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Perspective Article

The nature of innovation in global value chains

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ABSTRACT

Global value chains (GVCs) have revolutionized production processes and many companies no longer produce goods and services entirely in one single country or within their own organizational boundaries. Through offshoring and outsourcing, value chains are sliced up and activities are dispersed to locations and actors where they can be produced or executed most efficiently. The fine slicing of GVCs also implies that innovation activities can be geographically dispersed and separated from other GVC activities. However, there have been inconsistent arguments on the impact of this dispersion on innovations and on the effect of innovations on GVC activities, as research on the topic has been sporadic, inconclusive, and fragmented. Thus, this paper conceptually discusses the nature of innovation in GVCs by reviewing literature and raises important questions that should be addressed. It also outlines a variety of possible research directions and future research foci that can and should be taken to develop the field.

1. Introduction

The rise of global value chains (GVCs) has revolutionized the way that production processes are carried out. Thanks to reduced communication and transportation costs, many companies have abandoned the practice of producing goods or services entirely in a single country and within their own organizational boundaries. Through offshoring and outsourcing, firms have sliced up their value chains and dispersed activities to locations and actors where production processes can be most efficient, by leveraging resources that are either skilled and specific or economically convenient. As a consequence, supply chains have become more global although this trend has receded somewhat in recent years (Miroudot & Nordström, 2019).

Scholars have been quick to jump on this trend. Over the last two decades, an influential literature has analyzed the geographical spread of GVCs (Suder, Liesch, Inomata, Mihailova, & Meng, 2015; Turkina, Van Assche, & Kali, 2016), the factors that affect the decision where to locate activities (Doh, Bunyaratavej, & Hahn, 2009; Jensen & Pedersen, 2011; Ma & Van Assche, 2016), and how GVCs are governed (Gereffi, Humphrey, & Sturgeon, 2005).[2] Other firm-level studies have investigated the drivers of international production fragmentation (Kedia & Mukherjee, 2009; Schmeisser, 2013), the firm types more likely to follow this trend (Farinas & Martín-Marcos, 2010), and the effects GVC dispersion has on a firm's productivity or employment (Brandl, Mol, & Petersen, 2017; Hummels, Jørgensen, Munch, & Xiang, 2014; Kasahara & Rodrigue, 2008).

Remarkably absent in this literature, however, is a systematic discussion of innovation in GVCs (Pietrobelli & Rabellotti, 2011; Van Assche, 2017). This lack of insights represents an important research gap, especially when considering the prominence of innovation in today's global knowledge economy. Chen, Los, and Timmer (2018) estimate that intangible capital – notably in the form of technology, design, and branding – currently accounts for around one-third of the production value that is created in GVCs and this share has been rising over time. The aim of this special issue is to start addressing this research gap by compiling various articles that study the nature of innovation in GVCs

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[2] See De Marchi et al. (2020) and Kano et al. (2020) for recent reviews of the GVC literature.

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from different angles.

The fine-slicing of GVCs implies that innovation activities can be geographically dispersed and separated from other tangible GVC activities. However, there have been inconsistent arguments on the impact of production offshoring on innovation and vice versa. For instance, while Farrell (2005) and Vivek, Richey, and Dalela (2009) suggest that production offshoring can benefit innovation by allowing lead firms to free up resources that can then be invested in research and development (R&D) activities, Pisano and Shih (2009, 2012) warn that spatial separation of manufacturing and R&D activities may in some cases undermine a company's innovation capabilities.

Adding to this, innovation processes have themselves become "fine-sliced" and dispersed to different firms around the globe, leading to the emergence of global innovation networks (Andersson, Dasí, Mudambi, & Pedersen, 2016; Mudambi, 2008). Some scholars have considered R&D dispersion positive for innovation since it increases a firm's access to a portfolio of knowledge pockets around the globe (Levin & Barnard, 2013; Perri, Scalera, & Mudambi, 2017; Tzabbar & Vestal, 2015). Others have suggested that it amplifies the complexity of a firm's operations due to interdependencies of innovation activities, leading to limitations on managerial bandwidth (Ambos & Ambos, 2009; Narula, 2014; Scalera, Perri, & Hannigan, 2018) and increased challenges with firms' internal or external boundaries (Schotter, Mudambi, Doz, & Gaur, 2017).

These diverse arguments call for a systematic analysis of innovation in GVCs. In this article, we offer a conceptualization that allows to analyze and advance the literature on innovation in GVCs. To this aim, we adopt the distinction developed by Cohendet and Simon (2017) who describe how the dominant models of innovation have shifted over time from *linear & closed*, to *interactive & closed*, and finally to *interactive & open*. We then discuss the three separate literatures that have built on the interactive & open innovation model to study innovation in GVCs – *global knowledge sourcing, GVC governance* and *production-innovation co-location* – highlighting their similarities and differences. Finally, we develop suggestions for future research.

2. Towards an interactive and open view of innovation in GVCs

Since the beginning of the twentieth century, three sequential models of innovation have emerged, which each offers a common understanding of how ideas can be turned into final products or services, where resources should be allocated and how they should be managed to fuel the innovation process (Cohendet & Simon, 2017).[3] Historically, the first is the *linear & closed model of innovation,* i.e. the process of innovation resulting from linear sequences of phases - basic research, applied R&D, and production and diffusion (Arrow, 1962; Schumpeter, 1942) - where innovation was considered to be mainly sparked in R&D centers within the boundaries of lead firms in a single location. A vibrant literature in the field of international business (IB) used these arguments to study the early internationalization of R&D within multinational enterprises (MNEs). According to these studies, innovation takes place in the MNE's home country, while foreign subsidiaries mostly adapt the product and process technology to the local context (Håkanson & Nobel, 1993; Howells, 1990). In this configuration, foreign subsidiaries are categorized as 'Home-Base-Exploiting' (Kuemmerle, 1999) or 'Competence-Exploiting' (Cantwell & Mudambi, 2005) since they mainly receive knowledge developed in the MNE's domestic R&D center and only carry out the final adaptation steps of the innovation process prior to commercialization.

Countering this view, and building on Nelson & Winter's (1982) evolutionary approach to economic change, Lundvall (1985, 1988) highlighted the interactive nature of the innovation process, while Kline and Rosenberg (1986) noted that new ideas do not necessarily progress sequentially through definite stages and could emerge at any phase of the innovation process (see also Dosi, 1982; Malerba, 2002; Arora & Gambardella, 1994). Thus, a new model of innovation emerged in the 1980s: the *interactive & closed model of innovation* (Cohendet & Simon, 2017). In this configuration, R&D centers were no longer considered the sole organizational locus of technological development. Rather, innovation was started to be conceived as the result of interactions between various actors at different stages of the innovation process (see e.g. Van de Ven & Rogers, 1988). Within the IB literature, the seeds of this conceptualization can be identified in the research on transnational MNEs (Bartlett & Ghoshal, 1989), described as complex and interdependent organizational structures whose subsidiaries systematically leverage the internal network to share resources – including knowledge and information arising from their different local contexts – which may lead to highly interactive innovation processes.

Since the early 2000s, a third model has emerged that focuses on *open & interactive innovation*. Based on the premises of open innovation, technological knowledge is no longer considered to be solely sourced within the intra-organizational network, as external organizations along with different types of knowledge acquisition practices gain a prominent role in the firm innovation process (Chesborough, 2003; Laursen & Salter, 2006). To strengthen innovation capabilities, companies should, thus, leverage the distributed pools of knowledge both within and outside of the firm boundaries, since what matters is not owning the ideas per se, but having access to them to feed the re-combinatory process leading to new products or services (see e.g. Tolbert & Zucker, 1983; Teece, 1980).

In Table 1, we summarize the three dominant models adopted to interpret innovation, including their theoretical foundations, organizational structure, the type of networks, the typology of innovation activities and locations.

Building on this interactive & open approach, we consider innovation as all outputs and process activities that contain an aspect of novelty. Thus, we adopt a rather broad definition of innovation in GVCs, following the idea that it deals with the creation and application of *"any sort of novelty*" (Nelson & Winter, 1982: 130) *across any stage of the value chain* in fields spanning from science to practical life. This includes, for example, activities of entrepreneurial firms seeking to benefit from changing product/service offerings (e.g. Drucker, 2014), activities

Table 1
Innovation models.

Analysis level	Linear & closed innovation	Interactive & closed innovation	Interactive & open innovation
Organizational structure	Centralized	Decentralized	Decentralized
Network	Firm internal	Firm internal	Firm internal and external
Innovation activities and locations	Mainly in central R&D centers	In various centers and subsidiaries	Various sources and activities at various locations
Key contributions	Arrow (1962), Håkanson and Nobel (1993), Howells (1990), Schumpeter (1942)	Bartlett and Ghoshal (1989), (Cantwell & Mudambi, 2005), Kline and Rosenberg (1986), Nelson and Winter (1982)	Chesbrough (2003), Laursen and Salter (2006)
Key IB concepts	Central home-based R&D lab (R&D home bias); Home-Base-Exploiting or Competence-Exploiting foreign subsidiaries	Transnational MNEs; Home-Base Augmenting or Competence-Creating subsidiaries; Multi-country knowledge generation	GVCs; R&D offshore outsourcing; global knowledge networks

[3] In a similar fashion, Papanastassiou, Pearce, and Zanfei (2020) provide an overview of the changing perspectives on the internationalization of R&D and innovation by multinational enterprises.

associated to new marketing and distribution functions that are strongly influenced by local markets and institutions, and activities leading to the design of new products or production methods (e.g. Nelson, 1993).

The *interactive & open model of innovation* is a good starting point for studying innovation in GVCs. First, its definition centers on the idea of a typical innovation process dispersed across different actors (including suppliers, consumers, and users) and locations both within and outside of the focal firm, interconnected in a continuous exchange of information and co-creation. Second, its acknowledgement that the innovation process is decentralized and can be sparked at any value chain stage pushes researchers to not only focus on innovation conducted by lead firms, but also by other value chain actors. Third, the model's focus on the role of linkages lays bare that the innovation performance of specific nodes across the value chain depends on what happens in the value chain network as a whole. Fourth, the model acknowledges the importance of both internal linkages, i.e. connections between individuals and organizational subunits within firm boundaries, and external linkages, i.e. connections involving external organizations and individuals, which have become a central feature of GVCs (Buckley, 2009; Gereffi et al., 2005; Mudambi, 2008).

3. Innovation in GVCs: the existing building blocks

In this section, we provide an overview of three research streams in IB that have relied on features of the *interactive & open model of innovation* to study aspects of innovation in a GVC setting: (1) global knowledge sourcing, (2) GVC governance, and (3) co-location of innovation and production. While these literatures all emphasize the importance of GVC linkages for the development of a firm's innovation capabilities, they have embarked on distinct trajectories; each has provided key insights on innovation in GVCs, while at the same time providing unexploited opportunities for cross-fertilization.

3.1. Global knowledge sourcing

The global knowledge sourcing literature constitutes a first research stream that has studied linkage-induced innovation in a GVC setting. In this research field, the unit of analysis is generally the large MNE that operates as lead firm. This stream has mainly investigated the role of horizontal linkages between lead firms and foreign organizations that specialize in similar innovation-intensive value chain activities such as R&D centers.

The origins of this literature lie in studies on R&D internationalization. In line with the *closed & interactive innovation model*, MNEs were in the 1990s increasingly viewed as decentralized networks of subsidiaries, whose foreign R&D units both contribute and receive knowledge from the headquarter and other R&D subsidiaries (Håkanson, 1990). Consistent with this idea, the seminal work by (Bartlett & Ghoshal, 1990) suggested that MNEs' foreign subsidiaries are not mere "replicators" of their parent companies' activities abroad, whose R&D efforts are limited to the adaptation of central units' products and services to local needs. Rather, foreign units can engage in creative tasks to exploit opportunities emerging from their local contexts, and the innovative activities they perform locally may follow diverse routes and pursue different projects than those of the home country. Thus, while demand-driven factors were still considered fundamental drivers of the internationalization of firm innovative activities, as they prompt *home-base exploiting* FDI in R&D (Kuemmerle, 1999), supply-side factors emerged as critical triggers of this phenomenon (Cantwell, 1995); they contribute to explain the evolution of firms' innovative activities over time and space toward more *home-base augmenting* types of foreign R&D (Ambos, 2005).

This perspective has further been stimulated by the rise of global centers of excellence in geographically distributed areas of the world, which have worked as a powerful centrifugal force that pull MNE R&D activities outside of their home countries. As new locations emerged as generators of leading-edge technologies (Gerybadze & Reger, 1999), MNEs have recognized that the broad spectrum of scientific and technical inputs to which they need to gain access in order to stay abreast of the latest advances is unlikely to be available in a single location. In fact, regardless whether the MNE wants to expand into previously unexplored technical fields or reinforce its existing competence base, the growing complexity and interdependence of technologies requires it to widen the scope of knowledge search by building linkages to other locations (Cantwell & Piscitello, 2000; Cantwell, 1989).

As innovation studies moved to the *open & interactive model of innovation,* the global knowledge sourcing also increasingly acknowledged the role of both, intra-firm and inter-firm linkages for lead firms' abilities to tap into foreign knowledge pockets. That is, developing knowledge *connectivity* and *connectedness* that provide access to different regions' expertise, is considered highly beneficial to a firm's innovation capabilities. It contributes to overcome the constraint of local search and provides opportunities for knowledge recombination and, in turn, novelty (Cano-Kollmann, Cantwell, Hannigan, Mudambi, & Song, 2016; Scalera et al., 2018).

The literature on knowledge *connectivity* has emphasized the different types of linkages that lead firms can use to tap into foreign knowledge pockets (Lorenzen & Mudambi, 2013). They can build organization-based pipelines by setting up foreign subsidiaries or formal inter-firm linkages (Li & Bathelt, 2018; Turkina & Van Assche, 2018). They can also build individual-based linkages through global mobility of inventors and experts. Firms systematically bring foreign-educated scientists and engineers back home to gain access to the knowledge base of the countries in which these skilled resources have been trained (Choudhury, 2016). Firms also increasingly rely on geographically dispersed teams to make new discoveries (Kerr & Kerr, 2018; Marino, Mudambi, Perri, & Scalera, 2020; Perri et al., 2017), and the team's geographical dispersion has been found to exhibit a curvilinear relationship to the novelty of the team's innovative outcomes (Tzabbar & Vestal, 2015).

Connectedness refers to the strength of a lead firm's connections with organizations in foreign knowledge pockets. A key contribution of the global knowledge sourcing literature has been its embrace of a network approach to its study of the role of international connectedness on local innovation. There is a growing acknowledgement that both the organizational and the spatial distribution of a lead firm's inter-organizational and inter-personal network are critical for the understanding of the dynamics of knowledge sourcing (Asakawa, Song, & Kim, 2014). Cantwell and Zaman (2018) and Turkina and Van Assche (2018) show that improvements in a region's embeddedness in global knowledge networks enhances its local innovation performance. Scalera et al. (2018) distinguish between domestic and foreign knowledge-based connections, and analyze their interaction to unpack the effects on firm technological scope.

The literature has also noted that, due to high levels of interchange between the different moving parts of the innovation activity, the spatial transaction costs related to the involvement of several locations tend to increase even if communication and transportation costs are decreasing over time (Ambos & Ambos, 2009; Beugelsdijk & Mudambi, 2014; Gray, Siemsen, & Vasudeva, 2015; Hannigan, Cano-Kollmann, & Mudambi, 2015). On the other hand, it has been suggested that the potential gains of a geographically distributed innovation structure do not materialize automatically. Rather, these benefits can be only reaped by firms that are able to engage in fruitful processes of cross-fertilization that allow them to effectively integrate the specialized knowledge that is dispersed across different locations, while keeping coordination costs under control (Singh, 2008; Tzabbar & Vestal, 2015). MNEs' global innovation networks may also generate inefficiencies, stemming from how their international expansion has been designed. Specifically, the massive use of cross-border M&As as the preferred entry mode has led to the acquisition of global R&D centers, which often become part of the MNE's network as a by-product of the broader MNE's international

acquisitions strategy. Given their high political visibility, these "legacy" centers are often maintained but never really integrated into the MNE's global innovation network. As a result, this process can produce sub-optimal network configurations (Doz & Wilson, 2012; Håkanson & Kappen, 2016; Monteiro, Arvidsson, & Birkinshaw, 2008).

On the whole, the global knowledge sourcing research has provided new insights into the link between global connectedness and lead firms' abilities to enhance innovation. It has highlighted the importance of matching firm-specific innovative capabilities developed and embedded in the internal network with knowledge inputs externally sourced and strongly contextualized, which can only be captured through co-location (Demirbag & Glaister, 2010; Sturgeon, Van Biesebroeck, & Gereffi, 2008). Offshoring innovation activities or building knowledge pipelines, in fact, allows firms to tap into knowledge clusters or centers of excellence around the world, so to diversify the firm knowledge base and speed up the acquisition of knowledge inputs that would otherwise be difficult to generate internally (Cano-Kollmann et al., 2016; Dossani & Kenney, 2007; Mukherjee, Lahiri, Ash, & Gaur, 2019). However, it has also uncovered the most critical aspects of this knowledge sourcing approach, emphasizing the key role of integrative mechanisms and embeddedness in global knowledge networks.

More research is nonetheless needed to evaluate the conditions under which international connectedness spurs innovation. The paper by Sinkovics, Liu, Sinkovics, and Mudambi (2021) in this special issue is in this respect a welcome contribution. Focusing on the Taiwanese electronics industry, the article studies the role of knowledge connectivity in suppliers' new product innovation capabilities under various inter-firm pipeline combinations. Counter to traditional narratives, the study finds that knowledge connectivity is less likely to lead to new product innovation capabilities when there is high trust between the Taiwanese supplier and the foreign lead firm. They conjecture that this "dark side of inter-firm trust" may be because suppliers disproportionately rely on their lead firm partner to conduct problem solving when inter-firm trust is high.

3.2. GVC governance

The GVC governance literature constitutes a second research stream that studies innovation-related concepts within an *interactive & open model of innovation.* Unlike the global knowledge sourcing literature, this research field does not focus on innovation by lead firms but rather by their suppliers. Adding to this, the emphasis lies on the role of vertical supply chain linkages between firms specialized in different value chain stages instead of horizontal linkages between firms specialized in similar value chain activities.

A central argument in this literature is that vertical supply chain linkages with global lead firms provide suppliers access to foreign knowledge, which may help them build up their technological capabilities to conduct production-centered innovation (Gereffi et al., 2005; Morrison, Pietrobelli, & Rabellotti, 2008). For example, supplier firms can receive aid from network firms to upgrade technological capabilities through assistance in quality management/control and specialized workforce training (De Marchi, Giuliani, & Rabellotti, 2018). Thus, a supplier's technological capabilities in a GVC setting not only depend on its own actions to develop its technological capabilities, but also on those to which they are linked.

The question that this literature raises is through which channels vertical linkages can improve a supplier's technological capabilities so that it can economically upgrade its position within GVCs. Economic upgrading occurs when suppliers increase the value added that they create and appropriate within a value chain (Sako & Zylberberg, 2019). Humphrey and Schmitz (2002) identify four types of economic upgrading that can be stimulated through linkage-induced innovation: innovation that allows suppliers to more efficiently turn inputs into output (*process upgrading*), that permits the development of higher quality goods and services (*product upgrading*), that allows suppliers to change the mix of value adding activities (*functional upgrading*), and that lets suppliers move into more skill-intensive industries (*industry upgrading*). A range of empirical studies have used this upgrading typology to analyze how GVC participation may trigger economic development, including Bair & Gereffi's (2001) study of the apparel cluster in Torreon, Mexico, Guerrieri & Pietrobelli's (2004) analysis of the electronics industry in Taiwan, and Van Assche &Van Biesebroeck's (2018) study of the export processing regime in China.

Although economic upgrading and innovation are related, they are not perfect synonyms (De Marchi et al., 2018). Linkage-induced innovation is neither a necessary nor a sufficient condition for economic upgrading (De Marchi et al., 2018; Sako & Zylberberg, 2019). It is not sufficient since suppliers may profit little from linkage-induced innovation if barriers to entry in the industry segment are low (Kaplinsky & Morris, 2001), or if suppliers operate in a regime with weak appropriability (Sako & Zylberberg, 2019). And it is not necessary since economic upgrading can occur without an improvement in technological capabilities. Exploiting economies of scale, for example, can lead to process upgrading even if no linkage-induced innovation takes place (Ponte & Ewert, 2009). There is a general agreement in the GVC governance literature that more work needs to be done to identify under which conditions linkage-induced innovation can create economic upgrading.

A key insight from the GVC governance literature –which has been underappreciated in other research streams – is that the type and intensity of knowledge transfer to suppliers depends on the governance patterns ruling the connection between suppliers and lead firms (Schmitz & Knorringa, 2000). For example, lead firms are generally willing to tolerate or even support innovation by their suppliers along the dimensions of quality, flexibility and productivity if it helps strengthen the complementarities between the two value chain partners. In contrast, lead firms may discourage and even hinder the acquisition of technological capabilities by its suppliers if in the future this type of innovation risks to encroach on the lead firm's core competence. In this respect, the GVC governance literature has focused on how different patterns of governance may enhance or hinder different types of economic upgrading, which are themselves often the result of learning and innovation activities.

A challenge for the GVC governance literature is that it has remained predominantly qualitative, with quantitative measurement remaining largely elusive (McWilliam, Kim, Mudambi, & Nielsen, 2020) This is exemplified by the lack of agreement how to empirically measure economic upgrading (Van Assche & Van Biesebroeck, 2018) and the limited number of quantitative studies that have evaluated the relation between governance and performance outcomes (Kano, Tsang, & Yeung, 2020).

The paper by Pasquali (2021) in this special issue is in this respect a welcome addition. Focusing on the recent phenomenon that developing-country suppliers in the South increasingly sell their output to Southern GVC actors (Horner & Nadvi, 2018), the author evaluates both theoretically and empirically whether Kenyan leather suppliers' upgrading prospects vary if they sell to Northern versus Southern markets. Using highly disaggregated firm-level export data and interviews, he finds that product quality and product upgrading are higher for Kenyan leather exports to the North than to the South, which he attributes to lower Southern standard requirements. Moreover, he finds no systematic difference in product and functional upgrading between North and South. Digging deeper into variations between Southern markets, however, he shows that product upgrading is lowest when exporting to close by African nations and functional upgrading is highest when exporting to dissimilar Southern nations like China.

3.3. Co-location of production and R&D

A third literature studies how the geographical dispersion of vertically-linked value chain stages influences a lead firm's ability to innovate. International production offshoring provides lead firms with

both an opportunity and a problem concerning their own innovation activities. On the opportunity side, the geographic relocation of production allows to capitalize on country-specific advantages and the opportunity it brings in freeing up of resources. These resources can and often are invested in higher-value activities such as R&D, potentially improving firms' innovation capabilities (Bardhan & Jaffee, 2005; Farrell, 2005; Mukherjee, Gaur, & Datta, 2013).

On the problem side, however, production offshoring may also affect domestic innovation negatively by hampering feedback loops between the non-innovation and innovation stages of the value chain (Pisano & Shih, 2009, 2012). One challenge is the efficient transfer of knowledge across borders, as knowledge can be sticky and location-dependent, making it difficult to disperse internationally (Jensen & Szulanski, 2004).

The novelty of this research stream lies in its focus on the intrinsic interactions between innovation and non-innovation activities. Pisano and Shih (2009) argue that constant communication is needed between the production and development stages of the value chain for innovation to occur. Since production offshoring hinders communication between production and development, the geographical dispersion of production can reduce a firm's ability to innovate. Specifically, when a significant portion of production is performed abroad, the knowledge transfer can be hampered by geographical, cultural, and institutional differences with the home country (Lane & Lubatkin, 1998). Mihalache, Jansen, Van Den Bosch, and Volberda (2012) shows empirically that there is an inverse U-shaped relation between production offshoring and innovation. That is, when a substantial portion of production is offshored, this reduces a company's ability to transfer and assimilate new production-related knowledge due to a lack of overlap with their knowledge base at home.

These findings have led scholars to analyze the moderating role of a product's technological architecture on the link between manufacturing offshoring and innovation. Pisano and Shih (2012) identified two technical features: (1) the codifiability or "modularity" of the transactions between R&D and manufacturing; and (2) the "process maturity" of the technology. If the transactions between R&D and manufacturing are modular and the process technology is mature (*pure product innovation*), spatial transaction costs between the two activities are small both now and in the future and production offshoring entails limited dangers for a firm's innovation capabilities. When R&D and production are highly interdependent or manufacturing technologies are immature, production offshoring can be dangerous since it involves high and unpredictable spatial transaction costs. In that case, the value of co-locating R&D and manufacturing activities is high, and offshoring can have important negative implications on innovation. In line with these theoretical predictions, Castellani and Lavoratori (2019) found that the prevalence of production-innovation co-location is higher when tacit knowledge exchanges are more important between the two functions.

Table 2 summarizes the key insights from the three research fields and illustrates the key differences with regards to their focus on (1) different organization types (lead firm versus suppliers), (2) different types of GVC networks (horizontal versus vertical); (3) different types of opportunities and challenges generated by GVC linkages, and (4) different innovation activities (process, product or functional innovation).

4. Knowledge gaps and directions for future research

The previous section has highlighted the fragmented nature of existing research on the nature of innovation in GVCs. These diverse perspectives allow us to identify various research opportunities and missing links between the research streams. All three research streams have several elements in common that relate to the *interactive & open model of innovation*. Each stream recognizes the decentralized nature of innovation processes and acknowledges the importance of both internal and external linkages with other value chain actors to fuel innovation. At the same time, each research area zooms in on different actors and the role of different linkage types. For example, the focal firms in the global knowledge sourcing and co-location literatures are the lead firms, while the GVC governance stream pays attention to innovation by suppliers. Similarly, the GVC governance and co-location literatures focus on the role of vertical supply chain linkages between firms that specialize in distinct value chain stages, while the global knowledge sourcing field emphasizes the role of horizontal linkages between globally dispersed research centers. While these different perspectives are important for the respective fields, their diversity can lead to interesting academic spillover opportunities.

The global knowledge sourcing literature's recognition of the importance of network connectedness and connectivity is one of them. Integrating these concepts will require GVC governance and co-location studies to move beyond the simple dyadic analysis between a lead firm and supplier, and consider the broader network structure of the GVCs in which suppliers are involved. For instance, while the literature on GVC governance has focused on the role of power dynamics as drivers of suppliers' innovation, it has ignored that suppliers can themselves connect to global knowledge networks. Unexplored questions related to connectedness are, among others, whether suppliers that are more centrally embedded in local and global networks are more likely to have the capacity to absorb external knowledge. Also, can suppliers learn more from lead firms that are central in global knowledge networks, and vice versa? Adopting the connectivity concept could also push researchers to dig deeper into the role of individual-based linkages for both suppliers' and lead firms' abilities to innovate. Questions such as what role expatriates and other types of boundary spanners play in moving ideas from lead firms to suppliers deserves more attention. Similarly, the co-location literature could explore the conditions under which such individuals are able to transfer tacit knowledge required to smoothen communication between physically separated MNE units. This focus would allow effectively substituting for geographical proximity between manufacturing and innovative activities.

A second source of cross-fertilization among these streams lies in the role of governance structures within complex GVC networks, which has been widely explored by the GVC governance literature, but ignored in

Table 2
GVCs and innovation.

Research stream	Global knowledge sourcing	GVC governance	Co-location of innovation and production
Organization type	Lead firm	Supplier	Lead firm
Type of network	Horizontal	Vertical	Vertical
GVC arguments	Network provides knowledge diversity that boosts firm-level innovation, though not automatically	Linkages provide access to knowledge that boosts manufacturing capabilities	Dispersion frees resources but decouples production-innovation learning
Innovation activities	Process or product innovation	Process, product or functional innovation	Process or product innovation
Main focus	Network configuration and embeddedness	Governance structure	Technological architecture
Key contributions	Ambos (2005), Andersson et al. (2016), Cantwell (1989)	Gereffi et al. (2005), Schmitz and Knorringa (2000), Sako and Zylberberg (2019)	Bardhan & Jaffee, 2005, Farrell (2005), Pisano and Shih (2012)

the other research streams. The co-location literature, for example, could benefit from considering whether and how lead firms can mitigate spatial transaction costs related to the separation of production and innovation through the adoption of certain governance types. Similarly, the global knowledge sourcing literature, that often considers knowledge governance as a protective measure rather than an opportunity for innovation activities, could investigate which model of governance would allow better overall performance.

The paper of Buciuni and Pisano (2021) in this special issue exemplifies how cross-fertilization can lead to new insights about innovation in GVCs. By integrating the concept of governance structure into Pisano & Shih's (2012) Modularity-Maturity matrix, the authors argue that lead firms in a GVC can adopt four distinct innovation models depending on (1) the geographic dispersion of innovation and production and (2) the degree of a lead firm's control over production. The authors use case studies from four global manufacturing industries – pharmaceuticals, bicycle, design furniture and wine – to illustrate the existence of these four innovation models.

Finally, the co-location literature is the only research stream that has emphasized the role of technological architecture on linkage-induced innovation. More research is needed that analyzes, how technology moderates GVC actors' ability to benefit from external knowledge especially during this age of digitization. GVC studies need to acknowledge the different technology-supported interaction activities that influence governance considerations. The challenge will be to consider complex technological architectures that contest the configuration of linkages among GVC actors and their interaction in the creation of innovation. Similarly, while extant global knowledge sourcing literature has largely disregarded the role of technological architectures, these are likely to substantially affect the amount and type of knowledge sourced abroad, as well as its actual usage in lead firms' innovation processes and/or manufacturing activities. Unexplored questions related to the role of technological architecture within GVCs are, among others, how does the technological architecture affect the governance of innovation activities, and their interaction with non-innovation within GVCs, and how does it influence firms' reliance on global - *vis a vis* local - knowledge sourcing?

In our view, future research on innovation in GVCs can get most bang for the buck by adopting a more holistic view of GVCs that considers all actors and linkage types as parts of an integrated system (see Fig. 1). Extant studies have mostly limited their attention to a simplified value chain setting that includes a limited number of actor and linkage types, ignoring the reality that GVCs consist of multiple hierarchical layers of actors (lead firms, first-tier suppliers, second-tier suppliers etc.) and that the same organization can take on different positions in different GVCs. The analysis is also generally conducted in a setting that treats the technological architecture and governance structure as fixed. Such simplifying assumptions help in making the analysis tractable, but they come at the cost of ignoring important feedback loops that may shape innovation processes in integrated systems. In the remainder of this section, we provide three examples how a more holistic view of GVCs can help provide a deeper understanding of the role of network structure, governance form and technological architecture for innovation in GVCs. We also evaluate how the insights we have provided in this article allow us to identify the impact of the current Covid-19 pandemic on innovation within GVCs.

4.1. *Multiplex nature of the GVC network*

In the extant literature, scholars have generally concentrated on the role of a single linkage type on a GVC player's innovation performance. In reality, however, GVC actors often build a portfolio of horizontal and vertical linkages with their GVC partners, thus embedding themselves in a multiplex network composed of several overlapping and interconnected sub-networks by linkage type (Turkina & Van Assche, 2018). Acknowledging the multiplex nature of the network is valuable since it acknowledges that any shock or managerial decision that alters the structure in one sub-network, can also influence the structure of the other sub-network, thus, leading to extra feedback loops that influence innovation.

Consider, for example, the impact of production offshoring on innovation; the traditional argument is that a lead firm may use the freed up cash of production offshoring to enhance its innovation efforts at home (Farrell, 2005), but that this can be undermined by heightened spatial transaction costs between the dispersed production and innovation activities (Pisano & Shih, 2012). This perspective, however, ignores that the lead firm may use the freed up cash to internationalize its R&D, which may allow them to limit the increase in spatial transaction costs while tapping into foreign knowledge pockets. In this case, production offshoring may enhance a lead firm's innovation performance through the reconfiguration of both its vertical and horizontal linkages.

Building horizontal connectedness, then again, may help a supplier

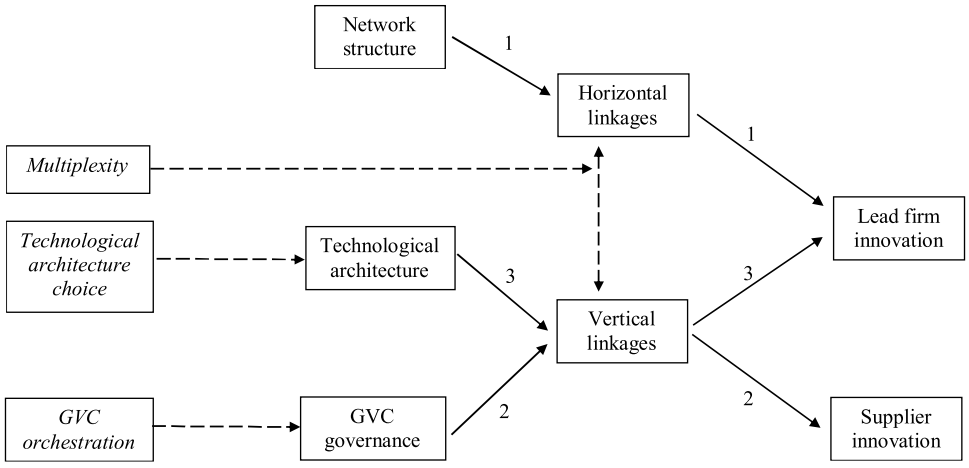

Fig. 1. Conceptual framework for innovation in global value chains.

economically upgrade within vertical chains. Indeed, stronger horizontal linkages can help strengthen a supplier's technological capabilities that allows them to functionally upgrade into new value chain activities. This, in turn, can push the suppliers to offshore their lower value-added activities to suppliers elsewhere while developing new relations with lead firms. Here again, stronger knowledge sourcing can generate a change in a supplier's position in the vertical sub-network which generates an extra feedback loop that influences innovation performance.

4.2. From governance to orchestration

A more holistic view of GVCs also challenges researchers to reflect more deeply on innovation that occurs at the GVC level instead of at the actor level. A key contribution of extant studies has been the analysis of linkages that allow firms to innovate the specific value chain activities in which they specialize (product or process innovation) or that allows firms to move into more sophisticated activities. Less attention has been paid to the types of innovation capabilities that lead firms need to develop to resolve system bottlenecks and ensure that the entire value chain acts as an integrated structure.

A deeper analysis of a lead firm's orchestration capabilities will in this respect be critical (Pitelis & Teece, 2018). It has been well documented that lead firms need to ensure that the entire value chain operates as a harmonious whole, which requires them to build the necessary "architectural knowledge" (Larsen & Pedersen, 2014) and "controlling intelligence" (Buckley, 2009) that allows the identification and resolution of system-wide bottlenecks in the GVC. Developing these orchestration capabilities goes beyond building competences that lead firms need to conduct their in-house design and manufacturing activities. As Brusoni, Prencipe, and Pavitt (2001) succinctly suggested, lead firms need to "know more than they make." First, they need to create technological capabilities in a much broader range of technical fields than the core product fields in which they compete so they can identify and coordinate the integration of new technological developments along the GVC. Second, they need to develop organizational knowledge that allows them to deal with both internal and external partners that are dispersed across the globe (Kotha & Srikanth, 2013; Larsen & Pedersen, 2014).

Creating these orchestration capabilities require lead firms to develop sophisticated inter-organizational coordination and collaboration routines that allow them to obtain knowledge from its GVC partners through horizontal and vertical linkages, transmit their expectations to their GVC partners, and monitor supplier actions appropriately. In our view, identifying areas of intervention in lead firms' innovation strategies that allow to strengthen their orchestration capabilities is a key area for future research.

4.3. Technological architecture choice

The studies described in this paper generally adopt the deterministic view that technological development is a trajectory, which is intrinsic to the technology itself and can be neither stopped nor controlled (Leonardi, 2008). Therefore, it is believed that a change in the properties of a technology can affect the organization of the value chain, but not the reverse. For example, innovation scholars have investigated how the shift towards open innovation leads to more organizationally decentralized MNE networks for knowledge development and exchange (Cantwell, 2017; Roper, Du, & Love, 2006), but little attention is paid to how R&D offshoring affects a firm's decision to adopt an open innovation system. Similarly, GVC studies have evaluated how the codification of transactions affects governance structure (Gereffi et al., 2005), but the question how a change in governance mode affects a firm's decision to codify its transactions has been largely ignored. Thus, future work could consider studying how a change in a firm's GVC structure affects its technological development path.

Moreover, while different GVC actors have the incentive to innovate in the specific portion of the value chain in which they operate, evolving technological architectures could generate substantial disruptions of existing GVC configurations along with the re-organization of the actor network. With changing GVC structures and a change of value creation within the GVC, the entire system might be impacted. Firm and geographic boundaries might shift as a result of these changes, leading to different innovation dynamics. Investigating which types of governance structures and knowledge sourcing strategies might help GVC actors and networks to manage such architectural shocks should be a primary question for scholars interested in innovation in GVCs.

Exploring this area of research allows to contemplate the possibility that a firm's technological architecture is not simply an attribute of knowledge but is sometimes a managerial decision (Henderson & Clark, 1990). In certain industries, firms can choose from a variety of technological architectures, which each have their own costs and benefits (Schilling, 2000; Ulrich, 1995). A modular architecture, for example, has the benefit that it reduces the interdependencies between modules, thus allowing firms to independently concentrate their capabilities on innovating a single module (Baldwin & Clark, 2000). But it comes at the cost that it narrows the degrees of freedom that researchers have in the design process as they need to adhere to the fixed interfaces (Christensen, 1992), which in the long term can lead to fewer innovative breakthroughs than integral systems (Fleming & Sorenson, 2001). This is relevant in a GVC setting since a change in the organization of a value chain can alter the cost–benefit balance of competing technological architectures and influence a firm's technological development path. In a case study of the optoelectronics industry, for example, Fuchs and Kirchain (2010) show that offshoring to East Asia has made an older design more cost effective, thus delaying the adoption of the emerging more innovative architecture.

4.4. COVID-19 and innovation in GVCs

The COVID-19 pandemic, which started in January 2020, raises a number of questions regarding the future of innovation in GVCs. Given the importance of connectivity, co-location and orchestration, as well as the impact of GVC configuration on the technology architecture choice, any such shift will naturally have an effect on innovation in GVCs.

The COVID-19 pandemic has hurt the production of intangibles by stifling lead firms' abilities to benefit from both local agglomeration economies and from international collaborations (Van Assche, 2020). The goals of stay-at-home orders and physical distancing rules put a halt to the planned and unplanned face-to-face meetings that undergird the vibrancy of local knowledge ecosystems. The closing of international borders to non-essential travel has limited the global mobility of knowledge workers, with direct consequences on the firms' abilities to collaborate and exchange knowledge with their foreign partners (Kano & Oh, 2020). We argue that this affects innovation in GVCs in a number of ways.

First, the "stay at home" policies do alter individual and team level dynamics in the production of intangibles. Employees that used to have daily office meetings and precise organizational routines were suddenly transformed in remote workers. It is often argued that this is less costly for knowledge workers since they do not have to be physically present to perform their job (Dingel & Neiman, 2020). But such claims severely underestimate the social nature and benefits of informal relations that happen during work and that are crucial for creativity and productivity (Johns & Gratton, 2013). The combined effect of these two contrary trends on innovation and creativity is not clear, because, if on the one hand, companies have heavily adopted mediating technologies to sustain and foster virtual collaborations, on the other hand, the dynamics underlying face-to-face interactions cannot be fully translated in a decontextualized virtual setting and dispersed R&D teams might lose their propellant, if not properly stimulated.

Second, the pandemic elevated challenges in inter-firm settings, and especially in buyer-seller relationships. With every contact requiring an

explicit meeting, sellers find it hard to rely on informal chat and empathy, particularly if they intend to establish new relations. As a result, this creates a huge shift towards more rational decision making and persisting travel-restrictions add to these problems. In contrast to the tangible component in value chains, intangibles can seldomly be stored or kept in "inventory". Bi-sourcing of creativity has long been practiced as a second opinion, but it is less effective once a decision is made. As a result, resilience in the production of intangibles primarily relies on flexibility.

Third, the pandemic has raised questions whether it is feasible for firms to follow political calls to reinstall more central or at least multi-domestic value chains. The answer to this question, to some extent, will depend on how path dependent and embedded innovation in GVCs really has become, and how this trend will be affected by the pandemic in the medium term and the systemic changes related to it. While the pandemic has disrupted existing networks, ecosystems and platforms linking lead MNEs, customers and other GVC partners (Zahra, 2020), recent anecdotal evidence in The Economist and the New York Times points to some of the difficulties that firms may face in altering the geographic set up of their innovative systems. As immediate response to the Covid-19 outbreak, companies have started to change the way they manage their intangible and tangible knowledge resources. They are promoting digital technologies and flexible time schedules by reducing the physical geographic dependence on certain locations, like global cities. However, shifting work from office to home also proved to be difficult in regions where homes lacked the IT infrastructure, where property was too expensive, or where data security was at stake. Overall, the pandemic has pressured GVCs to increase the geographical footprint of innovation, and even with inequalities and inefficiencies, collaborations remains the key functioning mechanism.

5. Conclusion

In this editorial we have highlighted the fragmented evolution of the literature on the dispersion of innovative activities in relation to the growing fine slicing of GVCs. Taking stock of key theoretical insights and empirical findings that have emerged in the streams on global knowledge sourcing, GVC governance and production-innovation co-location, we call for the adoption of a more holistic view of GVCs, wherein all actors and linkage types are considered as an integrated system. We claim that this will provide a clearer picture of how the organization, enactment and outcomes of innovative activities have evolved in the context of GVCs. In fact, GVCs are composed of several overlapping and interconnected sub-networks which influence one another via a web of direct and/or mediated relationships of different types. This approach will allow scholars to gain a more comprehensive view of the whole set of interdependencies that may affect or be affected by how innovation is carried out in GVCs. We envisage that this will also allow to advance our understanding of innovations that take place at the GVC level instead of at the actor level. This type of innovation might be of utmost importance during crisis or emergency situations, like the one induced by the COVID-19 pandemic, which require sudden and system-wide changes to the organization of the GVC as a whole. Similarly, a more systemic view of GVCs will provide scholars with the most appropriate viewpoint to consider the possible interactions between the GVC organization and the properties of the underlying technological architectures.

We acknowledge such a holistic approach to innovation in GVCs represents a challenge, both theoretically and empirically. From the theoretical viewpoint, it requires finding appropriate ways to combine streams of literature that build on very different premises and often adopt heterogeneous levels of analysis. From the empirical viewpoint, it urges scholars to observe, measure and analyse an already very complex phenomenon, i.e. innovation, in the context of environments that span different organizations and geographies and, thus, entail the ability to account for a variety of influencing factors.

As elaborated in the preceding sections this *JWB* special issue on *The Nature of Innovation in Global Value Chains* includes three original papers: Buciuni and Pisano (2021), Sinkovics et al. (2021) and Pasquali (2021), which take a step in the above mentioned direction by contributing to as many streams of literature reviewed in this editorial.

We hope that these papers stimulate members of the IB community and beyond to engage in conversations on the necessary blending of perspectives on the dispersal of manufacturing and innovation. Just like production processes today take place across firms' and countries' borders, innovation is interactive, open and geographically distributed. As a consequence, manufacturing and innovation processes, along with their respective players and underlying heterogeneous linkages, cannot be analyzed separately if we aim at gaining a comprehensive understanding of how such key activities create value in global organizations.

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