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Knowledge integration in multinational enterprises: The role of inventors crossing national and organizational boundaries

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ABSTRACT

Adopting a microfoundations approach to the analysis of intra-multinational enterprise (MNE) knowledge integration, we focus on mobile inventors and their boundary-spanning experience. Using inventor-patent data on US-based MNEs, we show that intra-organizational cross-border mobility and inter-organizational mobility have respectively a positive and a negative effect on knowledge integration. Cross-border mobility within the MNE enables the temporary co-location of mobile inventors in different units, facilitating the dissemination of their knowledge within the MNE. Conversely, "job-hopping" inventors may remain *organizational outsiders*, which hinders their ability to foster intra-MNE knowledge integration.

1. Introduction

One of the main goals of multinational enterprises (MNEs) is to ensure that their dispersed knowledge is available throughout the complex firm organization (Bartlett & Ghoshal, 1989; Kogut & Zander, 1993). This facilitates intra-firm knowledge integration, intended as the combination and synthesis of the firm's existing knowledge with other, possibly novel knowledge inputs from different areas of expertise (Kogut & Zander, 1992).

Intra-firm knowledge integration has been conceived as the outcome of an organizational capability that allows the MNE "*to reap the incremental value of being multinational*" (Kogut, 1989, p. 383). By participating in global value chains, business ecosystems, and a range of different national contexts, MNEs face substantial "*contextual and operational diversity*" (Schotter, Mudambi, Doz, & Gaur, 2017, p. 403), which provides them with the opportunity to access heterogeneous knowledge that could be useful across the firm's network. However, such diversity also creates a number of *implicit boundaries* (e.g., cultural, institutional, ethnic) within the MNE - which add to the *explicit, organizational boundaries* that define the firm's dispersed subunits, thus hindering effective intra-firm knowledge flows and lateral collaboration with the MNE (Schotter, Maznevski, Doz, & Stahl, 2021). As a consequence, inter-unit learning and knowledge integration are challenging undertakings for MNEs (Gupta & Govindarajan, 2000).

The international business (IB) literature has long explored the factors that facilitate intra-firm knowledge transfer and integration but has mainly adopted a subunit-level of analysis (Frost & Zhou, 2005; Gupta & Govindarajan, 2000; Monteiro, Arvidsson, & Birkinshaw, 2008). For instance, while early studies focused on the MNE units' absorptive capacity and knowledge capabilities (Minbaeva, Pedersen, Björkman, Fey, & Park, 2003; Szulanski, 1996; Tsai, 2000), recently scholars adopted a more socially constructed view of the phenomenon, investigating - among other things – the richness of transmission channels connecting different subsidiaries and the MNE units' position in the intra-organizational network (e.g., Becker-Ritterspach, 2006; Monteiro et al., 2008; Noorderhaven & Harzing, 2009). Thus, with few exceptions (Nerkar & Parachuri, 2005; Parachuri & Awate, 2017), we still have a limited understanding of the individual-level factors that may play a role in the intra-firm knowledge transfer and integration (Michailova & Mustaffa, 2012). This is surprising, yet very much in line with the call for more attention to microfoundations in IB research issued, among others, by recent works of Contractor, Foss, Kundu, and Lahiri (2019) and Foss and Pedersen (2019). A microfoundations approach allows to adopt the most appropriate lens to analyze the intra-firm knowledge transfer and integration, an organizational-level (thus macro-level) outcome that entails, and is highly dependent on, the actions and interactions of

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individuals, such as inventors, sharing knowledge within the MNE, as well as their characteristics, motivations, and behaviors within the organizational context (Alavi & Leidner, 2001; Dasi, Pedersen, Gooderham, Elter, & Hildrum, 2017; Felin & Foss, 2005; Foss & Pedersen, 2019).

This paper seeks to address this relevant gap in the IB literature, focusing on the integration of technological knowledge within MNEs. Starting from the knowledge-based theory of the MNE (Gupta & Govindarajan, 1991, 2000; Kogut & Zander, 1993), according to which the latter can be conceived as an efficient organizational vehicle to create, share and recombine tacit and idiosyncratic knowledge across borders, we explore knowledge sharing and integration by placing these phenomena at the level of the individual actors that are ultimately responsible for these processes, namely the inventors. Thus, our study focuses on the micro-macro level link underlying knowledge sharing and integration. From the social outcome observed at the MNE level, our analysis zooms in on the characteristics, human capital, and experiences of the individual agents who are sharing and integrating the MNE knowledge (Foss & Pedersen, 2019).

Specifically, we explore how the inventors' *mobility*, a key channel for networking and collaboration (Breschi & Lissoni, 2009) among individuals who are directly involved in the generation of technological knowledge, influences the patterns of integration of such knowledge within the MNE. Consistent with the literature on *intra-MNE boundaries* (e.g., Schotter & Beamish, 2011; Schotter et al., 2017), we investigate the role of mobile inventors (i.e. inventors who span these boundaries and temporarily co-locate with different intra-organizational environments), and support the idea that inventor mobility within dispersed organizations can be conceived as a critical integrative mechanism (Schotter et al., 2021; Singh, 2008). Furthermore, we acknowledge that boundary spanning may also occur across organizations. Over their career, inventors can move within the MNE's geographically dispersed network to perform their inventive activity in the context of other subsidiaries (i.e., intra-organizational cross-border mobility), but they can also engage in *job-hopping*, and join external organizations, such as rival firms (i.e., inter-organizational mobility) (Ganco, Ziedonis, & Agarwal, 2015). Building on previous insights on the role that inventors' experience and career may play in shaping their behavior, performance, and social networks (Melero & Palomeras, 2015; Murray, 2004), we argue that inventors' mobility history represents an important legacy, which is likely to influence their ability to facilitate knowledge integration within the MNE. Thus, while intra-organizational cross-border mobility eases communication, spurs trust-based relationships, and increases inventors' firm-specific human capital, facilitating the dissemination of their knowledge within the MNE, "job-hopping" inventors may be perceived as potential channels for knowledge leakage and remain *organizational outsiders*, which hinders their ability to develop key relational assets that are essential to foster intra-MNE knowledge integration.

We explore these issues using data on over 170,000 inventor-patent pairs, involving a cohort of approximately 40,000 inventors and 68,000 patents granted to 128 US-based MNEs operating in the pharmaceutical and semiconductor industries. Specifically, we analyze these firms' patenting activity over the period 1997-2007 using United States Patent Trademark Office (USPTO) data and relying on the "Disambiguation and co-authorship networks of the U.S. patent inventor database" (Li et al., 2014) to reconstruct the mobility history of their inventors. Using negative binomial regression models, we show that, consistent with our hypotheses, intra-organizational cross-border mobility and inter-organizational mobility (prior to joining the MNE) have respectively a positive and a negative effect on knowledge integration. We also find some evidence that the negative effect of inter-organizational mobility is alleviated for inventors who move across the MNE's international network, but this seems sensitive to the exclusions of some extreme cases of inventors with very high inter-organizational mobility.

This study offers three contributions to the existing literature. First, building on previous research that has recognized mobility as a particular type of boundary spanning (Shipilov, Godart, & Clement, 2017) and a powerful driver of knowledge-based collaboration and networking (Breschi & Lissoni, 2009), we expand the IB strand of literature on boundary spanning in global organizations (e.g., Schotter & Beamish, 2011; Schotter et al., 2017) by shedding light on the role of individuals' mobility history, a phenomenon that provides an indication of how individuals actually span organizational and geographical boundaries (Schotter et al., 2021). Focusing on a specific type of individuals, the inventors, we explore two key dimensions of mobility, such as the intra-organizational cross-border dimension and the inter-organizational dimension. Second, this study takes a micro-foundations approach to the analysis of MNE integrative mechanisms to complement the knowledge-based view of the MNE, which has mainly adopted a subunit, thus macro, level of analysis (Frost & Zhou, 2005; Gupta & Govindarajan, 1991, 2000). By showing that specific characteristics of key organizational members – such as the inventors' mobility history – play an important role in explaining the MNE's ability to successfully exchange and utilize knowledge within its network, this study enables to uncover micro-level mechanisms underlying aggregate organization-level processes (Felin, Foss, & Ployhart, 2015; Foss & Pedersen, 2004, 2019). Finally, by documenting the positive effect of cross-border mobility on the intra-MNE knowledge integration, this study also offers insights to the strand of literature highlighting the time dimension of co-location (Lavoratori, Mariotti, & Piscitello, 2020) and its micro-level implications (Catalini, 2018; Chai & Freeman, 2019).

2. Towards a micro-level approach to intra-MNE knowledge integration

Through the last decades, many industries have experienced a significant fragmentation of their value chains across the geographic space, and regions that were considered as "peripheral" increasingly participate in value-generating activities (Ambos, Brandl, Perri, Scalera, & van Assche, 2021; Gereffi, 1999; Lorenzen, Mudambi, & Schotter, 2020; Mudambi, 2008). These processes have intensified geographically dispersed knowledge sourcing. In this realm, MNEs increasingly use their foreign subsidiaries to tap into worldwide-dispersed clusters of technological expertise (Almeida, 1996).

Foreign research and development (R&D) subsidiaries embed in local geographic environments (Andersson, Forsgren, & Holm, 2002) that differ from their parents' domestic contexts to overcome distance barriers in knowledge acquisition and source location-specific technology (Singh, 2008), which can later be shared across the firm's international network. These processes are consistent with the knowledge-based view of the firm, according to which the MNE can be conceived as a social community that specializes in the cross-border transfer, sharing, and integration of tacit and idiosyncratic knowledge (Gupta & Govindarajan, 2000; Kogut & Zander, 1993).

However, despite the indisputable knowledge sourcing benefits associated with a geographically distributed R&D structure, integrating the knowledge sourced abroad within the complex MNE organization remains a very challenging activity (Gupta & Govindarajan, 2000; Marino, Mudambi, Perri, & Scalera, 2020; Meyer, Li, & Schotter, 2020; Singh, 2008). This is mainly due to problems of coordination and communication among units that are formally separated by *organizational boundaries* and informally divided by *implicit boundaries* arising from the diverse cultural, institutional, and social contexts in which the MNE R&D subsidiaries operate (Schotter & Beamish, 2011; Schotter et al., 2017).

2.1. Intra-MNE knowledge integration and boundary spanning

Over time, MNEs have developed a wide array of organizational mechanisms to overcome the barriers that impede the successful integration of knowledge across dispersed units (Bartlett & Ghoshal, 1989; Singh, 2008; von Zedtwitz, Gassmann, & Boutellier, 2004). Recently, scholars have focused on the role of boundary spanners, i.e., individuals who span the explicit and implicit frontiers that divide the internal environment of complex global organizations (Santistevan, 2021; Schotter et al., 2017; Schotter et al., 2021). Originally investigated for their ability to connect previously independent groups (Friedman & Podolny, 1992), boundary spanners have gained importance in the MNE differentiated network, as they develop brokering linkages that bridge different national contexts or constituencies (Mikami, Ikegami & Bird, 2021; Mudambi & Swift, 2009), thus facilitating the emergence of transnational trust between headquarters and subsidiaries, reducing dysfunctional conflicts to help govern complex situations, and enabling the integration of diverse perspectives and interests across the MNE network (Schotter & Beamish, 2011; Stendhal, Tippmann, & Yakhlef, 2021). Boundary spanners take advantage of structural holes (Burt, 1992) to serve as knowledge intermediaries among different individuals both inside and outside the boundaries of the firm, thus activating multidirectional information flows (Minbaeva & Santangelo, 2018). At the same time, research has shown that the ability of boundary spanners to contribute to the MNE's knowledge sharing goals within and across the organization should not be taken for granted. It depends upon a number of factors, such as the nature of the motivational forces that drive these individuals, the immediate organizational environment in which they are located, and the establishment of substantial lateral collaboration for achieving something together, and of lateral alignment for harmonizing goals across geographies and organizations (Minbaeva & Santangelo, 2018; Santistevan, 2021).

While this strand of research emphasizes the key role of individuals in knowledge dissemination within the MNE, the explicit account of the organizational members ultimately responsible for the recombination, sharing, and integration of the MNE knowledge is still nascent in the literature. However, to gain insights on the actual mechanisms underlying boundary-spanning, it is key to recognize that individuals in an organization cannot be seen as homogenous (Felin & Hesterly, 2007). Thus, a microfoundations approach prescribes to focus on the actors, a level of analysis lower than that of the phenomenon itself, as proximate causes of the higher-level organizational phenomena (Felin, Foss, Heimeriks, & Madsen, 2012; Felin et al., 2015). According to this view, the MNE knowledge process should be conceived as the aggregation of individual factors and attributes to a higher, collective level (Barney & Felin, 2013; Foss & Pedersen, 2019).

Building on these insights, we adopt a microfoundations approach focusing on the level of the inventors and their actions, to incorporate the literature on boundary spanning into the study of knowledge integration within the MNE. Established innovation studies suggest that when it comes to the circulation of technological knowledge, inventors are the leading characters to observe (Fleming, 2001) since they carry out the actual knowledge creation processes (Allen & Cohen, 1969). Specifically, this research stream stresses that inventors' experience and career influence their behavior, performance, and social networks (e.g., Melero & Palomeras, 2015; Murray, 2004). We draw on this premise to argue that inventors' boundary spanning experience - that is, their history in terms of both intra-organizational cross-border mobility and inter-organizational mobility (prior to joining the MNE) - represents an important legacy, which is likely to influence their ability to facilitate knowledge integration within the MNE.

2.2. MNE inventors and knowledge integration

The use of MNE-specific knowledge is primarily possible if the inventors involved in the knowledge creation process *know what the MNE knows*. However, the MNE's knowledge creation processes are increasingly dispersed, both geographically and organizationally. In this dispersed network, boundedly rational inventors have a limited attention span (Ocasio, 1997) and enjoy only a partial view of the MNE's innovation process, as they see it from their own organizational position. Thus, inventors might not be aware of the entire knowledge portfolio of the MNE (Parachuri & Awate, 2017; Scalera, Perri, & Hannigan, 2018). As a result, inventors tend to use the knowledge they are more familiar with, such as knowledge developed by (geographically, culturally, personally) close peers, and often overlook other potentially valuable pieces of knowledge that are available within the MNE boundaries. Even assuming that inventors can be exposed to the entire knowledge reservoir of the MNE (for example, thanks to a meticulous information system), still there are different mechanisms at work that may impede the efficient and effective utilization of such knowledge, and therefore hinder knowledge integration within the MNE. First, inventors might lack the necessary absorptive capacity to recognize the value and relevance of the knowledge available within the MNE network and to relate such knowledge to the innovation process in which they are involved (Cohen & Levinthal, 1990). Second, knowledge often has a tacit component that can be difficult to move across geographic space, even within the same firm (von Hippel, 1994). Such stickiness is exacerbated in presence of causal ambiguity (Szulanski, 1996). Thus, inventors who seek to apply the MNE knowledge to a setting that is different from the one in which it was originally generated might be unable to properly interpret such knowledge and adapt it to the idiosyncratic characteristics of the new context of application (Choudhury and Kim, 2019; Marino et al., 2020). The national diversity underlying the firm's distributed network entails different dimensions of distance (Berry, Guillén, & Zhou, 2010; Ghemawat, 2001; Hofstede, 1980) that render intra-firm communication and coordination more challenging (Choudhury, 2020; Reiche, Harzing, & Pudelko, 2015). Similarly, inventors might be reluctant to adopt knowledge developed in other MNE's R&D labs, especially if the knowledge at stake has been created in hierarchically-dependent MNE units, such as foreign subsidiaries - a phenomenon known as the "not-invented-here" (NIH) syndrome (Katz & Allen, 1982).

Thus, while in principle MNEs' network structures should facilitate international knowledge sourcing and the intra-organizational flow of knowledge (Bartlett & Ghoshal, 1989), in practice the complex distribution of activities across both country borders and intra-organizational boundaries could exacerbate the mechanisms hindering the knowledge integration process. The literature has suggested that cross-national integrative mechanisms can help overcome the barriers to knowledge integration within the MNE (e.g., Singh, 2008), by "bridging the social chasm" that divide geographically distributed organizations (Tzabbar & Vestal, 2015). Building on this insight, in what follows we focus on the role of inventors' intra-MNE cross-border mobility. Moreover, since inventors may move not only *within* but also *across* organizations, we explore the impact on knowledge integration of inventors' inter-organizational mobility history.

3. Hypotheses development

3.1. Intra-organizational cross-border mobility and knowledge integration within the MNE

Inventors' intra-organizational cross-border mobility occurs when inventors move across the MNE's international network to perform their inventive activity in the context of other foreign units. While intra-firm cross-border moves can vary substantially in terms of duration, spanning from permanent relocations to short travels (Choudhury, 2017; Edström & Galbraith, 1977; Karim & Williams, 2012), in this paper we focus on intra-organizational cross-border mobility that is temporary, but long enough to generate a relatively stable co-location of otherwise distant individuals working for the same MNE[1].

A key feature of intra-organizational cross-border mobility is that it facilitates knowledge transfer across locations (Oettl & Agrawal, 2008) by reducing the typical mis-communication problems that are associated with distance (Gibson & Gibbs, 2006; Maznevski & Chudoba, 2000; Srikanth & Puranam, 2011; Stahl, Maznevski, Voigt, & Jonsen, 2010). Knowledge created in foreign countries might be difficult to properly interpret, assimilate and redeploy elsewhere, as it is often "locked" into the broader societal, cultural, and institutional frameworks of the location in which it has been developed (Bartholomew, 1997; Choudhury & Kim, 2019). Such knowledge is largely embedded in technologically competent individuals (Grant, 1996) who are also capable to understand its subtle functioning mechanisms because they are integrated into the context in which knowledge was created. When these individuals move across borders, they carry their knowledge baggage with them, thus making it more readily accessible in the destination unit (Choudhury & Kim, 2019; Marino et al., 2020). Their physical presence in the receiving country, and the resulting face-to-face interaction with local inventors, facilitate the process through which knowledge is codified, interpreted, and thoroughly understood. Moreover, it allows mobile inventors to reframe and adapt their knowledge in the light of the local contexts' needs and idiosyncratic characteristics, as well as to advise co-located peers on the most appropriate opportunities to use such knowledge locally (Hocking, Brown, & Harzing, 2004; Choudhury, 2020). In so doing, internationally mobile inventors develop a special ability to seize different ways of conceiving technical problems and solutions, thus gaining useful clues on the opportunities to re-deploy their own knowledge across the MNE's international network. Also, given their experience from working in different national contexts, internationally mobile inventors often develop flexibility and heterogeneous perspectives (Solheim & Fitjar, 2018), along with intercultural skills (Rauch & Trindade, 2002) and a more open and cosmopolitan mindset (Saxenian, 2007). This reduces the risk of information distortion and fosters their ability to communicate and promote the value of their invention across the MNE geographically distributed network, facilitating the use of their technology as an input in new knowledge creation processes (Parachuri & Awate, 2017; Schilling & Phelps, 2007).

Intra-organizational cross-border mobility also generates persistent informal networks across different firm locations (Edström & Galbraith, 1977). In complex and internationally distributed organizations such as MNEs, *social uncertainty* – defined as the scarcity of information about organizational members' values, competences, and behavioral intentions (Sniezek, May, & Sawyer, 1990) – is likely to be high, since co-workers do not always have the chance to personally interact and get to know each other (McCarter & Sheremeta, 2013). In such contexts, national borders are the source of language barriers, institutional diversity, and a large variety of other cultural and social differences (Berry et al., 2010) that create additional layers of distance between physically separated individuals, hindering the development of key relational assets (Gibson & Gibbs, 2006; Nurmi & Koroma, 2020; Tenzer, Pudelko, & Harzing, 2014; Terzer, Pudelko, & Zellmer-Bruhn, 2021). By temporarily relocating to a new country within the same MNE, inventors have the opportunity not only to *form* ties with local peers but also to develop the trust that is necessary to *strengthen* such ties. This type of temporary co-location increases the likelihood of repeated face-to-face contacts (Storper & Venables, 2004; Tsai, 2000), giving previously disconnected inventors the time to overcome initial barriers arising from cultural diversity, manage task-related and interpersonal conflicts, and develop a familiar relational environment (e.g., Hackman & Katz, 2010; Dahlander & McFarland, 2013). Through personal interactions and sharing of tasks and ideas, inventors get to know each other, thus lowering social uncertainty, and establish relations that go beyond the professional bond (Tsai & Ghoshal, 1998; Uzzi 1997). Compared to infrequent interactions that give rise to weak ties (Hansen, 1999), strong, repeated ties are more efficient, as they allow to economize on the relationship's startup costs and spawn greater reciprocity (Katz, 1982; Marsden & Campbell, 1984; Uzzi, 1997). Thus, the informal networks that form and consolidate due to intra-organizational cross-border mobility are likely to persist even if, and when, the inventor leaves, since the trust established between peers reduces the costs and frictions of remote interactions (Catalini, 2018; Oettl & Agrawal, 2008). Because internationally mobile inventors are likely to have formed persistent and trust-based ties in different units of the same MNE, their knowledge can be expected to have a broad potential reach and to flow more effectively across the MNE network, as its dissemination can leverage more efficient and conducive communication channels.

Mobile inventors are also likely to develop a remarkable firm-specific human capital (Becker, 1964; Wang & Barney, 2006), along with significant awareness of key firm-specific complementary assets available across the MNE's distributed network, which are crucial to ensure the successful redeployment of the firm knowledge in a new location (Choudhury, 2020). By moving across the MNE's international network, inventors develop a deep understanding of the idiosyncratic organizational and social norms of different MNE units, thus gaining a more comprehensive view of the firm-specific functioning mechanisms as well as of the genesis of the MNE's overall knowledge portfolio. The intra-organizational cross-border mobility of inventors may serve as a socialization mechanism, that facilitates normative and cultural integration and the development of common values among members of the organization (Edström & Galbraith, 1977). Furthermore, the experience accumulated in the transmission and adaptation of knowledge in different MNE's locations allows mobile inventors to progressively evolve from mere conduits of knowledge to developers of original firm-specific practices (Galbraith & Edström, 1976; Choudhury, 2020). Over time, they are likely to be perceived as valuable "experts" across the MNE network (Choudhury and Kim, 2019), thus becoming more visible within the intra-firm community of peers. Because, especially in the context of complex and geographically dispersed organizations as MNEs, inventors' attention-span is limited (March & Simon, 1958), they are likely to engage in filtering processes to selectively allocate attention toward knowledge that originates from "popular" sources (Piezunka & Dahlander, 2015), which lower the search costs incurred to locate the knowledge inputs required for problem-solving (Sorensen & Stuart, 2001). Thus, internationally mobile inventors and their knowledge will be easier to recall and more readily available within the organization. Similarly, because internationally mobile inventors are often highly integrated and legitimized within the MNE network, their knowledge will be less exposed to the NIH syndrome, and more likely to be favorably received and utilized even across foreign units.

Based on these arguments, we hypothesize the following:

Hypothesis 1. Intra-organizational cross-border mobility of an inventor is positively associated with knowledge integration within the MNE.

3.2. *Inter-organizational mobility and knowledge integration within the MNE*

In a context where inventors' career tends to be increasingly fluid

[1] Thus, intra-organizational cross-border mobility is different from the intra-MNE *R&D co-practices*, as defined and theorized by Frost and Zhou (2005). While the latter entails the joint work on a specific technical activity that MNE inventors carry out from a distance (i.e., from their own geographically dispersed units), our focus is on the (temporary) relocation of inventors in a destination unit, which encompasses co-location with peers in this unit, and – at least in principle - could span different projects and entail collaboration along a broader set of tasks and situations.

(Dibble & Gibson, 2018; Summers, Humphrey, & Ferris, 2012), MNEs' knowledge integration processes may be influenced not only by the mobility of inventors within the organization but also by their inter-organizational mobility experience prior to joining the MNE.

Inventors who move across firms serve as portable repositories of knowledge, competences, and routines, which may be transferred from the firm they leave to the firm they join, often triggering imitative dynamics (Rosenkopf & Almeida, 2003). While research has mainly focused on the positive effect of inter-organizational mobility on the hiring firm, scholars have also suggested that losing key employees grants prior employers the opportunity to continue to benefit from these employees' knowledge (Corredoria & Rosenkopf, 2010). Through the social and professional relationships that mobile inventors often maintain with their former colleagues (Agrawal, Cockburn, & McHale, 2006), prior employers gain privileged access to mobile inventors' subsequent innovative outputs. Inventors with a history of inter-organizational mobility may thus be considered as potential channels of knowledge leakage to competitors. For this reason, integrating these inventors' new knowledge within the MNE innovation processes might be perceived as a risk by inventors who are loyal to the MNE.

In the absence of opportunities to personally interact, get to know each other, and establish communication routines and familiarity, the *social uncertainty* surrounding specific organizational members can be reduced by using indirect information about these individuals (McCarter & Sheremeta, 2013). Thus, peers' perceptions of a colleague are often influenced by this individual's history (for instance, in terms of prior performance) and reputation, which may serve as cues of their trustworthiness (McCarter & Sheremeta, 2013). Because a job-hopping history will arguably be common knowledge in inventors' small worlds (Fleming & Marx, 2006), mobile inventors' reliability and commitment to their new organization's goals may be questioned. As a result, job-hopping inventors may face difficulties in establishing trust-based linkages with peers in the new firm's inventor cohort, as well as in engaging in the formation of ties that involve not only a professional but also an interpersonal exchange. This may exacerbate communication and coordination barriers (Kane, Argote, & Levine, 2005), which are already very significant in the context of internationally distributed organizations. The lack of trust-based informal relationships linking job-hopping inventors with their peers in the MNE is also likely to reduce the reciprocal motivational disposition to share knowledge (Gupta & Govindarajan, 2000; Marsden & Campbell, 1984; Uzzi, 1997), lowering the likelihood that their inventions will disseminate and be redeployed with the firm's network.

Furthermore, inventors with a history of inter-organizational mobility may be more prone to continue job-hopping and explore future employment options outside of the MNE (Farber, 1994). Established literature indicates that employees tend to avoid firm-specific investment to maximize the chances of new and more attractive job opportunities in the future (Coff & Raffie, 2015; Wang & Barney, 2006). This suggests that job-hopping inventors are less likely to invest their time and effort in on-the-job training that is needed to adapt their skills to the idiosyncratic culture, routines, governance mechanisms, and social landscape of the MNE (Molloy & Barney, 2015).[2] In the absence of connections with the MNE's idiosyncratic organizational environment, the knowledge these inventors generate will be disproportionately exposed to the NIH syndrome. Failure to develop MNE-specific human capital also implies that these inventors will hardly be integrated within the MNE and will end up being perceived as *organizational outsiders* (Louis, 1980). In the context of complex and internationally distributed firms, where the knowledge domain from which inventors can pick inputs to incorporate in their recombination processes is ample and varied, the knowledge generated by "outsiders" will unlikely be able to enter the consideration set of their peers.

Based on these arguments, we posit that:

Hypothesis 2. Prior inter-organizational mobility of an inventor is negatively associated with knowledge integration within the MNE.

What happens when inventors joining the MNE with a job-hopping track record move across different MNE's units abroad to carry out their innovation projects? The abovementioned arguments suggest that inventors with a history of inter-organizational mobility will struggle to be considered as loyal members of the MNE community, and this exacerbates the typical mis-communication problems of internationally dispersed organizations (Kane et al., 2005). However, as job-hopping inventors move across MNE's units, informal ties with incumbent peers develop and strengthen and key relational assets such as mutual understanding emerge. Under these circumstances, the mis-communication problems that hinder the intra-firm diffusion of job-hopping inventors' knowledge may be partially offset. The enduring linkages established via temporary co-location with peers in foreign MNEs' units may also reduce the risk of information distortion, which tends to be particularly severe when the individual trustworthiness of a team member is questioned.

Furthermore, networks of informal linkages established with colleagues in different countries through intra-organizational cross-border mobility may change the *perception* of job-hopping inventors within the organization. Such informal networks pave the way for the emergence of trust-based relationships that these inventors would otherwise be unlikely to form, thus ultimately alleviating the negative effects of their job-hopping reputation on intra-MNE knowledge integration. Through repeated face-to-face interaction, inventors get to know each other based on the first-hand experience of their behaviors and values (Storper & Venables, 2004; Tsai, 2000). Thus, *social uncertainty* is reduced through the establishment of direct, informal networks with peers across the different MNE units via intra-organizational cross-border mobility, and inventors' inter-organizational mobility history loses importance as an indirect cue of individual trustworthiness.

Finally, while job-hopping inventors tend to maintain their human capital general (Coff & Raffie, 2015; Wang & Barney, 2006), moving across different MNE units in different countries inevitably exposes them to a wide array of MNE- and subsidiary-specific routines, as well as to the idiosyncratic culture, governance mechanisms and social infrastructure of the organization. Engaging in knowledge creation processes at different MNE locations allows inventors to develop awareness and understanding of the resources available at each unit as well as of the broader MNE's complementary assets and organizational policies and procedures (Choudhury, 2020; Hocking et al., 2004). Thus, job-hopping inventors who move across the MNE units are likely to accumulate a significant amount of organizational knowledge along with firm-specific capabilities that make their human capital less general. This increases inventors' integration within the MNE community, lowering the likelihood of being perceived as *organizational outsiders*. As they embed in the intra-MNE network, the knowledge they generate becomes more visible and less likely to be exposed to the NIH syndrome.

Hence, we hypothesize that:

Hypothesis 3. The negative effect of an inventor's prior inter-organizational mobility on knowledge integration within the MNE is reduced by the inventor's intra-organizational cross-border mobility.

Fig. 1 provides a graphical representation of our conceptual framework, to synthetically present the hypothesized relations between the inventor's intra-organizational cross-border mobility, prior inter-organizational mobility, and knowledge integration within the MNE, together with the underpinning main theoretical mechanisms suggested.

[2] It should be acknowledged that the nature of an employee's human capital may also be subject to influences derived from firm-specific strategic, HR and organizational choices, which could ultimately limit the ability of the employee to shape the individual human capital (Wright, Coff, & Moliterno, 2014).

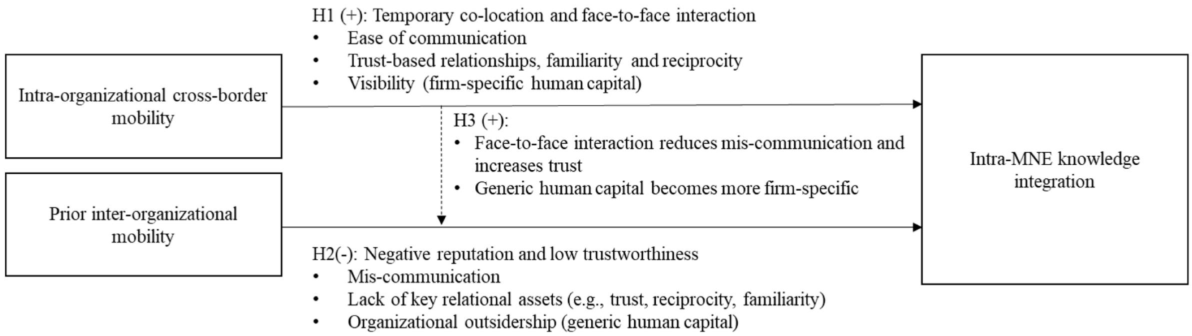

Fig. 1. Conceptual framework

4. Data and methods

4.1. Data

Our analysis exploits USPTO patent and inventor data on a sample of US-based MNEs operating in the pharmaceutical and semiconductor industries. To identify these MNEs, we draw on the NBER patent database (Hall, Jaffe, & Trajtenberg, 2001) that collects US patent and citation data, as well as on the "Disambiguation and co-authorship networks of the U.S. patent inventor database" (Li et al., 2014). First, from the NBER patent database, we select all firms that are assignees of patents granted in the period 1997-2006. Among them, we retain only companies headquartered in the US, using location information from Compustat. Because we are interested in complex organizations with geographically distributed innovation activities, we identify - among these assignees - those firms with (1) at least 50 granted patents and (1) at least one non-US inventor in the period (for a similar approach, see Frost & Zhou, 2005; Singh, 2008). To identify, among these MNEs, those operating in the semiconductor and pharmaceutical industries, we use Compustat data and retain only firms having the corresponding SIC codes (2834, for pharmaceutical companies; 3674, for semiconductor companies). These industries are ideal testbeds for our framework since they are among the most technology-intensive sectors, where relevant knowledge is both highly localized and distributed worldwide. In this context, patents accurately trace firms' innovative activities as companies strongly rely on such legal tool, although not necessarily for protection objectives (Hall & Ziedonis, 2001). The advantage of using patent data to explore knowledge integration lies in the rich information included in patent documents, which cover data on the organization to which the patent's ownership is assigned, and the invention's temporal and technological characteristics. Moreover, patent data allow us to identify the whole set of citations the focal invention receives from subsequent patents, a property that will enable us to identify whether and how the technological knowledge covered by patents is subsequently used as a knowledge input within the MNE organizational network. Finally, while the use of patent data to investigate the firms' innovative behavior entails well-known potential limitations (Hall et al., 2001), this data source is critical to conduct inventor-level analysis. Inventor data have been recently systematized in the "Disambiguation and co-authorship networks of the U.S. patent inventor database (1975 - 2010)" distributed by The Harvard Dataverse Network (Li et al., 2014), which we use to reconstruct the profile of inventors involved in our sample. The disambiguated USPTO data is available until 2010, but the number of granted patents in the NBER patent database drastically drops after 2004 due to the well-known right truncation issue. For this reason, we use granted patent data until 2004. However, because our measure of knowledge integration is based on intra-firm forward citations observed over 3 years from the patent application year, our empirical analysis extends until 2007.

As illustrated in Table 1, the initial sample of 384 US-based firms in the pharmaceutical and semiconductor industry were the assignees for 71,303 patents over the 1997-2004 period. A total of 43,174 inventors contributed to these patents, for an overall 182,472 inventor-patent pairs. While two-thirds of the firms are active in the pharmaceutical industry, these account for the 22% of patents and the 32% of inventors in the sample. This may reflect the fact that in the pharmaceutical industry small innovative firms, such as the entrepreneurial biotechnology firms, are rather common (Gambardella, 1995). After applying the selection criteria discussed above, the number of firms in the sample drops by two thirds, to a total of 128 firms (equally split between the two industries), but the number of patents drops by only 4.8% to 67,852 (the number of inventors drops a bit more, but still within the same order of magnitude). Importantly, while the number of pharmaceutical firms drops more, the distribution of patents and inventors between the two industries is largely unchanged (see the bottom panel of Table 1).

Table 1
Description of the sample.

	Inventor-patent pairs	N. inventors	N. patents	N. firms
a.) All sample				
Semiconductor	124,867	26,356	55,814	125
Pharmaceutical	57,605	16,464	15,489	256
Total	182,472	42,820	71,303	381
b.) Only firms with at least one non US-based inventor				
Semiconductor	122,160	25,505	54,572	84
Pharmaceutical	53,997	15,448	14,377	146
Total	176,157	40,953	68,949	230
c.) Only firms with at least one non US-based inventor and a patent stock of more than 50 patents				
Semiconductor	120,438	25,225	54,237	64
Pharmaceutical	50,397	14,330	13,615	64
Total	170,835	39,555	67,852	128

4.2. Variables

4.2.1. Dependent variable

The existing literature has widely employed patent citations as an indicator of knowledge flows (Jaffe et al., 1993). Intra-firm forward citations (known as self-citations) are used to capture the knowledge integration within the firm boundaries, as they enable to measure the extent to which existing firm knowledge is "internalized" in follow-up inventions (Trajtenberg, Henderson, & Jaffe, 1997), that is, used to develop new knowledge within the firm (Frost & Zhou, 2005).[3] The use of citation-based measures requires accounting for the fact that the number of citations a patent receives may depend on the patent's vintage. Older patents are more likely to be cited since they are exposed to the likelihood of citations for a longer period. To address this issue, we followed the previous literature and computed our dependent variable

[3] Intra-firm citations are less subject to the bias potentially introduced by the patent examiner(s), as such citations tend to be included and retained only if relevant to the knowledge underlying the patent (Nerkar & Paruchuri, 2005).

as the number of assignee self-citations received by the focal patent within 3 years from the patent's application (for a similar approach, see Sterzi, 2013). This variable is constructed for each inventor-patent pair and excludes inventor self-citations (that is citations from subsequent patents whose inventor team includes the focal inventor). It reflects the extent to which the knowledge that an inventor contributes to a patent is used by other inventors to produce subsequent inventions within the same firm (Frost & Zhou, 2005; Nerkar & Parachuri, 2005).

4.2.2. Main independent variables

The two main independent variables used in this study are built based on the information included in the patent document, regarding the patent inventors and assignees.

First, intra-firm cross-border mobility is computed as the number of unique countries in which an inventor has resided *during* the tenure at the MNE (i.e., from the application year of the first patent they have developed within the MNE until the application year of the focal patent). When filing a patent application, inventors are required to provide residence information (Singh & Marx, 2013). This enables us to identify all the distinct locations in which inventors have registered their address while working for the MNE. Capturing cross-border mobility through information on the inventor's change in residence address enables us to focus on cross-border moves that by definition are not short-termed, but rather more durable. Thus, while these moves are not necessarily permanent (as inventors might continue to relocate over their careers), they generate a relatively stable co-location with individuals working for the same MNE. Inventors who move (during their organizational tenure at the MNE) and develop knowledge in such locations arguably have the time to establish linkages with the receiving unit's peers and to become exposed to the local organizational environment, knowledge, and routines.

Second, inter-organizational mobility is computed as the number of unique organizations (different from the focal MNE) for which an inventor has patented *before* joining the MNE (from the application year of their first patent until the application year of the first patent developed within the focal MNE). To identify whether the assignees for which the inventor has worked prior to joining the MNE are independent from the MNE, we exploited the information available in the NBER database, which consolidates assignees' patent portfolios based on their dynamic corporate tree, mergers, and acquisitions (Hall et al., 2001). While some studies have highlighted the limitations associated with the use of patent data to measure inventors' inter-organizational mobility (Ge, Huang, & Png, 2016; Hoisl, 2007), previous research supports the use of this source of information to analyze this phenomenon (Song, Almeida, & Wu, 2003; Trajtenberg, Shiff, & Melamed, 2006).

4.2.3. Control variables

We control for the total number of citations received by the focal patent within 3 years of application, to account for the importance of a certain piece of knowledge and avoid that this could confound our results (Gittelman & Kogut, 2003). In addition, we include a large vector of time-varying inventor, patent, unit, and assignee/country-level variables, which are described in detail in Table 2.

To account for the fact that certain assignees may have more intra-firm citations, we include a vector of assignee (MNE) fixed effects. Furthermore, we account for country specificities by including a vector of fixed effects for the country where the inventor resides. Due to the presence of a tail of inventors from countries that have only a handful of observations, we have chosen to have specific dummies for the top 20 non-US countries[4], which account for 95.8% of all non-US observations, plus a residual category where we group all other countries (accounting for only 4.2% of the observations on non-US inventors). The US is our baseline category and accounts for 89% of our observations. Time-fixed effects are also included in our econometric regressions.

Table 2
Independent and Control Variables and description.

Variable	Variable Description
Inventor-level variables	
Intra-organizational cross-border mobility (during tenure)	Number of unique countries in which the inventor has been located during the tenure at the MNE i*
Inter-organizational mobility (before joining the MNE)	Number of unique organizations (different from the focal assignee) for which the focal patent p's inventor has patented before joining the focal MNE i**
Intra-organizational cross-border mobility (before joining the MNE)	Number of unique countries in which the inventor in the team has been located before joining the focal MNE i**
Inventor technological scope	Number of unique technological subcategories (Hall et al., 2001) in which the focal patent p's inventor has patented inventions during their tenure at the focal MNE i*
Inventor tenure	Number of years that the inventor in the team of the focal patent p has worked for the focal MNE i*
Inventor productivity	Number of patents granted to the inventor up to year t
Citations to the inventor's patents	Cumulative number of citations (excluding inventor self-citations) received by an inventor up to year t
Patent-level variables	
Intra-firm forward citations (3 years)	Number of intra-assignee forward citations received by the focal patent (within 3 years of application), excluding inventorself citations
Total citations (3 years)	Number of citations received by the focal patent (within 3 years of application)
Team size	Number of inventors in the patent
Collaborative patent	Dummy = 1 if the patent has more than one inventor
Non-US inventors in patent	Dummy =1 if at least one inventor in the patent team is based outside of the US
Geographical dispersion index	Geographical dispersion of the inventors' locations in the patent. computed as: 1 - Herfindahl-Hirschman Index (HHI) of inventors' countries) (cfr. Perri, Scalera, & Mudambi, 2017)
Patent technological breadth	Number of subcategories (Hall et al., 2001) in the patent
Co-assigned patent	Dummy =1 if the patent has more than one assignee
Colocation between citing and cited patents	Dummy =1 if at least one inventor of the forward (citing) patent inventor team is located in the same country of the inventor of the focal (cited) patent
Colocation between citing and cited patents (excl. US)	Dummy =1 if at least one inventor of the forward (citing) patent inventor team is located in the same country of the inventor of the focal (cited) patent (excluding the US)
Assignee/country-level variables	
Cumulative patents	Cumulative number of patents of an assignee in the country of the inventor up to the year prior to the focal patent's application year (in natural logarithm)

* From the application year of the first patent they have developed within the MNE i until the application year t of the focal patent.

** From application year of their first patent until the application year of the first patent developed within the MNE i.

Table 3 provides some basic descriptive statistics on the variables used. One can notice that each patent receives an average of 2.5 citations within the first three years from the patent's application date, out of which 0.81 are assignee self-citations (i.e., capturing intra-firm knowledge integration). However, as also demonstrated by Fig. 2, the distribution of intra-firm forward citations is highly skewed, with more than

[4] These countries are UK, Germany, Japan, France, Canada, Singapore, Israel, India, South Korea, Italy, Sweden, Ireland, Malaysia, Netherlands, Denmark, Philippines, Russia, Switzerland, Spain, Taiwan.

50% of patents never being cited by other patents within the same firm. Only a handful of patents (around 1%) receive more than 10 self-citations. Finally, it is worth mentioning that these self-citations are measured as count variables, that are discrete and non-negative by nature. This will affect the choice of the empirical model, as discussed in section 4.3.

As for the main independent variables, it should be observed that cross-border mobility is quite a rare event in our sample, with less than 10% of observations referring to inventors who have invented in more than one country during their tenure at a given firm. Inventors who have established their residence address in at least two distinct countries have arguably spent a relatively long period in the MNE location where they invented prior to the change of address. This indicates that a temporary, yet relatively stable co-location period has characterized the timespan prior to such move. Mobility across organizations before tenure with the focal assignee is slightly higher, with more than 25% of observations referring to inventors who have moved across at least another organization before joining the focal assignee. Correlations among our explanatory variables are shown in Table 4. Apart from some high correlation between *inventor productivity* and *citations to inventor's patents* (81%) and *inventor technological scope* (68%), and the correlation between *geographical dispersion index* and the presence of *non-US inventors in the patent* (65%) all correlations are relatively weak. While the high correlations of some variables may raise concerns of possible multicollinearity problems, we are reassured by the fact that three of these variables (*citations to inventor's patents, inventor technological scope,* and *geographical dispersion index*) which show high pairwise correlations have relatively small standard errors in the subsequent econometric estimations. As noted by Lindner, Puck, & Verbeke, (2020), dropping variables that are highly correlated may lead to estimation bias and spurious correlation due to deflation of standard errors. In their words, "[i]f in doubt, a researcher would be well advised to keep the variables in the regression model. Although this may inflate standard errors, it will not create spurious results" (p. 288).

Table 3
Descriptive statistics

N.	Variable name	N. obs.	mean	sd
(1)	Intra-firm forward citations (3 years)	170,835	0.81	2.21
(2)	Total citations (3 years)	170,835	2.56	5.16
(3)	Intra-org. cross-border mobility (during tenure)	170,835	1.03	0.19
(4)	Inter-organizational mobility (before joining the MNE)	170,835	0.69	1.62
(5)	Cross-border mobility (before joining the MNE)	170,835	1.03	0.18
(6)	Inventor technological scope	170,835	3.80	3.02
(7)	Inventor tenure	170,835	7.04	5.25
(8)	Inventor productivity	170,835	28.49	57.47
(9)	Citations to the inventor's patents	170,835	30.55	118.57
(10)	Non-US inventors in patent	170,835	0.15	0.36
(11)	Team size	170,835	4.00	3.27
(12)	Collaborative patent	170,835	0.87	0.34
(13)	Geographical dispersion index	170,835	0.03	0.11
(14)	Patent technological breadth	170,835	1.45	0.66
(15)	Co-assigned patent	170,835	0.03	0.16
(16)	Colocation between citing and cited patents	170,835	0.56	0.50
(17)	Colocation between citing and cited patents (excl. US)	170,835	0.02	0.15
(18)	Cumulative assignee/country patents	170,835	7.12	1.86

4.3. Econometric Model

As discussed in the previous section, our dependent variable is a count variable. This led us to choose an empirical model that can account for the nature of this variable, such as a Poisson or a negative binomial model (Cameron & Trivedi, 2013). We opted for a negative binomial regression, which allows for overdispersion of the dependent variable, and tested it against a Poisson model.

Our econometric specification takes the following form:

$$E\left(y_{ijpft}X_{ijpft}\right) = \exp\left(X'_{ipft}\beta\right) == \exp\left(\beta_0 + X'_{1ipft}\beta_1 + X'_{2ft}\beta_2 + X'_{3fjt}\beta_3 + \eta_f + \theta_j + \lambda_t + u_{ijpft}\right)$$

where *i, j, p,* and *f* denote an inventor, their country of residence, a patent, and a firm/patent assignee, respectively, while t indicates one year. The vector X_1 contains covariates varying over inventors, patents, and firms, including our main explanatory variables (measuring geographic and inter-organizational mobility), X_2 contains variables varying over patents and firms/assignees, while X_3 contains variables varying over firms/assignees and inventor countries. All variables are time-variant. η_f , θ_j and λ_t are firm, inventory country and time fixed effects, that we capture by adding vectors of firm, country and year dummies. We cluster standard errors at the level of the patent.[5]

5. Results

Results from the estimation of the negative binomial regression models are presented in Table 5. For each specification, we report the estimated coefficients, the standard errors, and the p-values of the null hypothesis that these coefficients are equal to zero. In column (1) we include only the control variables. The first thing to notice is that the log-transformed over-dispersion parameter (lnalpha) is always statistically different from zero. Since a Poisson model is one in which this value is constrained to zero, we have evidence supporting the use of the negative binomial model, rather than the Poisson regression model. As concerns explanatory variables, our results suggest that patents that are in general more cited, are also more likely to receive self-citations. However, the coefficient associated with the overall number of citations is much smaller than 1, thus suggesting that if we had specified our dependent variable as the share of self-citations in total citations, we would have probably biased our results. Among the characteristics of inventors that affect the probability of their patents to be cited within the organization, we find that those with longer tenure within the firm are more likely to be cited in other patents of the same assignee. Inventors who moved across different countries before joining the focal MNE are more likely to be cited. Not surprisingly, the most cited inventors are more likely to be cited also within the MNE. Instead, everything else constant, the number of patents an inventor has been involved in until the year of the focal patent is negatively associated with intra-firm forward citations.

As far as the characteristics of the patents are concerned, collaborative patents and those where the team of inventors is larger are more likely to be cited within the firm. Not surprisingly, it is more likely that a

[5] It might be worth highlighting that the source of variation of our data is at the individual inventor, at the patent and the firm/assignee level. Ideally, one would have accounted for this structure estimating a multi-level model. We ran a negative binomial mixed-effect model, but the maximization algorithm failed to converge. However, we partially account for the multilevel structure in our data by introducing assignee fixed effects and standard errors clustered at the level of the patent.

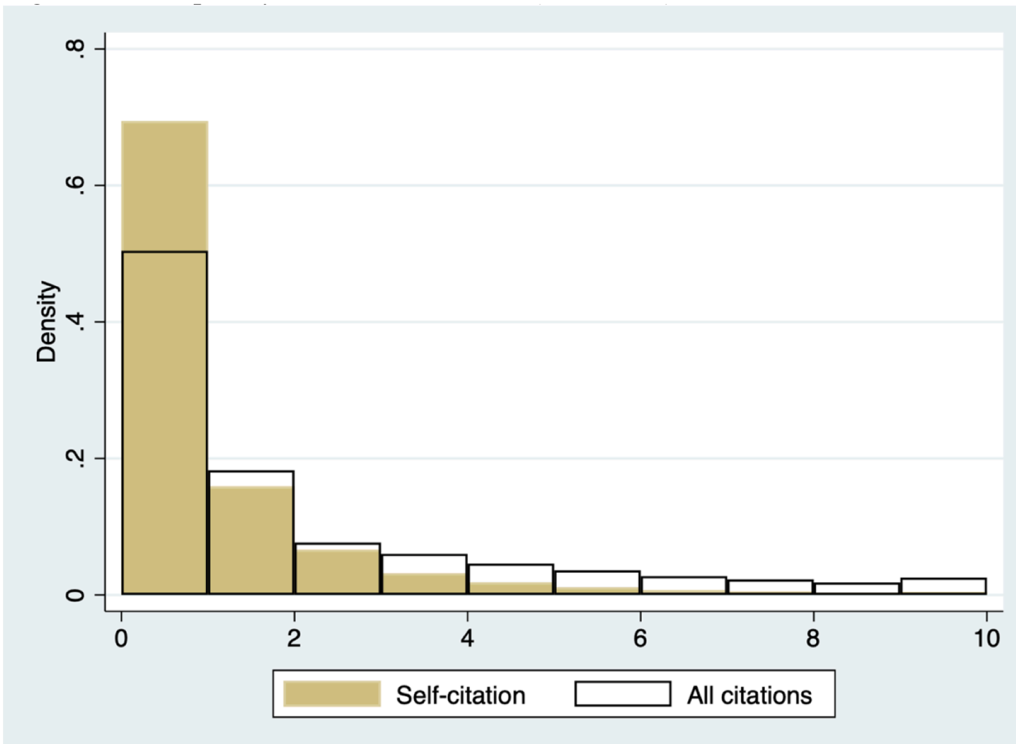

Fig. 2. Frequency distribution of self (intra-firm) and overall forward citations

Table 4
Correlation table.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1)	1.00																	
(2)	0.67	1.00																
(3)	-0.01	0.00	1.00															
(4)	0.00	0.00	0.13	1.00														
(5)	-0.01	0.00	0.36	0.28	1.00													
(6)	0.11	0.08	0.10	0.14	0.04	1.00												
(7)	0.07	0.05	0.09	-0.09	0.00	0.47	1.00											
(8)	0.10	0.07	0.06	0.10	0.03	0.68	0.39	1.00										
(9)	0.08	0.06	0.01	0.00	-0.01	0.48	0.23	0.81	1.00									
(10)	-0.04	-0.06	0.12	-0.02	0.03	-0.14	-0.08	-0.11	-0.08	1.00								
(11)	0.02	-0.02	-0.01	0.01	-0.02	-0.11	0.01	-0.06	-0.07	0.14	1.00							
(12)	0.05	0.01	0.00	-0.02	-0.03	-0.06	-0.02	-0.03	-0.03	0.09	0.35	1.00						
(13)	-0.02	-0.03	0.13	0.00	0.04	-0.07	-0.04	-0.06	-0.04	0.65	0.14	0.11	1.00					
(14)	-0.02	-0.04	-0.01	0.00	-0.01	0.10	0.02	-0.05	-0.06	0.06	0.13	0.05	0.03	1.00				
(15)	0.01	0.00	0.01	0.10	0.03	-0.04	-0.03	-0.02	-0.03	0.08	0.16	0.06	0.13	0.03	1.00			
(16)	0.19	0.18	-0.04	0.01	-0.02	0.05	0.04	0.03	0.02	-0.22	0.00	0.00	-0.11	0.00	0.00	1.00		
(17)	0.05	0.01	0.03	-0.01	0.00	-0.05	0.00	-0.03	-0.03	0.36	0.05	0.03	0.10	0.04	0.02	0.13	1.00	
(18)	0.04	0.05	-0.06	-0.10	-0.04	0.29	0.22	0.22	0.21	-0.48	-0.14	-0.08	-0.27	-0.07	-0.08	0.14	-0.19	1.00

Note: Numbers in brackets denote variables as from Table 3.

patent is cited when at least one inventor of the forward (citing) patent inventor team is located in the same country as the inventor of the focal (cited) patent, supporting the idea that knowledge flows more easily over short distances. Patents that involve non-US inventors are not more likely to be cited than patents with only US inventors, but patents with more geographically dispersed teams are more likely to be cited by later patents of the same assignee. Finally, our results support the idea that patents involving stronger subunits, as measured by the cumulative number of patents of an assignee in the country of the inventor, are likely to be more cited within the firm.

In columns (2), (3) we introduce our main explanatory variables one-by-one and then jointly in column (4). Results support both Hp. 1 and Hp. 2, and the coefficients of both variables are statistically significant, respectively showing a positive ($p<.01$) and a negative ($p<.05$) coefficient. In particular, inventors who moved across countries during their tenure at the focal firm are more likely to generate knowledge that is integrated within the firm knowledge portfolio, while inventors who hopped over several jobs before joining the focal firm are less likely to be conducive to intra-firm knowledge integration. The latter result is more precisely estimated when we include both explanatory variables (column (4)) jointly in the regression. It is worth highlighting that the stability and precision of the coefficients across specifications are also reassuring that multicollinearity is not an issue in our context (Lindner, Puck, & Verbeke, 2020).

In column (5) we test Hp. 3, by introducing the interaction between intra-organizational cross-border mobility (during tenure at the focal MNE) and inter-organizational mobility (before tenure at the focal MNE). The interaction is positive and statistically significant ($p<.05$),

Table 5
Determinants of intra-firm knowledge integration (negative binomial regressions; Dependent variable: Intra-firm forward citations (3 years))

	(1)		(2)		(3)		(4)		(5)		(6)*		(7)	
	b/se	p-value	b/se	p-value	b/se	p-value	b/se	p-value	b/se	p-value	b/se	p-value	b/se	p-value
Intra-organizational cross-border mobility			0.0697	[0.002]			0.0726	[0.001]	0.0604	[0.010]	0.0635	[0.005]	0.1346	[0.004]
(during tenure at MNE) (A)			(0.023)				(0.023)		(0.023)		(0.023)		(0.047)	
Inter-organizational mobility (before) (B)					-0.0063	[0.039]	-0.0068	[0.027]	-0.0157	[0.007]	-0.0119	[0.025]	-0.0219	[0.003]
					(0.003)		(0.003)		(0.006)		(0.005)		(0.007)	
(A) x (B)									0.0063	[0.036]	0.0055	[0.051]	0.0055	[0.066]
									(0.003)		(0.003)		(0.003)	
(A) x Inventor tenure													-0.0077	[0.053]
													(0.004)	
(B) x Inventor tenure													0.0012	[0.088]
													(0.001)	
Inventor-level variables														
Total citations (3 years)*	0.1851	[0.000]	0.1851	[0.000]	0.1851	[0.000]	0.1851	[0.000]	0.1851	[0.000]	0.1228	[0.000]	0.185	[0.000]
	(0.003)		(0.003)		(0.003)		(0.003)		(0.003)		(0.002)		(0.003)	
Cross-border mobility (before)	0.0631	[0.004]	0.0352	[0.129]	0.0783	[0.001]	0.0503	[0.035]	0.0471	[0.049]	0.0473	[0.040]	0.0415	[0.082]
	(0.022)		(0.023)		(0.023)		(0.024)		(0.024)		(0.023)		(0.024)	
Inventor technological scope	-0.0005	[0.826]	-0.0009	[0.702]	0.0002	[0.927]	-0.0001	[0.958]	-0.0001	[0.963]	-0.0021	[0.365]	-0.0006	[0.804]
	(0.002)		(0.002)		(0.003)		(0.003)		(0.003)		(0.002)		(0.003)	
Inventor tenure	0.0121	[0.000]	0.0119	[0.000]	0.0118	[0.000]	0.0116	[0.000]	0.0115	[0.000]	0.0133	[0.000]	0.0192	[0.000]
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.004)	
Inventor productivity	-0.0003	[0.052]	-0.0003	[0.054]	-0.0003	[0.081]	-0.0003	[0.086]	-0.0003	[0.084]	-0.0002	[0.131]	-0.0003	[0.120]
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Citations to the inventor's patents	0.0001	[0.065]	0.0001	[0.057]	0.0001	[0.112]	0.0001	[0.103]	0.0001	[0.101]	0.0002	[0.021]	0.0001	[0.127]
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Patent-level variables														
Non-US inventors	-0.0359	[0.556]	-0.033	[0.589]	-0.0367	[0.548]	-0.0337	[0.581]	-0.0341	[0.576]	-0.0356	[0.541]	-0.0342	[0.576]
	(0.061)		(0.061)		(0.061)		(0.061)		(0.061)		(0.058)		(0.061)	
Team size	0.0209	[0.000]	0.0209	[0.000]	0.0209	[0.000]	0.0209	[0.000]	0.0209	[0.000]	0.0218	[0.000]	0.0209	[0.000]
	(0.005)		(0.005)		(0.005)		(0.005)		(0.005)		(0.004)		(0.005)	
Collaborative patent	0.4385	[0.000]	0.4384	[0.000]	0.438	[0.000]	0.4378	[0.000]	0.4374	[0.000]	0.3697	[0.000]	0.4375	[0.000]
	(0.019)		(0.019)		(0.019)		(0.019)		(0.019)		(0.018)		(0.019)	
Geographical dispersion index	0.2033	[0.113]	0.1899	[0.139]	0.203	[0.113]	0.189	[0.141]	0.1908	[0.137]	0.1478	[0.223]	0.1892	[0.141]
	(0.128)		(0.128)		(0.128)		(0.128)		(0.128)		(0.121)		(0.129)	
Patent technological breadth	-0.0233	[0.049]	-0.0228	[0.054]	-0.0237	[0.045]	-0.0233	[0.050]	-0.0232	[0.050]	-0.0214	[0.056]	-0.0226	[0.056]
	(0.012)		(0.012)		(0.012)		(0.012)		(0.012)		(0.011)		(0.012)	
Co-assigned patent	0.0668	[0.303]	0.0678	[0.296]	0.0721	[0.267]	0.0735	[0.258]	0.0753	[0.247]	0.1108	[0.077]	0.0769	[0.237]
	(0.065)		(0.065)		(0.065)		(0.065)		(0.065)		(0.063)		(0.065)	
Colocation between citing and cited patents	1.0356	[0.000]	1.0354	[0.000]	1.0358	[0.000]	1.0357	[0.000]	1.0359	[0.000]	0.9541	[0.000]	1.0357	[0.000]
	(0.022)		(0.022)		(0.022)		(0.022)		(0.022)		(0.019)		(0.022)	
Colocation (excl. the US)	0.2771	[0.000]	0.2784	[0.000]	0.2774	[0.000]	0.2787	[0.000]	0.2785	[0.000]	0.3246	[0.000]	0.2799	[0.000]
	(0.053)		(0.053)		(0.053)		(0.053)		(0.053)		(0.050)		(0.053)	
Assignee/country-level variables														
Cumulative assignee/country patents	0.0345	[0.044]	0.0356	[0.038]	0.0341	[0.047]	0.0352	[0.041]	0.0348	[0.043]	0.0194	[0.215]	0.0354	[0.039]
	(0.017)		(0.017)		(0.017)		(0.017)		(0.017)		(0.016)		(0.017)	
Assignee fixed effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Year Fixed effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Country fixed effects	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Constant	-2.4867	[0.000]	-2.5361	[0.000]	-2.4945	[0.000]	-2.5464	[0.000]	-2.5272	[0.000]	-1.9093	[0.000]	-2.597	[0.000]
	(0.175)		(0.176)		(0.175)		(0.176)		(0.176)		(0.162)		(0.180)	
ln(Alpha)	-0.1553	[0.000]	-0.1555	[0.000]	-0.1553	[0.000]	-0.1556	[0.000]	-0.1557	[0.000]	-0.0269	[0.158]	-0.1558	[0.000]
	(0.025)		(0.025)		(0.025)		(0.025)		(0.025)		(0.019)		(0.025)	
N. Observations	170,835		170,835		170,835		170,835		170,835		170,835		170,835	

Robust standard errors (clustered by patent) in parentheses.

* Citations computed over 5-years

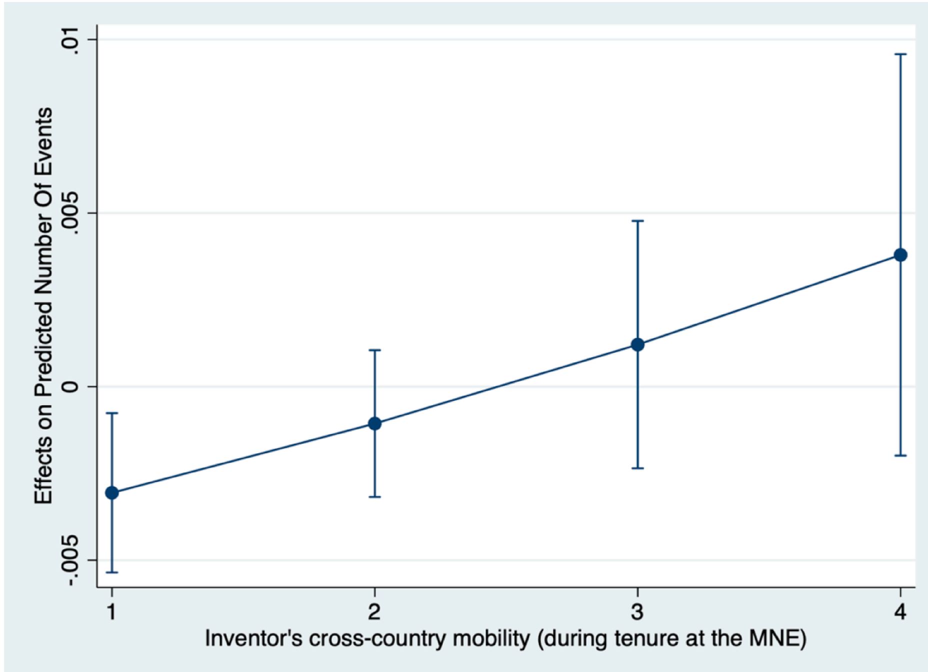

Fig. 3. Graphical representation of the marginal effects of inter-organizational mobility (before joining the focal firm) on the predicted number of intra-firm 3-years citations by levels of cross-country mobility (during tenure at the focal firm).
Note: based on estimates from column (5) in Table 5

thus providing support also to Hp. 3. Fig. 3 shows the graphical representation of the marginal effects of inter-organizational mobility (before tenure at the focal MNE) on the predicted number of assignee self-citations for different values of intra-organizational cross-border mobility (during tenure at the focal MNE). The figure reveals that indeed the association between the mobility of inventors across organizations before joining the focal MNE and the number of self-citations is negative and significant only for inventors who have resided only in one country during their tenure at the focal firm (i.e. they have never engaged in intra-organizational cross border mobility). The marginal effect increases for inventors who have moved across countries during their tenure at the focal MNE turning positive for the most internationally mobile inventors (who have resided in more than 2 countries). However, it is imprecisely measured and thus not statistically significant.

To test the robustness of our main results, we re-run the model shown in column (5) of Table 5 using as dependent variables citations over a longer period (5 years). Results, presented in column (6), are virtually unchanged.

In column (7) of Table 5, we present additional evidence aimed at providing a more nuanced result on the role of inter-organizational mobility. Indeed, in our Hp. 2 we postulate that, on average, inventors with higher inter-organizational mobility are less likely to facilitate intra-organizational knowledge integration. However, this may give a sense of perpetuity which may feel unrealistic. Instead, it is reasonable to hypothesize that the negative effect of a job-hopping history would fade with tenure at the MNE.[6] To address this issue, we have interacted our measure of inter-organizational mobility with the tenure at the MNE (measured by the number of years since the first patent of the inventor with the MNE). Results support the idea that tenure positively moderates the correlation between inter-organizational mobility and intra-organizational citations of an inventor. The marginal effects, plotted in Fig. 3a, reveal that inter-organizational mobility has a negative association with intra-firm knowledge integration for inventors with tenure of 7 years or lower, but it becomes not significantly different from zero when tenure exceeds this threshold. Interestingly, tenure has instead a negative moderating effect on intra-organizational cross-border mobility, suggesting some substitution effect among the two. Fig. 3b shows that the effect of intra-organizational cross-border mobility becomes not significantly different from zero when tenure exceeds 12 years. It is worth highlighting that this is quite a high threshold, which corresponds to the 86th percentile.

Finally, we test for the robustness of our findings by estimating our negative binomial regressions on a sample that excludes some extreme observations. In particular, following Hoisl (2007), we first drop inventors that have only one patent in our period of analysis, since for these cases it is not possible to observe any mobility event. Second, we drop cases of inventors who are characterized by very high levels of inter-organizational mobility, i.e. those who patented (on average) with more than one assignee per year since their first patent's application year. Extreme values of inter-organizational mobility can be explained by the presence of "freelance" inventors that are involved in contract R&D, which requires them to assign the rights of their inventions to their clients (Hoisl, 2007). These "freelance" inventors tend to have a track record of different assignees, but they might differ from inventors who are formally employed by a focal firm.

These tests reveal that our results are overall robust to the exclusion of inventors that have only one patent (Table 6, Sample A). When we drop inventors featuring very high levels of inter-organizational mobility (Table 6, Sample B), the main effects of geographical and organizational mobility are confirmed in sign, significance, and magnitude, thus providing robust support for Hp. 1 and Hp. 2. However, the interaction terms prove to be quite sensitive to the exclusion of such extreme cases. In particular, the interaction between our two main independent variables is very imprecisely estimated in Column 2 of Table 6 Panel B. Overall, this leads us to conclude that Hp. 3 is only weakly supported and highly sensitive to some cases of unusually high inter-organizational mobility. When the two filters are applied jointly (Sample C), also the interaction between inter-organizational mobility

[6] We would like to thank one anonymous reviewer for bringing this point to our attention.

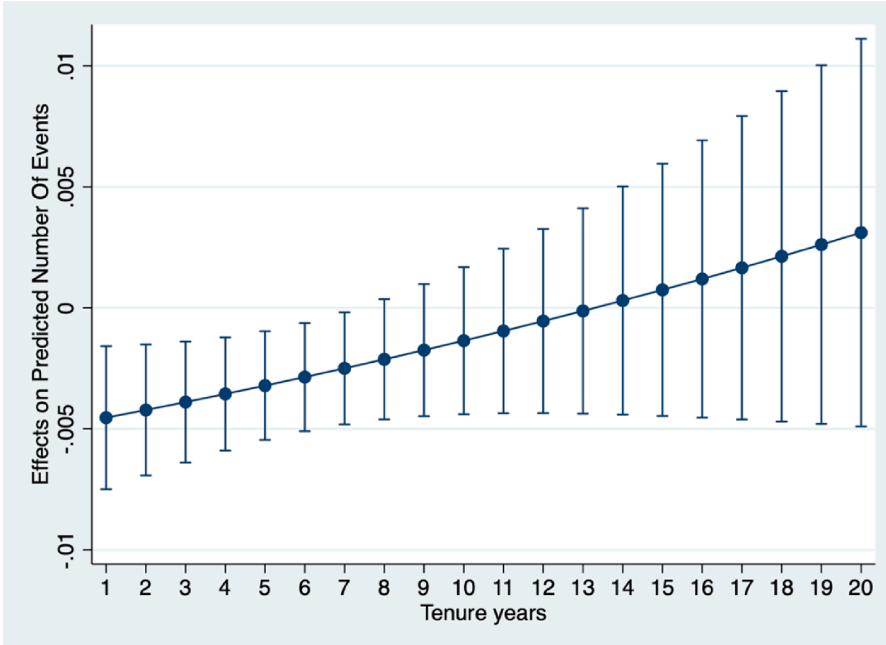

Fig. 3a. Graphical representation of the marginal effects of inter-organizational mobility (before joining the focal firm) on the predicted number of intra-firm 3-years citations by levels of inventor tenure at the focal firm.
Note: based on estimates from column (7) in Table 5

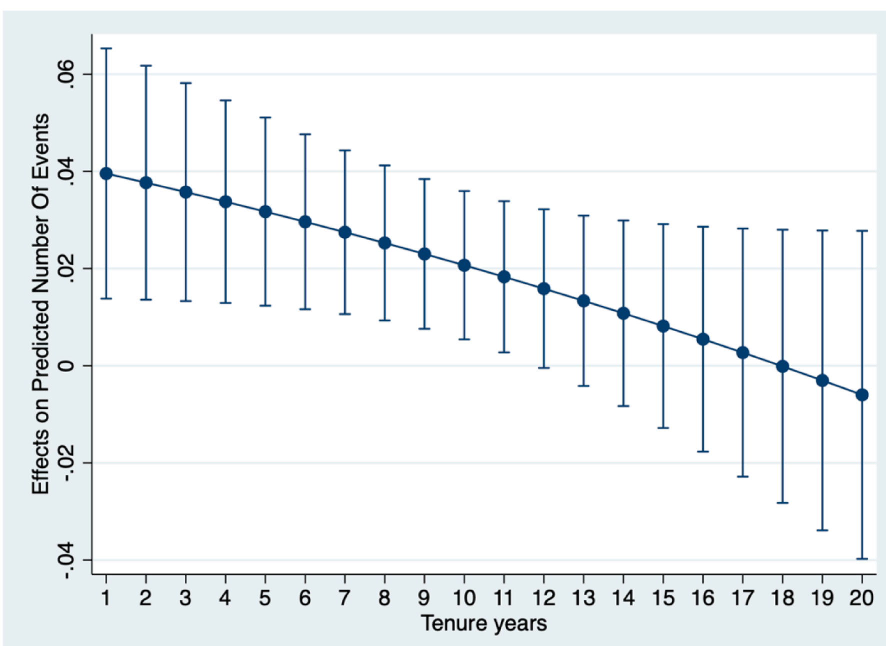

Fig. 3b. Graphical representation of the marginal effects of cross-border geographical mobility (before joining the focal firm) on the predicted number of intra-firm 3-years citations by levels of inventor tenure at the focal firm.
Note: based on estimates from column (7) in Table 5

and tenure is not significantly different from zero.[7]

[7] In additional robustness checks available from authors, but omitted here to save space, we have tested for the potential endogeneity of intra-organizational cross-border mobility. In fact, such mobility may not be random and inventors who are closer to organizational knowledge could be more mobile. Resorting to a control function approach (Wooldridge, 2015), and after controlling for the rich set of inventor, patent and country characteristics our results do not reveal any clear evidence of endogeneity.

6. Discussion and conclusions

The ability to integrate knowledge across different geographically dispersed units is a defining feature of MNEs. The IB literature has long explored the elements that facilitate such a process (Gupta & Govindarajan, 1991, 2000), but the role of factors at the individual level has been addressed only to a limited extent (e.g., Nerkar & Parachuri, 2005; Parachuri & Awate, 2017). In line with the recent call for more attention to microfoundations in IB literature (Contractor et al., 2019; Foss &

Table 6
Determinants of intra-firm knowledge integration (negative binomial regressions; Dependent variable: Intra-firm forward citations (3 years)) – Robustness checks

	(1) b/se	p-value	(2) b/se	p-value	(3) b/se	p-value	(4) b/se	p-value
Sample A: excludes inventors with only one patent with the focal assignee								
Intra-organizational cross-border mobility	0.0735	[0.001]	0.0577	[0.014]	0.117	[0.011]	0.0983	[0.038]
(during tenure at MNE) (A)	(0.023)		(0.023)		(0.046)		(0.047)	
Inter-organizational mobility (before) (B)	-0.0082	[0.012]	-0.0199	[0.001]	-0.0168	[0.005]	-0.0263	[0.001]
	(0.003)		(0.006)		(0.006)		(0.008)	
(A) x (B)			0.0084	[0.011]			0.0076	[0.022]
			(0.003)				(0.003)	
(A) x Inventor tenure					-0.0048	[0.224]	-0.0043	[0.278]
					(0.004)		(0.004)	
(B) x Inventor tenure					0.0013	[0.087]	0.0012	[0.131]
					(0.001)		(0.001)	
N. Observations	151,485							
Sample B: excludes inventors who patented (on average) with more than one assignee per year								
Intra-organizational cross-border mobility	0.0693	[0.002]	0.0616	[0.012]	0.1384	[0.003]	0.1359	[0.004]
(during tenure at MNE) (A)	(0.023)		(0.024)		(0.047)		(0.048)	
Inter-organizational mobility (before) (B)	-0.0092	[0.007]	-0.0152	[0.070]	-0.0174	[0.003]	-0.0192	[0.028]
	(0.003)		(0.008)		(0.006)		(0.009)	
(A) x (B)			0.0051	[0.431]			0.0019	[0.779]
			(0.007)				(0.007)	
(A) x Inventor tenure					-0.0074	[0.063]	-0.0074	[0.063]
					(0.004)		(0.004)	
(B) x Inventor tenure					0.0013	[0.075]	0.0013	[0.111]
					(0.001)		(0.001)	
N. Observations	170,778							
Sample C: intersection of Sample A and B								
Intra-organizational cross-border mobility	0.0609	[0.008]	0.0638	[0.015]	0.1208	[0.012]	0.1284	[0.012]
(during tenure at MNE) (A)	(0.023)		(0.026)		(0.048)		(0.051)	
Inter-organizational mobility (before) (B)	-0.0148	[0.000]	-0.0117	[0.389]	-0.0143	[0.059]	-0.0088	[0.548]
	(0.004)		(0.014)		(0.008)		(0.015)	
(A) x (B)			-0.0028	[0.818]			-0.005	[0.686]
			(0.012)				(0.012)	
(A) x Inventor tenure					-0.006	[0.143]	-0.0063	[0.130]
					(0.004)		(0.004)	
(B) x Inventor tenure					-0.0001	[0.938]	-0.0001	[0.932]
					(0.001)		(0.001)	
N. Observations	149,366							

All regressions include inventor-level, patent-level, assignee/country-level control variables, as well as assignee, time and country fixed effects, as in Table 5.
Robust standard errors (clustered by patent) in parentheses.

Pedersen, 2019), and building on the literature on boundary spanning in global organizations (e.g., Schotter & Beamish, 2011; Schotter et al., 2017; Schotter et al., 2021), this paper focuses on the role of mobile inventors in influencing the integration of technological knowledge within the MNE.

We argue that inventors who move across the MNE's geographically dispersed network to perform their inventive activities in different MNE units across countries take advantage of temporary co-location and repeated face-to-face interaction to develop strong ties and firm-specific human capital. Such ties are likely to persist even after the inventor leaves, allowing mobile inventors to address problems of miscommunication, reduce the frictions of remote interactions and, ultimately, disseminate their knowledge more easily within the MNE. On the other hand, inventors that move frequently across organizations may remain *organizational outsiders* due to their general human capital and low (perceived) trustworthiness, which hinder the integration of the knowledge they develop. For these inventors, intra-organizational cross-border mobility could mitigate the negative effect of their job-hopping track record, by making their human capital more firm-specific and creating opportunities to establish trust-based linkages within the organization.

Using data on over 170,000 inventor-patent pairs, involving short of 40,000 inventors and 68,000 patents granted to 128 US MNEs in the pharmaceutical and semiconductor industries over the 1997-2007 period, and after controlling for many confounding factors at the level of the inventor, patent and firm, we find that inventors who have resided in more than one country while patenting with an MNE receive more citations by other inventors of the MNE. Instead, inventors who moved across several organizations before joining an MNE are less likely to be cited. These results confirm our main hypotheses. We also find some support for the existence of a positive moderation effect of intra-MNE cross-border mobility on prior inter-organizational mobility. The negative effect of mobility across organizations seems to be a feature of inventors who do not move across countries within the MNE. However, this result is only weakly supported and highly dependent on extreme cases of very high inter-organizational mobility.

This study offers three contributions to the existing literature. First, we expand the IB strand of literature on boundary spanning in global organizations (e.g., Schotter & Beamish, 2011; Schotter et al., 2017) by shedding light on the role of individuals' mobility history. Exploring the role of inventors, we build on previous research that has recognized mobility as a powerful driver of knowledge-based collaboration and networking (Breschi & Lissoni, 2009) and investigate two key dimensions of mobility. Namely, the inter-organizational and intra-organizational cross-border mobility are recognized as two individuals' actions enabling boundary spanning (Schotter et al., 2021). Our results show that, consistent with our hypotheses, spanning different types of boundaries may have heterogeneous implications on the MNE's organizational capability to integrate knowledge. We also provide initial evidence that the two dimensions of mobility might interact to determine intra-organizational flows of technological knowledge. This could be an important finding because, to the best of our knowledge, no other study has simultaneously looked at the mobility history of inventors both within and across the geographically distributed MNE's organization. At the same time, this result should be taken with caution, since it did not pass the robustness checks performed in our empirical analysis.

Second, this study adds to the knowledge-based view of the MNE (Gupta & Govindarajan, 1991, 2000; Kogut & Zander, 1993) by taking a microfoundations approach to the analysis of MNE knowledge integration (Foss & Pedersen, 2004, 2019). The focus on a level of analysis lower than that of the phenomenon itself, as a proximate cause of the higher-level organizational phenomenon (Felin et al., 2012; Felin et al., 2015), enables us to develop arguments on how the characteristics of specific organizational members – i.e., the MNE inventors – are associated with the socio-structural mechanisms underlying intra-firm knowledge integration. Specifically, we show that the "legacy" that key individuals (i.e., inventors) carry with them before joining the MNE and during their career at the organization can substantially affect processes that are crucial for the firm's competitive advantage, such as the intra-firm knowledge integration. This occurs via the influence that this legacy exerts on the development of both individual (e.g., visibility, legitimacy) and relational (e.g., trust, mutual understanding) attributes. Failing to consider such mechanisms, and focusing only on more aggregate levels of analysis, hinders our understanding of knowledge processes that – while being significantly shaped by a firm's governance and organizational practices – ultimately occur at the level of individuals (Foss & Pedersen, 2019). Our results well resonate with evidence in this Special Issue on inter-firm knowledge sharing analysed via a microfoundations lens, which emphasizes the key role played by boundary spanners in fostering trust and discouraging opportunist behaviours to ultimately improving knowledge sharing across organizations (Mikami et al., 2021).

Finally, by documenting the positive effect on knowledge integration of cross-border mobility within the MNE, this study also offers some insights to the strand of literature on temporary co-location (Lavoratori et al., 2020) and its micro-level implications (Catalini, 2018; Chai & Freeman, 2019). Previous studies demonstrate that short-term co-location associated with events such as conferences and fairs is useful for tie *formation* (Chai & Freeman, 2019), while a longer co-location span is likely to ensure the emergence of key relational elements, such as mutual understanding and trust, which facilitate communication, coordination and knowledge sharing. Our results seem to support the view that these important relational assets operate not only at the time when individuals are physically proximate but also after the co-location terminates, thereby shaping the likelihood and effectiveness of future (remote) interactions (Agrawal et al., 2006). While this idea should be further investigated, our work lays the basis for a better understanding of the temporal dimension of co-location and its implications. Moreover, our results resonate well with the stream on ties' strength (Granovetter, 1973; Hansen, 1999). Previous studies have emphasized the value of weak and infrequent ties as drivers of novelty and conduits of non-redundant information (Granovetter, 1973), but have also demonstrated that strong ties are more likely to offer socio-emotional support, enable problem-solving and reciprocity, and, ultimately, facilitate the transfer of noncodified knowledge (Hansen, 1999; Reagans & McEvily, 2003). Our findings offer some support to this view in the context of geographically dispersed organizations, showing that the repeated contacts arising from stable, yet not necessarily permanent co-location, may help to channel knowledge, even in presence of those implicit and explicit boundaries that often divide the internal network of the MNE.

6.1. Managerial relevance

Our study carries several managerial implications. By showing that the inventors' mobility history matters for the circulation of the knowledge they develop within the MNE, our research can inform managerial decisions regarding the strategic composition of inventor teams. On the one hand, MNE managers who hire job-hopping inventors should account for the possibility that these remain isolated from the firm internal network, but the intra-firm circulation of inventors' knowledge could be boosted by relying on their global mobility within the MNE network. On the other hand, R&D managers can choose to allocate inventors with heterogeneous mobility profiles to teams working on different areas of technological development, depending on the MNE's objectives in terms of firm-level knowledge dissemination. For instance, innovative projects that are considered critical and potentially useful for the entire MNE could be allocated to teams involving inventors with a history of cross-border mobility within the MNE, thereby facilitating the intra-firm diffusion of the technological knowledge arising from their inventive work. Conversely, MNEs wishing to retain tighter control on specific technologies (whose diffusion to geographically decentralized R&D labs would expose to excessive risks of knowledge leakage to rivals) could assign responsibility for such projects to non-mobile inventors, who likely enjoy only a limited intra-firm social network.

6.2. Implications for the Covid-era and a post-pandemic world

While our study does not explicitly account for the duration of inventors' cross-border moves within the MNE, our results also point toward the idea that inventors who have been co-located for a significant amount of time can more easily overcome the barriers of remote interactions and leverage prior communication routines and reciprocity to seek assistance on specific tasks, such as the assimilation of complex knowledge. In conditions of restricted global mobility, as during the recent Covid-19 outbreak, the practice of short-term co-location (for example, in the form of business travels) cannot be easily adopted; thus, colleagues from foreign units working together would not be able to benefit from the positive mechanisms associated with physical co-location. Managers should carefully address the potential drawbacks of these impediments, since these may have direct implications on the MNE's ability to effectively leverage the knowledge developed within its internal network. If inventors are excessively relying on their local connections, one of the most tangible risks for MNEs is that their geographically dispersed units become increasingly isolated. During the pandemic, and more generally during periods of limited global mobility, managers should focus on developing strategies enabling their inventors to establish new ties with peers in other units and nurture the existing ones, even more so if job-hoppers inventors have recently joined. Stendahl et al. (2021) in this Special Issue demonstrates that digital platforms may provide an effective tool to foster the creation of novel knowledge via *improvisation*, by enabling geographically dispersed individuals across the MNEs' network of subsidiaries to interact and blend different perspectives.

In this respect, a key role may be played by inventors who have been highly mobile within the MNE international network and may stimulate mechanisms to reduce barriers to lateral collaborations within the MNE, which do not necessarily stem from the formal organizational setting (Schotter et al., 2021). These inventors could act as gatekeepers and (virtual) boundary-spanners, being assigned to virtual teams involving peers working in different foreign units that they have visited in the past or serving as facilitators of new remote collaborations. By exploiting their openness, previously established informal relations and intercultural skills, these inventors may contribute to build a virtual team culture, as well as to foster empathy and engagement, which are good practices to keep remote teams functioning and effectively collaborating (Rehberg, Danoesastro, Kaul, & Stutts, 2020). Next to work-related virtual meetings and initiatives, online technologies can be also adopted to facilitate work-unrelated events aimed at nurturing a sense of familiarity and reciprocity among inventors (Dahlander, Wallin, Carnabuci, & Quintane, 2021). Inventors who have been historically more mobile within the MNE network can rely on their MNE-specific experience and connections developed across the firm units and are, therefore, better positioned to spur participation and promote the events via the most effective channels across the different locations. In doing so, mobile inventors may also act as context-bridging boundary-spanners (Schotter, 2021), finding common interests that facilitate interpersonal relations and allow to overcome the perception of physical and cultural distance.

A critical question is whether the effectiveness of mobile inventors in ensuring collaborations across the MNE's geographically dispersed units will be preserved regardless of the duration of the shocks that restrict international mobility and prevent face-to-face contacts. It has been suggested that the benefits of boundary spanning may decay over time, particularly if the local agents who were exposed to direct interactions during the mobility period change (Schotter, 2021). The effectiveness of boundary-spanning inventors may also be at risk if key relational assets were not sufficiently developed when the mobility restrictions started, as in the case of an excessively short co-location with peers in destination units. While previous research suggests that even very short-term interactions might generate important relational resources (Chai & Freeman, 2019), these might not be sufficient to ensure the "resilience" of boundary spanners (Schotter, 2021). For instance, the specific type of trust emerging from temporary interactions – i.e., "swift trust" (Meyerson, Weick, & Kramer, 1996) – offers a useful starting point to develop more solid interpersonal collaboration (Schotter, 2021) and knowledge sharing channels, but this process requires effective reinforcing mechanisms (Crisp & Jarvenpaa, 2013). Thus, the MNE's management should design and enact organizational practices that allow mobile inventors to nurture and stabilize swift trust, with the ultimate aim of improving collaboration and knowledge sharing even in virtual spaces. In doing so, managers should also account for the role that boundary spanners' leadership styles may have in enabling a fruitful evolution of these collaborative relationships (see Lacoste, Zidani and Cuevas, 2021 in this Special Issue).

6.3. Limitations and future research developments

We acknowledge some limitations of our work, which could also indicate relevant avenues for future developments. First, the use of patent data to proxy both knowledge integration and inventor mobility does not enable us to fully capture the complexity of these phenomena. On the one hand, even if patent citations are a widely accepted tool for capturing knowledge flows in innovation processes (e.g., Frost & Zhou, 2005; Nerkar & Parachuri, 2005), knowledge integration within the MNE might also involve more tacit knowledge that cannot be traced with patent data. On the other hand, relying on patent data to track inventors' mobility exposes to potential biases. For instance, inventors moving from one country/company to another could patent only in one of them (either the source or the destination), reducing our ability to comprehensively detect their moves. At the same time, inter-organizational mobility could be overestimated if inventors assign their patents to different organizations without changing employer (Ge et al., 2016). As an example, companies might deploy inventors in research collaborations with external entities and assign the resulting patents only to their partners (Hoisl, 2007; Ge et al., 2016). While we share this limitation with previous literature that has used large-scale patent data to explore inventor mobility (e.g., Rosenkopf & Almeida, 2003), future studies should leverage other data sources that allow addressing this shortcoming (e.g., Hoisl, 2007).

Second, we focus on mobility to understand how this organizational arrangement can foster intra-MNE knowledge integration. However, other potential channels (e.g., involvement in geographically distributed inventor teams, specialized training programs, etc) should be investigated by future studies to determine how they interact with integration mechanisms associated with mobility, especially concerning the potentially troublesome role of job-hopping inventors. This becomes even more interesting in the light of the disruptions brought by Covid-19 since, as discussed, new (online-mediated) channels have been introduced to foster integration mechanisms and support trust-based relations.

Third, even though we could capture if inventors moved, and if they did so across national and/or organizational boundaries, we could not know why they moved. Understanding whether mobility was a personal choice or a top-down decision would be relevant to better disentangle the effect of hierarchical versus more bottom-up coordination mechanisms, and how they may ultimately affect the inventors' ability to integrate MNE knowledge.

Finally, while our arguments uncover the relevance of the temporal aspects of mobility, we do not explicitly account for the time dimension behind the mechanisms proposed in our theoretical framework. For instance, we have developed our theory based on the established idea that job-hopping inventors tend to maintain their human capital general to avoid restricting their future professional opportunities (Coff & Raffie, 2015; Wang & Barney, 2006). However, an employee's ability to control the evolution of their human capital could diminish with the time spent working for a given company. While our empirical models control for this potential effect and try to uncover its functioning by testing the interaction between inter-organizational mobility and inventors' tenure, future research could explore more explicitly whether this mechanism and the resulting implications on intra-MNE knowledge integration are stable over time. Similarly, future studies could explore whether the integrative potential of intra-organizational cross-border mobility changes with the vintage of inventors' moves within the MNE.

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