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Does Reshoring Affect the Resilience and Sustainability of Supply Chain Networks? The Cases of Apple and Jaguar Land Rover

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Extending the notion that reshoring can have a significant impact on a firm's supply network owing to the associated location decisions, we explore how reshoring influences the resilience and sustainability of a focal firm's supply network. While reshoring is triggered by aspects related to both the home (domestic) and the host (foreign) country, frequently more favourable aspects in the home country lead to the reshoring decision. To investigate these dynamics, we construct two large-scale networks consisting of 2066 and 1283 firms, respectively, capturing the supply networks of Apple and Jaguar Land Rover. Both networks have been experiencing the reshoring of previously foreign suppliers to domestic locations. Our investigation captures the network dynamics created by this relocation of tier 1 suppliers for the overall supply chain network, that is, also for higher-tier/sub-tier suppliers. The results reveal, contrary to our expectations, that indirect (sub-tier) foreign suppliers positively influence the network's resilience, with this impact, however, being negatively moderated by their degree centrality, that is, the number of ties a node possesses. In addition, existing indirect (sub-tier) domestic suppliers do not have a significant influence on the resilience of the network. No evidence was found for the impact of reshoring on sustainability. Overall, our study contributes to the reshoring literature by delineating its influence on both the resilience and the sustainability of a focal firm's supply chain network.

Introduction

Reshoring is a phenomenon that has been triggered by trade wars, rising labour costs in offshored countries, sustainability concerns (Gray *et al.*, 2013), and—most recently—supply chain disruptions due to the COVID-19 pandemic (Butt, 2021). As such, reshoring is being pursued to reduce both operational and strategic risks (Ellram, Tate and Petersen, 2013) and to advance a firm's sustainability agenda (Ashby, 2016). While firms have been aiming to achieve both resilience and sustainability imperatives with reshoring, little is known about 'resiliently sustainable' supply chains (Fahimnia and Jabbarzadeh, 2016; cf. Orzes and Sarkis, 2019), motivating us to investigate these dynamics jointly.

While prior reshoring studies have provided valuable insight into macro-level issues such as labour costs, transportation costs, and market proximity (Foerstl, Kirchoff and Bals, 2016; Fratocchi *et al.*, 2016), the dynamics of reshoring emanating from a firm's supply network have been largely neglected (Baraldi *et al.*, 2018).

We believe that this is a serious omission, since reshoring causes structural changes in the network of suppliers and customers, carrying significant potential to influence both the resilience and the sustainability of a firm. While the positive impact from direct (tier 1) suppliers is frequently evident and the reason to reshore in the first place, our focus does not restrict itself to this view, but also considers higher-tier (indirect) suppliers. This is a critical consideration, as evidenced by a recent survey that found that 40% of disruptions occurred beyond Tier 1 suppliers (Business Continuity Institute, 2021).

What makes the management of higher-tier suppliers so challenging is the associated lack of visibility. Within this context, we suggest that reshoring may enhance visibility not only in relation to Tier1 suppliers, but also in relation to higher-tier suppliers—we develop arguments in this paper to theorize about such dynamics. Anecdotal evidence is provided by Motor Car Parts of America Inc., which moved its production from China to the United States, eliminating foreign dependences and increasing the visibility of sourced parts (Reinsch *et al.*, 2021). It is, however, difficult to completely mitigate the dependence on foreign firms at the sub-tier level, especially considering the location of raw materials, such as steel and aluminium, and the associated production capabilities (Reinsch *et al.*, 2021). While all challenges cannot be taken away by reshoring, we suggest that the supply network resulting from reshoring is more resilient than before, owing to the dynamics elaborated throughout this paper.

Reshoring may also deliver significant benefits for sustainability, which is generally more difficult when entities (i.e., sub-tier suppliers) are in different locations. This view is predicated on the notion that more control can be exerted over a primarily domestic supply network, or that restrictions are more stringent in countries to which the reshored activities are moved (assuming that the offshoring decision was motived by a low-cost rationale). A greater push for sustainability has thus been associated with reshoring activities (Fratocchi and Di Stefano, 2019). Owing to the significant benefit of reshoring for sustainability, research at this intersection has been called for (Orzes and Sarkis, 2019). A gap in the existing literature on reshoring also exists when it comes to the inter-dependences in industrial networks stretching across both home and host countries (Baraldi *et al.*, 2018). For instance, studying the resilience of buyer–supplier–supplier networks, Durach *et al.* (2020) highlighted the potential of considering the criticality of sub-tier suppliers through structural analyses of large supply networks. Similarly, Jia, Gong and Brown (2019) called for future research on sustainability initiatives by sub-tier suppliers. Our study follows these calls and addresses these gaps, offering an understanding of the influence of sub-tier suppliers on the resilience and sustainability of large-scale networks within the context of reshoring.

Overall, while it is commonly accepted that home-country advantages, such as governmental incentives, play a crucial role (Wan *et al.*, 2019), little is known about the implications of the ensuing supply network structure, especially as it concerns constraints that may come from higher-tier suppliers. Our study explores these dynamics and aims to answer the following two research questions.

RQ1. How do firms beyond the visibility range (sub-tier suppliers) affect the resilience of the network, after the focal firm has reshored Tier 1 suppliers?

RQ2. How does the reshoring of Tier 1 suppliers enhance sustainability in the overall network?

To answer these questions, we categorize sub-tier suppliers into two categories—domestic and foreign—and analyse their influence on both the resilience and the sustainability of the firm's supply network. Since organizations are part of complex networks and do not necessarily have visibility beyond their Tier 1 suppliers, we view supply chain networks as complex adaptive systems (CASs) (Choi, Dooley and Rungtusanatham, 2001). Changes in the Tier 1 supplier structure thus have the potential to lead to significant changes in the overall network (Baraldi *et al.*, 2018), as these new Tier 1 suppliers may bring with them their own network of sub-tier suppliers. This deserves attention, since even a small change at a distant firm in this network can cause a disruption to spread to other parts (Craighead *et al.*, 2007). As such, in developing our hypotheses, we couple the CAS perspective with the structural hole concept as part of network theory. In conducting our investigation, we construct two large-scale supply chain networks focussing on two case firms—Apple and Jaguar Land Rover (JLR)—with both firms' networks consisting of suppliers in more than 100 industries across the world.

Background literature

Supply chain networks and resilience

A supply chain network (SCN) consists of relationships linking a defined set of actors (Harland *et al*., 2004), with each having a unique combination of resources. These heterogenous networks have been conceptualized as CASs consisting of both material and knowledge flows (Choi, Dooley and Rungtusanatham, 2001). The CAS framework focuses on the interplay between a system and its environment, as well as on their co-evolution. SCNs can be considered as comprising interrelated firms that operate in an environment consisting of markets generating demands for products and services, with the firms themselves being at the cross-section of multiple supply chains (Carter, Rogers and Choi, 2015). This perspective allows us to capture the complexity of real-world SCNs, which serves as a foundation for advancing supply chain management knowledge and theory (cf. Wieland and Durach, 2021). The network consists of the focal firm's suppliers and customers (Borgatti and Li, 2019), with the network evolving through competition and collaboration (Durach *et al*., 2020). While focal firms can manage relationships with their Tier 1 suppliers, managing extended supplier networks is often beyond contractual relationships, and thus oversight, control and visibility is limited. Obtaining insight into these higher-tier entities is however critical, especially when it comes to assessing the supply chain's resilience. When studying supply chain resilience (SCRes) it is thus paramount to take a network perspective, expanding the visible horizon of the supply chain.

SCRes captures a firm's capability to be ready for unanticipated events, to provide an effective and efficient response in such instances, and to recover from the disruption (Mertzanis, 2021; Ponomarov and Holcomb, 2009). All of these can be considered critical capabilities (Pettit, Fiksel and Croxton, 2010), together with agility and flexibility (Blackhurst, Dunn and Craighead, 2011; Pereira, Christopher and Da Silva, 2014; Scholten and Schilder, 2015). With our focus on the network level, SCRes can be defined as the ability to continue operations and maintain connectedness in the event of disruptions (Zhao, Harrison and Yen, 2011). This connectedness and associated supply network resilience can be captured by network characteristics (Kim, Chen and Linderman, 2015), which are measured at the node or the arc level, where nodes represent the various entities in the supply chain and arcs the connections between them. Of relevance for supply chain network resilience are the three centrality measures of Betweenness Centrality (BC), Closeness Centrality (CC) and Degree Centrality (DC) (Borgatti and Li, 2009). BC is a centrality measure capturing how often a node lies on the shortest path between all pair combinations of other nodes (Kim, Chen and Linderman, 2015); CC is a measure of the average shortest distance between nodes; and DC is the number of ties a node possesses (Kim, Chen and Linderman, 2015). Within this context, we view SCRes as 'the capacity of a supply chain to persist, adapt or transform in the face of change' (Wieland and Durach, 2021, p. 2).

Supplier sustainability risk

Scholars have long called for the importance of considering both upstream and downstream risks (Chopra and Sodhi, 2004). Based on Wagner and Bode's (2008, p. 309) definition of a supply chain disruption—namely the combination of '(1) an unintended, anomalous triggering event that materializes somewhere in the supply chain or its environment, and (2) a consequential situation which significantly threatens normal business operations'—Kim, Wagner and Colicchia (2019) drew parallels to supplier sustainability risks. Sustainability risks are events or conditions that can cause damage to the environment or the society with the potential to evoke significant negative stakeholder reactions. For example, Nike faced public outrage when its unsustainable labour practices, a consequence of cheap outsourcing, were revealed (Nisen, 2013). A tragic incident was also the Rana Plaza disaster in 2013, which resulted in significant financial loss for retailers and triggered many apparel companies to change their methods of supplier management (Jacobs and Singhal, 2017). Similarly, Kim, Wagner and Colicchia (2019) showed that supplier sustainability risks are associated with a significant reduction in shareholder wealth, suggesting that sustainability objectives should benefit from the reshoring decision. This was evidenced by Fratocchi and Di Stefano (2019), who identified three sustainability-related drivers for reshoring decisions: social pressures in the home country, carbon footprint considerations, and corporate social responsibility. In addition, the 'made-in' effect was a frequent motivation to reshore, generating additional appeal for consumers to buy products produced locally. While the connection between reshoring and sustainability is evident, there is limited research that investigates these two dimensions in an integrated fashion. We do so in the present study, which is especially relevant for a post-pandemic world destined to put sustainability front and centre (Pinner, Rogers and Samandari, 2020) as companies rebuild their supply networks. Specifically, we seek to develop finer-grained insight into the dynamics generated by the reshoring of Tier 1 suppliers and the effect that this has on the structure of the focal firm's supply chain network, with a particular emphasis on its resilience and sustainability.

Reshoring

Reshoring is a phenomenon that has come to the fore in developed countries in Europe (https://reshoring.eurofound.europa.eu/) and the United States (www.reshorenow.org). While it can be simplified as a manufacturing location decision (Ellram, Tate and Petersen, 2013; Gray *et al*., 2013), the underlying complexity makes it an intriguing topic. Foerstl, Kirchoff and Bals (2016, p. 495) defined it as 'the relocation of value creation tasks from offshore locations to geographically closer locations'. Conceptualizing this decision-making process is difficult as it is non-linear, dynamic and cyclical in nature (Boffelli *et al*., 2020). Challenges also include information availability, the risk appetites of decision-makers, and anchoring effects. These characteristics make finding generalizable patterns difficult, because every country has its own peculiarities (Wan *et al*., 2019). What has, however, been a common finding is that all reshoring decisions have a trigger point that starts the decision-making process (Boffelli *et al*., 2020), with the COVID-19 pandemic being one such illustrative trigger (Barbieri *et al*., 2020). While several drivers can lead to reshoring, we are particularly interested in the dimensions of resilience and sustainability, which can be associated with the seeking of efficiency based on the change in the external environment.

Prior to deciding whether to reshore, the cost–benefit trade-off needs to be analysed. In this vein, Chen and Hu (2017) highlighted that reshoring may yield lower profits, even when there are no low-cost advantages associated with offshoring, owing to supply dependence. Similarly, Rasel *et al*. (2020) found that companies are less likely to reshore owing to higher domestic production costs. That reshoring can, however, also be a profitable strategy was noted by Brandon-Jones *et al*. (2017), who found that reshoring announcements yielded an average abnormal stock return of 0.45%.

Our study differentiates itself in that we focus on the change in network structure that occurs with the reshoring of Tier 1 suppliers, which may bring with them an entirely new set of supply networks. The consideration of dynamics emanating from such higher-tier entities is critical, as reshoring decisions are enabled and constrained by inter-dependences in industrial networks stretching across home and host countries (Baraldi *et al*., 2018). This is particularly the case because a reshoring decision does not necessarily mean the insourcing of the production. In this vein, Foerstl, Kirchoff and Bals (2016) offer a framework with three types of possible contracting mechanisms that can occur while reshoring operations domestically: third-party outsourcing, strategic partnership, and in-house production. In addition to this make-or-buy decision, the new location decision also needs to be considered, whereby firms may seek border countries for nearshoring instead of reshoring domestically. Location dynamics can present themselves in the form of political stability, (Chen *et al*., 2016), flexibility (Fratocchi *et al*., 2016), cultural similarity (Hussein and Kanchamba, 2009), resource availability (Das and Teng, 2000), and benefits offered by home-country institutions that nullify higher transaction costs (Kirca *et al*., 2011).

Among the myriad of choices needing to be made with the reshoring decision, we focus on the continued outsourcing to third parties or the development of strategic partnerships with domestic entities, rather than on reshoring operations in-house (i.e., insourcing production). The decision to continue outsourcing—but just to move the outsourcing partner domestically—is a commonly applied strategy. For instance, Apple strategically invested in Corning Incorporated, a Tier 1 supplier, in 2018, yielding significant benefits (Apple, 2021). The reshoring of Tier 1 suppliers to the home country, however, implies significant structural changes to the entire supply network, because the new domestic supplier may have different higher-tier/sub-tier/indirect suppliers that they rely on. Specifically, many of these higher-tier suppliers may still be located in foreign locations, making the impact of the reshoring decision tenuous. As a result of these inherent complexities and the implications for network resilience, further research into the influence of such indirect suppliers has been called for (Barbieri *et al.*, 2018; Foerstl, Kirchoff and Bals, 2016; Fratocchi *et al.*, 2016; Gray *et al.*, 2013). We follow this call in the present paper and categorize suppliers in the network as direct (Tier 1) domestic suppliers (DDSs), direct (Tier 1) foreign suppliers (DFSs), indirect (sub-tier) domestic suppliers (IDSs), and indirect (sub-tier) foreign suppliers (IFSs). Consideration of these different types of suppliers and their influence on their supply networks offers us a unique opportunity to study a supply network's resilience and sustainability, which have both been identified as key drivers for reshoring decisions (Fratocchi *et al.*, 2016).

Theory and hypotheses development

Domestic and foreign effects on resilience

While reshoring impacts primarily Tier 1 suppliers, it can also have significant implications for the ensuing SCN, particularly regarding the higher-tier suppliers over which the focal firm generally does not have any control (Wang, Li and Anupindi, 2015; Ang, Iancu and Swinney, 2017). Similar conflicts may exist between Tier 2 and Tier 3 suppliers—even if the Tier 2 supplier decides to reshore as well, they may not be able to control the actions of their Tier 3 suppliers. It is therefore important to realize that analogous to direct connections, a focal firm's *indirect* connections may also affect its supply chain structure (Granovetter, 2005), which in turn affects SCRes. Therefore, reshoring direct (Tier 1) suppliers does not necessarily ensure that the entire supply network becomes resilient—it could simply mean that possible disruptions are pushed higher up in the supply chain.

While there is general support for the relationship between resilience and reshoring (Giuseppina and Michelle, 2018), what is still not clear is the role of *indirect* suppliers in driving resilience within the context of reshoring. As such, shifting to more DDSs does not necessarily impact the number of IDSs. Several perspectives can be taken to disentangle these complexities. On the one hand, network theory focuses on supplier relationships and the focal firm's power within the network (Granovetter, 2005; Kim, 2014), rather than on the focal firm's physical proximity to its suppliers. A firm may thus be physically close, but not very well connected to the focal firm owing to existing buyer–supplier relationship structures. However, on the other hand, it can also be argued that in a disruptive situation such as a pandemic, it is easier to source from local suppliers than from foreign suppliers (even though the relationship between the two firms may not be as strong). Support for these notions is provided by the structural hole perspective (Burt, 2008), with a structural hole representing the gap that exists when direct connections do not overlap, giving positional benefits to the focal firm. As illustrated in Figure 1, Firm X is in a position of power/benefit relative to Firm Y owing to the structural holes present between the direct connections of Firm X. Firms like X have high BC scores and work as gatekeepers, affording them greater control (Borgatti and Li, 2009). If these firms are disrupted, the network is exposed (Basole and Bellamy, 2014). Further, under significant network disruptions, firms with the highest BC scores influence the largest connected component of the supply network (Li *et al.*, 2020), making the functioning of this network dependent on this component (cf. Nair and Vidal, 2011).

SCNs can have several gatekeepers (Kim, Chen and Linderman, 2015; Sharma *et al.*, 2019), which can also be distant (Yan *et al.*, 2015). However, reshoring reduces this distance by replacing DFSs with DDSs, increasing the likelihood of indirect suppliers also being domestic. As such, there is the possibility that IFSs in the firm's supply network are replaced with IDSs, also potentially based on the focal firm's communication (including the firm's motivation for reshoring and the preference for domestic sub-tier suppliers) with the new DDSs as part of the supplier selection process. From a network perspective, this would mean that structural holes are made smaller, reducing the power of hub-firms (like X in Figure 1). We therefore theorize that with reshoring, a focal firm's dependence on IDSs would reduce owing to the IDSs' lower BC, which is a direct result of more indirect domestic suppliers now being available to the focal firm. With fewer network entities having large BCs, the impact of a disruption is likely to be reduced, strengthening the resilience of the network.

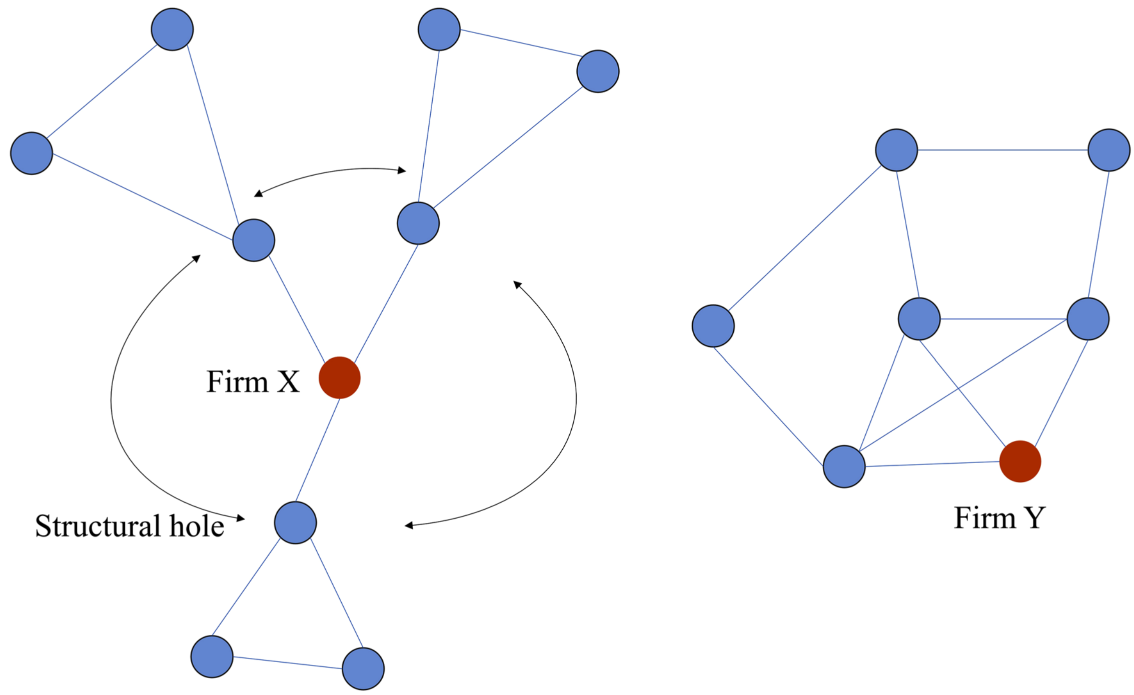

Figure 1. Illustration of a structural hole [Colour figure can be viewed at wileyonlinelibrary.com]

Hypothesis 1: As a result of the reshoring of DFSs to DDSs, the likelihood of having more IDSs increases, reducing their BC and strengthening SCNR.

Along similar lines, with more direct suppliers of the firm becoming domestic and the associated likelihood of the firm's number of indirect domestic suppliers increasing, the number of IFSs is likely to decrease in the firm's network. This would mean that while structural holes are made smaller among domestic suppliers, the structural holes would increase among foreign suppliers owing to their now greater BC. This would make the focal firm more dependent on these IFSs, due to their stronger role as gatekeepers for information and material flows. This, in turn, would make the network more prone to disruptions and thus reduce its resilience. We capture these notions in our second hypothesis.

Hypothesis 2: As a result of the reshoring of DFSs to DDSs, the likelihood of fewer IFSs increases, increasing their BC and weakening SCNR.

A further network characteristic that is likely to influence a network's resilience is degree centrality, which is based on the number of in-and-out connections that facilitate the flow of materials and information (Borgatti and Li, 2009). In this vein, if a node has many connections (i.e., high DC), a focal firm's dependence on this node increases, weakening the resilience of the network (Li *et al.*, 2020). This has also been referred to as the collaboration risk associated with suppliers and customers (Basole and Bellamy, 2014). The expectation is founded on the large number of suppliers and customers associated with a node's high DC, making this node a gatekeeper in the network, and rendering other firms dependent on this entity. Support for this notion has been provided by Zhang and Luo (2017), who noted a negative correlation between DC and BC. Looking at this through a structural lens, a firm with high DC but positioned at X (Figure 1) would have a higher impact on the network (i.e., be more critical for its resilience) than a firm positioned at Y (Figure 1). We thus theorize that while firms with high BC have the propensity to reduce SCNR, this beneficial dynamic is curtailed under conditions of high DC.

Hypothesis 3a: As a result of reshoring, the IDS's DC negatively moderates the relationship between the IDS' BC and SCNR.

Hypothesis 3b: As a result of reshoring, the IFS's DC negatively moderates the relationship between the IFS' BC and SCNR.

Effect of reshoring on sustainability

Motivations for reshoring are generally explained through transaction cost economics, internationalization theory, or other eclectic paradigms, highlighting the role of economic stability and governance. While studies on environmental sustainability have been proliferating, in recent years there has also been increased interest in the social sustainability dimension as well. In addition, while most work considers reshoring as primarily a location decision (e.g., Tate *et al*., 2014), it can also have a significant impact on sustainability (Heikkilä *et al*., 2018; Johansson *et al*., 2018). For instance, Engström *et al*. (2018) noted that in some reshoring cases within the context of Sweden, the intrinsic 'made in Sweden' effect triggered local suppliers to become more eco-friendly. The study also highlighted that a relocation to the home country increased work ethic and social transparency. As such, products made by direct suppliers domestically have been shown to have a significant country-of-origin effect on consumers (Götze and Brunner, 2019). It is, however, not only the patriotic view of manufacturing at home that leads consumers to prefer domestic versus foreign products, it is also that domestic products are associated with shorter supply chains, creating the belief that they are more sustainable (Guerrero *et al*., 2009). Support for this perception is, for instance, provided by the Finnish wine supply chain (Ponstein, Ghinoi and Steiner, 2019). We thus propose the notion that within our context, reshoring, that is, the move from DFSs to DDSs, also has beneficial implications for sustainability.

Hypothesis 4: Reshoring, that is, the move from DFSs to DDSs, increases the overall sustainability of the SCN.

Methodology

This section describes our data collection and associated network construction that captures direct and indirect suppliers of the focal firms, namely Apple and JLR. We collected data both for the current (offshored) footprint of the firm and, using an agent-based model, design a hypothetical network should the firm decide to reshore to its home country. Characteristics associated with the dynamics of both networks are illustrated.

Data collection and network construction

We relied on secondary data from the database Refinitiv Eikon by Thomson Reuters to develop the SCN. The use of secondary databases for supply network studies has become a popular approach (e.g., Bellamy, Ghosh and Hora, 2014; Borgatti and Li, 2019) because it allows the collection of supplier information beyond direct suppliers. Thomson Reuters provides information on competitors, customers, and suppliers collected from documents such as news, filings, and reports. The database also provides one of the most comprehensive Environment-Social-Governance (ESG) databases in the industry.

We collected data using a snowballing approach suitable for collecting large-scale network data (Carrington, 2005). Specifically, large-scale networks were constructed for both Apple and JLR as the two focal companies. We selected these two companies as focal firms for several reasons. First, both companies had announced their reshoring intention prior to the COVID-19 pandemic, which then triggered the implementation in both cases (Pesmedia, 2020; Apple, 2020). Second, both firms' supply networks are globally dispersed, such that the home- and host-country effect of firms in the network can be studied. Third, both firms are committed to increasing their supply chain sustainability. Fourth, Apple and JLR are headquartered in different countries, enabling us to address concerns that reshoring may be driven by home-country-specific factors. And finally, information regarding the supply network is available for both firms.

We collected information on the focal company's direct suppliers, indirect suppliers, and customers, capturing the supply network across four tiers (Figure 2). Because Sharma *et al*. (2019) noted that secondary databases possess some margin of error when reporting company information, we validated the existence of these firms from publicly available information and removed firms with no or only incomplete information in the database. This yielded an initial network of a total of 2066 firms and 3905 customer–supplier relationships for Apple, and a network of a total of 1283 firms

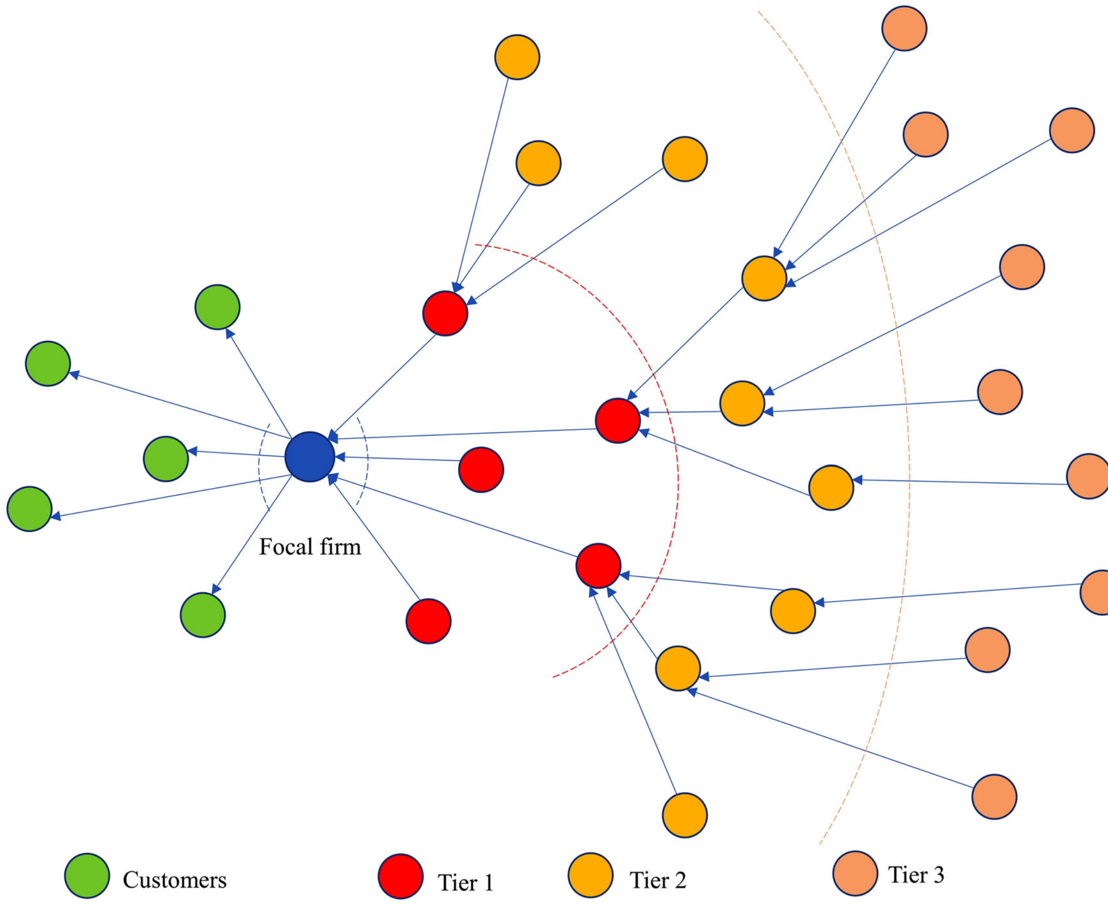

Figure 2. Scope of data collection [Colour figure can be viewed at wileyonlinelibrary.com]

Table 1. Topological network characteristics

	Apple		JLR	
	Existing network	Reshored network	Existing network	Reshored network
Nodes	2066	1991	1283	1242
Edges	3905	3520	1949	1783
Average degree	1.89	1.768	1.519	1.436
Graph density	0.001	0.001	0.001	0.001
Average path length	3.88	3.86	3.51	3.66
Network diameter	10	9	7	8
Average clustering coefficient	0.082	0.071	0.084	0.076
No. of domestic firms	1095	1201	68	79

Abbreviation: JLR, Jaguar Land Rover.

and 1949 customer–supplier relationships for JLR (Table 1).

To assess whether the two sample networks represent a typical population network, we compared the values for the average network characteristics of more than 600 networks calculated by Sharma *et al*. (2019), who used a construction procedure similar to ours. The average network density and the average clustering coefficient computed by Sharma *et al*. (2019) were 0.002 and 0.06, respectively, which closely resemble our sample network characteristics captured in Table 1.

The two SCNs, that is, the existing and the reshored ones, can be reflected by directed networks $G_e = (N_e, E_e)$ and $G_r = (N_r, E_r)$, where N represents a set of nodes, E represents the set of directed unweighted edges, and e and r indicate the existing and the reshored networks, respectively. Further, for both the Apple and the JLR network, we constructed both (a) the current existing network and (b) the reshored network formed by replacing DFSs with new domestic suppliers.

To construct the reshored network, we first identified all companies that belong to the same industry in the focal firm's home country. Because it is difficult to identify the exact product or service that the original supplier was providing to the focal firm, we selected a corresponding domestic firm that offered products or services similar to those of the original foreign supplier. If there were several firms offering the same range of products, we chose the firm with the highest market capitalization, as firms with higher market capitalization generally exhibit greater levels of supply chain integration (Davies and Joglekar, 2013). If there were no firms offering similar products or services, we identified such firms in the neighbouring countries, which would represent near-shoring (Soroka *et al*., 2016). For each new supplier, we collected their suppliers and the suppliers' suppliers. Following the above procedure, we used Gephi 0.9.2 (www.gephi.org) to construct, visualize and obtain the required values to test Hypotheses 1, 2 and 3 via ordinary least squares (OLS) regression analysis. To test Hypothesis 4, we complemented this data with ESG scores retrieved from the Refinitiv Eikon database. These ESG scores are highly comprehensive, with the Environment score being based on *resource use*, *emissions*, and *innovation*, the Social score consisting of *workforce, human rights, community* and *product responsibility dimensions*, and the Governance score being based on *management, shareholders*, and *corporate social responsibility strategy* (Refinitiv, 2021). These categories are aggregated from 186 comparable metrices across annual reports, company websites, websites by non-governmental organizations, filings, corporate social responsibility reports, and news sources worldwide. To assess whether reshoring changed the sustainability of the supply network, we compared the mean ESG score of all firms in the existing network with those in the reshored network for both Apple and JLR using t-tests.

Variable selection

Our first and second hypotheses assess the SCNR of the network and the BC of the firms. To measure network resilience, we recognize that supply chains are free-scale large networks (Choudhary *et al*., 2021; Borgatti and Li, 2019), which are nearly impossible to completely disrupt. Instead, the disruption of a node can make some of the nodes in the network weakly connected. Therefore, based on Zhao, Harrison and Yen (2011) and Kim, Chen and Linderman (2015), we operationalize the SCNR variable as the ratio of strong to weak nodes. The strength of the node depends on how many ways it is connected to other nodes. Strong nodes are those that are connected to the network via multiple links, while weak nodes are connected to the network via single links. This metric follows our definition of resilience, which considers adaptation to change or disruption.

$$\mathrm{SCNR} = \frac{\text{Number of strong nodes}}{\text{Number of weak nodes}} \tag{1}$$

We used Gephi 0.9.2, which deploys a depth-first algorithm, to find strongly and weakly connected nodes. For the independent variable we used change in BC (ΔBC) in both networks. BC is calculated as follows:

$$\mathrm{BC}(n_i) = \sum_{s \neq i \neq t} \frac{g_{st}(n_i)}{g_{st}} \tag{2}$$

where $g_{st}(n_i)$ is the shortest path between nodes n_s and n_t passing through n_i, and g_{st} is the total number of shortest paths. DC (equation 3) also affects the resilience parameters (Li *et al*., 2020), and is therefore used as a control variable. DC is defined by the number of edges of a node, which, in a directional network, depends on the flow initiated (out-degree) or flow received (in-degree) (Kim, Chen and Linderman, 2015) as follows:

$$\mathrm{DC}(n_i) = \sum_{i \neq j} e_{ij} \tag{3}$$

where e_{ij} represents an unweighted customer–supplier link between firms i and j. The change in BC is computed as follows:

$$\Delta\mathrm{BC}(n_{i=e=r}) = \mathrm{BC}(n_e) - \mathrm{BC}(n_r),\ n_e \in N_e,\ n_r \in N_r \tag{4}$$

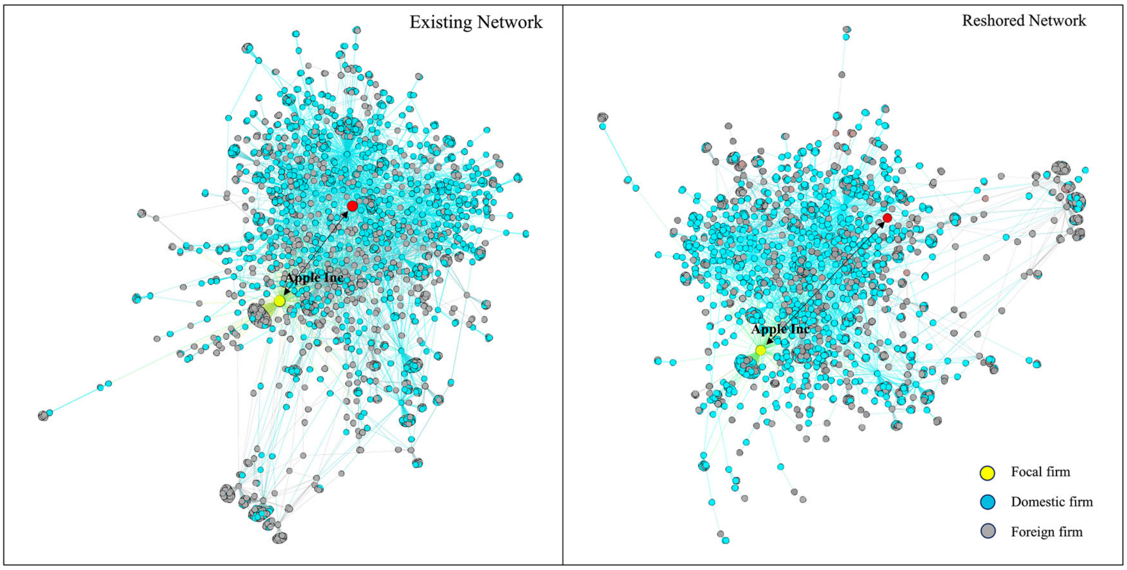

Figure 3. Apple network. To illustrate the difference, the Liquid Telecom Group (red node) is an IFS of Apple (yellow node) that moves farther away from Apple in the reshored network. [Colour figure can be viewed at wileyonlinelibrary.com]

where $BC(n_e)$ and $BC(n_r)$ represent the BC of node n_e and n_r, respectively, in network N_e and N_r, respectively. The change in SCNR is given as follows:

$$\Delta SCNR(n_i) = SCNR(n_e) - SCNR(n_r), \quad n_e \in N_e\, n_i, n_r \in N_r\, n_i, n_i \in N_e, N_r \tag{5}$$

For the fourth hypothesis, we use the mean ESG score of all firms in the network.

Analysis and results

Topological analysis

A comparative analysis of the network characteristics presents a high-level view of the structural changes occurring while reshoring to domestic suppliers (Figures 3 and 4). First, we observe a decrease in the number of nodes and edges, as well as in average DC. We thus conclude that the more local a firm's supply chain becomes, the greater the decrease in the number of connected edges. The network density, however, does not experience a significant change. We also note that these large-scale SCNs mostly follow a scale-free type, which is explained by the power-law degree distribution (Wiedmer and Griffis, 2021). Such networks are characterized by few nodes having many connections. In the event of the reshoring of direct suppliers by large multi-national firms such as Apple or JLR, the network type remains scale-free, which serves as a favourable property. Another advantage of constructing such a large-scale SCN is that several companies appear at more than one level of the hierarchy. For instance, AT&T is linked as a Tier 1 and a Tier 2 supplier, as well as a customer, while Microsoft is linked as a Tier 1 as well as a Tier 2 supplier in the Apple network. This adds to the relevance of our study, as the power and position of companies in the network define the structure and resilience of the whole network.

Results

Hypotheses 1, 2 and 3 were tested via OLS regression analysis, which we chose because the underlying model is uncertain and an explanation of a dependent variable is sought through independent variables (Hair *et al*., 2010). This is consistent with prior network studies investigating disruptions (Li *et al*., 2020; Borgatti and Li, 2019). To safeguard the quality of data points we ensured that nodes have at least 10 connections in the network. The hypotheses were tested with the following equation:

$$\Delta SCNR = \beta_0 + \beta_1 * \Delta BC_k + \beta_2 * DC_k + \beta_3 * \Delta BC_k * DC_k + \varepsilon \tag{6}$$

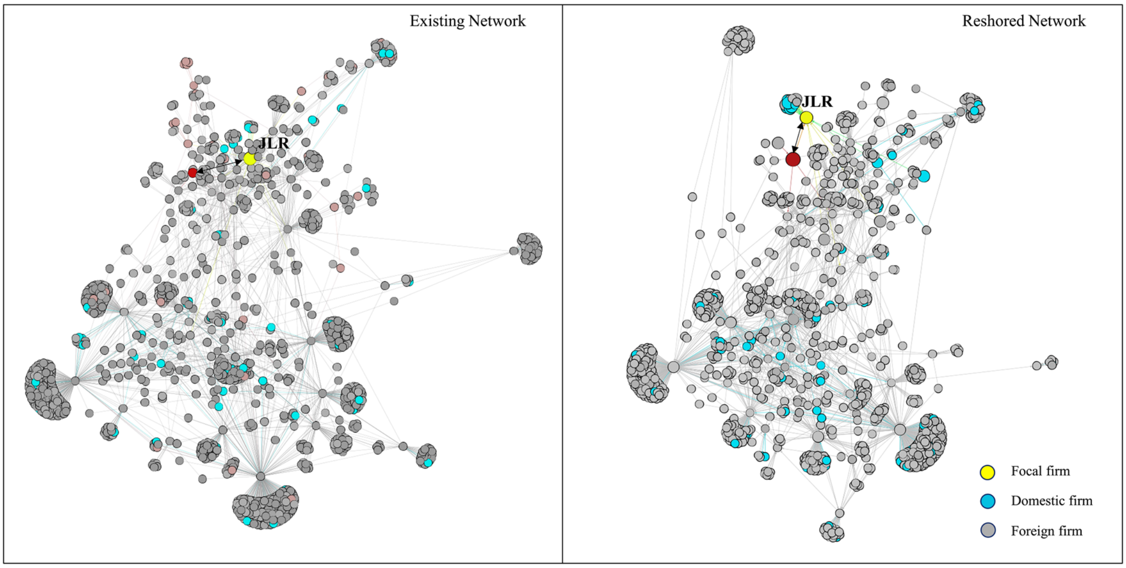

Figure 4. Jaguar Land Rover (JLR) network. To illustrate the difference, GKN Ltd (red node) is an IDS of JLR (yellow node) that moves closer to JLR in the reshored network [Colour figure can be viewed at wileyonlinelibrary.com]

Table 2. Regression results

		Indirect domestic suppliers' effect		Indirect foreign suppliers' effect	
	Variable	Model 1 Coefficient Estimates (SE)	Model 2 Coefficient Estimates (SE)	Model 3 Coefficient Estimates (SE)	Model 4 Coefficient Estimates (SE)
Control variable	DC	0.010 (0.146)	131.195 (146.859)	−0.2521 (0.401)	1315.68*** (0.053)
Independent variable	ΔBC	7857.257 (9188.631)	19284.431 (15762.291)	72641.233*** (16607.726)	175724.576*** (16042.805)
Interaction	$\Delta BC \times DC$		−131.094 (146.85)		−1314.764*** (154.920)
Adjusted R^2		−0.026	0.034	0.272	0.710
F		0.398	0.529	10.176***	41.044***
N		53		50	

Abbreviation: JLR, Jaguar Land Rover.
***$p < 0.001$.

where ΔBC_k represents the change in BC for firm k, and DC_k represents the DC for firm k. For Models 1 and 2, the set of firms k represent IDSs, while for Models 3 and 4 the set of firms k represent IFSs. The regression parameter estimates are indicated by β.

Models 1 and 2 in Table 2 capture the results of the effect emanating from IDSs, with Model 1 including DC as a control variable and the change in BC as the independent variable. Model 2 then adds the interaction term. As can be seen, the parameter estimates are not at statistically significant levels, rendering no support for H1 and H3a. In contrast, Models 3 and 4 in Table 2 capture the results of the effect emanating from IFSs with the same variables as in Models 1 and 2. As can be seen, the parameter estimates are significant, indicating that an increase in BC of IFSs increases the network's resilience, which is contrary to what we expected in Hypothesis 2. We do, however, observe a negative moderating effect of DC, which favours Hypothesis 3b (Figure 5). To fit the linearity assumptions of multiple regression analyses, the independent variable, that is, ΔBC, was transformed to an exponential form.

We assessed whether any of the regression assumptions were violated in the above models via the Harvey–Collier test for linearity, plotted

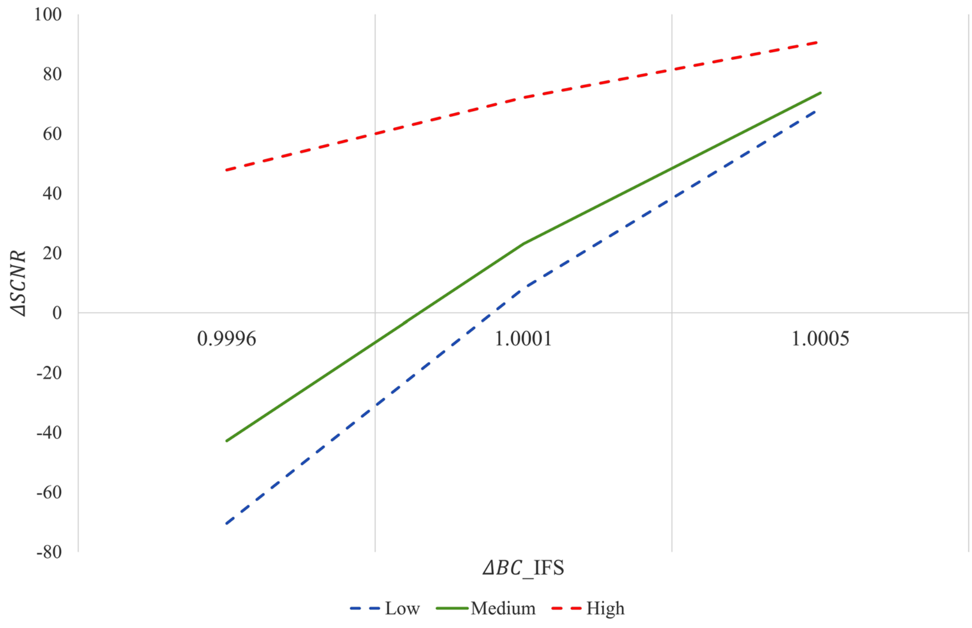

Figure 5. The moderating effect of degree centrality [Colour figure can be viewed at wileyonlinelibrary.com]

quantile–quantile plots and histograms to examine the normality of residuals, and used the Breusch–Pagan test for heteroscedasticity, in addition to the Durbin–Watson test for autocorrelation. The results of these tests suggest that there is no violation of the assumptions. To test the robustness of the results we used a single variable at a time (Model 1 and Model 3). We also assessed for any correlation of the regressor with the error term and found only a negligible correlation.

To test our fourth hypothesis, we utilized the collected ESG scores. Unfortunately, not all companies had reported their sustainability scores, leading to 510 and 555 firms for Apple in its existing and reshored networks, respectively, and 453 and 455 firms, respectively, for JLR. We conducted an independent t-test on the mean ESG score of the firms in the existing and the reshored networks, yielding insignificant results, suggesting no support for our fourth hypothesis. This was confirmed with non-parametric Mann–Whitney tests to assess the equality of medians in the two independent groups (Table 3: Panel A). We further assessed the mean of domestic and foreign firms' ESG scores before and after reshoring and did not find any evidence for change. This was again confirmed by non-parametric Mann–Whitney tests (Table 3: Panel B).

Implications

Theoretical implications

Our study focused on the intersection between the literatures of SCRes and sustainability within the reshoring context. Empirically grounding our study in network theory, we first explored the effect of domestic versus foreign suppliers as an outcome of reshoring, and followed this by an investigation of sustainability implications. While we captured resilience and sustainability separately, the two are intricately intertwined with the reshoring motivation, especially when considering the broader network structure. Within this setting, our study offers two novel contributions to the reshoring literature.

First, we highlighted the role of sub-tier suppliers that mostly lie beyond the visible horizon of focal firms (Carter, Rogers and Choi, 2015) within the context of reshoring. With prior studies noting the significance of SCN structure (Borgatti and Li, 2009; Sharma *et al.*, 2019), our analysis highlights how reshoring can change this structure and the role of sub-tier suppliers in influencing the focal firm's network resilience. While our analysis did not find support for the influence of IDSs on the resilience of the SCN, we were able to discern a counterintuitive yet intriguing positive relationship between IFSs and network resilience after

Table 3. Comparison of the networks' ESG scores

Panel A: Existing versus reshored network

	Apple network			JLR network		
	Existing		Reshored	Existing		Reshored
Mean ESG score	52.61		53.25	55.07		54.99
t-statistic		−0.483			0.060	
Median ESG score	54.06		55.04	56.66		56.34
z-statistic (Mann–Whitney test)		−0.919			0.050	
n	510		555	453		455

Panel B: Domestic versus foreign firms

	Apple network				JLR network			
	Domestic firms		Foreign firms		Domestic firms		Foreign firms	
	Ex.	Re.	Ex.	Re.	Ex.	Re.	Ex.	Re.
Mean ESG score	46.98	46.82	61.06	61.20	65.28	63.53	54.80	54.48
t-statistic	0.100		−0.079		0.270		0.223	
Median ESG score	46.21	45.30	62.80	62.93	75.81	70.14	56.00	55.96
z-statistic (Mann–Whitney test)	0.090		−0.030		0.239		0.200	
n	218	272	292	283	19	20	434	435

Abbreviation: JLR, Jaguar Land Rover.

reshoring. Although this contradicts Hypothesis 2, it is a novel finding that enables a better understanding of the dynamics of reshoring and its influence on resilience. Contrary to our theorizing of IFSs being disadvantageous to the network, our result suggests that when an IFS moves to a position of higher control and influence within the network and it experiences a disruption, the flow of material and information does not amplify this disruption throughout the entire supply network. This is similar to recent observations by Durach *et al.* (2020), who highlighted that co-opetition among direct suppliers can foster resilience against disruption originating at indirect suppliers. The result also sheds light on the problem discussed by Ang, Iancu and Swinney (2017), in that diversification of Tier 1 suppliers may not be effective against disruptions when they arise at the sub-tier level, owing to the limited number of sub-tier suppliers possessing deep expertise. This is further indicative of even higher-tier suppliers increasingly performing many more value-added tasks than in the past. Our analysis, however, shows that reshoring can lead to a diversification of sub-tier suppliers and enhance network resilience. As such, after reshoring, a disruption of IFSs does not distort the strongly connected firms, and can even reduce the number of weakly connected firms. However, this aspect is moderated by the number of connections that firms have. The effect of a change in BC among IFSs due to reshoring seems to be stronger at the network when IFSs have low DC. Further, a high DC of IFSs can reduce this resilience achieved through reshoring (Figure 5), implying that focal firms should still be concerned about highly connected sub-tier firms.

Surprisingly, we did not find evidence for the effect of BC among IDSs on resilience due to reshoring. However, overall, these results broaden the horizon of SCN studies that identify reshoring as a system reconfiguration, rather than merely as s geographical shift of operations (Baraldi *et al.*, 2018). As such, our results draw attention to the broader impact of reshoring, affecting not only the geographical location of the reshored firm itself, but also its broader network, which might create additional complexities that are greater than before. We thus encourage the departure from a myopic view of reshoring a singular firm and a pure geographical focus, and a move towards a systems perspective. The latter focuses on the cost–benefit aspect and is governed by transaction cost economics encompassing the entire SCN. While the benefit of structural advantage gained through reshoring can overcome cost inefficiency and offshore supplier dependence, these immediate advantages must be seen in light of the costs and challenges associated with the broader network, that is, the buying firm's new sub-tier suppliers that come with the new reshored direct supplier.

Although our study was aimed at understanding the outcome of reshoring, the findings also add value to the decision-making process of reshoring. As such, Boffelli *et al.* (2020) pointed to the complexity in reshoring decisions due to bounded rationality and anchoring bias effects as a result of limited information. In the aftermath of the COVID-19 pandemic, which served as a trigger for reshoring (Barbieri *et al.*, 2020), SCRes has been a focus for many companies (Ellingrud, 2020). With reshoring often being motivated by a reduction of risk and an associated improvement of resilience, the shift from foreign to domestic suppliers was confirmed to be prudent for the two networks considered. In this vein, it can be said that reshoring enables the possibility of neutralizing the influence of IFSs.

Second, we studied the sustainability motivation that is behind many reshoring decisions. Like resilience, we assessed the possibility of an increase in sustainability across the SCN as an outcome of reshoring. Our unsupported hypothesis in this regard calls attention to more powerful elements at play, one of which may be sustainable supplier selection policies (Rashidi *et al.*, 2020). Previous studies (Carter and Jennings, 2002; Thornton *et al.*, 2013) have highlighted that socially responsible supplier practices yield better financial performance, even in settings that are very different from each other, for instance in terms of national culture. As such, even in more distant locations, the firm's long-term strategy and imperatives may shine through, which may explain the non-significant finding in our study. Overall, while we did not find evidence for a connection between reshoring and sustainability, we believe that sustainable supplier selection and reshoring strategy can and should be pursued mutually (Baraldi *et al.*, 2018). Reshoring is a significant disruption, entailing numerous changes, a setting in which it might be prudent to also 'ramp up' sustainability efforts, so as to provide a sound foundation with the new (reshored) venture. We believe this area to be promising for future research, since in the absence of sustainability advantages in developed countries, cost advantages due to offshoring in emerging countries may prevail.

Our study also contributes to the growing number of network analyses that take a methodological perspective, particularly in our fine-grained and differentiated look at both domestic and foreign suppliers, as well as direct versus indirect suppliers. With this perspective, we were able to discern the dynamics emanating from the reshoring decision, which has been explored primarily via case analyses. We see great potential in extending this stream of research, by, for instance, considering temporal dynamics inherent to networks.

Managerial implications

Our study has important implications for multinational firms that are planning to reshore or are in the process of reshoring, as the ensuing supply network after reshoring might be driven by vastly different dynamics. While the focal firm can make decisions on Tier 1 suppliers, this choice is limited when it comes to indirect (higher-tier) suppliers. This lack of visibility beyond Tier 1 suppliers exacerbates the complexity of the reshoring decision-making process. Our findings provide insight into important dynamics that may be at play.

Specifically, IFSs with strong DC may offset the structural advantage of reshoring. This may be followed by reactive strategies of firms that are far away in the SCN. The focal firm's competitors may exploit such a potential disadvantage of IFSs and encourage offshoring to pursue cost advantages. For instance, as US firms aimed to reduce their dependence on China for the production of various goods, firms in the European Union were benefitting (BBC, 2021). It is therefore neither wise nor practical to design a SCN comprising only domestic companies. Supplier relationship management beyond direct suppliers is thus critical. Our study further emphasizes the importance of network structure, and calls for attention to be paid to the implications in relation to the higher-tier suppliers the firm is committing to, as a result of choosing particular Tier 1 suppliers. Recognizing these implied dependences may reduce the anchoring bias inherent in the reshoring decision (Boffelli *et al.*, 2020). For large-scale disruptions such as a pandemic, or where many firms are clustered in a single region, any outbreak in that region would challenge large portions of the network. Therefore, firms also need to consider the evolution of clustering in the network structure to ensure its resilience. For example, semiconductor manufacturing companies are presently clustered in Japan, South Korea, China, and Taiwan (Deloitte, 2020), with this clustering being one of the reasons for ensuing disruptions. Another major concern for firms is the reliability of new domestic suppliers, which may have the advantage of being geographically closer, but may not possess the expertise that foreign suppliers may be able to offer.

Sustainability has been one of the top agenda items for many multi-national firms owing to the growing awareness of consumers. Sustainability thus cannot be limited to the internal activities of organizations, but necessitates a network perspective, with focal firms scrutinizing their suppliers on this dimension (Kim, Wagner and Colicchia, 2019). While our finding does not provide evidence for reshoring to be able to foster sustainability in the SCN, we emphasize that sustainability should always be an objective while selecting suppliers at home and overseas. Reshoring can have significant impacts on carbon emissions, owing to the closer proximity of suppliers and the potentially shorter transportation legs. The 'country-of-origin' effect too can offer significant temporary benefits to stakeholders (Brandon-Jones *et al*., 2017). However, these benefits may not outweigh low-cost manufacturing advantages overseas. Decision-makers should thus cautiously weigh the associated long-term benefits and consequences. Our study has provided some insights that we hope will facilitate these decisions.

Limitations and conclusions

While our study has made substantial contributions to theory and practice, as outlined above, it is not without limitations. First, our networks are based on two focal firms having operations in several countries. The results may thus not be generalizable to smaller firms with a smaller offshore footprint or with fewer resources, which might prevent large-scale reshoring. Second, when we constructed the network, the edges were given equal weights, implying equal strength. Future research is encouraged to relax this property and add weights to customer–supplier relationships. This would make the network more realistic, because suppliers may not be equally significant for a firm. One potential way to address this is by using the firm's costs of the goods sold for each supplier. In addition, greater weights could be applied to suppliers providing crucial parts. Third, because we narrowed our scope to the structural understanding of the supply network, cost advantages due to infrastructure, labour cost, and skill gaps between domestic and foreign suppliers were disregarded. Emerging technologies can also change the landscape of resilience and reshoring. Studying networks longitudinally and factoring in such technologies would certainly provide a broader understanding. Finally, we did not consider the ripple effect while analysing the disruption of nodes. This may be needed, however, because a disruption can 'ripple through' and even be magnified as it traverses the supply chain. As such, a firm's disruption may also affect the cluster's surroundings (Kim, Chen and Linderman, 2015), owing to the tight interconnectedness of many supply chains. Hence, replacing nodes other than the initially affected node may be warranted. In this vein, instead of studying individual firms, future research could explore domestic and foreign clusters, which could then further broaden the understanding of structural holes and put especially our insignificant findings into context.

Overall, we have enriched our understanding of reshoring by viewing this decision from a network perspective and investigating the impact on both resilience and sustainability. With reshoring having come to the fore owing to the COVID-19 pandemic, our investigation is both timely and important. Our study used empirical secondary data to construct two large-scale networks by using two seed firms that are in the process of reshoring. The results highlight the possible effect on resilience that can arise from firms beyond the visibility of focal firms. We also established that reshoring to domestic suppliers does not necessarily contribute to increasing the average sustainability of the SCN. Overall, our study offers a broader understanding of reshoring that previous studies have not explored.

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