in commuting times shrink the opportunity set available to firms and workers, reducing welfare.

White et al. (2016) explored the relationship between commute mode, public transport connectivity and subjective wellbeing using data on 3630 commuters in London[11]. After controlling for individual level socio economic factors (e.g. income and education) (Clark et al., 2019), the results show that overall, younger workers are less sensitive to longer commute and more prone to use public transport. Also, individuals residing in areas with denser connections (e.g. individuals that can use public transport modes to commute from their residence to their workplace) reported fewer symptoms of mental distress with respect to individuals residing in poorly connected areas (St. Louis et al., 2014; White et al., 2016; Vilhelmson et al., 2016).

Giuliano et al., (2007, 2012) supported the idea of a better accessibility leading to better interaction firms-workers. The authors used data on 48 employment centres in Los Angeles, testing the effect of various measures of accessibility on centre growth. Specifically, they measured highway accessibility, network accessibility and labour force accessibility. The main argument here is that employment growth can be explained by the quality of local access to LA's extensive transport network. The interest in such topic may be found in firm's location choices. Giuliano et al. (2007) found a positive relationship between urban accessibility and location choices, which in turn may reflect employment centres to grow. It is argued that firms locate inside employment centres to benefit from economies of scale of locating in proximity

[11] Data are drawn from the Understanding Society Survey (2010/2011).

with other business, exploiting a large skilled labour pool. They define network accessibility as an impedance function in which the main variable of interest is shortest-path travel time. Next, they used distance to the nearest five airports in LA as an access to inter regional and international connections.

Martin-Barroso et al. (2017) used travel times to compute the accessibility level of manufacturing firms to labour markets in Spain. Results in Martin-Barroso et al., (2017) emphasise the importance of the accessibility to labour markets for firms. Precisely, most dynamic and productive firms are the ones that show better accessibility to labour markets and this in fact allows them a better matching and thus enhanced performance (Nuñez-Serrano et al., 2012). The authors used data on 60.000 Spanish manufacturing firms and over a million commuters across the urban and intercity network. The paper provides an accessibility indicator not computed at the individual level, but at a geographical level (provinces, regions) and by defining a labour accessibility indicator from the firm perspective, introducing both the individual characteristics of the economic agents involved and the urban structure. There are four main results worth to be highlighted: (i) there is evidence that the willingness to commute decreases with the length of journey, still (ii) the probability of commuting increases according to the qualification level (i.e. high skilled workers are associated with higher probabilities to commute over longer distances) and firm size, (iii) workers living in municipalities located in the neighbourhoods of large urban agglomerations show higher attraction by the firms located in these large cities, (iv) most dynamic and productive firms are the ones that exhibit a better accessibility to labour markets (as the bid-rent theory predicts[12]) and this allows them to have a better matching (Nuñez – Serrano et al., 2012).

To carry out the empirical analysis, the authors considered the whole road network (urban and intercity), calculating specific impedance functions[13] for each firm-worker's district of residence pair. The accessibility indicator is then calculated by combining the impedance functions with the demand and supply of labour observed within the area where the firm may catch its workers. Results showed that the accessibility of firms to workers is higher in large agglomerated urban areas. The indicator that authors propose implies that each firm

[12] In an economic geography context, it Is assumed that the price and demand for real estate change as the distance from the central business district (CBD) increases. In this case the wage increases offsetting the cost of longer journeys to work.

[13] The loss of utility associated with traveling (e.g. time, costs)

geographically defines its specific area of influence for hiring workers and it competes with other firms. They found that larger firms offer more specialised and better paid jobs, this implies, as said above, that skilled workers are willing to commute longer distances in order to improve their working conditions, as there is a trade-off between the cost of commuting and the level of wages (reservation wages). Younger and skilled workers prefer to use public transport, as a matter of fact, public transport availability may favour labour matching by higher hiring probabilities or may hinder them because of longer commuting times due to congestion.

1.4 Commuting, Wellbeing and Telework

The recent research conducted by Chatterjee et al., (2017) also reveals interesting insights about the relationship between commuting time, job satisfaction and the telework phenomenon. These issues are worth mentioning since they relate to workers' and activities characteristics which are likely to affect firms' location decisions across the value chain. This will help use developing arguments that different activities along the value chain may exhibit different sensitivity to the efficiency of transport infrastructure allowing intracity connectivity. The research has been conducted exploring the relationship between commuting and wellbeing in 26.000 commuters[14] living in England. It found out that every extra minute of commute time reduces job satisfaction altogether, though different mode choices may change the upside/downside effects of commuting. For instance, walking to work and shorter commute times increase job and leisure satisfaction while decreasing strain. Rail users feel more strenuous shorter commute times than longer ones (Chatterjee et al., 2017).

Also, commuting patterns and job satisfaction might relate to the phenomenon of telework, i.e. work which 'usually involves travel and/or spending time at the customers' premises' (Daniels et al., 2001:1154) or whichever location different from the usual workplace[15] (Vilhemson et al., 2016). Findings show that not all workers can choose how often and when

[14] The Commuting & Wellbeing Study examined the impacts of commuting on the wellbeing of over 26,000 employed people living in England between 2009/10 and 2014/15. The findings are based on data from Understanding Society - an innovative world leading study about 21st century life, in which members of 40,000 households are surveyed every year. The data set made it possible to examine how changes in subjective wellbeing from one year to the next are related to changing commuting circumstances. It also looks like there is no clear commuting boundary that define untangle commuting within and between cities.

[15] In Europe, Eurostat data from 2000 to 2017 teleworkers has increased from 5 to 7% between 2000-2005, being 9.6% in 2017 for the overall working population (15 – 64-year olds). However, what is interesting is that the frequency of working from home at least once a week, increases with age, being 4.7% of 25-49-year olds and 6.4 of 50-64-year olds

they travel and telework very much rely on job and worker's characteristics (Neirotti et al., 2013; Vilhemson et al., 2016)[16]. In this respect, Geurs et al., (2013), found that ICT technologies available on different transport modes, allow the commuter to combine work and travel while travelling by train, for instance. This has been connected to certain kinds of workers, namely business workers, who have the possibility to carry out their tasks by using a laptop or teleworking (i.e. working during off hours in a location different from the workplace). What stands out is that low capital-intensive industries (e.g. services) are more prone to allow teleworking, while high capital-intensive industries (e.g. production), are expected to have less interest in telework, because jobs in these firms are more likely to require worker's physical presence in the place where production occurs (Peters et al., 2004; Gil Solà et al., 2012; Neirotti et al., 2016). Not surprisingly, the use of telework is more spread in APS because of their increasing digitalisation, but also because commuting-based workers' preferences for telework are not that sensitive to geographical distance, being the majority of teleworkers located in urban areas, where the APS and businesses with low capital intensity are increasingly clustered. Also, older and high skilled white-collars employed in advanced services as well as in headquarters are much more prone to telework with respect to their younger counterparts – this may be due to personal factor, like having a family and/or young children -. Additionally, we may assume that, although knowledge intensive workers, are less sensitive to commuting (Neirotti et al., 2013; Martin – Barroso et al., 2017) and more prone to telework, those employed in R&D, still need to be in the lab to carry out their work (see Figure 3 in Appendix).

Hypotheses Development

Connectivity and the location of MNEs' activities

The different perspectives on commuting times on firms and workers helped us to develop some hypotheses on the determinants of the location of different MNE activities across the value chain. In particular, we focus on four types of activities: Production & Logistics, Advanced Producer Services, Research & Development and Headquarters. We argue that the effect of intracity mobility change across these activities in consideration of their

[16] While Vilhemson et al. (2016) used cross-sectional survey data on Sweden from 2005-2012, therefore taking the employee's point of view, Neirotti et al., used firm level data for the Piedmont region (Italy), thus taking the employer's point of view.

characteristics and of the type of workers more likely to be employed in these tasks. As emerged from the discussion in the previous section, the literature studying commuting flows stresses the role of age as a characteristic affecting the willingness to commute for workers. Overall, scholars found out that overall *young* high skilled workers are less influenced by the journey to work, they on average prefer to live in urban areas (Zhao et al., 2017), enjoy higher degrees of urban connectivity, perceive less strain and mental distress, or take advantage of this off-work time while travelling to do business-related activities (Flint et al., 2014; Martin et al., 2014; St. Louis et al., 2014; Chatterjee et al., 2017; Chng et al., 2016; Titheridge et al., 2016). Conversely, *older* high skilled workers are less prone to travel, since their dwelling preferences for residential areas "push" them to commute from outside the city boundary to the core city. Building upon the literature we have just reviewed, investigating the link between age and intracity connectivity on the one hand, and skills and intracity connectivity on the other, we argue that such links may be also found in the interplay between urban mobility and the business activities across the value chain. By looking at the data reported in the latest Labour Force Survey from 2004 to 2018 (Eurostat[17]) we may find further empirical evidence supporting our arguments. In Europe on average 70% of Managers are older (+55) and highly educated (ISCO-08[18] Classification ED5-8, i.e. tertiary education), whilst Professionals are younger and highly educated as well. By looking at Figure 1 in Appendix, we may also observe that on average the highest percentage of these workers (Y axis) can be found in services rather than production activities. Contrarily, Plant, Machinery and Craft workers tend to employ unskilled and slightly older workers (see Figure 2 in Appendix).

Based on the literature we discussed we formalize our hypotheses on the role of connectivity in shaping location decisions of MNEs across different business activities. Our line of argument consists of three interrelated analytical steps. First, we argue that some characteristics of workers (particularly their age and skill intensity) and the intensity telework opportunities affect the sensitivity of labor force to intracity connectivity. This is illustrated in Taxonomy 1 below. Second, we submit that specific business activities significantly differ in terms of such characteristics of workers and of teleworking opportunities, as shown in Taxonomy 2. Third and finally, we discuss how MNEs' locational patterns in each of these business activities are

[17] Employees by educational attainment level, sex, age and occupation (%) [lfsa_egised]
[18] https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf

affected by their distinctive sensitivity to intra-city connectivity. This will lead us to Taxonomy 3.

Taxonomy 1. Sensitivity to Intracity Connectivity by Workers' Characteristics and telework opportunitiees

	High Skilled	***Low Skilled***	***Young Age***	***Old Age***	***High Opportunity to telework***	***Low Opportunity to Telework***
Sensitivity to intracity connectivity	LOW	HIGH	LOW	HIGH	LOW	HIGH

As for the first step, Taxonomy 1, draws from the empirical literature recalled earlier and suggests that younger workers are less sensitive to commuting than older workers; whilst more educated workers are less sensitive to commuting than less educated workers; and workers active in environments with higher teleworking opportunities are less sensitive to travel times as well.

Taxonomy 2. MNEs' Value Chain Activities by Workers' and Jobs characteristics

	Production & Logistics	***R&D***	***APS***	***HQs***
AGE	OLD	YOUNG	YOUNG	OLD
SKILLS	LOW	HIGH	HIGH	HIGH
OPPORTUNITY TO TELEWORK	LOW	LOW	HIGH	HIGH

Taxonomy 2 presents some stylised facts on how business functions differ in terms of the characteristics discussed above: (i) APS and HQs employ on average highly educated workers, younger in the case of APS, whilst HQs tend to employ older and highly educated workers, e.g. upper level executives. Both are characterised by relatively high opportunities to telework (see Figure 3[19]). This combination of factors implies that workers in APS and HQs are not so sensitive to travel times. (ii) Production, Logistics are less amenable to telework, employ on

[19] Labour Force Survey 2019, [LFSO_19FXWT03__custom_147213]

average older and less educated workers, thus are expected to be more sensitive to the quality of intracity connections. (iii) Although R&D employ on average workers having similar characteristics as APS, young and highly educated, they are indeed more sensitive to travel times than other advanced services as they may be characterised by fewer opportunities to telework.

Based on taxonomies 1 and 2 we shall make inference on MNE's location decisions across different value chain activities.

The Location choices of MNEs along the value chain

Production and Logistics

Overall, what emerges from previous IB literature on the location of Production activities, aside the traditional motives such as "trade and tariff concessions, cheap labour, reduced logistics costs" (Verbeke, 2017:220), MNEs should leverage also the chance to get closer to customers and suppliers exploiting a better degree of accessibility to the market. In this sense, the economic literature goes along with the IB perspective finding that manufacturing is affected by the improvement in city's accessibility locating near the metro stations (Dorantes et. al., 2012), also better accessibility improves firm's productivity, because firm may exploit an improved access to the market for their products and reduce the costs of inputs (Holl, 2016).

Despite its growing importance in the global economy, the theory of logistics firms' decision making is hitherto understudied (Hesse & Rodrigue, 2004) and very little has been said in the IB literature. However, geography and transport empirical literature has found that the location of logistics firms is a function of the city's proximity to ports, airports, highways, railroads and of their relative costs, and they play a crucial role when logistic firms locate in large urban areas, allowing them to meet the increased scale and time-sensitiveness of goods distribution (O'Connor, 2010). In fact, the physical good needs to be shipped either to the manufacturing plant or to the market for consumption and higher levels of urban accessibility may ease logistics activities to fulfil those activities they carry out. (Alonso, 1967; Krugman, 1991; Hesse & Rodrigue, 2004; Hong et al., 2007; Pisano & Sinh, 2009; Masson & Petiot, 2015; Kang, 2018). By banking upon the extant of literature proposed above, we link jobs' activities with the workers those activities tend (on average) to employ. Therefore, contrarily to APS/HQs, production and logistics activities on average may employ more unskilled workers,

the so called blue-collars (Acemoglu, 2002; Autor, 2008; Neirotti et al., 2013; Cirillo, 2017), who in principle are more tied where the production occurs. Again, the LSF survey from Eurostat might support such argument whereby the highest percentage of unskilled workers is typically employed in plant and craft activities (figure 2 in Appendix), who face lower opportunities to telework, as the workers need to be in the plant for production to occur.

Accordingly, for production and logistics activities we expect to be more sensitive to both the city's degree of intracity and intercity connectivity. Particularly, location decisions vary across business activities according to the likelihood characteristics of workers employed in such activities that are more sensitive to intracity connectivity. More precisely, as previous studies have shown that the perceived costs of commuting are negatively associated with educational levels and positive with the age of individuals, we predict that production and logistics activities -where these types of workers account for a larger share of employment- should locate in cities with more efficient urban mobility systems.

Research & Development

Empirical IB literature on R&D location decisions has led, among others, to three main findings: (i) MNEs locate their R&D subsidiary in cities where they can enjoy higher levels of international connectivity (Goerzen et al., 2013; Goerzen et al., 2017; Belderbos et al., 2017; Castellani & Lavoratori, 2020), (ii) where they can exploit location specific knowledge – e.g. centres of excellence - , (iii) and lastly they locate in those cities that ease knowledge exchange, which often require face-to-face meetings. (Cantwell & Mudambi, 2011). For the purpose of easing such knowledge exchange, intracity connectivity should not be disregarded. In fact, a better network of physical connections might ease the flows of intangibles as it is by means of transportation infrastructures, that ultimately allow the mobility of knowledge embodied in human beings[20], and make it possible for people to interact, and to generate, exchange and combine the competencies and skills which foster long-term growth (Pisano & Shih, 2009; Hannigan & Mudambi, 2015). However, while the role of intercity connectivity has been extensively studied, the role of intracity connectivity has been hitherto understudied. Concerning our analysis on the role that also intracity connectivity has in shaping MNEs' location choices, R&D activities, may stand in between of production and services activities, on the one hand, they employ high skilled workers, who, as a stream of economic literature

[20] Please see also Chapter 3 of this dissertation for a discussion on the topic.

found out, are less sensitive to commuting. On the other hand, in the case of R&D there might not be possibility to telework – linked also to those aforementioned worker's characteristics - because the activity they carry out is very much tied to the physical place. This might impact negatively on how those workers perceive the travel time from home to work, as they have no opportunity to do otherwise (Gil Solà et al., 2012; Neirotti et al., 2013). Accordingly, we may assume that intercity connections are likely to exert a positive effect, while intracity connectivity – notably commuting times – are likely to negatively influence these activities.

Advanced Producer Services

Given their manifold nature, Advanced Producer Services (APSs) serve global production functions by creating a unique pooling of managerial capabilities, providing those "*organisational commodities*" to support the "*command – and – control*" functions of their global clients (e.g. Headquarters) (Dunning & Norman, 1983; Storper & Venables, 2004; Bathelt et al., 2004; Jacobs et al., 2010, 2011). Previous literature on APSs' location choices, also found out that these firms tend to be localized towards the top of urban hierarchy (Shearmur et al., 2007; Rubalcaba, 2013), because the access to highly qualified labour pool (Henderson, 2000; Shearmur et al., 2002; Coffey & Shearmur, 2002; Taylor, 2004; Derudder et al., 2010) and physical accessibility act as pulling factor (Graham et al., 2010; Nuñez Serrano et al., 2012; Holl, 2012; Melo et al., 2013; Martin-Barroso et al., 2015). These last two aspects are common in the locational behaviour of HQs as well, since both activities are biased to the urban, they prefer to enjoy a cosmopolitan environment and ultimately exploit a privileged position in a valuable network of physical connection across cities (Sassen, 1991; 2012; Taylor et al., 2004; Berube and Parilla, 2012; Goerzen et al., 2013; Taylor and Derudder, 2016; Belderbos et al., 2017), typically endowed with the kind of high skilled human capital they tend to employ. Contrarily to production and logistics workers, the literature discussed so far seems to suggest that young and high skilled workers, on average more employed in advanced services and HQs, are less sensitive to intracity connectivity (commuting within the city and its suburbs). As it has emerged from the discussion in the previous section, the literature studying commuting flows found out that overall young and high skilled workers are less influenced by the journey to work, they on average prefer to live in urban areas (Zhao et al., 2017), enjoy higher degrees of urban connectivity, perceive less strain and mental distress, or take advantage of this off-work time while travelling to do business-related activities (Flint et al., 2014; Martin et al., 2014; St. Louis et al., 2014; Chatterjee et al., 2017; Chng et al., 2016;

Titheridge et al., 2016). Therefore, we assume that these worker-characteristics relate to APS/HQs, which notably employ high skilled professionals (Acemoglu, 2002; Feenstra et al., 2003; Vilhemson et al., 2016, Neirotti et al., 2013; Bogliacino et al., 2016; Cirillo, 2017). Given the distinctness of APSs, we may assume a lower influence of commuting times, while we expect higher sensitivity for intercity connectivity. Moreover, it may be worth to be pointed that these activities, contrarily to production, logistics and R&D, may have easier opportunity to telework (see Figure 3 in Appendix), making them less sensitive to commuting within city and its suburbs (the spatial dimension in which intracity connectivity is defined here). It is also interesting to note that such activities, as being amenable to work away from the office (see figure 3 in appendix), may be as well linked with the phenomenon of extreme commuting, i.e. commute for more than 90 minutes each way every day. Most often extreme commuting behaviour is associated to executives and upper level management who face a complex trade-off between dwelling preferences and work-life balance, reflecting inter alia the willingness to commute for very long distance over relocating close to the workplace (Molloy et al., 2013; Vincent-Geslin et al., 2016). According to the Trades Union Congress, over 3.7 million white-collars workers in Britain endured a daily commute of two hours or more in 2015, an increase of 900,000 units since 2010 (Financial Times, May 17th, 2017[21]). The increasing trend is registered in the U.S. as well, where the Census Bureau registered a 31.7% raise in the number of super commuters[22] since 2005. A further 76% is registered for telecommuters. This is certainly possible if there is a network of intercity connections which ultimately allow long-distances journey to work, for flight and interregional trains are on average the preferred mode choices in the case of super commuting (Forbes, Aug 21st 2013[23]; March 14th 2019). We may assume that APS/HQs' workers characteristics might fit in these trends as well, for two reasons: (i) extreme commuting is a very income-elastic phenomenon and as such it may be experienced by those individuals who are engaged in managerial position and as such receive a wage premium for the long distance travelled (ii) empirical research shown that super commuting is experienced mainly in knowledge intensive activities by the upper level management. Thus, though these individuals are highly skilled and in principle less sensitive, flexible work schedule, smart-working opportunities and dwelling preferences make them

[21] https://www.ft.com/content/4fd8769c-2f89-11e7-9555-23ef563ecf9a
[22] https://www.forbes.com/sites/alyyale/2019/03/14/work-from-home-americans-super-commuters-are-more-likely-to-own-a-home/#43eb97861ee5
[23] https://www.forbes.com/sites/learnvest/2013/08/21/i-take-a-plane-to-work-the-rise-of-supercommuting/#479cdc25565e

suitable to be super commuters as well, and therefore more sensitive to the extension and quality of international connections.

Headquarters

Similarly, literature on HQs' location choices, highlights how it is crucial for this function to be located where physical and digital connections make them effective and efficient in their operations. They deal with important strategic tasks such as planning, marketing, finance and create the overarching administrative framework and entrepreneurial support for the subsidiaries upon which rely the overall company's success. Like APS, HQs choose to locate in urban areas where they can exploit the presence of a larger pool of skilled labour force and managerial capabilities, agglomeration economies, higher levels of business services, and with good airport facilities which tend to keep them put (Henderson et al., 2008; Strauss-Kahn et al., 2009; Pastor et al., 2014; Belderbos et al., 2017). Building on previous research arguing that HQs are more attracted by those urban areas where they can tap into a larger pool of managerial capabilities (Belderbos et al., 2017), we assume that managers employed in HQs are older and highly skilled professionals (in Figure 1 it is possible to observe that person with the highest education ED08 are older than 54[24]), therefore, we may expect that those firms, that, among others, exploit the presence of a skilled human capital and managerial capabilities, might enjoy higher levels of intercity connectivity (e.g. air connections), while being less sensitive to intracity connections. As a matter of fact, the higher sensitivity to international connections has been quite documented by the bulk of empirical research. Bel & Fageda (2008) found a positive relationship between air connection and the location of HQ in Europe. More recently Hoenen & Kostova (2015) found a positive relationship between the location of HQs and proximity to infrastructures allowing cross-border mobility. Castellani & Lavoratori (2020) supporting this evidence by showing that HQ activities are sensitive to intercity connectivity measured, among others, by the number of international passengers. This is consistent with the idea that MNEs will more likely minimize travel costs and management time by establishing HQs in locations offering high quality of transport services and infrastructures that are nodes of passenger transportation networks, facilitating cross border mobility of people (Goerzen et al., 2013; Ma et al., 2013; Belderbos et al., 2017). Similarly to the arguments proposed above, we assume that being HQs a key orchestrating

[24] In the US, the median age of managers resulting from the American Community Survey from 2011 to 2019 is 44 years old. https://www.bls.gov/cps/cpsaat11b.htm

actor in manage the worldwide activities of the MNEs, we may find that on average these activities employ more experienced personnel to pursue management activities, highly skilled, older (figure 1 in appendix), with more opportunities to work away (see figure 3 in appendix) and therefore more sensitive to the quality and extension of transport infrastructures allowing international connections. Although data are very sparse, these are nonetheless compelling and highlighting how certain professional roles, i.e. managers, are less sensitive to urban mobility. Very recently, the New York Times, Bloomberg, Financial Times and Forbes, reported several convincing experiences about executives and upper level managers who are super commuters. Here we propose again the argument raised in the previous paragraph by assuming that HQs' workers, like APSs', characteristics might fit in these trends as well, for the same reasons we proposed above, (i) extreme commuting is a very income-elastic phenomenon (ii) empirical research shown that super commuting is experienced mainly in knowledge intensive activities by the upper level management. Here it is to be highlighted that HQs, as well as APS, are less sensitive to intracity mobility in front of a more flexible work schedule allowing their workers to work away from the office.

Lastly, we summarize the different sensitivity we expect MNEs may exhibit in each business activity along the value chain, due to the intrinsic jobs' and workers' characteristics and opportunity to telework as proposed in taxonomies 1 and 2. Particularly, we point to intracity connectivity, which reflect the quality of within city connections, whereby the city comprises both its core and the suburbs.

Finally, taxonomy 3 shows that we expect (i) Production and Logistics will be positively affected by lower commuting times, and thus more sensitive to the quality and extension of urban mobility networks. (ii) APS and HQs may be the least sensitive to intracity connections, being more amenable to work away. (iii) R&D exhibits an intermediate profile. Although these activities employ on average young and highly educated workers, expected to be less sensitive to longer commutes, they are also less amenable to work away as they need the lab to carry out their jobs and thus showing similar patterns to production and logistics in the way they enjoy higher levels of intracity connections.

To summarise the discussion above one may thus draw the following Taxonomy 3 that illustrates how firms' business functions differ in terms of their sensitivity to intra-city connectivity.

Taxonomy 3. Sensitivity to Intracity Connectivity by MNEs' Business Activity

	Production & Logistics	***R&D***	***APS***	***HQs***
Sensitivity to Intracity Connectivity	HIGH	MEDIUM	LOW	LOW

By intertwining the taxonomies we have developed, we formalize the following hypotheses:

Hypothesis 1: *MNE investments in Production and Logistics, being less amenable to telework, employing on average older and less educated workers and being less characterised by teleworking opportunities, are the most sensitive to intracity connectivity*

Hypothesis 2: *MNE investments in APS/HQ activities, being more amenable to telework, employing on average younger and more educated workers are the least sensitive to intracity connectivity*

Hypothesis 3: *MNE investments in R&D activities, being limitedly amenable to telework, employing on average younger and more educated workers have an intermediate sensitivity to intracity connectivity*

Therefore, we argue that cities in which getting around is easier, are more attractive for Production, Logistics and R&D, while they do not necessarily attract APS and HQs.

Data

In order to study the effect of the urban and the international dimension of connectivity in FDI location decisions across the value chain, the empirical analysis draws on data from two main datasets, fDi Markets[25] and Urban Transport Data Analysis Tool (UT-DAT)[26]. The first one is a commercial online database, produced by fDi Intelligence, a specialist division of the Financial Times Ltd, which provides information on FDI projects. Relying on media sources and company data, fDi Markets collects detailed information on cross-border investments. Data are based on the announcement of the investment and updated daily. For each project, fDi Markets reports information on the industry and main business activity involved in the project, the location where the investment takes place (host country, regions and cities), as well as the

[25] www.fdimarkets.com

[26] http://www.worldbank.org/en/topic/transport/publication/urban-transport-data-analysis-tool-ut-dat1

name and location of the investing company (home). The database contains around 143,000 investment projects referring to the period 2003-2015 in 184 countries, covering several business activities, such as Research & Development, Production, Logistics, headquarters (HQs), Business Services, Marketing, Education & Training and Technical Support, ICT. Advanced Producer Services (i.e. accountancy, banking/finance, law, real estate – Business services activities – and advertising - Marketing activities) are built according to the literature conceptualizing this kind of services (Sassen, 1991; Taylor, 2004[27]). The database reports information about the characteristics of each investment project, for instance the parent company name, home country and city, the industry and the business activity involved in the project, as well as the location of project destination, host country and city. The UT-DAT dataset is a freely online available dataset built up by the World Bank for policy-making purposes and contains data on city's transportation system for 92 cities in 2011[28], such as average time to work (including all mode choices), number of buses, number of metro coaches, length of urban roads, consumption in terms of energy for private and public vehicles, number of total vehicles. Out of these 92 cities, we selected the 69 for which data on FDIs and location's characteristics are available over the period 2012-2015. For the purpose of this paper we rely on information on a total of 21.888 international investments projects from 2012-2015 made by 18.902 MNEs in 69 cities across the world. Out of these 21.888 investments, 15.445 involves Advanced Producer Services, 2.946 production and logistics, 1804 in R&D and 1.693 in HQs. Table A2 in Appendix reports a detailed list of the cities included in our sample by number of investments per business activity.

Methodology

In order to capture the role of the urban transport endowment in FDI location decisions across the value chain, among a set of locations, we implement a Conditional Logit Model (McFadden, 1974) in line with past empirical literature investigating location choices (Nielsen et al., 2017; Belderbos et al., 2017). The model assumes that firms are profit-maximizing economic actors that will choose the location yielding the highest net profits. While it is not

[27] For more details see https://www.lboro.ac.uk/gawc/rb/rb349.html according to which the service sector has grown immensely in the last century and now dominates all modern economies Industries in this sector can be divided into those servicing individuals and households (e. g. supermarkets) and those servicing businesses (e.g. advertising). These are commonly referred to as consumer services and producer services respectively. The latter include very high value services – professional, creative and financial – that are termed advanced producer services.

[28] Data are drawn from each public transport company operating in each city.

possible to observe directly the profit associated with each location, we can observe the chosen location's characteristics and the characteristics of all the alternative choices, cities in our case. We assume that if investment *i* locates in city *j,* then j must be the location yielding the highest profit. The CLM allows to estimate the probability with which the firm will choose for the investment i the city j with the highest net profits. This can be formally expressed as:

$$P_{ij} = \frac{\exp\left(\beta \mathbf{X_{ij}}\right)}{\sum_{l=1}^{n} \exp\left(\ \beta \mathbf{X_{ij}}\right)}$$

Where **X** is a vector of location and firm characteristics at the city level. Yet, CLM implies a strong assumption, which is the Independence of Irrelevant Alternatives (IIA). According to IIA, the relative choice probabilities is independent from any characteristics of all the alternatives in the choice set.

In order to test for the different role of connectivity across the value chain, we will estimate different models for subsamples of investment projects in different activities (namely, production and logistics, R&D, Advanced Producer Services, and Headquarters).

Variables

Dependent variable

The dependent variable is the location choice for a new investment project. This is a binary variable assuming value one if a given project i, made by the firm f in the city j, and it assumes value zero for all the other possible alternative cities (not chosen) j≠j*.

Our focal *explanatory variables* are different measures of connectivity both within urban areas (intracity connectivity) and between urban areas (intercity connectivity).

Intracity Connectivity

Average Time to Work

Average travel time to work has been drawn from the UT-DAT dataset. This variable considers the average time spent to commute[29] considering the actual time spent for each transportation mode available in each city, both active (i.e. car, walk and bike) and inactive

[29] Despite the actual formula the WB applied to build the variable, the simplest way to calculate commuting time is to take the average trip length divided the average journey time/60. For a deepest analysis on the valuation of time see Small & Verhoef (2007:45)

(i.e. subways, light rails, metro coaches, regional railways, private vehicles). Across the board, we expect a negative impact of the travel time to work. As we discussed earlier, commuting times represent an opportunity costs for workers when they decide between workplace and residence, but it is also a cost for the firm through the reservation wage they have to pay to offset workers' longer journeys to work, besides, it is time lost that could have been used more productively (Redding & Turner, 2014). We expect that the commuting time shall exert a stronger negative impact for the location of MNEs engaged in production, logistics activities and R&D that bear more the costs of longer trips to work. Conversely, commuting times should be less important for the location of HQ and APS activities of MNEs.

Total number of suburban public vehicles

To empirically represent the intracity connectivity as a measure capturing the commuting and flow of people within the city, whereby the city comprises both the core and the suburbs. Therefore, we consider inter-urban and extra urban public transport means, which are conceived for connecting suburbs and extra-city areas, namely the total number of regional railways coaches in the city. We assume that this variable may capture the commuting towards suburban areas of the city. In a recent research, the International Association of Public Transport (UITP, 2016[30]), clarifies the importance of accounting for suburban and regional railways, by showing that in Europe they account for 90% of total railway passengers. Following this first report, UITP in 2018 published a report on Commuters Railway Landscape[31], and the main findings show that, because of increasing urban sprawl, commuter railways play a pivotal role in ensuring day-to-day mobility: nearly 27 billion journeys in Europe for a fleet of 90.000 railway coaches. We expect a positive effect of this variables for MNE activities in production and logistics activities, and, to a lesser extent, for R&D for which we hypothesize a relatively higher sensitiveness to intracity connectivity (Geurs et al., 2004; Neirotti et al., 2013; Zhao et al., 2017). Conversely, we expect less sensitiveness of the number of suburban vehicles for MNE location choices in APS and HQs.

[30] https://www.uitp.org/sites/default/files/cck-focus-papers-files/Regional%20and%20Suburban%20Railways%20Market%20Analysis.pdf

[31] https://www.uitp.org/news/commuter-railways-landscape-new-statistics-report-shares-global-figures

Control Variables

Intercity Connectivity

Number of Airport Passengers

We measure air connectivity as the flows of people. We obtain information of the number of passengers per each city's airport from international and national sources – namely Eurostat for European cities, U.S. Department of Transportation (DOT) for cities located in the United States, and from OpenFlights[32] a freely online available source, for the remaining cities.

Distance to airport

For each airport in each city we obtained the average Euclidean distance in kilometers to the city center from Google Maps enquiries. Firms and workers are thus assumed to be located in city's centroids.

Number of National and International Flights

To further address the influence that each city's airport has on firm's decision, we used the total number of national and international flights from each airport. We draw these data from OpenFlights, a freely online available source. We believe that might be pivotal to distinguish connectivity by accounting for its national and international dimension when it comes to airport mobility. The argument here is that APS as well as managers employed in MNE's headquarters might be more interested in enjoying a higher degree of international connectivity made being possible by the higher number of international connections supplied by each city's airport.

Presence of a Port

In order to account for those cities that are land-locked, but still play a role in global sea trade through their river access (e.g. London), the variable assumes value 0 if the city does not have access neither to the sea nor to a river for commercial purposes, and assumes value 1 otherwise.

Port commercial capacity

To capture the effect a port might exert for MNEs' strategic decision, we go beyond its mere presence by considering its commercial capacity measured in terms of Twenty Equivalent Unit.

[32] For more details, see https://openflights.org/data.html

The twenty-foot equivalent unit (TEU) is a unit of cargo capacity used to describe the capacity of container ships and container terminals within a port. It is based on the volume of a 20-foot-long (6.1 m) intermodal container. Such measure allows further consideration on the commercial value of the port in terms of its trade capacity.

According to the extent of empirical literature we expect differentiated effect for our measures of intercity connectivity as factors impacting MNEs' location choices along the value chain. Particularly, in the case of *air connectivity* the empirical research about APS, R&D and HQs' location choices found out that these business activities tend to locate in urban areas endowed, among others with good airport facilities, which keep them put and easing global intra firm linkages (Strauss-Kahn et al., 2009; Goerzen et al., 2013; Belderbos et al., 2017). We also might expect that the flows or airport passenger do not exert any significant effect for Manufacturing and Logistics activities, which are likely to be influenced by the presence of railways connections and commercial ports, thus facilities easing the flow of goods across cities. Moreover, we expect that the *distance to airport* has a negative impact across all the functions of the value chain we are considering. Empirical research (Small & Giuliano, 2007 & 2012) found out that the presence of the airport and its accessibility as physical infrastructure along its physical distance to and from the city center may be more relevant than unique factors location and fiscal policies. Moreover, proximity to large airports influence urban centre formation and employment centre growth. We expect a negative impact of the distance to the airport across the board for all the functions considered in this paper. Consistently with past empirical research investigating the role of port infrastructures, both the presence of the port and its commercial capacity if a port invest in a city, we expect that the presence of the port exerts a positive influence for production and logistics activities (Kawamura, 2001; Holl et al., 2016). This may be apparent if one considers the global production, distribution and consumption of tangible goods that cannot occur without a multimodal transportation system allowing freight flows. We do not expect a particular effect of this variable on R&D, HQs and APS, though we might assume that, since the presence of the port may ease the city's position in global trade patterns, this should influence positively firms' location decisions. We expect that production and logistics, engaged in the production and shipment of physical goods might be positively influenced by a higher number of TEU, therefore by a higher flow of goods. The use of TEU is largely used in transport and geography studies, since it measures a ship's cargo carrying capacity and the statistics of the container

transit in a port. The higher the TEUs the higher is the capacity of the port, the higher the value of the port in its commercial configuration. We consider total number of containers in each port to get a better understanding on the effect that the presence of a port might exert, we expect that the commercial value of the port positively impacts production and logistics activities. It is worth mentioning that when TEU approaches zero, the port can be considered mainly a touristic port. In this case, the attractiveness of port stems not so much from its use to transport goods, but rather as an indicator of leisurely activities. Hence, we expect that touristic port may positively impact the location of APS, R&D and HQs.

Other Controls

We also consider standard control variables in our specification, such as city area, population density and minimum hourly wage. We use the city's area as a proxy for city's market-size, which is one of the main drivers for all the function of the value chain considered in this paper. We expect that market size may exert a positive effect, since might be associated with more MNEs activity (Rugman et al., 2004; Franco et al., 2008; Crescenzi et al., 2016). Moreover, Production, Logistics and APS are considered as market-seeking activities, therefore the greater the market size, the more MNEs may decide to locate their activities. Conversely, we expect a negative effect of population density, which makes cities less attractive. Moreover, we account for the overall public transport consumption in terms of energy use, the idea is that the more efficient the transportation network, the better. The more the vehicles consumer energy, the higher the costs bore by the users, workers and firms in the case at hand. We also expect that higher wages are negatively associated with MNEs investments. This is particularly true for efficiency seeking MNEs engaged in production and logistics activities. Concerning HQs and APS, we expect a positive impact, since higher wages might be associated with higher quality of the human capital, which proxy is also the total number of higher education institutions (henceforth HEI) in each city. We further account for the presence of agglomeration economies, by computing the prior stock of FDI from 2003 to 2011 for each function of the value chain we consider. Overall, the presence of agglomeration economies is positively associated to MNEs investments which benefit from them (Marshall, 1920; Ellison et al., 2010; McCann & Van Oort, 2019; Faggio et al., 2020). Finally, we consider the average journey covered by car in kilometers. Here the main argument is that the car represents an inactive travel mode choice to commute, therefore we extend our expected outcomes about travel times to the average kilometers covered by car. However, it should be

considered that the car trip length might capture also the dwelling residence of workers who commute by car. For instance, older and highly skilled workers (e.g. managers) who tend to live in residential areas outside the core city might tend to have longer journeys by car. A summary with description and sources of all variables included in the analysis is reported in table A1 in appendix.

Results

Table 2 presents the main results of our econometric estimation. We run separate regressions estimating the determinants of the location choice for four different types of investments in 69 cities all around the world. Investment decisions in Manufacturing & Logistics, Research & Development, Advanced Producer Services, and Headquarters are separately considered, disentangling the effects of the two different aspects of connectivity we are addressing, namely intracity and intercity connectivity. Results highlight both similarities and differences in the location determinants for different activities across the value chain. Concerning the impact of intracity connectivity, we find that higher travel time to work discourage most types of investments, but the different activities show different elasticities to an increase in travel time to work. In particular, the effect is stronger for Manufacturing and Logistics and R&D activities and it is weaker (or not significant) for APS and HQs. The number of mass transit vehicles - namely, trains and metro coaches - which accounts for connectivity between the city and its suburban areas, reveals very similar patterns. Such connections positively affect Manufacturing & Logistics, and R&D activities. These results suggest that connectivity within the city and between the city and its suburbs is more important for Manufacturing & Logistics and R&D activities, while APS and HQs are less sensitive to extension of suburban connections. Overall, these results are consistent with our hypotheses and past literature (Nuñez-Serrano et al., 2012; Wee et al., 2013; Melo et al., 2013; Andres et al., 2013; Neirotti et al., 2016; Chatterjee et al., 2017; Martin Barroso et al., 2017; Clark et al., 2019), which found out that bearing the 'cost' of commuting also depends on jobs' and workers characteristics, notably older and/or less educated workers employed in high capital intensive industries, such as Manufacturing & Logistics, are more sensitive to commuting, therefore these activities are more likely to be located in cities where they can enjoy higher levels of intracity connectivity. As argued in Martin-Barroso et al., (2017) that skilled workers are willing to commute longer distances in order to improve their working conditions by receiving a *wage premium* for longer journeys to work, as there is a trade-off between the cost of commuting and the level of wages

(reservation wages). Ultimately, younger and skilled workers prefer to use public transport, as a matter of fact, public transport availability may favour labour matching by higher hiring probabilities or may hinder them because of longer commuting times due to congestion.

On the contrary, young and more educated professionals - that are more prevalent in APS and HQs – are less sensitive to commuting, hence these activities may be located also in cities where the urban and sub-urban mobility is less efficient. HQs may employ also a non-negligible share of older workers in top management positions, but these may enjoy a substantial degree of flexibility in the way the organize their workday, hence they are less sensitive to commuting times. These findings are also consistent with the fact that intra-city connectivity is crucial for activities where working from home is more difficult (such as in Manufacturing and Logistics), while it is less important in service activities that are amenable to both working from home or even during commuting. MNE investments in R&D have an intermediate profile, since workers are generally young and well educated, which normally are less sensitive to commuting, but their activities are more capital intensive need the lab facilities, hence less amenable to working away.

Regarding the control variables, the number of air passengers positively impact production and logistics, which, contrarily to what we expected, is sensitive to this dimension of intercity connectivity. Consistent with past empirical research, higher international flows of people, measured by the number of international airport passengers, encourage APS to localize where they can exploit a higher degree of people intercity connectivity, which allow them to carry out those intrafirm linkages across cities for which literature on world cities has largely investigated these activities. (Strauss-Kahn, 2009; Small & Giuliano, 2012; Goerzen et al., 2013; Goerzen et al., 2017). Conversely, the coefficient does not impact location decisions of R&D, which is coherent with findings presented in Castellani et al., (2021) who show that these activities are more sensitive to people knowledge connectivity, thus they are attracted towards areas connected to the rest of the world by international networks of inventors. HQs**,** which according to past literature we would expect to be influenced by the international flow of people (Goerzen et al., 2017). A tentative explanation might reside in the other connectivity dimensions considered in this paper, which, *ceteris paribus*, are likely to affect more the location decisions of such activities. In addition, the number of international and national flights, i.e. air connectivity positively influences *soft functions* – APS, HQs, and to a less extent production, logistics and R&D coherently with past literature. Findings suggest that the

number of international flights is not significant for R&D activities, which as anticipated seems to be more sensitive to people knowledge connectivity (Castellani et al., 2021).

Moreover, the closer the airport to the core city the better for all the functions of the value chain, since the proximity to airports might be more relevant when multinationals decide where to invest abroad (Small & Giuliano, 2012). When looking at the presence of the port, it emerges that, once controlling for the commercial capacity, the presence of the port exerts a negative (or non-significant) effect. While these results may seem puzzling, it may simply reflect that the dummy captures the effect of a port, when the commercial capacity tends to zero, that is when the port is mostly touristic. Hence, the presence of a mostly touristic may discourage the location of MNE. Conversely, an increase in commercial capacity is, not surprisingly, an important determinant of MNEs' investments in production and logistics, since it allows goods to ship in and out of the city.

The other control variables are consistent with the existing literature on the location choices of production firms, extending for the analysis to firms engaging in logistics activities, which are scarcely studied in the business literature. Cheaper labor costs, higher level of agglomeration economies and a higher number of top HEI, favor the location of services, while discouraging production activities.

Conclusions & Implications

This work provides evidence on the spatial determinants of MNEs' location choices in cities, by analysing the attractiveness of distinct dimensions of urban connectivity for different MNE activities across the value chain. Particularly, the novelty of the paper is to shed some light on the effect of *intracity connectivity*, which reflects the efficiency and the extension of urban mobility systems providing within-city connections as proxied by commuting times. In this respect, the value chain perspective allowed us to show differential results across business activities. Notably, we argued that - due to the intrinsic characteristics of business activities and of workers engaged in each of them – location decision across the value chain may exhibit different sensitivity to the efficiency of transport infrastructure allowing intracity connectivity. Building on research showing that older and less educated workers are relatively more sensitive to commuting times (Nuñez-Serrano et al., 2012; Melo et al., 2013; Chatterjee et al., 2017; Martin-Barroso et al., 2017; Clark et al., 2019), we show that production and logistics activities -where these types of workers account for a larger share of employment- should

locate in cities with more efficient urban mobility systems. On the contrary, advanced producer services and headquarter activities, where workers tend to be relatively younger and/or more educated, less sensitive to commuting and with higher chances to telework (Wee et al., 2013; Andres et al., 2013; Melo et al., 2013; White et al.,2016; Chatterjee et al., 2017; Martin-Barroso et al., 2017) are actually less influenced to how efficient intra-city connectivity works. Additionally, R&D activities exhibit an intermediate profile, since workers are generally young and well educated, which normally are less sensitive to commuting, but their activities need the lab facilities, hence less amenable to working away. Moreover, we contribute to the literature on the relationship between connectivity and MNEs' investments decisions by bringing the attention towards a crucial dimension of the connectivity itself, i.e. the urban dimension. While the bulk of the business literature focussed more on its international dimensions, our results reveal that unpacking further aspects of connectivity, with respect to previous empirical research can lead to interesting insights on the importance of hard infrastructures within and across cities. Notably, ensuring an effective system of connections within cities might lower commuting time, making cities more attractive. Additionally, we highlight how jobs' and workers' characteristics play an important role in determine MNEs' sensitiveness to both intracity and intercity connectivity. Our research has relevant implications for policy makers involved in location decisions or transport planning. As shown, improving intracity connectivity may have different impact on distinct stages of global value chains. Therefore, urban planners should focus on investing on those hard infrastructures that promote and attract business activities that are most desirable to pursue the objectives of their cities.

Our findings are particularly relevant in an age of disruptions of caused by the Covid-19 pandemic that we have been experiencing since the early 2020. Although Covid-19 began as an urban disease, it rapidly spread far beyond the densely populated areas, affecting many commuter towns, and apparently lowering the importance of physical connections allowing movement of people. The rise of home-working among the *salariat* means that urban transport networks might not appear as essential as before, this was especially true in the first half of 2020 when the *domino effect* of the virus put almost all national governments all over the world in need of a generalised lockdown. However, as we extensively argued in this paper, not all jobs are amenable to work from home, and thus jobs' and workers characteristics are playing a fundamental role in understanding the possible impact that this pandemic has been

having on workers and firms. Our findings open new research avenues on the implications of the ongoing pandemic on the relationship between connectivity and jobs-workers' characteristics. A research published in 2020 by the RSA[33], support the fact that not all jobs are amenable to smart working, and if the least amenable jobs are in the top 20 percent of the fastest-growing occupations, the lower importance of commuting networks might as well be temporary rather than a new stylized fact. Important considerations there may be found also in those presented residential decisions for which we assumed that older and highly educated workers may prefer to live in residential areas, where they can enjoy more amenities and most likely pursue a better work-life balance. As we argued in presenting the extant literature, this might suggest that intercity connections are likely to weigh more in the foreseeable future. In the longer term, the pandemic may likely accelerate the shift towards homeworking, but as we showed in our results, firms engaged in production, logistics and R&D activities will most likely be still sensitive to the quality of intracity connections as they need to be in the plant/lab to carry out their work.

[33] The royal society for arts, manufactures and commerce. https://www.thersa.org/blog/2020/04/low-pay-lack-homeworking

Tables

Table 1. Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Average time of journey to work (minutes)	2,242,873	31.79538	10.33198	16	69
Log Tot. Number of Mass Transit Vehicles - Including Regional Railways	2,626,743	4.595915	3.165238	0	9.912596
Log Tot. Number of Air Passengers	2,434,808	16.09294	1.162792	13.58519	18.69348
Distance to Airport (KM)	2,553,829	22.36147	15.47678	2.2	99.9
Log of Total National Flights by each city	2,630,780	1.206962	1.967553	0	5.880533
Log of Total International Flights by each city	2,630,780	2.961586	2.441208	0	6.940222
Presence of a Port	2,626,743	.5657626	.4956565	0	1
Log of Total Twenty Feet Unit per Port in 2011	2,363,944	7.361251	7.234301	0	17.27306
Public Transport Energy Use (MJ/ Pax km)	2,626,743	.5784073	.501935	0	2.41
Average trip length by car (km)	2,166,099	12.1503	4.956213	4	24.7
Log Population Density	2,588,356	8.53881	.86363	6.245363	10.66564
Log City Area	2,626,743	5.897029	1.441978	2.768204	9.975855
Minimum Hourly Wage rate (PPP $ 2007)	2,166,099	4.615	3.351915	.6096147	11.34834
N. of Top Higher Education Institutions	2,630,605	1.50459	1.737634	0	8
MNE's Past Experience 2003-2011	2,497,040	1.189272	.6452126	1	17
Past Stock of FDI for over the period 2003-2011	278,388	52.14832	99.53773	2	733

Table 2: Conditional Logit Model. The Location of New International Investments Projects

	Manufacturing & Logistics	R&D	Advanced Producer Services	Headquarters
Getting Around				
Average time of journey to work (minutes)	-0.0238***	-0.0129***	-0.00765***	0.00566
	(0.00344)	(0.00486)	(0.00139)	(0.00536)
Log Tot. Number of Mass Transit Vehicles - Including Regional Railways	0.0419***	0.0718***	-0.000735	0.0302
	(0.0137)	(0.0182)	(0.00610)	(0.0248)
Getting There				
Log Tot. Number of Air Passengers	0.112**	-0.0319	0.163***	0.0532
	(0.0484)	(0.0696)	(0.0233)	(0.0850)
Distance to Airport (KM)	-0.0316***	-0.0221***	-0.00538***	-0.0245***
	(0.00409)	(0.00452)	(0.00125)	(0.00532)
Log of Total National Flights by each city	0.0698**	0.0297	0.107***	0.202***
	(0.0277)	(0.0377)	(0.0106)	(0.0427)
Log of Total International Flights by each city	-0.0143	-0.00305	0.122***	0.157***
	(0.0250)	(0.0337)	(0.0101)	(0.0390)
0 if the city does not have a port 1 otherwise	-0.310***	-0.0225	-0.0670*	-0.465***
	(0.108)	(0.139)	(0.0373)	(0.139)
Log of Total Twenty Feet Unit per Port in 2011	0.0375***	0.00504	-0.00906***	-0.00255
	(0.00782)	(0.00887)	(0.00235)	(0.00844)
Control Variables				
Public Transport Energy Use (MJ/ Pax km)	0.344***	-0.261**	-0.0134	-0.160
	(0.0994)	(0.125)	(0.0364)	(0.112)
Average trip length by car (km)	0.0379***	-0.0147	0.0407***	0.0783***
	(0.00954)	(0.0123)	(0.00368)	(0.0105)
Log Population Density	0.268***	0.460***	0.359***	0.449***
	(0.0831)	(0.107)	(0.0347)	(0.103)
Log City Area	0.156***	0.213***	0.275***	0.142**
	(0.0505)	(0.0676)	(0.0211)	(0.0677)
Minimum Hourly Wage rate (PPP $ 2007)	-0.139***	0.0112	-0.0175***	0.101***
	(0.0160)	(0.0212)	(0.00615)	(0.0184)
N. of Top Higher Education Institutions	-0.134***	-0.0199	0.0676***	0.00786
	(0.0288)	(0.0347)	(0.00933)	(0.0364)
MNE's Past Experience 2003-2011	0.142***	0.0537**	0.136***	0.0131
	(0.0276)	(0.0268)	(0.0232)	(0.125)
Past Stock of FDI 2003-2011	0.00173***	0.00659***	0.00132***	0.00973***
	(0.000286)	(0.000602)	(5.96e-05)	(0.00113)
Observations	107,994	72,204	682,456	73,998

Standard errors in parentheses

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Appendix

Table A1. List and Description of Variables.

Variable	***Description***	***Source***
Location Choice	Dummy variable assuming 1 if the given project i is located in city j, 0 otherwise	Author Elaboration based on FDi Markets Data
Average Time to Work	Average travel time among all the public urban means of transportation (i.e. buses, trolley, light rail, cycling, walking, private vehicles), included active modes (i.e. car).	UT-DAT database
Total number of interurban public vehicles	The sum of each public transport vehicle available providing intercity connections (log) (i.e. regional railways, light rail).	UT-DAT database
Number of Airport Passengers from International Airports	Number of passengers per each International City Airport (log)	Eurostat, U.S. Bureau of Transportation and from each city's airport website and, where available from ICAO (International Civil Aviation Organization).
Distance to the Airport	Average Euclidean distance from the city centre to each airport in the city in kilometres	Author Elaboration, Google Maps
Total Number of National Flights	The sum of the Number of national flights from each city's airport in 2014 (log)	OpenFlights
Total Number of International Flights	The sum of the Number of international flights from each city's airport in 2014 (log)	OpenFlights
Total Twenty Feet Unit per Port	Total TEU (container ships and terminals) in 2011 for each port city (log)	Data have been provided upon request to Prof. Jean Paul Rodrigue
Presence of a Port	Dummy, assuming value 1 if the city has a commercial port and assuming value 0 otherwise	Author Elaboration based on FDi Markets Data
Public Transport Energy Use (MJ/ Pax km)	Measure of energy consumption in Public Transport vehicles, measured as MegaJoule/ passengers per KM	UT-DAT database
Car trip length	Average distance covered by car (KM) within the city.	UT-DAT database
City Area	Area of the City measured in squared KM (log)	UT-DAT database
Population density	Number of people living in the city divided by the land area (log)	UT-DAT database
Minimum hourly wage in 2007 PPP$	Minimum hourly wage in local currency converted in 2007 PPP$	UT-DAT database
MNE's Past Experience	Stock of Past Investment by each MNE in each city in the choice set	Author Elaboration based on FDi Markets Data
Number of Top Higher Education Institutions	Number of top higher education institutions per each city in year 2011	Leiden Ranking Database
Past Stock of FDI	The prior stock of FDI from 2003 to 2011 per each city (log)	Author Elaboration based on FDi Markets Data

Table A2. Number of FDIs by City and Business Activity

City	***Advanced Producer Services***	***Headquarters***	***R&D***	***Production & Logistics***	***Total***
Accra	33	3	2	9	47
Ahmedabad	30	1	6	14	51
Amsterdam	213	58	5	23	299
Athens	86	5	1	5	97
Bangalore	270	15	296	106	687
Bangkok	196	16	22	53	287
Beijing	840	53	149	128	1170
Berlin	165	27	9	18	219
Bogota	112	9	8	13	142
Bologna	7	0	0	4	11
Budapest	150	11	28	59	248
Busan	15	0	1	13	29
Cairo	94	6	9	22	131
Cebu	10	0	4	4	18
Chandigarh	12	1	2	3	18
Chennai	135	6	99	147	387
Chicago	116	20	5	17	158
Copenhagen	184	46	21	10	261
Curitiba	12	1	3	11	27
Danang	12	0	0	19	31
Dubai	1107	163	28	150	1448
Dublin	215	53	30	18	316
Geneva	118	26	3	2	149
Glasgow	41	5	3	10	59
Guangzhou	182	7	30	173	392
Hamburg	137	16	9	25	187
Hanoi	177	6	13	64	260
Helsinki	81	4	2	5	92
Ho Chi Minh City	224	6	27	88	345

Continued Table A2

Hong Kong	998	160	37	71	1266
Jaipur	8	0	1	7	16
Jakarta	108	2	4	32	146
Johannesburg	148	12	7	33	200
Kolkata	46	4	10	19	79
Krakow	24	0	11	21	56
Kuala Lumpur	194	31	17	23	265
Kunming	6	0	1	7	14
Lisbon	74	2	1	13	90
London	1448	206	27	39	1720
Madrid	379	30	20	23	452
Manchester	78	11	4	13	106
Manila	43	6	6	7	62
Marseilles	15	1	1	11	28
Milan	251	6	14	18	289
Moscow	551	21	23	82	677
Munich	293	23	21	15	352
Nantes	21	1	1	5	28
New York	522	40	15	48	625
Newcastle upon Tyne	16	0	4	9	29
Paris	725	44	27	30	826
Patna	2	0	0	0	2
Pune	83	7	85	115	290
Rome	100	0	1	6	107
Rotterdam	51	1	1	36	89
Santiago	101	14	8	11	134
Sao Paulo	346	29	29	53	457
Seville	19	4	2	14	39
Shanghai	1244	144	307	579	2274
Singapore	1077	247	204	267	1795
Stockholm	225	19	13	11	268
Stuttgart	83	5	4	5	97
Surabaya	9	0	0	6	15

Continued Table A2					
Tallinn	38	2	2	32	74
Tokyo	528	16	28	12	584
Toronto	224	17	20	14	275
Turin	20	1	8	3	32
Vancouver	61	4	12	5	82
Warsaw	247	14	12	35	308
Washington DC	65	5	1	3	74
Total	15445	1693	1804	2946	21888

Table A2 reports the 69 cities in our sample and the number of hosted FDIs in each business activity over the period 2012-2015. Table A2.2 reports the number of cities by main geographical region.

Table A2.2 Number of Cities by Region

Region	Number of Cities
Africa	2
EU-28	30
Non - EU Europe	1
North America[1]	5
South America	4
Asia-Pacific	25
Middle East	2

[1] North America region includes U.S.A. and Canada which have 3 and 2 cities respectively

Table A3. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Average time of journey to work (minutes)	1.000															
Log Tot. Number of Mass Transit Vehicles - Including Regional Railways	0.246	1.000														
Log Tot. Number of Air Passengers	0.407	0.623	1.000													
Distance to Airport (KM)	0.230	0.561	0.591	1.000												
Log of Total National Flights by each city	0.269	0.094	0.152	0.304	1.000											
Log of Total International Flights by each city	-0.101	0.233	0.261	0.074	-0.727	1.000										
Presence of a Port	-0.064	0.082	0.169	0.104	0.159	0.050	1.000									
Log of Total Twenty Feet Unit per Port in 2011	-0.022	0.106	0.205	0.149	0.221	0.009	0.985	1.000								
Public Transport Energy Use (MJ/ Pax km)	0.232	0.057	-0.040	-0.050	0.161	-0.013	-0.017	-0.046	1.000							
Average trip length by car (km)	0.103	0.301	0.111	-0.165	-0.222	0.130	0.009	-0.037	-0.074	1.000						
Log Population Density	-0.041	0.017	0.201	0.226	0.018	0.093	-0.105	-0.105	-0.248	-0.217	1.000					
Log City Area	0.494	0.205	0.375	0.400	0.428	-0.285	-0.019	0.074	-0.117	-0.258	-0.214	1.000				
Minimum Hourly Wage rate (PPP $ 2007)	-0.191	0.290	0.160	-0.033	-0.225	0.367	0.396	0.321	0.315	0.369	-0.356	-0.402	1.000			
N. of Top Higher Education Institutions	0.161	0.653	0.698	0.582	0.207	0.094	0.172	0.193	0.082	0.147	0.102	0.124	0.347	1.000		
MNE's Past Experience 2003-2011	0.015	-0.146	-0.091	0.045	0.079	0.012	0.006	0.023	0.111	-0.103	0.042	0.009	-0.038	-0.130	1.000	
Past Stock of FDI 2003-2011	0.229	0.451	0.631	0.613	0.243	0.107	0.183	0.231	-0.236	-0.254	-0.032	0.507	-0.049	0.562	-0.051	1.000

Figures 1 and 2 show the percentage of workers (Y axis) by educational level and age codified according to the ISCO 08 classification. In figure 1 age bands are classified as 18-24; 24-54 and 55+. Educational levels are classified as follows:

- ED0 2: Less than primary, primary and lower secondary education (levels 0-2) [ED0-2]
- ED3-4: Upper secondary and post-secondary non-tertiary education (levels 3 and 4) [ED3_4]
- ED5-8: Tertiary education (levels 5-8) [ED5-8]

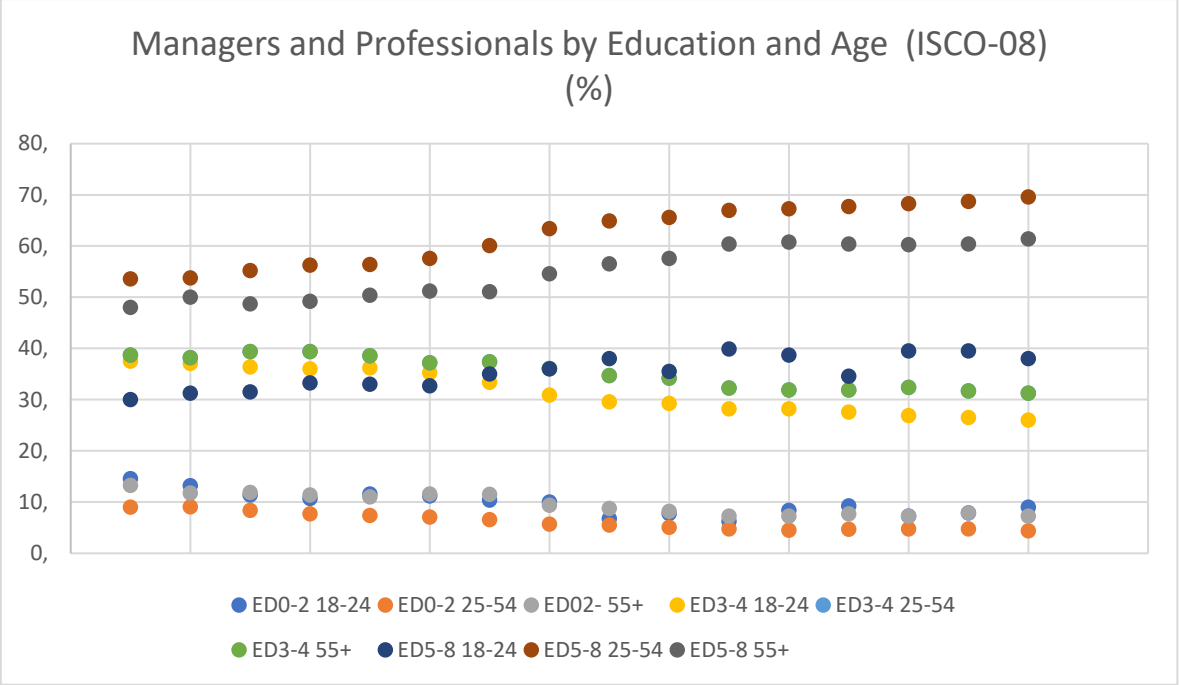

Figure 1. Age class and Education for Managers and Professionals over the period 2004-2019. The Y axis represents the % of workers employed in these activities. The X axis represents the yearly trend. Source: Own elaboration based on Eurostat Data.

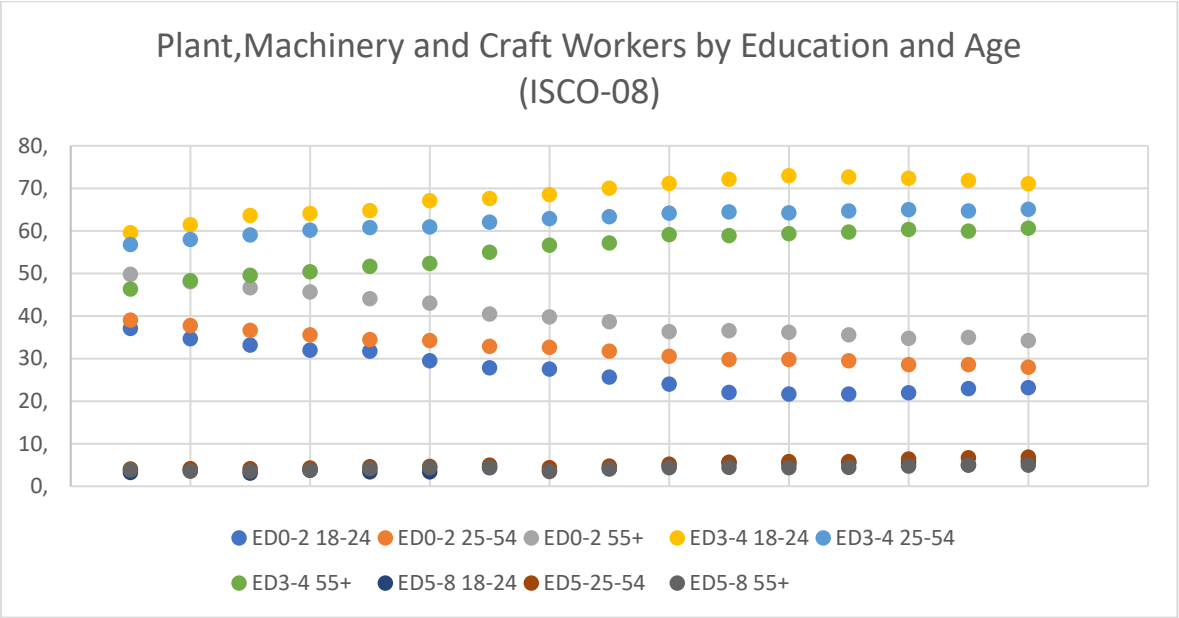

Figure 2. Age class and Education for Plant, Machinery and Craft workers over the period 2004-2018. Y axis is the % of workers employed in these activities by education and age. The X axis represents the year. Source: Own elaboration based on Labour Force Survey 2004, 2008 and 2019.

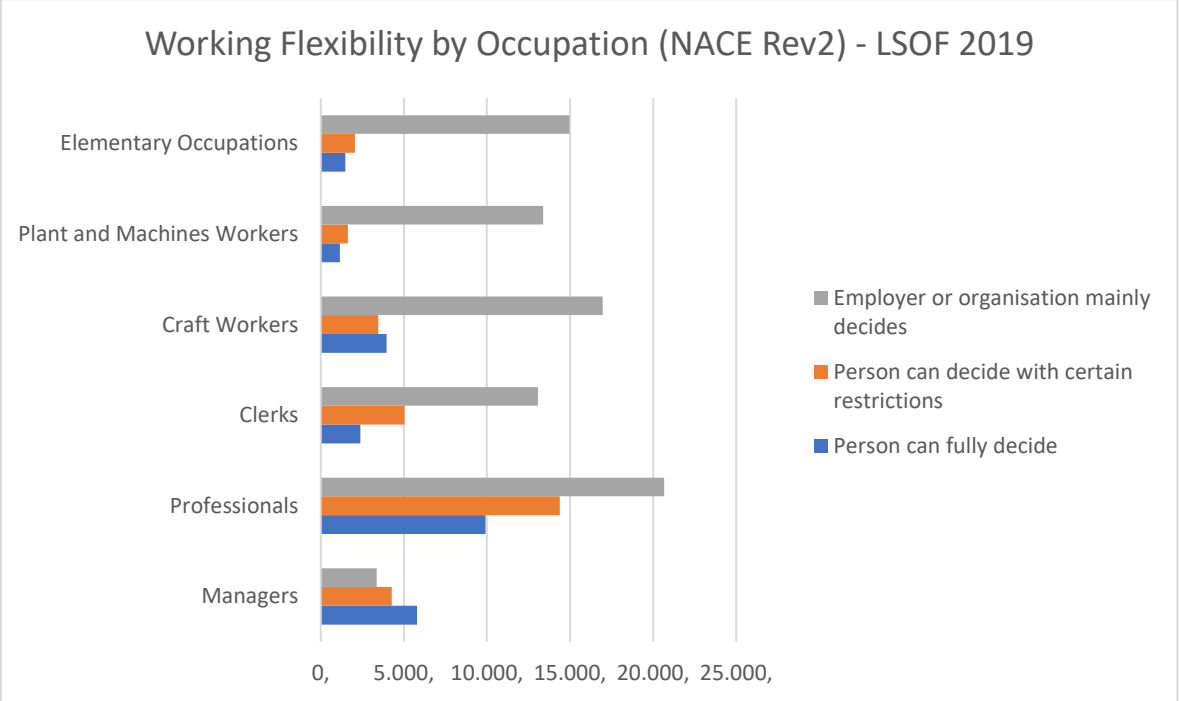

Figure 3. Working Flexibility by Occupation Sectors (NACE_rev2). The X axis is the number of person by occupation in 2019. Source: Own elaboration based on Labour Force Survey Data 2019

Chapter 2

The determinants of logistics firms' location choices: A focus on vertical linkages across European regions[1]

Abstract

Logistics plays a crucial role in overcoming time and distance constraints in supply chain management. Firms are now concentrating more on specific consumers' requests, on delivering goods with greater speed, seeking ways to reduce costs, and improving quality in an increasingly demand-driven supply chain. It thus appears of paramount importance to place logistics in close connection to where value sources and cost reduction opportunities are available. Nonetheless, location decisions in logistic activities have been largely disregarded by extant literature. While a large body of the empirical research investigating firms' location decisions devoted attention to the location of production activities, little evidence has yet been provided on the logistics industry. This paper aims to fill the gap by studying the locational behaviour of MNEs in the logistics industry across European NUTS3 regions. We place specific attention on vertical linkages with retailers and wholesalers as attractors for logistics services FDIs at the NUTS3 level. The empirical analysis draws upon data from fDi Markets database, for which we selected MNEs' investment projects in the Logistics industry, having NUTS3 as a destination over the period 2011 – 2018. Our findings reveal that the magnitude of vertical linkages with the retail and wholesale industry in a region exerts a positive impact despite controlling for production intermediate demand, intra-and inter-regional connectivity and other factors.

Keywords: FDIs, MNEs Location Choices, Logistics, Vertical Linkages, Backward and Forward Linkages

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This paper is part of the PhD dissertation project undertaken by the author under the supervision of Prof. Davide Castellani and Prof. Antonello Zanfei and relies on work conducted in collaboration with them during research activities carried out at the University of Urbino, Italy, and at the Henley Business School at Reading, UK. This paper has been presented at the PhD workshop in Urbino, May 2020

Introduction

The logistics function arranges the linkages between production, suppliers, and the end-market. It has a long history as its use has been documented since the ancient Roman Empire, when it was introduced for military purposes. Nowadays, logistics is a rather complex process. Because of the increasing fragmentation of industrial production processes, the logistics services play a crucial intermediate role by organizing the linkages from the different *loci* of production to the different *loci* of consumption, either domestically or internationally. In 2014 the Council of Supply Chain Management Professionals defined the logistics industry as the "*part of the supply chain that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption to meet customer's requirements*" (Verhetsel et al., 2015). As an intermediate player in the supply chain (Bowen 2008; McKinnon, 2009, Van Den Heuvel et al., 2015), this industry has been experiencing increasing demand from both the upstream and downstream segments of the value chain (Hesse & Rodrigue, 2004). Yet, very little has been in said in the economic and business literature in terms of locational behaviour of firms engaged in this industry sector, even less so in the case of multinational firms. Accordingly, we decide to focus our study on inward FDIs, addressing the location decisions of logistics MNEs.

Multinationals corporations are the most international of all businesses indeed, and as such, a strategic decision they have to make is where to locate and which host economy has the location advantage yielding the highest net profits. Despite the recent advances in the theory of location, the analysis of the role of intermediate services, as in the case of logistics, has been largely neglected. As Philip McCann argues, logistics and distribution activities "*are the lifeblood of the economy, keeping all other sectors (quite literally) moving. […] Understanding the modern role played by these activities therefore calls for a renewed efforts at building the research base in these arenas […] and until recently in fields such as economic geographic and regional science there has been insufficient interest… even though the movement of goods and people is so central"* (McCann, 2014:7).

In the last two decades, much attention has been paid to business services surrounding production activities (Defever, 2006; Meliciani et al., 2012, 2016) while considering location decisions in logistics as merely determined by production. In other words, logistics is assumed

to "follow" manufacturing activities wherever these take place. Literature addressing FDIs determinants in business services (BS), and more specifically, Knowledge Intensive Business Services (KIBS) argue that localization economies and higher vertical linkages are most likely to attract KIBS FDIs (Meliciani et al., 2012, 2016). However, this perspective has just addressed KIBS-type of BS, disregarding the ones delivered by logistics firms. Holl & Mariotti (2018), approach the location determinants of logistics firms through the lens of accessibility, i.e. emphasizing the degree with which the efficiency of transportation infrastructures allow economic agents to reach places, by assuming that logistics services may be more sensitive to the geographical proximity (measured either in kilometres or minutes) to larger markets and pivotal infrastructures, e.g. highways. Here the authors, particularly stressed the lack of focussed research on the location determinants of logistics-type of business services.

We argue that to derive location decisions of logistics MNEs from the ones of producers may be not sufficient to explain their locational behaviour. Logistics services nowadays are experiencing outstanding growth in demand in advanced economies, increasing time-sensitiveness deliveries, generating higher demand for these services independently from the pre-existing manufacturing base (McKinnon, 2009; Holl & Mariotti, 2018b). As argued in Bonacich & Wilson (2008) firms are now concentrating more on specific consumers' requests, particularly on the increasing demand for faster goods' deliveries. To achieve this end, firms formulate strategies, including the use of international logistics techniques to gain competitive advantage in the management of supply chains (Wood et al. 2002). In this respect, British investors led the way with almost 8€bn invested in distribution facilities to support the take-off of cross-border e-retail in 2014 (which has heavy logistics requirements in terms of warehouses and fleet to distribute goods purchased by customers – The Economist, 28th May, 2020[2]), and this is a common trend among European business actors (Financial Times, February 9, 2015). The underlying mechanism here bank on the increasing demand by customers for differentiated products delivered in a shorter and shorter amount of time. Scholars reckon this phenomenon as the gradual shifting towards a consumer-oriented economy as argued by McKinnon (2009), which makes the management of the supply chain even more complex bringing the strategic focus of firms from a "*supply-push*" to a "*demand-pull*" economy (McKinnon, 2009; Fernie et al., 2010; Holl & Mariotti, 2018b; Mangan, 2019).

[2] https://www-economist-com.dblibweb.rdg.ac.uk/business/2020/05/28/the-e-commerce-boom-makes-warehouses-hot-property

Bowen (2008) argues that in a "supply-push" economy, firms ''pushed" their output into distribution channels based on demand forecasts. In the latter, i.e. "demand pull" firms gear their production in response to real-time information about what consumers are buying. Coping with this increasing consumer demand, can be a challenge for firms and particularly for MNEs, which have to manage geographically dispersed value chain activities, but also a potential source of competitive advantage (Bowen, 2008). For instance, DELL Corp., sources the components of laptops from different countries, but its ability to quickly integrate those components and deliver the products thousands of kilometres away in less than 10 days worldwide, gives the company a competitive advantage in dealing with time-issues over its competitors (Holzner, 2006). Zooming in the logistics industry, another suitable example comes from Deutsche Post DHL. Germany's privatised post office, as FedEx, TNT and other logistics giants is increasingly moving downstream. The logistics multinational planned to invest 750€m by 2014 to double its parcel sorting capacity in order to respond to the increasing consumers' demand (Financial Times, December 4, 2011). Notwithstanding these trends, empirical research discerning the determinants that drive logistics' investment projects is quite scant. We therefore deem it crucial to investigate the location decisions of logistics multinationals, and specifically whether higher inter sectoral demand from the retail and wholesale sector positively impacts on such choices. To comply with such research gap, our study assesses the role of vertical linkages with retail and wholesale, and manufacturing sectors as determinants for the location of inward FDIs in the logistics industry. We rely upon the theoretical contribution of Hirschman (1958) on the concept of forward linkages, which will be thoroughly developed in the next section. It is key to note that Hirschman's theoretical contribution on forward and backward linkages is based on the fact that that once FDIs are located, they create forward and backward linkages with upstream and downstream activities active on the territory. However, past research emphasized how even pre-existing input-output relations may attract international investments, which is the focus in our analysis[3]. Particularly, we will stress the role of inter sectoral demand generated by retailers and wholesalers in European regions at a fine geographical level, the NUTS3 level.

[3] Although the seminal contribution of Hirschman may signal a reverse causation (from location decisions to linkage creation), we bank upon past research (Meliciani et al., 2012, 2016) to suggest that the actual and potential vertical linkages may act as an attractor of investors in downstream industries (in the case of backward linkages), and in upstream industries (in the case of forward linkages). Past input-output relationship at the regional level can thus be used to explain the location of FDIs in business services in the same regions. To circumscribe the impact of possible reverse causation, we use input-output data in 2010, thus before investments which we observe in the subsequent period.

The general argument is that, given the intermediary nature of logistics services, considering the sole production industry as a source of demand for logistics services ends up disregarding an important part of the story. In fact, firms engaged in the downstream part of the supply chain such as retailers and wholesalers, which are the closest points to the end market, are very much exposed to consumers' pressure for quicker distribution services, and hence create increasing market opportunities for logistics service suppliers. We will contribute to the current literature investigating MNEs' location decisions (Arauzo-Carod et al., 2010; Ascani et al., 2017), to shed some light on the attractive factors that lure investments in Logistics, a quite neglected activity in the literature. Indeed, most of the studies addressing industrial location concerned the location of manufacturing plants, or FDIs occurrence at different level of spatial disaggregation (Arauzo-Carod et al., 2010). Moreover, these empirical studies mostly focussed on the occurrence of FDIs as determined by agglomeration economies, human capital characteristics, as common in a neoclassical perspective, still, to the best of our knowledge the literature studying location decisions of MNEs in the logistics industry is very sparse, and has not addressed the role of vertical linkages with retail and wholesale, and manufacturing as a factor attracting FDIs to specific locations.

In this respect, we believe that European regions are a particularly suitable context for a study on the location of logistics activities. In fact, the logistics industry in Europe represents a market volume of circa €878 bn in 2012 (Analysis of the Logistics Sector, European Commission, 2017) and 7% of EU27 GDP, with Germany being the largest "logistics nation" (so defined for having a well-developed logistics market) with the highest *Logistic Performance Index* (henceforth, LPI - 3.56 out of 5) (€ 228 bn market size), while Spain, Italy, Sweden, the Netherlands and Poland hold the lowest number of logistics service providers and therefore may be profitable markets. In addition, according to the World Bank LPI, the global top largest logistics service providers are all based in Europe: six countries out of the global top-10 logistic performers are EU Member States. Still, very little is known in terms of logistics location decision in Europe. In addition, the relationship between logistics performance (LPI) and higher incomes (GDP) demonstrates the industry's contribution to productivity and growth (World Bank, 2020). On top of these figures, policy actions at the European level have been taken on, such as the *Freight Transport Logistics Action Plan 2007* established a list of activities to improve the framework for transport logistics operations in the EU. We also believe that including retail and wholesale industry in the analysis might be worthy given the increasing

global trend of retailers to hold their inventory and integrate with logistics providers to meet customers' demand for quicker deliveries (McKinnon, 2009; Mesic, 2015; Mangan, 2019).

The remainder of this paper is organized as follows: in section one we review the literature concerning logistics' location choices. Then, we present the empirical methodology we applied to study such location decisions. Finally, we present the results and further discussions.

Background Literature

The location determinants of logistics firms are strongly affected by the nature and intensity of supplier-user interactions that characterise this industry (Meliciani et al., 2012;2015). To assess whether vertical linkages exert a positive effect on the location decisions of multinational firms engaged in logistics, we draw from past economic geography literature addressing firms' location choices, arguing that in the case of the logistics industry, sectoral interdependencies with retailers and wholesalers are a crucial factor in attracting logistics MNEs at the NUTS3 level. This hypothesis is based on the evidence that the growth of services, and we argue also logistics services, is mainly due to the increasing intermediate demand by other industries. Yet, scholars scarcely addressed the role of pre-existing vertical linkages in MNEs' location decisions, and even more so for logistics industry, most of the empirical research focused on accessibility patterns and their impact on logistics' location choices (Holl & Mariotti, 2018b). As anticipated, the logic behind the creation of forward linkages has been emphasized by the key contribution in development economics by Hirschman in 1958. In the essay, the author pointed to the creation of backward and forward linkages after the MNEs locate in the host economy. However, there is past research that argue that past input-output relationship, and therefore the existing levels of intermediate demand may act as a pull factor for FDIs, particularly for those engaged in intermediate activities as services are. A less explored aspect in the literature, consist in analysing existing input-output relationship between logistics and vertically related sectors, such as manufacturing and retail, to explain the location determinants of logistics MNEs[4]. In this respect, the literature may be summarized in two mains streams. A first strand of literature, more focused on transport-

[4] We are aware that the intended contribution of Hirschman was to explain the linkages after the occurrence of the FDI. However, past research used pre-existing input-output relationship to explain the location of MNEs, particularly in services, sensitive to the level of intermediate demand and characterised by strong user-supplier interactions (Meliciani et al., 2012, 2016). Here we tackle the possible reverse causation that might stem from applying Hirschman's theoretical framework, by using data on input-output relationships in 2010, thus before the occurrence of FDIs in our considered period of analysis.

intensive firms, stresses the role that transportation infrastructures and accessibility to markets as drivers influencing firms' decisions, bringing accessibility-patterns considerations at centre stage, i.e. assuming that transport infrastructures act as main determinants in location choices of logistics firms (Holl 2004; Sheffi, 2012; Sheffi & Rivera, 2014; Mariotti,2014; Holl & Mariotti, 2018b). Here, Holl & Mariotti (2018a; 2018b) implement an indicator of market potential to approach the relationship between access to markets and logistics' location decision. The variable is simply a measure of aggregate accessibility, where accessibility is determined by the distance to and the size of the markets, expressed in terms of population or income per spatial unit. The measure has the purpose of reflecting the volume of economic activity in each location and its accessibility in terms of distance. The authors found that the higher the market potential in Spanish urban areas, the higher the probability for a logistic firm to locate in those areas. Also, closeness to major transportation infrastructures makes logistics firms more productive, hence helping explain location decisions where there exist higher quality connections with both suppliers and customers (Hong and Chin, 2007; Hong, 2007, 2010; Bowen, 2008; O'Connor, 2010; Mariotti et al., 2015). A second stream addresses location choices, mostly for manufacturing and KIBS FDIs, by looking at the impact of intermediate manufacturing demand on such decisions (Venables, 1996; Nefussi and Schkellnus 2010; Meliciani et al 2012; Mariotti et al. 2013). Here, Meliciani et al.,(2016) found that inter sectoral demand from manufacturing attracts business services in European NUTS2 regions. In the context of our work, we bridge these two perspectives by considering vertical linkages, particularly with retail and wholesale industry, as pivotal factors in shaping locational patterns for logistics FDIs yet controlling for accessibility to markets and infrastructures at the NUTS3 level.

1.1 Accessibility in Logistics location choices

As anticipated, the logistics industry has been mainly investigated by considering transport infrastructures and various forms of proximity to them as main location and/or productivity determinants. This first strand of literature stresses the role that transportation infrastructures and accessibility to markets have in influencing logistics firms' decisions, bringing the industry under accessibility-patterns considerations. Here, the literature may be further grouped in two strands of studies. On the one hand, there is an extensive body of literature addressing accessibility as physical proximity to pivotal infrastructures, e.g. airport, road, port. On the other hand, we find measures of market potential (or market accessibility)

like the one conceptualized by Harris (1954) used to study the impact of geographical proximity to markets. Overall, the literature considering accessibility, either in terms of closeness to transportation infrastructure or as proximity to neighbour markets has found that higher accessibility brings benefits to firms for having a better access to inputs and product market, customers and/or suppliers (Graham 2007a, 2007b). Concerning the former stream of research, Gibbons et al., (2017, 2019) studied the impact of road accessibility on firms' productivity in the UK, finding out that better road accessibility favour the growth of logistics establishments. Small & Giuliano (2007, 2012) found out that the presence of the airport and its accessibility as physical infrastructure along its physical distance to and from the city centre may be more relevant than unique factor location and fiscal policies in U.S. metropolitan areas. Further empirical research revealed that the location of logistics firms is a function of the city's proximity to ports, airports, highways, railroads and their relative costs, playing a more crucial role when the firms locate in large urban areas, allowing them to meet the increased scale and time-sensitiveness of goods distribution (O'Connor, 2010). Bowen (2008) examines the changing geography or warehouses in the U.S. between 1998 and 2005. The scope of the analysis was to determine up to which degree the distribution of warehouses gravitated towards places with superior accessibility. Results show that the number of establishments located in 143 metropolitan areas, in 2005 and the rate of growth of the number of establishments between 1998-2005 were strongly correlated with the county level measures of accessibility in air, highways and to a less extent, rail networks. The author selected randomly 50 Metropolitan Statistical Areas (MSAs) in the U.S., and developed four county-level accessibility measures, namely (i) air accessibility, measured as the distance to the nearest airport and the air cargo tonnage handled at the airport in 2004, (ii) port accessibility, measured as the distance to the nearest container port and the number of containers handled at the port, (iii) highways accessibility, was measured using data from the National Atlas of the US, for each county the density of major highways was calculated by dividing the total centreline lengths by the county's area, and (iv) rail accessibility, was measured by examining the network Class I railroads (the largest in the US) which account for 92% of rail freight revenues in the USA. The empirical finding based on spearman correlation indicate that air and highway transport matter more than rail, while sea accessibility was not significant. Holl & Mariotti (2018a) used geo-referenced data on 6542 firms from SABI[5] to

[5] Bureau Van Dijk database dedicated to firm located in Spain.

analyse the effects of highway development on logistics firm-level performance in Spain over the period 1999-2014. They found that higher accessibility to highways (i.e. a reduction in the distance to the nearest highway) increases their productivity.

Empirical literature more focussed on proximity to markets as a main determinant, build upon market potential measures closely related to Harris (1954), where accessibility is determined by the distance[6] between alternative locations and by the size of market in alternative locations (a detailed explanation of this indicator will be given in following sections – Methodology and Variables). Graham (2007a, 2007b) studied the effects of transportation infrastructures on firms' productivity in the UK at the ward level. The author developed a market potential measure called "effective density" in which the market size is proxied by the employment accessible to any firm located in the ward i, and the distance is geodesic[7]. The results show that an increase in the effective densities are associated with productivity improvements, wherein the major impact concerns transport-intensive services, e.g. logistics. Holl & Mariotti (2018b), used geo referenced firm level data on 8959 logistics firms from the SABI database, along with information on transport infrastructure to investigate the geography of logistics firms in nearly 8000 municipalities in Spain, posing attention to the relationship between logistics firm location, accessibility and urban structure. Specifically, they relate firms to the highway network, airports and seaports. As measure of accessibility the authors used a market potential measure, whereby size market has been proxied by the municipality population and the distance is expressed as travel time. Empirical results from a Poisson distribution and a negative binomial model show that the logistics industry in Spain is located closer to highways, highly urbanized, and the number of logistics establishments grows where the market potential is higher.

1.2 Intermediate demand and Inter sectoral Linkages

A second strand of literature approaches MNEs' location choices by looking at the magnitude of pre-existing intermediate demand. Particularly, it recognizes the role of intermediate demand as important attractive force behind the location on international investments in knowledge intensive services, typically characterised by high supplier-user interactions. To develop both theoretically and empirically this relationship between intersectoral demand

[6] The distance may be expressed either as a geodesic measure or as travel time along the road network
[7] Geodesic Distance is the shortest distance measured along the ellipsoidal surface of the earth

and location (Meliciani et al., 2016) (or productivity as in Mariotti et al., 2013). The bulk of literature point back to the work of Hirschman in 1958 on the creation of linkages due to the presence of MNEs in the territory[8]. In his The Strategy of Economic Development (1958), Hirschman introduced the linkage concept, generalised to the observation that ongoing activities "induce" agents to take up new activities.[9] Here the author distinguished two types of spillover effects associated with the so called growth pole theory[10]: *backward linkages* and *forward linkages*. The former effects are associated with activities that provide inputs to economic activities, drawing towards the location where the clients are. The latter concerns activities that use outputs by new activities or existing activities that draw them towards locations where these existing activities are already represented (McCann & Van Oort, 2019). Here we focus on the latter aspect, i.e. forward linkage, related to output utilisation, i.e. the outputs from a given activity will induce attempts to use this output as inputs in some new activities (Hirschman, 1958, p. 100). In terms of location behaviour, certain sectors tend to concentrate where their clients are located or migrate where there is a growing community of suppliers and/or customers. Over the last decades, scholars have built upon Hirschman's work to understand the complex relationships between economic actors and regional dynamics. Particularly, the literature mostly takes two perspectives: one addressing the relationship between FDIs and productivity levels of domestic firms; the other one, studies FDIs' location strategies taking the magnitude of existing vertical linkages as pivotal determinant. Rodriguez – Clare (1996) empirically defined both backward and forward linkages in the context of multinationals in underdeveloped countries under the assumptions

[8] As presented in Hirschman, the linkages will be created after the occurrence of an investment. However, past research used antecedent (with respect to the location of the FDI) input-output relationship to explain the localisation of MNEs (Meliciani et al., 2016). Here we are aware of a possible problem of reverse causation stemming from the use of a theoretical background that assumed a different temporality in the creation of linkages, therefore we use data previous to the investment to infer on the location determinants of logistics FDIs.

[9] "*Here the establishment of one industry is a contributing factor which by· itself is quite unlikely to result in the creation of the others; but when we speak of external economies and complementarities, we think at least as much of these uncertain linkages as of the far more certain, but also far less significant, satellites with which any industry of a certain size surrounds itself. The weakness of the stimulus in the case of non-satellites can be explained by the absence of the three factors that define satellites. Linkage is reduced to the fact that an input of the newly established industry is an output of the to-be-created industry or vice versa, but the established industry would not be the principal customer or sup-plier of the to-be-created industry; in fact, particularly in cases of backward linkage, minimum economic size of the to-be-created industry would frequently be larger than that of the industry where the linkage originates*." Albert Hirschman (1958: 108)

[10] The growth pole theory was first advanced by Perroux (1950) in contributing to the theoretical development on the role of knowledge diffusion across space in economic geography. Its main assumption is that economic growth, manifested in the form of innovations, is spread throughout a growth centre's hinterland to lower-order cities and localities nearby. Innovations and knowledge once generated in a particular central location are expected to spread among regions from one locality to its neighbours (McCann & Van Oort, 2019).

of love of variety of intermediate goods and increasing returns to scale in their production. The findings reveal that multinationals' linkage effect on the host country is more likely to be positive when the good that multinationals produce uses intermediate goods intensively.

Further empirical conceptualisation of vertical linkages has been given by Venables (1996). The author aimed at explaining the location choices of vertically linked industries under imperfect competition assumptions. The idea is that if industries are vertically linked through input-output relationships, then the downstream industry forms the market for firms operating in the upstream, then because of higher market access, upstream firms decide to locate where there are relatively many downstream firms, i.e. demand linkage. Although the empirical framework has the purpose of explaining agglomeration through the interplay of firms vertically linked, yet it supports the argument of location decisions driven by intermediate demand linkages for firms with strong supply-user interactions.

Most of the empirical work built upon the theoretical and empirical framework presented above, has addressed, among others, how FDIs affects the creation of external linkages and through that mechanism, the productivity levels of domestic firms (Rodriguez-Clare et al., 2004; Giroud, 2007; Mariotti et al., 2013), yet very scant work focussed on the role of intermediate demand to assess the location's attractiveness for logistics FDIs. In fact, most of the literature addressing the magnitude of linkages generated by FDIs in host countries relies on the fact that FDIs can be a source of productivity for domestic firms, wherein MNEs are likely to generate both pecuniary (e.g. from the firm to consumer when a new good is introduced – Rodriguez-Clare, 1996) and technological spillovers (Scitovsky, 1956). One robust argument standing out from the literature, confirms the existence of positive externalities from MNEs to local firms in upstream activities (suppliers) and/or downstream sectors (customers) because of forward/backward linkages and knowledge spillover (Rodriguez – Clare & Alfaro 2004). Following this argument, Mariotti et al. (2013) dealt with backward and forward linkages stemming from MNEs in service sectors and their impact on local manufacturing firms' productivity. Using data on MNEs in Italy over the period 1999-2005, they found that vertical linkages positively influences local customer firms because of the increased competition in the sector. As common in the literature, the authors chose to study business services and their linkages with the manufacturing sector.

Past research has argued that the rise of services is mostly due to changes in the production processes in many sectors, and to the resulting increase in the demand for services as

intermediate goods (Savona & Lorentz, 2005). Meliciani et al., (2012) studied sectoral specialisation in KIBS services (BS) across the European NUTS2 regions over the period 1999-2003 as determined by: agglomeration economies, the magnitude of intermediate linkages, technological innovation and knowledge intensity, and the presence of these factors in neighbouring regions. Particularly, the authors focussed on Hirschman-type of forward linkages between KIBS and manufacturing industry. The empirical results drew upon Eurostat Symmetric input – output table in 2000 and show that, besides urbanisation economies, the spatial structure of intermediate sectoral linkages and innovation, notably in the Information and Communication Technologies (ICTs), are important determinants of specialisation in KIBS services. Meliciani et al (2016), focussed on the role of forward linkages with manufacturing sectors and other services as attractors of business services FDIs at the NUTS2 level over the period 2003-2008. Drawing data from fDi Markets and the Eurostat Symmetric input-output table in 2005, the authors found out that regions with higher intersectoral linkages with manufacturers attract more KIBS FDIs than other regions.

Overall, the literature suggests that the sectoral composition in a regional context and the nature of vertical linkages between firms are pivotal determinants in services' location choices along with spatial proximity between services and their clients. Yet, literature devoted most of the attention towards the financial and KIBS services, largely neglecting the ones engaged in the distribution of goods and freights. We also argue that focusing on the magnitude of pre-existing vertical linkages with the retail and wholesale sector, we may be able to capture the effect of what scholars and business analysts define as a consumer-driven economy (McKinnon, 2009). This may have relevant policy implications within the debates that opened at the European level to develop a competitive service economy independently from the magnitude of the manufacturing base - notably the Logistics Action Plan, the New Silk Road, which are likely to increase the demand for logistics hubs along the way. Furthermore, considering forward linkages with retailers is relevant for different reasons. First, in the last decade, logistics providers have been optimising their services to meet increasingly technology-driven retail consumption. The outstanding growth of ecommerce offers excellent opportunities for growth in modern logistics real estate such as mega-distribution centres, smaller urban facilities within city limits and click-and-collect pick-up points. Increasing complexity in customer requirements concerning availability, choice, speed and flexibility create need for additional points in the logistics supply chain. This can be attributed to higher

inventory turnover and a wider product range and greater need for outbound shipping space and logistics capacity for customer returns (Savills, 2017). To meet this growing demand, European companies are keener to invest in logistics warehouses and fleet. The underlying mechanism relies on the increasing demand by customers for differentiated products delivered in a shorter amount of time. For instance, consumers' preference for ordering online has helped boost the size of UK parcel market to almost 9bn pounds, making the B2C markets more profitable for logistics operators than the B2B (Financial Times, February 9th, 2015[11]). In 2018 in Italy, the outsourcing to logistics firms of distribution services has reached a peak of 41,7% over the total of all logistics activities, out of these 41% of new ventures involved foreign logistics firms (Sole 24 Ore, November 22nd, 2019[12]).

Data

In order to study the effect of vertical linkages and accessibility as determinants for the location choices of inward logistics FDIs, the empirical analysis is based on fDi Markets[13] data, a commercial online database, produced by fDi Intelligence, a special division of the Financial Times Ltd, which provides information on FDI projects. Relying on media sources and company data, fDi Markets collects detailed information on cross-border investments. Data are based on the announcement of the investment and updated daily. For each project, fDi Markets reports information on the industry and main business activity involved in the project, the location where the investment takes place (host country, regions and cities), and the name and location of the investing company (home). The database contains around 203,360 investment projects referring to the period 2003-2018 in 197 countries, covering several business activities, such as Research & Development, Production, Headquarters (HQs), Business Service, ICT, Logistics, Marketing, Education & Training and Technical Support and associated 2-digit NACE Rev.2 codes[14]. For this paper we rely on information on a total of 1.777 international investments projects in the Logistics industry from 2011-2018 made by 818 MNEs in 380 NUTS3 regions. Our sample covers 6% of total inward FDIs in Europe over the same period and 40% of geographical coverage with respect to the total NUTS3 in Europe that

[11] https://www.ft.com/content/ea735d38-af99-11e4-a418-00144feab7de
[12] https://www.ilsole24ore.com/art/non-conosce-crisi-logistica-conto-terzi-business-84-miliardi-ACwmNh0
[13] www.fdimarkets.com
[14] As in Holl & Mariotti (2018a, 2018b) we identify Logistics as H49-H52, excluding all passengers related transport and postal and courier activities as we focus specifically on logistics firms. This group does not include transport operators.

received new FDIs. For this analysis we rely on logistics operators and transport operators handling freights and cargo according to past literature, we therefore excluded all passengers' carriers (Mariotti, 2014).

Methodology

In order to capture the role of vertical linkages in logistics FDIs' location decisions, among a set of locations, we implement a Conditional Logit Model (McFadden, 1974) coherently with past empirical literature investigating location choices (Goerzen et al., 2013; Belderbos et al., 2017). Firms as profit-maximizing economic actors, will choose the location yielding the highest net profits. While it is not possible to observe directly the profit associated with each location, we can observe the chosen location's characteristics and the characteristics of all the alternative choices, NUTS3 regions in our case. We assume that if investment *i* locates in NUTS *j,* then j must be the location yielding the highest net profit. The CLM allows to estimate the probability with which the firm will choose for the investment i the NUTS j with the highest net profits. This can be formally expressed as:

$$P_{ij} = \frac{\exp\left(\beta \mathbf{X_{ij}}\right)}{\sum_{l=1}^{n} \exp\left(\ \beta \mathbf{X_{ij}}\right)}$$

Where X is a vector of location and firm characteristics at the city level. Yet, CLM implies a strong assumption, which is the Independence of Irrelevant Alternatives (IIA). According to IIA, the relative choice probabilities is independent from any characteristics of all the alternatives in the choice set.

Variables

Dependent variable

The dependent variable is the location choice for a new investment project. This is a binary variable assuming value one if a given project i, made by the firm f in the NUTS3 j, and it assumes value zero for all the other possible alternative NUTS3 (not chosen) j≠j*.

Hirschman Vertical Linkages

Our main explanatory variable is a measure of vertical linkages with retail and wholesale and manufacturing sector. According to past literature (Rodriguez-Clare, 1996; Meliciani et al., 2012, 2016) we built our main indicator as a weighted share of employment in retail,

wholesale and manufacturing sectors that are above average users of logistics services[15]. In particular, we take a vector measuring the use of services on output for retail and wholesale, and manufacturing sectors that are above average logistics services users and, for each region, we multiply it by total employment in each respective retail and wholesale/manufacturing sector; this number is then divided by the region's j total employment:

$$VL = \frac{\sum_{s=1}^{m} W_s E_{js}}{\sum_{s=1}^{n} E_{js}}$$

Where: j=region, s=sector (retail and wholesale, manufacturing), m=number of above average logistics services users retail and wholesale and manufacturing sectors, n=total number of sectors, E=employment, W=weight given by the average (across European countries) value of logistics services used as inputs by sector j, as a share of industry j total output as computed from Eurostat symmetric Input Output tables in 2010. The indicator is an increasing function of the regional employment in retail/manufacturing sectors that are users of logistics services with respect to total regional employment. Table 4 reports the coefficients that are used as weights to build our indicator[16].

Control Variables

According to past literature we control for a set of independent variables capturing the market size, i.e. *Gross Domestic Product,* and other locations' characteristics, e.g. population density by taking the average over the period 2006-2010 for which data are available for all the NUTS3 regions included in our sample.

Agglomeration Economies

According to past literature we compute a measure of agglomeration economies drawing data from our main dataset, fDi Markets and from Amadeus[17] when controlling for agglomeration economies generated by the presence of firms either domestic or foreign over the period 2006-2010. Overall, agglomeration economies are positively associated to MNEs investments

[15] In Guerrieri & Meliciani (2005), Meliciani et al., (2015) taking the above average users is a good way to proxy "potential" intermediate demand. Intuitively the indicator is higher for those countries that have a manufacturing industry that is more oriented towards those sectors that are, on average, high users of services (Guerrieri et al., 2005)

[16] These have been obtained by regressing the share of logistics services on total industry output and industry dummies for all the European countries included in the analysis in year 2010.

[17]Amadeus contains comprehensive information on around 21 million companies across Europe. We collected data on 46.886 firms, out of which 28% are foreign firms 72% are domestic. Ownership is based on Amadeus definition of Ultimate Owners with 50.1% of direct ownership. 76% of firms are large companies (average number of employees over 2006-2010 > 150) https://help.bvdinfo.com/mergedProjects/64_EN/Home.htm

that benefit from them (Marshall, 1920; Belderbos et al., 2016; Defever, 2012). We expect a positive effect of each agglomeration on the location choices of logistics MNEs. However, according to the past literature we expect a stronger effect of past investments in the NUTS3 with respect to the presence of domestic firms, captured in Amadeus (Alfaro et al., 2010). In fact, MNEs are willing to agglomerate with other MNEs, as they bet on a positive balance between knowledge inflows and outflows (Piscitello et al., 2010) showing isomorphism in their location decisions.

Accessibility

Market Potential

The logistics services are non-traded or delivered at higher costs the higher the distance, which supports the argument in favour of geographical proximity to markets and infrastructures (i.e. ports and airports) as determinants to be included in our study (Markusen et al., 2005; Holl & Mariotti, 2018a). Using geo-coded data at the investment level[18] allowed us to relate our investment-level data to geo-referenced digital vector maps of all European NUTS3[19] regions. Having geo-coded data means that we are able to calculate the exact distance from the NUTS3 regions in which FDIs in logistics takes place can be integrated with other spatial data on a fine-grained spatial scale, NUTS3 regions in our case. The variable, also known as market potential (Harris, 1954) is simply a measure of aggregate accessibility, where accessibility is determined by the distance to, and the size of, the markets in alternative locations. Market potential in location j is the sum of the market sizes, measured as the NUTS3 GDP in all other locations divided by their inverse squared distance dij to k. Distance is measured as Euclidean distance between each NUTS3 and all the other NUTS3 regions. Firstly, we built a spatial weight matrix **W**, imposing a structure in terms of what are the neighbors for each location. Then we assigned weights that measure the intensity of the relationship among spatial units, in our case the weights are a function of the distance between NUTS3 regions *i* and NUTS3 *j*, *dij. Dij* has been computed as the distance between their centroids. Secondly, we computed the inverse distance:

[18] We processed geocoded data using QGIS 3.10

[19] We drew geo data from Eurostat (https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts) using NUTS3 2010 classification, notably we worked on the multi polygons regions. More detailed information can be found in the metadata pdf file here http://ec.europa.eu/eurostat/web/nuts/overview

$$\boldsymbol{w_{ij}} = \frac{1}{d_{ij}^{\alpha}} \; if \; i \neq j$$

Where α =2. As last step, we calculated our market potential measure as follows:

$$MP_j = \sum_{j=1}^{J} w_{ij} x_j$$

Where x is the value of the GDP in location j. We measured market potential building upon past empirical literature (Weibull, 1980; Bruinsma & Rietveld, 1996; Holl & Mariotti, 2018b). The measure has the purpose of reflect the volume of economic activity in each location and its accessibility in terms of distance. The idea is that closer markets shall be preferable markets over farther ones.

Distance to Airport

Drawing data from GISCO database – Eurostat[20] we were able to geocode each international airport[21] within the NUTS3 region using QGIS. We then computed distance matrices for each pairwise combination of investment – airport. Consistently with past literature, we expect a negative impact of the distance on the logistics' location decisions. Negative impact means that logistics' firms shows sensitiveness to proximity to crucial infrastructures, therefore, the higher the distance, the lower the attractiveness of that NUTS3. Empirical research (Small & Giuliano, 2007, 2012) found out that the presence of the airport and its accessibility as physical infrastructure along its physical distance to and from the city center may be more relevant than unique factors location and fiscal policies.

Distance to Port

Drawing data from GISCO database – Eurostat[22] we were able to geocode each international port within the NUTS3 region using QGIS. We then computed distance matrices for each pairwise combination of firm – port. We do not expect a particular result from this measure, since empirical research points puzzling results in terms of port's accessibility as it varies upon the geographical context. While McKinnon (2009) and Hong (2007) found a positive effect of a higher proximity to ports in UK and China respectively, Bowen (2008) found no significant

[20] https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/transport-networks
[21] We selected airports which provided freights and mail deliveries services according to the categorisation provided in the EU regulation n. 437/2007. https://webgate.ec.europa.eu:80/inspire-sdi/srv/eng/search?uuid=%7B1CBF6227-A0F4-4277-9FB4-FE071FCCC1CF%7D&hl=eng
[22] https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/transport-networks

effect in the USA. However, given the increasing trend of gross weight seaborne freight in European Ports (3.000 million tonnes on average[23]) we may expect this variable to negatively impact logistics firms[24], hence, we expect that logistics' firms show higher sensitiveness to proximity to ports, therefore, the higher the distance, the lower the attractiveness of that NUTS3.

Finally, given the primary nature of logistics firms to move goods in *different loci of* consumption, we also included in our model variables accounting for the road freight flows in each NUTS3, and Airport and Port freights stock in the greater NUTS2 region (data on port and airport freight are not available at a smaller geographical level). Notably, we compute the sum of each inward and outward flow of freights per each region via road[25], port and airport. Using freights stock not only allows to control for the regions' market size, but also to control for the capacity of key hard infrastructures: airport, port and road links. We expect a positive impact of freight stock since they may generate a higher local demand for distribution activities within the region. Lastly, we computed a measure of proximity to country borders as the shortest distance from where the investment is located and the neighbouring(s) country's border(s). The variable should capture the fact that logistics MNEs, as actors involved in the movement of goods and an integral part of the global value chain, may well be attracted by regions that share a border with a foreign country and therefore enjoy an easier physical access to that market. Since we expressed this variable as distance in KM, we expect a negative impact, and therefore the higher costs of overcoming distance to reach neighbour countries discourage the location of logistics MNEs. A summary with description and sources of all variables included in the analysis is reported in table A1 in Appendix.

Results

To address logistics MNEs' location choices we run different regressions, testing the role that vertical linkages with retail and wholesale, and manufacturing sector have in determining such strategic decisions, controlling for agglomeration, accessibility and other locations'

[23] https://ec.europa.eu/eurostat/statistics-explained/index.php/Maritime_ports_freight_and_passenger_statistics

[24] The distance to port may affect the investments in inland regions as well because of the increasing trend in Europe in the development of dry ports https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/brochures_images/ports2013_brochure_lowres.pdf, see also (Rodrigue et al., 2012; Olah et al, 2018)

[25] More than three quarters of total inland freight transport in 2017 in the EU was by road https://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics#Modal_split

characteristics. In order to do this, we estimate a conditional logit model that allows to include NUTS3 characteristics as independent variables. We estimate different model specifications. The table 2 reports the model estimates for inward FDIs directed to the logistics industry, using NUTS3 as geographical unit of analysis. In table 3 we run five regressions controlling for agglomeration economies generated by the total population of firms in each NUTS3. In Mod. 1 we consider only vertical linkages with the retail and wholesale sector as main independent variable and other controls. Similarly, in Mod. 2 we consider only for vertical linkages with the manufacturing sector as main independent variable. In Mod. 3, our final and preferred specification we control for vertical linkages with both retail and wholesale, and manufacturing sector.

In Mod. 1 we show that Logistics FDIs are attracted by stronger vertical linkages with the retail and wholesale sector, market size, proxied by the NUTS3 GDP exerts a positive effect, while the size of markets in alternative location, i.e. weighted spatial lag, does not influence such decisions, as well as the geographical proximity to pivotal infrastructures or the magnitude of infrastructures' capacity, i.e. freights stock. Similarly, in Mod. 2 we run the same specification though focussing on linkages with the manufacturing sector, and what we can see is that consistently with past literature the coefficient is positive and significant, meaning that supply side forward linkages positively influence the location of FDIs in the logistics industry. Market size in the chosen location, as well as in the alternative ones does not exert any effect, so does the proximity to infrastructures and their relative freights stock. In mod. 3, our preferred specification, we include full controls and we observe jointly the role of linkages with both industrial sectors considered in our study. Again, we support past literature finding that vertical linkages with the manufacturing sector exert a positive impact. However, vertical linkages with the retail sector do have a positive impact although we control for manufacturing intermediate demand. This result is consistent with the current debate in the literature arguing the shifting towards a *demand- driven* economy, in which consumers' preferences for quicker deliveries are paving the way to a more customer-based supply chain. Indeed, we observe that higher sectoral interconnectedness, with those business actors closer to the end market, is likely to be a stronger attractive factor for FDIs in the logistics industry in across European regions. As in Mod. 1, we observe the positive impact of NUTS3 market size and no effect of the GDP's lagged effect. Also, a common result in all the three specifications is the effect of agglomeration economies stemming from the past stock of FDIs

in the same region. We can observe that consistently with past literature multinationals are positively driven by the presence of other multinationals in their chosen location, either in the same industry or in the other industrial sectors. Also, we may observe a path dependency in the in choice of location given by the experience that MNEs have in the same region.

To get a full understanding of logistics FDIs' determinants, we run five more regressions, presented in table 3, where we disaggregate our agglomeration economies control variables. In table 2 we presented three specifications where we control for agglomeration economies generated by the sole presence of other MNEs in logistics and all the other aggregated sectors, meaning that we are unable to observe for the disaggregated effect of agglomeration of firms operating in the supply-side of the economy, namely manufacturing, and firms operating in demand-side of the economy, i.e. retailers. We wanted to observe these effects by capturing also the presence of all the firms present in the region over the period 2006-2010 and not only FDIs. In order to do so, we have drawn data from Amadeus for all the population of firms operating in our sample of regions. We run 5 regressions, in Mod. 4, 5 and 6 we account for the aggregate presence of FDIs, domestic (72% of all firms) and foreign-owned firms (28 % of all firms) in Logistics and other sectors; in Mod. 7 and 8 we disaggregate further by controlling both for FDIs and firms in logistics, retail and wholesale, manufacturing and other sectors to observe whether an agglomeration on the supply side, may change the effect of vertical linkages with retailers in the chosen region. Overall, we observe at least three interesting results. First, we are consistent with past literature arguing that multinationals tend to follow each other and therefore detecting an isomorphism of MNEs (Alfaro, 2010; Piscitello et al., 2010). Results show that the sole presence of FDIs capture the effect of agglomeration economies in the region. Since most firms included in our controls are domestic (72%), we may conclude that the presence of local actors in the regions, do not exert any effect in the case of logistics FDIs. Second, the presence of manufacturing firms exerts a lightly positive effect, while logistics and other firms do not have any impact.

Conclusions & Implications

A large body of the literature investigating firms' location decisions devoted attention to the location of production activities, whilst little evidence has yet been provided on the logistics industry. The literature is very sparse and has mainly addressed the sprawl of warehousing activities at the regional/metropolitan level. Very recently empirical literature has started to investigate logistics services' location decision (Mariotti, 2014; Holl & Mariotti, 2018a, 2018b), yet the role of vertical linkages, particularly with the retail and wholesale sector has been largely neglected. However, we argue that the boosting demand coming from online retail might particularly affect logistics operators independently from the manufacturing base already present in the local context (Meliciani et al., 2012; Holl & Mariotti, 2018b). Due to the increasing consumers' demand for fast goods' deliveries (partially to be attributed to the growth of online-retail as further sales channel) the logistics industry and consequently companies and governments are boosting investments in logistics property in Europe. The underlying mechanism here bank on the increasing demand by customers for differentiated products delivered in a shorter amount of time. Scholars reckon this phenomenon as the gradual shifting towards a consumer-oriented economy as argued by McKinnon (2009), which makes the management of the supply chain even more complex bringing the strategic focus of firms from a "*supply-push*" to a "*demand-pull*" economy (Bowen, 2008; McKinnon, 2009; Fernie et al., 2010; Holl & Mariotti, 2018b; Mangan, 2019). In this study we decided to focus on the location choices of inward international investment projects. Here the general idea is that for MNEs, decide to locate is a crucial decision, since among a potential choice set, they have to choose which host economy has the location advantage yielding the highest net profits. Also, there are certain issues that arise only when considering for MNEs' location, e.g. border effects (Arauzo-Carod et al.,2010).

To assess whether vertical linkages with the retail and wholesale sector positively impact FDIs in NUTS3 regions we rely on one main dataset: fDi Markets, running separate conditional logit models over the period 2011-2018 for 1777 FDIs located in 380 NUTS3 regions. Consistently with past literature, our findings show that logistics MNEs are attracted by the inter-sectoral demand generated by producers, although the presence of vertical linkages with the retail and wholesale sector exert a much stronger effect in luring logistics operators in NUTS3 regions, supporting the argument of a shifting from a supply-push to a demand-pull economy. Moreover, according to past empirical research, we can observe isomorphism in MNEs'

location decision. Foreign investors may suffer from adverse asymmetry in information costs compared with insiders (Mariotti et al., 2013), therefore the opportunity to reduce information costs from foreign agglomeration may be grater in areas with higher penetration for a longer period (Mariotti, 2014). In fact, when disaggregating our agglomeration economies control variables, we show that although an agglomeration on the supply side has a light positive effect, the one in the demand-side exerts a way stronger effect. Interestingly enough, we may observe that market potential in alternative location does not exert any effect, meaning that MNEs are much more driven by the local market in which they are embedded than by markets outside the chosen region.

Our paper contributes to the current empirical literature addressing logistics multinationals' location choices, unpacking those determinants that attracts FDIs into European NUTS3 regions. We contribute to the current literature arguing the existence of isomorphism in MNEs' location decisions, i.e. MNEs tend to follow other MNEs, providing further evidence that they are more likely to locate where there is a denser presence of MNEs, that is where agglomeration economies are made possible by the co-location of multinational activities. Most importantly, we believe that our results may provide some contributions to the current dialogue between economic literature and business practitioners arguing a gradual shifting towards a demand-driven economy in which keep up with consumers' preferences for differentiated products delivered in a shorter amount of time may be source of competitive advantage for MNEs. This may have important policy implications in building a competitive service economy independently from the pre-existing manufacturing base across European regions. Our results show that stronger vertical linkages with the retail and wholesale sector it is a stronger determinant in their location decisions, among the ones included in our study. These findings may open new avenues for future research concerning the location decisions of logistics MNEs in a post pandemic perspective. As a matter of fact , as Covid-19 began to spread worldwide in early 2020, the generalised lockdown and border closure severely impacted almost all industries, and particularly Logistics, by hampering the flows of goods and freights between countries. At the very beginning of this dissertation work we argued about the complexity of logistics activities and how the heterogenous bundle of operations may be broken down in those devoted to serve industrial production and those devoted to serve the final market. Here we posed the attention towards the latter (although controlling for the former) by arguing that in a changing demand-driven economy the sectors closer to

consumers may exert a stronger attractive force in luring logistics MNEs by sourcing intersectoral demand. During the pandemic, because of the lockdowns and borders closure, freight flows, particularly between countries have been severely affected. However, this impact has been mitigated by the outstanding demand from online retail as consumers started to opt for online shopping for groceries and non- essential products (Luke & Rodrigue, 2008; Rodrigue, 2020). Surely in the absence of data on the magnitude and quality of supply chain disruptions it is not possible to forecast the long-term effect of covid-19 on the logistic industry. However, our results may support the need to shape more tailored policies devoted to attracting logistics firms regardless the manufacturing base within the region in light of the increasing trend of a customer-based supply chain.

Tables

Table 1. Descriptive Statistics

Variables	***Obs***	***Mean***	***Std.Dev.***	***Min***	***Max***
Log. Hirschman Vertical Linkages of Logistics users in the Retail and Wholesale Sectors	1409	0,02	0,19	0	0, 93
Log. Hirschman Vertical Linkages of Logistics Users in the Manufacturing Sector	1077	0,43	0,61	0	3,52
Log. Gross Domestic Product NUTS3	1777	7,2	4,33	0	12,18
Log. Weighted Spatial Lag – GDP based	1777	6,82	4,18	0	14,71
Log. Population Density	1777	5,2	2,7	0	9.95
Stock of other firms over over 2006-2010	1777	102,85	283,32	0	1599
Stock of Manufacturing firms over 2006-2010	1777	10,61	227,59	0	9558
Stock of Retail firms over over 2006-2010-	1777	10,17	50,49	0	508
Stock of Logistics firms over 2006-2010	1777	0,73	6,96	0	137
Stock of Past Other FDIs over 2006-2010	1777	148,97	214,2	0	1117
Stock of Past Manufacturing FDIs over 2006-2010	1777	11,26	28,76	0	181
Stock of Past Retail and Wholesale FDIs over 2006-2010	1777	17,09	45,96	0	444
Stock of Past Logistics FDIs over 2006-2010	1777	3,19	12,44	0	112
MNEs Past Investments in NUTS3 over 2006-2010	1777	0,84	0,41	0	3
Log. Total Freights stock in Th. Tonnes	1777	5,33	4,46	0	12.92
Log. Total Freights stock in Th. Tonnes	1777	6,94	4,84	0	12.67
Distance to Port in KM from each FDI	1654	159,46	66,63	0,42	249,95
Distance (KM) to Country Borders	1744	287,36	225,16	0,39	223,07
Distance (KM) to closest Airport	1777	1614,82	1480,81	7,6	132,25

Table 2. *Conditional Logit Model. The Location of Inward FDIs in the Logistics Industry*

	Logistics Mod. 1	Logistics Mod. 2	Logistics Mod. 3
Vertical Linkages			
Log. Hirschman Vertical Linkages of Logistics users in the Retail & Wholesale Sector	7.194***		5.779***
	(1.917)		(1.995)
Log. Hirschman Vertical Linkages of Logistics users in the Manufacturing Sector		0.507***	0.505***
		(0.0319)	(0.0322)
Control Variables			
Market size			
Log. Gross Domestic Product NUTS3	0.220***	0.0656	0.0980**
	(0.0483)	(0.0465)	(0.0480)
Log. Weighted Spatial Lag - GDP Based	-0.00732	0.0263	0.0113
	(0.0338)	(0.0351)	(0.0349)
Log. Population Density	-0.0303	-0.0147	-0.0276
	(0.0200)	(0.0197)	(0.0202)
Agglomeration Economies			
Log. Stock of Past FDIs over 2006-2010	0.000619***	0.000524***	0.000543***
	(0.00040)	(0.00041)	(0.00043)
Log. Stock of Past Logistics FDIs over 2006-2010	0.0201***	0.0136***	0.0135***
	(0.00293)	(0.00293)	(0.00295)
MNEs' Experience	0.778***	0.584***	0.558***
	(0.0792)	(0.0851)	(0.0866)
Freight Flows			
Log. Total Freights stock in Th. Tonnes by NUTS2 via Port and Airport	-0.0288***	0.0119	0.00691
	(0.00820)	(0.00857)	(0.00870)
Log. Total Freights stock in Th. Tonnes by NUTS3 via Road	0.0249***	-0.00196	0.0104
	(0.00921)	(0.00805)	(0.00909)
Log. Distance to Port in KM from FDI	0.000452	0.000421	0.000425
	(0.000886)	(0.000888)	(0.000888)
Log. Distance (KM) to Country Borders	-0.00161	-0.00164	-0.00164
	(0.00113)	(0.00117)	(0.00116)
Log. Distance (KM) to closest Freight Airport	0.0583	0.0595	0.0594
	(0.0490)	(0.0490)	(0.0490)
Observations	228,404	228,404	228,404
Number of NUTS3	380	380	380

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3. *Conditional Logit Model. The Location of Inward FDIs in the Logistics Industry*

	Logistics Mod. 4	Logistics Mod. 5	Logistics Mod. 6	Logistics Mod. 7	Logistics Mod. 8
Vertical Linkages					
Log. Hirschman Vertical Linkages of Logistics users in the Retail & Wholesale Sector	9.241***		7.488***	6.127***	7.422***
	(1.940)		(1.995)	(1.934)	(1.964)
Log. Hirschman Vertical Linkages of Logistics users in the Manufacturing sector		0.568***	0.563***	0.720***	0.632***
		(0.0313)	(0.0315)	(0.0435)	(0.0453)
Control Variables					
Market size					
Log. Gross Domestic Product NUTS3	0.343***	0.154***	0.192***	0.252***	0.201***
	(0.0507)	(0.0492)	(0.0502)	(0.0495)	(0.0526)
Log. Weighted Spatial Lag - GDP Based	-0.0366	0.00188	-0.0160	0.0303	-0.00723
	(0.0352)	(0.0365)	(0.0361)	(0.0339)	(0.0353)
Log. Population Density	-0.0578***	-0.0298	-0.0465**	0.0394**	-0.0337*
	(0.0198)	(0.0194)	(0.0198)	(0.0197)	(0.0203)
Agglomeration Economies					
Log. Stock of firms over 2006-2010 (excl. Logistics - Amadeus)	-0.000336	-0.000137	-0.000127		
	(0.000095)	(0.0000964)	(0.0000969)		
Log. Stock of logistics firms over 2006-2010 (Amadeus)	-0.00334	-0.00831	-0.00776	-0.00908	-0.0110
	(0.00578)	(0.00691)	(0.00689)	(0.00847)	(0.00789)
Log. Stock of Past FDIs over 2006-2010 (excl. Logistics FDIs)	0.000689***	0.000560***	0.000581***		
	(0.00043)	(0.00048)	(0.00042)		
Log. Stock of Past Logistics FDIs over 2006-2010	0.0221***	0.0143***	0.0140***		
	(0.00290)	(0.00291)	(0.00293)		
Log. Stock of Manufacturing firms over 2006-2010				0.0564*	0.00219**
				(0.0304)	(0.00109)
Log. Stock of Retail firms over 2006-2010				-0.0411	-0.0000126
				(0.0279)	(0.000605)
Log. Stock of Other firms over 2006-2010				0.0357*	-0.00148
				(0.0203)	(0.0198)
Log. Stock of Past Other FDIs over 2006-2010					0.00222***
					(0.000189)
Log. Stock of Past Manufacturing FDIs over 2006-2010					0.00194
					(0.00127)
Log. Stock of Retail FDIs over 2006-2010					0.0883***
					(0.0203)
Stock of Past Logistics FDIs over 2006-2010					0.0176***
					(0.00302)
MNEs' Experience	0.0773***	0.0711***	0.6883***	0.856***	0.597***
	(0.07847)	(0.08016)	(0.08164)	(0.0802)	(0.0845)
Freight Flows					
Log. Total Freights stock in Th. Tonnes by NUTS3 via Road	0.0355***	-0.00135	0.0141	-0.0152*	-0.0146*
	(0.00932)	(0.00835)	(0.00928)	(0.00833)	(0.00869)
Log. Total Freights stock in Th. Tonnes by NUTS2 via Port and Airport	-0.0306***	0.0150*	0.00861	-0.0249***	0.0183*
	(0.00834)	(0.00873)	(0.00881)	(0.00854)	(0.00944)
Log. Distance to Port in KM from FDI	0.000436	0.000405	0.000413	0.000435	0.000454
	(0.000887)	(0.000889)	(0.000888)	(0.00088)	(0.000890)
Log. Distance (KM) to Country Borders	-0.00152	-0.00161	-0.00161	-0.00162	-0.00159
	(0.00108)	(0.00114)	(0.00114)	(0.00114)	(0.00112)
Log. Distance (KM) to closest Freight Airport	0.0576	0.0592	0.0591	0.0637	0.0586
	(0.0491)	(0.0491)	(0.0491)	(0.0489)	(0.0491)
Observations	228,404	228,404	228,404	228,404	228,404
Number of NUTS3	380	380	380	380	380

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4. Share of Logistics Users in total industry output in 2010, average across European countries

Industries (2digit)	Use of Logistics Services (%)
Manufacturing	
Furniture and other manufactured goods	10,8
Machinery and equipment n.e.c.	9,03
Other transport equipment	8,4
Wholesale and retail trade and repair services of motor vehicles and motorcycles	8
Basic pharmaceutical products and pharmaceutical preparations	7,97
Repair and installation of machinery equipment	7,56
Coke and refined petroleum products	7,34
Textiles, wearing apparel, leather and related products	7,31
Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	6,39
Rubber and plastic products	5,93
Food, beverages and tobacco products	5,66
Motor vehicles, trailers and semi-trailers	5,25
Other non-metallic mineral products	3,36
Paper and paper products	2,7
Basic metals	2,34
Fabricated metal products, except machinery and equipment	2,08
Printing and recording services	1,39
Chemicals and chemical products	1,15
Computer, electronic and optical products	1,14
Electrical equipment	0,23
Retail Trade	
Wholesale trade services, except of motor vehicles and motorcycles	7,65
Retail trade services, except of motor vehicles and motorcycles	6,57
Average	*5,37*
Standard Deviation	*2,98*

Source: Author Elaboration based on Eurostat Regio Database

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Appendix

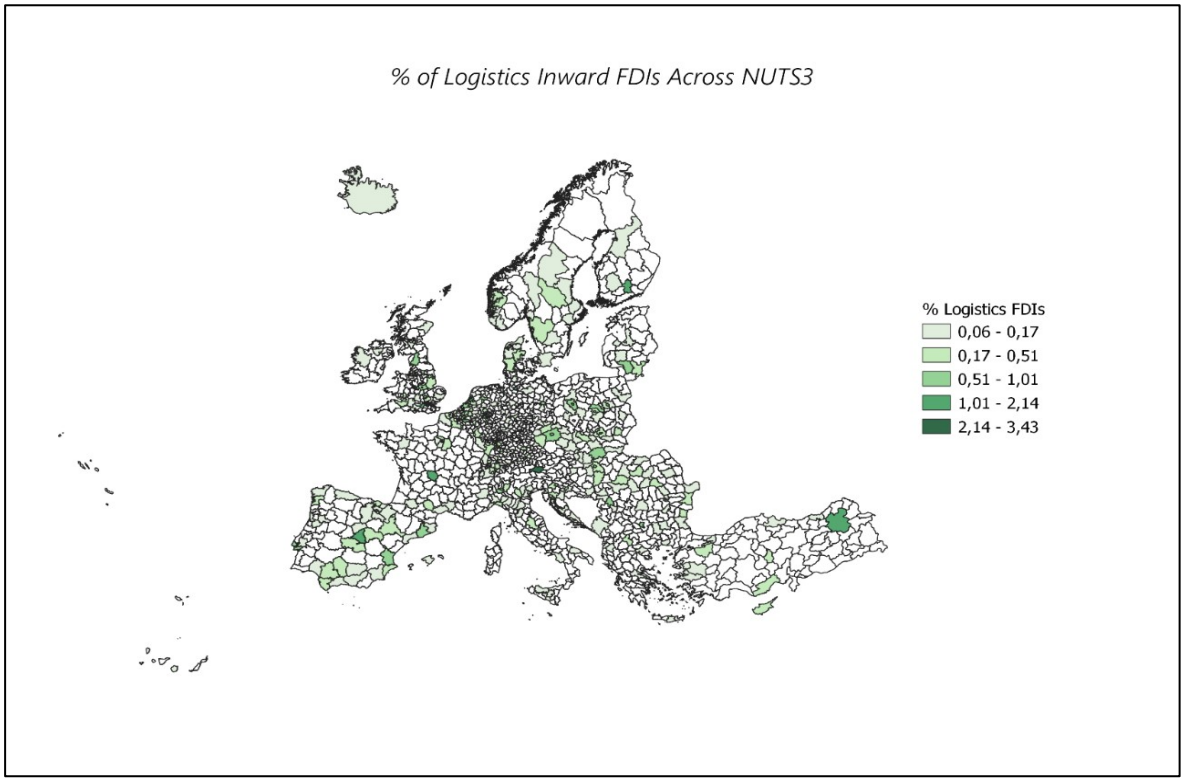

Figure 1. Distribution of Inward Logistics FDIs across European NUTS3 regions. Author Elaboration based on FDi Markets data using QGIS 3.10

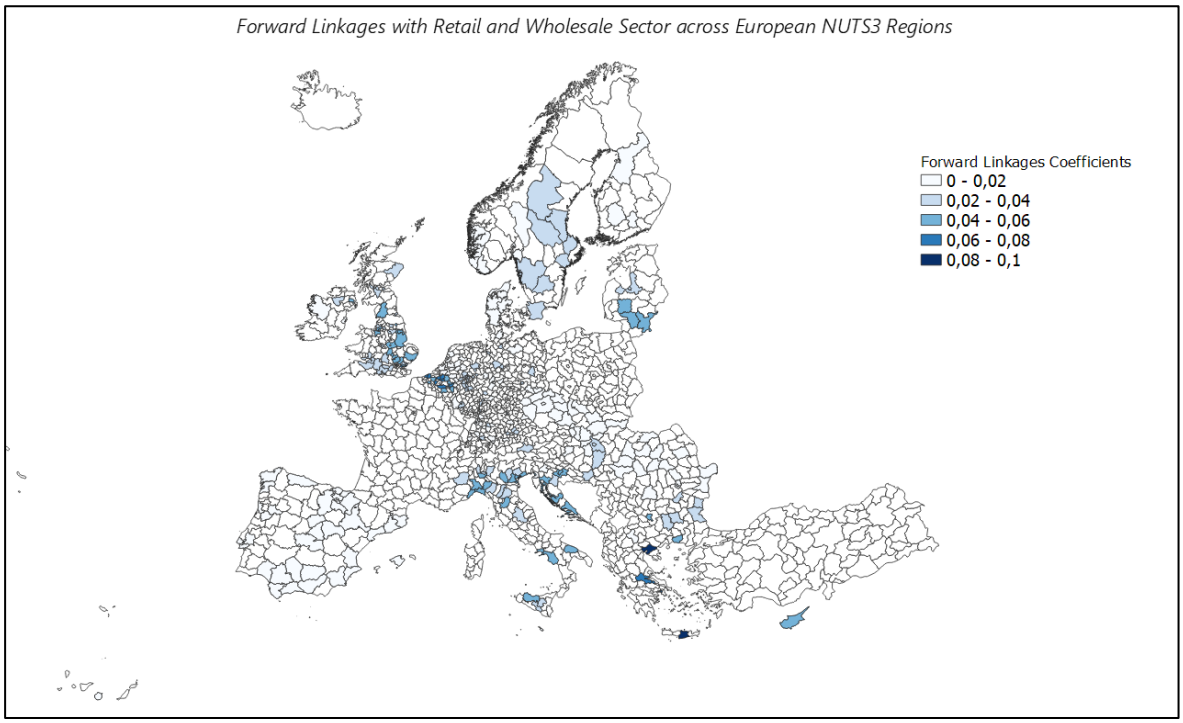

Figure 2. The map shows the geographical distribution of the Forward Linkages with the Retail and Wholesale sector coefficients used in the empirical analysis. Source: own elaboration based on the Eurostat Symmetric Input-Output Tables in 2010.

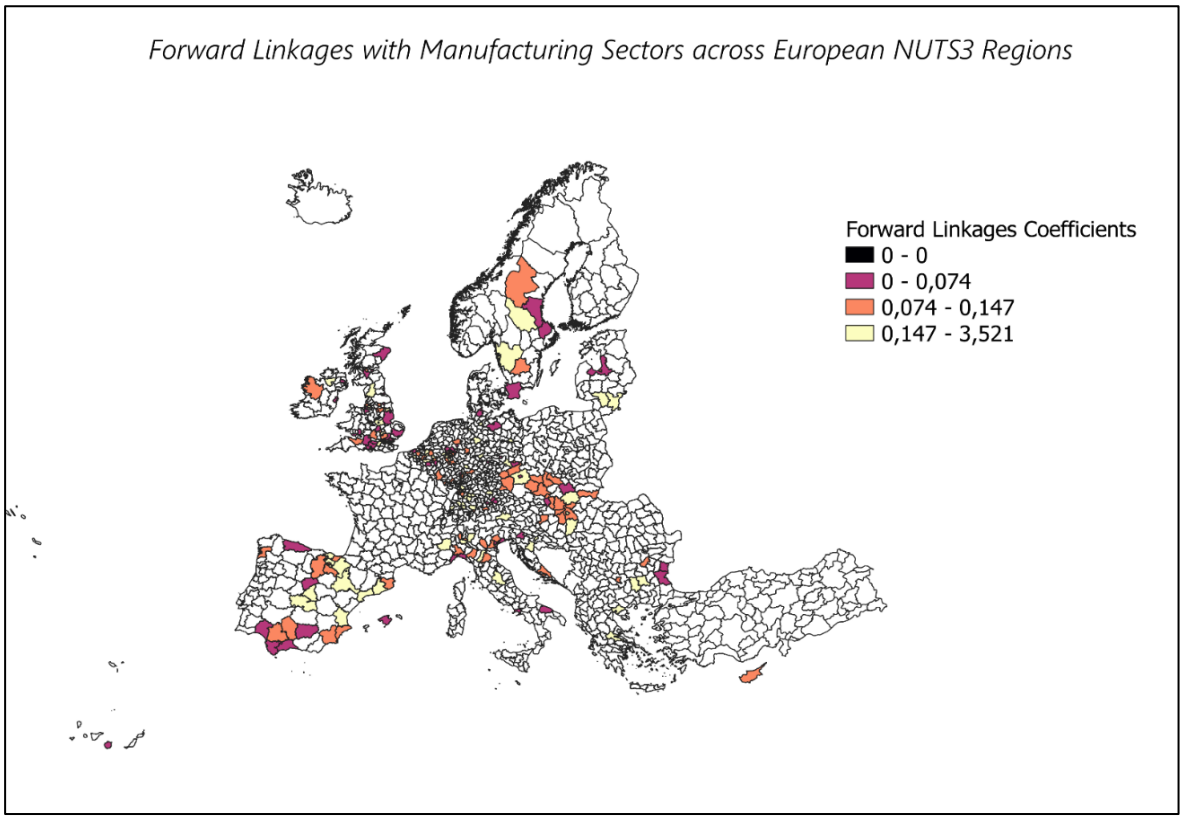

Figure 3. The map shows the geographical distribution of the Forward Linkages with Manufacturing sectors coefficients used in the empirical analysis. Source: own elaboration based on the Eurostat Symmetric Input-Output Tables in 2010.

Table A1. List and Description of Variables

Variable	***Description***	***Source***
Location Choice	Dummy variable taking value 1 if the given project i is located in region j, 0 otherwise	Author Elaboration based on fDi Markets
Hirschman Vertical Linkages with the Retail Sector	Weighted share of employment in Retail and Wholesale industries that are users of Logistics Services over total employment	Symmetric Input- Output Tables 2010. Eurostat
Hirschman Vertical Linkages with the Manufacturing Sector	Weighted share of employment in Manufacturing industries that are users of Logistics Services over total employment	Eurostat. Symmetric Input- Output Tables, ESA 2010
Log. GDP	Log. Gross Domestic Product per NUTS3	Eurostat
Market Potential	Market potential in location j is the sum of the market size, measured as the NUTS3 GDP in all other locations divided by their inverse squared distance to alternative location.	Author Elaboration based on calculated Euclidean distance and GDP at the NUTS3 level
Log. Population Density	Population / Land Area	Author Elaboration based on Eurostat
Stock of Past Logistics FDI over 2006-2010	Stock of past FDI from 2006 – 2010. Count of each FDI per NUTS3 polygon in QGIS	Author Elaboration based on fDi Markets
Stock of Past FDIs (all industry sectors, excl. Logistics) over 2006-2010	Stock of past FDI from 2006 – 2010. Count of each FDI per NUTS3 polygon in QGIS	Author Elaboration based on fDi Markets
MNEs' Experience	Stock of MNEs' past FDI in the same NUTS3 from 2006 – 2010.	Author Elaboration based on fDi Markets
Stock of Other Firms over 2006-2010	Stock of Firms from 2006-2010 per NUTS3. The count excludes logistics, manufacturing and retail firms.	Author Elaboration based on Amadeus Database
Stock of Retail and Wholesale Firms over 2006-2010	Stock of Retail and Wholesale Firms from 2006-2010 per NUTS3.	Author Elaboration based on Amadeus Database
Stock of Manufacturing Firms over 2006-2010	Stock of Manufacturing Firms from 2006-2010. Per NUTS3	Author Elaboration based on Amadeus Database
Log. Stock of firms over 2006-2010 (excl. Logistics - Amadeus)	Stock of Firms from 2006-2010 per NUTS3.	Author Elaboration based on Amadeus Database
Log. Stock of logistics firms over 2006-2010 (Amadeus)	Stock of Firms from 2006-2010. Per NUTS4	Author Elaboration based on Amadeus Database
Log. Stock of Manufacturing firms over 2006-2010	Stock of Firms from 2006-2010 per NUTS3.	Author Elaboration based on Amadeus Database
Log. Stock of Past Other FDIs over 2006-2010	Stock of past FDI from 2006 – 2010. Count of each FDI per NUTS3 polygon in QGIS	Author Elaboration based on fDi Markets
Log. Stock of Past Manufacturing FDIs over 2006-2010	Stock of past FDI from 2006 – 2010 in the Manufacturing sectors. Count of each FDI per NUTS3 polygon in QGIS	Author Elaboration based on fDi Markets
Log. Stock of Retail FDIs over 2006-2010	Stock of past FDI from 2006 – 2010 in the Retail and Wholesale Sector. Count of each FDI per NUTS3 polygon in QGIS	Author Elaboration based on fDi Markets
Total Freight stock by Port and Airport per NUTS2	Sum of Inward and Outward flow of goods handled by each Airport and Port NUTS2 Region level over 2006-2010- Thousands of Tonnes	Author Elaboration based on Eurostat
Total Freights stock by Road per NUTS3	Sum of Inward and Outward flow of goods distributed via road at the NUTS3 Region level over 2006-2010- Thousands of Tonnes	Author Elaboration based on Eurostat
Distance (KM) from Local Logistics to International Airports	Distance from each Firm/FDI to each NUTS3's airport in KM	Author Elaboration using QGIS Distance Matrix based on GISCO – Eurostat GIS shapefile
Distance (KM) from local Logistics to Port	Distance from each Firm/FDI to each NUTS3's Port in KM	Author Elaboration using QGIS Distance Matrix based on GISCO – Eurostat GIS shapefile
Distance (KM) to Country Borders	Distance from each FDI to Country Borders. (Islands included)	Author Elaboration using QGIS

Table A2. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Log. Hirschman Vertical Linkages of Logistics users in the Retail & Wholesale Sector	1.00																					
Log. Hirschman Vertical Linkages of Logistics users in the Manufacturing sector	-0.0082	1.00																				
Log. Gross Domestic Product NUTS3	0.0196	0.1484	1.00																			
Log. Weighted Spatial Lag - GDP Based	0.1203	0.1407	0.6066	1.00																		
Log. Population Density	0.1180	0.0624	0.2867	0.4212	1.00																	
Log. Stock of firms over 2006-2010 (excl. Logistics - Amadeus)	-0.0765	0.0899	0.2605	0.1645	0.0723	1.00																
Log. Stock of logistics firms over 2006-2010 (Amadeus)	-0.0358	0.0546	0.0864	0.0268	0.0164	0.1187	1.00															
Log. Stock of Past FDIs over 2006-2010 (excl. Logistics FDIs)	0.0583	0.3550	0.2618	0.1526	0.1306	0.1297	0.0887	1.00														
Log. Stock of Past Logistics FDIs over 2006-2010	0.0925	0.1164	0.1323	0.1105	0.1046	-0.0152	0.0410	0.0659	1.00													
Log. Stock of Manufacturing firms over 2006-2010	-0.2147	0.1630	0.2514	0.1399	-0.0513	0.0306	0.0577	0.0607	0.1386	1.00												
Log. Stock of Retail firms over 2006-2010	-0.2157	0.0512	0.0262	0.0025	-0.0014	0.2094	0.0030	0.0172	-0.0308	-0.1724	1.00											
Log. Stock of Other firms over 2006-2010	0.0561	0.1291	0.1948	0.1353	0.0739	0.4776	0.0624	0.0777	-0.0163	-0.1036	-0.0439	1.00										
Log. Stock of Past Other FDIs over 2006-2010	0.0491	0.3980	0.2546	0.1176	0.0914	0.1641	0.1107	0.9771	0.0413	0.0720	0.0366	0.1152	1.00									
Log. Stock of Past Manufacturing FDIs over 2006-2010	-0.0497	0.3448	0.0426	-0.0041	-0.0618	0.0022	-0.0074	0.4193	-0.0433	0.0848	0.0947	-0.0392	0.4683	1.00								
Log. Stock of Retail FDIs over 2006-2010	0.0900	0.2477	0.1131	0.1547	0.1058	-0.0543	-0.0044	0.2060	0.1347	0.1329	-0.0833	-0.0404	0.2441	0.0498	1.00							
Stock of Past Logistics FDIs over 2006-2010	0.0925	0.1164	0.1323	0.1105	0.1046	-0.0152	0.0410	0.0659	1.00	0.1386	-0.0308	-0.0163	0.0413	-0.0433	0.1347	1.00						
MNEs' Experience	0.0595	0.2560	0.2511	0.0719	-0.0268	0.1160	0.0436	0.2464	0.1313	0.0558	0.0493	0.0862	0.2918	0.1534	0.1560	0.1313	1.00					
Log. Total Freights stock in Th. Tonnes by NUTS3 via Road	0.1884	-0.2025	0.3717	0.0443	-0.0011	0.0181	0.0323	0.0418	0.1469	0.1808	-0.1463	0.0172	0.0207	-0.0688	-0.0711	0.1469	0.1252	1.00				
Log. Total Freights stock in Th. Tonnes by NUTS2 via Port and Airport	-0.3593	0.0873	0.0207	0.1066	0.3136	0.0138	0.0331	-0.1065	0.0087	0.1933	0.1037	-0.1022	-0.0996	-0.0043	-0.0164	0.0087	0.0166	-0.1437	1.00			
Log. Distance to Port in KM from FDI	-0.0000	-0.0052	0.0018	-0.0007	-0.0008	-0.0010	0.0013	-0.0066	0.0021	0.0023	0.0009	-0.0002	-0.0090	-0.0014	-0.0085	0.0021	-0.0019	0.0046	-0.0023	1.00		
Log. Distance (KM) to Country Borders	0.0005	-0.0009	-0.0019	-0.0018	0.0012	-0.0141	0.0016	-0.0024	0.0006	-0.0041	0.0008	0.0002	-0.0034	-0.0005	-0.0017	0.0006	-0.0028	-0.0002	-0.0022	-0.0319	1.00	
Log. Distance (KM) to closest Freight Airport	0.0020	0.0003	-0.0007	-0.0006	-0.0018	-0.0113	-0.0006	0.0028	-0.0003	0.0043	-0.0016	-0.0012	0.0040	-0.0003	0.0041	-0.0003	0.0012	-0.0008	0.0011	0.0127	0.0950	1.00

Chapter 3

Accessibility and the micro-geography of firm productivity[1]

Abstract

Several studies look at the spatial interaction between accessibility and firms' productivity at different geographical levels, namely regions and municipalities, but very little is known about the micro-level determinants of firms' productivity within urban boundaries. In this paper we focus on the relationship between firms' productivity and accessibility to specialized inputs, most notably talents. The general idea is that better urban networks enhance economic productivity by (i) allowing a better matching between the firm and a specialized labour pool, and by (ii) favouring knowledge spillovers, which tend to be highly localized in space. We rely on an unbalanced panel at the firm-level for 4090 firms located across the Greater London area for the period 2012 – 2019. The results show a significant positive effect of our indicator of accessibility to talents on firm-level productivity. Moreover, we tested our results for different functional forms of distance – namely squared and square root of travel minutes necessary to reach talent sources within cities, confirming that indeed it is important to account for strong spatial decay effects, and that firms may be more productive if they are able to tap into a pool of talents, who reside in a sufficiently close area of influence.

Keywords: accessibility, transport infrastructure, spatial decay, productivity, knowledge spillovers, market potential, firm-level productivity

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Introduction

The positive effects of transport infrastructures on economic growth, firms' location choices and firms' productivity have been well documented since the 1990s (Graham 2007a; Holl, 2012; Melo et al., 2013 Martin – Barroso et al., 2015, 2018; Gibbons et al., 2019; Asmussen et al., 2020). The general idea shaping the bulk of research is that transport infrastructures affect the extent to which firms can access places and opportunities, i.e. *accessibility*, and in turn, enjoying better connections between territories may broaden firms' markets leading to specialization, economies of scale and increased productivity. Several studies in this line of research have looked at the relationship between firms' productivity and different dimensions of accessibility, most often access to markets (Rice et al., 2006; Graham 2007a; Holl, 2012), and very recently to specialized workers (Martin-Barroso et al., 2015;2017) or workers – regardless of their skills- (Gibbons et al., 2019) between large municipalities or regions. Similarly, literature investigating firms' location choices found out that firms prefer to locate in cities where they can enjoy more efficient within-city connections (Martin-Barroso et al., 2017; Clark et al., 2019)[2]. The general idea is that better urban networks enhance economic productivity by (i) allowing a better matching between the firm and a specialized labour pool, (ii) and by favouring knowledge spillovers, highly localized in space. The underlying mechanisms that yields productivity gains to firms for being closer to talents may also act upon market-based channels. Here, the idea is that to some extent labour markets are segmented (e.g., in terms of qualification obtained), and workers/firms are restricted by certain geographical boundaries, therefore across segmented labour markets, talents compete for jobs and firms compete for talents (Martin-Barroso et al., 2017). Therefore, by having greater access to talents within-city, firms may gain higher productivity benefits, that stem from being closer to the pool of workers they wish to hire. Similarly, these mechanisms may bank on non-market-based channels, such as knowledge spillovers. e.g. knowledge-intensive workers, such as consultants in services, move from one organization to the other but are relatively immobile in space (Breschi & Lissoni, 2009), confirming that knowledge is transferred and used within a close distance (Torre, 2008). In fact, talents within the same geographical area, exposes themselves to many potential social ties, whilst reducing the costs of forming and maintaining such links. Although scholars argued that knowledge spillovers from competitors

[2] For a review on this topic please refer to Chapter 1 of this dissertation.

are much more localized phenomena, we may also argue that they may also be very sensitive to minor differences in travel times and likely to impact firms' productivity (Eriksson, 2011; Proost & Thisse, 2019). Even in a world of fast communication technologies, close connections between people - talents in our case- and firms provide more opportunities for learning and more opportunities for face-to-face contact, which tend to facilitate knowledge exchange and transfer of skills (Duranton & Puga, 2004). Both the generation of knowledge and its diffusion benefit from these interactions (Graham et al., 2010). Particularly, extensive empirical literature agreed on a fundamental observation that workers tend to work close to where they live (Bosquet & Overman, 2019), and knowledge spillovers are highly geographically localised (Rosenthal & Strange, 2008; Torre, 2008; Azoulay et al., 2017; Breschi & Lissoni, 2009). Yet, research at a micro geographical level is still in its infancy, even more so in the case of accessibility to *talents*[3] as determinant of productivity gains, with only a few pioneering contributions (Gagliardi & Percoco, 2017; Andersson et al., 2016, 2019). The key interest here is to estimate the productivity gains at the firm-level from access to talents 'unpacking' the city dimension, building on the assumption that firms may be more productive if they tap into a pool of a specific set of specialized inputs, which reside in a sufficiently close area of influence, by considering the concrete firm- neighbourhood pairs (full-digit postcode[4] of workers' residence), taking the Greater London area (UK) as a case study.

However, firms may be sensitive to other dimensions of accessibility as pointed out by the literature, we therefore control for accessibility to (i) markets (Graham 2007a; Graham et al., 2010; Holl, 2012) and to (ii) suppliers (Ottaviano & Pinelli, 2006) or (iii) competitors (Andersson et al., 2016, 2019). Measures of access to markets, or market potential[5], have been extensively adopted in the NEG literature. The idea behind market potential measures is to create an index of consumer demand based on the number of consumers (or income) in neighbouring regions. Here, firms enjoying higher access to markets are found to be more productive and this productivity gains decline with distance. Similarly, in investigating the causes and dynamics of

[3] We define *talents*, as the resident population having at least a bachelor's degree, as in Florida (2005). Overall, the empirical literature defined talents as highly skilled labour force. The common proxies used to identify talents are persons having a PhDs and/or MDs as in Azoulay et al., (2017), inventors as in Miguelez et al., (2016), or scientists as in Verginer & Riccaboni (2021). In the absence of patent-inventors-level data at this disaggregated level of analysis we rely on a quite common definition of talents dependent on the education level. Consistently with past literature, we are aware that it is not possible to cleanly discern "innate ability".

[4] In the UK a full-digit postcode, also known as postcode unit, represents a single street, a part of a street, a single address or a group of properties lying in the same street.

[5] Please refer to Chapter 2 of this dissertation for an extensive review on the conceptualisation of market potential indicators and firms' location choices and productivity.

agglomeration economies, geography scholars found that firms benefit from being close to their suppliers (forward linkages) by saving on transportation costs and being able to find the match between suppliers and the firm[6]. Proximity to competitors generates Marshallian externalities, as well as potential crowding out effect, which can reflect in firms' productivity. In this vein, a growing number of studies moved beyond the typical city-wide unit to explore inner city differences in agglomeration externalities (Rosenthal & Strange, 2003; Arzaghi & Henderson, 2008; Andersson et al., 2019; Harris et al., 2019), and although the number of studies is still limited, the evidence may be rather compelling in highlighting the sub-city variation in agglomeration economies and positive productivity gains for firms located in proximity with firms within the same industry (potential competitors). Andersson et al. (2016) investigate the effects of agglomeration economies on the productivity of Swedish firms, in terms of TFP growth. Using disaggregated geo-coded firm-level data for the cities of Stockholm, Gothenburg and Malmö with a sub-city geographical level of analysis, they show that firms may benefit from being located in more specialised neighbourhood, but within a diversified city. Particularly, empirical analysis focused on the distance-decay effects of general agglomeration effects (Andersson et al., 2016; Rice et al., 2006) or the proximity to firms in the same industry (Arzaghi & Henderson, 2008) suggests that high density of similar establishments is important in enhancing local productivity for those industries found in large cities, where information sharing plays a critical role. Andersson et al., (2019) using a microgeography approach for three Swedish cities as in Andersson et al., (2016), found that firms in the same three-digit industry, positively impact firms' productivity and thus finding positive specialization externalities at the sub-city scale. A much weaker effect appeared to be experienced in the case of diversity (between industry) externalities. Overall, the literature shows that in general firms may benefit productivity gains for being close to firms operating within the same sectors, and that this effect appears to be greater for large firms than smaller ones due to higher absorptive capacity in the case of knowledge spillovers from competitors (Wang & Zhao, 2018; Harris et al., 2019).

We aim to position our research in this space, by testing the role of accessibility to talents relying on large-scale firm-level and Census data for the Greater London (UK) area at the Super Output Area level (henceforth, SOA - areas with an average population of 300

[6] For an extensive review on the relationship between market potential, productivity and forward linkages please refer to Chapter 2 of this dissertation.

residents). We will consider the trade-offs that firms face when choosing their location. For example, being close to the market may imply locating farther away from the talents that firms may wish to hire. According to past research we focus on road networks, and distances are expressed as real travel times in minutes. Real travel times[7] are economically more relevant of standard Euclidean distances, as they reflect the efficiency of the transport system allowing economic agents to reach places and resources (Geurs et al., 2001; Holl, 2012; Gibbons et al., 2019). We chose road systems as they traditionally dominate transport infrastructure in most countries: in the UK in 2008, 91% of passenger transport and around 67% of goods transport was by road. In the Greater London area, people travelling via car are across the period 2000 – 2012 is 40% out of which 32% is for work purposes (Transport for London, 2012). We rely on data at the firm-level for 4090 firms located across the Greater London area for the period 2012 – 2019 at the SOA level.

The novelty in our approach relies on the very micro geographical level, i.e. SOA, and in our set of destination weights. Building on past research arguing that spatial interaction between firms, skilled human capital and knowledge externalities are very limited in space, we expect to observe firms' productivity gains for enjoying higher accessibility to talents, and that this spatial interaction declines with distance and happens at a remarkably small geographical level.

The remainder of the papers is organized as follows. The first section surveys the extant literature on the relationship between accessibility and firms' productivity. The second section describes the data and the empirical strategy we adopted to test whether firms are more productive because of higher access to a pool of talents. The last two sections are devoted to presentation of results and discussion

Related Literature

Accessibility and Firms' Productivity

Overall, the bulk of empirical literature recognizes the positive relationship between firms' productivity and accessibility. Notably, research spans from productivity gains at the regional

[7] Travel times are a proxy for travel costs. A generalised measure of transport costs would require additional information on the other characteristics of infrastructure (e.g. reliability), energy use, labour, insurance, tolls. However, as demonstrated by Combes & Lafourcade (2005), using detailed French data, most of the spatial variation in transport costs is driven by time saving along the transport network.

level (Rice & Venables, 2006) industry level (Graham 2007a, 2007b), to firm-level (Holl, 2012; Nuñez-Serrano et al., 2012; Martin-Barroso, 2017; Gibbons et al., 2019). Overall, the questions scholars aimed to answer to concerned whether and to which degree, accessibility generates productivity gains for regions, specific industrial sectors and firms. Typically, to address these questions, scholars used measures of accessibility like the one developed in Harris (1954) and known as market potential. The variable is simply a measure of aggregate accessibility, where accessibility is determined by the distance to and the size of the markets, expressed in terms of population or income per spatial unit. As anticipated, in the NEG literature, the idea of market potential measures is to create an index of consumer demand based on the number of consumers (or income) in neighbouring regions. The measure has the purpose of reflecting the volume of economic activity in each location and its accessibility in terms of distance (either in KM or minutes), and it has been widely used in the economic geography, regional science, international trade and spatial economics literature. Market potential variables typically use area expenditure, income, aggregate employment or population in the numerator as proxies of economic activity weighted by the distance to neighbour markets. This measure has been called in different ways by the literatures: index of accessibility (Vickerman, 1999), effective density (Graham, 2007), market potential (Holl, 2012) or market access (Ottaviano & Pinelli, 2006). Regardless of the wording, these indexes share the same theoretical and empirical foundation as developed in Harris (1954). We here use the word 'accessibility' as in our empirical context the accessibility index is based on different choices of destination characteristics, and/or functional forms of spatial decay (Graham et al., 2010; Gibbons et al., 2019).

In Nuñez-Serrano et al., (2012), the authors address the relationship between Spanish manufacturing firms' TFP (total factor productivity) and transport networks between 47 municipalities. Using firm-level data drawn from SABI (the Iberian branch of AMADEUS database) and individual level data (age, occupation, skills) from the Spanish Population Census (SPC), the authors built two accessibility indexes, one for workers and one for commodities along the complete road network, using the city dimension as spatial unit. Using a two-step approach as in Holl (2012) the authors estimate a firm-level production function assuming the Cobb Douglas form and taking the accessibility index as main independent variable. Results show that higher accessibility to commodities exerts a positive and stronger effect than accessibility to workers for firms engaged in manufacturing activities. Similarly,

Martin-Barroso et al. (2017) used travel times to compute the accessibility level of manufacturing firms to labour markets in Spain. Results in Martin-Barroso et al., (2017) emphasise the importance of the accessibility to labour markets for firms, using aggregate data on employment as destination weight at the municipality level. Precisely, most dynamic and productive firms are the ones that show better accessibility to labour markets and this in fact allows them a better matching and thus enhanced performance (Nuñez -Serrano et al., 2012). The authors used data on 60.000 Spanish manufacturing firms and over a million commuters across the urban and intercity network. The paper provides an accessibility indicator not computed at the individual level, but at a geographical level (provinces, regions). The key result worth to be highlighted is that most dynamic and productive firms are the ones that exhibit a better accessibility to labour markets and this allows them to have a better matching with the labour pool. The findings are consistent with the bid- rent theory according to which it is assumed that the price and demand for real estate change as the distance from the spatial unit of analysis increases. In this case, wage increases may offset the cost of longer journeys to work. To carry out the empirical analysis, the authors considered the whole road network (urban and intercity), calculating specific impedance functions[8] for each firm-worker's pair a between municipalities. The accessibility indicator is then calculated by combining the impedance functions with the demand and supply of labour observed within the area where the firm may catch its workers. Results showed that the accessibility of firms to workers is higher in large agglomerated urban areas. With a specific focus on firm level productivity, Holl (2012), focussed on market potential as a source of differences in productivity across Spanish manufacturing firms. Here market potential is measured using resident population per each Spanish municipality with more than 10.000 inhabitants, and travel times along the Spanish road network as a measure of distance and takes in to account the improvements that have taken place in Spain over the period 1991 – 2005. The final sample include firms with more than 10 employees and are not multi-plant firms. The objective of the articles is to analyse the degree to which market potential contributes to firm-level productivity. The empirical strategy is based on the estimation of a firm-level production function taking the general Cobb Douglas. Here the TFP is a function of the market potential experienced by the firm. To deal with unobserved heterogeneity and simultaneity bias in inputs the author implemented a GMM model as in Olley and Pakes (1996) using as instrument

[8] The loss of utility associated with traveling (e.g. time, costs)

the historical road network and the population in 1831. Results in Holl show a significant positive effect of market potential on firm-level productivity with a 4% elasticity level. As a robustness check the author also used Labour Productivity as independent variable over the same period implementing a 2SLS. The results here support a positive elasticity of firms' productivity to market potential.

Gibbons et al., (2019) measured the effects of new road infrastructures on firms in terms of market potential. The authors investigated the causal impacts of road improvements on employment and productivity using administrative data at the ward level (on average the ward is about 24 KM2 per 6000 inhabitants) in Great Britain over the period 1997-2008. For a given origin location, the authors estimated the change in the accessibility index of potential destinations along the major road networks using the weighted sum of inverse optimal travel times to all other destinations, using aggregate employment as destination weight in 1997. Results from a fixed effect OLS regression showed that for existing establishments there is increase in output per worker, wages and use of intermediate inputs, notably, a 1% increase in road accessibility leads to 0.5% increase in

As already said, a second strand of the literature mostly concerned with transport-induced[9] agglomeration economies and productivity gains at the firm and industry level. Rice & Venables (2006) investigated the effect of proximity to mass economy on spatial productivity. Precisely, their paper focussed on regional variations in earnings per worker and income disparities as determined by the regional performance, using NUTS3 as spatial unit. Here performance is related to proximity to centres of activity in travel times. Their argument is based on the economic geography literature suggesting that performance is associate with proximity to "economic mass". They used a measure of economic mass as given by the population of working age per 119 NUTS3 regions in Great Britain over the period 1998-2001, and an interaction term, *a*, which captures the interactions between areas. These interactions are a function of distance given by travel times via road, i.e. driving time, between NUTS3 regions at different driving time bands around regions' centroids (i.e. 0-30min, 60, and 90min at 60 mph as speed value). The underlying assumption is that the population of each NUTS3 is concentrated at the economic centre of the area, typically the area's centroid, which lies

[9] In the literature, transport-induced agglomeration economies, highlights the strengthening/creation of agglomeration dynamics *after* an improvement in the transport network due to a public investment. Here the interest is on investment schemes that change the transport networks.

within a proximity band. Results from OLS and a 2SLS show that the positive elasticity of productivity with respect to the accessibility variable, specified as a time-weighted economics mass, concluding that a hypothetical reduction of 10% in all travel times, would increase regional productivity by 1,2%. It may be worth to pinpoint that distances between NUTS3 centroids may be a coarse measure to capture the effect of distance decay (Graham, 2010). For the purpose of determine whether access to talents is likely to impact firms' productivity, we propose a much-disaggregated unit of analysis, the SOA, which capture a group of adjacent street units and the distance between firms and each SOA is expressed as real travel time in minutes.

Graham (2007a) addressed the links between agglomeration, productivity, and transport investments. The underlying idea is that by reducing travel times along the road network, improvements in the transport system can induce positive benefits via agglomeration economies. The author estimated a market potential variable of employment for each province, i.e. the "effective density", which is essentially an accessibility measure, expressed at the ward level in Great Britain, using data on travel time along the road network between provincial capitals. By using firm-level data from the FAME database, the author computed sector-level productivity for eight industrial sectors and found out that better access to economic mass leads to a 10%-20% increase in productivity for manufacturing and service firms. Moreover, both Rice and Venables (2006) and Graham (2007a, 2007b) estimate that a hypothetical reduction of 10% in travel times would increase productivity by 1.2%. Ottaviano & Pinelli (2006) position their research in between these two main strands by investigating the role of market potential either at the firm and region level, with a specific focus on the latter. The authors studied the effect of market potential in Finnish NUTS4 regions from 1977 to 2002. Under a NEG theoretical framework, the authors proposed a methodology to assess whether demand linkages (better access to customers) and forward linkages (better access to suppliers) are relevant in assessing Finnish regions' productivity. Here accessibility has been measured via a market potential indicator a la Harris (1954) where geodesic distance along the road network are computed as population – weighted between NUTS5 centroids and NUTS 4 regions and market size is proxied with the region aggregated income. Particularly they focused on two prediction of NEG models. First, by fostering agglomeration of workers and firms, labour mobility and specialization hamper the process of regional convergence in productivity. Second, regardless the presence of labour mobility, agglomeration happens in

places enjoying better market and supplier access. Results from an OLS estimation showed a dominant positive impact of market potential on firms' productivity when controlling for human capital and house prices. At the regional level the authors found that in the long run regions that enjoy better market and supplier access tend towards higher levels of productivity, therefore demand (access to customers) and cost linkages (access to suppliers) seem to sustain agglomeration processes in Finland.

Data

In order to study the effect of different dimensions of market access at this great level of geographical disaggregation – notably, access to talents, customers, competitors and suppliers in each SOAs, we rely on data drawn from two main sources. We have extracted census data for each SOAs in London area in year 2011 from the Office of National Statistics (ONS). SOAs were created for Census data, specifically for the output of census estimates. The SOA is the lowest geographical level at which census estimates are provided and were introduced in the UK in 2001. They are built from clusters of adjacent unit postcodes. The SOA population has a maximum of 625 people or 250 households' residents[10]. Using this disaggregated level of analysis may shed some light on the spatial extent to which access to *talents,* accrues productivity benefits to firms. We exploit the richness of the 2011 Census data at the SOAs level for which data at the SOA level are provided, notably educational level of resident population.

To estimate firms' productivity, we rely on firm level data drawn from Financial Analysis Made Easy (FAME) which is a commercial database provided by Bureau Van Dijk. FAME records extensive financial data for each company including turnover, turnover per employee, a breakdown of costs, and information on the number of employees and on the total assets held by firms. We use *turnover per employee* as our measure of productivity. Although we are aware of the limitations of this indicator of productivity, this measure has been employed as it is available for a larger sample of firms as compared to value added, which is only available for a relatively small subsample of firms. In our regressions, we control for the capital-labour ratio. FAME also records information about the location of the company providing complete

[10] Currently in London there are 25,039 SOAs. There are then two further and slightly bigger levels introduced in the 2001 Census: The Lower Super Output Area (LSOA), population up to 3,000 people or 1,200 households and the Middle Super Output Area (MSOA) population exceeded 15,000 people or 6,000 households. Currently there are 4,835 LSOAs and 983 MSOAs.

postcode information, address and geographic coordinates. The FAME data are available for a number of years, although the quantity and quality of data diminishes as we go back in time (Graham 2007b). We have data from 2001 to 2019 for a total of 62,876 firms in 28 macro industry group using the Standard Industrial Classification 2007 (henceforth, SIC2007) at the two-digit level (see table A1 in Appendix). For the purpose of our analysis we rely only on those active firms for which both firm-level and geographical (postcode) data are available over the period from 2012-2019. Since the data are provided by companies and not plants, they can include firms that have plants in many locations but only report aggregated records. Consequently, it is neither possible to know the location of additional plants, nor to assign correctly employment and other balance sheet data among plants of multi-plant companies. To isolate single plants from the FAME data we have taken the following steps as widely adopted in the empirical research and specifically in Graham (2007a; 2007b), Holl (2012) and Gibbons et al., (2019). We have removed firms that record more than one trading address in the Greater London, and firms that do not have a foreign holding or subsidiary company. We rely only those firms for which we have firm-level and location (postcode) data over the period of analysis 2012 – 2019. To partially rule out endogeneity issues, we use census data in 2011, thus before our period of observation. Our final dataset is unbalanced panel of 4.090 firms for which we have data over the period 2012-2019, located in 1.051 SOAs across 33 districts (100% of total districts)[11].

[11] Further geographical coverage includes LSOAs (17,3%) and MSOAs (47%)

Variables

Dependent Variable

Turnover per Employee

We measure firms' productivity by taking the Turnover per Employee for each firm *i* at the time *t* over the period 2012 – 2019.

$$TUEMP_{it} = \frac{Turnover_{it}}{Nr.of\ Employees_{it}}$$

Independent Variables

Accessibility

From an empirical point of view, it becomes key to be able to find a way to compute measures of proximity of each firm to key resources. We measure accessibility to talents, (i.e. the number of residents in each SOA with at least a bachelor or higher degree as in Florida (2005), competitors (i.e. firms in the same three-digit level sector, suppliers (i.e. firms in other three-digit sectors), and final market (using the number of residents) as follows:

$$ACCESSIBILITY_{w,ij} = W_{ij} + \sum_{k \in K} \frac{W_{ik}}{d^r_{ijk}}$$

Where W_{ki} is the key resource (talents, competitors, supplier, customers) in area k and d_{ijk} is the distance between i, the exact position of the firm (given by its postcode and coordinates), located within the focal area j and each area k and is based on the shortest path travel times along the major road network[12] in minutes. Here, the precise position of the firm is crucial, as distances are calculated on its exact location (postcode and coordinates). In other words, if two firms are located in the same SOA, we expect to observe higher accessibility levels because of better connections and/or lower distances to where talents are located. Optimum travel times along the major road network are imputed using the GIS (Geographical

[12] Major roads exclude private roads, pedestrian only streets, roads in residential areas and smaller local roads in 2014. Source: Open Street Maps, 2014. http://download.geofabrik.de/osm-data-in-gis-formats-free.pdf

Information System) network analysis[13], meaning that in calculating the cost (time) during travel we consider speed limits and junctions that can prevent a right turn for instance. Specifically, we build an Origin – Destination (OD) journey-time matrix[14] for each firm to each SOA centroid taking the minimum journey time for each combination pair (see Figure 4 in Appendix). Travel times are calculated using the shortest-path algorithm along the network applying the route formula, $time = length/velocity$.

The empirical way in which we express our accessibility indicator is similar to Graham (2007a, 2007b), Graham & Kim(2008) and Holl (2012). For each SOA we exploit 2011 census data to retrieve socio-demographical information at the lowest geographical level[15]. In order to test the "*importance of distance*" we compute our indicators with different parametrizations of *r*. Our baseline specification uses r=1, but we also try to give more weight to distance, using the squared distance (r=2), and a lower weight to distance, using the square root of distance (r=0.5). Using this conceptualization we build our main independent variable, *accessibility to talents* and three accessibility controls: market potential, accessibility to firms in same (different) three digit sectors. The former reflects the access to potential markets and as literature suggests i) firms are attracted to location where they can tap into a larger market ii) firms enjoying higher accessibility are more productive as well[16] (Graham 2007a, 2007b; Holl & Mariotti, 2018b). The latter(s) are computed taking the stock of past firm over the period 2001-2011 in the same(different) three-digit sector of firm i located in area j weighted by the real travel times as in the case of accessibility to talents. The argument here is that in the presence of increasing returns to scale firms are drawn towards places characterized by higher access - geographical proximity- to suppliers, or forward linkages (Ottaviano & Pinelli, 2006; Mariotti et al., 2013; Meliciani et al., 2016).

[13] Network Analysis in GIS is based on graph theory. Any network consists of a set of connected nodes and edges (e.g. junctions in a road). The object traversing the network follows the edges, and junctions appear when at least two edges intersect. Junctions and edges can have certain attributes affixed to them that increase the cost of traveling in the network, known as *impedance*. For example, a road network can have speed limits attached to the edges, and a junction can prevent left turns. http://wiki.gis.com/wiki/index.php/Network_Analysis

[14] The matrix included 4090 x 25154 combination pairs of journey times.

[15] Office for National Statistics ; National Records of Scotland ; Northern Ireland Statistics and Research Agency (2016): 2011 Census aggregate data. UK Data Service (Edition: June 2016). DOI: http://dx.doi.org/10.5257/census/aggregate-2011-1

[16] Please refer to Chapter 2 of this dissertation for an extensive review on the relationship between firms' productivity, firms' location decisions and market potential.

Capital/Labour Ratio

As a proxy for capital input we use information on total assets. This includes the value of 'fixed assets' such as buildings, plant, machinery and equipment and 'current assets' such as stocks and various debts owed by and to the company. Here total assets may be used as a proxy for capital input (K) in the sense that they give a measure of the value of the non-labour inputs available (Graham, 2007b). As measure of labour, L, we use the number of employees in company's payroll. Positive K/L ratio may indicate the presence of increasing returns to scale.

Foreign Ownership

Extensive empirical literature showed that on average foreign owned firms are more productive than domestic firms (De Backer et al., 2003; Griffith et al., 2004; Castellani & Zanfei, 2006; Girma & Gorg, 2007; Bentivogli & Mirenda, 2017). To test whether foreign ownership impacts firms' productivity in our empirical context, we rely on the information provided by FAME according to which a firm is classified as foreign owned if the ultimate owner of the firm is located outside the UK and has at least the 50.01% of direct ownership. In our analysis is a binary variable taking value 1 if the firm is foreign owned (49% of firms), 0 otherwise (51%). In the case of London area, there is quite an equilibrium in our sample between foreign and domestic firms, although domestic firms tip the scale.

Size

Within our empirical setting we control for the size of the firm, which is likely to impact firms' productivity. Larger firms usually offer more specialised and better-paid jobs and are also capable of having more sophisticated processes for selecting their job candidates when searching, and therefore it may come with no surprise that large firms might be more productive than small firms. Our measure of *size* is a categorical variable based on the firms' *Turnover* and widely adopted by the ONS[17] European Union and by . According to this widely adopted classification Micro firms are defined as firms having a turnover under £2million (25% of firms). Small and medium-sized enterprises (SMEs) are classified as having a turnover under

[17] https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation. The classification is also adopted in the European Union following the same thresholds of firms' turnover https://ec.europa.eu/regional_policy/sources/conferences/state-aid/sme/smedefinitionguide_en.pdf

£10 million (26%) and under £50 million (31%) respectively. Lastly, large enterprises have a turnover above £50 million (18%).

Costs of Production

As a further control in our empirical analysis we include all the costs related for production the firm must bear. We have drawn data about the costs of production, which are costs directly related to the production of the goods sold to the net of depreciation of those costs over the period 2012-2019.

Empirical specification

The objective of this paper is to analyse the degree to which accessibility to talents contributes to firm-level productivity. The empirical strategy is therefore based on the estimation of a firm-level production function in which our measure of firm productivity is the *Turnover per Employee*.

$$lTUEMP_{ijt} = \beta_o + \sum_w \beta_w \text{ACCESSIBILITY}_{w,ijt} + \sum_l \beta_l X_{l,ijt} + \eta_j + \mu_s + \theta_t + u_{it}$$

Where *lTUEMP* is the log of *Turnover per Employee* of firm i in industry s located in SOA j at time t, *w* refers to either talents, markets, suppliers or competitors. Our main independent variable is the accessibility to talents experienced by the firm i at time t. Although we here place specific attention on accessibility to talents as main source of productivity benefit for firms, we reckon that firms may be sensitive to other dimensions of accessibility as pointed out by the literature, we therefore control for accessibility to (i) markets, and to (ii) suppliers or (iii) competitors. Here, firms enjoying higher access to markets are found to be more productive and this productivity gains decline with distance. Similarly, geography scholars found that firms benefit from being close to their suppliers (forward linkages) by saving on transportation costs and being able to find the match between suppliers and the firm[18]. Proximity to competitors generates Marshallian externalities, which can reflect in firms' productivity. We measure the market based on resident population, competitors as the

[18] For an extensive review on the relationship between market potential, productivity and forward linkages please refer to Chapter 2 of this dissertation.

number of firms *in same three-digit sectors*, while suppliers are proxied by *the number of firms in different three-digit sectors* but having the same two-digit SIC2007. The variables $X_{k,it}$ are our set of firm-level controls, namely: the *K/L* ratio, a time invariant dummy indicating *foreign ownership* and a categorical time variant variable indicating the *Size* of firm i at time t[19]. The baseline for these two dummies is *foreign owned* and *large* respectively. To partially rule out endogeneity issues, we use Census data in 2011 to build our main independent variable, thus previous to our period of analysis. Similarly, the stock of firms used to compute accessibility to firms in same (different) three-digit sectors refers to the number of past firms over the period 2001-2011. A widely recognized practical problem faced by empirical studies analysing spatial differences in productive performances is that the type of economic activity in an area is not independent of the characteristics of the location. In a new economic geography framework, Baldwin and Okubo (2006) show how location in the largest markets is most attractive for the most productive firms. Nocke (2006) shows in a theoretical model how more efficient entrepreneur's self-select into larger markets. This implies that the choice of location may be related to unobservable characteristics such as management ability or attitude towards risk that influence at the same time firms' productivity. Moreover, the OLS estimates of β are very likely to be biased, because accessibility is non-random across space and time, and so is correlated with the unobserved location attributes. In particular: a) faster transport connections may have been built to link more productive places; b) dense places may be more productive, and origins and destinations j and k are by definition closer together and network travel distances shorter in denser places, implying greater accessibility; c) the destination weights W_{ij}, if based on measures of economic activity (e.g. firms in linked sectors) will be endogenous if the outcome in j and in connected destinations k, are affected simultaneously by unobserved common productivity advantages.

In this case, the accessibility measure is partly determined by the initial location decision and thus potentially endogenous. Cross-section analysis could produce upwards biased estimates of productivity wherever spatial selection on unobservable leads more productive firms to locate in high-market potential areas. As pointed in Anselin et a., (1988) when observations are available across space, in which the possible dependence pertains to neighbouring locations, controlling for fixed-effects at the SOA level (η_j) should alleviate this problem (Holl, 2012; Gibbons et al, 2019) and help provide consistent estimates where the simultaneous

[19] Foreign Ownership and Size are categorial variables, therefore n-1 entities are included in the model.

nature of firm productivity and accessibility is due to time-invariant unobserved location characteristics. Yet, another source of simultaneity could arise if roads where specifically improved in areas that were expected to experience greater productivity increases and hence greater demand for infrastructure. We therefore include in all our specification, industry (μ_s) at the three digit-level (216 sectors) and time (θ_t) fixed effects to control for other time - varying characteristics not explicitly accounted for in the specification. Moreover, as heteroskedasticity often characterizes cross-regional analyses, all tables report robust standard errors at the SOA level (Ottaviano & Pinelli, 2006; Holl, 2012; Gibbons et al., 2019).

Results

We estimate different model specifications, whereby Table 2 presents the main results of our econometric estimation. Similarly to our dependent variable, the accessibility variables are also evaluated in logarithms. First, we test our main independent variable, accessibility to talents, controlling for a set of accessibility indicators and other controls, across the total population of firms running separate regressions. We then present a second level of analysis in which we test our accessibility measures to firms' key resources, i.e. talents, markets and firms by weighting our destination characteristics for the squared distance (higher sensitivity to distance) and the square root of distance (we attach a lower weight to distance). The idea is that if the proximity to talents exerts a positive effect when the distance is squared (r=2), it means that the spatial decay effect is greater, so it is important that the firm is located very close to the potential talents, to benefit from accessibility to this resource. Conversely, when we weight for the square root of distance (r=0.5), we are assuming that distance is a less important dimension. The main estimation results are presented in Table 2. As a starting point and benchmark, pooled OLS without SOA fixed effect are reported in mod. (1). Coefficients of capital/labour ratio, foreign ownership and costs related with production have the expected sign. The OLS estimation could still be upward biased if for example, there are unobservable area-specific characteristics that are not captured by the SOA fixed effect and that lead highly productive firms to concentrate in areas with higher density of talents, or higher market potential. Mod. (2)-(5) show results with SOA fixed effects. Overall, results reported in column (2) show that the closer firms are to pools of talents the more productive they are. Instead, proximity to other firms in the same industry (competitors), in other industries (potential suppliers) and consumers is not significantly correlated with productivity. Consistently with

past literature, large firms are on average more productive than smaller enterprises and foreign owned firms are on average more productive than their domestic counterparts. *Capital/labour ratio and Costs of Production* exhibit the expected sign, showing that more capital-intensive firms tend to be more productive, while higher cost of production is negatively associated with productivity.

In table 3 and 4 we report the same specifications as in table 2 mod. (2) to (6), by weighting all our accessibility indicators for the squared (r=2) and square root (r=0.5) of travel times respectively. Here we wanted to test if by attaching a different "importance" to distance, accessibility to talents and the other accessibility indicators would change accordingly. In table 3 we weight our accessibility to talents by the squared of distance, meaning that we are attaching a greater weight to the way distance interact with the presence of talents, and therefore it is more "important". Mod (1) present our main estimation results. Here, the findings show that firms are more productive if they can tap into a closer pool of talents, and the coefficient associated with accessibility to talents is larger in magnitude, suggesting that spatial decay effects are very strong. This supports the idea that accessibility to pools of talents and the knowledge externalities they may spill over, are very much localized phenomena and may be very sensitive to minor differences in travel times and likely to impact firm productivity. Other accessibility dimensions remain not significant throughout all the estimations reported. In table 4 we test our indicators of accessibility weighted for the square root of distance, thus attaching a lower weight to the distance itself. In this parametrisation, the coefficient of accessibility to talents is no longer significant. This result confirms that indeed it is important to account for strong spatial decay effects.

This is a quite new facet explored in empirical analysis. At the best of our knowledge there are no studies testing these accessibility dimensions at this very disaggregated geographical level, the SOAs. We here argue that firms might be more productive where they can access the skills they may wish to hire within a remarkably small area. Consistently with past research, we show that distance is crucial dimension, the greater the distance, the smaller the productivity gains firms might benefit. Moreover, we add that the spatial interaction between these two happen to be at a very small spatial scale. The density of talents weighted by travel times reflects the efficiency and the extension of urban mobility systems providing within-city connections and allowing firm-labour pool matching. As a robustness check we test our baseline specification presented in table 2, including interaction terms with firm size (see table

A5 in Appendix), firm age[20] (see table A7) and foreign ownership (see table A8). Additionally, given the bias towards services industry in London (see table A2 and A3), we rely on SIC 2007 macro industry classification based on technology intensity (Office of National Statistics Economic Review, 2018)[21] in order to test whether the impact of access to talents is differentiated among industries with different knowledge intensity (see tables A6). Results do not significantly vary from the baseline regressions.

Conclusions & Implications

This paper investigates the micro-level determinants of firms' productivity against degrees of *accessibility to talents* at a very fine-grained geographical level taking the Greater London area as case study. We use an accessibility index based on the methodological proposal of Holl (2012), and theoretically grounded on classical indicators of market potential a la Harris (1954), which reflects the volume of *talents,* i.e. resident population with at least a bachelor's degree, in each location and its accessibility in terms of distance in travel times to neighboring areas. The idea is that the 'cost' (i.e. time) grows with distance between the origin, where firm is located, and destination, all other areas. Therefore, we expected that positive productivity gains for firms, generated for accessing a pool of talents, decline with distance. We based our hypothesis on a central tenet of modern theories of labour markets arguing that that better urban connections may enhance economic productivity by (i) allowing a better matching between the firm and a specialized labour pool, (ii) by favouring knowledge spillovers, highly localized in space. Particularly, extensive empirical literature agreed on a fundamental observation that worker mobility and the knowledge they embody and spill-over tends to be highly localized in space. Yet, the bulk of the empirical work consider much broader spatial units, - municipalities, functional areas, industrial districts, etc (Azoulay et al., 2017; Gibbons et al., 2010; 2019; Verginer & Riccaboni, 2021), and the work at a micro geographical level is

[20] According to past literature, the Firm age captures knowledge accumulation and learning by doing processes (Huergo and Jaumandreu, 2004). The age of the firm is calculated by subtracting the year when the firm was first incorporated, from 2019.

[21] The aggregated industry structure classification combines the two-digit level industries breakdown of the 2007 SIC into 11 aggregations which were further grouped into 6 categories according to their technological or knowledge intensity. Manufacturing sectors were aggregated according to technological intensity (research and development expenditure over value added) and based on the NACE European classification of economic activities
https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities/uksic2007.

still at its infancy, except for a few pioneering contributions (Gagliardi & Percoco, 2017; Andersson et al,. 2016, 2019). We focused on the accessibility to *talents* as the accessibility dimension likely to positively impact firms' productivity the most. We bring new evidence on the literature investigating the micro – level determinants of productivity at a remarkably small spatial scale by providing further insights on the geographical extent in which the spatial interaction between accessibility and firms' productivity gains may occur. To test our hypothesis, we rely on an unbalanced panel of 4.090 firms located in the Greater London area over the period 2012-2019. Using this disaggregated level of analysis may shed some light on the spatial extent to which access to specialized workers, i.e. talents, accrues productivity benefits to firms. We exploit the richness of the 2011 Census data at the SOAs level for which data are provided, notably educational level of resident population resident as a measure of talents pool from which firms may tap into to hire the specialized workers they need. Here, the findings show that firms are more productive if they can tap into a closer pool of talents. We may confirm past literature results, by bringing further geographical disaggregated evidence that accessibility to pools of talents and the knowledge externalities they may spill over, are very much localized phenomena and may be very sensitive to minor differences in travel times and likely to impact firm productivity.

Our findings contribute to the current debate on accessibility, via the real transport network, as a key dimension in firms' productivity, by precisely estimating the role of specialized workers and the spatial interaction between firm and talents zooming within the concrete firm- neighbourhood pair. Results show that firms' productivity increases the lower the distance to talents. Here we may argue that the volume of talents across areas within-city is not a sufficient condition for firms to be more productive, they should be remarkably close, via the transport network, to enjoy productivity gains.

We are aware of the possible limitations in our work which need be addressed in future research. First, we cannot infer on accessibility via public transport as data availability at this fine level of analysis for the covered period is limited. Additionally, we are not able to make inference on the knowledge intensity of suppliers and competitors and thus on talents employed in such firms, and on the input-output relations with either of those groups. Further research may investigate more precisely the inner-city variation in the magnitude of intersectoral demand and its impact on firms' productivity. Moreover, due to the fact that our accessibility measures are computed at the firm-level but time-invariant, we cannot exploit

the within-firm variation to account for firm-level unobserved heterogeneity. This may potentially introduce a bias in our estimation, which we aim to address in further developments of this work. We are also aware that our findings may need further interpretation considering the pandemic caused by the Covid-19. The rise of homeworking among the *salariat* means that urban transport networks might not appear as essential as before. However, as argued in Chapter 1 of this dissertation, it should be noted that not all jobs are amenable to work from home, and most of the research intensive work need to be carried out at the lab, therefore as it may appears that now cities are breathing out of commuters, this does not mean in itself, the end of work-office even for those works that can be conducted at home, e.g. consultancy services. As working from home appears to have suited many white-collar employees, as lockdown eases, people have started to go out once more, to enjoy commuting as 50% of office workers in the five biggest European cities spent every workday in the office full-time (The Economist, Sept. 12th, 2020). For the time being there are no sufficient data to make plausible conclusions, as on the one hand work from home seemed to boost happiness and productivity, on the other hand it caused wage cuts (e.g. wage premiums for longer commutes), meetings after work hours and made more difficult the work-life balance as the boundaries between home and work are blurred (The Economist, Spt. 12th, 2020; The Financial Times, Oct. 1st, 2020). A research published from the University of Amsterdam (Rubin et al., 2020) used survey data launched internationally through social network platforms among individuals who regularly commuted to their workplace before the pandemic and worked from home during the period from March to May 2020. Their results suggest that face-to-face contacts is important not only for the sharing of ideas, knowledge externalities, but also for enjoying work more generally. The argument largely gravitates on the extent to which the bringing-together of people under one roof promotes behaviour conducive to new ideas. This is not new in the empirical research as we argued knowledge externalities between workers are confined to a limited geographical space, in which proximity brought by lower travel times, ease the formation and maintenance of social ties and promote the "bursty" communication, i.e. people exchanging ideas rapidly for a short period of time without the long lag responses typical of remote work (Riedl & Woolley, 2017; Choudhury et al., 2020). In other words what the research pre and post covid-19 seems to suggest, is that (i) physical proximity can help people come up with new ideas, (ii) although workers enjoy work from home, as lockdown eases a (less) crowded *commuterland* breath in again. Thus we may more likely expect a reconfiguration of the office spaces and a

more flexible arrangement between the home and the office, rather a disappearing of the offices themselves and consequently the benefits in access to specialized inputs as talents are, may be mitigated rather than sponged away. Companies promoting flexible office spaces, e.g. WeWork[22] may enjoy a much larger market share in the future and the office as the writer Charles Lamb[23] described it will most likely change. For some firms (e.g. consultancy firms) may be a less important aspect to have closer a talents pool to tap into, but not a negligible one; for research-intensive firms access talents in a remarkably close area of influence may weigh even more indeed, especially if 'postcode' lockdowns[24] will be the rule rather the exception in the foreseeable future.

[22] American commercial real estate company that provides flexible shared workspaces for technology start-ups and services for other companies.

[23] Charles Lamb was an English writer during the 19th century and a clerk for the East India Company in London. In one of his letters addressed to a friend, Lamb described the office as a wearisome place in which enthusiasm for one's job is sponged away little by little. Although the world he lived in disappeared, the office as we know it today is still enduring. However, the pandemic makes Lambs' words still resonate today and might bring about a change in the way office spaces are thought of.

[24] Restrictions to the mobility of people are differentiated across areas within a city or a region

Tables

Table 1. Descriptive Statistics

Variable	*Obs.*	*Mean*	*Std.Dev.*	*Min*	*Max*
Log. Turnover per Employee	25154	12.26	1.44	1.05	17.01
Access to talents	25154	6.15	80.12	.05	4234.54
Access to Firms (same 3-digit)	25154	2.45	3.33	0	11.33
Access to Firms (different 3-digit sectors)	25154	5.1	2.58	.69	13.18
Market Potential -Population Based	25154	4.95	1.72	1.11	10.71
Nr. Firms in different 3-digit sector but same 2-digit	25154	3.86	3.42	0	8
Capital/Labour ratio	25154	2.03	16.7	0	670.92
Foreign Ownership	25154	.48	.5	0	1
Costs of Production	25154	-20.47	78.73	-3303.43	2.45
Firm Size	25154	2.66	0.95	1	4
Firm Age	25154	21.14	15.023	4	163

Table 2. Baseline Specifications. OLS Estimation.

	Dependent Variable: log Turnover per Employee					
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS
Main Independent Variable						
Access to talents	0.000302***	0.000071**	0.000075*			0.000076**
	(0.000058)	(0.000036)	(0.000037)			(0.000037)
Control Variables						
Access to Firms (same 3- digit)	0.0128	-0.173		-0.126		
	(0.0219)	(0.105)		(0.112)		
Access to Firms in Other 3-digit sectors	0.00338	-0.0708		-0.0846		
	(0.0234)	(0.173)		(0.173)		
Market Potential - Pop. Based	-0.0152	0.00879	0.00610	0.00901	0.00641	
	(0.0147)	(0.0117)	(0.0115)	(0.0117)	(0.0115)	
Capital/Labour ratio	0.0153***	0.0135***	0.0136***	0.0136***	0.0136***	0.0136***
	(0.00423)	(0.00352)	(0.00355)	(0.00355)	(0.00355)	(0.00355)
Firms in different 3-digit sector but same 2-digit	0.0224**	-0.0496*				
	(0.00913)	(0.0263)				
Foreign Ownership	0.185***	0.178**	0.179**	0.180**	0.179**	0.179**
	(0.0544)	(0.0710)	(0.0708)	(0.0707)	(0.0708)	(0.0708)
Costs of Production	-0.000951***	-0.000908***	-0.000910***	-0.000914***	-0.000910***	-0.000910***
	(0.000318)	(0.000287)	(0.000288)	(0.000288)	(0.000288)	(0.000288)
size = 2 Small	0.665***	0.695***	0.690***	0.690***	0.690***	0.690***
	(0.0495)	(0.0571)	(0.0574)	(0.0571)	(0.0573)	(0.0574)
size = 3 Medium	1.175***	1.178***	1.166***	1.166***	1.166***	1.166***
	(0.0588)	(0.0722)	(0.0732)	(0.0730)	(0.0731)	(0.0731)
size = 4 Large	1.543***	1.579***	1.566***	1.565***	1.566***	1.565***
	(0.0959)	(0.105)	(0.106)	(0.106)	(0.106)	(0.106)
Constant	11.27***	12.22***	11.28***	11.99***	11.28***	11.31***
	(0.108)	(0.721)	(0.0861)	(0.703)	(0.0860)	(0.0628)
Observations	25,154	25,154	25,154	25,154	25,154	25,154
R-squared	0.279	0.480	0.480	0.480	0.480	0.480
Time FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
SOAs FE	NO	YES	YES	YES	YES	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

Table 3. OLS Estimation with Distance Squared (r=2)

	Dependent Variable: log Turnover per Employee				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
Main Independent Variable					
Access to Talents (r=2)	0.000028**	0.000046**			0.000029**
	(0.000009)	(0.000018)			(0.000009)
Control Variables					
Access to Firms (same 3-digit) (r=2)	-0.152		-0.0977		-0.0917
	(0.234)		(0.239)		(0.238)
Access to Firms (different 3-digit) (r=2)	-0.120		-0.130		-0.136
	(0.202)		(0.206)		(0.204)
Market Potential - Pop. Based (r=2)	0.00595	0.00352	0.00465	0.00420	0.00407
	(0.0214)	(0.0213)	(0.0211)	(0.0211)	(0.0212)
Capital/Labour ratio	0.0135***	0.0136***	0.0136***	0.0136***	0.0136***
	(0.00351)	(0.00355)	(0.00355)	(0.00355)	(0.00355)
Foreign Ownership	0.177**	0.179**	0.179**	0.179**	0.179**
	(0.0711)	(0.0708)	(0.0708)	(0.0708)	(0.0708)
Costs of Production	-0.000906***	-0.000910***	-0.000912***	-0.000910***	-0.000912***
	(0.000288)	(0.000288)	(0.000289)	(0.000288)	(0.000289)
size = 2 Small	0.694***	0.690***	0.690***	0.690***	0.689***
	(0.0571)	(0.0574)	(0.0571)	(0.0573)	(0.0572)
size = 3 Medium	1.177***	1.166***	1.166***	1.166***	1.165***
	(0.0723)	(0.0731)	(0.0730)	(0.0731)	(0.0730)
size = 4 Large	1.579***	1.566***	1.565***	1.566***	1.565***
	(0.105)	(0.106)	(0.106)	(0.106)	(0.106)
Firms in different 3-digit sector but same 2-digit	-0.0485*				
	(0.0265)				
Constant	12.38***	11.31***	12.15***	11.30***	12.16***
	(0.708)	(0.0628)	(0.711)	(0.0627)	(0.706)
Observations	25,154	25,154	25,154	25,154	25,154
R-squared	0.480	0.480	0.480	0.480	0.480
Time FE	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES
SOAs FE	YES	YES	YES	YES	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

Table 4. OLS Estimation with the Square Root of Distance (r=0.5)

	Dependent Variable: log Turnover per Employee				
	(1)	(2)	(3)	(7)	(5)
VARIABLES	OLS	OLS	OLS	OLS	OLS
Main Independent Variable					
Access to talents- (r=0.5)	-0.000812	-0.000791			-0.000795
	(0.00192)	(0.00190)			(0.00190)
Control Variables					
Market Potential - Pop. Based (r=0.5)	0.0586	0.0500	-0.0273	-0.0285	0.0523
	(0.194)	(0.191)	(0.103)	(0.102)	(0.191)
Access to Firms (same 3- digit) - (r=0.5)	-0.0989		-0.0607		-0.0647
	(0.0926)		(0.0966)		(0.101)
Access to Firms (different 3- digit) - (r=0.5)	-0.0807		-0.0834		-0.199
	(0.0891)		(0.0888)		(0.241)
Firms in different 3-digit sector but same 2-digit	-0.0501*				
	(0.0263)				
Capital/Labour ratio	0.0135***	0.0136***	0.0136***	0.0136***	0.0136***
	(0.00351)	(0.00355)	(0.00355)	(0.00355)	(0.00355)
Foreign Ownership	0.179**	0.180**	0.180**	0.179**	0.180**
	(0.0711)	(0.0708)	(0.0708)	(0.0709)	(0.0708)
Costs of Production	-0.000907***	-0.000910***	-0.000913***	-0.000910***	-0.000913***
	(0.000288)	(0.000288)	(0.000289)	(0.000288)	(0.000289)
size = 2 Small	0.696***	0.691***	0.690***	0.691***	0.691***
	(0.0570)	(0.0573)	(0.0571)	(0.0572)	(0.0572)
size = 3 Medium	1.178***	1.166***	1.165***	1.166***	1.166***
	(0.0720)	(0.0730)	(0.0729)	(0.0730)	(0.0729)
size = 4 Large	1.578***	1.565***	1.563***	1.565***	1.563***
	(0.105)	(0.106)	(0.106)	(0.106)	(0.106)
Constant	12.14***	11.15***	12.17***	11.44***	11.91***
	(0.859)	(0.734)	(0.627)	(0.476)	(0.902)
Observations	25,154	25,154	25,154	25,154	25,154
R-squared	0.481	0.480	0.480	0.480	0.480
Time FE	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES
SOAs FE	YES	YES	YES	YES	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

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Appendix

Table A1. Number of firms by Industry groups

Industry groups based on BvD classification and SIC 2007	Nr. Firms	%
Agriculture, Horticulture & Livestock	8	0,20%
Banking, Insurance & Financial Services	405	9,90%
Biotechnology and Life Sciences	9	0,22%
Business Services	985	24,08%
Chemicals, Petroleum, Rubber & Plastic	30	0,73%
Communications	73	1,78%
Computer Hardware	3	0,07%
Computer Software	129	3,15%
Construction	281	6,87%
Food & Tobacco Manufacturing	49	1,20%
Industrial, Electric & Electronic Machin	50	1,22%
Information Services	3	0,07%
Leather, Stone, Clay & Glass products	4	0,10%
Media & Broadcasting	139	3,40%
Metals & Metal Products	30	0,73%
Mining & Extraction	27	0,66%
Miscellaneous Manufacturing	31	0,76%
Printing & Publishing	63	1,54%
Property Services	168	4,11%
Public Administration, Education, Health	248	6,06%
Retail	276	6,75%
Textiles & Clothing Manufacturing	22	0,54%
Transport Manufacturing	7	0,17%
Transport, Freight & Storage	118	2,89%
Travel, Personal & Leisure	490	11,98%
Utilities	40	0,98%
Wholesale	389	9,51%
Wood, Furniture & Paper Manufacturing	13	0,32%

Table A2.Broad Industry Groups based on two-digit SIC2007 code

6 Broad Industry Groups	*11 Industry Groups*
Knowledge Intensive Services (KIS)	High-tech Knowledge Intensive Services
	Knowledge Intensive Financial Services
	Knowledge Intensive Market Services
Less Knowledge Intensive Services	Less Knowledge Intensive Market Services
	Other Knowledge Intensive Services
Low to Medium Tech Manufacturing	Low Technology Manufacturing
	Medium-Low Technology Manufacturing
Medium to High Tech Manufacturing	Medium-High Technology Manufacturing
	High Technology Manufacturing
Other Production	Other Production
Real Estate	Real Estate

Source: ONS Economic Review (2018)

Because of the overlapping between the industry aggregations, we rely on the ONS lookup tables to generate broader categories, namely Low, Medium and High technology intensity based on two-digit SIC 2007 groups. We grouped together KIS, Less KIS and High-tech Manufacturing as High Knowledge intensive industries; Medium – High as Medium Knowledge intensive industries, and Low and Medium – Low as Low Knowledge Intensive. The ONS follows the Eurostat sectoral approach[1] to define the technology intensity of industries, i.e. R&D Expenditure/Value Added in the case of manufacturing industries and share of tertiary educated persons in the case of services.

Table A3. Technology intensity by number of firms.

3 Broad Industry Group	*Nr. of Firms*	*%*
High Intensive Technology	3.317	81
Medium Intensive Technology	100	2
Low Intensive Technology	673	17

Source: Author own elaboration based on ONS Economic Review Lookup Tables (2018)

[1] https://ec.europa.eu/eurostat/cache/metadata/EN/htec_esms.htm

Table A4. List and Description of Variables

Variable	*Description*	*Source*
Log Turnover per Employee	Turnover/Nr. Of Employees	FAME Database
Access to Talents	Accessibility to talents for each firm i in i location k is the sum of the of the own-SOA residents with at least a BA degree and the residents with at least a bachelor's degree of other SOAs discounted by travel time	Author own elaboration based on UK Census Data for the year 2011
Market Potential	Market potential in location k is the sum of the market size, measured as the sum of the own-SOA Population where firm i is located and the population of other SOAs discounted by travel time	Author own elaboration based on UK Census Data for the year 2011
Access to Firms in same 3-digit industry	Accessibility to Firms in same three-digit industry for each firm i in i location k is the sum of the number of past firms in the same three-digit industry according to the SIC2007 classification over the period 2001-2011, measured as the sum of the own-SOA within-3-digit firms and the number of within-3-digit firms in other SOAs discounted by travel time	Author own elaboration based on FAME data over the period 2001 - 2011
Access to Firms in different 3-digit industry	Accessibility to Firms in other three-digit for each firm i in i location k is the sum of the number of past firms in a different three-digit industry according to the SIC2007 classification over the period 2001-2011, measured as the sum of the own-SOA number of other-3-digit firms and the number of other-3-digit firms in other SOAs discounted by travel time	Author own elaboration based on FAME data over the period 2001 - 2011
Capital/Labour ratio	Total Assets/Nr of Employees	FAME Database
Foreign Ownership	Dummy Variable taking value 1 if the firm is foreign owned and 0 otherwise	Author own elaboration based on FAME data over the period 2012-2019
Costs of Production	Costs directly related to the production of the goods sold + depreciation of those costs	FAME Database
Size	Firms size is a Categorical Variable taking value 0 for micro firms (turnover < £2mln) , 1 for small firms (turnover < £10mln), 3 for medium (turnover < £50mln) and 4 for large firms (turnover > £50mln).	Author own elaboration based on FAME data
Firms in different 3-digit sectors, but same 2-digit	Stock of Past firms over the period 2001-2011 by firm i in location j in a different three-digit sector, but same two-digit based on SIC 2007 classification.	Author own elaboration based on FAME data
Firm Age	The age of the firm is calculated by subtracting the year when the firm was first incorporated, from the final year of our time series (2019)	Author own elaboration based on FAME data

Table A5. OLS Estimation – Interacting Access to Talents to Firm Size

	Dependent Variable: log Turnover per Employee			
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
Main Independent Variable				
Access to talents	0.000589	0.000459	0.000295*	0.000850
	(0.000594)	(0.000401)	(0.000176)	(0.000565)
Access to Talents * Large		0.000058	0.000086	-0.000144
		(0.000422)	(0.000442)	(0.000445)
Access to Talents * Medium	-0.000078		0.000047	-0.000199
	(0.000222)		(0.000163)	(0.000212)
Access to Talents * Micro - baseline	0.000241	0.000295	0.000333	
	(0.000283)	(0.000252)	(0.000227)	
Access to Talents * Small	-0.000116	-0.000062		-0.000254
	(0.000223)	(0.000142)		(0.000180)
large = 1		0.378*	0.848***	1.639***
		(0.210)	(0.223)	(0.235)
med = 1	-0.368***		0.482***	1.263***
	(0.134)		(0.0965)	(0.129)
micro = 1	-1.681***	-1.302***	-0.836***	
	(0.174)	(0.142)	(0.115)	
small = 1	-0.834***	-0.455***		0.804***
	(0.141)	(0.0873)		(0.0951)
Control Variables				
Market Potential - Pop. Based	0.00965	0.00768	0.00670	0.0146
	(0.0112)	(0.0112)	(0.0117)	(0.0123)
Access to Firms (same 3- digit)	-0.0836	-0.0874	-0.0921	-0.0732
	(0.135)	(0.133)	(0.133)	(0.133)
Access to Firms in Other 3-digit sectors	-0.141	-0.135	-0.129	-0.156
	(0.127)	(0.125)	(0.126)	(0.124)
Firms in different 3-digit sector but same 2-digit	-0.0503*	-0.0518*	-0.0528**	-0.0459*
	(0.0266)	(0.0267)	(0.0266)	(0.0263)
Constant	14.04***	13.62***	13.13***	12.48***
	(0.489)	(0.493)	(0.498)	(0.487)
Observations	25,154	25,154	25,154	25,154
R-squared	0.481	0.481	0.481	0.481
Firm Level Controls[2]	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
SOAs FE	YES	YES	YES	YES
Baseline for Firm Size	Large	Medium	Small	Micro

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

[2] Firm level controls include the Capital/Employee Ration, Costs of Production and Foreign Ownership

Table A6. OLS Estimation- Interacting Access to Talents to Firm Technological Intensity

	Dependent Variable: log Turnover per Employee	
	(1)	(2)
	OLS	OLS
Main Independent Variable		
Access to Talents	0.000036*	0.000022
	(0.000019)	(0.000035)
Access to Talents * Medium-Low Tech Intensity	0.000143	0.000485
	(0.000206)	(0.000493)
MediumLow = 1	0.468***	
	(0.120)	
Control Variables		
Market Potential - Pop. Based	0.00797	0.00946
	(0.0114)	(0.0117)
Access to Firms (same 3-digit)	-0.0913	-0.0819
	(0.131)	(0.133)
Access to Firms in Other 3-digit sectors	-0.117	-0.142
	(0.125)	(0.126)
Firms in different 3-digit sector but same 2-digit	-0.0508*	-0.0496*
	(0.0260)	(0.0263)
Capital/Labour ratio	0.0130***	0.0135***
	(0.00330)	(0.00352)
Foreign Ownership	0.178***	0.178**
	(0.0668)	(0.0710)
Costs of Production	-0.000919***	-0.000909***
	(0.000283)	(0.000287)
size = 2 Small	0.724***	0.695***
	(0.0545)	(0.0571)
size = 3 Medium	1.211***	1.178***
	(0.0664)	(0.0722)
size = 4 Large	1.614***	1.579***
	(0.100)	(0.105)
Constant	12.29***	12.46***
	(0.483)	(0.497)
Observations	25,154	25,154
R-squared	0.485	0.481
Time FE	YES	YES
Industry FE	YES	YES
SOAs FE	YES	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

Table A7. OLS Estimation- Interacting Access to Talents to Firm Age

	Dependent Variable: log Turnover per Employee
	(1)
VARIABLES	OLS
Main Independent Variable	
Access to talents	-0.000671
	(0.000947)
Access to Talents * Firm Age	0.000014
	(0.000016)
Firm Age	-0.00500***
	(0.00183)
Control Variables	
Capital/Labour ratio	0.0135***
	(0.00354)
Foreign Ownership	0.180**
	(0.0699)
Costs of Production	-0.000951***
	(0.000287)
Market Potential - Pop. Based	0.00891
	(0.0116)
Access to Firms (same 3- digit)	-0.0801
	(0.135)
Access to Firms in Other 3-digit sectors	-0.137
	(0.127)
Firms in different 3-digit sector but same 2- digit	-0.0352
	(0.0262)
size = 2 Small	0.699***
	(0.0575)
size = 3 Medium	1.187***
	(0.0725)
size = 4 Large	1.595***
	(0.106)
Constant	12.47***
	(0.500)
Observations	25,154
R-squared	0.482
Time FE	YES
Industry FE	YES
SOAs FE	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

Table A8. OLS Estimation- Interacting Access to Talents to Firm Ownership

	Dependent Variable: log Turnover per Employee
	(1)
VARIABLES	OLS
Main Independent Variable	
Access to talents	0.000289***
	(0.000037)
Control Variables	
Access to Talents * Foreign Ownership	-0.000145
	(0.000236)
Foreign Ownership = 1	0.250***
	(0.0564)
Capital/Labour ratio	0.0122***
	(0.00323)
Costs of Production	-0.00416***
	(0.000659)
Market Potential - Pop. Based	-0.00718
	(0.0112)
Access to Firms (same 3-digit)	0.154
	(0.149)
Access to Firms in Other 3-digit sectors	-0.309**
	(0.149)
Firms in different 3- digit sector but same 2 -digit	0.0728***
	(0.0273)
size = 2 Small	0.842***
	(0.0697)
size = 3 Medium	1.859***
	(0.0877)
size = 4 Large	1.501***
	(0.0810)
Constant	11.78***
	(0.583)
Observations	25,154
R-squared	0.499
Time FE	YES
Industry FE	YES
SOAs FE	YES

Note: Robust standard errors corrected for clustering at the Super Output Area - size level are reported in parentheses. Significant coefficients are indicated by *, **, ***, for significance at the 1%, 5% and 10% level, respectively

Table A9: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Log. Turnover per Employee	1.00										
Access to talents	0.02	1.00									
Access to Firms (same 3-digit)	0.06	-0.02	1.00								
Access to Firms (different 3-digit sectors)	0.04	-0.01	0.89	1.00							
Market Potential - Population Based	0.02	0.06	0.67	0.74	1.00						
Nr. Firms in different 3-digit sector but same 2-digit	0.08	-0.03	0.63	0.52	0.41	1.00					
Capital/Labour ratio	0.20	-0.00	0.07	0.08	0.07	0.04	1.00				
Foreign Ownership	0.12	-0.01	0.14	0.13	0.10	0.11	0.01	1.00			
Costs of Production	-0.18	0.01	0.00	-0.01	-0.01	0.02	0.01	-0.02	1.00		
Firm Age	0.04	0.04	-0.07	-0.08	-0.09	-0.04	-0.02	0.003	-0.10	1.00	
Firm Size	0.41	-0.01	-0.02	-0.04	-0.05	-0.03	0.02	0.09	-0.37	0.17	1.00

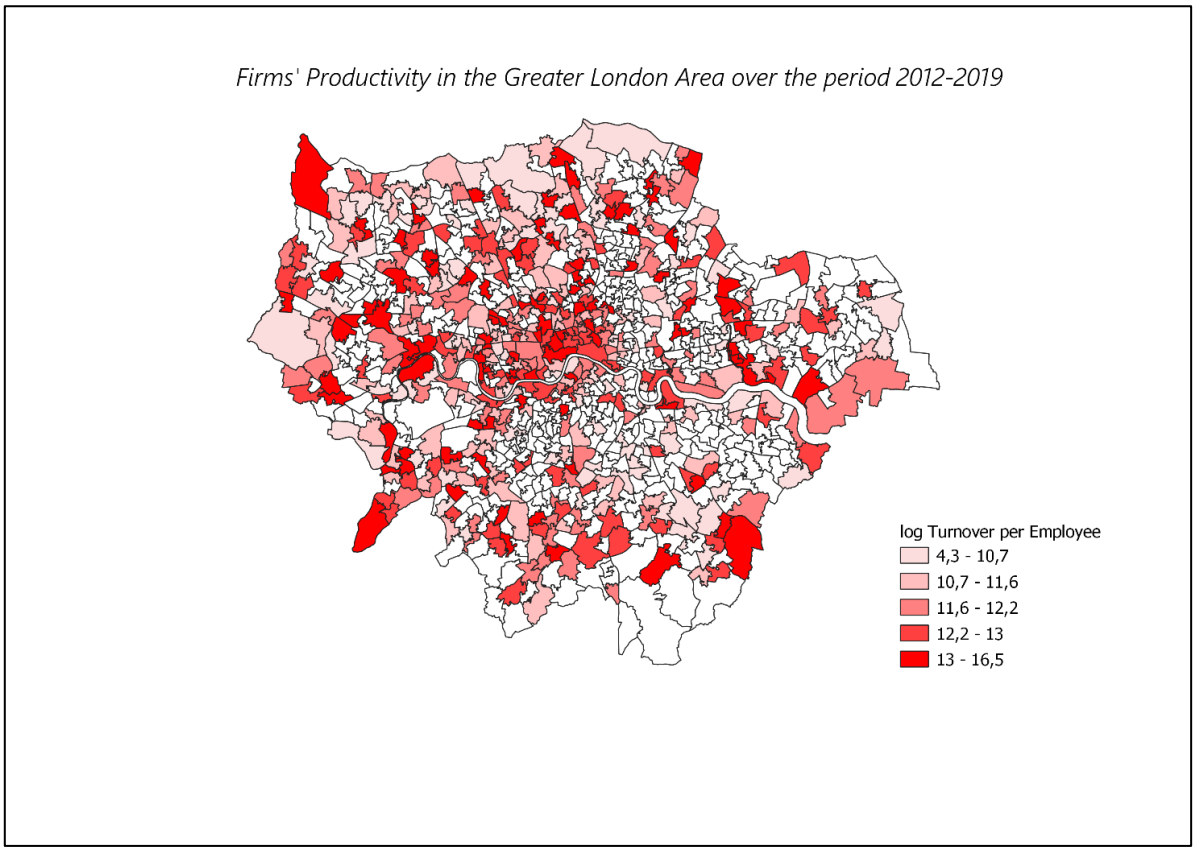

Figure 1. log Turnover per Employee in Greater London Area. Source: Author own elaboration based on FAME data over the period 2012-2019

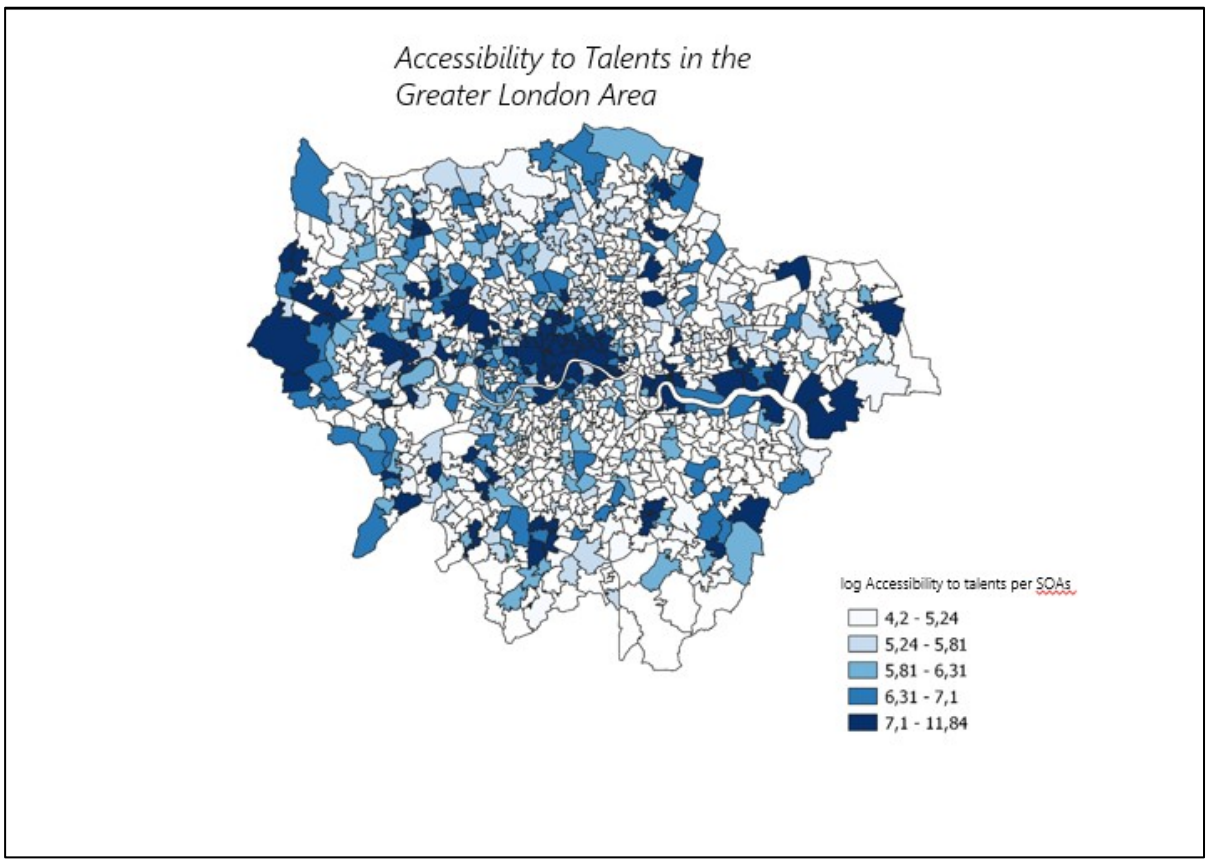

Figure2. log Access to Talents in the Greater London Area. Source: Own elaboration based on 2011 ONS Census Data

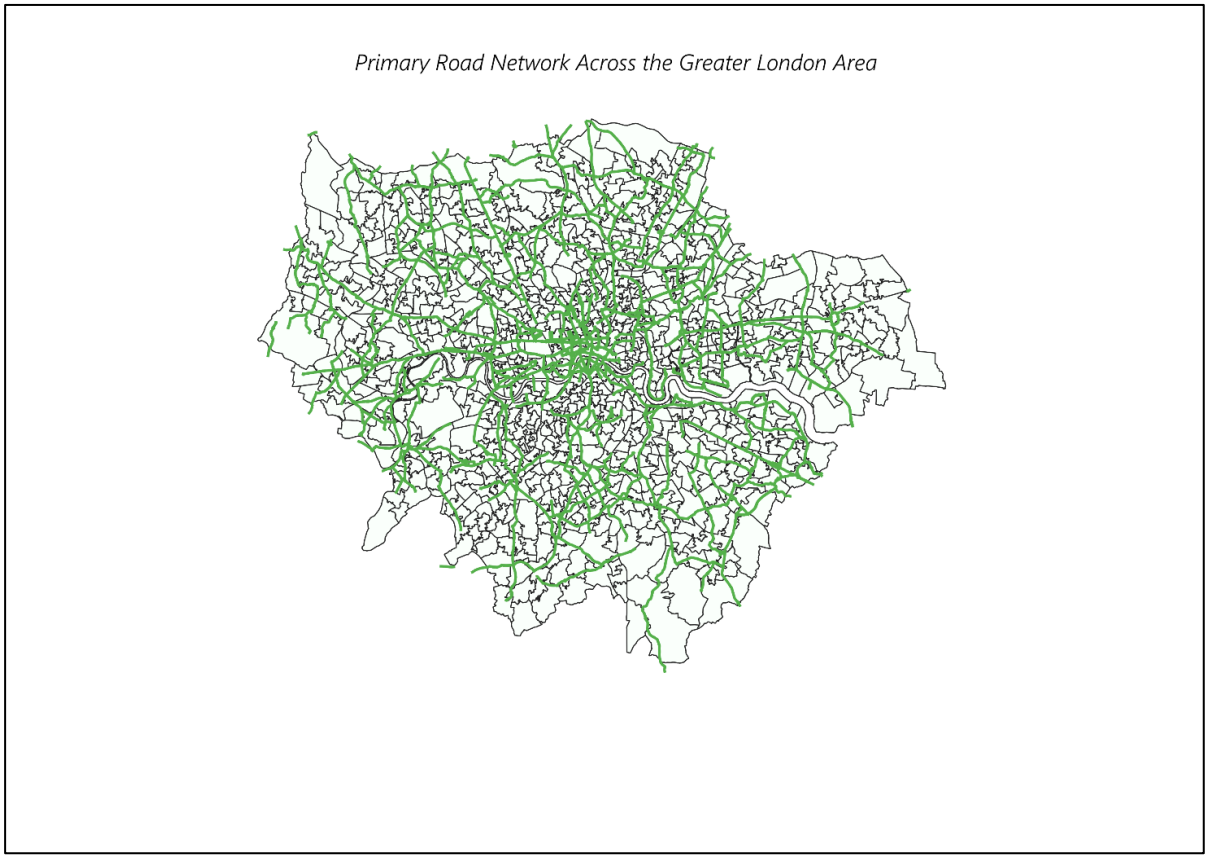

Figure 3. Major Primary Road Network in the Greater London Area. Source: Open Street Maps (OSM) latest update in 2014

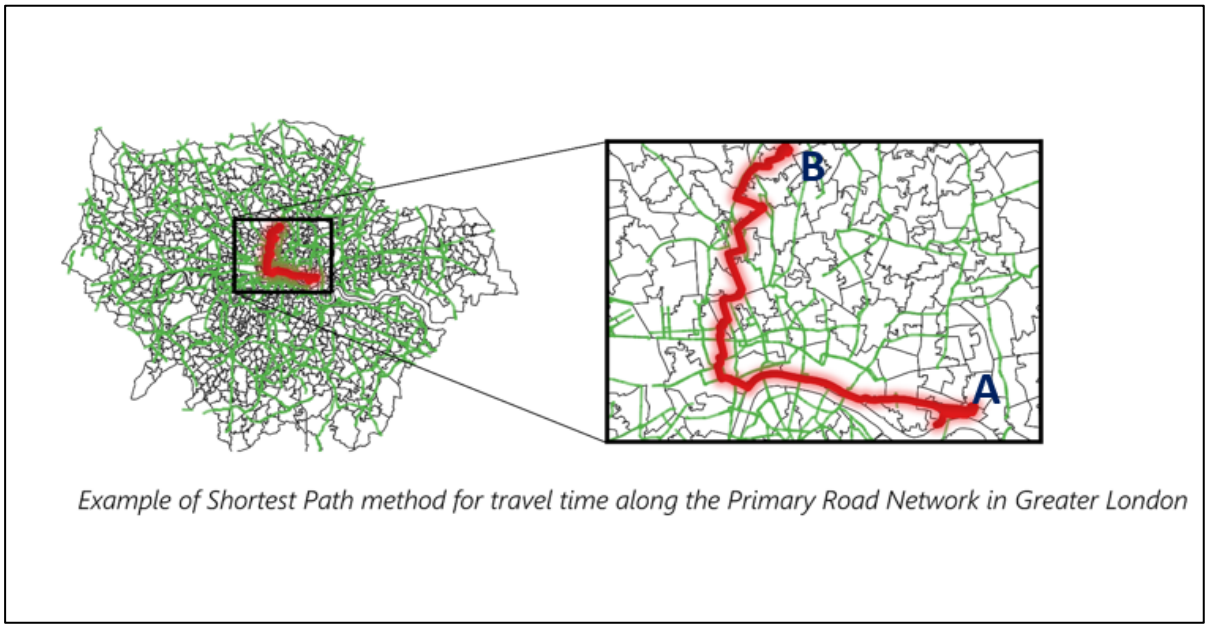

Figure 4. Example of Journey- Time calculation between point A and B. Own elaboration based on Open Street Maps network using QGIS.

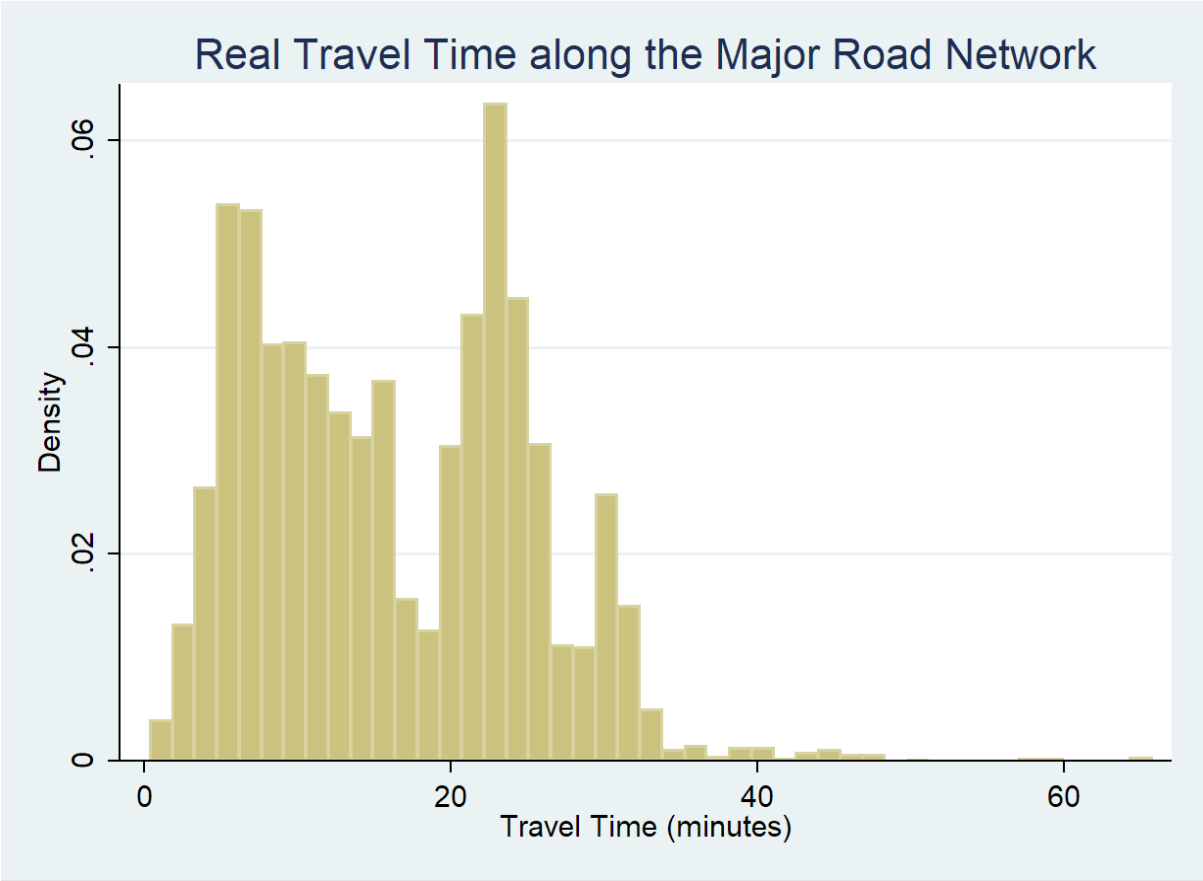

Figure 5. Real travel times in minutes along the major road network in the Greater London Area. Source: Author own elaboration based on Open Street Maps network layer in QGIS 3.10.