



EDITORIAL

Industry 4.0 in international business research

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Abstract

The advent of Industry 4.0 promises to transform the global business landscape, the nature of markets and industries, and the way multinationals organize their operations as well as how and where they compete. These changes will have important – indeed profound – implications for IB scholarship. In this article, we explain Industry 4.0 and its distinguishing characteristics; discuss its organizational and strategic implications for multinationals; and outline the fundamental questions it raises for future IB research. To spur future analysis, we also present a conceptual foundation that articulates the new features, processes, and capabilities that support MNEs' pursuit of Industry 4.0-related opportunities surrounding digitalization, intelligence, technology, and innovation. We also discuss what Industry 4.0 means for IB research concerning social engagement, environmental sustainability, and international entrepreneurship. We elucidate how this new landscape shapes the extant IB literature and how future research can push it further along.

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INTRODUCTION

International business (IB) has entered a new era in the convergence between industrialization and globalization under the umbrella name of Industry 4.0. With every major industrial and technological change, the characteristics of globalization have been altered (Friedman, 2007). With the advent of Industry 4.0 or the 4th industrial revolution (hereafter 4IR), the digital and physical worlds are irrevocably linked, with machines, systems, and people able to exchange information and automatically adjust. Thus, 4IR not just revolutionizes global manufacturing processes but promises to a powerful impact on the ways and processes of conducting international business, demanding greater attention in IB scholarship. Fundamental changes prompted by this inter-linked environment are likely to have implications for how multinational enterprises (MNEs), both large and small, define their businesses, organize their operations, develop and protect their firm-specific advantages, and manage the relationships with their diverse stakeholders around the globe. For this reason, 4IR has been added

as one of the two new sub-domains (along with global sustainability) to be covered by *JIBS*.

But to address these issues and take advantage of the opportunities that 4IR offers, MNEs need to undergo transformations, raising a series of questions for them to rethink their global strategies and needed capabilities. They also challenge IB scholars to extend the extant knowledge of designing, organizing, and harnessing global activities in the new era. In this article, we intend to discuss how IB scholarship may tackle 4IR for MNEs (established and nascent) that vie for new competitive advantages by leveraging increased digital connectivity, which in part replaces physical connectivity whose importance and processes have been richly addressed in traditional IB theories. To accomplish this goal, we offer a conceptual foundation that defines the key concepts and features relating to 4IR, delineate its implications for MNE strategies and behaviors, and discuss transformation processes and new capabilities needed to cope with this new landscape. We combine the strategic, organizational, entrepreneurial, and social engagement lenses to provide a nuanced understanding of the issue, seeking a broad picture that both connects with existing IB research and illuminates new research directions based on important issues bearing theoretical and practical implications.

NEW FEATURES OF INDUSTRY 4.0

Industry 4.0 refers to the fourth industrial revolution. It emphasizes the critical role of intelligent machines and smart automation of business activities, advancing a vision of a workplace that values interconnectivity, smart automation, machine learning, and real-time data (see Ahi, Sinkovics, Shildibekov, Sinkovics, & Mehandjiev, 2022; EIU, 2014). It transforms IB operations in several ways by allowing MNEs to: (1) run operations for physical goods digitally (e.g., embedding Internet of Things, or IoT, data into business processes); (2) develop IB processes and analytics autonomously at the edge, often through a central cloud environment; (3) orchestrate global value chain activities via digital connectivity and intelligence that work together with technology and innovation; and (4) create digital platforms that enable internal members (e.g., global employees) and external partners to contribute.

Technically, digital connectivity and industrial IoT are central enablers of 4IR. The two together provide the data backbone with comprehensive

capabilities that create new features, such as smart sensing, big data management, analytics and intelligence, and intelligent edge technology. In turn, these qualities enable device connectivity, smart manufacturing, connected decentralization, edge processing, and real-time contextualization of IoT data. Technology drivers underlying these new features are numerous, including ICT (information and communication technologies), data science and analytics, automation technologies, AI and machine learning, cyber-physical system, virtual reality, and 3D printing, among others (EIU, 2014). These new features enable businesses to orchestrate their operational processes in a central cloud environment and scale across global operations with cloud and edge computing (Li et al., 2019). Moreover, they technically allow MNEs to coordinate their vast global networks, achieving effective synchronization while gaining efficiency, agility, and speed.

Our review of multi-field literatures and industry reports, along with our field studies and executive interviews, suggests that, for international business, 4IR highlights the interplay of four key pillars: digitalization, intelligence, technology, and innovation (hereafter DITI, also see Figure 1). Consensus holds, for instance, that technology nourishes digitalization, which in turn stimulates innovation of business models and marketing (Tallman et al., 2018). Digitalization provides MNEs with opportunities to create value by combining technology, capital, products, brands, and other value-creation activities, giving rise to a potential advantage over global rivals (Nambisan & Luo, 2022). In particular, many disruptive business model innovations are grounded on digital platforms and digital connectivity (Nambisan & Luo, 2021). These disruptive innovations form an important foundation for building and reinvigorating MNEs' firm-specific advantages (FSAs). Intelligence, on the other hand, depicts the transformation of data and information into insights and knowledge (encompassing both human and non-human intelligence), informing multi-location decision-makers of the MNE to properly respond to new opportunities and threats. This intelligence, coupled with digitalization, is instrumental to mobilizing global resources, coordinating with internal and external networks, and achieving "scale without mass" (OECD, 2017).

With digitalization and intelligence in place, complex interactive systems for technology and innovation evolve in real time across organizations and locations. In this fashion, the MNE becomes a



Figure 1 International business under 4IR: a strategic management framework.

knowledge network or community (Kogut & Zander, 1993), but how this community is organized and how knowledge diffuses will hinge on the architecture that combines potent strengths of DITI. Cano-Killmann and his colleagues (2016) observe that a key objective of MNEs is to codify and systematize tacit knowledge in order to transform specialized processes into standardized and automated ones. With 4IR, the entire industrial environment for global operations becomes digitally connected, making codification much easier (e.g., AI can run algorithms and find patterns). This connection helps integrate the physical world of engineering, manufacturing, supply chain, and distributions with enterprise business information, processes, and systems. For this reason, the interactive elements (DITI) of 4IR are less functioning as direct production inputs per se but more as critical process enablers that jointly and interactively improve the efficiency of bundling and harnessing important production factors (e.g., labor, capital, and technology) obtained from various countries in an integrated manner.

Along with a myriad of opportunities, such as improving productivity and streamlining processes, 4IR has fostered many changes (and also

challenges), some of which have yet to be well attended by practitioners and scholars but merit future inquiries. First, *it fundamentally shapes how to run global value chain*. MNEs can monitor emerging trends and opportunities in overseas markets without the need to make substantial resource commitments in local marketing affiliates. They will be able to more effectively optimize their supply, production, logistics, and distribution activities around the world (Strange & Zucchella, 2017). 4IR also offers new ways to monetize customer relationships and utilize market data given the emergence of new technologies and new market opportunities (Nambisan & Luo, 2022). This environment helps MNEs better explore and exploit new opportunities from extended global economies of scale, scope, speed, and space (Ahi, et al., 2022). Yet, dependence risks can be greater under 4IR. Heightened connectivity with foreign suppliers, for instance, may fortify contagion or spillover effects from global supply chain disruptions (Luo, 2022). Physical-cyber interfaces can sometimes accelerate this contagion (Beltrami, et al., 2021).

Second, *4IR changes the ways MNEs monitor global operations and mobilize global resources*. 4IR affords opportunities for faster global reach, greater intra-

and inter-organizational sharing, and less hierarchical decision-making (Castagnoli, et al., 2022). 4IR drives the prevalence of using global hubs that leverage connectivity, resources, and market advantages (Tallman et al. 2018). Digitalization and intelligence facilitate cross-border coordination among these hubs. Thus, forces under 4IR facilitate progression towards a less hierarchical structure and towards heavier reliance on information connections and data flows within the MNE. However, the digital path of organizing global activities will not, and cannot, substitute other critical mechanisms of managing offshore activities (e.g., resource deployment, rules and compliance, and culture and values).

Finally, 4IR expands the ways of bundling and leveraging FSAs and CSAs (country-specific advantages). 4IR technologies facilitate the achievement of this bundling that is less location-bound and less subject to time compression (Beugelsdijk & Mudambi, 2013). The ownership-internalization-location factors stated in the eclectic paradigm (Dunning, 1979) will undoubtedly remain relevant. However, these technologies and intelligent processes significantly alter and modify the degree and ways of such relevance (Buckley & Ghauri, 2004). Internalization advantages can be amplified by re-bundling firm-specific and network advantages in this case (Verbeke & Kano, 2015). Digitalization-enabled linkage emerges as a new potential and potent advantage (Luo, 2021). But this, too, involves new challenges associated with information security and inter-dependence risks. Per the classic FSA/CSA matrix (Rugman, 2016), which is used to explain, predict or prescribe the optimal organization of an MNE's international operations, 4IR reminds international executives to prioritize the country's digital connectivity with the rest of the world as the key CSA and align it with FSA in a way that the firm can grow in trans-continental scale without an increase in its physical presence in the location of its global customers.

Industry 4.0 at present is occurring in an environment characterized by growing global fragmentation, rising trade barriers, and competing ideologies reflecting deep-seated concerns over national identities and sovereignty. Further, some countries have become proactive in working with their national companies in their quest to gain strong positions in world markets. World institutions have also been the subject of considerable assault from nationalistic leaders, arguing that these institutions have become instruments of

political, cultural, and economic hegemony, benefiting certain countries at the expense of others (Snyder, 2019). Along with these ongoing institutional changes, there is also concern about who will control and benefit from the next wave of technological change. Collectively, these forces might delay or even stifle the transfer of technologies and related knowledge and skills essential to the development of 4IR. This dynamic is especially worrying given rising concerns about national sovereignty and security in different parts of the globe. Such changes can also have an additional negative effect where innovation and startup creation decline, reducing technological and economic progress and employment wealth creation. Likewise, talent wars, in which countries compete to attract and retain the best experts in emerging technological fields, may erupt—further limiting the diffusion of knowledge and inhibiting employee mobility across international borders, undermining innovation and startup activities.

IMPLICATIONS FOR MNES

New Opportunities

Industry 4.0 creates significant opportunities that, we think, outweigh associated costs. 4IR makes it possible for MNEs to better identify where, when, and what global resources should be deployed in a more productive way, helping them to reconfigure, maneuver, and repurpose existing resources and capabilities for global operations (Phan, Wright, & Lee, 2017). These resources are likely to facilitate knowledge deployment and integration within the MNE. Cross-border knowledge sharing requires three distinct yet interrelated elements: codification, search, and access (Kogut & Zander, 1993). Each of these three elements can be potentially augmented by digital connectivity and resultant intelligence, thus having a significant influence on the speed of knowledge transfer (Strange & Zucchella, 2007). Moreover, an MNE's global intranet provides a great vehicle for developing automated business processes across the entire organization. The connectivity helps develop global, virtual organizations with team members around the world who meet via various virtual tools (Luo, 2021).

Opportunities also abound for optimizing global operations. Firms can improve the process from engineering and development to manufacturing to manage product complexity and quickly respond to



changing demands in various countries (Ahi, et al., 2022). New technologies, notably, industrial IoT, catalyze a shift of focus from maximizing capacity and lowering cost to agility in operations while still controlling cost, capacity, and quality (Beltrami, et al., 2021). Smart factories, for example, may use real-time data and AI to run autonomously and flexibly. They are adaptable and ready to support different production scenarios and manage different variable production configurations, demand volume, and manufacturing technologies (Ancarani, Mauro, & Mascali, 2019). Data from subsidiary activities can turn into improved business process automation, productivity, agility, and actionable insights through a wealth of contextualized machines, sensors, and device data (IoT data) along with artificial intelligence (AI). When cross-national trade barriers are low, this could allow the MNE to eliminate some less efficient activities and scale DITI resources across global operations via cloud solutions. As reported by *EIU* (2014), with 4IR, MNEs can visualize and reconfigure their entire global operation, enabled by digital operations management with both predictive and prescriptive capabilities, along with real-time data, feedback loops, and network capabilities for design collaboration.

Another set of opportunity centers on the potential for improvement of global connections through partners and stakeholders. 4IR pushes firms to consider an expanded global web of loosely coupled external communities through digital platforms and ecosystems, alliances, global freelancers, open source communities, online innovation, crowdsourcing, and the like (Nambisan & Luo, 2022). Teece (2014) suggests that by investing in complements, MNEs can enhance the vitality of their ecosystems, which are partly exogenous as they are often co-created by global companies. That a growing number of global players use peer-to-peer product innovation and crowdsourcing customer services to gain insights illustrates this point (OECD, 2017). Likewise, many MNEs use big data and predictive analytics to improve network-based learning and knowledge development, and provide real time feedback, knowledge sharing, and joint learning (Chinn et al., 2014).

Required Transformation

To harness these new opportunities, however, organizational support and transformation is vital. Transitioning into 4IR demands major strategic changes during which some MNEs may need to

even “remake” themselves and rethink the concept of the firm and its boundaries in order to thrive in this new environment (Ancarani, et al., 2019), as we explain below.

Transformation aims to enhance MNEs’ organizational agility and responsiveness, reduce costs, and improve efficiency (Lanzolla, Lorenz, Miron-Spektor, Schilling, Solinas, & Tucci, 2020; Phan et al., 2017). It also seeks to promote innovation, the mainspring of MNEs’ entrepreneurial activities (Amabile, 2020). By fostering and enabling innovation, 4IR transformation also facilitates co-creation activities within MNEs’ subsidiaries as well as in their different international networks (Birkinshaw, 2000). In turn, co-creation can spark radical innovation by learning from and engaging with different types of collaborators, giving MNEs access to diverse and sometimes radically new knowledge and skills that allow them to build new capabilities or upgrade existing ones (Cano-Killmann, et al., 2016). While IB scholars have shown interest in the timing and approaches of MNEs’ digital transformation, to date, there has been limited attention to the bigger picture of transformation that entails not just digital and technological but also organizational, behavioral, and managerial, and to the reconfiguration of their internationalization, both being important issues that deserve systematic and close study. Table 1 highlights some of these issues that we consider especially worthy of future research.

With the onset of 4IR, many industries are undergoing major structural changes because technology is rapidly converging, blurring industry boundaries. Thus, it is hard for MNE leaders to predict the direction and magnitude of this divergence or its implications for connectivity across business domains and national borders. Yet, these changes are occurring at the domestic and international levels, highlighting the heterogeneous effects of the technological changes arising from 4IR on industry and firm evolution (Iammarino & McCann, 2013). Country- and firm-related factors will further accentuate these differences in the scope, speed, and direction of these changes, and potential associated effects. Managerial cognition, in particular, has to shape such discussions and analyses and ensure that different scenarios are considered to avoid blind spots when analyzing competition (Jacobides, Brusoni, & Candelon, 2021). These blind spots include ignoring smaller and lesser-known players (such as born globals international new ventures), overlooking

Table 1 Future research agenda: some key questions

Key Issues	Research Questions	Contributions
Building and harnessing digitalization, intelligence, technology & innovation (DITI)	<p>How can an MNE manage, measure, and monitor the wholeness of DITI that connect decentralized global operations?</p> <p>What does it take to create complementarity and synergy among DITI components?</p> <p>DITI significantly change global value propositions, value delivery, and value chain systems, compelling MNEs to be fast, streamlined, and integrated. But how so and towards what outcomes?</p> <p>DITI mandate enormous investment in technology drivers and enablers, and require organizational transformation too. What are proper organizational policies that transform DITI from technical to corporate mindset and routines undertaken by both headquarters and foreign subsidiaries?</p>	<p>This helps inform the new characteristics of MNEs at onset of a new era of international production, operations, and networks</p> <p>MNEs are more complex than other organizations, calling for an integrated and orchestrated structure in which all units are connected via DITI</p> <p>Integrated DITI revamps theories of internationalization in location, diversification, and entry modes, as well as internal and external networking</p>
Managing digital-physical interfaces and process integration	<p>4IR redefines interfaces between real (physical) world and digital world, making potentially everything smarter across the entire value chain. What efforts should MNEs make to ensure scalability and interoperability between digital and physical?</p> <p>4IR will not replace key value chain activities but will make them more visualized, connected, automated, and intelligent. In what ways can MNEs foster mutual support between digital and physical for the MNE's globally differentiated operations?</p> <p>What kind of "soft" skills are needed to improve digital-physical interfaces for the MNE? How can MNEs balance between centralization and decentralization for such interfaces?</p>	<p>This effort offers a deepened view toward innovated GVC integration</p> <p>This helps MNEs embrace digitalization while maintaining stability, guiding them to properly mobilize global resources</p> <p>These new interfaces are a vital part of re-bundling digital assets with physical assets across locations</p> <p>This interoperability is a critical part of global integration in the new era</p>
New ways of organizing global activities	<p>With 4IR, the entire industrial environment is digitalized, connecting the physical world of engineering, manufacturing, and supply chain with enterprise business information, processes, and systems. This environment requires huge and new orchestration – how can MNEs achieve this?</p> <p>Global orchestration requires both top-down and bottom-up measures from home and abroad and involves numerous departments. What does it take and who should orchestrate such sophisticated design, planning, and monitoring? How should MNEs reconfigure global production and the value chain system to embrace 4IR? How does this orchestration differ from traditional organizational orchestration?</p>	<p>This endeavor informs strategic actions and policies that guide corporate headquarters and foreign subunits to work together for this orchestration</p> <p>It offers insights into corporate coherence, stimulating economies of scale, scope, speed, and space (4S)</p> <p>Digital orchestration can help both global integration and local adaptation, providing new insights into the I-R balance paradigm</p>



Table 1 (Continued)

Key Issues	Research Questions	Contributions
Transforming DITI into FSAs	<p>DITI integration goes beyond integrated automation, global value chain connectivity, and lifecycle services; it extends to new business models, new forms of global knowledge and dynamic capability, and new ways of global reach. How do these processes really work? 4IR also creates a new economy of global linkages, internally and externally, accentuating rent-generation from re-bundling CFAs and FSAs. Can this enrich MNE theories (e.g., internalization, process-based, and capability-based theories)? And How?</p> <p>How does organizational behavior, such as digital mindfulness and transformational leadership, support integrated DITI?</p>	<p>This advances our understanding of a full range of new capabilities needed in the 4IR era</p> <p>It has potential to extend capability-based, internalization, network-based, and process-based theories of IB</p> <p>Organizational structure and routines, global mindset and behavioral agility underpin this new FSA</p>

companies with different organizational forms or business models (such as those from emerging markets), and downplaying the role of intangible resources in shaping competitive rivalries. Such blind spots can undermine the firm's transformation to capitalize on 4IR, making it difficult for leaders to determine where to best position themselves, how to compete, and with whom to engage in the collaborative and co-creation activities needed for successful strategic transformation (Gregory, Henfridsson, Kaganer, & Kyriakou, 2022). Some MNEs have shown great difficulties in predicting the path of technological development, identifying new industry evolutionary trajectories, and evaluating competitors with different attributes from those common in industry (Bergek, Berggren, Magnusson, & Hobday, 2013). These changes should be documented; and their implications for IB theories in general, and theory of the firm in particular, need to be clarified.

CAPABILITY AUGMENTATION TO COMPETE UNDER INDUSTRY 4.0

Adaptability for Industry 4.0

What new capabilities are needed for MNEs to compete in the 4IR era perhaps forms one of the most critical questions for IB scholarship. While efficiency reigns in a relatively stable world, adaptability and resilience overwhelm efficiency as uncertainty rises. Responses to global crises, like climate change and COVID-19, put a premium on the organizational attribute of resilience, and for this reason, *JIBS* added global sustainability as

another new sub-domain of IB research. While digital connectivity helps MNEs to cope with adversity and organize their global operations in ways that are fast, integrated, and streamlined (Nambisan & Luo, 2022), achieving this response calls for numerous new capabilities that cement MNEs' pursuit of strategic and structural adaptability. The response may require a managerial (and corporate) cognitive shift from pursuing strategic renewal (rejuvenating their ongoing business activities) to inducing and shaping MNEs' strategic transformation (e.g., developing new businesses) and the redefinition of their missions and strategies.

Global leadership is vital to accomplish the above goal. Multinational enterprises can reimagine their strategies based on 4IR in many ways. Yet, much of this transition depends on the vision, creativity, skills, and capabilities of their top management teams. Research suggests that changes in global environments necessitate changes in the composition and decision-making processes of their teams (Post, Lokshin, & Boone, 2022). These changes prompt the need to recruit, develop, retain, and empower leaders who understand the global environment and articulate a vision for MNEs' strategic transformations. Visionary leaders are also better able to connect their global companies to the political, social, and economic forces shaping their business environments (Srinivasan & Eden, 2021). Additionally, they appreciate the perils and powers of the digital transformations that MNEs need to undergo. These teams also have to be diverse to ensure inclusion of different groups who

understand the different interests of MNEs' various communities around the globe (Morris, Hammond, & Snell, 2014). Future research may provide important contributions by revealing how MNE leaders adjust organizational structure to be less hierarchical, what it takes to sharpen digital mindfulness and transformational leadership, and what measures and routines are needed to incentivize foreign subunits for committing boldly to the transformation (also see Table 1).

Orchestration Capability

To meet the challenges of 4IR, MNEs will always need strong (and perhaps different) organizing capabilities and people skills, an issue that has actually been well recognized lately (e.g., Amabile, 2020; Colbert, Yee, & George, 2016; Glikson & Woolley, 2020). For these international firms, a capability in digital connectivity forms only part of an overarching capability in orchestration, which signifies a key dynamic organizational capability (Tece, 2014). An orchestration capability describes the firm's ability to pursue opportunities by assembling, organizing, synthesizing, and integrating globally available resources including those from open markets, network partners, and the firm itself, requiring tacit expertise and process knowledge (Admin & Cohendet, 2004). Orchestration, therefore, relies on the recognition and management of interdependencies inside the MNE and with its external network partners. Research shows that the combination of global vision and intelligence, business continuity plans responding to disruptions, and structural flexibility enable network-structured MNEs to speed up problem solving and quickly adapt to market disruptions (Buckley & Ghauri, 2004; Chinn, et al., 2014; Clough & Wu, 2022).

To succeed in 4IR, MNEs need two types of architectures to support their orchestration capability. One relates to digital architecture and the other centers on organizational architecture, with both mutually complementary and supportive of each other. The digital architecture should support interoperability, integration, and extension (Nambisan & Luo, 2022). This structure helps MNEs to strike a balance between process standardization and visibility on an enterprise or global level, supported by data-driven, end-to-end business processes based on the industrial IoT (Kohli & Melville, 2019). Obviously, no organization can do it alone, given current market fragmentation and complexity. Increasingly, MNEs rely on their partnerships

and investment in promising startups and co-creation activities to address this challenge (Zahra & Hashai, 2022). A major question that follows will be how to govern co-creation when competition or conflicting elements exist or as external conditions, including geopolitical disruptions, emerge. In Table 1, we present several IB research agenda on organizing and orchestrating 4IR forces and processes.

Organizational Innovation

Several recent studies underscore the important point that 4IR actually compels companies to pay greater attention to organizational and managerial innovation to develop structures and systems compatible with the needs of successful adaptation in a rapidly changing, rich knowledge-based, competitive environment (Amabile, 2020; Ancarani, et al., 2019; Raisch & Krakowski, 2021). Given that highly trained knowledge workers will dominate their operations, MNE leaders need to reconsider their cultures and create greater opportunities for employees' participation, as well as counteract their concerns about privacy, excessive organizational control, and dehumanization. Such major cultural changes are hard to achieve, though essential to gaining the benefits associated with 4IR. Yet, these cultural changes are also essential for promoting MNEs' innovation and entrepreneurial activities (Klobukowski & Pasieczny, 2020; Kohli & Melville, 2019). As Tung and Stahl (2018) called for, business leaders need to revamp their organizational structures, systems, and processes to reflect these cultural changes, while IB scholars need to pay a greater attention to the evolving context and process of organizational cultural changes.

We here add a point that MNEs also have to ensure the currency of their absorptive capacity, because 4IR builds on emerging technologies that will embody complex and radically new knowledge that is not easy to comprehend and absorb. Some of these technologies are unrelated to MNEs' current knowledge bases. Hence, MNEs face three challenges in this regard. The first is to keep their absorptive capacity current by engaging broadly and deeply in search for knowledge in frontier areas of potential interest for the development and evolution of 4IR. The second is to upgrade the content of their absorptive capacity to better understand emerging trends and the forces shaping 4IR. The third is to effectively deploy their absorptive capacity to ensure rapid knowledge sharing and dissimulation throughout their international



operations in ways that foster innovation and enable converting these innovations into marketable and profitable applications (e.g., products). These challenges suggest opportunities for future IB research into how global businesses build, maintain and deploy their absorptive capacity, and the effect of digital and strategic transformation on the approaches they undertake.

Moreover, as the application of technologies associated with 4IR accelerates, the need for MNEs to develop a capability to convert discoveries and innovations into products, systems, processes, services, business models, and other useful applications is crucial for their success (Zahra et al., 2007). MNEs invest hugely in R&D and innovative activities, but do not always do as well in commercializing their innovations (Cano-Kollmann, Cantwell, Hannigan, Mudambi, & Song, 2016). For example, millions of patents go non-commercialized, leading to wasted resources. This scenario may frustrate talented employees who leave and start their own businesses; other companies may commercialize the innovations developed (but overlooked) by MNEs. To date, IB literature has focused on how MNEs acquire, accumulate, process, share and integrate knowledge to build capabilities and innovate. Yet, researchers has paid little attention to the internal processes that MNEs need to convert their discoveries and innovations into profitable applications, a major challenge in the context of 4IR. The processes associated with knowledge conversion require different organizational skills; they are also likely to be performed by different groups of people within the MNE. Therefore, greater attention to organizational design issues (e.g., structure, communication, division of labor, and coordination) is essential to ensure the timely and effective transition from ideas to discoveries and then to products and applications (Clough & Wu, 2022; Majchrzak, Markus, & Wareham, 2016).

Managing Changing Workforce

Industry 4.0 also has serious implications for the dynamics and management of the workplace. While IB scholars have focused on the external social challenges that MNEs face, they have not studied internal changes that result from the evolving industrial era. These changes require creative solutions to ensure strategic transitions and build human resource capabilities essential to compete in the new global marketplace, which opens a new avenue for IB scholars to probe not just organizational behavior and human resources

management but to integrate these issues with strategic and social performance views in the 4IR setting. As one pointed example, the wide scale industrial changes induced by 4IR may leave millions unemployed or temporarily out of the workforce, especially among less educated employees who do not have the skills necessary for the new industrial order (Verbeke & Hutzschenreuter, 2021). In turn, this scenario may intensify a sense of inequality where a portion of the labor force bears the brunt of the transitions required to make 4IR a reality. In the meantime, more people (i.e., digital nomads) choose to embrace a location-independent, technology-enabled lifestyle that allows them to travel and work remotely (Muller, 2016). With the advent of 4IR, “digital nomads” may become prevalent, moving from one task in one organization to another, undermining their bonds to their employers and raising questions as to how to best cultivate the knowledge of these employees.

Similarly, changes in the nature and scope of the firm, as a result of 4IR, will alter how companies organize the global workforce, influencing how people interact with and relate to each other. These disruptions to ongoing operations will affect existing social relationships and interpersonal networks, leading to a sense of anomie and alienation (Rockmann & Pratt, 2015). With the growing sophistication of technology and widespread adoption of AI, questions also arise about the content of employees’ job roles and performance expectations (Colbert et al., 2016; Dery, Sebastian, & van der Meulen, 2017), raising questions as to which jobs are performed by humans or by machines. This may arouse a sense of dehumanization among employees, who may feel undervalued by their employers. Even when MNE leadership works hard to reduce the ill effects of 4IR-related transitions, adjustments to these changes could take time, with serious short-term negative effects on employee morale and company productivity. This new reality also propels multicultural team leaders to orchestrate and facilitate new ways of multicultural teams’ interactions that cultivate a social fabric facilitating effective knowledge sharing in a digital era (Tung, 2016). As well, concerns arise about employees’ rights and privacy in the 4IR environment. With the adoption of intelligent monitoring systems and increased focus on connectivity, employees’ privacy in the workplace may become limited. Also, while useful for making important decisions, big data (Li et al. 2019) enable companies to collect and

store considerable amounts of data about employees' performance, work history, and medical records, heightening concerns about the ownership, control, and use of such data (Glikson & Woolley, 2020). IB researchers need to pay greater attention to these concerns and how MNEs address them. Our preliminary literature survey across fields seems to suggest that IB research on this agenda, to some extent, lags behind other fields and behind present practices undertaken by MNEs.

SOCIAL ENGAGEMENT AND SUSTAINABILITY FOR INDUSTRY 4.0

The IB field has a major opportunity to address social impacts and consequences of 4IR across countries, particularly the role of technology. One such consequence points to the emergence of different types of companies that are likely to replace some traditional ones; this is part and parcel of the cycle of creative destruction, where innovative and efficient entrepreneurial companies (i.e., corporate and independent startups) come to dominate the new economic order by introducing innovations that spur greater productivity and better economic, technological, and social outcomes (Zahra & Hashai, 2022). At the national level, differences among countries will play a key role in the redistribution of economic activities resulting from 4IR (World Bank, 2016). Some countries may not be quick or proficient enough in making these transitions because of their existing industrial base, the irreversible commitments they have made to particular economic sectors, and the geo-political and cultural forces shaping their choices (UNCTAD, 2013). As a result, IB scholars have a golden opportunity to document changes in the different strategies that different countries adopt to build their positions in the new economic world order, document the factors that shape these decisions, and study how these positions evolve as 4IR forces continue to unfold. The effect of these changes on national systems of innovations that enable these transitions is another area worthy of study. In conducting their research, IB scholars can draw important lessons from business history especially about the effect of technological evolution on industry and corporate transitions, as well as the implications for communities and the evolutionary patterns of international competition.

Industry 4.0 also means that MNEs need to decide how to engage with their diverse and demanding stakeholders along every phase of their

global value and supply chains. Paradoxically, the widespread use of digital technologies will significantly empower stakeholders as they interact with MNEs, making their expectations and demands regarding diversity, equality, social and economic justice, and inclusion heard and hard to ignore (Van Zanten & Van Tulder, 2018). Although these technologies raise expectations that MNEs can address persistent social challenges, they also make communication with these different stakeholders easier. In this "fishbowl" environment where transparency and speed are expected, MNEs need to demonstrate greater responsiveness to strike an effective balance between their social, technological, and economic goals (Verbeke & Hutzschenreuter, 2021). Recently, the role of technology multinationals in helping to achieve global sustainability goals has been a subject of considerable interest (e.g., Montiel, Cuervo-Cazurra, Park, Antolín-López, & Husted, 2021). Though newer technologies are increasingly more environmentally friendly and enable cleaner and greener manufacturing, serious risks are associated with shifting to these newer systems and technologies. MNEs also need to make these transitions without wasting resources, damaging the environment, or degrading quality of life.

Relatedly, there is growing recognition that technological advances are magnifying concerns over diversity, equality, and inclusion. Transitions such as those associated with 4IR are usually surrounded with insecurities as to who in society will win and who will lose, highlighting concerns about the nature of the social contract between MNEs and the communities where they operate around the globe. While many MNEs increasingly espouse a belief that they are (or can be) a force for good, societal expectations continue to change and accelerate, presenting new challenges and arenas for their social engagement (World Bank, 2016). Some global companies may find inspiration in their transitions to the developing industrial era in identifying emerging social issues that could serve as the foundation for social innovation and can also lead to new business creation and novel business model development (Srinivasan & Eden, 2021). With the technological advances that come with transitioning into 4IR, MNEs will become better positioned to recognize and exploit such opportunities for social innovation and connection with different community groups, local institutions, and NGOs. These innovations help address community needs but also pinpoint areas for



potential business development and growth for MNEs, in collaboration with other companies in and outside their markets.

We have seen a significant rise in activism by different groups demanding greater corporate responsiveness and transparency (Acharya, Gras, & Krause, 2022; Davis & Kim, 2021). Further, policymakers and regulatory agencies have shown considerable interest in redefining firms' social roles. One consequence of this interest is the growing recognition among MNEs of the need to better align their economic and social missions (Davis & Kim, 2021). Consequently, many MNEs have taken major steps to link their competitive strategies with their social goals (Lubinski & Wadhvani, 2020). With 4IR, this alignment can help to avert the potential side effects of technological transitions on communities, employees, and other stakeholders. Fortunately, digital technologies can make this alignment feasible and even profitable by providing timely information that enables MNEs to work more closely with social entrepreneurs, NGOs, and local groups. These technologies also give international companies real life data about community needs, a gauge of community reactions to their different initiatives, the ability for interventions essential to support social innovations, and the ability to undertake experiments to determine which social interventions or innovations are likely to pay off better in different international markets. Moreover, 4IR technologies can facilitate meta-learning, where MNEs can effectively discern key principles that allow them to map out effective strategies for social engagement and innovation in different markets (Kohli & Melville, 2019).

We foresee that digitalization and technology and innovation activities may significantly enable MNEs act in consort with the global mandates and values laid out by the United Nations (e.g., Global Compact; Sustainable Development Goals, or SDGs), creating transparency where their physical footprints on the planet become visible for the rest of the world to see. We suggest that these DITI measures enable MNEs to better achieve sustainability targets through such mediums as green enablement, efficiency and productivity, ecological optimization of stakeholder values, and global ecosystem sustainability. Digital technologies, for example, can improve climate and green enablement in numerous ways. A technology in point is AI, which can be used to benefit the environment through optimized energy system forecasting, demand-response charging infrastructure in

transportation, analytics and automation for smart urban planning, "hyperlocal" weather forecasting for crop management, and supply chain monitoring and transparency (PwC, 2019). Similarly, digital sensor technologies can track the movement of water and chemicals that permeate the earth's soils and its outer atmosphere. Sophisticated physical models, from climate simulators to continental-scale hydrologic models, may attend to sensing technologies and AI. Potential application areas might include the development of new climate solutions, land management practices, water security, environmental justice, prediction of air and groundwater pollution, preventing extinction, and optimizing nature for human health and well-being.

These issues, and our observations underlying these issues, point to the need for IB scholars to deepen these inquiries. We need to know more about how MNEs choose the social causes they focus on, how they decide to divide their attention to varying social and sustainability goals and to different types of countries (home vs. host; emerging vs. advanced economies), how they build momentum internally for them, how they develop the organizational capabilities necessary to address them, and how to capture learning from these engagements. Another question to explore is whether MNEs from different countries of origin or with varying CSR commitment will approach these issues differently, and if yes, then how the macro-level institutional condition (regulatory incompatibility across nations) and micro-level institutional condition (corporate social policies within the MNE) shape this commitment.

INDUSTRY 4.0 IN INTERNATIONAL ENTREPRENEURSHIP

Industry 4.0 is highly relevant to research in international entrepreneurship (e.g., born-global, new ventures, small and medium businesses). By disrupting existing business ecosystems, platforms, and established business models, this industrial environment creates bountiful opportunities in fields away from MNEs' traditional businesses. It also prompts them to reimagine their existing businesses and introduce new business models that free up resources, and allow investments in new business activities (Zahra, 2005; Zahra & Hashai, 2022). Digitalization, in particular, induces a virtuous cycle in which MNEs' innovation leads to the creation of new businesses (e.g., new corporate

startups) that, in turn, engage in innovations that generate new (additional) entrepreneurial activities of different types, fostering the adoption and development of digital technologies and so on. This follows that 4IR may create additional waves of entrepreneurial activities that enable MNEs to exploit emerging opportunities ushered in by the emerging industrial landscape (Prashantham, 2021). Many of these entrepreneurial activities cross international borders, intensifying MNEs' international entrepreneurship activities in both developing and developed economies. Local entrepreneurs in emerging markets, for example, can take advantage of their collaborations with multinational enterprises to gain access to funding to expand and scale up their operations, while pursuing increasingly international sources of funding such as venture capital or crowdfunding.

These changes should offer IB researchers an opportunity to study changes in types and location of international entrepreneurship activities undertaken by companies from emerging and advanced economies and their contribution to growth and wealth creation. Given that these companies increasingly collaborate and compete with MNEs, it is important to study how these collaborations lead to innovation, counter trade barriers, overcome institutional voids and instability, and address social issues in different parts of the globe. It is also worth exploring how resource-constrained local entrepreneurs in emerging and developing countries take on niche strategies associated with 4IR opportunities and what conditions are necessary for these niche strategies to be more likely to succeed.

Industry 4.0, meanwhile, also holds implications for MNEs' corporate entrepreneurship, a process that centers on promoting innovation and discovery internally while gaining new skills and capabilities from external sources (Phan, et al., 2009) and exploring and exploiting opportunities made possible by the 4.0 business environment. Venturing programs, in particular, are intended to complement internal innovation activities, and ongoing entrepreneurial activities taking place in MNEs' subsidiaries. The dual focus of corporate entrepreneurship reflects the realities of 4IR, where many of the skills and capabilities MNEs need are developed and controlled by other companies even in unrelated industries, frequently in other countries (Zahra & Hashai, 2022). Aware of this challenge, some MNE leaders have created venturing programs that allow them to work closely with

startups through their corporate venturing and accelerator programs. MNEs also work collaboratively with other multinationals, family firms and SMEs to learn, acquire resources, and pursue promising business opportunities (Prashantham, 2021). Further, MNEs have acquired other companies (especially technology-based startups), seeking to expedite their access to new knowledge essential to development (Amabile, 2020; Castagnoli, et al., 2022).

Our preceding observations indicate a need for future IB research that documents the changing nature of MNEs' corporate entrepreneurship and venturing programs that keep pace with 4IR, especially concerning how the programs influence the relationships with other MNEs and startups overseas and how corporate venturing and entrepreneurship influence companies' internationalization decisions and outcomes. Moreover, future research may examine how these programs are organized via new connectivity associated with 4IR and how foreign subsidiaries contribute as well to the MNE's entrepreneurial pursuit as a whole.

DISCUSSION AND CONCLUSION

Industry 4.0 has unleashed new, powerful technological forces that promise to reshape the international business environment, redistributing economic activities around the world. We propose that 4IR highlights the interplay of four key pillars combined – digitalization, intelligence, technology, and innovation – which together presents both abundant opportunities and significant changes in how MNEs extend their global reach, connect with internal and external stakeholders, and streamline global operations in a more efficient and productive way. Taking advantage of opportunities in this dynamic landscape requires MNEs to undergo massive digital, strategic, and organizational transformation, modifying their focus on co-creation activities by building closer relationships with diverse partners, platforms, startups, and local institutions. To address this change and spur future research, we illustrate what required transformation entails and what new capabilities are needed to compete under 4IR. We view 4IR not just as impacting international businesses but also the global society, pointing out what this developing industrial environment means for social engagement, sustainability and international entrepreneurship, and how MNEs contribute to these activities.



We suggested future research directions or issues for each major issue we covered above, some of which are also shown in Table 1. But still, there are many more. As this article focuses on strategic, social and entrepreneurial aspects of 4IR for large and small MNEs, we did not elaborate on how 4IR affects macro-level international business – that is, how home or host country governments improve 4IR competitiveness for their social and economic development and what it takes to attract high-tech MNEs to invest and contribute. This competitiveness constitutes an essential new CSA for all nations, and even more so for developing countries to catch up in the digital era (Stephenson, et al., 2021). Future research can revisit MNE-government relations in the 4IR context, dissecting a co-evolving and co-opetition view towards MNEs and host governments in improving and leveraging this competitiveness. More global and local stakeholders (e.g., consumers, NGOs, industrial associations, policy institutions, etc.) should be engaged in this process as well.

Industry 4.0 engenders research opportunities to modify long-established IB issues, such as location selection, entry mode choice, global integration, and FDI motives, to suit the context of 4IR. The alignment between these decisions and country conditions relating to 4IR carriers strong transaction cost implications for businesses. FDI motives and locations may be altered in a manner that digital linkage or digital connectivity advantages may overwhelm conventional cost saving logic, prompting MNEs to prioritize cross-border connectivity-enabled speed, space and scale that involve the real-time orchestration of global value chain networks. It merits inquiry, for instance, upon how digitalized orchestration systems and organizational coordination systems complementarily work together to improve this combined orchestration.

Industry 4.0 incubates new players, new businesses, new sectors, and new forms of management involving international business. Fintech, for example, grows exponentially due to 4IR, fostering digital banking, crowdfunding, block-chain, cryptocurrencies, and much more (Nicoletti, 2017). This opens new avenues for future research to

investigate how international startups and established businesses in these new sectors explore business opportunities in a way that may differ from the approach adopted by traditional MNEs. Important too, these nascent businesses require IB scholars to pay more attention to enacting and enforcing global norms and standards that must be complied by MNEs. This is an exemplary area in which MNEs and public-policy institutions (national, regional and global) can, and should, work together to ameliorate institutional (regulatory and normative) environment for the benefits of global society in general, and important stakeholders in particular.

Finally, we must also highlight that 4IR is rife with challenges, a big agenda on IB scholars' desk. Operationally, Industry 4.0 elevates challenges in cybersecurity, data protection, interdependence risk, data architecture, networking requirement, and organizing processes within the firm. Institutionally, 4IR technologies can be sensitive to national security and geopolitical rivalry (e.g., the United States Chips and Science Act showcases this). Around the globe, international businesses in high-tech and strategic industries encounter a slate of new legislative, governmental and regulatory policies in various countries that aim to regulate global value chains for geopolitical gains. The intertwinement between techno-nationalism and geopolitical frictions may escalate both environmental and operational uncertainties for MNEs and stifle some opportunities that could otherwise arise from 4IR together with globalization. In closing, Industry 4.0 we have envisioned and described in this article offer new agenda and new opportunities for meaningful and impactful IB research, and to this end we presented numerous research questions in the spirit of advancing this emerging frontier for the IB community.

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