Pengfei Li* and Ram Mudambi

The complementarity and connectivity of locations: digitalization, sustainability, and disruptions

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Abstract: This paper explores the intersection of international business and economic geography through the lens of connectivity and complementarity of locations. Both facets are leveraged by economic agents like multinational enterprises (MNEs). Complementarity highlights the value created by integrating diverse locational assets, addressing why locations are connected, while connectivity focuses on how linkages are established and maintained. Our framework highlights the reciprocity between the dimensions of complementarity and connectivity to foster intellectual dialogue between the two fields of international business and economic geography. Disrupted global value chains and the digital transformation of economic activities are substantially reshaping the complementarity and connectivity of locations. In this context, we emphasize the need to incorporate technological, socio-political, environmental, and geopolitical dimensions into the analysis of MNE-location interaction.

Keywords: multinational enterprises; location; complementarity; connectivity; digitalization

1 Introduction: the MNE-location interaction

Economic geography focuses on spatial economic processes and structures, whereas international business centers on the global business environment at the country level, including the strategies and operations of multinational enterprises (MNEs). While these two disciplines have different emphases, they share a foundational premise, namely that location matters. They examine many of the same issues and are therefore deeply interconnected.

For economic geography, place occupies a central position, and it emphasizes the role of location as a core lens to understand regional socio-economic performances. As such, economic geography conceptualizes clusters and city regions as distinct bundles of capabilities, assets, relations, and institutions (Bathelt et al. 2004; Boschma 2005; Trippl et al. 2020). This conceptualization views the spatial organization of economic activities from a community perspective, a meso-level between the micro-level of firms and the macro-level of national and global economies. In contrast, international business research centers on the macro-level of countries and the micro-level of MNEs, seeking to explain their strategies and practices for coordinating cross-border activities (Cantwell and Mudambi 2005; Rugman and Verbeke 2001). Hence, some of the key interests include MNE country-level location choices, strategies to mitigate the liability of foreignness, and approaches to subsidiary management.

The locational perspective in economic geography and the organizational approach in international business interact since MNEs represent significant collective actors in local business communities and locational characteristics shape MNEs' strategic choices. Over the past two decades, intellectual exchange and collaboration between the two fields have intensified, as evidenced by dedicated issues in leading journals such as the *Journal of Economic Geography* (Bathelt et al. 2018; Beugelsdijk et al. 2010) and the *Journal of International Business Studies* (Beugelsdijk and Mudambi 2013; Mudambi et al. 2018). Recognizing the role of MNEs in regional development, economic geography highlights the strategic coupling of regions with MNEs' global production networks (Yeung 2016) and the opportunities provided by MNEs for developing regions to upgrade global value chains (Giuliani et al. 2005). In international business, location represents a foundational block to understanding MNEs (Cantwell 2009; Verbeke 2009; Mudambi 2021), as illustrated in Dunning's OLI (Ownership-Location-Internalization) framework (Dunning 2001). Locational characteristics, such as agglomeration economies (Alcácer and Chung 2014; Belderbos et al. 2024a) and social

***Corresponding author: Pengfei Li**, University of Calgary, Calgary, Canada, E-mail: pengfei.li1@ucalgary.ca.
https://orcid.org/0000-0002-5511-6751
Ram Mudambi, Temple University, Philadelphia, USA,
E-mail: ram.mudambi@temple.edu.
https://orcid.org/0000-0002-5396-5602

fabrics (Hernandez 2014), significantly shape MNEs' location decisions.

Despite these overlaps in the two disciplines, which help "address the blind spots of their research traditions" (Lorenzen et al. 2020, p.1217), there are still two critical limitations in our understanding of the MNE-location interaction. First, this interaction is often framed narrowly between a *single* MNE and a *single* location. Hence, "MNEs are still basically portrayed in geographical space as independent units agglomerating in certain locations, leaving the nature of the interaction between places and space as a black box" (Beugelsdijk et al. 2010. p.488). Such a unitary view of MNEs and locations neglects their broader systemic relationships – how locations are connected by MNEs globally. To address this limitation, recent conceptual developments in international business emphasize the role of MNEs as location-connecting organizations (Cano-Kollmann et al. 2016; Castellani et al. 2022; Cuypers et al. 2020). Similarly, in economic geography, frameworks of global networks of clusters and cities have been developed to highlight the pattern and process of how locations are connected through foreign direct investments (Bathelt and Li 2014; Coe et al. 2010).

Second, conceptualizations of the MNE-location interaction often presume flows of capital, labor, goods, and knowledge across borders, though with frictions (Bathelt et al. 2018). These enable MNEs to use their firm-specific advantages (FSAs) to efficiently leverage diverse and complementary locational advantages (Rugman and Verbeke 2001). However, rising global value chain disruptions, geopolitical tensions, and social and environmental challenges amplify the cross-border frictions that MNEs face, while digitalization enables competitors to curtail the value of their FSAs. Under these conditions, it has become increasingly difficult for MNEs to access, mobilize, and leverage local resources. To gain support from various local stakeholders, MNEs need to address not only economic development issues but also social, political, and environmental impacts in local settings. These new requirements suggest putting the MNE-location interaction in a broader research agenda that incorporates social dynamics, sustainability, and geopolitical concerns alongside the economic development and innovation dimensions.

In an effort to frame the MNE-location interaction in a broader context, this paper proposes a framework centered on two interrelated concepts with regard to locations: connectivity and complementarity. Connectivity emphasizes the linkages MNEs create among locations, while complementarity highlights the potential synergies between these connected locations. In the following sections, we first elaborate on the two concepts to show how their relationship helps understand the MNE-location dynamics more broadly. We proceed to incorporate the effects of digitalization into our analysis, illustrating how this has altered the connectivity-complementarity nexus over the last few decades. Finally, we introduce the contributions in this special issue through the lens of the connectivity-complementarity framework.

2 Complementarity and connectivity of locations: a framework

In a general sense, the interaction between MNEs and locations raises two fundamental questions: 1) Why are locations connected? and 2) How are locations connected? The concept of complementarity addresses the *why*, while connectivity focuses on the *how* (Figure 1).

2.1 Complementarity of locations

Complementarity refers to the added value generated when two assets are combined (Teece 2018). The degree of complementarity can range from weak to strong. Weak complementarity arises when assets generate independent value but yield more when integrated (Jacobides et al. 2018). Under strict complementarity, individual assets have little to no value unless used together (Hart and Moore 1990). In a spatial context, locational complementarity occurs when assets *in two locations* produce greater value together than separately. This definition assumes that locations differ in their profiles along dimensions such as economic development, knowledge specialization, social systems, and institutional structures. Hence, it is the heterogeneity of locational assets that creates the potential for complementarity.

Locational complementarity manifests in various forms. For instance, one location's production capacity can complement another location's market demand, as seen in trade relations between countries or between a city

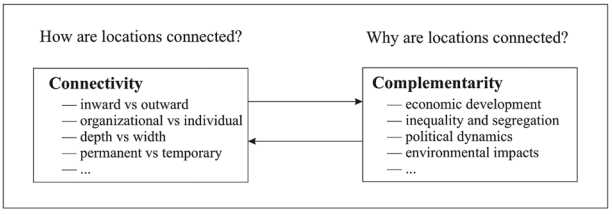

Figure 1: A framework on connectivity and complementarity of locations.

and its surrounding catchment area. The complementarity of locations also results from the spatial division of labor, in which regions become specialized in different but complementary activities in global value chains. In the knowledge economy, locational complementarity becomes more critical since regional innovation ecosystems increasingly specialize in niche knowledge domains while new product development requires creative combination and integration of diverse but related knowledge across multiple locations (Frenken et al. 2007; Li and Bathelt 2021).

2.2 Connectivity of locations

While complementarity explains why locations are connected, connectivity focuses on how complementary assets embedded in different locations are linked to create value (Belderbos et al. 2024b; Cano-Kollmann et al. 2016). This process is largely facilitated by MNEs, which, through their organizational networks, possess the capacity to mobilize and integrate these locational assets effectively (Zaheer and Nachum 2011).[1] Although certain locational assets, such as the market, can be accessed via trade, integrating specific and complex locational assets often requires tight governance. MNEs, with their capability to coordinate activities across geographic and institutional boundaries, are particularly well-suited to perform this function (Rugman and Verbeke 2001).

The modes of locational connectivity differs depending on the agents involved, and on the linkage duration, direction, and scope. First, in terms of agents, connectivity can be constructed by organizations (Bathelt et al. 2004; Lorenzen and Mudambi 2013) or individuals, such as transnational entrepreneurs and mobile professionals (Saxenian 2006). The two types of agents overlap as expatriate assignments and international travel within MNEs reflect both organizational and individual connectivity among locations. Organizational connectivity of locations can be further classified into intra-organizational connectivity, in which one MNE establishes operations in multiple locations, and inter-organizational connectivity, in which firms from different locations form strategic alliances, merge or acquire, or become buyers and suppliers (Turkina et al. 2016).

Second, the connectivity of locations varies in duration, direction, and scope. Locational linkages can be either durable or temporary (Li 2014). Durable or permanent connections include the establishment of subsidiaries or joint ventures in new locations, while temporary connections arise through professional interactions, such as those occurring at industry conferences or trade fairs. In terms of linkage direction, connectivity of locations can be either inbound, where a location attracts foreign direct investment (FDI), thereby bringing in external resources, technologies, and expertise, or outbound, where firms from a location invest externally, allowing the transfer of local capabilities and expertise to other regions (Bathelt and Buchholz 2019; Berman et al. 2020).

Further, the connectivity of locations can have different scope reflecting its depth and breadth (Cantwell and Zaman 2024). Deep connectivity involves repeated, enduring linkages with specific locations, fostering intense interdependence and mutual reliance. In contrast, wide connectivity spans a broad range of locations, enabling diversification and access to a wide variety of complementary assets.

Together, these dimensions highlight the multifaceted nature of the connectivity of locations. As primary agents of location connectivity, MNEs play a crucial role in linking complementary assets across geographically dispersed locations. In leveraging their location-connecting networks, MNEs cannot only create value for their shareholders but also, purposely or unintentionally, shape the socio-economic development, political tensions, and environmental goals of the communities they connect.

3 Dynamics of locational complementarity and connectivity

After explaining the forms of locational complementarity and the modes of locational connectivity, we now elaborate the framework further in a dynamic and interconnected perspective. Locational complementarity and connectivity can be significantly altered by technological progress, geopolitical tensions, policies and regulations, conflicts and wars, as well as natural disasters. For instance, anti-globalization forces, nationalistic policies, and tariffs make connectivity of locations not only more costly but also politically risky (Prasad 2025). Understanding how technological, socio-political, and natural forces shape locational complementarity and connectivity represents a fruitful avenue of research. We begin by investigating how digitalization, the major technological force of the current era, is changing locational complementarity and connectivity. Subsequently, we explore the reciprocal relationship between complementarity and connectivity and its implications for the research on the MNE-location interaction.

1 Besides MNEs, labor flow and inter-government collaboration also play an important role in connecting locations.

3.1 Digitalization

A particularly important aspect of the 21st-century global economy that affects both connectivity and complementarity is digitalization. Digitalization manifests in two distinct but interconnected forms, each with unique implications for global business organizations. In its first form, as information and communications technologies (ICT) that transmit data seamlessly at minimal costs, digitalization enhances connectivity between geographically separated locations. In its second form, *in situ* digital technologies, such as smart factories using artificial intelligence and robotics to redesign production processes and empower human productivity, it transforms activities within specific locations. Together, these technological developments create opposing forces that reshape the global footprint of multinational enterprises (Autio et al. 2021).

Information and communications technologies have dramatically improved the efficiency and effectiveness of connectivity between distant locations. Through advancements in telecommunication infrastructure, cloud computing, collaborative software, and digital platforms, ICT has fundamentally altered how information, knowledge, and instructions flow across geographic space. This enhanced connectivity significantly reduces the spatial transaction costs, i.e., the costs associated with conducting business across geographic spaces like borders and continents.

As these spatial transaction costs decrease, MNEs find it increasingly viable to disperse their activities across a broader geographic range. The ability to coordinate complex operations remotely enables firms to distribute different functions to optimal locations without sacrificing operational cohesion. For example, research and development may be located in innovation hubs, while customer service operations might be situated in regions with appropriate language skills and time zone advantages.

Consequently, ICT advancements generally increase the centrifugal forces acting on MNEs, promoting greater geographic dispersion of their activities. More locations become viable operational sites, and the volume of activities undertaken at a distance from headquarters expands. This dispersion allows MNEs to leverage location-specific advantages across a broader geographic canvas. In short, it increases the extent of locational complementarity.

The second form of digitalization involves *in situ* digital technologies that transform activities within specific locations (Autio et al. 2021; Choi et al. 2023; Yoon et al. 2023). Technologies such as robotization, 3D printing, artificial intelligence, and the broader Industry 5.0 paradigm focus on enhancing productivity and effectiveness at the point of operation. These technologies fundamentally alter the production function of various business activities, changing the input requirements and comparative advantages of different locations.

A critical consequence of *in situ* digital technologies is their tendency to reduce locational complementarity. As advanced economies increasingly adopt automation and robotization, the traditional comparative advantage of low-cost, low-skill labor locations diminishes. When robots can perform tasks previously delegated to human workers in lower-wage economies, the economic rationale for offshoring weakens. The production function transforms from labor-intensive to capital- and technology-intensive, reducing the need for geographic dispersion based on labor cost differentials.

As a result, *in situ* digital technologies generally strengthen centripetal forces, promoting the concentration rather than dispersion of MNE activities. As the value of low-cost labor diminishes relative to technological capabilities, production may "reshore" or "near-shore" to locations closer to end markets or innovation centers.

The overall impact of digitalization on the geographic dispersion of MNE activities depends on the balance between ICT-driven centrifugal forces and *in situ* digital centripetal forces. This balance is not uniform across industries, functions, or time periods. Rather, it evolves with technological developments, business model innovations, and changes in the global economic landscape.

For activities where knowledge transfer, coordination, and communication are paramount (such as business services or software development), the centrifugal forces of ICT may dominate, leading to greater geographic dispersion. Conversely, in manufacturing activities where automation and robotization can substantially replace labor inputs, the centripetal forces of *in situ* digital technologies may dominate, leading to greater geographic concentration. Moreover, the balance may shift over time as technologies mature and diffuse globally. What begins as a concentrating force may eventually enable new forms of dispersion as technologies become more accessible across diverse locations.

Digitalization represents a transformative force in the 21st-century global economy, fundamentally altering both connectivity and complementarity of locations. Through ICT, digitalization enhances the ability of MNEs to coordinate activities across geographic space, promoting greater dispersion. Through *in situ* digital technologies, digitalization transforms the production function within locations, possibly reducing the complementarity that previously drove geographic dispersion.

The net effect on the geographic dispersion of MNE activities depends on the relative strength of these opposing

forces. As digitalization continues to evolve, MNEs must continuously reassess their global footprint, balancing the enhancing connectivity offered by ICT against the changing locational complementarities resulting from *in situ* digital technologies. Understanding this dynamic interplay is essential for both business strategy and public policy in an increasingly digital global economy.

3.2 From complementarity to connectivity

After explaining the concepts of connectivity and complementarity of locations and their dynamics shaped by digitalization, we now turn to their relationships, aiming to understand the MNE-location interaction systematically in the current new context. Placing regions as the contextual backdrop and MNEs as the central actors, this section examines how regional characteristics (economic, socio-political, or environmental), reflecting locational complementarity, influence the location decisions of MNEs, or the decisions of generating or discontinuing connectivity.

While MNEs' rationale for location choices can be broadly characterized as market seeking and asset acquisition (Dicken 2014), the interplay between regional attributes and MNEs' location strategies is complex (Crescenzi et al. 2014). For instance, Alcácer and Chung (2014) measure the three elements of agglomeration economies (labor market pooling, knowledge spillovers, and supplier sharing) and find the first two exert much greater effects on foreign direct investment (FDI) attraction. Similarly, Asmussen and others (2020) measure various urban features, showing infrastructure and cosmopolitan culture in globally connected cities draw knowledge-intensive FDIs.

In addition to economic features, social structures, geopolitical tensions, and environmental concerns are increasingly pronounced in local settings, factoring into MNEs' decisions in making connectivity. For example, Ascani and others (2023) find that Chinese FDI in manufacturing activities may favor locations with fragile environmental conditions. On geopolitical tensions, Li and others (2023) suggest that, when the relation between the host country and their home country deteriorates, MNEs tend to choose locations in the host country where firms from their home country have already agglomerated to mitigate political risk. Further, with a case study of a peripheral region in East Germany, Henn and Hannemann (2024) demonstrate how local political resentment can translate into hostile business practices against foreign firms, exacerbating liabilities of foreignness. This aligns with the well-known case of Amazon's second headquarters in North America. Initially, Amazon chose New York City but then decided to withdraw due to urban politics and protests from local groups (Durkin 2018). These studies illustrate how MNEs' decisions of establishing or discontinuing locational connectivity are increasingly shaped by location-specific social and political dynamics. Understanding how these dynamics play out will be invaluable to extend our understanding of the MNE-location interaction.

3.3 From connectivity to complementarity

Shifting the focus from MNEs to regions, we can explore how the trans-local linkages created by MNEs (connectivity) influence regional socio-economic features and sustainability goals (complementarity). While it is widely acknowledged that global pipelines complement local buzz (Bathelt et al. 2004) and that "connectivity is an essential dimension of regional economic development" (Crescenzi and Iammarino 2017, p.110), the effects of different types of connectivity on local social and economic development, including the mechanisms associated, remain unclear.

For instance, policymakers tend to presume that inward investment can stimulate employment and economic growth, while outward investment seems to imply the loss of local wealth and development opportunities (Castellani and Pieri 2016). However, empirical studies challenge this assumption (Crescenzi and Ganau 2025). Bathelt and Buchholz (2019) find positive relations between outward investment and home region's economic development, channeled through mechanisms including knowledge transfer, job creation and income growth in the home region. Equally, the positive impact of inward investment in the host region may also be exacerbated. Lorenzen and others (2020) indicate that while MNEs connect with major urban centers, they may inadvertently disconnect them from these and other urban centers' surrounding areas, exacerbating inequalities between urban cores and their catchment areas. Further in this direction, Cantwell and Zaman (2024) show that international knowledge connectivity leads to increasing innovation concentration in global cities. These findings suggest that MNEs' choices and actions may play a role in creating the current social-economic landscape characterized by interregional inequality and social fragmentation (Storper 2018; Bathelt et al. 2024). As argued by Wiessner and others (2024), the impacts of MNEs on regions need to be examined from a broader perspective that integrates economic, social, and ethical considerations.

Beyond MNEs' direct impacts in their host regions, MNEs also shape regional socio-economic development indirectly through the global patterns of their linkages (connectivity), as manifested in global networks of clusters and city regions. These global patterns emerge from organizational and individual linkages. At the organizational level,

Li and Bathelt (2018, 2021) identify a pattern of investment linkages across clusters, which may channel more growth potential to these locations, leaving unconnected regions marginalized. Focusing on the aerospace industry, Turkina and others (2016) find buyer-supplier relationships tend also to be formed across clusters. Further, Berman and others (2020) show that Italian industrial districts exhibit greater inbound investments from foreign firms than outbound investments by local players, suggesting the direction of connectivity can be important to understand innovation of interconnected clusters. At the individual level, Saxenian (2006) highlights the role of transnational entrepreneurs in fostering high-tech cluster connectivity, while Park and others (2019), using LinkedIn data, depict cluster networks formed through labor mobility. In light of rising geopolitical tensions, restrictive immigration policies, and regulatory barriers for cross-border investments, it is interesting to examine the dynamics of these global networks of clusters and city regions and their influences on regional socio-economic development, such as inequality and segregation.

In sum, the two previous sections examine the two-way relationships between connectivity and complementarity of locations. It is important to note that their interplay and dynamic is deeply interwoven, like two sides of the same coin. International connectivity often channels innovation and economic activity into specific locations, exacerbating inter-regional differences, but also inequalities and intensifying social and political segregation. These pressures, in turn, can generate backlash from marginalized places (Rodríguez-Pose 2018) to disrupt global connectivity established by MNEs. To understand the reciprocal interaction between MNEs and locations in the current context requires collective efforts from international business and economic geography.

4 Contributions in the special issue

Through the lens of the complementarity-connectivity framework, the four papers in the special issue can be classified in two groups, addressing complementarity and connectivity, respectively. Parnreiter and colleagues (2025) and Pishdadian and others (2025) explore complementarity between connected locations, while Bathelt and Cantwell (2025) and Sielker and Dannenberg (2025) focus on the construction and destruction of connectivity among locations with complementary assets.

Parnreiter and colleagues (2025) broaden the scope of locational complementarity by examining MNEs' repatriation of profits across space. Focusing on German investments in China, their estimates indicate that 71 % of repatriated profits from manufacturing sectors like automobiles and chemics are directed to just four western Länder (sub-national states) in Germany, while the five eastern Länder receive only 9 %, exacerbating west-east disparities within the country and echoing a pattern of local disconnectivity intertwined with international connectivity (Lorenzen et al. 2020).

Pishdadian and others (2025) compare the transition toward sustainability in two aerospace clusters – one in Montreal, Canada and the other in Toulouse, France. The two clusters exhibit heterogeneous but complementary assets. While the former cluster excels in developing sustainable innovations, exemplified by Bombardier's C-Series aircraft, the latter is strong in its global production and service capabilities through Airbus' extensive operations. This complementarity between the two clusters propels their connectivity, as demonstrated by Airbus' acquisition of Bombardier's C-Series. Further, the study highlights increasing collaboration and knowledge exchange between the two clusters to leverage their complementarities in aircraft development and production after Airbus' acquisition of Bombardier's C-Series.

Shifting from complementarity between locations to connectivity, Sielker and Dannenberg (2025) investigate the vulnerabilities of global trade and supply chain infrastructures, using China's Belt and Road Initiative as a case study. Their analysis, set against the backdrop of the Ukraine war, identifies the geopolitical risks that threaten connectivity along key infrastructure routes between Europe and Asia. Besides wars, geopolitics can also translate into trade policies, such as tariff or not-tariff barriers, which can equally disrupt locational connectivity. These risks highlight the need to integrate geopolitical considerations into the analysis of the MNE-location interaction. For MNEs, managing the geopolitical risks represents a crucial and systematic challenge in global value chains.

The fragility of international connectivity raises questions about how to establish and sustain resilient linkages among locations. In an era of increasing investment restrictions and tightening immigration policies, building and maintaining organizational pipelines and individual connections has become more challenging. In this context, Bathelt and Cantwell (2025) propose a novel perspective by emphasizing the role of professional communities – groups of professionals tied by shared industry experience and qualifications, independent of their organizational affiliation. They argue that dynamic local professional communities with intensive interactions with global professional communities are essential for fostering resilient international connectivity and facilitating knowledge transfer for

MNEs. Their arguments resonate with the emphasis on subnational scales in understanding MNE strategies (Beugelsdijk 2022; Mudambi et al. 2018). Importantly, they highlight the role of MNEs' communities of origin, besides their countries of origin, in shaping their internationalization processes. Future research can examine how MNEs engage with local professional communities and facilitate interactions between local and international professional networks.

5 Conclusions

This paper revisits the intersection between international business and economic geography through the lens of connectivity and complementarity of locations, emphasizing their reciprocal relations. The complementarity-connectivity framework focuses on two fundamental questions regarding MNEs and locations: 1) why locations are connected, which highlights location heterogeneity, and 2) how locations are connected, which emphasizes the agency of MNEs. The forms of locational complementarity and the modes of locational connectivity are shaped by technological, socio-economic, political, and natural forces. We illustrate how the transformative force of digitalization can alter the relationship between locational connectivity and complementarity. Moreover, as incipient aspects of digitalization like artificial intelligence and machine learning continue to develop, this relationship will evolve further. Hence, the complementarity-connectivity framework can serve as a schema to incorporate artificial intelligence and other new forces in contemporary contexts into the analysis of MNE-location interplay.

We aim to inspire future collaborations between the two closely related fields, which often approach the same phenomena from distinct yet complementary perspectives. The complementarity-connectivity framework builds on existing efforts to develop a holistic understanding of the MNE-location interaction (e.g., Iammarino and McCann 2013; Bathelt et al. 2018; Mudambi et al. 2018; Beugelsdijk 2022) and argue for integrating digitalization, sustainability, inequality, and disruptions into the analysis.

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