When the rain comes, don't stay at home! Regional innovation and FDI in the aftermath of the Great Recession[*]

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Abstract
Global connectivity is necessary for innovation to thrive. However, in response to external shocks, economies reduce external exposure and focus resources on internal markets. This closure is in contrast with the need for innovative solutions for recovery. We explore this paradox looking at regional innovation in the USA in the aftermath of the Great Recession. We compare FDI with similar domestic, inter-state investment to assess whether a 'local innovation premium' is associated with global connectivity vis-à-vis domestic linkages. We show that what matters for post-crisis innovation is active internationalization through outward FDI and congruence in technological capabilities between connected territories.

Keywords
Innovation; Foreign Direct Investment; Domestic Investment; Great Recession; Regions; USA.

JEL Codes
F21; O19; O3; O51; R12.

1. Introduction

Globalization and innovation have been seen as two inseparable and self-reinforcing terms of the same economic growth equation. Economic and political integration are made possible by new technologies, while technological advancement needs global connectivity and knowledge circulation to thrive.

However, current geo-political tensions and recovery policies might split the two processes for the foreseeable future.[1] On the one hand, virtually all countries are responding to economic challenges of recovery from COVID-19 and the conflict in Ukraine by supporting domestic activities and offering (direct and indirect) incentives to promote the reshoring of foreign activities.[2] In addition, growing geo-political tensions and conflicts are offering a new rationale for a more stringent scrutiny of foreign activities by domestic firms on 'national security', supply chain risk management, as well as economic nationalism grounds (Myles, 2023). On the other hand, innovation is a crucial factor to respond to global shocks and offer new products and processes to deal with their social and economic impacts and promote sustainable and inclusive recovery (Banholzer et al., 2023).

This paper offers a first attempt to revisit the globalization-innovation nexus in times of crisis by looking at the Great Recession in the United States of America (USA) and comparing domestic inter-regional investments—that tap into external knowledge but within national boundaries—with truly global foreign activities in the form of Foreign Direct Investment (FDI) in terms of regional innovativeness. This comparison makes it possible to assess the 'premium' (if any) associated with a truly global unconstrained process of knowledge search by local domestic companies in comparison with attempts to ring-fence national activities within national boundaries, limiting extra-local activities to inter-regional domestic connections—as advocated in current policy debates on security and stability grounds.

This paper focuses on FDI as a channel allowing connections and knowledge flows among geographically distant territories. It provides a comparative analysis between new, greenfield inward and outward US domestic, inter-state investments vs. 'global' FDI, and focuses on the innovative performance—defined in terms of new patents—of US Economic Areas (EA) in the aftermath of the Great Recession.[3] Following Barba Navaretti and Venables (2004), US inter-state direct investments—that is, those pursued by US-based companies in US states other than the headquarters—are classified as domestic. This makes the USA an ideal case study to analyze the spatial extent of extra-regional connectivity, as it allows one to compare the association with local innovation of investment projects which differ only in their national (i.e., intra-US) vs. global (i.e., extra-US) nature.

There is consensus in the Economic Geography (EG) literature that local innovation is the result of a balanced combination of local knowledge (Storper and Venables, 2004) and global connectivity (Fitjar and Rodríguez-Pose, 2011). Global connectivity should be intended as a dynamic process based on the interaction between purely local, spatially-bounded conditions and extra-local factors (Feldman and Kogler, 2010) which allows territories to engage in innovation-driven economic growth processes promoted by increasing knowledge availability (Grossman and Helpman, 1991; Kogler, 2015) within an integrated local-global framework.

Among the many channels through which regions can interact and exchange knowledge globally (e.g., trade, human capital, collaborative networks), FDI has received great attention by both scholars and policy makers, given their role as conduits of global connectivity among territories (Sturgeon et al., 2008; Crescenzi and Iammarino, 2017). The empirical evidence has highlighted the relevance of knowledge-based FDI-driven externalities, which shape innovative behaviors and promote innovation and innovative outputs (e.g., Iammarino and McCann, 2013, 2018; Crescenzi et al., 2015; Crescenzi et al., 2022).

Despite the academic consensus on the importance of regional openness and global connectivity to promote innovation, competitiveness, economic development and growth of local systems, recent economic (e.g., the Great Recession), political (e.g., *Brexit*, the war in Ukraine, etc.) and global health (COVID-19) crises have called into question the benefits of the process of global economic integration and internationalization, with relevant implications for firms' cross-border activities and regional integration within global networks. This calls for further research into regional connectivity to uncover new patterns of association between extra-regional knowledge flows and the innovative behavior of regions (Bailey et al., 2020). This, particularly, implies to disentangle a series of interrelated dimensions, including the spatial (national vs. global) extent of regional connections, the directionality of connectivity (passive internationalization based on inward investment vs. active internationalization based on outward flows), and the congruence between the regional systems being connected in terms of their technological capabilities.

This paper contributes to the debate on global connectivity by analyzing the role of trans-local connectivity in driving regional innovation following a global shock (Sturgeon et al., 2008; Crescenzi and Iammarino, 2017). Indeed, the EG literature has underlined how global connections—e.g., through trade linkages (Silva and Leichenko, 2004; Rodríguez-Pose, 2012)—operate as a key factor influencing the innovative capacity of regions by helping them to enter new growth and development paths driven by processes of knowledge acquisition, technological change) and industrial re-configuration (Rigby and Essletzbichler, 1997; Eriksson, 2011; Neffke et al., 2011; Kogler et al., 2023).

Global shocks offer an interesting opportunity to study these mechanisms for two convergent reasons. First, they call into question global connectivity, threatening existing links. Second, they force regional economies to 'innovate out of the crisis'. The advantage of global connectivity becomes more apparent (and easier to differentiate from the 'background noise' of everyday simultaneous expansion of innovation and connectivity) when regions are forced to innovate in response to the crisis (Archibugi and Filippetti, 2011). It is during the recovery from the shock, when the development of new external connection is more difficult and riskier, that the value of pre-existing connection emerges and becomes more visible in terms of innovation in the wider eco-system.

In line with this conceptual framework, we attempt to contribute to the existing regional studies and Geography of Innovation (GoI) literature by relying on an approach that is common to both fields, that is, the focus on regions as the pivotal units of observation. In this context, we identify a notable gap in the literature concerning how regional innovation is influenced and shaped by local characteristics and different forms (and geographies) of external connectivity: this is key for understanding the multifaceted nature of the geography of innovation in a (de)globalized world.

In particular, and considering data availability constraints, this paper offers a threefold contribution to the existing literature. First, it explores regional innovation trajectories in response to the Great Recession, offering timely new input to current policy debates on the possible risks of global disconnect due to the push for a 're-nationalization' of the foreign activities of domestic firms. In this respect, it is worth clarifying that our paper does not focus on the Great Recession per se. Conversely, it exploits its 'global shock' nature as a context to examine shifts in (local and global) connectivity patterns. Second, the innovative dataset leveraged for the analysis makes it possible to match and compare greenfield US domestic, inter-state investments vs. 'purely' foreign investments to capture the 'value added' offered, ceteris paribus, by the foreign nature of the investment. Moreover, the interplay between US domestic, inter-state and foreign investments is analyzed considering the innovative congruence between destination and source economies, as well as comparing two different types of patents, namely more 'domestic' US patents granted under the United States Patent and Trademark Office (USPTO) vs. international Patent Cooperation Treaty (PCT) patents (as a proxy for truly new-to-the-world innovations). Third, we aim to capture a wider dimension of extra-regional connectivity by simultaneously accounting for both inward and outward investments, shedding new light on the directionality of global connectivity.[4]

The results offer three key additions to the existing literature. First, what matters for post-shock innovation is 'active' internationalization in the form of outward FDI. Outward investment makes it easier to tap into selected pools of external knowledge in the short-run response to a crisis. Second, truly global connectivity matters the most for post-crisis innovation: investing abroad offers the highest short-term returns vis-à-vis domestic inter-regional investments. Third, it is 'active' FDI connectivity with highly innovative territories that matters when innovation is needed to respond to a crisis. However, low-innovation regions can still profit from connectivity with other relatively less advanced regions due to higher technological congruence.

The rest of the paper is organized as follows. Section 2 presents the conceptual framework and derives the research hypotheses. Section 3 presents the data and methodology. Section 4 presents and discusses the results. Section 5 concludes with some reflections on the lessons learned from the Great Recession for innovation in the aftermath of global shocks.

2. Connectivity, knowledge flows and regional innovation after a shock

Over the past four decades, technological development and dramatic reductions in transport and communication costs seemed capable of underpinning a self-reinforcing process of economic integration. This process came to a halt first with the Great Recession in 2008 and, a decade later, with the COVID-19 crisis (Baldwin and Weder di Mauro, 2020a, 2020b; IMF, 2020), the growing geo-political tensions, and the war in Ukraine.

These global shocks have all increased—in different ways—the cost of economic transactions across distance and national borders, disrupted supply chains, and triggered a process of ‘re-nationalization’ and reshoring of economic activities back to their home countries (IMF, 2020). US President Donald Trump has notoriously embedded this goal into his economic policy objectives by incentivizing US firms to ‘bring jobs back to America’ (Nicholas, 2020). The COVID-19 crisis has further reinforced this call for a global reshoring of previously internationalized activities in the US and across the globe (Bloom, 2020). The ‘recovery plans’ in both the US and the European Union (EU) place a strong emphasis on—and make incentives available for—re-shoring of domestic activities back to their domestic jurisdictions as a means to boost domestic employment and increase domestic security and self-sufficiency in essential and strategic sectors (e.g., food, micro-processors).

As a consequence of these dramatic (and highly spatially asymmetric) changes in international competition, regions have to redefine their competitive strategies to ‘bounce back’ after the shock, or, alternatively, identify new and more suitable development paths (Martin et al., 2016; Crescenzi and Iammarino, 2017; Xiao et al., 2018). In this respect, regions are required to intensify or initiate innovation processes to both sustain and foster productivity and efficiency (through process innovation) and differentiate their portfolios of goods and services (through product innovation) in order to compete successfully (Castellani and Zanfei, 2007; Cassiman et al., 2010; Antonietti and Cainelli, 2011) and develop new resilience patterns (Archibugi and Filippetti, 2011).

The short-run local capacity to innovate in response to external shocks is therefore central to the economic destiny of regions and beyond. However, innovation does not happen in isolation. Globalization has allowed firms and regions to connect globally, giving them the possibility to discover and acquire knowledge generated in distant places, and which can be adapted to, and integrated with, preexisting local knowledge (Canello, 2017).

The importance of regional connectivity has been highlighted by various contributions on regional innovation systems. This literature has moved from the idea of innovation driven by knowledge spillovers occurring among geographically proximate actors within spatially-bounded local systems (Porter, 1990; Jaffe et al., 1993; Audretsch and Feldman, 1996; Cooke et al., 1997) to the idea of innovation resulting from trans-local interactions and externalities (Bathelt et al., 2004; Kogler et al., 2023).

The argument supporting the need for regions to establish trans-local 'pipelines' relies on the risk of localism which could arise as a consequence of too little connectivity (Boschma, 2005; Boschma and Frenken, 2010). In fact, although knowledge flows among economic actors are facilitated by geographic proximity within spatially-bounded systems (Jacobs, 1969; Glaeser et al., 1992), excessive proximity and closure can make regions static, and prevent them from undertaking innovation-driven processes of transformation towards new competitive trajectories (Crescenzi and Iammarino, 2017).

Extra-regional connectivity can help regions avoid—or at least limit—lock-in effects by allowing them to access new, non-locally available knowledge, as regions differ in their knowledge profiles (Chung and Yeaple, 2008). The expansion of local firms beyond regional and national boundaries makes it possible to organize and manage spatially dispersed activities to maximize value added creation by exploiting heterogenous competitive advantages (Dicken, 2003; Gereffi, 2005; Hess and Yeung, 2006; Dicken, 2007). Firms can capture new knowledge generated in different regional systems and recombine it with existing local knowledge (Coe et al., 2008; Cusmano et al., 2010), interacting local and extra-local knowledge (Ernst and Kim, 2002; Coe et al., 2004).

However, if the importance of extra-regional connectivity for local innovation is well established in the GoI literature, there is less clarity on the importance of the spatial extent of this trans-local connectivity. External economic shocks—such as the Great Recession or the COVID-19 pandemic—make simultaneously the need for innovation more pressing (i.e., regions needing to 'innovate out of the crisis') and the uncertainty and costs of long-distance connectivity higher (i.e., the growing pressures for near-shoring or friend-shoring). As a result, cost and risk minimization would suggest that more ‘domestic’ connectivity would offer the highest innovation returns in a time of crisis. Lower cultural and cognitive distance, as well as lower communication costs and risk, would make access to extra-local knowledge easier when connecting with more proximate domestic regions enabled by local firms with establishments in multiple regions within the same country. Conversely, as highlighted by Archibugi and Filippetti (2011), the challenges and competitive pressures triggered by crises often call for the innovative recombination of highly diverse knowledge components in a short timeframe. As a result, more diverse, open and wide-ranging international innovation connectivity might offer the necessary competitive edge to the regional economy, similarly to what Cantwell and Marra (2022) describe for the internal dynamics of multinational enterprises (MNE). ‘Open innovation’ and ‘open networks’ explain successful stories of local systems which have relied on international networks to renew and improve innovation-based strategies in the face of increased global competition (Fitjar and Rodríguez-Pose, 2011). In this respect, internationalization through FDI seems to represent the most important channel for regions to develop, amplify and leverage global connections (Iammarino and McCann, 2013). Even if it is more costly to establish and maintain—in particular in times of high uncertainty during a crisis—, global connectivity, unconstrained by national boundaries, makes it possible for regions to define a new knowledge profile based on the combination of old, new, local and external knowledge through which novel and improved innovation processes promote economic development (Boschma and Iammarino, 2009) and, ultimately, resistance to shocks and resilience.[5] Thus, global connectivity represents a fundamental way for regions to develop new competitive advantages. In this context, the larger (and less constrained) the radius of search for new knowledge, the higher the potential gain in terms of new non-redundant knowledge that investing firms can access and ‘channel’ back to their local innovation ecosystem.

This leads to the formulation of our first hypothesis:

Hypothesis #1: *Global connectivity through 'foreign' direct investment stimulates regional innovation in the aftermath of a global shock vis-à-vis equivalent 'domestic' inter-regional connectivity.*

Knowledge flows exchanged through FDI are bi-directional: they involve both the host regions where subsidiaries are located, and the home regions where investing companies are headquartered. FDI-mediated knowledge flows in the host region may arise from different channels, namely: intra-industry demonstration, competition and labor market effects, which drive innovativeness, efficiency and productivity of domestic firms mainly indirectly (Fosfuri et al., 2001; Castellani and Zanfei, 2003; Görg and Greenaway, 2004); and inter-industry backward and forward linkages, through which knowledge flows directly among foreign-owned and domestic firms (Ernst and Kim, 2002; Javorcik, 2004; Javorcik and Spatareanu, 2008). All in all, the presence of foreign-owned firms is likely to promote innovative behaviors in the host region through knowledge exchange and technological improvement, thus pushing the regional system towards increases in efficiency and productivity (Barba Navaretti and Venables, 2004). Conversely, FDI-related effects in the home region depend both on the ability of the MNE to manage reverse knowledge transfers, that is, its capacity to transfer the acquired knowledge from the foreign subsidiaries to the headquarter, as well as on the possibility of knowledge exchange between the MNE and the local firms within the home regional system, for example through forward and backward linkages, imitation and competition processes, or labor mobility (Griffith et al., 2006; Castellani and Pieri, 2013; Rabbiosi and Santangelo, 2013).

In this sense, FDI acts as a 'bridge' through which knowledge may spread among different geographies worldwide. Thus, it represents a channel for regions to expand trans-local connections to a global extent (Iammarino and McCann, 2013). This idea finds confirmation in several empirical studies analyzing the innovative returns of both inward (Antonietti et al., 2015; Crescenzi et al., 2015; Crescenzi and Jaax, 2017) and outward (Criscuolo et al., 2005; Criscuolo, 2009) FDI-related externalities.

The discussion on FDI networks highlights the second dimension characterizing regional connectivity: its directionality. Knowledge acquisition through extra-regional networks is the result of a dynamic and complex process which is bi-directional in nature. In fact, regions can enlarge their internally-generated knowledge set with novel, external knowledge both by exploiting new inputs brought into the region by non-local economic actors (e.g., by subsidiaries of foreign firms), and by actively looking for new knowledge sets available outside the regional system (e.g., through foreign subsidiaries of domestic firms). This means that knowledge acquisition through trans-local connectivity is the result of a combination of a 'passive' injection of inputs and an 'active' search of *ad hoc* resources. This dynamic process characterizes not only knowledge flows based on FDI (inward and outward investments) but also extra-regional connections through trade, sub-contracting and human capital mobility. When regions have to quickly adapt existing local knowledge to a new competitive environment in response to a shock, they need to be highly selective and effective in their search. Local actors need to effectively tap into external pools of knowledge without the barrier of the strategic behavior of foreign firms hosted in the regional economy that might actively try to minimize local knowledge spillovers, particularly in times of crisis (Alcacer and Chung, 2007; Crescenzi et al., 2022). In a time of crisis, active outward connectivity of local domestic firms might offer the most effective practical means to access new non-redundant knowledge set, by-passing strategic barriers imposed by inward investors active in the local economy.

This leads to the second hypothesis:

Hypothesis #2: *Active outward connectivity offers the higher short-term innovation returns to respond to a global shock in comparison with passive connectivity.*

A third dimension characterizing regional knowledge connectivity concerns the technological congruence among the regional systems being connected (Boschma, 2005). With specific reference to innovation, technological proximity and congruence in innovative capability between interconnected regional systems are likely to play a crucial role for knowledge to flow (Castellani and Zanfei, 2003), particularly in the aftermath of a global shock. For example, little innovative congruence between the sourcing and receiving regions may prevent—and certainly slow-down—the identification, acquisition, transfer and, finally, use of new knowledge urgently needed to respond to shocks and the corresponding changed competitive landscape. This can happen if two local systems, although connected, occupy distant relative positions in the territorial distribution of innovative capability, independent of the spatial extent of the connection and the direction of the flow. Thus, technological and innovative congruence among interconnected regional systems may facilitate and speed-up the process of adaptation, integration and recombination of the different knowledge sets acquired through trans-local connectivity (Boschma and Iammarino, 2009).

This leads to the third hypothesis:

Hypothesis #3: *Higher congruence between inter-connected regions/countries facilitates (short-run) innovation in the aftermath of a global shock.*

By combining the three dimensions characterizing regional connectivity, a broad conceptual framework emerges to identify successful regional innovation patterns in the aftermath of a shock. Regions may develop new innovation-driven competitive strategies by exploiting knowledge generated outside their regional boundaries. This new knowledge can be sourced from a variety of places, at both national and global level. In particular, FDI represents a key channel for knowledge to flow, as it connects regional systems globally and allows for bi-directional knowledge sourcing resulting from both a 'passive' acquisition (through inward flows) and an 'active' search (through outward flows). In addition, the process of extra-regional knowledge acquisition may also depend on the level of technological congruence among the interconnected regions. Thus, a region can enter trans-local connectivity selectively in order to acquire novel knowledge which maximizes the configuration of its new knowledge profile, and, consequently, allows for the identification of an optimal new innovation-driven competitive trajectory in response to a crisis. Figure 1 summarizes this conceptual framework.

[INSERT FIGURE 1 HERE]

In this framework, we refer to 'global knowledge' as the bulk of knowledge a regional system can source and integrate "from dispersed geographic locations" (Santos et al., 2004, p. 31) when "relevant knowledge is locally unavailable" (Hannigan et al., 2015, p. 615), and that allows it to "generate more innovations of higher value" (Santos et al., 2004, p. 31). 'Local knowledge', that is, knowledge generated by the indigenous actors within the national market, can be accessed more easily and at lower costs due to higher social and institutional proximity. Conversely, as previously discussed, 'global knowledge' may allow a regional system to access more advanced technologies and limit the risks of a technology trap due to excessive localism, closure and technological redundancy in situations of decline or crisis (Hannigan et al., 2015; Crescenzi and Iammarino, 2017).

3. Empirical framework

The focus on the USA is justified for two reasons. First, the USA serves as the global benchmark for studying fully economically integrated trade and investment areas in international trade and investment literature. As a large economy encompassing virtually all sub-sectors and exhibiting (almost) perfect internal mobility of production factors—with minimal barriers to spatial adjustment, such as regulatory constraints or language differences—, the USA represents the world's most extensive economically integrated space. Consequently, it is frequently used as a reference point for evaluating the potential benefits of deeper economic integration—for example, within the EU. The second reason is practical: the USA is the only economy where inter-regional (inter-state) investment flows are recorded in a manner that is both comparable to and consistent with international investment flows (i.e., truly 'Foreign' Direct Investment), as documented by the Financial Times. The combination of its high level of institutional and economic integration, along with the unique availability of comparable investment data, makes the USA an ideal case study for analyzing the differential economic impacts of domestic versus international investments. This setting allows us to investigate the spatial extent of trans-local connections characterizing US regions by comparing (inward and outward) flows of investment occurring domestically (i.e., across US regions) and globally (i.e., between US regions and foreign countries). In addition, the USA is both highly innovative and deeply involved in global networks managed by MNEs, although profound heterogeneity characterizes US regions with respect to both innovation activity and investment patterns.[6]

3.1. Data

Regional patent data are drawn from the *PatentsView* database and the *REGPAT* database provided by the USPTO and the OECD, respectively. While USPTO patents present a more domestic nature, PCT patents can be considered as 'worldwide patent applications' (OECD, 2009). Thus, the use of both types of patent data allows us to provide a more comprehensive analysis of the national vs. global extent of extra-regional connections by comparing the more ‘domestic’ vs. ‘international’ innovative returns of investments.

Data on inward and outward investments are drawn from the Financial Times’ *fDi Markets* database, which provides information on brand new greenfield investment projects in terms of set up year, source and destination region, industrial sector at the two-digit level of the North American Industry Classification System (NAICS) and business activity. The *fDi Markets* database presents two main limitations. First, it only collects information on greenfield investments, excluding data on other types of investments. Second, it collects information on planned future investments, although regular updates of the database mitigate this second issue because investment projects which have not been completed are deleted from the database. However, it presents significant advantages, at least for the purposes of this paper. The data collected for the US economy includes both purely foreign investments, that is, investment projects realized by US companies outside the USA and realized by non-US companies in the US territory, and intra-US domestic investments, that is, investment projects realized by US companies across US states. In addition, the geographic information on the source and destination territory of the investments is available at the county level: this allows us to identify US domestic investments realized across different EAs.[7]

Data on private firms’ R&D expenditure, sales and geographic location are drawn from the North American firm-level *COMPUSTAT* database provided by Standard and Poor’s Corporation.[8] Data on regional human capital are drawn from the *American Community Survey* and are elaborated by the US Census Bureau’s Population Estimates Program. Population data are drawn from the *American Community Survey*, while data on personal income and sectoral employment are provided by the US Bureau of Economic Analysis (BEA). Due to data restrictions, the empirical exercise focuses on the 2007–2013 short-run period.

3.2. Empirical modeling

The empirical analysis is based on the knowledge production function (KPF) framework originally proposed by Griliches (1979) in the context of firm-level studies, and subsequently largely employed to analyze the innovation-FDI nexus at the regional level. The aim of the analysis is to provide a descriptive comparison between inward and outward US domestic, inter-state investments vs. FDI, and to assess whether a potential statistical association exists between regional connectivity—here proxied by inward and outward investments—and the innovative performance of US EAs in order to test our three hypotheses.

We thus specify the following cross-sectional augmented regional KPF-type equation to study patterns of association between regional connectivity and innovation:[9]

$$\log\left(Patent_{r,t}\right) = \alpha + \sum_{c=1}^{C} \beta_c Investments_{r,t-1}^{c} + \sum_{d=1}^{D} \gamma_d Controls_{r,t-1}^{d} + \boldsymbol{\zeta}_s + \varepsilon_{r,t} \quad (1)$$

where the dependent variable ($Patent_{r,t}$) denotes the fractional number of patents—either granted under the USPTO or filled under the PCT, and regionalized by inventors' residence—per 100,000 inhabitants in EA $r = 1, \ldots, 179$ over the 2010–2013 period.[10] The vector $Investments_{r,t-1}^{c}$ includes four variables capturing inward and outward new greenfield US domestic direct investments and FDI defined in percentage terms as monetary value of the investments over personal income in EA r over the 2007–2009 period. The vector $Controls_{r,t-1}^{d}$ includes: a measure of R&D, defined as percentage of R&D expenditure over sales performed by US private firms in EA r over the 2007–2009 period; a measure of human capital, defined as the percentage of US population aged 18 or more with at least a bachelor degree in EA r in year 2009; a variable capturing the number of (either USPTO or PCT) patents per 100,000 inhabitants in EA r over the 2007–2009 period; three sectoral controls defined for the year 2009, namely a Herfindahl-Hirschman Index (HHI) defined at the two-digit level of the NAICS, the share of manufacturing employees over total employment, and the share of services employees over total employment.[11] The terms ζ_s denotes a vector of state dummy variables, while ε_{rt} is the error term.[12] We estimate Equation (1) via Ordinary Least Squares (OLS).

As the empirical exercise aims to provide a comparison, although descriptive in nature, between US domestic, inter-state investments vs. FDI, the four EA-specific variables entering the vector $Investments^{c}_{r,t-1}$ in Equation (1) have been constructed also considering sub-sets of US domestic vs. foreign individual investment projects with the same 'structural' characteristics, besides the true population of investments. To this aim, we have performed a preliminary one-to-one, exact matching procedure with random sampling on the sets of individual inward (outward) US domestic and foreign investment projects at the US level, that is, before aggregating them at the EA level. Thus, we have adopted such matching strategy in order to derive exactly the same profile of inward (outward) US domestic and foreign investments that have been set up in the USA (abroad) over the 2007–2009 period. In this respect, we have relied on two matching criteria: the first one considers 'structural' characteristics of individual investments in terms of two-digit NAICS sector and business activity; the second one considers a third dimension, namely the low or high level of innovativeness of the source (destination) territory of the inward (outward) investment. Specifically, we have defined inward (outward) US domestic investments as low- or high-innovative according to the level of innovativeness of the EAs setting up (receiving) the investments, and the level of innovativeness of an EA is defined by considering its share of PCT patents filed over the 2000–2009 period with respect to the US total. Similarly, we have defined inward (outward) foreign investments as low- or high-innovative according to the level of innovativeness of the countries setting up (receiving) the FDI, and the level of innovativeness of a country is defined by considering its share of PCT patents filed over the 2000–2009 period with respect to the world total excluding the USA.[13]

We have performed the one-to-one, exact matching procedure with random sampling separately for inward and outward investment projects as follows. First, we have matched individual inward (outward) US domestic investments with individual inward (outward) foreign investments in the same two-digit NAICS sector and business activity pair. Second, we have performed a random sampling procedure to pick one-to-one matched pairs of inward (outward) US domestic and foreign investments. Finally, we have aggregated individual randomly-sampled matched investments at the EA level to construct the four variables entering the vector $Investments_{r,t-1}^{c}$ in Equation (1). We have performed the same procedure when considering as matching criterion the triplet defined by two-digit NAICS sector, business activity, and low vs. high level of innovativeness of source—for inward—and destination—for outward—territory.[14]

The one-to-one matching approaches allow us to identify sets of investments which are identical in terms of economic sector, business activity, and innovativeness of the source/destination territory, thus allowing for a clearer analysis of the spatial (national vs. global) extent of extra-regional connections.[15]

4. Empirical results

Table 1 synthesizes the results of the OLS estimation of Equation (1) and reports the estimated elasticities of the variables for inward and outward US domestic and foreign investments defined on the true population of investments and the sub-sets of matched investments.[16]

The results suggest that, in the aftermath of the Great Recession, regions are better off when they 'actively search' for new knowledge sources outside their regional boundaries (i.e., through outward investments). In particular, a positive and statistically significant association emerges between outward investments and patenting independently of the spatial extent of connections, confirming Hypothesis #2. However, it should be noted that the estimated elasticity referring to truly global connectivity (i.e., outward FDI) is both larger in magnitude and more significant than the elasticity referring to national connectivity (i.e., US domestic investment) in four out of six specifications, independently of the type of patent and the set of investment projects considered, thus providing overall support for Hypothesis #1.[17]

Therefore, it emerges how trans-local connections matter for regions to identify new knowledge sets to be exploited in order to move towards new innovation-driven competitive strategies. However, the results also suggest that only the proactive search of *ad hoc* inputs outside regional boundaries matters, and that this process of knowledge acquisition tends to be magnified by the global extent of connections.[18]

[INSERT TABLE 1 HERE]

The evidence presented until this point has exclusively considered two of the three dimensions of regional connectivity previously discussed, that is, the spatial extent and the direction of connectivity. However, the third dimension concerning the congruence between the interconnected territories is likely to play a key role in understanding the association between regional connectivity and innovation. In fact, in order for knowledge to flow along trans-local 'pipelines' and, more importantly, contribute to a region's renewal process in the aftermath of a global shock, it is required that the source and destination territories of the flow present some form of congruence in terms of technological capabilities to facilitate timely knowledge acquisition, transformation and use.

To this aim, and in order to test Hypothesis #3, we have split each of the four variables capturing inward and outward US domestic and foreign investment into two variables capturing the level of innovativeness of the source/destination territories of the inward/outward investments. Following the same operationalization approach presented before in the context of matching, we have grouped inward (outward) US domestic investments at the EA level according to the level of innovativeness of the EA setting up (receiving) the investments; similarly, we have grouped inward (outward) foreign investments at the EA level according to the level of innovativeness of the countries setting up (receiving) the FDI. Moreover, in order to investigate the role played by innovative congruence between source and destination EAs and countries, we have augmented the regression equation with a series of interaction terms between a dummy variable capturing the low- or high-innovative status of an EA and each of the eight EA-specific investment variables.

Table 2 reports the elasticities obtained from the OLS estimation of the modified version of Equation (1).[19] The results suggest that, first, inward regional connectivity seems to remain negligible as a channel for regions to access new knowledge, with the only exception being inward US domestic investments originating from highly innovative EAs and realized in highly innovative EAs. However, the estimated elasticity turns out to be statistically significant with respect to the most advanced and innovative PCT patents. Second, US domestic investments to highly innovative EAs seem to matter only for high-innovative sourcing EAs. Third, the role of a proactive search of new knowledge is further reinforced looking at outward FDI to high-innovative countries, that seem to matter only for high-innovative sourcing EAs.[20]

The results presented in Table 2 confirm Hypothesis #2, while do not confirm Hypothesis #1. Moreover, Hypothesis #3 is only partially confirmed: in fact, it seems that innovative congruence matters, but only between high-innovative source and destination regions/countries. By contrast, trans-local connectivity through either domestic or foreign direct investments does not seem to be associated with the innovativeness of low-innovation EAs in the aftermath of a global shock, independently from the low- or high-innovative level of the source—for inward—and destination—for outward—territory.[21]

[INSERT TABLE 2 HERE]

Ford Motor Company's experience in the post-2009 period exemplifies how outward FDI can drive innovation more effectively than domestic R&D consolidation and the corresponding search for technological congruence in foreign regions. In the early 2000s, Ford attempted to centralize its US-based R&D efforts, focusing on key domestic R&D hubs which supported North American operations. However, these efforts faced significant obstacles. Despite investments in autonomous driving and electrification, Ford struggled to match the rapid advancements of competitors such as Tesla. Innovation stagnated due to limited knowledge spillovers, regulatory uncertainties, and a lack of breakthrough technological outputs (McKinsey, 2010).

Recognizing these constraints, Ford shifted its innovation strategy by prioritizing the search for knowledge and ideas on a truly global scale: "We need to stay humble, and by that I mean recognizing that good ideas are coming from everywhere. We need to embrace good ideas no matter where they come from. For many years, we didn't do much of that. Now we're really reaching out to people across the globe. We're working with universities and suppliers all around the world. We're getting, therefore, a lot more out of it." (Bill Ford, 2010 in McKinsey, 2010). This shift resulted in investment in Europe, where well-established automotive technology clusters provided a conducive environment for electric vehicle (EV) development.

In line with this strategy of international R&D expansion via outward FDI, in 2010 Ford secured a £450 million loan from the European Investment Bank (EIB), backed by an 80% guarantee from the UK government. This funding was part of Ford's £1.5 billion program to develop a new generation of low-carbon engines and vehicle technologies over five years. The investment aimed to advance research and development at Ford's UK facilities, including the Dunton Technical Centre in Essex (EIB, 2010). More investment in Europe followed over the years along the same strategic lines. A pivotal step in this shift was the company's $2 billion investment in the Cologne Electric Vehicle Center, a new hub for EV production (Ford Motor Company, 2023). This enabled Ford to fully integrate into Europe's EV ecosystem, leveraging existing battery supply chains, research networks, and incentives designed to accelerate the transition to electrification. Unlike its previous domestic approach, the Cologne facility provided Ford with direct access to a region where technological advancements and regulatory support aligned closely with its innovation goals.

Ford's European expansion also reflected a strategic realignment of its R&D partnerships, exemplified by its collaboration with Volkswagen. This collaboration made it possible for Ford to gain immediate access to an advanced EV architecture without the need for costly independent development (Volkswagen Group, 2022). This collaboration underscores the importance of technological congruence between origin and destination countries in maximizing knowledge spillovers. Both companies operate at similar levels of technological sophistication, allowing Ford to seamlessly integrate Volkswagen's innovations into its European production network.

Ford's case highlights how international investment can yield superior innovation outcomes compared to domestic consolidation efforts. The challenges faced in its US R&D strategy illustrate the limitations of relying solely on internal knowledge networks, whereas its expansion into Europe demonstrates the advantages of embedding within a highly developed technological ecosystem. By shifting its focus toward outward FDI and leveraging synergies with a technologically congruent partner, Ford reinvigorated its innovation trajectory in the face of a major technological shift in the sector.

5. Conclusion

This paper contributes to the debate on the responses to globalization shocks by exploring the role of regional connectivity in shaping the response to the Great Recession. Specifically, we provide a comparative—although descriptive—analysis of inward and outward US domestic direct investments vs. FDI and the innovative performance of US EAs over the short-run, post-crisis period. The paper aims to provide some preliminary evidence on how the different dimensions characterizing regional connectivity—namely, the spatial (national vs. global) extent of connectivity, the directionality (inward vs. outward) of connectivity, and the innovative congruence among the connected territories—interact with the innovative behavior of regions in the aftermath of a major shock.

Three key results emerge as lessons from the Great Recession. First, truly global connectivity is key to 'innovate out' of any crisis. Domestic inter-regional connections are no substitute for global connectivity. Second, a proactive search for new knowledge through outward investments is associated with more innovative regions in the post-shock period. This is the case, in particular, for the production of international PCT patents that capture most radical innovation new to the world. Third, the innovative congruence among connected territories matters for regions to successfully exploit extra-regional connections. This means that it is not the establishment of trans-local connectivity per se that matters for a region but the identification of appropriate knowledge-generating places to connect with.

The empirical results have to be taken with caution and, particularly, should not be interpreted as causality effects. In fact, we aim to detect patterns of association between regional connectivity and short-term innovative behavior in order to highlight the complexity of trans-local connections and, by no means, seek to quantify the effect of domestic or foreign investments on regional innovation outcomes. In addition, the empirical exercise is limited by the unavailability of detailed data to capture the different modes of regional connectivity.

Greenfield FDI represents only one possible channel for regions to connect, and it operates jointly with several other forms of networking, such as trade, human capital migration, sub-contracting, joint ventures and M&A. Therefore, the contribution of this paper should be read as purely descriptive of some of the dynamics characterizing trans-local 'pipelines' in the context of US regions. The possibility of addressing the main limitations of this paper remains on the agenda for future research. In addition, while the US economy provides an ideal case for comparing and contrasting the regional economic implications of 'domestic' vs. 'foreign' investment flows, some caution is needed when generalizing these results to other economies that are less internally integrated and potentially less internationalized. The US analysis offers a 'lower bound' estimate of the potential 'loss' incurred when otherwise identical investment projects are restricted to the domestic market rather than being truly international. Smaller, less diversified, and more internally segmented economies may experience greater disadvantages when investors constrain themselves to the domestic market, limiting their ability to optimize the match between investment projects and host economies.

Having acknowledged these relevant caveats, our results should stimulate a wider reflection on the future challenges to local innovation systems in the recovery phase following the COVID-19 pandemic and the conflict in Ukraine. Regional innovation systems where local actors can leverage global outward connectivity are in a strong position to reinvent themselves in the new economic order. However, the reconfiguration of geo-political equilibria and the corresponding internationalization (or re-nationalization/reshoring) policies can ultimately jeopardize this possibility with adverse overall consequences on technological development.

In terms of reflections for regional policies, our descriptive results highlight the importance of new forms of coordination between policy tools at the local and international levels. In the context of growing geopolitical fragmentation and a potential sharp shift away from substantially free international trade, our results provide actionable insights for regional innovation policies. In particular, they underscore that regional innovation policy cannot be separated from internationalization policies—how regions access external knowledge through the investment strategies of their firms has profound implications for local innovation. Our findings strongly suggest that active outward internationalization is essential for driving innovation in the post-crisis period. To fully harness this potential, policymakers must re-evaluate and expand the mandate of Investment Promotion Agencies (IPA) to support domestic firms in scaling their operations internationally.

By implementing targeted measures—such as tax incentives, co-financing schemes, and risk-sharing mechanisms—, IPAs can help lower barriers to outward FDI, enabling firms to tap into global knowledge networks, and foster the kind of radical innovation reflected in the production of international PCT patents. Recent evidence on FDI inflows in Europe highlights that well-targeted investment promotion strategies can enhance the quality and impact of foreign investments (Crescenzi et al., 2021). In this context, establishing dedicated internationalization units within IPAs could streamline efforts to facilitate bilateral and multilateral innovation partnerships, effectively integrating domestic firms into global networks. Moreover, embedding robust risk assessment protocols—such as advisory boards composed of industry experts and academic researchers—within these expanded IPA frameworks would ensure that firms' foreign ventures align with their technological capabilities and long-term innovation goals.[22] Institutionalizing these risk management measures would not only support a more proactive outward internationalization strategy but also shield regions from the potential downsides of global market fluctuations. In doing so, IPAs can help translate international connectivity into sustainable, knowledge-driven regional development.

Finally, even if all types of regions benefit from international connectivity, less innovative regions should not follow the same patterns as the most advanced localities. They need to look for realistic internationalization patterns in terms of technological congruence with the destination regions while investing in reinforcing the absorptive capacity of their local eco-systems.

Future research should examine how the brokerage network position of regions influences their capacity to benefit from inward and outward FDI. Beyond technological congruence, regions that act as brokers in global innovation networks may facilitate more effective knowledge diffusion and enhance firms' ability to integrate external knowledge into local innovation ecosystems—see the Ford example and strategic choice of its investment hubs in Europe. This perspective aligns with findings on how regions positioned as intermediaries in collaboration networks can play a crucial role in fostering novel innovations (Aquaro et al., 2023; Kim et al., 2024). Understanding these dynamics could provide further insights into how outward FDI-driven knowledge spillovers vary across regions and how policies can optimize their impact on innovation.

Additionally, future research should explore the micro-level mechanisms that shape the relationship between active internationalization (outward FDI) and domestic innovation. While this paper takes a regional perspective, firm-level heterogeneity in absorptive capacity, organizational strategies, and collaboration patterns could significantly mediate the benefits of outward and inward FDI for innovation performance. Investigating how firms of different sizes, sectors, and internationalization profiles leverage external knowledge could refine our understanding of the micro-foundations of global connectivity and technological upgrading. This would complement regional approaches and provide more targeted insights for firm-specific and policy-level interventions.

Endnotes

1. For a summary of recent general interest debates see, for example, the report "*Fostering economic resilience in a world of open and integrated markets*" prepared by the OECD (2021) for the UK presidency of the G7.
2. See, for example, US President Biden's 'Buy American' executive order (*Executive Order on Ensuring the Future Is Made in All of America by All of America's Workers*, January 25, 2021) aimed to reverse the decades-long trend of US firms moving production abroad.
3. It is worth noting, already at this point, that although patents are commonly used to measure innovation, patent count is far from being a perfect proxy of innovation simply because "not all patents are innovation-related, and not all innovations are patentable or patented" (Ganau and Grandinetti, 2021, p. 751). In other words, measuring innovation with patents involves not taking into account all those innovations that are not—or cannot—be patented including "incremental or non-technological innovations, such as many service and low-tech innovations, innovations from smaller firms, and from firms with lesser resources" (Morales et al., 2024, p. 925). Indeed, the literature has highlighted heterogeneity in propensity to patent and patent intensity related to firm size (e.g., Arundel and Kabla, 1998; Brouwer and Kleinknecht, 1999; Arundel 2001), as well as a higher tendency to patent in high-tech manufacturing sectors compared to low-tech and services ones (e.g., Archibugi, 1992; Arundel and Kabla, 1998; Hipp and Grupp, 2005; Janger et al., 2017). However, patents represent a simple and intuitive—although imprecise—proxy for innovativeness and, as highlighted by Acs et al. (2002, p. 1080), they "provide a fairly reliable measure of innovative activity" at the US sub-national level.

4. It is worth mentioning, already at this stage, that the empirical analysis carried out has a descriptive nature and, thus, that the empirical evidence presented has to be interpreted as a simple, though robust, correlation among variables.
5. This is true, of course, when considering the regional system and its dynamics as a whole, that is, when the investing patterns of individual firms are aggregated at the regional level. Indeed, this is the focus of our analysis, with regions representing our units of observation. We acknowledge heterogeneity in the motivations and strategies driving the domestic and/or international investment decisions of individual firms (e.g., Bernard and Jensen, 1995; Melitz, 2003; Helpman et al., 2004). However, such heterogeneity is outside the scope of our analysis, which is concerned to the aggregate, regional implications of firms' investment patterns for regions' innovative capacity.
6. Online Appendix A provides a detailed discussion of the patterns of trans-local investment and innovation in the USA.
7. Online Appendix B discusses the main limitation of the *fDI Markets* database and presents the distribution of the investment projects included in the sample by two-digit NAICS sector and business activity.
8. The use of R&D firm-level data is due to the absence of official R&D regional statistics for the US. Although private firms' R&D expenditure represents only a proxy for a region's R&D endowment, similar measures have been employed in the analysis of sub-national innovative dynamics in the US (e.g., Feldman, 1994; Crescenzi and Rodríguez-Pose, 2013).

9. The time variability of our FDI data does not allow the proper specification of a panel data model with fixed effects. From a regional standpoint, the measurement of regional outward connectivity makes it necessary to pool multiple years in order to develop a consistent picture of the nature and destination of regional outward FDI flows. A fixed effects estimation, that would leverage within variations, would emphasize idiosyncratic year-on-year differences that are the norm when dealing with infrequent FDI decisions. For this reason, it is important to recall the exploratory nature of our empirical analysis that does not have any ambition in terms of causal claims.
10. By geo-localizing patents based on the residence of the inventor—as it is customary in the literature (see, for example, Crescenzi et al., 2022, for an extensive discussion covering the entire world)—, we are able to capture the link between the location of a particular investment project and innovation involving individuals situated within the same local labor market. These locations represent the primary hubs of innovation and frequently coincide with a firm's main R&D facilities rather than merely administrative units. Moreover, this approach helps avoid issues arising when firms register their official headquarters in US states with favorable tax or regulatory regimes without relocating any substantial R&D activity there. Conversely, attributing patents to the location of the company acting as the applicant would associate patents with the legal headquarter of the firm, making it impossible to confidently link new investment projects with local patenting output.
11. Data on human capital at the county level to be aggregated at the EA level are available starting from the year 2009.

12. Table C1 (Online Appendix C) presents preliminary estimates of a baseline KPF equation used to identify the R&D input. As the variable for human capital is available only for the year 2009, we have estimated the KPF using the R&D variable defined for the year 2009 and the 2007–2009 period alternatively. The results obtained with respect to both USPTO and PCT patents suggest a negligible coefficient of the 2009 R&D variable, while a positive and statistically significant coefficient of the R&D variable defined over the 2007–2009 period. This exercise has guided the choice to include the 2007–2009 R&D variable in the main empirical analysis. Table C2 (Online Appendix C) presents the correlation coefficients between the USPTO and PCT dependent variables and the set of explanatory variables. Tables C3 and C4 (Online Appendix C) present some descriptive statistics of the variables entering Equation (1) and the correlation matrix of the explanatory variables, respectively.
13. The choice of using only PCT patents to classify EAs and extra-regional connected territories (i.e., the EAs and the countries sourcing and receiving investments) is motivated by the international nature of PCT patents and the standardized procedure used to evaluate applications (Khan and Dernis, 2005). This facilitates the comparison among geographically different territories.
14. Table C5 (Online Appendix C) presents the distribution of investments recorded over the 2007–2009 period by domestic vs. foreign nature, and by direction.

15. The two matching procedures not only lead to the identification of highly homogenous profiles of inward (outward) US domestic vs. foreign investments but also reduce differences between the sets of inward (outward) US domestic and foreign investments in terms of monetary value. Indeed, the mean difference in monetary value between the sets of inward (outward) US domestic and foreign investments becomes statistically negligible when considering the sub-sets of matched investment projects—see Table C6 (Online Appendix C).
16. Table D1 (Online Appendix D) reports the estimated coefficients of the innovation inputs and control variables.
17. The results reported in Table 1 may appear surprising as we do not find evidence of a positive and statistically significant association between inward FDI and regional innovation, that is, a well-established result in the literature. To assess the validity of our results, we have thus estimated the baseline model on the true population of investments by considering each investment variable separately. The results reported in Table D2 (Online Appendix D) suggest a positive and statistically significant association between inward FDI and regional innovation, besides confirming the evidence on outward (domestic and foreign) investments. Taken together, our evidence points to two relevant insights: first, it corroborates the importance of international connectivity for innovation to thrive; second, it highlights how the role of inward FDI could be overestimated if outward connectivity is not accounted for. Indeed, the role of inward FDI becomes negligible when outward (domestic and foreign) investments are included in the analysis.

18. We confirm the results presented in Table 1 through a variety of robustness tests. First, we omit the time-lagged dependent variable from the regression model (Table D3, Online Appendix D). Second, we replace the time-lagged dependent variable with a variable capturing the relative innovativeness of an EA relative to the US in the 2007–2009 period, that is, through a variable capturing the share of (USPTO or PCT) patents of an EA (Table D4, Online Appendix D). Third, we consider the number of investments (normalized with respect to EAs' population) rather than their monetary value (Tables D5 and D6, Online Appendix D). Fourth, we exploit the yearly variability of investment and patent data to estimate a (static) panel data model with EA and year fixed effects—although at the expense of not controlling for EA-level human capital endowment, being this variable unavailable on a yearly basis (Table D7, Online Appendix D). Fifth, we replicate the panel analysis with EA and year fixed effects by controlling for the yearly number of inventors of PCT patents residing in an EA (relative to EAs' population) as an alternative proxy for regional human capital endowment (Table D8, Online Appendix D). Finally, we replicate the baseline analysis on the true population of investments by restricting the focus to only those investments realized in innovation-related business activities as defined by Crescenzi et al. (2014, p. 1067), namely education, training, and R&D (Table D9, Online Appendix D).
19. Table D10 (Online Appendix D) reports the estimated coefficients of the innovation inputs and control variables.
20. The results presented in Table 2 are confirmed when considering the number of investments (normalized with respect to EAs' population) rather than their monetary value (Table D11, Online Appendix D).

21. We have further tested the role of technological congruence by relying on an alternative strategy aimed at capturing the degree of technological overlap between pairs of territories interconnected through investments. Specifically, we have considered the true population of investments, and constructed each of the four variables capturing inward and outward US domestic direct investments and FDI as follows:

$$Weighted\ Investment_{r,t-1} = \frac{1}{PI_{r,t-1}}\left[\sum_{i=1}^{N}\left(V_{r,p,t-1}^{i} \times \omega_{r,p,T}\right)\right]$$

where $PI_{r,t-1}$ denotes personal income of US EA r over the period $t-1$ (i.e., years 2007, 2008, 2009); $V_{r,p,t-1}^{i}$ denotes the monetary value of inward/outward domestic (foreign) investment i connecting destination/source US EA r with source/destination US EA (foreign country) p; and $\omega_{r,p,T}$ denotes the destination-source pair specific weighting component defined with respect to the period $T = 2000, \dots, 2009$. In particular, the term $\omega_{r,p,T}$ is defined as the number of IPC classes of PCT patents common to two interconnected territories r and p relative to the total number of existing patented IPC classes in the 2000–2009 period (i.e., 125 IPC classes). Therefore, it captures the degree of technological overlap between two interconnected territories through a measure of the number of realized common occurrences over the total number of possible common realizations (Crescenzi and Ganau, 2024). The results obtained by estimating the modified version of Equation (1) to account for the weighted investment variables are reported in Table D12 (Online Appendix D), and fully corroborate the main ones.

22. A practical example would be the establishment of Industry Trade Advisory Committees (ITACs), modelled on existing frameworks such as those employed by the US International Trade Administration (ITA). ITACs function as dedicated hubs where industry experts, academic researchers, and trade specialists collaborate to advice the US government in shaping its trade policies. In practice, similar committees could be

established to work closely with IPAs to offer tailored guidance on identifying emerging market opportunities, evaluating geopolitical and economic risks, and ensuring that investment strategies align with firms' technological capabilities and long-term innovation goals, thereby equipping firms with the insights needed to make informed decisions in terms of their outward foreign investment strategies. Additionally, through direct consultations and industry roundtables, ITACs can foster dialogue between policymakers and business leaders, ensuring that investment promotion strategies remain responsive to the evolving international landscape. By bridging the gap between firms and policymakers, ITACs can help create a more dynamic, well-informed, and globally competitive investment environment.

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The authors have no interests to declare.

Data availability statement

There are no data available.

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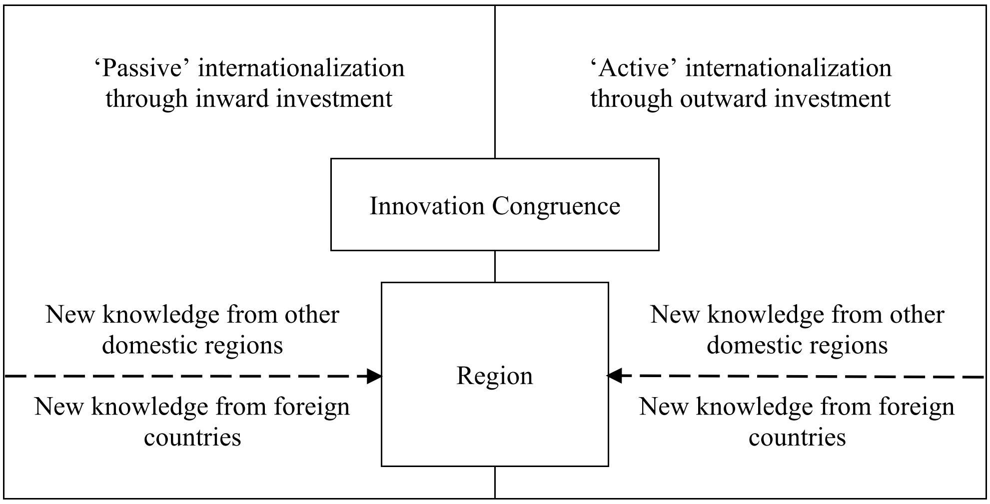
Figure 1: Conceptual framework.



Notes: Authors' elaboration.

Table 1: Spatial extent and directionality of regional connectivity.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Inward US Investments}_{r,t-1}$	0.0038	-0.0040	0.0054	0.0072	0.0006	0.0011
	(0.0095)	(0.0145)	(0.0040)	(0.0043)	(0.0030)	(0.0050)
$\text{Outward US Investments}_{r,t-1}$	0.0222***	0.0193*	0.0179*	0.0216*	0.0453***	0.0358*
	(0.0075)	(0.0101)	(0.0096)	(0.0121)	(0.0139)	(0.0207)
$\text{Inward FDI}_{r,t-1}$	-0.0010	-0.0030	-0.0017	-0.0022	-0.0027	-0.0037
	(0.0056)	(0.0076)	(0.0036)	(0.0060)	(0.0035)	(0.0053)
$\text{Outward FDI}_{r,t-1}$	0.0294****	0.0334****	0.0305****	0.0319****	0.0217****	0.0248****
	(0.0072)	(0.0080)	(0.0069)	(0.0077)	(0.0054)	(0.0069)
Innovation Inputs	Yes	Yes	Yes	Yes	Yes	Yes
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179
R^2	0.893	0.896	0.893	0.899	0.903	0.898
H_0: Homoskedasticity (p-value)	0.094	0.078	0.040	0.021	0.017	0.015

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table 2: Spatial extent and direction of regional connectivity: innovativeness of source/destination regions/countries and EA patenting heterogeneity.

Dependent Variable	$\log(\text{Patent}_{r,t})$							
Preliminary Matching on Individual Investments								
NAICS Sector and Business Activity	No				Yes			
Innovative Congruence of Source/Destination Region	No				Yes			
Patent Office	USPTO		PCT		USPTO		PCT	
Innovativeness	Low	High	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inward US $\text{Investments}_{r,t-1}$ – HIEA	-0.0004	0.0129	-0.0162	0.0200**	-0.0049	0.0004	-0.0266	0.0030
	(0.0170)	(0.0082)	(0.0211)	(0.0099)	(0.0161)	(0.0025)	(0.0335)	(0.0033)
Outward US $\text{Investments}_{r,t-1}$ – HIEA	0.0235**	0.0342***	0.0118	0.0284*	0.0294	0.0323**	-0.0055	0.0246*
	(0.0099)	(0.0113)	(0.0146)	(0.0153)	(0.0394)	(0.0130)	(0.0572)	(0.0146)
Inward US $\text{Investments}_{r,t-1}$ – LIEA	0.0038	0.0007	-0.0020	-0.0039	0.0020	-0.0020	0.0017	-0.0018
	(0.0030)	(0.0068)	(0.0057)	(0.0092)	(0.0044)	(0.0033)	(0.0029)	(0.0028)
Outward US $\text{Investments}_{r,t-1}$ – LIEA	-0.0014	-0.0004	0.0058	0.0017	0.0091	0.0024	0.0067	0.0027
	(0.0038)	(0.0071)	(0.0053)	(0.0078)	(0.0109)	(0.0028)	(0.0101)	(0.0027)
Inward $\text{FDI}_{r,t-1}$ – HIC	-0.0002	-0.0188	-0.0023	-0.0152	-0.0018	-0.0221	-0.0026	-0.0240
	(0.0060)	(0.0189)	(0.0081)	(0.0219)	(0.0045)	(0.0219)	(0.0065)	(0.0308)
Outward $\text{FDI}_{r,t-1}$ – HIC	0.0160	0.0160*	0.0238	0.0219**	0.0362	0.0185**	0.0336	0.0218**
	(0.0420)	(0.0096)	(0.0385)	(0.0098)	(0.0221)	(0.0089)	(0.0227)	(0.0109)
Inward $\text{FDI}_{r,t-1}$ – LIC	-0.0024	0.0018	0.0010	0.0021	-0.0013	0.0012	0.0010	0.0013
	(0.0016)	(0.0016)	(0.0027)	(0.0020)	(0.0011)	(0.0013)	(0.0018)	(0.0014)
Outward $\text{FDI}_{r,t-1}$ – LIC	0.0140	0.0023	0.0165**	0.0021	-0.0041	0.0013*	0.0098	0.0011
	(0.0084)	(0.0021)	(0.0079)	(0.0027)	(0.0387)	(0.0007)	(0.0219)	(0.0009)
Innovation Inputs	Yes		Yes		Yes		Yes	
Control Variables	Yes		Yes		Yes		Yes	
State Dummies	Yes		Yes		Yes		Yes	
Number of EAs	179		179		179		179	
R^2	0.915		0.918		0.914		0.914	
H_0: Homoskedasticity (p-value)	0.011		0.024		0.004		0.004	

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. Low and high levels of EA patenting are defined around the median value of the distribution of the EAs' share of PCT patents filled over the 2000–2009 period with respect to the US total. The median value is chosen as the skewness test rejects the null hypothesis of normality with p-value equal to 0.000. The dummy variable for EA patenting takes value one if an EA has a value above the median, while it takes value zero if an EA has a value below or equal to the median. There are 90 (89) EAs with low (high) value of patenting. The dummy variable for EA patenting is interacted with all investment variables. HIEA stands for high-innovative EA; LIEA stands for low-innovative EA; HIC stands for high-innovative country; LIC stands for low-innovative country. Source/destination regions/countries are defined as high- or low-innovative with respect the distribution of their share of PCT patents filled over the 2000–2009 period. The total value for EAs reflects the US total. The total value for countries is the world total excluding the US. All specifications include a constant term.

ONLINE APPENDIX

When the rain comes, don’t stay at home!
Regional innovation and FDI in the aftermath of the Great Recession

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Table of Content

APPENDIX A—Trans-local investment and innovation in the USA

The US is the country most heavily involved in international cross-border activities, in particular in terms of FDI (UNCTAD, 2017). The recent dynamics of US foreign investments has been characterized by a positive trend, and FDI has recovered quite rapidly after the negative peaks reached during both the 2001 stock market crash and the 2007 financial crisis (Figure A1). This positive FDI dynamics also characterizes the USA's world primacy: indeed, the US was classified as both the largest recipient of FDI and the most outward-investing economy during the last decade (Table A1).

Besides contributing to the USA's primacy in global ranks, both inward and outward FDI seem to play a significant role in supporting the US economy (Kornecki, 2014). For example, Goss et al. (2007) estimate that foreign-owned capital accounted for 16% of the overall US productivity growth during the 1990s, while Payne and Yu (2011) underline the contribution of foreign-owned firms to employment, job creation and high wages in the USA. Similarly, Slaughter (2010) and Jackson (2017) suggest that outward FDI contributes to the US economy in terms of employment, output, capital investment, exports, and research and development (R&D) activity through increases in the performance of US parent companies which are driven by their foreign affiliates.

In particular, the evidence of a strict relationship between FDI and R&D activity is presented in Figure A2, which shows the dynamics of business R&D expenditure in the USA in the aftermath of the Great Recession. For example, 16% of the R&D activity performed by US businesses in 2012 can be ascribed to subsidiaries of foreign MNEs, while 77% can be ascribed to US parent companies, for which foreign affiliates' R&D activity amounted to approximately US$ 45 billion (NSB, 2016).

R&D represents one of the main drivers of the innovative capacity of firms, regions and countries, and this holds true in particular for the USA. Jaffe (1989), Acs et al. (1992), Acs et al. (2002) and Crescenzi and Rodríguez-Pose (2013), among others, underline both the importance of R&D as an input for the production of innovation in the USA, as well as how R&D differentials help to explain differences in innovativeness across US localities, at both state and sub-state level.

In this respect, the literature also provides evidence on the existence of a strong spatial heterogeneity in terms of innovation—mainly captured by patent measures—within the USA (Carlino et al., 2007; Crescenzi et al., 2007; Usai, 2011). This is evidenced in Figure A3, which maps the spatial distribution of PCT patents over the 2004–2013 period, clearly highlighting a phenomenon of spatial concentration in terms of innovative performance.

For example, Crescenzi and Rodríguez-Pose (2013) show that 35% of all US patenting over the 1994–2007 period was concentrated in the top five innovative EAs. Using a similar measure of patenting and the same geographic level of aggregation, a very similar result emerges considering the subsequent 2007–2013 period: the top five most innovative EAs concentrated 40.1% of all PCT patents ascribable to the USA.[1] There is evidence of a strong spatial concentration also in terms of inward and outward FDI. The top ten innovative EAs, identified over the 2010–2013 period, concentrated over the previous 2007–2009 period a share of inward greenfield FDI ranging from 31% to 42%, and a share of outward greenfield FDI ranging from 56% to 60%. Greenfield investment projects realized over the 2007–2009 period by US-based companies across US EAs are also characterized by high levels of concentration: the share of inward US domestic investments concentrated in the top ten innovative EAs ranges from 18% to 19%, while the share of outward US investments ranges from 30% to 46% (Table A2).[2]

This evidence suggests a clear pattern characterizing regional connectivity of US EAs and their innovative performance. Specifically, the best performing regions in terms of innovative behavior have also been highly connected with other domestic and foreign territories. In other words, regions with good innovative capacity are also highly involved in trans-local connectivity at both national and global level.

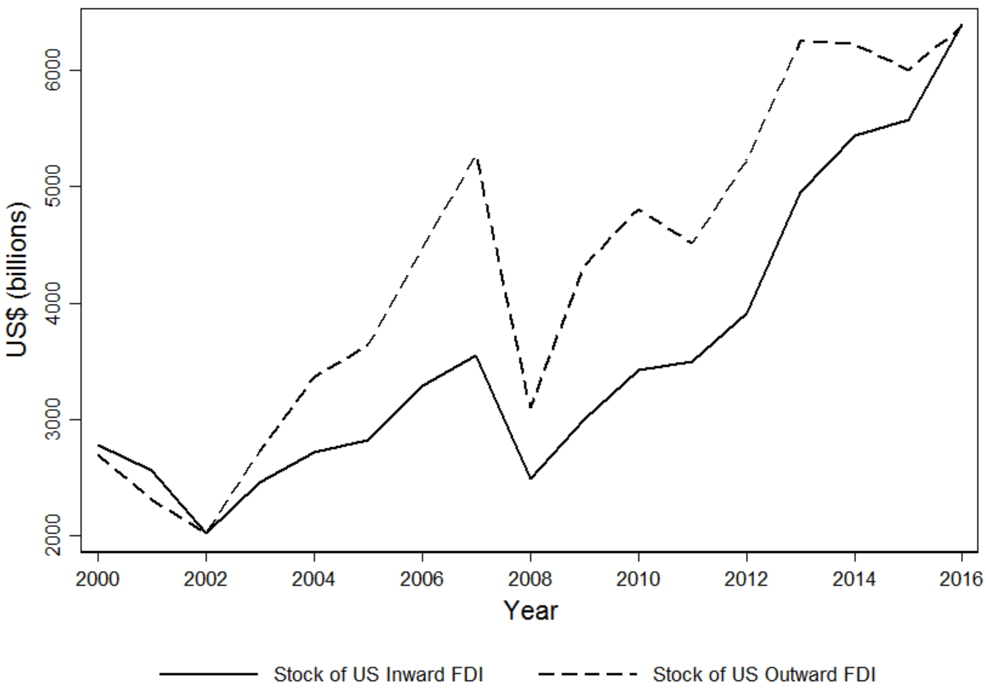
Finally, a more in-depth look at the ‘dimensions’ of US regional connectivity through greenfield direct investments over the 2007–2009 period shows that 38% of inward investment projects are of foreign origin, while foreign investments represent 69% of outward investment projects. Indeed, 105

[1] A similar figure emerges when considering USPTO patents. In this case, the top five EAs concentrated 40.3% of all USPTO patents ascribable to the USA. In addition, four of the top five innovative EAs are included in both the USPTO and PCT figures.

[2] Data on brand new greenfield investments drawn from the *fDi Markets* database (Financial Times) are used due to the absence of official statistics available at the EA level.

of the 179 US EAs have been involved in both domestic and foreign inward and outward investments, while only three EAs reported zero investments. Focusing on the 176 EAs which have shown some kind of extra-regional connections, a variegated picture emerges: 82 regions recorded more inward US domestic investments than any other type, 39 regions recorded more outward US domestic investments, 13 regions recorded more inward foreign investments, and 42 regions recorded more outward foreign investments. Overall, this preliminary evidence suggests that US EAs have shown very different patterns of regional connectivity, both in terms of spatial extent and direction of the extra-regional connectivity.

Figure A1: Inward and outward FDI in the USA, 2000–2016.



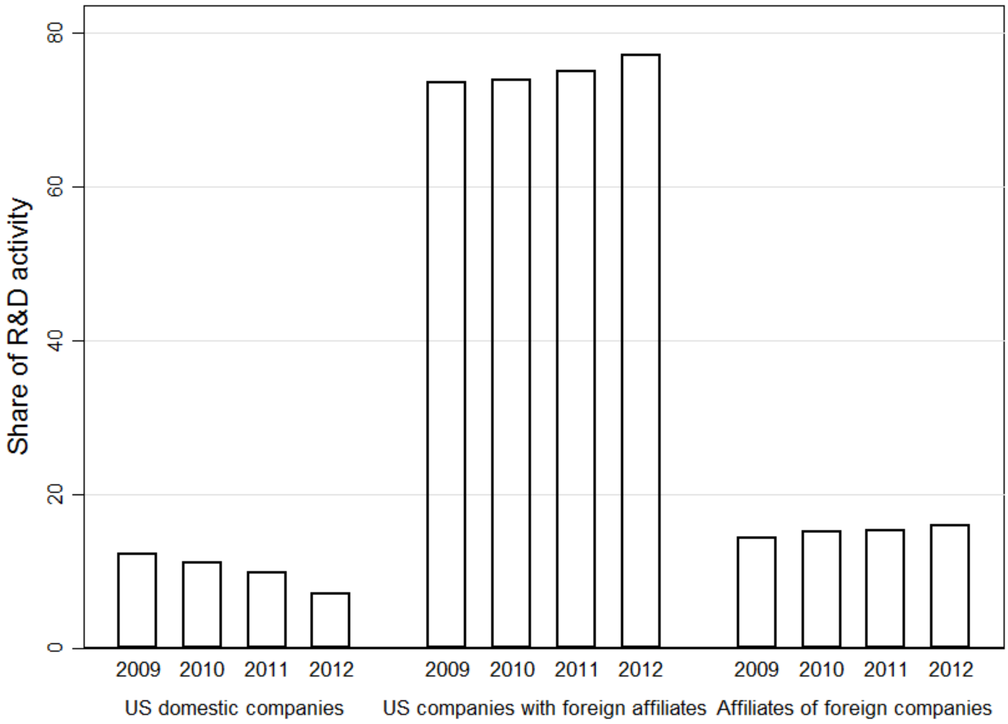
Notes: Authors' elaboration on UNCTAD data.

Table A1: FDI top performing countries.

Inward FDI Stock		Outward FDI Stock	
2006	2016	2006	2016
USA	USA	USA	USA
(23.37)	(23.91)	(29.79)	(24.40)
United Kingdom	People's Republic of China	United Kingdom	People's Republic of China
(7.35)	(11.02)	(9.75)	(10.74)
Germany	United Kingdom	Germany	United Kingdom
(5.67)	(4.48)	(6.57)	(5.52)

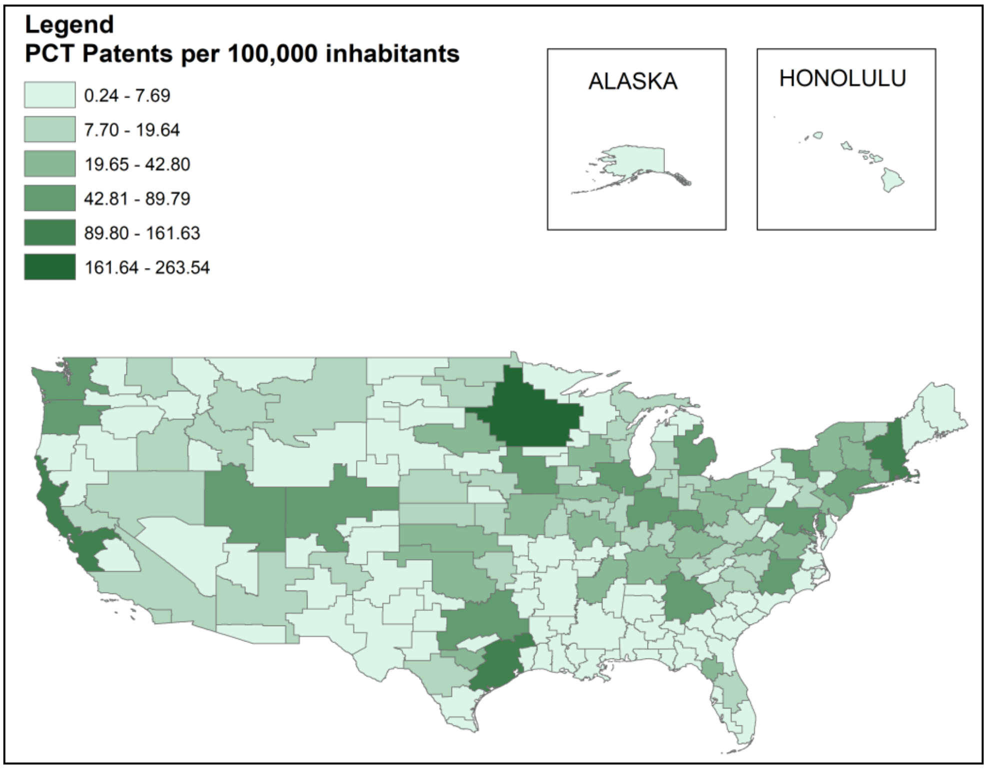
Notes: People's Republic of China includes Hong Kong. Percentages on world's total in parentheses. Authors' elaboration on UNCTAD data.

Figure A2: Dynamics of R&D activity in the USA by type of business.



Notes: Authors' elaboration on data collected by the National Science Board (NSB, 2016). A firm is defined as a foreign affiliate if more than 50% of its capital is owned by a parent company.

Figure A3: Geographic distribution of PCT patens in US EAs, 2004–2013.



Notes: Authors' elaboration on data provided by the Organization for Economic Cooperation and Development (OECD) and the US Bureau of Economic Analysis (BEA). Average values over the 2004–2013 period.

Table A2: Top ten innovative EAs and spatial concentration of greenfield investment projects.

Dimensions	Top 10 Innovative EAs (2010–2013)	
	USPTO	PCT
Patents (number, 2010–2013)	55.44	58.25
Patents (number, 2007–2009)	53.64	57.45
Inward FDI (US$, 2007–2009)	42.17	31.18
Outward FDI (US$, 2007–2009)	59.87	55.92
Inward US Investments (US$, 2007–2009)	19.31	18.24
Outward US Investments (US$, 2007–2009)	30.47	46.40
Personal Income (US$, 2009)	39.06	36.54
Population (number, 2009)	32.45	33.46

Notes: Percentage values on US totals. Inward (outward) FDI refers to greenfield investment projects realized by foreign companies (US companies) in US EAs (other countries). Inward (outward) US investments are greenfield investment projects realized by US-based companies across US EAs. Authors' elaboration on patent data drawn from the *PatentsView* database (USPTO) and *REGPAT* database (OECD); on greenfield investment data drawn from the *fDi Markets* database (Financial Times); and on US BEA data.

APPENDIX B—The *fDi Markets* database

As highlighted in the main text, the main limitation of the *fDi Markets* database is that it only collects information on greenfield investments, excluding data on other types of investments, especially mergers and acquisition (M&A). Indeed, the analysis of FDI connectivity would benefit from the possibility to leverage a comprehensive, comparable and fully geocoded dataset for both greenfield FDI (as the one we leverage in this paper) and M&A.

Ensuring data comparability and consistency across different types of investments to render fully homogeneous insights into their regional impacts would require data work that is in our agenda for future research but that goes beyond the scope of this paper. Indeed, M&A deals often involve multiple entities, have undisclosed values and need very specific assumptions on what share of ownership determines control over the foreign subsidiary in the same way as a fully owned 'greenfield' operation. Therefore, the comparability of the connectivity enabled by these two investment modes would require relevant *ad hoc* assumptions and, for this reason, the existing literature has extensively relied on greenfield FDI as a proxy of regional FDI connectivity. It is also worth underlying that FDI, particularly M&A vs. greenfield investments, may have differing propensities towards knowledge-seeking or asset-seeking motivations (Carril-Caccia and Pavlova, 2018).

However, our paper—by focusing on regional rather than firm-level dynamics—seeks to capture the aggregate impact of such investments on regional connectivity without making any ad hoc assumption on the primacy of one investment motivation over others. The differentiation of investment motivations at the firm level may indeed offer a granular understanding of investment impacts, which a regional or country-level analysis may not fully disentangle. It is also essential to acknowledge that accurately attributing a single motive to multifunctional investments can be challenging, given that firms often pursue several objectives simultaneously. Therefore, while our paper might not delve into the specific motivations behind each investment, it aims to provide a comprehensive view of how varied types of investments collectively influence regional connectivity profiles, acknowledging the complex interplay of investment motives in shaping economic dynamics. In addition, statistical data provided by UNCTAD in its "*World Investment Report"* (2022, and previous editions) offer reassurance over the relative importance of greenfield FDI in terms of global investment flows vs. M&A.

In summary, our selection of greenfield investments as the primary data source is a deliberate methodological choice grounded in the aim to provide clear, actionable insights into the regional economic impacts of new investments. While we recognize the limitations of this approach and the broader significance of M&A, we believe that our analysis contributes valuable perspectives to the understanding of regional economic development and connectivity in the context of (local and global) investment flows.

Moreover, the use of the *fDI Markets* database to capture outward FDI connectivity is in line with previous contributions analyzing the home returns of outward FDI at the regional level. For example, Castellani and Pieri (2013) analyze the aggregate region-level returns of outward FDI in R&D and manufacturing activities on the home region's labor productivity in the EU, and use the same *fDi Markets* database that we also leverage to capture outward FDI. Similarly, Castellani and Pieri (2016), by employing the *fDi Markets* database, analyze the aggregate region-level returns of overall outward FDI on the home region's labor productivity in the EU. More recently, Crescenzi et al. (2022) have employed the *fDi Markets* database to analyze the returns of outward FDI on regional employment in the USA.

Concerning our sample, Tables B1 and B2 report the distribution of investment projects by two-digit NAICS sector and business activity, respectively.

Table B1: Distribution of investment projects by two-digit NAICS sector.

Two-Digit NAICS Sector	US Domestic Investments		FDI			
			Inward		Outward	
	No.	%	No.	%	No.	%
11 – Agriculture, Forestry, Fishing, Hunting	2	0.05	3	0.13	9	0.11
21 – Mining, Quarrying, Oil and Gas Extraction	20	0.54	14	0.63	92	1.13
22 – Utilities	139	3.75	56	2.52	147	1.80
23 – Construction	75	2.03	14	0.63	168	2.06
31 – Manufacturing	109	2.94	77	3.46	296	3.63
32 – Manufacturing	300	8.10	225	10.12	646	7.92
33 – Manufacturing	532	14.37	670	30.13	1,794	22.00
42 – Wholesale Trade	4	0.11	0	0.00	1	0.01
44 – Retail Trade	47	1.27	185	8.32	437	5.36
45 – Retail Trade	27	0.73	4	0.18	39	0.48
48 – Transportation, Warehousing	52	1.40	19	0.85	53	0.65
49 – Transportation, Warehousing	167	4.51	49	2.20	210	2.57
51 – Information	429	11.59	342	15.38	1,673	20.51
52 – Finance, Insurance	728	19.67	186	8.36	676	8.29
53 – Real Estate, Rental, Leasing	66	1.78	63	2.83	123	1.51
54 – Professional, Scientific, Technical Services	604	16.32	207	9.31	1,027	12.59
56 – Administrative and Support and Waste Management and Remediation Services	174	4.70	48	2.16	302	3.70
61 – Educational Services	42	1.13	9	0.40	78	0.96
62 – Health Care and Social Assistance	122	3.30	20	0.90	34	0.42
71 – Arts, Entertainment, Recreation	6	0.16	11	0.49	48	0.59
72 – Accommodation and Food Services	57	1.54	22	0.99	303	3.72
Total	3,702	100.00	2,224	100.00	8,156	100.00

Notes: Percentage values on column totals. Sector 31 includes: food manufacturing; beverage and tobacco product manufacturing; textile mills; textile product mills; apparel manufacturing; leather and allied product manufacturing. Sector 32 includes: wood product manufacturing; paper manufacturing; printing and related support activities; petroleum and coal products manufacturing; chemical manufacturing; plastics and rubber products manufacturing; non-metallic mineral product manufacturing. Sector 33 includes: primary metal manufacturing; fabricated metal product manufacturing; machinery manufacturing; computer and electronic product manufacturing; electrical equipment, appliance and component manufacturing; transportation equipment manufacturing; furniture and related product manufacturing; miscellaneous manufacturing. Sector 44 includes: motor vehicle and parts dealers; furniture and home furnishings stores; electronics and appliance stores; building material and garden equipment and supplies dealers; food and beverage stores; health and personal care stores; gasoline stations; clothing and clothing accessories stores. Sector 45 includes: sporting goods, hobby, musical instrument, and book stores; general merchandise stores; miscellaneous store retailers; non-store retailers. Sector 48 includes: air transportation; rail transportation; water transportation; truck transportation; transit and ground passenger transportation; pipeline transportation; scenic and sightseeing transportation; support activities for transportation. Sector 49 includes: postal service; couriers and messengers; warehousing and storage.

Table B2: Distribution of investment projects by business activity.

Business Activity	US Domestic Investments		FDI			
			Inward		Outward	
	No.	%	No.	%	No.	%
Business Services	1,410	38.09	395	17.76	1,448	17.75
Construction	132	3.57	39	1.75	411	5.04
Customer Contact Centre	98	2.65	23	1.03	123	1.51
Design, Development, Testing	96	2.59	73	3.28	523	6.41
Education and Training	47	1.27	18	0.81	143	1.75
Electricity	45	1.22	24	1.08	54	0.66
Extraction	10	0.27	3	0.13	68	0.83
Headquarters	145	3.92	244	10.97	476	5.84
ICT and Internet Infrastructure	107	2.89	28	1.26	169	2.07
Logistics, Distribution, Transportation	385	10.40	113	5.08	297	3.64
Maintenance and Servicing	46	1.24	22	0.99	70	0.86
Manufacturing	517	13.97	335	15.06	971	11.91
Recycling	26	0.70	10	0.45	17	0.21
R&D	37	1.00	37	1.66	190	2.33
Retail	0	0.00	253	11.38	765	9.38
Sales, Marketing, Support	561	15.15	598	26.89	2,295	28.14
Shared Services Centre	15	0.41	4	0.18	57	0.70
Technical Support Centre	25	0.68	5	0.22	79	0.97
Total	3,702	100.00	2,224	100.00	8,156	100.00

Notes: Percentage values on column totals.

APPENDIX C—Descriptive statistics and preliminary analyses

This Appendix presents some descriptive statistics on the sample and the data used in the empirical analysis, as well as the results concerning the preliminary analyses carried out on the specification of the regional knowledge production function and the matching procedures.

Table C1: Baseline regional knowledge production function.

Dependent Variable	$\log(\text{Patent}_{r,t})$			
Patent Office	USPTO		PCT	
	(1)	(2)	(3)	(4)
$\text{Human Capital}_{r,2009}$	0.1154***	0.0937**	0.1222***	0.0972**
	(0.0397)	(0.0399)	(0.0409)	(0.0410)
$\text{R\&D}_{r,2009}$	0.0627	…	0.0751	…
	(0.0617)		(0.0636)	
$\text{R\&D}_{r,t-1}$	…	0.2256**	…	0.2631***
		(0.0977)		(0.1002)
State Dummies	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179
R^2	0.495	0.515	0.514	0.539
H_0: Homoskedasticity (p-value)	0.850	0.578	0.567	0.786

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Standard errors in parentheses.

Table C2: Correlation coefficients of patents with innovation inputs and investment variables.

Dependent Variable	$\log(\mathrm{Patent}_{r,t})$			
Patent Office	USPTO		PCT	
	ρ	p-value	ρ	p-value
$\log(\mathrm{Patent}_{r,t-1})$	0.8420	0.0000	0.8445	0.0000
$\mathrm{Human\ Capital}_{r,2009}$	0.3479	0.0000	0.3585	0.0000
$\mathrm{R\&D}_{r,2009}$	0.1724	0.0210	0.1688	0.0239
$\mathrm{R\&D}_{r,t-1}$	0.2780	0.0002	0.2898	0.0001
$\mathrm{Inward\ US\ Investments}_{r,t-1}$	0.0033	0.9651	-0.0128	0.8651
$\mathrm{Outward\ US\ Investments}_{r,t-1}$	0.0613	0.4147	0.0754	0.3157
$\mathrm{Inward\ FDI}_{r,t-1}$	-0.1014	0.1767	-0.1118	0.1364
$\mathrm{Outward\ FDI}_{r,t-1}$	0.2039	0.0062	0.2616	0.0004

Table C3: Descriptive statistics of the dependent and explanatory variables.

	Mean	Std. Dev.	Min.	Max.
$\log(\text{USPTO Patent}_{r,t-1})$	5.2949	1.2608	1.6191	8.7563
$\log(\text{PCT Patent}_{r,t-1})$	4.2752	1.3257	0.9037	7.8741
$\text{Inward US Investments}_{r,t-1}$	0.0007	0.0012	0.0000	0.0103
$\text{Outward US Investments}_{r,t-1}$	0.0003	0.0011	0.0000	0.0133
$\text{Inward FDI}_{r,t-1}$	0.0004	0.0012	0.0000	0.0132
$\text{Outward FDI}_{r,t-1}$	0.0005	0.0014	0.0000	0.0162
$\text{Human Capital}_{r,2009}$	18.7932	4.3628	11.7778	34.0000
$\text{R\&D}_{r,t-1}$	0.6231	1.2233	0.0000	8.5551
$\log(\text{USPTO Patent}_{r,t-1})$	2.9432	0.9230	0.2881	5.6270
$\log(\text{PCT Patent}_{r,t-1})$	2.2481	0.9965	0.0576	4.7668
$\text{Sectoral Concentration}_{r,2009}$	0.0037	0.0069	0.0000	0.0614
$\text{Manufacturing Share}_{r,2009}$	0.1022	0.0452	0.0213	0.2600
$\text{Services Share}_{r,2009}$	0.7571	0.0640	0.5910	0.8894

Table C4: Correlation matrix of explanatory variables.

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Inward US Investments$_{r,t-1}$	[1]	1										
Outward US Investments$_{r,t-1}$	[2]	-0.03	1									
Inward FDI$_{r,t-1}$	[3]	0.00	-0.03	1								
Outward FDI$_{r,t-1}$	[4]	-0.06	0.05	-0.05	1							
Human Capital$_{r,2009}$	[5]	-0.04	-0.02	-0.03	0.13	1						
R&D$_{r,t-1}$	[6]	-0.04	0.00	0.13	0.04	0.30	1					
$\log(\text{USPTO Patent}_{r,t-1})$	[7]	-0.07	-0.01	-0.10	0.19	0.53	0.41	1				
$\log(\text{PCT Patent}_{r,t-1})$	[8]	-0.02	0.01	-0.08	0.23	0.53	0.43	0.87	1			
Sectoral Concentration$_{r,2009}$	[9]	0.11	-0.01	0.01	-0.12	-0.14	-0.12	-0.33	-0.36	1		
Manufacturing Share$_{r,2009}$	[10]	-0.06	0.06	-0.03	0.03	-0.33	0.01	0.07	0.04	-0.01	1	
Services Share$_{r,2009}$	[11]	-0.18	-0.02	-0.01	0.13	0.47	0.16	0.40	0.43	-0.55	-0.57	1

Table C5: Inward and outward US domestic and foreign investments.

Spatial Extent / Direction	True Sample		Matched Sample (a)		Matched Sample (b)	
	Inward	Outward	Inward	Outward	Inward	Outward
US Domestic Investments	3,702	3,702	1,290	2,665	1,283	2,561
FDI	2,224	8,156	1,290	2,665	1,283	2,561

Notes: Number of investment projects. (a) One-to-one exact matching with random sampling of matched investments based on two-digit NAICS sector and business activity of individual investment projects (b) One-to-one exact matching with random sampling of matched investments based on two-digit NAICS sector, business activity, and innovative congruence of source (inward) / destination (outward) region of individual investment projects. Regions (i.e., EAs for domestic investments, and countries for FDI) are defined as either low- or high-innovative with respect to the distribution of PCT patents filled over the 2000-2009 period. The total value for EAs reflects the US total. The total value for countries is the world total excluding the US.

Table C6: Difference in mean monetary value of investments: pre- and post-matching procedure.

Spatial Extent / Direction	Inward					
	True Sample		Matched Sample (a)		Matched Sample (b)	
	Mean Value	Difference [p-value]	Mean Value	Difference [p-value]	Mean Value	Difference [p-value]
US Domestic Investments	31.77	-4.27 [0.089]	52.33	7.40 [0.519]	41.57	-0.60 [0.936]
FDI	36.04		44.93		42.17	
Spatial Extent / Direction	**Outward**					
	True Sample		Matched Sample (a)		Matched Sample (b)	
	Mean Value	Difference [p-value]	Mean Value	Difference [p-value]	Mean Value	Difference [p-value]
US Domestic Investments	31.77	-13.85 [0.000]	48.12	-9.07 [0.168]	49.21	-4.67 [0.494]
FDI	45.62		57.19		53.88	

Notes: Mean monetary value of investment projects (in US million dollar). (a) One-to-one exact matching with random sampling of matched investments based on two-digit NAICS sector and business activity of individual investment projects (b) One-to-one exact matching with random sampling of matched investments based on two-digit NAICS sector, business activity, and innovative congruence of source (inward) / destination (outward) region of individual investment projects. Regions (i.e., EAs for domestic investments, and countries for FDI) are defined as either low- or high-innovative with respect to the distribution of PCT patents filled over the 2000-2009 period. The total value for EAs reflects the US total. The total value for countries is the world total excluding the US.

APPENDIX D—Additional results and robustness analysis

This Appendix presents the estimated coefficients of the control variables not included in the tables reported in the main text, as well as the results of the robustness exercises.

Table D1: Innovation inputs and control variables not shown in Table 1 in the main text.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(\text{Patent}_{r,t-1})$	0.6514****	0.5692****	0.6468****	0.5786****	0.6394****	0.5651****
	(0.0544)	(0.0594)	(0.0560)	(0.0567)	(0.0576)	(0.0628)
$\text{Human Capital}_{r,2009}$	0.1908**	0.2311*	0.2034**	0.2528*	0.1937**	0.2291*
	(0.0867)	(0.1249)	(0.0820)	(0.1297)	(0.0878)	(0.1263)
$\text{R\&D}_{r,t-1}$	0.0018**	0.0056**	0.0038**	0.0050**	0.0050**	0.0026*
	(0.0008)	(0.0024)	(0.0016)	(0.0022)	(0.0021)	(0.0014)
$\text{Sectoral Concentration}_{r,2009}$	-0.0049	-0.0107	-0.0048	-0.0124	-0.0074	-0.0152
	(0.0126)	(0.0129)	(0.0107)	(0.0115)	(0.0115)	(0.0112)
$\text{Manufacturing Share}_{r,2009}$	-0.0925*	-0.0839	-0.0682	-0.0583	-0.1111**	-0.0976
	(0.0542)	(0.0746)	(0.0560)	(0.0720)	(0.0545)	(0.0745)
$\text{Services Share}_{r,2009}$	0.5675**	0.4647	0.5298	0.4717	0.6529**	0.5283
	(0.2650)	(0.4504)	(0.3195)	(0.4351)	(0.2501)	(0.4355)
Number of EAs	179	179	179	179	179	179

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses.

Table D2: Spatial extent and directionality of regional connectivity – Assessing the individual role of investment variables.

Dependent Variable	$\log(\text{Patent}_{r,t})$							
Preliminary Matching on Individual Investments	No							
Patent Office	USPTO				PCT			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Inward US Investments}_{r,t-1}$	0.0066	…	…	…	0.0023	…	…	…
	(0.0097)				(0.0142)			
$\text{Outward US Investments}_{r,t-1}$	…	0.0293****	…	…	…	0.0243*	…	…
		(0.0080)				(0.0131)		
$\text{Inward FDI}_{r,t-1}$	…	…	0.0060*	…	…	…	0.0075**	…
			(0.0032)				(0.0035)	
$\text{Outward FDI}_{r,t-1}$	…	…	…	0.0340****	…	…	…	0.0354****
				(0.0071)				(0.0082)
$\log(\text{Patent}_{r,t-1})$	0.7630****	0.7389****	0.7608****	0.6597****	0.6871****	0.6554****	0.6835****	0.5957****
	(0.0680)	(0.0596)	(0.0703)	(0.0569)	(0.0556)	(0.0564)	(0.0568)	(0.0552)
$\text{Human Capital}_{r,2009}$	0.1095*	0.1344*	0.1259*	0.1909**	0.1683**	0.1662*	0.1693*	0.2425*
	(0.0644)	(0.0790)	(0.0740)	(0.0898)	(0.0792)	(0.0977)	(0.0890)	(0.1275)
$\text{R\&D}_{r,t-1}$	0.0015***	0.0016***	0.0022*	0.0046***	0.0018**	0.0034**	0.0059***	0.0054***
	(0.0006)	(0.0006)	(0.0013)	(0.0014)	(0.0008)	(0.0014)	(0.0020)	(0.0019)
$\text{Sectoral Concentration}_{r,2009}$	0.0019	0.0032	0.0038	-0.0041	-0.0005	-0.0023	-0.0015	-0.0113
	(0.0134)	(0.0133)	(0.0132)	(0.0115)	(0.0153)	(0.0133)	(0.0139)	(0.0114)
$\text{Manufacturing Share}_{r,2009}$	-0.0554	-0.0910	-0.0585	-0.0713	-0.0478	-0.0673	-0.0470	-0.0658
	(0.0614)	(0.0555)	(0.0613)	(0.0571)	(0.0778)	(0.0753)	(0.0779)	(0.0733)
$\text{Services Share}_{r,2009}$	0.2407	0.3966	0.2232	0.4537	0.1155	0.2278	0.1255	0.3990
	(0.3168)	(0.2817)	(0.3250)	(0.2961)	(0.4718)	(0.4530)	(0.4660)	(0.4406)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179	179	179
R^2	0.859	0.875	0.858	0.883	0.874	0.880	0.874	0.892

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D3: Spatial extent and directionality of regional connectivity – Lagged dependent variable omitted from the regression model.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
Inward US $\text{Investments}_{r,t-1}$	0.0034	-0.0026	0.0180	0.0096	0.0018	0.0005
	(0.0060)	(0.0172)	(0.0148)	(0.0071)	(0.0051)	(0.0063)
Outward US $\text{Investments}_{r,t-1}$	0.0407***	0.0179**	0.0107*	0.0310*	0.0748**	0.0461*
	(0.0122)	(0.0077)	(0.0061)	(0.0177)	(0.0343)	(0.0245)
Inward $\text{FDI}_{r,t-1}$	-0.0069	-0.0602	-0.0574	-0.0871	-0.0294	-0.0462
	(0.0098)	(0.2066)	(0.1244)	(0.1955)	(0.1722)	(0.1927)
Outward $\text{FDI}_{r,t-1}$	0.0211***	0.0732****	0.0596****	0.0727****	0.0460****	0.0527****
	(0.0068)	(0.0145)	(0.0098)	(0.0133)	(0.0086)	(0.0104)
$\log(\text{Patent}_{r,t-1})$	No	No	No	No	No	No
Human $\text{Capital}_{r,2009}$	0.0159**	0.0255****	0.0143**	0.0182****	0.0150****	0.0189****
	(0.0075)	(0.0067)	(0.0059)	(0.0052)	(0.0034)	(0.0046)
$\text{R\&D}_{r,t-1}$	0.0072****	0.0325***	0.0258***	0.0358***	0.0280****	0.0379****
	(0.0019)	(0.0110)	(0.0080)	(0.0108)	(0.0081)	(0.0106)
Sectoral $\text{Concentration}_{r,2009}$	-0.0092	-0.0358	-0.0271	-0.0421	-0.0297	-0.0296
	(0.0085)	(0.0231)	(0.0171)	(0.7243)	(0.0181)	(0.1240)
Manufacturing $\text{Share}_{r,2009}$	-0.0395*	-0.0604	-0.1234	-0.1164	-0.0434**	-0.0503
	(0.0212)	(0.1231)	(0.0820)	(0.1156)	(0.0216)	(0.1016)
Services $\text{Share}_{r,2009}$	1.0106***	0.1037	0.2033	0.1905	0.2120****	0.0168
	(0.3023)	(0.8401)	(0.4795)	(0.8028)	(0.0400)	(0.7854)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179
R^2	0.740	0.767	0.739	0.759	0.752	0.769
H_0: Homoskedasticity (p-value)	0.035	0.025	0.053	0.034	0.033	0.024

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D4: Spatial extent and directionality of regional connectivity – Controlling for the relative innovativeness of US EAs in 2007–2009.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Inward US Investments}_{r,t-1}$	0.0019	0.0022	0.0097	0.0020	0.0011	0.0020
	(0.0068)	(0.0057)	(0.0064)	(0.0050)	(0.0062)	(0.0172)
$\text{Outward US Investments}_{r,t-1}$	0.0132**	0.0117**	0.0151***	0.0174***	0.0386****	0.0187**
	(0.0052)	(0.0054)	(0.0046)	(0.0066)	(0.0113)	(0.0076)
$\text{Inward FDI}_{r,t-1}$	-0.0019	-0.0017	-0.0014	-0.0020	-0.0142	-0.0129
	(0.0068)	(0.0068)	(0.0074)	(0.0057)	(0.0086)	(0.0082)
$\text{Outward FDI}_{r,t-1}$	0.0554***	0.0529***	0.0433****	0.0538****	0.0362****	0.0422****
	(0.0186)	(0.0178)	(0.0102)	(0.0138)	(0.0092)	(0.0107)
$\text{Share Patent to US}_{r,t-1}$	0.0230***	0.0229*	0.0223****	0.0295**	0.0197**	0.0244**
	(0.0073)	(0.0133)	(0.0057)	(0.0125)	(0.0091)	(0.0123)
$\text{Human Capital}_{r,2009}$	0.1408***	0.1222*	0.1065**	0.1861*	0.2285**	0.1344*
	(0.0431)	(0.0690)	(0.0407)	(0.1050)	(0.0874)	(0.0758)
$\text{R\&D}_{r,t-1}$	0.0387*	0.0274**	0.0228***	0.0285**	0.0253***	0.0318***
	(0.0222)	(0.0114)	(0.0076)	(0.0109)	(0.0075)	(0.0108)
$\text{Sectoral Concentration}_{r,2009}$	-0.0122	-0.0315	-0.0225	-0.0350	-0.0248	-0.0108
	(0.0081)	(0.0237)	(0.0160)	(0.0216)	(0.0180)	(0.0068)
$\text{Manufacturing Share}_{r,2009}$	-0.0790	-0.0456	-0.0900	-0.0826	-0.0374	-0.0209
	(0.1549)	(0.1226)	(0.0774)	(0.1130)	(0.0971)	(0.1214)
$\text{Services Share}_{r,2009}$	0.1860**	0.1867	0.1611	0.2098	0.0568	0.0957
	(0.0774)	(0.8704)	(0.4498)	(0.8202)	(0.7215)	(0.8238)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179
R^2	0.762	0.779	0.773	0.784	0.778	0.785
H_0: Homoskedasticity (p-value)	0.054	0.022	0.038	0.016	0.016	0.066

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D5: Spatial extent and directionality of regional connectivity – Number of investments per 100,000 inhabitants.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Inward US Investments}_{r,t-1}$	0.0159	-0.0017	0.0298	0.0282	0.0213	0.0317
	(0.0161)	(0.0333)	(0.0191)	(0.0246)	(0.0308)	(0.0391)
$\text{Outward US Investments}_{r,t-1}$	0.0470**	0.0822**	0.0366**	0.0568**	0.0484**	0.0622**
	(0.0203)	(0.0379)	(0.0172)	(0.0255)	(0.0237)	(0.0288)
$\text{Inward FDI}_{r,t-1}$	0.0242	0.0271	0.0022	-0.0039	0.0050	0.0192
	(0.0172)	(0.0288)	(0.0151)	(0.0191)	(0.0241)	(0.0296)
$\text{Outward FDI}_{r,t-1}$	0.0975***	0.1378*	0.0476**	0.0789***	0.0308*	0.0274*
	(0.0359)	(0.0743)	(0.0209)	(0.0293)	(0.0162)	(0.0165)
$\log(\text{Patent}_{r,t-1})$	0.6498****	0.6067****	0.6553****	0.5948****	0.6292****	0.5694****
	(0.0709)	(0.0517)	(0.0594)	(0.0544)	(0.0706)	(0.0559)
$\text{Human Capital}_{r,2009}$	0.1203**	0.1634***	0.0928**	0.1288**	0.1306**	0.1685*
	(0.0509)	(0.0615)	(0.0396)	(0.0554)	(0.0565)	(0.0873)
$\text{R\&D}_{r,t-1}$	0.0001*	0.0109*	0.0008*	0.0112**	0.0035*	0.0053*
	(0.0001)	(0.0059)	(0.0004)	(0.0048)	(0.0018)	(0.0028)
$\text{Sectoral Concentration}_{r,2009}$	-0.0026	-0.0070	-0.0004	-0.0063	-0.0000	-0.0049
	(0.0119)	(0.0148)	(0.0111)	(0.0146)	(0.0124)	(0.0139)
$\text{Manufacturing Share}_{r,2009}$	-0.0791	-0.0879	-0.0924	-0.1090	-0.1077*	-0.1153
	(0.0601)	(0.0809)	(0.0585)	(0.0802)	(0.0593)	(0.0776)
$\text{Services Share}_{r,2009}$	0.6883**	0.7282	0.6539*	0.7557	0.7163**	0.7619
	(0.3340)	(0.5285)	(0.3443)	(0.5458)	(0.3447)	(0.5279)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179
R^2	0.883	0.898	0.883	0.901	0.887	0.898
H_0: Homoskedasticity (p-value)	0.098	0.041	0.096	0.028	0.046	0.021

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D6: Spatial extent and directionality of regional connectivity – Number of investments per 100,000 inhabitants and lagged dependent variable omitted from the regression model.

Dependent Variable	$\log(\text{Patent}_{r,t})$					
Preliminary Matching on Individual Investments						
NAICS Sector and Business Activity	No		Yes		Yes	
Innovative Congruence of Source/Destination Region	No		No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)	(5)	(6)
Inward US $\text{Investments}_{r,t-1}$	0.1080	0.1679	0.0100	0.0628	0.0281	0.0384
	(0.2014)	(0.1245)	(0.0067)	(0.0456)	(0.0418)	(0.0496)
Outward US $\text{Investments}_{r,t-1}$	0.0747***	0.1041**	0.0449**	0.0644**	0.0732**	0.1141***
	(0.0280)	(0.0414)	(0.0216)	(0.0321)	(0.0328)	(0.0381)
Inward $\text{FDI}_{r,t-1}$	0.0157	0.0005	0.0305	0.0136	0.0294	0.0014
	(0.0242)	(0.0516)	(0.0285)	(0.0408)	(0.0265)	(0.0341)
Outward $\text{FDI}_{r,t-1}$	0.0773****	0.1441***	0.0892***	0.1405****	0.0783****	0.1024****
	(0.0175)	(0.0491)	(0.0306)	(0.0372)	(0.0205)	(0.0254)
$\log(\text{Patent}_{r,t-1})$	No	No	No	No	No	No
Human $\text{Capital}_{r,2009}$	0.2129***	0.1598***	0.1167***	0.1349***	0.0792**	0.0702***
	(0.0734)	(0.0582)	(0.0397)	(0.0452)	(0.0337)	(0.0238)
$\text{R\&D}_{r,t-1}$	0.0660*	0.0229**	0.0140*	0.0223*	0.0198**	0.0295***
	(0.0348)	(0.0113)	(0.0080)	(0.0130)	(0.0084)	(0.0105)
Sectoral $\text{Concentration}_{r,2009}$	-0.0164	-0.0276	-0.0144	-0.0208	-0.0158	-0.0243
	(0.0101)	(0.0205)	(0.0169)	(0.0182)	(0.0141)	(0.0177)
Manufacturing $\text{Share}_{r,2009}$	-0.0482	-0.0649	-0.0487	-0.0213	-0.0225	-0.0149
	(0.0403)	(0.1108)	(0.0855)	(0.1093)	(0.0900)	(0.1156)
Services $\text{Share}_{r,2009}$	0.3964*	0.4424	0.2286*	0.3460	0.4188*	0.5634
	(0.2090)	(0.7315)	(0.1292)	(0.8265)	(0.2385)	(0.7461)
State Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of EAs	179	179	179	179	179	179
R^2	0.730	0.739	0.728	0.752	0.746	0.771
H_0: Homoskedasticity (p-value)	0.049	0.079	0.033	0.090	0.073	0.046

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D7: Spatial extent and directionality of regional connectivity – Static panel regression model.

Dependent Variable	$\log(\text{Patent}_{r,t})$			
Estimation Method	Two-Way FE			
Unit of Measurement of Investments	Monetary Value		Number	
Patent Office	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)
$\text{Inward US Investments}_{r,t}$	0.0179	0.0037	0.0049	-0.0147
	(0.0124)	(0.0118)	(0.0150)	(0.0129)
$\text{Outward US Investments}_{r,t}$	0.0186*	0.0105***	0.0020**	0.0008*
	(0.0105)	(0.0038)	(0.0009)	(0.0004)
$\text{Inward FDI}_{r,t}$	0.0081	-0.0002	-0.0023	-0.0009
	(0.0086)	(0.0045)	(0.0020)	(0.0020)
$\text{Outward FDI}_{r,t}$	0.0213****	0.0210**	0.0080****	0.0038***
	(0.0048)	(0.0106)	(0.0013)	(0.0012)
$\log(\text{Patent}_{r,t-1})$	No	No	No	No
$\text{Human Capital}_{r,t}$	No	No	No	No
$\text{R\&D}_{r,t}$	0.5407**	0.2544**	0.5704**	0.2226*
	(0.2659)	(0.1252)	(0.2523)	(0.1265)
$\text{Sectoral Concentration}_{r,t}$	-1.6527	-1.0149	-1.8377	-1.0692
	(1.6533)	(1.4758)	(1.5206)	(1.4222)
$\text{Manufacturing Share}_{r,t}$	-0.0710	-0.0873	-0.0625	-0.0894
	(0.0662)	(0.0711)	(0.0643)	(0.0717)
$\text{Services Share}_{r,t}$	0.7249****	0.1729	0.6267****	0.1591
	(0.1850)	(0.1624)	(0.1749)	(0.1607)
EA Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,253	1,253	1,253	1,253
Number of EAs	179	179	179	179
Number of Years	7	7	7	7
Model F Statistic [p-value]	20.25 [0.000]	30.57 [0.000]	33.68 [0.000]	34.62 [0.000]

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term. The variable for human capital is excluded from the regression model due to unavailable data before the year 2009.

Table D8: Spatial extent and directionality of regional connectivity – Static panel regression model proxying human capital by the yearly number of PCT patents' inventors per 100,000 inhabitants.

Dependent Variable	$\log(\text{Patent}_{r,t})$			
Estimation Method	Two-Way FE			
Unit of Measurement of Investments	Monetary Value		Number	
Patent Office	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)
$\text{Inward US Investments}_{r,t}$	0.0166	0.0042	0.0073	0.0089
	(0.0124)	(0.0158)	(0.0081)	(0.0096)
$\text{Outward US Investments}_{r,t}$	0.0174*	0.0109**	0.0021**	0.0012*
	(0.0098)	(0.0049)	(0.0009)	(0.0006)
$\text{Inward FDI}_{r,t}$	-0.0064	-0.0021	-0.0024	-0.0005
	(0.0050)	(0.0018)	(0.0019)	(0.0006)
$\text{Outward FDI}_{r,t}$	0.0205****	0.0143*	0.0079****	0.0028**
	(0.0046)	(0.0082)	(0.0013)	(0.0011)
$\log(\text{Patent}_{r,t-1})$	No	No	No	No
$\text{Patent Inventors}_{r,t}$	0.2285**	1.8076****	0.1993**	1.8053****
	(0.0885)	(0.2070)	(0.0840)	(0.2072)
$\text{R\&D}_{r,t}$	0.5451**	0.2092*	0.5731**	0.1911*
	(0.2685)	(0.1066)	(0.2549)	(0.1076)
$\text{Sectoral Concentration}_{r,t}$	-1.6533	-1.0193	-1.8353	-1.0476
	(1.6443)	(1.2578)	(1.5165)	(1.2232)
$\text{Manufacturing Share}_{r,t}$	-0.0731	-0.0713	-0.0643	-0.0734
	(0.0709)	(0.0598)	(0.0684)	(0.0593)
$\text{Services Share}_{r,t}$	0.7192****	0.1376	0.6232****	0.1349
	(0.1847)	(0.1509)	(0.1750)	(0.1500)
EA Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,253	1,253	1,253	1,253
Number of EAs	179	179	179	179
Number of Years	7	7	7	7
Model F Statistic [p-value]	18.74 [0.000]	12.80 [0.000]	32.21 [0.000]	14.12 [0.000]

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

Table D9: Spatial extent and directionality of regional connectivity – Investments in innovation-related business activities.

Dependent Variable	$\log(\text{Patent}_{r,t})$	
Preliminary Matching on Individual Investments	No	
Patent Office	USPTO	PCT
	(1)	(2)
Inward US Investments in Innovation Activities$_{r,t-1}$	0.0316	0.0242
	(0.0297)	(0.0956)
Outward US Investments in Innovation Activities$_{r,t-1}$	0.1203***	0.1296***
	(0.0377)	(0.0405)
Inward FDI in Innovation Activities$_{r,t-1}$	0.0249	0.0212
	(0.0298)	(0.0952)
Outward FDI in Innovation Activities$_{r,t-1}$	0.1268***	0.1393***
	(0.0384)	(0.0431)
$\log(\text{Patent}_{r,t-1})$	0.6786****	0.6681****
	(0.0473)	(0.0572)
Human Capital$_{r,2009}$	0.1393**	0.1619*
	(0.0630)	(0.0906)
R&D$_{r,t-1}$	0.0084*	0.0139*
	(0.0047)	(0.0080)
Sectoral Concentration$_{r,2009}$	-0.0084	-0.0030
	(0.0063)	(0.0127)
Manufacturing Share$_{r,2009}$	-0.0217	-0.0583
	(0.0260)	(0.0756)
Services Share$_{r,2009}$	-0.2422	-0.2738
	(0.1630)	(0.4297)
State Dummies	Yes	Yes
Number of EAs	179	179
R^2	0.864	0.880
H_0: Homoskedasticity (p-value)	0.094	0.028

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term. Innovation-related investments are those in education, training, and R&D activities (Crescenzi et al., 2014, p. 1067).

Table D10: Innovation inputs and control variables not shown in Table 2 in the main text.

Dependent Variable	$\log(\text{Patent}_{r,t})$			
Preliminary Matching on Individual Investments				
NAICS Sector and Business Activity	No		Yes	
Innovative Congruence of Source/Destination Region	No		Yes	
Patent Office	USPTO	PCT	USPTO	PCT
	(1)	(2)	(3)	(4)
$\log(\text{Patent}_{r,t-1})$	0.5689****	0.4797****	0.5801****	0.4853****
	(0.0675)	(0.0643)	(0.0691)	(0.0643)
$\text{Human Capital}_{r,2009}$	0.1830**	0.2060*	0.1946*	0.2218*
	(0.0893)	(0.1067)	(0.0980)	(0.1313)
$\text{R\&D}_{r,t-1}$	0.0022**	0.0021*	0.0055**	0.0014*
	(0.0009)	(0.0011)	(0.0024)	(0.0007)
$\text{Sectoral Concentration}_{r,2009}$	-0.0078	-0.0163	-0.0086	-0.0224
	(0.0123)	(0.0149)	(0.0127)	(0.0155)
$\text{Manufacturing Share}_{r,2009}$	-0.1081*	-0.1388	-0.1502**	-0.1871**
	(0.0590)	(0.0880)	(0.0603)	(0.0884)
$\text{Services Share}_{r,2009}$	0.8078***	1.0477**	0.9042***	1.0954*
	(0.2615)	(0.5193)	(0.2753)	(0.5573)
Number of EAs	179	179	179	179

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses.

Table D11: Spatial extent and direction of regional connectivity: innovativeness of source/destination regions/countries and EA patenting heterogeneity – Number of investments per 100,000 inhabitants.

Dependent Variable	$\log(\text{Patent}_{r,t})$							
Preliminary Matching on Individual Investments	No				Yes			
Patent Office	USPTO		PCT		USPTO		PCT	
Innovativeness	Low	High	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inward US $\text{Investments}_{r,t-1}$ – HIEA	-0.0092	0.0054	-0.0786	0.0795**	-0.0057	0.0008	-0.0253	0.0099
	(0.0491)	(0.0135)	(0.0615)	-0.0389	(0.0676)	(0.0005)	(0.0391)	(0.0253)
Outward US $\text{Investments}_{r,t-1}$ – HIEA	0.1072**	0.2884**	0.0386	0.2244***	0.0347	0.0722*	-0.0050	0.0984*
	(0.0501)	(0.1342)	(0.0363)	(0.0700)	(0.0319)	(0.0371)	(0.0475)	(0.0554)
Inward US $\text{Investments}_{r,t-1}$ – LIEA	0.0175	0.0020	0.0071	-0.0039	0.0023	-0.0029	0.0016	0.0022
	(0.0113)	(0.0122)	(0.0152)	(0.0133)	(0.0071)	(0.0034)	(0.0069)	(0.0036)
Outward US $\text{Investments}_{r,t-1}$ – LIEA	-0.0087	-0.0074	0.0198	0.0018	0.0032	0.0090	0.0065	0.0549
	(0.0166)	(0.1095)	(0.0205)	(0.0083)	(0.0128)	(0.0223)	(0.0144)	(0.0433)
Inward $\text{FDI}_{r,t-1}$ – HIC	0.0435	-0.0523	-0.0074	0.0234	-0.0041	-0.0190	0.0186	-0.0480
	(0.0280)	(0.0553)	(0.0365)	-0.0447	(0.0320)	(0.0387)	(0.0421)	(0.0431)
Outward $\text{FDI}_{r,t-1}$ – HIC	-0.0139	0.0178**	0.0389	0.1184**	0.0034	0.0109**	0.0048	0.0660*
	(0.0322)	(0.0078)	(0.0440)	-0.0513	(0.0200)	(0.0046)	(0.0282)	(0.0342)
Inward $\text{FDI}_{r,t-1}$ – LIC	0.0119	0.0037	0.0005	0.0019	0.0117	0.0006	0.0035	0.0026
	-0.0085	(0.0392)	(0.0067)	-0.0068	(0.0077)	(0.0023)	(0.0130)	(0.0049)
Outward $\text{FDI}_{r,t-1}$ – LIC	0.0717	0.0012	0.0061*	0.0029	0.0046	0.0021**	0.0004	0.0000
	(0.1072)	(0.0104)	(0.0035)	-0.0076	(0.0282)	(0.0010)	(0.0005)	(0.0005)
$\log(\text{Patent}_{r,t-1})$	0.5318****		0.4899****		0.5768****		0.5057****	
	(0.0676)		(0.0565)		(0.0697)		(0.0675)	
Human $\text{Capital}_{r,2009}$	0.1658**		0.2179**		0.1737**		0.2246***	
	(0.0707)		(0.0925)		(0.0743)		(0.0813)	
$\text{R\&D}_{r,t-1}$	0.0025*		0.0055*		0.0007*		0.0042*	
	(0.0014)		(0.0029)		(0.0004)		(0.0023)	
Sectoral $\text{Concentration}_{r,2009}$	-0.0071		-0.0207		-0.0044		-0.0141	
	(0.0151)		(0.0155)		(0.0151)		(0.0158)	
Manufacturing $\text{Share}_{r,2009}$	-0.0801		-0.1294		-0.1137		-0.1490	
	(0.0707)		(0.1001)		(0.0772)		(0.1166)	
Services $\text{Share}_{r,2009}$	0.7703*		0.9830		0.8556**		1.0221	
	(0.4203)		(0.6695)		(0.3557)		(0.6454)	
Number of EAs	179		179		179		179	
R^2	0.922		0.926		0.911		0.914	
H_0: Homoskedasticity (p-value)	0.010		0.001		0.006		0.003	

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. The preliminary matching on individual investments is based on NAICS sector, business activity, and innovative congruence of the source/destination region. All specifications include State dummies and a constant term.

Table D12: Spatial extent and directionality of regional connectivity: technological overlap between pairs of interconnected territories.

Dependent Variable	$\log(\text{Patent}_{r,t})$	
Preliminary Matching on Individual Investments	No	
Patent Office	USPTO	PCT
	(1)	(2)
Weighted Inward US $\text{Investments}_{r,t-1}$	0.0035	0.0090
	(0.0050)	(0.0068)
Weighted Outward US $\text{Investments}_{r,t-1}$	0.0232**	0.0109*
	(0.0115)	(0.0057)
Weighted Inward $\text{FDI}_{r,t-1}$	-0.0001	-0.0015
	(0.0016)	(0.0069)
Weighted Outward $\text{FDI}_{r,t-1}$	0.0176****	0.0300****
	(0.0043)	(0.0064)
$\log(\text{Patent}_{r,t-1})$	0.6733****	0.5567****
	(0.0482)	(0.0592)
Human $\text{Capital}_{r,2009}$	0.1246**	0.2601**
	(0.0622)	(0.1227)
$\text{R\&D}_{r,t-1}$	0.0064**	0.0058**
	(0.0028)	(0.0025)
Sectoral $\text{Concentration}_{r,2009}$	-0.0059	-0.0148
	(0.0070)	(0.0113)
Manufacturing $\text{Share}_{r,2009}$	-0.0161	-0.0688
	(0.0266)	(0.0724)
Services $\text{Share}_{r,2009}$	0.3640**	0.4760
	(0.1701)	(0.4447)
State Dummies	Yes	Yes
Number of EAs	179	179
R^2	0.901	0.900
H_0: Homoskedasticity (p-value)	0.037	0.028

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. All specifications include a constant term.

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