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Ph.D. Programme in Applied Economics and Management

“Resilience building mechanisms within Global Value Chains: coping with uncertainty and addressing sustainability opportunities”

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XXXVI CYCLE

*"I HAVE, alas! Philosophy,
Medicine, Jurisprudence too,
And to my cost Theology,
With ardent labour; studied through.
And here I stand, with all my lore,
Poor fool, no wiser than before."*

Faust, Part I, Johann Wolfgang von Goethe

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Executive summary

Although MNEs undoubtedly operate in an uncertain environment (Taskan et al., 2022), the last few years have proven especially challenging. The global financial crisis of 2008, the increase of nationalistic tendencies, warfare, environmental disasters and a pandemic are just a few events on the extremely long list of disruptions that MNEs have had to face in the last 15 years (European Central Bank, 2012; Maidment, 2019; The Financial Times, 2022a; Ghadge et al., 2021; UNCTAD, 2020).

Consequently, in the last few years IB researchers have to address the topic of resilience (Barbieri et al., 2020; Gereffi, 2020; Strange, 2020; Verbeke, 2020; Ku & al., 2020; Buckley, 2021). It is in fact widely believed that resilience is what will allow MNEs to overcome sudden disruptions (Ciravegna & Michailova, 2022; McKinsey, 2021; The Financial Times, 2022b). Nevertheless, the urgent challenges that endanger MNEs operations and global value chains (GVC) in general have contributed to the start of the study of resilience in the IB field (Gereffi et al., 2022; Khan et al., 2024), which at the moment results mostly conceptual and lacks empirical investigation.

Therefore, the present doctoral research addresses an existing research gap in the IB field concerning GVC resilience and it adopts a qualitative methodological approach because of the complex and multi-layered nature of the research scope (Dyer & Wilkins, 1991).

The thesis is composed of three interrelated chapters, each of which represents a paper addressing a specific research question.

The **first chapter** aims at developing a theoretical framework of GVC resilience by conducting a systematic literature review (Tranfield et al., 2003) that bridges IB and operations management literatures (De Marchi et al., 2020). In particular, the systematic

literature review investigates how *GVC* resilience is conceptualized, measured in existing literature and aims at understanding what are the contributing factors to *GVC* resilience.

The objective of the **second chapter** is the development of a theoretical model that identifies what are the resilience building mechanisms in *GVCs*, with a focus on governance structure (Kano et al., 2022) and geographical dispersion of value chain activities (Barbieri et al., 2021; Cohen et al., 2020; Strange, 2020). The theoretical model is developed through a multiple case study (Stake, 1995) featuring five MNEs operating in the pharmaceutical and medical devices industries.

Finally, the **third chapter** represents a preliminary empirical contribution to the nascent research theme of trade-offs and synergies between resilience and sustainability as strategic objectives in IB (Gauri, 2022). The study is developed using a Resource Dependency Theory (RDT) (Pfeffer & Salancik, 2015) perspective and follows the Extended Case Method (ECM) (Burawoy, 1998) in the analysis of a *GVC* in the semiconductor industry. Specifically, the study investigates how power asymmetries between MNEs and suppliers influence the design of resilient and sustainable *GVC*.

Overall, the contribution of the present doctoral thesis is threefold. First, it provides a definition of resilience that applies to the *GVC* context, taking into consideration both governance structure and geographical dispersion (Buckley, 2004). Second, by associating the topic of *GVC* resilience to the business model perspective (Onetti et al., 2012), it detects how governance structure and geographical dispersion of the *GVC* can interact for what concerns *GVC* resilience. Third, it empirically supports the synergy between resilience and sustainability in the *GVC*. In particular, findings evidenced how a Resource Dependency Theory perspective is relevant when addressing both objectives, because of the role played by power asymmetries between parties and specifically differences in resources and capabilities (Pfeffer & Salancik, 2015).

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INTRODUCTION

1. Relevance of the doctoral thesis

It is a consensus that firms face uncertainty when they operate internationally (Vahlne et al., 2017). Specifically, Multinational enterprises (MNEs) operate in a volatile, uncertain, complex and ambiguous (VUCA) environment (Vertinsky et al., 2023; Cavusgil et al., 2021). In fact, MNEs face a complexity that is specific to their international operations, such as hostile geopolitical dynamics, fluctuating exchange rates, trade tensions, varying cultural, legal, and economic contexts, and regulatory variations across different jurisdictions.

Nevertheless, the last two decades have been particularly challenging because of repeated disruptive events which have been affecting firms' configuration of global value chains (GVCs) (Cavusgil et al., 2020; Ghauri et. al., 2021; Oh & Oetzel, 2022).

The first disruption that is impossible not to mention is the Global Financial Crisis of 2007-2008, which affected GVCs in several ways: for example, it led to a significant drop in trade flows, affecting countries worldwide and causing a "Great Trade Collapse" (European Central Bank, 2012). This decline in trade was particularly severe and synchronized across all countries: the crisis was probably the first to reveal the heavy interdependence of the world economy.

Moreover, in the last few years, international relations among countries have become increasingly hostile, posing an ulterior challenge for MNEs. Events such as Brexit and policy decisions such as the "Chips and Science Act" - or its European equivalent - are ascribable to the line of geopolitical tensions that have always challenged MNEs in their operations. However they present peculiar traits that are worth mentioning. The Brexit outcome directly challenged the long-standing assumption of economic and political integration of developed countries (Maidment, 2019), while the government policies that aim at the protection of the

procurement of strategic assets represent a very self-evident example of the peak reached by protectionist and nationalistic tendencies.

Geopolitical tensions have also extended beyond international relations issues, resulting in full-blown military conflicts. For example, in 2022 the Russian invasion of Ukraine brought the largest military conflict in Europe since World War II. Evidently, the conflict has directly impacted MNEs operations but it also had foreign policy implications, since it pushed up prices and highlighted the threat of raw materials becoming a foreign policy weapon (The Financial Times, 2022a).

A third determinant of uncertainty for MNEs has been climate change. In fact, the consequences of climate change - i.e. repeated natural disasters - have been particularly impactful for firms during the last years (Ghadge et al., 2020). This type of disasters - which include droughts, floods, windstorms, hurricanes, earthquakes and tsunamis - has increased in number and in intensity during the last decades and has a greater economic impact (CEPR, 2021; Parker, 2023).

Ultimately, the COVID-19 pandemic introduced an additional layer of unpredictability for companies engaged in GVCs, which impacted in the long-term income, Foreign Direct Investment (FDI) flows, greenfield investment initiatives, and cross-border mergers and acquisitions (UNCTAD, 2020).

All these events have contributed to create an operating environment that hinders the procurement in GVCs (The Guardian, 2022; McKinsey, 2022a), determining the beginning of an “era of shortages” (The Economist, 2021b).

These circumstances have sparked a growing interest has in value chain resilience (Barbieri et al., 2020; Gereffi, 2020; Strange, 2020), especially among international business (IB) researchers (Verbeke, 2020; Ku & al., 2020; Buckley, 2021) who argue that resilience will allow GVCs to overcome sudden disruptions (Ciravegna & Michailova, 2022). For the same

reasons, the topic is crucial for practitioners as well (McKinsey, 2021; The Financial Times, 2022b).

2. Research aims

Resilience is certainly not a new concept in organizational literature and Supply Chain Management (SCM) (Hillmann & Guenther, 2021; Iftikhar et al., 2021; Bhamra et al., 2011). In particular, Iftikhar et al (2021) highlighted the importance of investing in flexible and resilient capabilities in the supply chain to enhance firm performance, while also pointing out the influence of contextual factors (i.e national culture and industry affiliation) on how these capabilities can determine firm resilience.

I argue that, because of this “contextualized” nature of resilience, the organizational and SCM perspectives of resilience are not completely applicable to MNEs, as they face specific challenges, as mentioned above. Notwithstanding the recent events that have endangered MNEs operations and GVC in general in recent times, the literature concerning resilience in the IB field is nascent and mostly conceptual (Gereffi et al., 2022; Khan et al., 2024), with scant empirical investigation.

Previous research in the IB context has considered resilience in a trade-off relationship with efficiency (Gölgeci et al., 2020), how resilience relates to reshoring (Pla-Barber et al., 2021; Van Hoek & Dobrzykowski, 2021; Chen et al., 2022), the role of financial resilience in MNE performance (Mouzas & Bouer, 2022), and GVC capabilities for resilience (Aslam et al., 2018). However, the IB field still lacks a specific definition and conceptualization of resilience in GVCs.

Therefore, the present doctoral dissertation proposes to address the topic of GVC resilience from an IB perspective, adopting a predominantly qualitative approach to the investigation. In fact, because of the early stage of knowledge development on GVC resilience, I deemed

appropriate to adopt a more qualitative approach, also addressing a widespread call for this type of research in the IB field (Sinkovics et al., 2008).

3. Structure of the doctoral thesis

The present doctoral dissertation presents a threefold contribution:

1. The development of a theoretical framework of GVC resilience developed through a systematic literature review (Tranfield et al., 2003) that bridges IB and supply chain management literatures (De Marchi et al., 2020). The addressed research questions is: *How is GVC resilience conceptualized, measured, and what are the key contributing factors acknowledged by the literature?*
2. The development of a theoretical model that identifies what are the resilience building mechanisms in GVCs, with a focus on governance structure (Kano et al., 2022) and geographical dispersion of value chain activities (Barbieri et al., 2021; Cohen et al., 2020; Strange, 2020). The theoretical model is developed through a multiple case study (Stake, 1995) featuring five MNEs operating in the healthcare industry - pharmaceutical and medical devices sectors specifically. The addressed research question is: *How do governance structure and geographical dispersion of value chain activities contribute to building resilience within GVCs?"*
3. A preliminary empirical contribution to the nascent research theme of trade-offs and synergies between resilience and sustainability as strategic objectives in IB (Ghauri, 2022). The study is developed using a Resource Dependency Theory (RDT) (Pfeffer & Salancik, 2015) perspective and follows the Extended Case Method (ECM) (Burawoy, 1998) in the analysis of a GVC in the semiconductor industry. Specifically, the study addresses the following research question: *how do power asymmetries between MNEs and suppliers influence the design of resilient and sustainable GVC?*

Table 1 presents an overview of the doctoral thesis' contents.

Table 1. Overview of the doctoral thesis

Title	Methodology	Outcome
CHAPTER 1 A review of Global Value Chains resilience: reconciling literature streams to define it and frame it	Systematic Literature Review	A theoretical framework of GVC resilience
CHAPTER 2 Resilience building mechanisms in Global Value Chains: a multiple case study in the medical devices and pharmaceutical sectors	Multiple Case Study	A theoretical model of resilience building mechanisms in GVCs
CHAPTER 3 Two birds with one stone? An in-depth study on resilience and sustainability in a semiconductor Global Value Chain	Single Case Study adopting the Extended Case Method	A set of propositions concerning the synergy between resilience and sustainability in GVCs

Here below I introduce the first Chapter of the present dissertation, entitled “A review of Global Value Chains resilience: reconciling literature streams to define it and frame it”.

CHAPTER 1. A review of Global Value Chains resilience: reconciling literature streams to define it and frame it

Abstract

Following a consistent call from both academia and practitioners, the present study tries to frame and define resilience of Global Value Chains (GVCs). By developing a systematic literature review at the crossroads of international business (IB), supply chain (SC) literature and grey literature, the study presents three main contributions: (i) it provides a definition of GVCs resilience; (ii) it analyzes its relationship with other recurring concepts (such as flexibility, adaptability, robustness and agility), and with key actors along the chain; (iii) it systematizes the measures related to GVC resilience.

Keywords: Resilience; Global Value Chains; International Business; Systematic Literature Review

1. Introduction

According to the Collins English Dictionary, “Permacrisis” is 2022’s word of the year. A permacrisis is defined as “an extended period of instability and insecurity, especially one resulting from a series of catastrophic events” (BBC, 2022a). Although firms always face uncertainty when they operate internationally (Vahlne et al., 2017) - the last two decades have been particularly challenging because of the uncertainty brought by repeated disruptive events which have been affecting firms’ configuration of international (or global) value chains (GVCs) (Cavusgil et al., 2020; Ghauri et. al., 2021; Oh & Oetzel, 2022).

While events such as Brexit and the trade war between China and the U.S.A. are ascribable to the line of geopolitical tensions that have always challenged MNEs in their operations, they present peculiar traits that are worth mentioning. The Brexit vote weakened the long-standing assumption of economic and political integration of developed countries (Maidment, 2019), while President Trump tariffs on the imports of steel and aluminum from China (Fortune, 2018; The Economist, 2021a) represented the peak of protectionist and nationalistic tendencies that have characterized the political debate in the last few years. Moreover, more recently the Russian invasion of Ukraine has pushed up prices and highlighted the threat of raw materials becoming a foreign policy weapon (The Financial Times, 2022a).

These uncertain conditions, however, are not only the outcome of geopolitical tensions.

Climate change has produced over time repeated natural disasters which have been particularly impactful for firms during the last years (Ghadge et al., 2020). Examples are the threat of worldwide pharmaceutical and medical device shortage caused by Hurricane Maria impact on Puerto Rico (New York Times, 2017), the record-setting drought in southeast China that hindered global automotive production (The New York Times, 2022) and the recurring extreme heat waves that threaten labor productivity in India (McKinsey, 2020a).

Another source of uncertainty for firms GVCs was the COVID-19 pandemic. Since its start in 2020, analysts have expressed extreme concern for the repercussions on value chains since its early outbreak in China, which is a country the whole world depends on as a “manufacturing workshop” (The New York Times, 2020). Soon the pandemic developed into a global crisis, affecting income, FDI flows, greenfield investment projects and cross-border merger and acquisitions (Saurav et al., 2020; UNCTAD, 2020). Moreover, its consequences had a long-lasting effect: for example, at the beginning of 2022 with a record 109 container ships carrying US imports surrounding the twin ports of Los Angeles and Long Beach still at the beginning of 2022 (Bloomberg, 2023), affecting firms’ ability to continue production.

All these events have contributed to create an operating environment that hinders the procurement of both raw materials and more advanced production inputs (e.g. semiconductors) (BBC, 2022b; The Guardian, 2022; McKinsey, 2022a), opening an “era of shortages” (The Economist, 2021b): it is not uncommon for the supply of a good not to be able to meet its demand because of events that are independent from producers. For all these reasons, a growing interest has sparked in relation to the issue of value chain resilience (Barbieri et al., 2020; Gereffi, 2020; Strange, 2020), especially among international business (IB) researchers (Verbeke, 2020; Ku & al., 2020; Buckley, 2021) who argue that resilience will allow GVCs to overcome sudden disruptions (Ciravegna & Michailova, 2022). For the same reasons, the topic is of particular interest to practitioners too (McKinsey, 2021; The Financial Times, 2022b). Yet, while a debate has opened on the need for GVCs to become more resilient, there is still a need of conceptualizing what does the latter mean: a theoretical conceptualization would serve as the basis to then generate robust empirical research, which at current is quite scant too.

Thanks to a systematic literature review at the crossroads of international business (IB) (Gereffi et al., 2022; Choksy et al., 2022) and supply chain (SC) literature (Ivanov & Dolgui,

2021; Hosseini et al., 2019), the present study contributes to the understanding of GVC resilience, by: (i) providing a definition of GVC resilience; (ii) analyzing its relationship with other recurring concepts (such as flexibility, adaptability, robustness and agility), and with key actors along the chain; (iii) systematize the measures related to GVC resilience.

2. SLR setting: reconciling literature streams

To organize the existing literature on GVC resilience, I exploit the links of IB with the SC literature (De Marchi et al., 2020). This approach is suitable because “the link between the two [...] goes back to the recent origins of supply chain research and the rise of the GVC perspective in the early 2000s” (Gereffi et al., 2022: p. 2). Moreover, it is in line with the recent tendency to acknowledge the multidisciplinary nature of IB research in general and GVC studies in particular (Bello & Kostova, 2012; Kano et al., 2020).

Supply chain resilience is an established topic of research in SC literature (Ponomarov & Holcomb, 2009; Christopher & Peck, 2004; Brandon-Jones et al., 2014), although still lacking consensus (Mackay et al., 2020) about the meaning of SC resilience itself, even if there is a theoretical overlapping between the concept of resilience and other related concepts such as robustness (Fynes et al., 2004; Brandon-Jones et al., 2014; Cohen & Kouvelis, 2021; Pavlov et al., 2019), flexibility (Remko, 2020; Ivanov et al., 2014), agility and adaptability (Eckstein et al., 2015).

Bhamra et al. (2011) defines resilience as a multilevel concept - ecological, individual, community, organisational, supply chain- and encourages future research that considers firms, and specifically SMEs, as a sub-system within the extended supply chain. From a SC perspective, Iftikhar et al. (2021) found that SC integration influences firm resilience along with flexible SC capabilities to enhance firm performance, especially noting a stronger impact on non-financial performance compared to financial performance. Finally, Hillman &

Guenther (2011) highlights how SC literature defines resilience as concerning the maintaining of functionality and service delivery and how its achievement is dependent on the alignment between the strategic and the organizational level.

For what concerns IB, recent events have spiked interest in resilience at the GVC level (Gereffi et al., 2022), but extant studies are still mostly conceptual. Moreover, while various definitions of SC resilience exist, a definition of resilience specific to the IB research area is missing.

By integrating the SC and IB perspectives, this study proposes to answer the following research questions: *How is GVC resilience conceptualized, measured, and what are the key contributing factors acknowledged by the literature?* At the same time, the study proposes a literature framework in order to provide a conceptual ground for future studies about GVC resilience.

A conceptualization of resilience that includes the IB perspective is needed because there are GVC peculiarities that are not addressed in the SC literature on the topic. First, the geographical distribution of value chain activities is peculiar to IB literature on GVC and it is recognized as relevant for limiting negative effects of disruptions (Gereffi, 1995). This first aspect has been particularly debated. If on one hand there is a current of thought that considers reshoring or near-shoring of value chain activities as a strategy to build resilient GVCs (Barbieri et al. 2021), on the other hand, there are scholars that support the idea that redundancy of value chain activities may create more responsive GVCs, avoiding overreliance on few locations (Gereffi, 2020; Cohen & Kouvelis, 2021; Strange, 2020). However, the debating point that cannot reconcile the two visions is the expected consequences on cost efficiency: detractors of the redundancy adduce the difficulty to maintain cost benefits through the offshoring of activities, which has been the most important driver of this strategy but also the main cause of GVCs rigidity. Second, recent studies have

discussed how governance strategies and configurations within a GVC can influence its resilience (Kano et al., 2022; Ryan et al., 2022). Third, resilience in IB is a multidimensional concept that can be analysed on three levels (i.e. firm, GVC, country/state) and the interplay between these levels can generate distinct resilience dynamics (Gereffi et al., 2022). Therefore, it is proposed that the achievement of resilience within GVCs is not only determined by the strategic decisions of its actors, but also by external uncontrollable factors, such as conditions of market or policy failure (Pananond et al., 2020).

3. Methodology

The study is developed through a systematic literature review (SLR) as formalized by Tranfield et al. (2003). The aims of this approach are three: (i) to identify key scientific contributions in the research field; (ii) to articulate how the existing knowledge could be utilized; and (iii) to identify areas of rebalancing and opportunities for future research (Rojon et al., 2021).

By exploiting the areas of connection between the two literature streams, the present study is designed with a “prospector” approach, as defined by Breslin & Gatrell (2020): the aim is that of developing conceptual insights through the cross-fertilization of ideas, by exploring how findings in in IB and SC literature can contribute to enhance knowledge about GVC resilience in the IB field. According to Post et al. (2020), this multidisciplinary approach allows for theoretical advances with the identification of emerging perspectives by “analysing underlying assumptions in the body of literature, demonstrating the consequences of such assumptions or alternative assumptions on theorizing” (p. 355).

The review is conducted following a detailed and iterative protocol, to ensure the quality of the study and its replicability (Denyer et al., 2009) as reported in the below sections. Further details about the protocol are available in Appendix A1.

3.1 Review scope

I started the SLR considering articles published in peer-reviewed English language journals. However, due to the topic examined, I also choose to integrate resources from first and second-tier grey literature, i.e. reports by institutions, governmental agencies, and global consulting companies, to “capture the full spectrum of available knowledge” (Rojon et al., 2021: p. 200). In line with the conceptual boundaries, the study includes articles that investigate resilience either in GVC or geographically dispersed supply chains. Finally, I chose not to limit my search to a specific time frame, since a preliminary analysis of existing literature revealed that the study of resilience in this context is relatively recent and, to the best of my knowledge, there aren't previous systematic literature reviews that explore this topic in the same context.

3.2 Data sources

To select relevant scientific publications I carried out a search on both Scopus and Web of Science. I conducted the search on these platforms using one search string with terms combined through Boolean logic (Zahoor et al., 2020): “global value chains” was used in combination with “international supply chain” and “international network”; “resilience” was used in combination with “flexibility”, “robustness”, “adaptability” and “agility”. The choice of this search terms combination resulted from a preliminary literature review: they appeared to be strictly associated with resilience and often used as synonyms. I first run the database search in July 2021; in January 2023 I rerun the search on both Scopus and Web of Science, filtering for the years 2021 and 2022 to update the database.

To keep the results within the study's conceptual boundaries, the search was conducted only within the title, abstract, and keywords of the articles, and results were filtered according to

the field. This first phase allowed to identify 178 articles from Scopus and 173 from Web of Science. The results were then analysed to identify duplicates: 68 articles were removed, resulting in a first articles pool of 284 results. The articles were subsequently evaluated according to specific inclusion and exclusion criteria, to assess their relevance for literature review. Articles to be included in the review had to be:

- published in English and categorized in the following subject areas on the platforms: “Business, Management and Accounting” on Scopus and “Management”, “Operations research management science”, “Business”, “International relations” on WoS. This inclusion criterion was controlled for in the search phase;
- published in peer-reviewed journals ranked 3/4/4* in the Academic Journal Guide (AJG) (ABS, 2021) (Zahoor et al., 2020).
- consistent with the conceptual boundaries of the study, i.e. articles investigating resilience in GVC and geographically distributed SC.

Therefore, the analysis excludes those articles that are published in journals ranked AJG 1/2 and that focus, among others, on humanitarian supply chains, airport scheduling, scheduling of public transportation, expatriate management, turnaround management, and individual level investigations (i.e. concerning for example CEO narcissism and cognitive bias).

The application of these inclusion/exclusion criteria resulted in a final pool of 43 articles from database search. Following the same procedure, I added 3 additional references in the January 2023 database update.

3.3 Manual additions to the data set

The results of the database search are included in three research fields, as classified by the AJG: “Operations and Technology Management”, “International Business and Area Studies” and “Operations Research and Management Science”.

By looking at the AJG list, I found that 30 3/4/4* journals of those fields did not appear in the results of the database search. I decided to conduct a manual research on those 30 journals, using the same keywords of the database search. This manual search resulted in the identification of 1,127 articles. After the application of the inclusion criteria, I added 41 articles to the database. These articles were published in 11 journals which, although present in both Scopus and WoS resources lists, did not appear in the database search for two main reasons: (1) in the case of one journal, the articles identified were published in a time period not covered in the databases; (2) in the remaining cases, the manual search was conducted considering the whole article and not just title, abstract and keywords, because of the limited options of the single journal's websites, thus adopting a wider research scope.

Additionally, to avoid possible personal bias, I included papers suggested by renowned researchers in the field, either by contacting them directly or by asking for suggestions at conferences, workshops and doctoral colloquia. In this phase, 19 articles were added: inclusion criteria were not applied, giving precedence to the experience of the researcher.

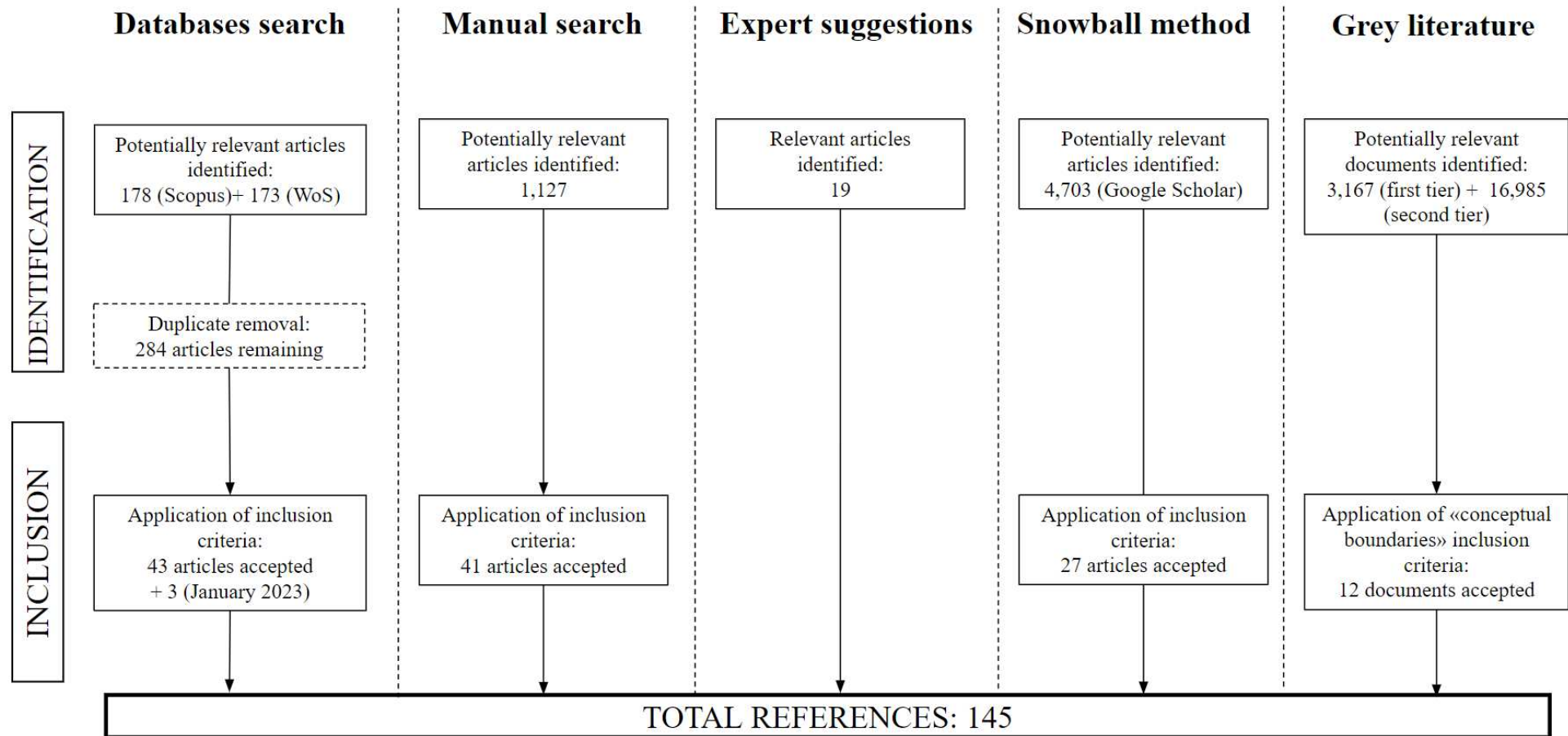
Likewise, to include also most recent studies, I deployed a snowball approach by tracing citations forward (Greenhalgh et al., 2005) and relied on more extensive searches through Google Scholar, although restricted to year interval from 2019 to 2022 to focus on the most recent contributions and acknowledging that this period was particularly thriving for research on the topic. In this phase, a total pool of 4,703 articles (including duplicates) was constructed, 27 of which respected the inclusion criteria.

Finally, since resilience is a theme that practitioners are widely discussing, I decided to manually identify publications from grey literature to include in my analysis. In fact, following the Covid-19 pandemic, resilience and international business became a paramount issue for public opinion. Moreover, as pointed out by Rojon et al. (2021: p. 200): "the exclusion of grey literature may result in conclusions drawn that do not capture the full

spectrum of available knowledge, which for management research can contribute to a richer understanding of the linkages between academia and practice, and gaps for future (applied) research”. Therefore, in this phase, I decided to include both first-tier (i.e. institutions and governmental agencies) and second-tier (i.e. global consulting companies strictly in the field of management) grey literature, excluding other forms for their lower reliability. Grey literature sources were chosen following the list drawn up by Bonato (2018). In this final phase, the search was the least focused, since it was not possible to properly filter results for each chosen database; therefore, the data selection was mostly conducted manually, often using only the term “resilience” in the search query. This phase produced a total of 3,167 documents for the first tier and 16,985 documents for second-tier (duplicates included), only 12 of which respected the inclusion criteria. I chose to exclude those documents that were not reports based on data (e.g. online articles, which can be an expression of personal opinions), integrating one exclusion criterion.

The final database of articles and documents for the systematic literature review consisted of 145 references. A visual presentation of the data collection process is presented in Fig. 1. The full references list is available in Appendix B1.

Figure 1. Systematic review flow diagram



Source: Author's elaboration

3.4 Analysis of the selected literature

I first read the papers several times in order to become familiar with the topic and make sense of the data. Then, I carried out a descriptive analysis (Seuring et al., 2008), encompassing the following dimensions: (i) the distribution of papers across time; (ii) the research areas of the papers; (iii) the main theoretical perspective adopted; (iv) the research methodologies implemented.

In a second phase, I identified the definitions of resilience and measurement approaches provided by the authors of the selected papers.

First, I investigated whether and how GVC resilience is defined in the literature, and how the concept of resilience itself interacts with other related concepts - i.e. flexibility, robustness, agility and adaptability - at GVC level. For this purpose, I first analysed the definitions of resilience separately and then the papers as a whole to understand the relations with the aforementioned concepts. Second, I analyzed how GVC resilience has been measured in the literature in order to support future empirical research and enhance the scientific relevance of GVC resilience (Hillmann & Guenther, 2021),

Because of the fragmented nature of knowledge on GVC resilience I decided to develop a content analysis via inductive coding (Elo & Kyngas, 2008; Bengtsson, 2016) to make sense of the literature. In particular, I adopted a “conventional approach” to the content analysis, which is common when the research aims to describe a phenomenon when existing theory or research literature is limited (Hsieh & Shannon, 2005). I analysed the papers to identify meaningful codes that were integrated or modified as the analysis progressed. To validate the results, I presented the preliminary findings to expert researchers during conferences and workshops to obtain feedback and suggestions.

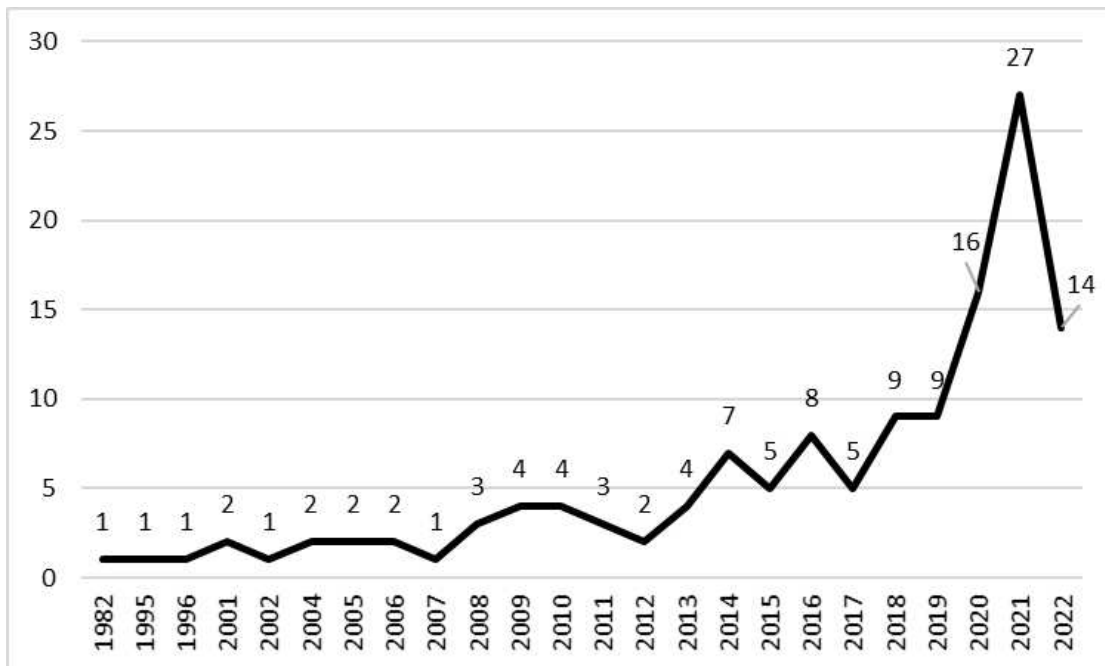
4. Findings

4.1 Descriptive analysis

The publication trend of scientific papers over the years shows that there has been a significant increase since 2020, confirming the growing interest in the topic (Fig. 2). The papers are published across 43 journals, also confirming the fragmented nature of the existing knowledge on GVC resilience. Almost 43% of the selected papers belong to the “Operations and Technology Management field”, followed by “International Business and Area Studies” (21%) and “Operations Research and Management Science” (17%). The most represented journals in the database are “International Journal of Production Economics” and “Management International Review”. This reflects the recent interest developed in the topic in these research areas and confirms the need for further research from these two theoretical perspectives.

For what concerns the grey literature, the resulting references are equally split between first and second tier. I have to note that, however relevant, the resulting documents are a handful and they are concentrated in 2020 and 2021. I can therefore conclude that the relevance of the topic among practitioners has been recognized only following the COVID-19 pandemic.

Figure 2. Publication trend of scientific papers across the years



Source: Author's elaboration

4.2 Theoretical perspectives

Data analysis revealed the prevalence of four main theoretical perspectives: (i) resource-based view (RBV) (Peteraf, 1993); (ii) dynamic capabilities view (DCV) (Teece et al., 1997); (iii) organizational information processing theory (Galbraith, 1974); (iv) internalization theory (Buckley & Casson, 1976). RBV is adopted in the investigations of the antecedents (Sinkovics et al., 2011) and consequences (Alfalla-Luque et al., 2018) of supply chain agility and flexibility. Moreover, the DCV is sometimes combined with RBV when exploring the antecedents of supply chain agility both in supply chain operations (Jajja et al., 2018) and international business (Gölgeci et al., 2019).

The organizational information processing theory is adopted in SC studies that focus on the role of information quality and flow within the supply chain in relation to the achievement of resilience. In particular, the pivotal themes are the role of technology in the improvement of the information flow (Belhadi et al., 2021; Dubey et al., 2021), and the significance of the

relationship between supply chain actors for the exchange of information (DuHadway et al., 2019).

Finally, internalization theory is the one that mostly supports IB studies concerning the interactions between the governance perspective and resilience (da Silveira, 2014; Kano et al., 2022).

For what concerns methodologies, there is an almost equal division between conceptual (48%) and empirical (52%) studies. Moreover, empirical articles largely leverage quantitative methods (71%), with a prevalence of Structural Equation Modelling (SEM) methodology. The emerged information shows a research topic that is still significantly conceptual and, when an empirical approach is implemented, the examination mostly focuses on its effects rather than its dynamics.

4.3 GVC resilience: how to define it

The present section is structured as follows: first, I present the themes associated with GVC resilience that emerged from the analysis of the identified definitions; subsequently, I present how GVC resilience relates to flexibility, robustness, adaptability and agility in the existing literature. Along the paragraph, I highlight differences and similarities in how each concept is treated in both IB and SC literature.

4.3.1 Resilience as a process

The data analysis of both scientific and grey literature allowed to identify 37 references to resilience (see Appendix C1). The most recurring reference, both in the SC and IB, is that of Christopher and Peck (2004, p. 4): “the ability of a system to return to its original state or move to a new, more desirable state after being disturbed”.

However, through the analysis of the definitions in the sample, I identified four main themes that can be ascribed to the “process perspective” of resilience (Conz & Magnani, 2020).

A first theme is the “anticipation” of disruption (Ciravegna & Michailova, 2021), which is associated with the preparedness of the supply chain to withstand an unexpected event (Ali et al., 2022; Gebhardt et al., 2022). This theme is often treated through the lenses of supply chain risk management (Colicchia et al., 2010; Rajesh, 2020; Ivanov & Dolgui, 2021), with frequent reference to the benefits of technology (e.g. Industry 4.0) for risk mitigation. Moreover, studies that address this preparedness from an IB perspective, often consider long-lasting strategic changes that take time to implement - such as supplier economic upgrading (Ryan et al., 2022) and evaluation of the geographical configuration of the value chain (Ciravegna & Michailova, 2021) - as relevant for GVC resilience.

The second theme is the “responsiveness” of the value chain to the disruption (Colicchia et al., 2010; Canada. National Round Table on the Environment and the Economy, 2012; Ali et al., 2022; Gebhardt et al., 2022). Responsiveness has been addressed mostly by SC literature and it consists of the ability to react to unexpected events to reduce the negative consequences. The concept of responsiveness is sometimes associated with the implementation of mitigation actions and contingency plans to reduce supply lead times (Colicchia et al., 2010) and operational strategies that are actionable at the moment of the disruption impact (e.g. switch to remote working, flexible contracts, re-budgeting of activities, etc) (Ali et al., 2022). However, few recent studies also link responsiveness to resilience from an IB perspective (Ryan et al., 2022; Orlando et al., 2022).

A third key theme that emerged is “adaptation”, which is addressed similarly in both literary streams. A value chain is considered resilient when it can adapt to the new external conditions (Azad et al., 2013; Ciravegna & Michailova, 2021; Ryan et al., 2022; Ivanov & Sokolov, 2012; Rajesh, 2020; Wieland & Durach, 2021; Gereffi, 2021). The identified

definitions of resilience, however, refer to different types of adaptation: (i) product portfolio strategies and technology (e.g. digital twins and cloud connectivity) from a SC perspective (Cohen & Kouvelis, 2021); (ii) value chain governance and geographical configurations from an IB perspective (Gereffi, 2021). Moreover, from a SC perspective, the capacity to adapt is also considered consequential to continuous learning progress within the environment (Belhadi et al., 2021) and feedback reception from external stakeholders (i.e. organizations, institutions, socio-ecological systems) (Novak et al., 2021). Overall, there is no consensus on the aim of the adaptation process after a disruption: some definitions consider adaptation necessary to return to the previous state of the supply chain, while others consider the possibility of a “new”, “optimal” and “improved” state (Mandal, 2019; Miroudot, 2020) or, to use the ecological perspective, the supply chain should enter an “alternative stability domain” (Wieland & Durach, 2021).

A fourth theme is the “recovery” or “continuity”- i.e. the outcome of a resilient value chain - and it has been mostly addressed from SC and grey literature with few IB exceptions (Gereffi et al, 2022, Orlando et al., 2022). A part of the references considers resilience as an attribute that allows the value chain to recover operations after the impact of the disruption (Akkermans & Van Wassenhove, 2018; Boston Consulting Group, 2021; Brandon-Jones et al., 2014; McKinsey, 2020b; Mena et al., 2022), while others consider it as a property of the value chain that allows operations to not be interrupted after the impact of the disruption (Azadegan & Dooley, 2021; Novak et al., 2021; European Commission, 2021).

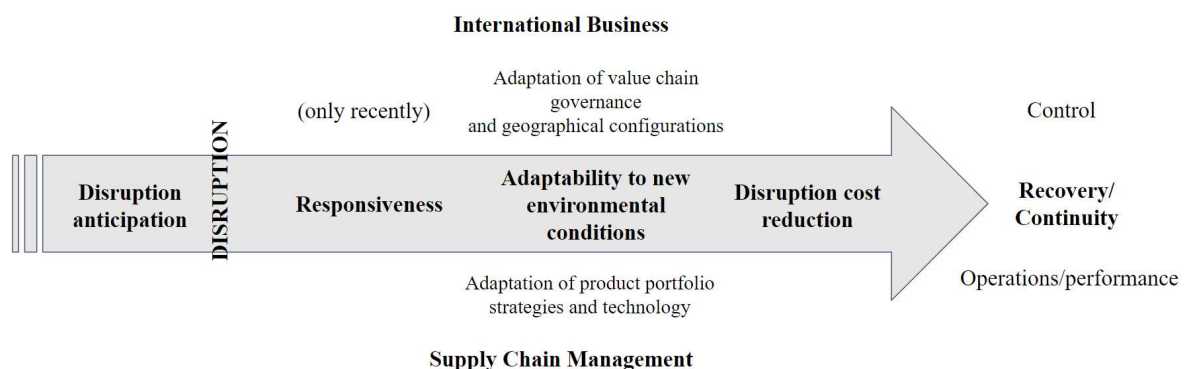
A secondary and consequent theme that reconciles the “recovery/continuity” is that of “timing”: the supply chain should be able to recover its operations in the shortest time possible; when the recovery is immediate, there is operational continuity. Moreover it is not unequivocal what recovery and continuity are referred to: from a SC perspective, it is either operations (i.e. resilience allows continuity or recovery of operations) (Wong et al., 2020;

Mwangi et al., 2021; Ruel et al., 2021), or performance (i.e. resilience allows continuity or recovery of company performance) (Brandon-Jones et al., 2014; Ivanov, 2020; El Baz & Ruel, 2021; Dubey et al., 2021); from an IB perspective, it is the desired level of connectedness and control of the value chain (Orlando et al., 2022).

Finally, I identified a theme that is addressed almost exclusively by grey literature: “disruption cost reduction”. Disruptions are costly in terms of reduction of company performance and consequent necessary investments to recover after disruption impact (Mckinsey, 2022a). According to the identified definitions, resilience allows value chains to recover from disruption by minimizing this cost (DuHadway et al., 2019; Mckinsey, 2020c). However, the recent study by Mouzas & Bauer (2022) introduces to this discussion in the IB field with the concept of financial resilience, i.e. “aspiration level to withstand adversities by building a solvent firm that is not vulnerable to unforeseen contingencies and risks”. This declination of resilience is considered to allow GVCs to bounce back in the face of adversities (ibid).

Fig. 3 is a visual representation of the processual nature of resilience and how it is addressed by IB and SC literature.

Figure 3. GVC resilience as a process in IB and SC



Source: Author's elaboration

4.3.2 Resilience and flexibility

The number of references that takes into consideration flexibility is the most consistent, amounting to 61 over the whole database. While it is rarely used as a synonym of resilience, in these references flexibility is unequivocally considered as an antecedent of resilience in both IB and SC literature streams (Ivanov, 2020; Bain & Company, 2020; Kano et al., 2022; Kano & Hoon Oh, 2020; Gereffi et al., 2022).

The IB literature refers to one main form of flexibility, i.e. multinational operational flexibility. This declination is recognized as an underlying and fundamental capability of multinational companies, which consists of the ability to relocate resources and production by engaging in intra-firm trade (Song, 2014; 2015). The aim of these relocations is generally ascribed to the MNE need to exploit value or cost differential on a global scale (i.e. perform operational hedging) (Huchzermeier & Cohen, 1996; Song, 2017) and to respond to uncertain environmental conditions (Chung et al., 2008; Mascarenhas, 1982). Strictly associated with multinational operational flexibility is the concept of locational flexibility, which is the ability to shift the location of production activities when necessary (Azmeah & Nadvi, 2014). Because of its characteristics, multinational operational flexibility is addressable in the GVC geographical configuration.

In the SC literature, flexibility is declined through three core dimensions: supply, manufacturing, and distribution (Sreedevi & Saranga, 2017).

Supply flexibility concerns the upstream supplier network and it is associated with a flexible supply base, flexible supply contracts, and collaborative supplier relationships (Swafford et al., 2006), while distribution flexibility concerns the supply chain ability to adapt the process of controlling the flow and storage of materials, finished goods, services, and related information from origin to destination in response to changing marketplace conditions (Kalchschmidt et al., 2020). Since they relate to the control activity exercised by the company

on the value chain, both supply and distribution flexibility are addressable through the lenses of GVC governance structure, which has emerged as relevant for resilience.

Manufacturing flexibility concerns the capability of the firm to control production resources and manage uncertainty to fulfill customer needs (Zhang et al., 2003). This dimension is in turn disaggregated in terms of volume flexibility, mix (in some instances “variety”) flexibility, and product flexibility.

Volume flexibility is strictly connected to the manufacturing activity since it is considered the ability to rapidly respond to short-term changes in demand and supply by adapting product volumes (Alfalla-Luque et al., 2018). Mix/variety flexibility concerns the composition of the company’s product range (Pagell & Krause, 2004; Alfalla-Luque et al., 2018) and the ability to handle a range of products or variants with fast setups (Gerwin, 1993) in response to short-term changes in demand and/or supply, while product flexibility concerns the ability of the company to introduce novel products or to modify existing ones (Slack, 1987). Therefore, both mix/variety flexibility and product flexibility are addressable in the product portfolio dimension identified as relevant for GVC resilience.

Finally, a point of intersection between SC and IB literature is the concept of financial flexibility, which concerns the ability to borrow and lend, to increase and decrease assets and liabilities, in various currencies (Mascarenhas, 1982). This dimension of flexibility is relevant because capital constraints influence GVCs configurations, both in terms of geographical configuration and governance strategies (Wang & Huang, 2019).

4.3.3 Resilience and adaptability

Adaptability presents overlapping traits in SC and IB literature. In both theoretical perspectives, adaptability is considered an antecedent of both resilience (Miroudot, 2020; Wieland, 2021) and robustness (Kwak et al., 2018). It emerges as the ability to adjust value

chain's design, strategies, operations, product designs, and technologies (i.e. products' technology cycles and technology for the analysis of the external environment) in response to structural changes in the competitive environment and natural disasters (Kauppi et al., 2016; Cohen & Kouvelis, 2021; Mwangi et al., 2021). A key theme of adaptability is that of the "identification" of both external threats and trends: in fact, adaptability is considered an asset that can support the organizations not only in dealing with external uncertainty factors but also in identifying changes in the competitive environment that can be exploited for competitive advantage (Gölgeci et al., 2019). Moreover, as already discussed for resilience, a recurrent association exists between adaptability and technology for the identification of external changes (Cohen & Kouvelis, 2021; Mwangi et al., 2021). Finally, adaptability seems to be considered a capability an organization can exploit in dealing with structural changes in the long-term, rather than short-term modifications of the competitive environment (Feizabadi et al., 2021).

4.3.4 Resilience and agility

Agility is acknowledged by both SC and IB literature as an antecedent of resilience (Colicchia et al., 2020; Rajesh, 2020) and robustness (Qi et al., 2011; Kwak et al., 2018). Data analysis revealed two main conceptions of agility, i.e. strategic agility in the IB literature and manufacturing agility in the SC literature. Strategic agility is considered the ability to remain flexible in facing new developments, to continuously adjust the company's strategic direction, and to develop innovative ways to create value (Shams et al., 2021) and it is mostly addressed at the individual firm level. Manufacturing agility is considered the ability of the company to cope with volatile market demand by allowing changes in the manufacturing activity that are timely and economically viable, through a combination of flexibility and responsiveness (Lalmazloumian et al., 2016).

Across the database, agility is especially associated with the ability of the organization to rapidly respond to environmental changes (Van Hoek et al., 2001; Alfalla-Luque et al., 2018; Chaudhuri et al., 2018; Mandal, 2019), closely following the “responsiveness” theme that I identified for GVC resilience. In particular, existing studies consider this responsiveness to be influenced by four strategic organizational dimensions: the interaction with customers, the cooperation with actors involved with the organization’s activity, the organization mindset, and the management of people and information (Van Hoek et al., 2001).

The difference between agility and adaptability is labile: apart from the responsiveness theme, agility is also associated with the need to quickly identify environmental changes (Alfalla-Luque et al., 2018; Gölgeci et al., 2019). Therefore, while adaptability is associated with response to disruption in the long-term, agility is considered an asset when addressing environmental changes in the short-term (Cohen & Kouvelis, 2021; Feizabadi et al., 2021; Pereira et al., 2021).

4.3.5 Resilience and robustness

With a total of 16, robustness references in the database are much more meager if compared to the other concepts. Robustness appears nestled in the SC literature, with few and recent references in IB (Miroudot, 2020; Gereffi et al., 2022). Overall, it is considered the ability of the supply chain to resist the disruption, maintaining its functions and planned performance (Brandon-Jones et al., 2014; Ivanov, 2020). Two main reflections can be inferred from this definition: first, what the existing literature considers “robust” is not the supply chain itself, but the achievement of its goals (i.e. robust performance); second, referencing the timing theme presented in the findings relating resilience, a supply chain is considered robust when the time it employs to recover its performance after a disruption is null. In particular, while resilience is associated with both “recovery” and “continuity” of operations, robustness is

exclusively associated with the latter. This thematic overlap and the fact that adaptability and agility are considered antecedents of both make it difficult to understand the difference between robustness and resilience. I therefore argue that while the achievement of robustness has similarities with the achievement of resilience, there are two main differences: first, robustness has as exclusive outcome continuity, while resilience addresses also recovery when the value chain is not able to maintain its operations/performance; second, robustness is a value chain quality that is relevant in the short-term - i.e. at the disruption impact - while resilience is relevant in the long-term.

Finally, in the database, the concept of robustness is at times associated with that of closed-loop supply chains (Chen et al, 2015; Keyvanshokoh et al., 2016), in the sense that the adoption of a closed-loop structure could enhance the robustness of the supply chain.

Table 2. Resilience and related concepts: reconciling IB and SC literature streams

	Relation with resilience	Associated interpretations		
		<i>IB</i>	<i>Both IB and SC</i>	<i>SC</i>
Flexibility	Antecedent	<ul style="list-style-type: none"> • Multinational operational flexibility 	<ul style="list-style-type: none"> • Financial flexibility 	<ul style="list-style-type: none"> • Supply flexibility • Manufacturing flexibility • Distribution flexibility
Adaptability	Antecedent		<ul style="list-style-type: none"> • Identification of external threats and trends • Adaptability of the value chain to new environmental conditions 	
Agility	Antecedent	<ul style="list-style-type: none"> • Strategic agility 		<ul style="list-style-type: none"> • Manufacturing agility
Robustness	Associated with continuity outcome			<ul style="list-style-type: none"> • Performance robustness • Continuity

Source: Author's elaboration

4.4 GVC resilience: actors

After having framed GVC resilience vis-à-vis other concepts repeatedly mentioned in the literature, I discuss how MNEs, as GVC orchestrators, can determine the achievement of the

latter, and then I address the role played by interactions between the different actors. The analysis of the literature has in fact revealed as relevant for the achievement of GVC resilience not only how the orchestrator structures the GVC but also the interactions among value chain actors, i.e. the MNE, suppliers, buyers, other industry players, external stakeholders (such as institutions), and the socio-ecological system as a whole (Novak et al., 2021).

4.4.1 The orchestrator's role in building GVC resilience

MNEs, as GVC orchestrators, have a decisive role in determining the location of value chain activities. What emerges from the analysis is a consensus on the need for geographical diversification of value chain activities to achieve resilience (Cuervo-Cazurra et al., 2020). For example, from an IB perspective, Song (2013) demonstrates how high geographical concentration of subsidiaries negatively influences the ability of the firm to react in case of uncertainty. From a SC perspective, location strategy is also conceptualized as hybrid, in the sense that the lead firm can adopt different approaches according to whether the activities are upstream or downstream: for example, Cuervo-Cazurra et al. (2020) suggests a combination of both multilocal assembly facilities and a diverse and dispersed network of suppliers.

The orchestrator decision about the location of value chain activities is linked to the governance structure decisions in the study of how operational hedging - i.e. the shifting of production to more favorable locations- is a potential strategy that firms can adopt in case of uncertainty to gain competitive advantage (Song, 2015). However, the study of operational hedging is exclusively contextualized in the case of exchange rate uncertainty (Gutierrez & Kouvelis, 1995; Huchzermeier & Cohen, 1996; Song, 2015) and it is often linked to the concept of financial hedging (Huchzermeier & Cohen, 1996; Weiss & Maher, 2009). The study of operational hedging in IB literature is often contextualized in vertically integrated value chains, where the focus is on ownership levels: these studies agree that intra-firm trade

is preferable over production shifting and that higher ownership levels make intra-firm trade easier and therefore facilitate operational hedging (Song, 2015; Shin & Lee, 2019).

Overall, the choice of value chain activity location is considered dynamic, in the sense that it can change and evolve over time, according to both internal and external stimuli (Qi et al., 2011; Gebhardt et al., 2022).

Therefore, orchestrators can reconfigure the GVC geography according to the changed circumstances (da Silveira, 2014; Lampón, 2020; Ciravegna & Michailova, 2022). This idea is associated with concepts such as nearshoring and reshoring, i.e. the relocation of value chain activities to the lead firm home country or closer geographical areas, as potential steps in the reconfiguration of GVCs (Cuervo-Cazurra et al. 2020; Hahn et al., 2011; Ciravegna & Michailova, 2022; da Silveira, 2014). However, the reconfigurations that feature the reshore/nearshore of production activities are seen as both costly and complex (Lampón, 2020; Ciravegna & Michailova, 2022) and potentially based on a lower perception of risks rather than actual lower risks (Hahn et al., 2011).

Finally, studies almost exclusively from SC literature address how technology can support the orchestrator both in control and location choices: the focus is primarily on IT (Sinkovics et al., 2011) and artificial intelligence (Belhadi et al., 2021) for the monitoring and response to disruptions along the value chain and the analysis of big and small data to support reconfiguration decisions (Rengarajan et al., 2022).

4.4.2 Orchestrator-suppliers relationships affecting GVC resilience

Existing literature, especially in the SC field, emphasizes collaboration with suppliers for the achievement of resilience (Lam & Bai, 2016).

According to these studies, resilience is built by forging stronger supplier partnerships (Contractor, 2021; McKinsey, 2020a), not only with key suppliers but with the extended

network (i.e. suppliers beyond first tier) (Ang et al., 2017). In this sense, MNEs should coordinate with suppliers for decisions concerning inventory management, planning, forecasting, replenishment, and flows of physical resources to build a resilient value chain (Dunke et al., 2018; He et al., 2014; Jajja et al., 2018). Two main takeaways on this topic have been identified in the grey literature: first, the orchestrator needs to establish collaborative relationships with their suppliers, in order to decentralize decision-making processes (European Commission, 2018); second, these collaborative relationships can enhance visibility along the value chain, i.e. the extent to which actors within the value chain have access to timely and accurate information about its status (Bain & Company, 2020).

The theme of visibility is here intrinsically linked to that of technology (big data, IoT, SC digital twin) as an instrument to improve data collection and information flow along the value chain (Mandal, 2019; Dunke et al., 2018; Ivanov & Dolgui, 2021). However, technology – and Industry 4.0 in particular - is also presented as a strategic instrument for the improvement of operational performance when combined with the lead firm's support of the digital capabilities development in SMEs that are included in the value chain and development a co-innovative relationship with them (Dilyard et al., 2021). More broadly, the theme of governance in relation to GVC resilience is explored by adopting a relational perspective, drawing the attention to the need to investigate governance mechanisms that balance power dynamics between MNEs and their suppliers (Verbeke, 2020; Kano & Hoon Oh, 2020).

4.4.3 The role of institutions for GVC resilience

Mainly in the IB literature, institutions (i.e. governments, other public bodies and local economic development organizations) are considered to play an important role in building GVC resilience as well (Gereffi et al., 2022; United States, 2021; OECD, 2021a; Dallas et al., 2021). They are here seen as facilitators of resilience (Gereffi et al., 2022; United States,

2021), by acting either on GVC orchestrator or on the environment in which it operates. For example, institutions can “guide” MNEs in their decision-making process concerning the value chain, by requiring specific sourcing or geographical configurations according to the industry (Scottish Procurement and Property Directorate, 2021; Dallas et al., 2021). However, institutions can also act on the environment in several ways: they can reduce unnecessary heterogeneity of norms and standards, facilitating substitutability between production inputs (OECD, 2021a); they can support SMEs and workforce capability development with ad hoc investments (White House, 2021; UN, 2021); they have the power to influence international trade policies (Gereffi, 2021).

4.4.4. Other GVC actors: emerging insights

While the role of institutions and the relationship between MNEs and suppliers in GVC resilience are part of a wide discussion, there are minor references to the role played by other actors. These references are exclusively found in SC and grey literature.

Here resilience is not considered an ability that can be cultivated with the orchestrator efforts alone, but it requires to nurture collaborative relationships with external stakeholders: not only suppliers, and institutions, but also buyers, and other MNEs from other unconnected value chains (McKinsey, 2020b; Gereffi et al., 2022; Azadegan et al., 2021; UN, 2021). Accordingly, Jajja et al. (2018) puts forward how the relationship of MNEs with customers can contribute to building resilience. In particular, this study refers to consumer integration, i.e. involvement with key customers to understand their requirements and align organizational functions to create value for customers (Koufteros et al., 2005). It is found that customers are the source of information to demand markets and a weak connection with them would delay the access to market information, which is crucial during disruptions (Jajja et al., 2018)

Additionally, Azadegan & Dooley (2021) and the European Commission (2021) highlight the need to collaborate with firms belonging to different supply networks and that are not necessarily trade partners. This type of collaboration usually takes the form of trade or industry associations: they are characterized by adaptive membership and address long-term industry wide risks (Azadegan & Dooley, 2021). European Commission (2021) proposes that these large-scale industry coalitions and partnerships can contribute to GVC resilience by aligning the vision and goals of different players in the industry. Industry-wide coalitions concerning value chain sustainability are offered as an example of these interactions (Azadegan & Dooley, 2021; European Commission, 2021)

4.5 GVC resilience: how to measure it

The analysis of the identified references showed that the measurement of resilience at the value chain level is limited to few instances. Table 3 presents an overview of these measurement approaches. The first relevant finding is that all the measurements emerged are derived from SC literature, revealing a consistent lack in IB. Second, the few papers that indeed measure resilience employ survey as a data collection method and resilience is measured on a Likert scale as a combination of different items. The analysis of these measures allowed to identify three main recurring themes:

- (i) how quickly the value chain can respond to the disruption (Brandon-Jones et al., 2014; Dubey et al., 2021; El Baz & Ruel, 2021; Yang et al., 2022).
- (ii) how quickly the flow of materials or production activities is restored within the value chain (Brandon-Jones et al., 2014; Belhadi et al., 2021; Dubey et al., 2021; Yang et al., 2022)

(iii) how quickly the value chain can return to its original state or can recover operating performance (Brandon-Jones et al., 2014; Wong et al., 2020; Belhadi et al., 2021; Dubey et al., 2021; Yang et al., 2022)

Ali et al. (2022) stands out for measuring resilience as a multidimensional concept, taking into account three dimensions: “readiness”, “response” and “recovery”. In this case, the measurement focuses on a more operational level, by detecting the adoption of specific managerial approaches (e.g. the switch to remote working, excess stock, workforce training, coordination with industry body and governments, flexible contracts, cross-sector collaboration, rebudgeting, ecc).

Table 3. Identified measures of resilience

<i>Author(s)</i>	<i>Measures</i>
Brandon-Jones et al. (2014)	RES1: Material flow would be quickly restored RES2: It would not take long to recover normal operating performance RES3: The supply chain would easily recover to its original state RES4: Disruptions would be dealt with quickly
Wong et al. (2020)	SCR1: Our firm’s supply chain can quickly return to its original state after being disrupted SCR2: Our firm’s supply chain has the ability to maintain a desired level of connectedness among its members at the time of disruption. SCR3: Our firm’s supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption SCR4: Our firm’s supply chain has the knowledge to recover from disruptions and unexpected events
Belhadi et al. (2021)	SCRes_1: Our firm’s supply chain is well prepared to face constraints of supply chain disruptions SCRes_2: Our firm’s supply chain can rapidly plan and execute contingency plans during disruptions SCRes_3: Our firm’s supply chain can adequately respond to unexpected disruptions by quickly restoring its product flow SCRes_4: Our firm’s supply chain can swiftly return to its original state after being disrupted SCRes_5: Our firm’s supply chain can gain a superior state compared to its original state after being disrupted
Dubey et al. (2021)	SCRES1: Our organization can easily restore material flow. SCRES2: Our organization would not take long to recover normal operating performance. SCRES3: The supply chain would quickly recover to its original state. SCRES4 :Our organization can quickly deal with disruptions.
El Baz & Ruel (2021)	RESIL1: the ability of the SC to cope with changes due to a SC disruption RESIL2: the ability to adapt to a SC disruption RESIL3: the ability to provide a quick response RESIL4: the ability to maintain high situational awareness
Ali et al. (2022)	<u>Readiness</u>

	<p>Rdns1: Our firm proactively switched to remote work and ensured workers safety and well-being. Rdns2: Our firm organised the excess stock and minimised unnecessary expenses to deal with unanticipated shocks. Rdns3: Our firm proactively trained workforces to deal with potential uncertainties. Rdns4: Our firm has backward and forward integration. Rdns5: Our firm implemented omnichannel.</p> <p><u>Response</u> Resp1: Our firm has effectively responded to the unexpected shocks of the pandemic. Resp2: Our firm maintained close coordination with government and industry bodies for support. Resp3: Our firm extended payables and expedited receivables. Resp4: Our firm continued employees' screening, safety and well-being. Resp5: Our firm introduced flexibility in contracts with value chain partners (partial order and payment, partial shipments etc.). Resp6: In response to social distancing, our firm quickly moved to telework/flexible work arrangements.</p> <p><u>Recovery</u> Rec1: Our firm has better-absorbed shocks and recovered in a short time. Rec2: Our firm formed a cross-sector collaboration to restructure the current business model and recover from crises at less cost. Rec3: Our firm has reinvigorated operational costs (re-budgeting, refinancing of the loan, sold un-productive assets, restaffing) to recover back to a normal state. Rec4: Our firm has been reflecting and reimagining current business by integrating digital capabilities and reconsidering current buyers/suppliers' networks.</p>
<p>Yang et al. (2022)</p>	<p>When our organization faces supply chain disruptions, it can SCR1. ... respond to threats quickly. SCR2. ... make appropriate adjustments. SCR3. ... increase operational flexibility. SCR4. ... maintain business continuity. SCR5. ...develop redundancy (e.g., extra inventory, multiple suppliers). SCR6. ... strengthen internal and external collaborations</p>

Source: Author's elaboration

5. GVC resilience: a theoretical framework and a definition

Our findings show that the study of resilience and its associated concepts (i.e. flexibility, adaptability, agility and robustness) at the GVC level presents relevant touchpoints between IB and SC literatures.

Both research areas share some of the identified themes - such as disruption anticipation, adaptability to new environmental conditions and recovery/continuity as outcomes. On the contrary, responsiveness theme in connection to resilience is well established in the SC literature, while it is very recent to IB.

Following the analysis of resilience definitions, the relationships between resilience and associated concepts, resilience measures and actors associated with resilience, I advance a theoretical framework to frame GVC resilience.

First, flexibility, adaptability and agility firmly emerged as antecedents of resilience (Ivanov et al. 2020; Kano et al., 2022; Miroudot, 2020; Wieland, 2021; Colicchia et al., 2020; Rajesh et al., 2020), but with different assumptions.

Flexibility is regarded as foundational antecedent of the resilient value chain, in the sense that it is not only considered the antecedent of both resilience and robustness (Kwak et al., 2020), but also an antecedent of adaptability and agility (Feizabadi et al., 2021; Ivanov et al., 2019; Shams et al., 2021). According to the analysis, value chain flexibility appears to be influenced by strategic choices concerning governance and geographical configuration of the GVC, and product portfolio of the MNE (Kalchschmidt et al, 2020; Hunchzermeier & Cohen, 1996; Wang & Huang, 2019; Alfalla-Luque et al., 2018)

Adaptability emerged as an antecedent of resilience, associated with the anticipation of the disruption (Golgeci et al., 2021) and the adaptation of the value chain to the new environmental conditions (Mwangi et al., 2021; Ruel et al., 2021). In particular, adaptability is considered a quality that enables the value chain to cope with uncertain conditions in the long term (Kalchschmidt et al., 2020; Azadegan et al., 2019; Feizabadi et al., 2021). Especially in the SC literature, the choice of technologies to monitor the value chain is considered the main factor influencing adaptability (Kohen & Kouvelis, 2021; Mwangi et al., 2021).

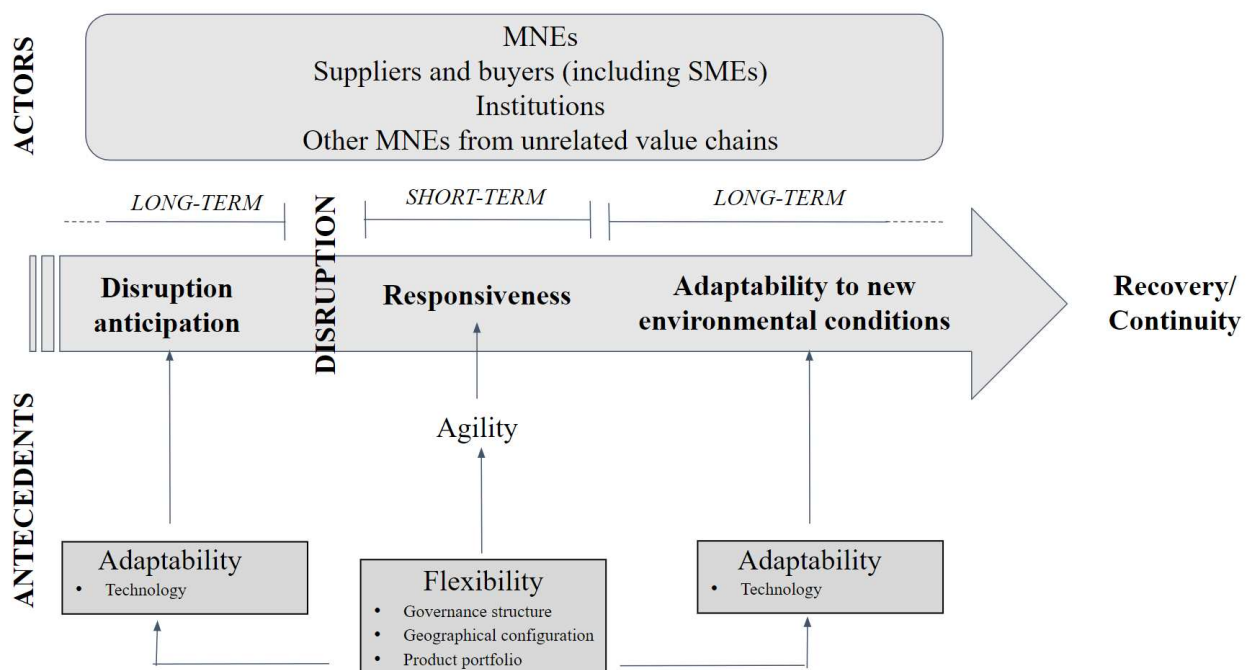
Agility is considered the capability of the value chain to cope with the short-term effect of environmental alterations (Cohen & Kouvalis, 2021; Pereira et al., 2020) and it is specifically linked to the value chain responsiveness to the disruption (Golgeci et al., 2019; Alfalla-Luque et al., 2018; Feizabadi et al., 2021).

For what concerns robustness, it is not considered an antecedent of resilience, but rather an outcome of the resilience process exclusively associated with the operational continuity of the value chain (Gereffi et al., 2022; Cohet & Kouvalis, 2021).

Second, data analysis also identified actors that have an influence over GVC resilience. In this area, most of the attention has been focused on MNEs as GVC orchestrators, but suppliers and buyers (including smaller actors, such as SMEs), institutions and MNEs from unrelated value chains appear to be influential in achieving resilience.

Figure 4 proposes a visual representation of the GVC resilience theoretical framework.

Figure 4. A theoretical framework for GVC resilience



Source: Author's elaboration

Taking into account this convergence of themes and actors and acknowledging how SC literature can contribute to the IB perspective, the following definition of GVC resilience is proposed:

“A Global Value Chain is resilient when the orchestrator can recover or maintain control over performance/operations by identifying and responding to a disruption through the adaptation to new environmental conditions - which in turn depend on governance structure, geographical configurations, product portfolio strategies, and technologies - in collaboration with other GVC actors, including suppliers, buyers, institutions and MNEs from unrelated value chains”.

6. Avenues for future research

In this section avenues for future research opened by the findings of this study are proposed.

First, I recognize four strategic dimensions that MNEs can act upon to achieve value chain resilience: governance structure and geographical configurations of the value chain, product portfolio strategies and the adoption of technologies for value chain monitoring. The governance structure and geographical configuration are prevalent themes of the IB field that have only recently and sparsely been associated with resilience. On the other hand, technology and product portfolio strategies are two dimensions that are consistently connected to resilience in the supply chain literature, while lacking in the IB field. However, it is not yet clear *how* these dimensions influence resilience in the GVC context. While research in IB is already exploring the role of geographical configuration and governance structure, future studies could address the role of product portfolio strategies and technologies in the context of GVCs.

Second, while collaborative relationships within GVC is not a new area of investigation in IB (Khan et al.: 2015, 2018; Pipkin & Fuentes, 2017), findings revealed how this aspect was almost exclusively taken into account by SC literature in addressing collaboration with suppliers at the operational level when investigating resilience. This perspective, however, is

in line with Hillmann & Guenther (2021), which already identified networks as relevant for achieving organizational resilience. In particular, networks - including those external to the organization - are considered important for sharing information and developing collective responses to disruptions (Lengnick-Hall et al, 2011). Therefore, future studies could explore two possible avenues for research: (i) to address collaboration with suppliers from both the governance and geographical perspective in relation to GVC resilience; (ii) to explore how collaboration with other GVC actors - such as customers and institutions - can affect resilience.

Finally, this study uncovered how, although being different concepts with different definitions, resilience and robustness are consistently used as synonyms in both the SC and IB research, although robustness is specifically associated with continuity of operations. Since the theoretical framework highlighted the differentiations between the two, future research should address how the strategic dimensions here identified allow GVCs to achieve one or the other.

7. Conclusions

Increasing attention has been posed on resilience in IB, but it still lacks a solid conceptualisation. Studies often employ a definition of resilience borrowed from supply chain literature and overlap resilience with resilience related concepts, i.e. flexibility, robustness, agility and adaptability. The present systematic review aimed to address this gap by advancing a conceptual framework for GVC resilience that could represent the basis for further theoretical and empirical developments in the field. In doing so, its contribution is tripartite: first, it provides a definition of resilience that applies to the GVC context; second, it identifies the actors and measurement approaches addressed by existing literature; third, it

reconciles resilience with the meanings of flexibility, robustness, adaptability, and agility, providing a theoretical framework applicable in future research.

The current study is not free from limitations. Since it has a wide scope and takes into consideration two areas of research (i.e. IB and SC management), it focuses only on peer-reviewed articles from 3/4/4* journals in order to address established research. Given the number of selected studies (n = 145) and the inclusion of grey literature, the study could present a comprehensive picture of GVC resilience. Nevertheless, it must be acknowledged that there might be publication bias (Harrison et al. 2017).

Appendix A1: Systematic Literature Review Protocol

SCOPE AND BOUNDARIES OF THE REVIEW

Scope of the study: articles published by peer-reviewed English language journals (ABS journal ranking 2021) or resources from grey literature (practitioner oriented journals, reports by global consulting companies and governmental agencies). Books, book chapters, conference proceedings are excluded because the final output of the search could be redundant, since this material is often also present in the literature as journal articles (Danese et al., 2018).

Conceptual boundaries: articles that investigate resilience in GVC, especially those taking into consideration the interactions within the actors of the GVC

Time frame: resilience in GVC is a relatively recent area of research. Because of this and since, there is not another SLR on the topic, a time restriction is not applicable

STUDY IDENTIFICATION AND SCREENING AND SELECTING PROCESS

Five subsequent techniques are adopted to locate references, in order to take into consideration all available studies.

1. Research in electronic databases

Search terms: GVC (as synonyms: international supply chain, international networks), resilience (as synonyms: flexibility, robustness, adaptability, agility). These terms are combined in one search string through Boolean logic.

Database: Scopus (limited to: Business, Management and Accounting) and WoS (limited to: Management, Operations Research Management Science, Business, International Relations, Business Finance)

Table 4. Keywords and search strings in electronic databases

Database	Search string
Scopus	TITLE-ABS-KEY (("GVC*" OR "global value chain*") OR ("supply chain*" AND "international") OR ("international network*")) AND ("resilience" OR "flexibility" OR "robustness" OR "agility" OR "adaptability") AND (LIMIT-TO (SUBJAREA , "BUSI"))
WoS	TOPIC: (("global value chain*" OR "GVC*") OR ("supply chain*" AND "international") OR ("international network*")) AND TOPIC: ("resilience" OR "flexibility" OR "robustness" OR "adaptability" OR "Agility") Refined by: WEB OF SCIENCE CATEGORIES: (MANAGEMENT OR OPERATIONS RESEARCH MANAGEMENT SCIENCE OR BUSINESS OR INTERNATIONAL RELATIONS OR BUSINESS FINANCE)

After the identification of double results, the following inclusion and exclusion criteria are applied, in succession:

Table 5. Inclusion and exclusion criteria for peer-reviewed articles

<i>Description</i>	<i>Reason for inclusion</i>	<i>Reason for exclusion</i>	<i>Methodology</i>
Journal quality criteria	ABS ranked 3/ 4/ 4* journal articles	ABS 1/ 2 journals	Filter database
Conceptual boundaries	Articles investigating resilience in GVC and geographically distributed SC Articles taking into consideration the interactions within the actors of the GVC	Articles that focus on humanitarian supply chains airport scheduling work scheduling, scheduling of public transportation, scheduling of travelling tournaments, surgery scheduling, women entrepreneurship, expatriate management, turnaround management, home delivery cultural management CEO narcissism, cognitive bias, blood SC	Analysis of title and Abstract
Document type (grey literature only)	The document must be a report of a more comprehensive research	Online article Editorial Description of services offered by the company	Filter the search on the database Manual evaluation

2. Manual search of peer-reviewed journals

- Identification of those journals that score a 3/ 4/ 4* in the ABS ranking but are not represented in the databases results that are particularly relevant. Before applying the inclusion/exclusion criteria to the articles found through database search, the more represented ABS 2021 fields of research are identified: OPS&TECH, IB&AREA, OR&MANSCI. The manual search is carried out in 3/4/4* rated journal belonging to these three fields and not yet represented in the database search.

Table 6. List of journals in the manual search

Journal
Computers in Industry
Journal of Purchasing and Supply Management
Journal of Supply Chain Management
African Affairs
Asia Pacific Journal of Management
Journal of Common Market Studies
Management and Organization Review
Management International Review
Management Science
IEEE Transactions on Evolutionary Computation
Mathematical Programming
IEEE Transactions on Systems, Man, and Cybernetics: Systems
ACM Transactions on Modeling and Computer Simulation
Annals of Operations Research
Computational Optimization and Applications
Computers and Operations Research
Decision Sciences
Evolutionary Computation
Fuzzy Optimization and Decision Making
IEEE Transactions on Cybernetics
IIE Transactions
INFORMS Journal on Computing
International Journal of Forecasting
Journal of Heuristics
Journal of Optimization Theory and Applications
Journal of the Operational Research Society
Mathematics of Operations Research
Naval Research Logistics
SIAM Journal on Optimization
Transportation Science

- Search with the same search string as the databases.
 - Analysis of conceptual boundaries was conducted through title and abstract analysis.
- 3. Suggestions by expert researchers in the field**
- Request to expert researchers in the field to suggest studies to include in the research. These experts will be aware of the database already formed (to avoid duplication of results).
 - Suggested references are accepted without applying the inclusion criteria
- 4. Snowball method (forward)**
- Starting from the articles selected with the first three methods, I use Google Scholar to find if there are articles that cite them.

- In this case the time frame will be 2019-2021 (COVID-19 timeframe)
- Apply the same inclusion/exclusion criteria applied previously

5. “Grey literature”

- Select non-peer-reviewed research from reliable outlets: institutions and governmental agencies; global consulting companies strictly in the field of management.
- First tier sources were selected from the list provided by Bonato (2018)¹, selecting all those outlets associated with governments and institutions.
- In this case, material will be evaluated exclusively on the basis of the “conceptual boundaries”.

Table 7. Data collection of grey literature

Source	Type of search		Search results	Check for conceptual boundaries	Notes
UN Online document system	Full text search	global value chain resilience	0	0	
		supply chain resilience	20	2	
Australian Government Publications	Full text search	global value chain resilience	0	0	
		supply chain resilience	0	0	
Catalogue of US government Publications	Full text search	global value chain resilience	0	0	
		supply chain resilience	1	1	
CORDIS	Full text search	global value chain resilience	495	3	Research restricted to the following programmes: Seventh framework programme (FP7) and Horizon2020 (most recent research), : business and management, crisis management
		supply chain resilience	1471	3 (duplicates)	
Government publications Canada	Full text search	Resilience	164	1	Filtered for department (Bank of Canada, Department of Finance, Global Affairs Canada, International Development Research Centre, National Research Council of Canada, Policy research initiative, Western economic diversification Canada, National Round Table on the Environment and the Economy, Treasury board)
Publications New Zealand	Full text search	global value chain resilience	0	0	
		supply chain resilience	5	0	

¹ Bonato, S. (2018). Searching the grey literature: A handbook for searching reports, working papers, and other unpublished research. Rowman & Littlefield.

Publications UK	Full text search	global value chain resilience	23	1	
		supply chain resilience	956	0	
Scottish government publications	Full text search	global value chain resilience	4	0	
		supply chain resilience	28	1	
Second tier					
McKinsey	Full text search	global value chain resilience	1770	2	
		supply chain resilience	3644	3 (2 of which duplications)	
Boston Consulting Group	Full text search	global value chain resilience	4945	2	
		supply chain resilience	4788	1 (duplications)	
Bain & Company	Full text search	global value chain resilience	4929	2	
		supply chain resilience	1697	1 (duplication)	

Data extraction

- All the resulting reference were managed with an Excel spreadsheet. The following table reports the categories of information extracted.

Table 8. Categories of data extracted from references

Authors Title Year Source title Volume; Issue; Pages Abstract
Main theoretical perspective Research question(s) Empirical (E) or Conceptual (C) Qualitative (QL), Quantitative (QN), Both (BO) Cross-sectional (CS), Longitudinal (L) Analytical methodology Sample size Country Sector Main findings Directions for future research Definition of resilience (Y/N)
Notes

Appendix B1: List of selected references

Table 9 . List of selected references

Authors	Title	Year	Source title
Aerts, A. T. M., Szirbik, N. B., & Goossenaerts, J. B.	A flexible agent-based ICT architecture for virtual enterprises	2002	Computers in Industry
Akkermans, H., & Van Wassenhove	Supply Chain Tsunamis: Research on Low-Probability, High-Impact Disruptions	2018	Journal of Supply Chain Management
Alfalla-Luque R., Machuca J.A.D., Marin-Garcia J.A.	Triple-A and competitive advantage in supply chains: Empirical research in developed countries	2018	International Journal of Production Economics
Ali, I., Arslan, A., Chowdhury, M., Khan, Z., & Tarba, S. Y.	Reimagining global food value chains through effective resilience to COVID-19 shocks and similar future events: A dynamic capability perspective	2022	Journal of Business Research
Ali, I., Arslan, A., Khan, Z., & Tarba, S. Y.	The role of Industry 4.0 technologies in mitigating supply chain disruption: empirical evidence from the Australian food processing industry.	2021	IEEE Transactions on Engineering Management.
Ang, E., Iancu, D. A., & Swinney, R.	Disruption Risk and Optimal Sourcing in Multitier Supply Networks	2016	Management science
Arvanitis, S., Bolli, T., & Stucki, T.	In or Out: How Insourcing Foreign Input Production Affects Domestic Production	2017	Management International Review
Azad, N., Saharidis, G. K., Davoudpour, H., Malekly, H., & Yektamaram, S. A	Strategies for protecting supply chain networks against facility and transportation disruptions: an improved Benders decomposition approach	2013	Annals of Operations Research

Azadegan, A., & Dooley, K.	A Typology of Supply Network Resilience Strategies: Complex Collaborations in a Complex World	2021	Journal of Supply Chain Management
Azadegan, A., Modi, S., & Lucianetti, L.	Surprising supply chain disruptions: Mitigation effects of operational slack and supply redundancy.	2021	International Journal of Production Economics
Azadegan, A., Srinivasan, R., Blome, C., & Tajeddini, K.	Learning from near-miss events: An organizational learning perspective on supply chain disruption response.	2019	International Journal of Production Economics
Azmeh S., Nadvi K.	Asian firms and the restructuring of global value chains	2014	International Business Review
Bain & Company	Beyond Cheaper and Faster: Resilience in Tech Supply Chains	2020	Technology report 2020
Banalieva, E. R., Santoro, M. D., & Jiang, J. R.	Home Region Focus and Technical Efficiency of Multinational Enterprise	2012	Management International Review
Belhadi, A., Mani, V., Kamble, S. S., Khan, S. A. R., & Verma, S.	Artificial intelligence-driven innovation for enhancing supply chain resilience and performance under the effect of supply chain dynamism: an empirical investigation	2021	Annals of Operations Research
Bimpikis, K., Candogan, O., & Ehsani, S.	Supply Disruptions and Optimal Network Structures	2019	Management science
Boston Consulting Group	Real-World Supply Chain Resilience	2021	
Brandon-Jones, Emma, Squire, Brian, Autry, Chad W., Petersen, Kenneth J.	A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness	2014	Journal of Supply Chain Management
Cattaneo, O., Gereffi, G., & Staritz, C.	Global value chains in a postcrisis world: resilience, consolidation, and shifting end markets.	2010	Global value chains in a postcrisis world: A development perspectiv

Chaudhuri A., Boer H., Taran Y.	Supply chain integration, risk management and manufacturing flexibility	2018	International Journal of Operations and Production Management
Chen, F. Y., & Yano, C. A.	Improving Supply Chain Performance and Managing Risk Under Weather-Related Demand Uncertainty	2010	Management science
Chen, WY; Kucukyazici, B; Verter, V; Saenz, MJ	Supply chain design for unlocking the value of remanufacturing under uncertainty	2015	EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
Choksy, U.S., Ayaz, M., Al-Tabbaa, O., Parast, M.	Supplier resilience under the COVID-19 crisis in apparel global value chain (GVC): The role of GVC governance and supplier's upgrading	2022	Journal of Business Research
Chung, C. C., Lu, J. W., & Beamish, P. W.	Multinational networks during times of economic crisis versus stability	2008	Management International Review
Chun-Wei R. Lin Hong-Yi S. Chen	A fuzzy strategic alliance selection framework for supply chain partnering under limited evaluation resources	2004	Computers in Industry
Ciravegna, L., & Michailova, S.	Why the world economy needs, but will not get, more globalization in the post-COVID-19 decade.	2021	Journal of International Business Studies
Cohen M.A., Kouvelis P.	Revisit of AAA Excellence of Global Value Chains: Robustness, Resilience, and Realignment	2021	Production and Operations Management
Colicchia C., Dallari F., Melacini M.	Increasing supply chain resilience in a global sourcing context	2010	Production Planning and Control
Contractor, F. J.	The world economy will need even more globalization in the post-pandemic 2021 decade.	2021	Journal of International Business Studies
Cuervo-Cazurra A., Doz Y., Gaur A.	Skepticism of globalization and global strategy: Increasing regulations and countervailing strategies	2020	Global Strategy Journal

Curran L., Eckhardt J.	Why COVID-19 Will Not Lead to Major Restructuring of Global Value Chains	2021	Management and Organization Review
Da Silveira G.J.C., Cagliano R.	The relationship between interorganizational information systems and operations performance	2006	International Journal of Operations and Production Management
da Silveira, GJC	An empirical analysis of manufacturing competitive factors and offshoring	2014	International Journal of Production Economics
da Silveira, GJC	Effects of simplicity and discipline on operational flexibility: An empirical reexamination of the rigid flexibility model	2006	Journal of Operations Management
Dallas, M. P., Horner, R., & Li, L.	The mutual constraints of states and global value chains during COVID-19: The case of personal protective equipment.	2021	World development
De Marchi, V., Di Maria, E., Golini, R. & Perri, A.	Nurturing international business research through global value chains literature: a review and discussion of future research opportunities.’	2020	International Business Review
Demeter, K.	Operating internationally - The impact on operational performance improvement	2014	International Journal of Production Economics
Dilyard, J., Zhao, S., & You, J. J.	Digital innovation and Industry 4.0 for global value chain resilience: Lessons learned and ways forward.	2021	Thunderbird International Business Review
Dong L., Kouvelis P.	Impact of tariffs on global supply chain network configuration: Models, predictions, and future research	2020	Manufacturing and Service Operations Management
Dubey, R., Gunasekaran, A., Childe, S. J., Fosso Wamba, S., Roubaud, D., & Foropon, C.	Empirical investigation of data analytics capability and organizational flexibility as complements to supply chain resilience.	2021	International Journal of Production Research
DuHadway, S., Carnovale, S., & Hazen, B.	Understanding risk management for intentional supply chain disruptions: risk detection, risk mitigation and risk recovery	2019	Annals of Operations Research

Dunke, F; Heckmann, I; Nickel, S; Saldanha-da-Gama, F	Time traps in supply chains: Is optimal still good enough?	2018	EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
El Baz, J., & Ruel, S.	Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era.	2021	International Journal of Production Economics
European Commission	Consistently Optimised Resilient Secure Global Supply-Chains	2018	
European Commission	REMPPLANET (Resilient Multi-Plant Networks)	2012	
European Commission, Directorate-General for Research and Innovation, Dixson-Declève, S., Bria, F., Charveriat, C., et al.,	Transformation post-COVID. Global value chains : harnessing innovation to protect and transform the backbone of global trade	2021	European Commission
Fayoumi, A.	Ecosystem-inspired enterprise modelling framework for collaborative and networked manufacturing systems	2016	Computers in Industry
Feizabadi J., Gligor D.M., Alibakhshi S.	Examining the synergistic effect of supply chain agility, adaptability and alignment: a complementarity perspective	2021	Supply Chain Management
Forget, P., D'Amours, S., Frayret, J. M., & Gaudreault, J.	Study of the performance of multi-behaviour agents for supply chain planning	2009	Computers in Industry
Gebhardt, M., Spieske, A., Kopyto, M., Birkel, H.	Increasing global supply chains' resilience after the COVID-19 pandemic: Empirical results from a Delphi study	2022	Journal of Business Research
Gereffi, G.	Written Testimony to the United States on Legislative Hearing on "Implementing Supply Chain Resiliency" (July 12, 2021),	2021	Committee on Commerce, Science and Transportation United States Senate

Gereffi, G., Pananond, P., & Pedersen, T.	Resilience Decoded: The Role of Firms, Global Value Chains, and the State in COVID-19 Medical Supplies	2022	California Management Review
Gölgeci I., Assadina S., Kuivalainen O., Larimo J.	Emerging-market firms' dynamic capabilities and international performance: The moderating role of institutional development and distance	2019	International Business Review
Gutierrez, G. J., & Kouvelis, P.	A robustness approach to international sourcing	1995	Annals of Operations Research
Hada, M., Grewal, R., & Chandrashekar, M.	MNC subsidiary channel relationships as extended links: Implications of global strategies.	2013	Journal of International Business Studies
Hahn, E. D., Bunyaratavej, K., & Doh, J. P.	Impacts of Risk and Service Type on Nearshore and Offshore Investment Location Decisions	2011	Management International Review
He Y., Keung Lai K., Sun H., Chen Y.	The impact of supplier integration on customer integration and new product performance: The mediating role of manufacturing flexibility under trust theory	2014	International Journal of Production Economics
Huchzermeier, A; Cohen, MA	Valuing operational flexibility under exchange rate risk	1996	OPERATIONS RESEARCH
Ivanov, D.	Exiting the COVID-19 pandemic: after-shock risks and avoidance of disruption tails in supply chains	2021	Annals of Operations Research
Ivanov, D.	Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic	2020	Annals of Operations Research
Ivanov, D.	Digital supply chain management and technology to enhance resilience by building and using end-to-end visibility during the COVID-19 pandemic.	2021	IEEE Transactions on Engineering Management.

Ivanov, D., & Dolgui, A.	Low-Certainty-Need (LCN) supply chains: a new perspective in managing disruption risks and resilience.	2019	International Journal of Production Research
Ivanov, D., & Dolgui, A.	A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0.	2020	Production Planning and Control
Ivanov, D; Sokolov, B	Structure dynamics control approach to supply chain planning and adaptation	2012	International Journal of Production Research
Jajja M.S.S., Chatha K.A., Farooq S.	Impact of supply chain risk on agility performance: Mediating role of supply chain integration	2018	International Journal of Production Economics
Jiménez, A., Benito-Osorio, D., & Palmero-Cámara, C.	Learning from Risky Environments: Global Diversification Strategies of Spanish MNEs	2015	Management International Review
Kalchschmidt M., Birolini S., Cattaneo M., Malighetti P., Paleari S.	The geography of suppliers and retailers	2020	Journal of Purchasing and Supply Management
Kano L., Narula R., Surdu I.	Global Value Chain Resilience: Understanding the Impact of Managerial Governance Adaptations	2022	California Management Review
Kano, L., & Hoon Oh, C.	Global value chains in the post-COVID world: Governance for reliability.	2020	Journal of Management Studies
Kano, L., Tsang, E. W., & Yeung, H. W. C.	Global value chains: A review of the multi-disciplinary literature.	2020	Journal of international business studies
Kauder, S; Meyr, H	Strategic network planning for an international automotive manufacturer	2009	OR SPECTRUM
Kauppi, K; Longoni, A; Caniato, F; Kuula, M	Managing country disruption risks and improving operational performance: risk management along integrated supply chains	2016	International Journal of Production Economics

Kazaz, B., Dada, M., & Moskowitz, H.	Global Production Planning Under Exchange-Rate Uncertainty	2005	Management science
Keyvanshokoo, E., Ryan, S. M., & Kabir, E.	Hybrid robust and stochastic optimization for closed-loop supply chain network design using accelerated Benders decomposition	2016	EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
Kinra, A; Kotzab, H	A macro-institutional perspective on supply chain environmental complexity	2008	International Journal of Production Economics
Kırılmaz O., Erol S.	A proactive approach to supply chain risk management: Shifting orders among suppliers to mitigate the supply side risks	2017	Journal of Purchasing and Supply Management
Kovach, JJ; Hora, M; Manikas, A; Patel, PC	Firm performance in dynamic environments: The role of operational slack and operational scope	2015	Journal of Operations Management
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Lam J.S.L., Bai X.	A quality function deployment approach to improve maritime supply chain resilience	2016	Transportation Research Part E: Logistics and Transportation Review
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Phillips W., Roehrich J.K., Kapletia D., Alexander E.	Global Value Chain Reconfiguration and COVID-19: Investigating the Case for More Resilient Redistributed Models of Production	2022	California Management Review
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Qi, Y., Zhao, X., & Sheu, C.	The Impact of Competitive Strategy and Supply Chain Strategy on Business Performance: The Role of Environmental Uncertainty*	2011	Decision Sciences
Quesada, G., Rachamadugu, R., Gonzalez, M., & Martinez, J. L.	Linking order winning and external supply chain integration strategies	2008	Supply Chain Management
R. Rajesh	A novel advanced grey incidence analysis for investigating the level of resilience in supply chains	2020	Annals of Operations Research
Ray, P; Jenamani, M	Mean-variance analysis of sourcing decision under disruption risk	2016	EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
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Roscoe, S., Skipworth, H., Aktas, E., & Habib, F.	Managing supply chain uncertainty arising from geopolitical disruptions: evidence from the pharmaceutical industry and brexit.	2020	International Journal of Operations and Production Management
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Simchi-Levi, D., Wang, H., & Wei, Y.	Increasing supply chain robustness through process flexibility and inventory.	2018	Production and Operations Management
Sinkovics, R. R., Jean, R. J. B., Roath, A. S., & Cavusgil, S. T.	Does IT Integration Really Enhance Supplier Responsiveness in Global Supply Chains?	2011	Management International Review
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Song, S.	Entry mode irreversibility, host market uncertainty, and foreign subsidiary exits	2014	Asia Pacific Journal of Management
Song, S.	Ownership Increase in International Joint Ventures: The Within- and Across-Country Flexibility Perspective	2017	Management International Review
Song, S.	Inter-Country Exchange Rates and Intra-Firm Trade Flow Within Global Network of Multinational Corporations	2015	Management International Review
Song, S.	Subsidiary Divestment: The Role of Multinational Flexibility	2014	Management International Review
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Sreedevi R., Saranga H.	Uncertainty and supply chain risk: The moderating role of supply chain flexibility in risk mitigation	2017	International Journal of Production Economics

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White House	Building resilient supply chains, revitalizing American manufacturing, and fostering broad-based growth.	2021	

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Wong, C. W., Lirn, T. C., Yang, C. C., & Shang, K. C.	Supply chain and external conditions under which supply chain resilience pays: An organizational information processing theorization.	2020	International Journal of Production Economics
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Appendix C1: Identified definitions of resilience

Table 10. Identified definitions of resilience

	Authors	Definition	Source	Field (AJG 2021)
1	Sheffi & Rice (2005)	A company's resilience is a function of its competitive position and the responsiveness of its supply chain	MIT Sloan Management Review	ETHICS-CSRMAN
2	Ali et al (2022)	The adaptive capability of the system to prepare for, respond to, and recover from disruptions and continue operations in a normal or even better than pre-disruptive state	Journal of Business Research	ETHICS-CSRMAN
3	Gereffi, G., Pananond, P., & Pedersen, T. (2022)	Ability of firms to resume normal operations after disruptions have occurred	California Management Review	ETHICS-CSRMAN
4	Ryan et al. (2022)	Adaptive capability of the supply chain to organize for unexpected incidents, act in response to disruptions, and recuperate from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function	California Management Review	ETHICS-CSRMAN
5	Choksy et al. (2022)	Ability to rebound from adverse conditions; suppliers' abilities to respond to large-scale disruptions and return to normal operations	Journal of Business Research	ETHICS-CSRMAN
6	Gebhardt et al. (2022)	A company's ability to prepare for, respond to, and recover from an unexpected supply chain disruptions (SCD)	Journal of Business Research	ETHICS-CSRMAN
7	Mouzas & Bauer (2022)	The aspiration level to withstand adversities by building a solvent firm that is not vulnerable to unforeseen contingencies and risks; and, hence, capable to bounce back in the face of adversities in global value chains.	Journal of Business Research	ETHICS-CSRMAN
8	Mena et al. (2022)	Ability of a system to withstand an impact (robustness) and recover from it (responsiveness)	Journal of Business Research	ETHICS-CSRMAN

9	Ciravegna & Michailova (2021).	The ability of organizations to anticipate, avoid, and adjust to shocks in their environment	Journal of International Business Studies	IB&AREA
10	Orlando et al. (2022)	The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function	Journal of International Management	IB&AREA
11	Mandal (2019)	The essence of SC resilience is to restore operations to an optimal state or an improved state post-disruption	Information Technology & People	INFO MAN
12	Miroudot (2020)	The ability of a system to return to its original state or move to a new more desirable state after being disturbed'	Journal of International Business Policy	N/A (expert suggestion)
13	White House (2021)	A resilient supply chain is one that recovers quickly from an unexpected event		N/A (grey literature)
14	Gereffi (2021)	Adaptation via modes of governance established by lead firms that maximize system-level efficiencies and cushion against vulnerabilities, taking into account the organizational and geographic configurations of each supply chain.	Committee on Commerce, Science and Transportation United States Senate	N/A (grey literature)
15	Colicchia et al. (2010)	The ability of a system to quickly react to the undesired events when they happen	Production Planning and Control	OPS&TECH
16	Ivanov & Sokolov (2012)	Supply chains' property to maintain, execute, and recover (adapt) their behavior	International Journal of Production Research	OPS&TECH
17	Brandon-Jones et al. (2014)	The ability of a supply chain to return to normal operating performance, within an acceptable period of time, after being disturbed	Journal of Supply Chain Management	OPS&TECH
18	Kauppi et al. (2016)	Ability to bounce back from a disruption	International Journal of Production Economics	OPS&TECH
19	Akkermans et al. (2018)	Ability to cope with the consequences of unavoidable risk events and resume normal operations or move to a new, more desirable state after a disruption	Journal of Supply Chain Management	OPS&TECH

20	Ivanov & Dolgui (2019)	System's ability to sustain or restore its functionality and performance following a significant change in the system and environment conditions	International Journal of Production Research	OPS&TECH
21	Wong et al (2020)	Supply chain resilience is the capacity of firms to recover supply chain operations from unforeseen disruptions	International Journal of Production Economics	OPS&TECH
22	Cohen & Kouvelis (2021)	Ability to adapt to structural changes by modifying supply chain, products and technologies strategies	Production and Operations Management	OPS&TECH
23	Wieland (2021)	The amount of disturbance that a system can withstand before it shifts into an alternative stability domain	Journal of Supply Chain Management	OPS&TECH
24	Azadegan et al. (2021)	A supply chain is considered resilient to the degree that it provides the buying company operational continuity in place of disruption risks	Journal of Supply Chain Management	OPS&TECH
25	Song et al. (2021)	Capability to withstand and recover from supply chain disruptions	International Journal of Operations and Production Management	OPS&TECH
26	Dubey et al. (2021)	The property of supply chain, which enables the disrupted supply chain to recover its normal operating performance, within an acceptable period, after the disrupting forces are withdrawn or disappear	International Journal of Production Research	OPS&TECH
27	Wieland & Durach (2021)	Supply chain resilience is the capacity of a supply chain to persist, adapt, or transform in the face of change.	Journal of Business Logistics	OPS&TECH
28	Novak et al. (2021)	A supply chain is resilient to the extent that the system can maintain core functionality by continually adapting, evolving, and transforming in response to the dynamic multiscale feedbacks that occur between the multitude of interconnected organizations, institutions, and social and ecological systems that are all parts of the larger supply chain.	Journal of Business Logistics	OPS&TECH
29	El Baz & Ruel (2021)	Ability of SCs to recover their performance after having absorbed the disruption effects	International Journal of Production Economics	OPS&TECH
30	Azad et al. (2013)	The ability to adapt to disruptive phenomena	Annals of Operations Research	OR&MANSCI

31	DuHadway et al. (2019)	A system is resilient when it is able to withstand and return to the previous state without sustaining significant costs	Annals of Operations Research	OR&MANSCI
32	Rajesh (2020)	The adaptive capability of a system to return to its original state or even better after being disturbed	Annals of Operations Research	OR&MANSCI
33	Ivanov (2020)	The ability to withstand a disruption (or a series of disruptions) and recover the performance	Annals of Operations Research	OR&MANSCI
34	Mwangi et al. (2021)	Capacity of a supply chain to cope with the consequences of vulnerabilities and to get back to its original state or an even more desirable state once it is disrupted; adaptive capability to prepare for unexpected eventualities respond and recover while at the same time maintaining a continuation of operations at a desirable level	Annals of Operations Research	OR&MANSCI
35	Belhadi et al. (2021)	Situational capability acquired through continuous learning and adaptations from a series of disruptions	Annals of Operations Research	OR&MANSCI
36	Ruel et al. (2021)	A firm's capability to recover from disruptions to meet customer demand, ensure target performance, and maintain operations in vulnerable environments; ability to bounce-back and recover towards an "old normal" once disrupted	Annals of Operations Research	OR&MANSCI
37	Lam & Bai (2016)	Ability to tackle unexpected disturbances across the SC, enhanced by collaboration, flexibility and visibility among multiple ties of suppliers and customers	Transportation Research Part E: Logistics and Transportation Review	SECTOR

CHAPTER 2. Resilience building mechanisms in Global Value Chains: a multiple case study in the medical devices and pharmaceutical sectors

Abstract

Notwithstanding the importance of global value chains (GVCs) in the global economy, recent developments are posing serious threats to the resilience of the former. Repeated shocks to business continuity, such as extreme natural events, a global pandemic, trade wars, conflicts, and the consequent geopolitical tensions, are challenging the role of “orchestrators” multinational enterprises (MNEs) play within GVCs. Therefore a growing interest of international business scholars has sparked in value chain resilience, yet, research on the topic is still mostly conceptual and lacks empirical investigation. The present study proposes to investigate how the governance structure and geographical dispersion of GVCs activities can contribute to the chain’s resilience. In order to answer this question, I developed a multiple case study contextualized in the healthcare industry. The final outcome of the study is a theoretical model which can be adopted for further quantitative enquiries.

Keywords: global value chains; resilience; multinational enterprises; relational governance; pharmaceuticals; medical devices

1. Introduction

As a consequence of the fast globalization of trade started in the 1980s, firms' value chains have become increasingly fragmented and dispersed across the world, giving rise to the so-called Global Value Chains (GVCs). GVCs have so far characterised the backbone of international trade (World Bank & World Trade Organization, 2019), where multinational Enterprises (MNEs) often act as coordinators of production and distribution activities along the chain. The OECD estimated that in 2018 the value added trade across countries amounted to 82.961 billion dollars, a 5,9% increase from the previous year (OECD, 2021b). However, recent developments in the global economy have brought attention to the shortcomings of globally dispersed GVCs, which present a diminished responsiveness and an excess of rigidity (Gereffi, 2020). In the last few years, GVCs orchestrators have faced consistent challenges stemming from all-encompassing crises in the increasingly uncertain and dynamic environment in which they operate.

First, from a geopolitical point of view, even if we still experience a global economy, the free trade imperative has weakened in the last decades, with a rise of protectionist and nationalistic tendencies (The Economist, 2021a; Buckley, 2022; Fortune, 2018) and the collapse of long-standing assumptions, such as the static view of the economic and political integration of developed countries with the 2016 Brexit vote (Maidment, 2019). More recently, the war in Ukraine has demonstrated how raw materials can become a foreign policy weapon (The Financial Times, 2022a)

Second, climate change is considered the greatest challenge of the century for both businesses and society at large. This aspect is particularly relevant for GVCs since the increasing threat of natural disasters (i.e. geophysical, meteorological, hydrogeological, climatological, and biological) poses a distressing risk for business continuity and logistics (Ghadge et al., 2020; Oh & Oetzel, 2022).

Third, the recent COVID-19 pandemic has dramatically exposed the fragility of international production systems vis-à-vis the condition of environmental uncertainty (Downey et al., 1975): for example, it resulted in an income decline of 37% for more than 80% of MNEs by September 2020 (Saurav et al., 2020).

This general instability has projected the world economy into an “era of shortages” (The Economist, 2021b): it has become increasingly common the condition in which it is not possible to satisfy the demand for certain goods, such as raw materials (e.g. wheat, energy) and more advanced production inputs (e.g. semiconductors) (BBC, 2022; The Guardian, 2022; McKinsey, 2022a).

Existing literature already recognizes that MNEs operate in a volatile, uncertain, complex and ambiguous (VUCA) environment (Vertinsky et al., 2023; Cavusgil et al., 2021). However, in light of such developments, Buckley (2022) argues that it is not possible to assume that there is a single “environment” for MNEs to operate into and we should not treat disruptions as temporary events, but as the symptom of a “new normality”. This new condition requires a long-term shift in how both practitioners and researchers approach how MNEs strategize.

For these reasons, a growing interest has sparked in value chain resilience (e.g. Barbieri et al., 2020; Gereffi, 2020; Strange, 2020; Ku et al., 2020; Buckley, 2021). However, only recently scholars have started to address the concept of resilience from an IB perspective (Kano et al., 2022) and the topic still lacks clarity and general conceptual consensus.

In particular, while location strategies are part of an ongoing and ample debate, that includes both scholars and practitioners (Barbieri et al. 2021; Gereffi, 2020; Cohen et al., 2020; Strange, 2020; UNCTAD,2020), how GVC governance affects resilience remains scantily debated and unclear.

Therefore, by acknowledging how both control and location decisions are considered as influential to GVC resilience but still lack empirical support, the present study commits to

answer the following research question: *How do governance structure and geographical dispersion of value chain activities contribute to building resilience within GVCs?*

The study adopts a multiple case study methodology and has as final outcome a theoretical model that contextualizes the identified resilience building mechanisms.

2. Theoretical background

2.1 From uncertainty to “a new normality”: A call for resilient GVCs

Going back to its roots in economics, uncertainty can be defined as a condition in which it is not possible to assign an objective probability to all outcomes or it isn't even possible to know the outcomes of single events (Knight, 1921). This condition affects decision-making of all firms as it is determined by different sources: the environment, the industry and the firm itself (Miller, 1992). Environmental uncertainty is particularly relevant for MNEs, as they are directly exposed to an array of political systems, government dynamics, macroeconomic conditions, social contexts and natural events because of the geographical reach of their operations.

Existing literature already recognizes that MNEs operate in a volatile, uncertain, complex and ambiguous (VUCA) environment (Vertinsky et al., 2023; Cavusgil et al., 2021). However, in light of recent developments, Buckley (2022) argues that it is not possible to treat disruptions² as temporary events, but as the symptom of a “new normality”. The acknowledgment of this paradigmatic shift in IB research has contributed to encouraging the investigation of how MNEs can cope with these new environmental conditions (Zámborský et al., 2022; Sallai et al., 2024; Benischke et al., 2022) and particularly of MNE resilience (Khan et al., 2024; Ryan et al., 2022; Barbieri et al. 2021; Gereffi, 2020; Cohen et al., 2020).

² In this study, I define disruption as “the action of preventing something, especially a system, process, or event, from continuing as usual or as expected” (Cambridge Dictionary)

On the one hand, IB research has a long standing tradition of investigating how MNEs can cope with uncertain environments. Rugman (1976) applied the concept of portfolio diversification to foreign direct investment, showing that engaging in foreign operations reduces the MNE's corporate risk. Subsequently, numerous studies have investigated how, in an uncertain environment, international diversification reduces risk without sacrificing performance (Dess et al., 1995; Grant et al., 1972; Levi & Sarnat, 1970). Also real options theory (Myers, 1977) represents a consolidated theoretical perspective in IB: it suggests that firms can benefit from internationally dispersed subsidiaries by having the right, but not the obligation, to shift value chain activities among subsidiary locations in uncertain times (Allen & Pantzalis, 1996; Chung et al., 2010). Nevertheless, these two theories mostly address disruptions of economic nature adopting the individual firm as a unit of analysis. Moreover, while these theories address the choice of location, they do not consider how diversification benefits can vary across different governance mechanisms of inter-firm relationships (Ioulianou et al. 2021). Additionally, Luo & Van Assche (2023) has recently argued that the high techno-geopolitical uncertainty MNEs are facing could eventually signify an inversion of the real option problem.

Unlike these long-standing theoretical perspectives, the study of resilience in IB is more recent. The concept of resilience is embedded in consolidated research traditions in both supply chain (SC) management (Christopher and Peck, 2014; Brandon-Jones et al., 2014) and general management (Annarelli & Nonino, 2016), where it is increasingly conceptualized as a capability developed over time through a dynamic and interactive process between the firm and the environment, rather than a static quality of the firm (Conz & Magnani, 2020; Kantabutra & Ketprapakorn, 2021).

At the firm level, MNE resilience can be considered as the organization's ability to plan, absorb, sustain, and adapt to disruptions (Pettit et al., 2010). In the past, IB studies have

addressed resilience in the context of developing countries (Ali et al., 2011; Branzei & Abdelnour, 2010) and mostly treating it as a desired managerial capability (Fainshmidt et al., 2017; Al-Atwi et al., 2021).

More recently, resilience in IB has also started to be investigated at the firm level in terms of Business Model (BM) transformations, recognizing that how MNEs configure their BM can influence their ability to prepare for or react to disruptions (Grego et al., 2024; Galkina et al., 2023). It has also been argued that the scarce responsiveness of MNEs to the pandemic disruption was determined by an over-reliance on key exporting economies, such as China, in structuring international value chains and an hyper-focus on cost-optimization in the MNE business model (e.g. JIT practices) that hindered value chain flexibility (Gereffi, 2021; O'Leary, 2020).

Therefore, as both the firm level and value chain level perspective appear as relevant, Gereffi et al. (2022) advocate for the need to understand how firm-level strategies are integrated in the evolving structural context of GVCs on matters of resilience.

Mostly conceptual contributions developed on anecdotal evidence have suggested that redundancy can be a strategy for resilience: the replication of value chain activities in home countries or across more than two locations could supposedly help MNEs to cope with unexpected disruptions (Gereffi, 2021; O'Neil, 2020). This represents a strategic approach that addresses the geographical scope of the MNE value chain activities.

Academic research has also linked MNE resilience to how the MNE interacts with other entities. For example, Gereffi (2020) has suggested the stipulation of production, research and marketing partnerships with firms in related industries as a possible MNE strategy to develop resilience. Other studies have specifically focused on the MNE-supplier relationships, arguing that resilience in GVCs can be determined by the adoption of adaptive

governance structures (Islam & Chadee, 2024) and the implementation of supplier integration programs (Chatterjee et al., 2024).

Overall, MNEs seem to be responsible for two decisions that can affect resilience within GVC: control and location of value chain activities.

2.2 MNE resilience: Location and control decisions

This study employs a “global factory” perspective (Buckley, 2004), in which MNEs are identified as GVC “orchestrators”, i.e. coordinators globally dispersed value chains through more precise use of ownership and location strategies (Buckley, 2011). In their capacity of GVC orchestrators, MNEs ““fine slice” their activities [...] locate each “stage” of activity in its optimal location and [...] control the whole supply chain, even when not owning all of it” (Buckley, 2011: 270). Therefore, in the global factory perspective, there are two strategic choices to take into account when addressing the issue of resilience: location and governance of value chain activities, as illustrated in this section.

MNE’s decisions concerning the geographical configuration of value chain activities are believed to influence its capacity to limit the negative effect of environmental disruptions since the conception of GVCs (Gereffi, 1995; Ivanov et al., 2010). However, recent events have contributed to re-ignite the interest in such a perspective. In particular, following the pandemic, both scholars and practitioners have extensively focused on reshoring, near-shoring and friendshoring, i.e. the relocation of value chain activities back to the home country, the home region or third countries that entertain friendly relationships with the MNE home country (Fratocchi et al., 2014; Pedroletti & Ciabuschi, 2023; UNCTAD, 2020). The widespread argument considers the geographical reconfiguration of GVCs, and specifically the regionalization of value chain activities, as a solution for MNEs to build resilient GVCs (O’Neil, 2022; Witt et al., 2023). However, this type of approach could hardly be adopted in

the short-term, because it does not take into account how forty years of globalization “have created international markets of specialized suppliers who compete with operational excellence and product innovation” (Thakur-Weigold & Miroudot, 2024: p. 106). Therefore, this re-configurative approach to GVC devises a one-size-fits-all solution without considering comparative and competitive advantage issues that are at least industry specific (Contractor, 2021; Kogut, 1985)

On the other hand, MNE resilience has been also discussed in terms of geographical diversification, i.e. the structuring of redundant value chains in order to enhance their response to disruptions by avoiding overreliance on a few locations (Gereffi, 2020; Cohen et al., 2020; Strange, 2020). This perspective has been associated with strategic approaches such as multiple input sourcing and diversification of suppliers (Oh & Oetzel, 2022) in synergy with the geographical diversification of the value chain (e.g. geo-redundancy: Verbeke, 2020). The argument is in line with the more traditionally IB approaches to how MNEs cope with uncertainty, as discussed in the previous section. However, by moving beyond the logic of subsidiary location, there is an acknowledgment of intra-firm relationships as a possible determinant of MNE resilience at the GVC level.

This first section has highlighted that while debated by both researchers and practitioners, the empirical implications of GVC geographical configuration on resilience remain ambiguous and the investigation of the geographical perspective without acknowledging the role of control dynamics within the value chain is insufficient in matters of resilience.

In fact, while the geographical configuration of GVC has been part of a widespread debate, how value chain control can influence MNE resilience has been the subject for a much more limited debate.

As orchestrators, MNEs have a crucial role to determine the control relationships within GVCs: they assign “transactions [...] to governance structures [...] in a discriminating way”

(Williamson, 1985: 18). Traditionally, outsourcing is considered a way for MNEs to achieve more efficient response to changing economic conditions through outsourcing, by exploiting the ability to focus on the MNE's core competences (Hamel & Prahalad, 1990), the ability to leverage complementary resources and capabilities possessed by the outsourcee (Gottfredson et al., 2005) and the ability of the outsourcee to perform tasks more efficiently (Abraham & Taylor, 1996).

Recently, Cuypers et al. (2021) has argued how, although relevant, there is little systematic evidence on the direct effect of environmental uncertainty on governance choices: for example, uncertainty makes it more difficult to contractually specify ex ante all the circumstances surrounding a specific exchange. However, relational dynamics within governance structures have increasingly captured researchers' interest, emphasising the evolving nature of the ongoing transactions among actors (Carson et al., 2006). In particular, Kano et al. (2022) conceptualises three types of relationships (i.e. "managerial governance mechanisms") associated with MNE resilience at the GVC level: inter-firm adaptations, i.e. of relationships among GVC actors; extra-GVC adaptations, i.e. of relationships with actors outside of formal GVC boundaries; intra-firm adaptations, i.e. of routines, processes, and decision rules within the GVC orchestrator. Ultimately, although relevant, the understanding of how governance influences GVC resilience is still at its conception and lacks empirical support.

Therefore, in this study I acknowledge that both control and location decisions about the MNE value chain are considered influential to its resilience. Moreover, I recognize that their role remains ambiguous and their interaction on matters of resilience lacks empirical investigation.

3. Methodology

The study is designed as a multiple case study (Stake, 1995) and follows a Grounded Theory rationale, according to which the organizational world is a dynamic, co-created system whose parts are so interrelated that one part inevitably influences the other (Cohen et al., 2011). Because of the nature of the research question, case selection followed an intensive sampling logic, i.e. choice of “information-rich cases that manifest the phenomenon of interest” (Patton, 2015: 279): the investigation is carried out in GVCs that present resilient qualities, in order to understand how do their governance structure and geographical dispersion to building that resilient quality. Consequently, the context of analysis was chosen after a preliminary exploratory phase, which consisted of interviewing companies’ executives from various industries, experienced consultants and academics to determine the appropriate context of analysis for the research purpose. Details about these exploratory interviews are available in Appendix A2.

3.1 Context of analysis

Following the preliminary exploratory phase, the analysis was contextualized within the medical devices and pharmaceutical sectors. This choice had the following rationale: First, the Covid-19 pandemic impacted the GVCs of these sectors in their entirety. In the first phase of the pandemic, companies faced an abnormal increase in global demand for a set of covid-related treatments and medical devices in a very short period of time (Gereffi, 2020). Consequently, supply chains came under enormous pressure as consumers stockpiled and governments sought to protect national interests (KPMG, 2020a). For example, the U.K. government restricted the export of pharmaceutical products adopted in the treatment of Covid-19 patients - e.g. adrenaline, insulin, paracetamol and morphine (Department of Health and Social Care, 2020). Therefore these two GVCs have faced challenges for what concerns

both the upstream and downstream operations. Moreover, the geographical configuration of pharmaceutical GVCs was particularly critical in the first pandemic phase, as over 70% of world “Active Pharmaceutical Ingredient” (API) production was located in China and API manufacturing facilities have doubled in China from 2010-2019 (KPMG, 2020b; KPMG, 2020c). At the same time, although the pharmaceutical and medical devices companies were not subjected to complete shutdowns during the pandemic, the reduced lab capacity and the reduced willingness to take part in clinical studies caused profound disruptions in clinical and product development pipelines (McKinsey, 2020d; KPMG, 2020a), determining the state of uncertainty to prolong in the long-term.

Second, conditions of uncertainty in both sectors have also been determined by man-made disruptions, associated with the climate of geopolitical tensions. For example, in the last few years, Ukraine has established itself in the pharma GVC as a significant supplier of medicinal chemistry services - such as the synthesis and optimisation of biologically active drug compounds and off-the-shelf reagents- which has been problematic in the aftermath of the Russian invasion of the country (The Telegraph, 2022). At the same time, disruptions to the global markets caused this conflict have been reflected in the state of uncertainty surrounding the supply of critical raw materials - such as nickel - utilized in medical device production, which stem from import restrictions, concentration of production in only a few countries, and decades of bilateral dependency (OECD, 2022). More recently, the escalated instability in the Middle East area has added to this turmoil. In fact, Israel serves as a global hub for generic pharmaceuticals and medical supplies and the country hosts nearly 700 medical device MNEs (Resilinc, 2023).

Third, because of the nature of their business, it is crucial for MNEs in the healthcare industry to maintain business continuity in order to provide the final consumer, i.e. patients, with the

necessary medical treatments (Bierenbaum et al., 2009). Therefore, it can be assumed that companies in this sector prioritize resilience of their GVC.

Therefore, the pharmaceutical and medical devices sectors are an interesting context of analysis because of the all-encompassing effects of recent disruption (both natural and man-made) on their value chains and the intrinsic attention to resilience determined by the type of business.

The following sections provide an overview of the inner workings of the medical devices and pharmaceutical value chains.

3.1.1 Pharmaceutical value chains

A pharmaceutical product (also called medicinal product) is “any substance or combination of substances presented as having properties for treating or preventing disease in human beings” (European Commission, 2001: p. 2).

The pharmaceutical value chain comprehends three macro-activities (Aitken, 2016: p.56):

- (i) manufacturing the medicine, i.e. R&D, gaining regulatory approval, manufacturing and commercialization.;
- (ii) distribution to the dispensing point, i.e. transportation and handling of the medicine from the manufacturer to the end user, which can be a retail pharmacy, an hospital or dispensing doctor;
- (iii) dispensing to the end user, i.e. providing the correct medicine dosage and form, to the right patient, in a convenient and timely manner.

For what concerns localization of value chain activities, the pharmaceutical sector has been characterized by truly globalized supply and demand since 1994, with the Agreement on Trade Related Aspects of Intellectual Property Rights (WTO, 1994).

For what concerns governance, it is possible to distinguish three main structures in the pharmaceutical industry, according to the production type (Haakonsson, 2009):

(i) producers of branded products structure their value chain preferring vertical integration in association with strategic alliances, cross-licensing arrangements and multi-firm alliances for functions that do not constitute the core business;

(ii) Producers of quality generics adopt a mixed governance structure where R&D is either carried out in-house or outsourced, while production is outsourced to low-cost production sites;

(iii) For producers of low-value generics, R&D activity is almost non-existent and the primary interest is that of low cost production, which in turn determines whether the production is carried out in-house or it is outsourced.

3.1.2 Medical devices value chains

A medical device is any product or equipment that is intended for use within the healthcare industry to diagnose, monitor or treat diseases or to act as a supportive aid for people with any form of illness or disability (Global Harmonization Task Force, 2000)

The medical devices value chain has been mapped by Bamber & Gereffi (2013), which present the following value chain activities: (i) R&D; (ii) component manufacturing; (iii) assembly; (iv) sterilization; (v) distribution, marketing and sales.

In the case of medical devices, as for pharmaceuticals, end clients may be hospitals or clinics, professionals responsible for direct patient care (i.e. doctors, nurses, specialists), and the patient itself through retail.

For what concerns geographical dispersion, both supply and demand are global and establishing production plants abroad and building regional production capacity through foreign acquisitions have been common practices in the industry for a long time (Gereffi, 2013)

For what concerns governance, the value chain tends to be highly vertically integrated, with strong concerns for intellectual property protection (ibid).

3.2 Case selection

Case sampling has been carried out according to two purposeful sampling criteria (Patton, 2015):

1. The MNE is a leading actor in a GVC within the pharmaceutical and/or medical devices industries;
2. One or more highly knowledgeable person(s), i.e. directly involved in the inner workings of the company value chain, was available to participate in the data collection.

A first prospective list of 15 companies was drawn from the authors' personal network, by considering those companies that already took part in previous research projects. From this list, the authors identified those companies that would be more amenable to take part in the data collection, because of the sensitive topic of analysis. Of these companies, 5 agreed to be interviewed.

Table 11 summarizes key facts and figures about the interviewed companies and brief profiles of each of the five firms are provided below.

Table 11. Key cases information

Firm	Number of employees (2023)	Turnover (2023, mln \$)	Foundation year	Sector
Amgen Inc.	26,700	29,190	1986	Pharmaceuticals
GE HealthCare Technologies Inc.	51,000	19,552	1892*	Medical devices
Pfizer Inc.	88,000	58,496	1942	Pharmaceutical
Roche Holding AG	103,605	72,421	1896	Medical devices & Pharmaceuticals
Medtronic plc.	95,000	31,388	1949	Medical devices

**Spin-off of GE Company since January 2023
Source: ORBIS database*

Amgen is an American biotech company that operates in a wide set of therapeutic areas, with commercial presence in approximately 100 countries worldwide. In Amgen, the value chain is mostly vertically integrated. R&D is completely carried out in-house in the research centers in North America and Europe. Apart from R&D, the rest of the Amgen value chain is regionalized, i.e. all the other value chain activities are carried out in four different geographical areas (North America, South America, EMEA and Asia). *GE HealthCare* is a spin-off of GE Company and it operates in the industry of healthcare systems and pharmaceutical diagnostics in three key care areas: neurological disorders, cancer and industrial internet, i.e. creating and enabling technology and services which can help improve the way healthcare is delivered to patients globally. As in the previous case, except for raw materials, also the GE HealthCare value chain is vertically integrated. Moreover, sourcing, production, and distribution network is managed globally while products are manufactured at and distributed by facilities serving specific regions.

Pfizer is an American research-based biopharmaceutical company that specializes in the discovery, development, manufacture and wholesale of prescribed medicines. The company has a leading portfolio of products and medicines that support wellness and prevention, as well as treatment and cures for diseases across a broad range of therapeutic areas. The company's operations are conducted globally and it supplies to over 185 countries. Differently from the previous cases, the Pfizer value chain is not completely vertically integrated. In Pfizer, R&D is carried either in-house and or in collaboration with other pharmaceutical companies, according to the type of product and the required competences. Overall, Pfizer depends on third-party collaborators, service providers, and others in the research, development, manufacturing and commercialization of its products. Moreover, the company also enters into JVs and other business development transactions, Pfizer also outsources certain services, including activities related to transaction processing, accounting,

IT, manufacturing, clinical trial recruitment and execution, clinical lab services, non-clinical research, safety services, integrated facilities management and other areas.

Roche is a Swiss health-care company active in the discovery, development, manufacture and marketing of products and services that address diseases prevention, diagnosis and treatment. within two operating divisions: the pharmaceuticals division and the diagnostics division. I The Roche value chain is globally distributed, with manufacturing steps centralised in single locations. Moreover, the value chain is vertically integrated for those activities that are strategically valuable (such as R&D), while manufacturing is organised in a network that balances between owned sites and contracts with third parties, which are qualified and certified according to Roche standards, and distribution is also outsourced.

Finally, *Medtronic* is a healthcare technology company headquartered in Ireland. The company operates in four segments that primarily develop, manufacture, distribute, and sell device-based medical therapies and services. Medtronic serves healthcare systems, physicians, clinicians, and patients in more than 150 countries worldwide Also in the case of Medtronic, the value chain is globally dispersed. The company purchases many of the components and raw materials used in product manufacturing from numerous suppliers located in various countries, some of which are necessarily sole suppliers. Moreover, manufacturing of product families is centralised in single locations. The Medtronic value chain is not perfectly vertically integrated: R&D is also carried out with collaborations with third parties and manufacturing - although mostly carried out in-house - is partially outsourced for specific processes.

3.3 Data sources

Primary data were collected through semi-structured interviews consisting of 11 open-ended questions. The interview focused on four main macro sections: i) the description of the firm's GVC (i.e. input-output structure, the geographical dispersion and governance of value chain

activity); ii) the most critical uncertainties connected to the firm's value chain activities; iii) how geographical and control dynamics between the firm and other GVCs actors come into play during disruptions; iv) any other location or control decision adopted by the MNE to cope with disruptions. Details about the interview protocol are available in Appendix B.

All informants were first approached through email, providing an overview of the research project and a participant informative concerning data treatment. Moreover, whenever requested, interview questions were shared beforehand. Interviews were conducted either in Italian or in English, according to the language most comfortable for the interviewee. Interviews took place either in person or through VoIP technology, and they were audiotaped and subsequently transcribed. All interviews were double-checked by the authors and sent back to managers for feedback and integrations, where necessary. After the interviewee's approval, the interviews conducted in Italian were translated into English. Primary data collection consisted of a first interview and a second interview only when necessary. Moreover, subsequent doubts were clarified through follow-up interactions with the interviewees, either by email or by phone.

Data collection took place between January 2022 and November 2023 and it also included secondary data (Fielding & Fielding, 1986), in particular information collected from proprietary websites, companies' reports (including financial reports and sustainability reports), Form 10-K when available, and ORBIS reports.

Table 12 reports key information concerning the collection of primary and secondary data.

Table 12. Data collection

Company	Nr. of interviews, Total time	Informants (role)	Secondary data
Amgen Inc.	2 interviews 1h 25 min	Portfolio Contract & Distribution Sr. Manager, Italy Head of Value Chain Management EMEA	2023 Form 10-K Company reports ORBIS report
GE HealthCare	2 interviews 1h 53 min	Order operations manager IMI, GE Medical Systems Italia CEO & President, Italy, GE Healthcare	2023 Form 10-K Company reports ORBIS report
Pfizer Inc.	1 interview 1h 27 minutes	Supply chain and operational excellence manager, Ascoli Piceno production site, Italy	2023 Form 10-K Company reports ORBIS report
Roche	2 interviews 1h 43 min	Supply Chain & Customer Care Lead, Roche Italia Supply Chain Business Partner, Roche Nederland B.V.	Company reports ORBIS report
Medtronic	2 interviews 2h 20 min	Director Logistic Italy, Greece & Israel, Deliver Operations Managing Director Medtronic Italy, Sr. Finance Director Italy, Iberia, France	2023 Form 10-K Company reports ORBIS report

3.4 Data analysis

First, I developed single case analyses for each company to familiarize with the data and identify the main emerging themes (See Appendix C2). These single case histories were organized according to the following sections: i) the company; ii) a description of the value chain, with a focus on governance and geographical dispersion of activities; iii) the GVC resilience building mechanisms according to their experience during times of disruptions.

After having developed the single cases, I proceeded with a cross-case comparison adopting the Gioia's methodology protocols (Gioia et al., 2013), particularly suitable for qualitative studies in IB (Magnani & Gioia, 2023). Accordingly, I worked on developing a data structure.

First I identified informant-centred (first order) codes adhering to the participants' quotes,

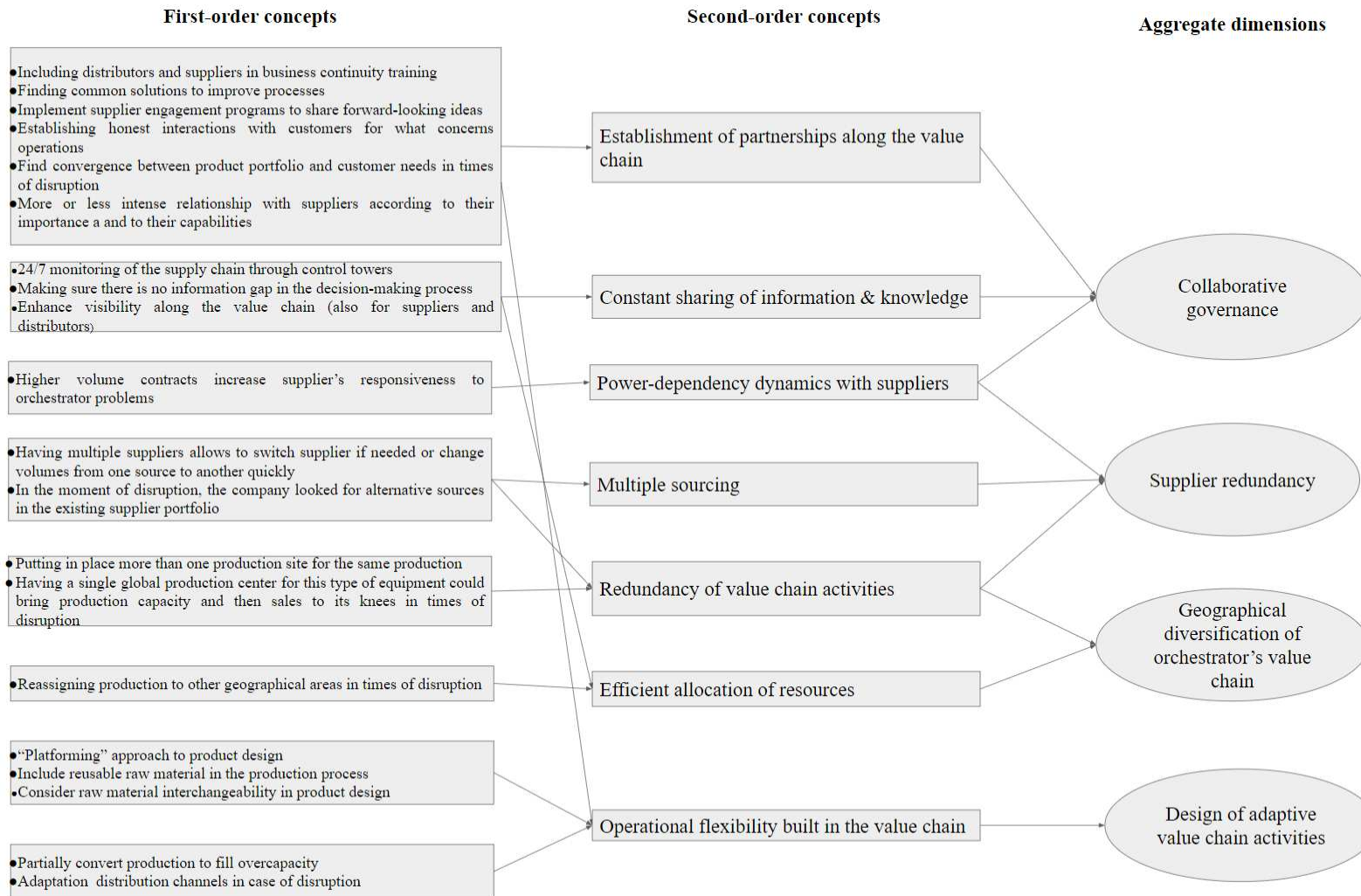
through an open coding logic (Corbin & Strauss, 1990). A list of most representative quotes from interviews is available in Appendix D2. Subsequently, I identified relationships among first-order codes and developed second-order concepts, following an axial coding approach (ibid). Finally I identified key “aggregate dimensions” as overarching conceptual categories. Through an abductive approach, I systematically combined empirical observations and existing theory (Dubois & Gadde, 2002; Magnani & Gioia, 2023) to “put in motion” the data structure. I developed a substantive theoretical model depicting how the aggregate dimensions are related and the overall process of resilience building. This abductive approach resulted in the acknowledgment of a dynamic and processual perspective of MNE resilience, according to which firm’s location and governance decisions can be differentiated according to three moments in time (Conz & Magnani, 2020) : before the disruption ($t-1$) to proactively prepare for it, during the disruption (t), and after the disruption ($t+1$) as a reaction.

4. Findings

Findings are presented according to Gioia’s methodology practices, i.e. by detailing in a dedicated section the meaning of each aggregate dimension and the underlying second-order concepts.

The data structure that emerged from the data analysis is presented in Fig. 5: it is a visual representation of first- and second- order concepts that support the aggregate dimensions. The cross-case analysis allowed us to identify four aggregate dimensions which reflect four resilience building mechanisms within GVCs: collaborative governance, supplier redundancy, geographical diversification of the orchestrator's value chain, and the design of adaptive value chain activities.

Figure 5. Resilience building mechanisms in GVCs: emerging concepts and aggregate dimensions



Source: Author's elaboration

4.1 Collaborative governance

The establishment of collaborative relationships along the value chain with third parties, and specifically suppliers, distributors and customers (i.e. other firms or professionals, since the market we are considering is B2B) emerged as a resilience building mechanism in the case studies. It is characterized by three underlying themes: i) the establishment of partnerships along the value chain ; ii) the constant sharing of information and knowledge; iii) power dependency dynamics with suppliers.

First, the establishment of collaborative relationships is usually configured as relationships with third parties in the GVC that go beyond a contractual relationship. For example, in Amgen's experience "*it is a continuous working together and finding solutions to improve the processes*". This collaboration is developed in the long-term (i.e. before the disruption), through the enactment of dedicated engagement programs, where the company can share forward-looking ideas with third parties that are identified as strategic for the value chain and vice versa.

According to the data, this type of relationship, especially with distributors and suppliers, allows a higher level of coordination and commitment along the value chain in times of disruption. In Roche's experience:

"The better your partnership with your suppliers, the more you speak the same language, which allows for a very good understanding in times of stress [...] when you have a good partnership, you can actually solve your problems faster and also you know your suppliers will actually go the extra mile to help you out".

Moreover, since these partnerships are developed in the long-term, they allow third parties to develop experience and capabilities that are specific for the relationship with the firms. In GE HealthCare experience: "*we are lucky enough to work with a partner who has followed us for many years, which has the expertise to carry out certain operations*".

Data analysis also revealed that a partnership with customers is influential to the GVC resilience. This partnership is specifically strategic to develop trust with the customer, that will pay off in the sense of protecting the contractual relationship in case of disruptions. In GE Healthcare words: *“Customers must be educated, we must establish intimacy, an honest interaction, explaining the reasons why the company, not by its own will, is not able to manage deliveries within the times required by the procurement contracts , for specific legal conditions, in the signed offers”*.

Moreover, a customer relationship that is structured as a partnership allows the firm to better understand customer’s needs and find convergence between the firm's product portfolio and customer demand during the disruption. For example, a drug previously developed by Roche was also used off-label to reduce the most extreme covid symptoms during the pandemic. At the same time, the drug was still employed in its original application. Therefore, Roche faced an extreme surge in demand, while increase in production was not a short-term option. In this situation, Roche leveraged its partnership with customers (i.e. doctors in this case) and interacted with them, in order to understand how the different formulations of the same drugs could be allocated among the diseases. This approach allowed the company to respond to the disruption in the short-term by allocating more efficiently its supply to market, while a more structural adaptation (i.e increase in production volume) was planned.

Second, data analysis revealed how the interviewed firms have encouraged information sharing along the value chain to enhance visibility. This approach to the information flow in the value chain is believed to allow an increased responsiveness for all parties in case of disruption. In fact, firms have reported how both information inflow and outflow are crucial for the value chain to respond in a timely manner in times of disruption. Information inflow (i.e., from third parties to the firm) allows greater visibility for the firm and for it to develop more accurate plans for sudden changes. On the other hand, information outflow (i.e., from

the firm to third parties) is considered crucial to enhance third parties responsiveness, which, in turn, strengthens the resilience of the value chain as a whole.

For example, in Amgen experience: *“I strongly believe in the collaboration with vendors and suppliers, together with manufacturing and supply chain. Because in that ecosystem there is still a lot that you can gain in efficiency from an information sharing point of view [...] Basically, we want to put more emphasis on the visibility across all parties in the supply chain. To ensure that there is no information gap, that nothing is falling into the cracks, and that we can more easily plan what is needed”*.

Finally, specifically for what concerns the relationship with suppliers, the establishment of collaborative governance also depends on the power-dependency dynamics existing between the supplier and the MNE. In fact, data analysis shows how the commitment of the MNE to the relationship in terms of volumes influences the suppliers' level of commitment in the partnership for resilience. In Amgen's experience: *“If you are small, the raw material suppliers will not give you the highest priority”*. In this sense, these power-dependency dynamics are influential to the strengthening of trust among parties in the relationship and the consequent commitment by the suppliers in terms of resources to the partnership.

4.2 Supplier redundancy

The second resilience building mechanism that emerged from data analysis is supplier redundancy. This mechanism is characterized by three underlying themes: i) multiple sourcing; ii) redundancy of value chain activities; iii) and power dependency dynamics with suppliers.

First, multiple sourcing emerged as a strategy, regardless of the geographical configuration of the value chain. Each firm has cited multiple sourcing as a strategy to enhance value chain flexibility in case of disruption, and specifically to avoid production blockage that would be

determined by single sourcing. However, the multiple sourcing strategy appears to be enacted with two different approaches. On the one hand, companies have structured their value chain in order to systematically employ a multiple sourcing strategy, regardless of whether there is a disruption in progress. On the other hand, another approach is to devise the company's supplier portfolio in such a way that it allows switching suppliers or increasing the number of suppliers in the short-term, in case of disruption. For example, in Pfizer's experience: "*[At the moment of the disruption] We have expanded the range of suppliers for the materials for which there was more difficulty, that is, we searched for alternative suppliers for a product among those already verified and qualified*". Therefore, this second approach determines the need to enact a supplier evaluation and selection process that takes into consideration this type of strategy.

Supplier redundancy is also considered functional for value chain redundancy. Multiple sourcing emerges as an enabling factor for the replication of value chain activities - typically across different geographical locations- which is unanimously recognized by the interviewee as a strategy for resilience. Therefore, multiple sourcing is considered a structural element of an MNE's networks that contributes to reducing overall risk of production interruption per se, and it is also considered functional in the creation of a redundant value chain.

In Roche's experience: "*We tend to do double sourcing. So we have two geographical locations, two production sites who are actually equipped to make the same drug[...]We've done this multiple times and it has actually saved us, from a supply disruption from an external source or from a manufacturing error or something similar.*"

Finally, directly connected to the supplier redundancy theme is the power-dependency dynamics within the value chain. In this case, the supplier redundancy approach appears to reflect negatively on the MNE's power in the relationship with the suppliers. In GE HealthCare experience: "*If I want a value chain that is as resilient as possible, I must have,*

for example, as many suppliers as possible, which means not having the negotiating capacity of saying "I give you 100% of my need for this component". But I have two, three suppliers and this gives me more flexibility".

Consequently, supplier redundancy is considered a strategy that is put into place specifically to build resilience, while contravening to the efficiency imperative of cost reduction.

4.3 Orchestrator's value chain geographical diversification

The third resilience building mechanism highlighted in the data analysis is the geographical diversification of the orchestrator's value chain. This mechanism is characterized by two underlying themes: i) redundancy of value chain activities; ii) the need for efficient allocation of resources.

First, redundancy of value chain activities across different geographies, independently from who carries out the different activities, is considered critical to mitigate the disruption effects. In Roche's experience: *"If you make use of redundancy throughout different geographical locations, you could actually significantly reduce the risk. [...] If you have a strategic product for which there's no alternative on the market, it pays for you to have a redundant production chain"*. Data analysis also evidenced how the choice of this redundancy approach is dependent on a preliminary evaluation concerning the strategic value of the production.

Second, geographical diversification of the value chain emerges as a facilitating condition for efficient resource allocation during disruptions. By diverting value chain activities to locations that have not been impacted by the disruption, the orchestrator is able to minimise its impacts. In Roche experience: *"It no longer is a normal inclusion in the planning and replenishment systems, but it is possible to create dedicated task forces which, if the criticality is on a global scale, somehow decide on a global scale to "allocate" the products correctly in the various countries, taking the required specifications, evaluating and*

re-assigning production". However, as evidenced by this quote, while geographical diversification emerges as a resilience building mechanism, it is not associated with a de-centralization of the decision making process. Rather, through stronger and constant communications with third parties, the orchestrator is able to enhance its visibility along the value chain and decide faster and more accurately the resource allocation at times of disruption. This approach is extreme in Medtronic experience: *"[the company] has overturned the concept of mega regions and created a single global region, except China: "let's put all the demand together, starting from the demand for materials of the production plants". [...] a global team, which takes demand [from plants] from all over the world, puts it together and searches for large suppliers, depending on the product type"*.

Therefore, while decision-making remains centralized - in accordance with the praxis established in verticalized value chains, such as in the healthcare sector - what emerges as pivotal is the relationship with third parties (e.g. suppliers), which are part of the value chain nevertheless, and therefore contribute to the centralized decision-making process through information sharing.

4.4 Design of adaptive value chain activities

Finally, data analysis highlighted how GVC resilience also depends on designing value chain activities that are adaptive, i.e. designed with flexible operations that can adapt to the changing environment.

This need for flexibility was evidenced in three main spheres: product design, production and distribution.

First, by designing the product including reusable materials in terms of production inputs, the value chain gains resilience in facing possible disruptions in the supply chain. This was observed in GE HealthCare experience for what concerns MRI production: *"the heart of the*

machine is a magnet, a huge magnet, to simplify. That magnet has an average life of 25 years, maybe even 30. [...] We have implemented procedures whereby we replace all the electronics, even the plastics for a more adequate "look and feel", but the heart, which is the magnet, remains there. This certainly means having one less production and supply problem upstream of the magnet components”.

Moreover, resilience can be influenced by product design in the sense that the orchestrator should plan for interchangeability of production inputs, once again to avoid ripple effects in case of supply chain disruptions. This was observed in Pfizer experience during the pandemic, when suppliers were not able to provide the type of paper that was typically required for production: *“always adhering to the mandatory specifications to maintain quality, the production range of the machines has been expanded (in paper weight, mm of ribbons, etc...) [...] to increase the range of materials that can be used with the machinery”.*

At the same time, interchangeability of production inputs is also considered between different products of the same product family. This is what emerged, for example, in GE HealthCare experience with CT scans: *“we are trying, clearly with a long-term strategy, to make product families increasingly "compatible". [...] To simplify, I'll tell you that it's the same concept as the car:[...] car chassis have become increasingly standardized, i.e. in common with even more families of car manufacturers. [...] What we are now evaluating is: what do these machines have in common? The mechanics, the electronics, the tubes, x-rays. For each component, do they have common bases? It means lowering production costs and having more resilience in the face of supplier problems”.* In this case, the interchangeability of production inputs is determined by a standardization of common features within a product family, which creates the opportunity to reallocate resources more effectively in case of disruption.

It is important to note that this approach to resilience through product design is facilitated by the partnership established between the orchestrator and the suppliers, who - with their know-how - can support the orchestrator in these tasks.

Another aspect that is associated with this resilience building mechanism is the ability to convert - at least partially - production whenever there is an overcapacity determined by a disruption. This emerged, for example, in the case of Medtronic, which suffered interruptions during the pandemic and swiftly acted to fill out those plants that were rendered vacant from the disruption: *“I have R&D people, specialists, production sites with clean rooms, I can collaborate with other companies. So open the door and say: these are my technologies, we can improve them together, we can invest to create something new, to address this demand. [...] For example, during the pandemic there were no masks. Medtronic opened the door to an Italian-level working group by saying: ‘I have the spaces, the staff; if there is a mask manufacturer that already has a patent and the capabilities, we are ready to produce them’”*.

Also, in this case, collaboration was essential, and specifically collaboration with other companies that were themselves trying to compensate for their limits in volume of production, to respond to a sudden and exponential increase in demand.

Finally, resilience was also determined by the orchestrator's ability to adapt distribution channels. In Roche's experience during the pandemic: *“The person who was ill found it difficult to go to hospital, because every time he had a risk of infection. In this context, a need has arisen to ensure that for certain therapies the patient can not go to hospital but can be treated elsewhere, perhaps at home. This determined a first step that Roche implemented on certain types of drugs, creating a home delivery service”*.

This specific adaptation did present a specific set of challenges (e.g. the patient's privacy protection), that the orchestrator was able to mitigate thanks to the partnership established in

the long-term with the distributors, who had acquired specific experience and knowledge of the company and of the industry standards and requirements.

Therefore, data analysis highlighted how resilience building mechanisms pertain to value chain structuring, in the sense that the orchestrator should take into account how to build resilience when designing value chain activities, taking into account the role of control decisions as well.

5. Discussion

5.1 Resilience building mechanisms in GVCs: Towards a theoretical model

The findings identified four resilience building mechanisms for MNEs orchestrating GVCs. These mechanisms pertain to three different areas: i) the establishment of collaborative relationships and suppliers redundancy pertain to MNEs control decisions within the GVC; ii) the geographical diversification of orchestrator's value chain pertains to MNEs location decisions within the GVC; iii) the design of adaptive value chain activities pertains to the MNE operations.

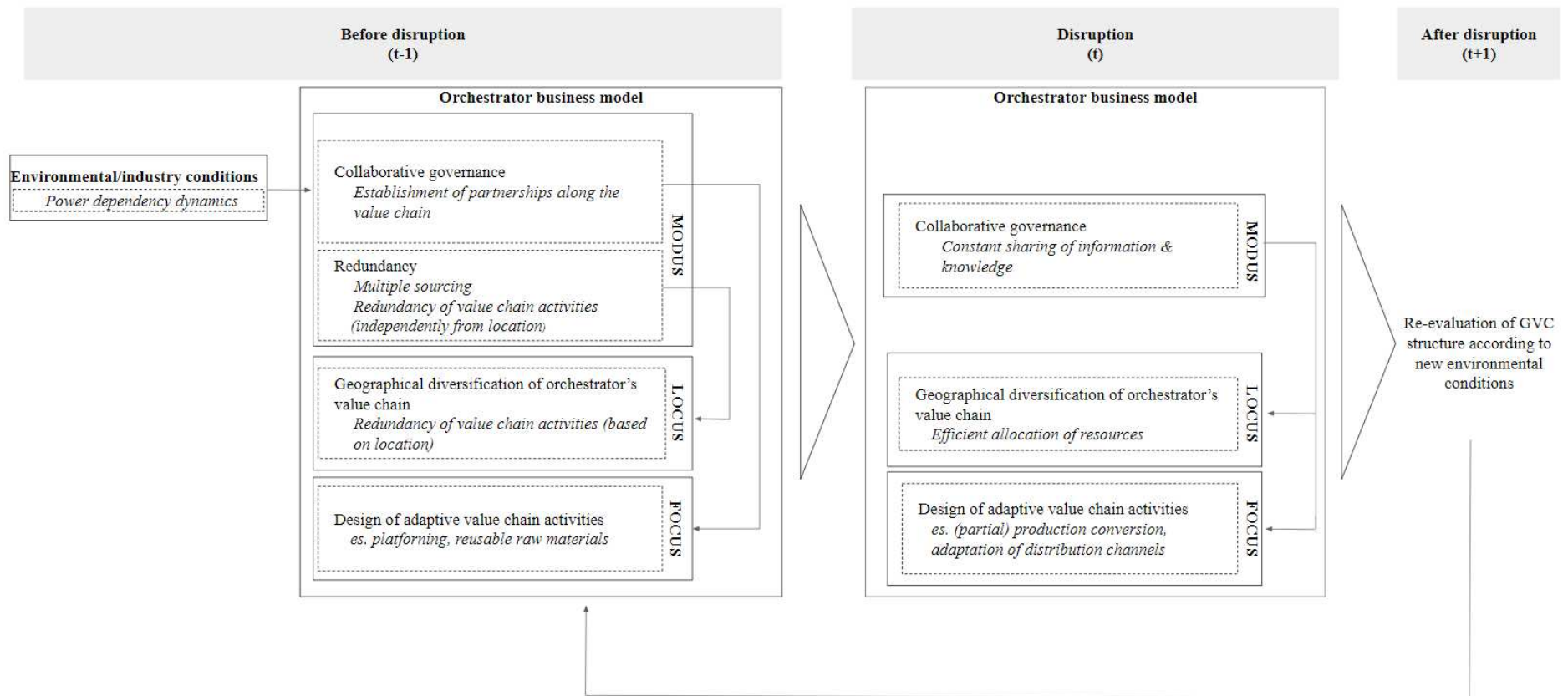
A first consideration is that these findings appear best framed within the business model definition by Onetti et al. (2012), which is characterized by three building blocks: *modus*, i.e. the business modes with regards to the internal organization and the network design; *locus*, i.e. the locations across which the firm's resources and activities are spread; and *focus*, i.e. the activities which provides the basis of the firm's value proposition. This business model definition is particularly functional to addressing the research question, as it allows to formalize the interactions between MNE's control, location and operational decisions.

A second consideration is that different aspects of the resilience building mechanisms within GVCs are pertinent to different moments in time in relation to the disruption. In particular,

we can identify three moments: $t-1$, before the disruption; t during the disruption; $t+1$, after the disruption. These findings are in line with previous studies on resilience at the organizational level that assume a processual and dynamic perspective (Conz & Magnani, 2020; Ambulkar et al., 2015).

Fig. 1 is a visual representation of how these two perspectives interact with the four resilience building mechanisms in the proposed theoretical model.

Figure 6. Resilience building mechanisms in GVCs: a theoretical model



Source: Author's elaboration

5.1.1 Resilience building processes at $t-1$: a prepared GVC

Before the disruption (at $t-1$), MNEs can enact resilience building mechanisms to structure the GVC so that it is prepared to respond to the disruption: this is in line with previous studies that associate preparedness to GVC resilience (Orlando et al., 2022), which has mostly been addressed from an operational point of view. At $t-1$, resilience building mechanisms can be thus differentiated:

1. For what concerns the *modus* (or control decisions) I identified collaborative governance through the establishment of partnerships along the value chain and value chain redundancy enabled by multiple sourcing;
2. For what concerns the *locus* (or location decisions) I identified redundancy of value chain activity based on geographical location;
3. For what concerns the focus (or the operational level) I identified the design of adaptive value chain activities in terms of production process and inputs of production.

First, the establishment of partnerships along the value chain is coherent with recent studies concerning the relationship within governance and resilience in GVC (Kano et al. 2022). However, this study enhances existing literature by highlighting how this resilience building mechanism is functional to the design of an adaptive value chain for two main reasons. First, the partnerships allows both the orchestrator and third parties (i.e. suppliers, distributors and customers) to develop relationship-specific experience that allows the value chain to respond in case of disruption. Moreover, these partnerships allow MNEs to benefit from the experience and know-how of third parties. These exchanges can complement possible MNEs knowledge gaps when designing adaptive value chain activities, for example in terms of input of production and distribution channels. Therefore, this resilience building mechanism pertaining to control decisions is directly linked to the *focus* of the orchestrator.

The second resilience building mechanism in the *modus* building block is redundancy through the adoption of a multiple sourcing approach. To the best of my knowledge, this study is among the first to find empirical evidence of the phenomenon within the IB literature. This aspect, however, is in line with previous literature in the operations management field, that, however, does not take into account the international aspect of the issue (Namdar et al, 2018; Hearnshaw & Wilson, 2013). At the same time, this diversification approach is functional to the redundancy of value chain activities, both domestically and internationally. These findings concerning the theme of redundancy are connected to previous research concerning supply chain risk management in the operations management field (Kovach et al., 2015; Lin et al., 2021), which has been acknowledged by IB scholars but hasn't yet received empirical support. Moreover, findings also allow to enlarge the scope of enquiry for resilience within GVCs, by encouraging the investigation of resilience building mechanisms that can be specific for the last part of the value chain (i.e downstream activities).

Findings also reveal that an underlying consideration to be made when addressing the *modus* building block in relation to GVC resilience is the influence of power-dependency dynamics with suppliers. In particular, what emerged is that a trade-off exists amongst the governance approach for resilience and the contractual power the orchestrator has towards the suppliers. Building a collaborative relationship requires commitment of resources - both to build the relationship and to support the supplier's effort by acquiring in higher volumes - which is difficult to reconcile with the need to design a multiple sourcing approach. In turn, the multiple sourcing approach further erodes the orchestrator's contractual power towards suppliers, implying higher costs. Therefore, while multiple sourcing and collaborative governance are both desirable to achieve resilience, they present inherent trade-offs.

In the resulting theoretical model, the multiple sourcing approach is directly linked to the *locus* building block, or location decisions: it is functional for the establishment of an internationally redundant - and diversified - GVCs. Although this is consistent with previous studies that takes a real option theory approach to uncertainty for MNEs (Levi & Sarnat, 1970; Ioulianou et al., 2021), this study's contribution acknowledges this approach outside of the headquarter-subsidiary relationships, by addressing inter-organizational relationships within GVCs. Moreover, findings can be framed within the debate on GVC re-configuration, which still presents tension between geographical dispersion and redundancy (Barbieri et al. 2021; Gereffi, 2020; Cohen et al., 2020; Strange, 2020). In particular, the present study supports the argument that favours redundancy and geographical dispersion of the value chain over regionalization for building resilience within GVCs.

Finally, before the disruption MNEs can build resilience in their GVC by designing more adaptive value chain activities, i.e. addressing the *focus* building block, and therefore obtaining higher operational flexibility at times of disruption (*t*). At *t-1*, two main strategies for this purpose were identified in the findings. First, a higher standardization of the product design, which can allow interchangeability of production inputs and/or the use of the same production inputs for different products in the portfolio, appears to contribute to build operational flexibility in case of disruption. Second, product design is functional to value chain resilience with the inclusion of reusable raw material. With this insight, this study directly associates the theme of resilience within GVCs to that of sustainability. This is strictly connected to previous research in operations management addressing the connection between closed-loop supply chains (CLSCs) and resilience (Mehrjerdi & Shafiee, 2020; Yavari & Zaker, 2019). However, within the IB literature, this insight also contributes to a recent stream of research that is starting to discuss the link between resilience and

sustainability in MNEs operations (Ghauri, 2022; van Zanten and van Tulder, 2018), and, in particular, it evidences how a further investigation of complementary approaches is called for.

5.1.2 Resilience building processes at t : a responsive GVC

During the disruption (t), the identified resilience building mechanisms serve the purpose of enabling the GVC to actively respond to the disruption. In this sense, findings are coherent with previous studies that associate resilience to responsiveness in the supply chain context (Chowdhury et al., 2019; Han et al., 2020).

At t , resilience building mechanisms can be thus differentiated:

1. For what concerns the *modus*, I identified collaborative governance in terms of constant sharing of information and knowledge along the value chain;
2. For what concerns the *locus*, I identified the efficient allocation of resources enabled by the geographical diversification of the orchestrator's value chain;
3. For what concerns the *focus*, I identified the design of adaptive value chain activities in terms of production conversion and adaptation.

At the moment of the disruption, the collaborative approach among GVC actors is characterized by a constant and timely sharing of information and knowledge along the value chain. The information sharing - both inflow and outflow from the orchestrator's perspective - appears as essential to enact a centralized decision-making process, enhance coordination along the value chain, and to allow the GVC to promptly respond to the disruption. Collaborative relationships are also understood as sharing knowledge, to transfer best practices along the value chain during the disruption, in order to leverage on all the actors' past experience. Therefore, these findings represent empirical evidence that highlight how the debate about GVC governance and resilience should include the perspective of inter-firm knowledge transfer practices (Mohr & Sengupta, 2002; Soontornthum et al., 2020).

Additionally, being pivotal for the decision-making process during the disruption, the *modus* decisions seem to directly influence the *locus* and *focus*.

On the one hand, the improved visibility along the value chain granted by the information flow allows a smoother re-allocation of resources across the geographical scope of the GVC, which determines responsiveness along the value chain.

On the other hand, the collaborative relationship instated with third parties allows the triggering of resilience mechanisms at the operational level that are functional to the responsiveness of GVC, i.e. reaction in the short term, such as temporary production conversion and temporary adaptation of distribution channels.

5.1.3 Resilience building processes at $t+1$: re-evaluating the GVC structure

Finally, findings have shown that after the disruption ($t+1$), the orchestrator is required to carry out a re-evaluation of control, location and value chain activities within GVCs- following the *modus*, *locus* and *focus* logic - according to the new environmental conditions. This is represented in my theoretical model in the form of a feedback loop between $t+1$ and $t-1$. Therefore, findings support the perspective of the achievement of a “new”, “optimal” and “improved” state after a disruption (Mandal, 2019; Miroudot, 2020) or, to use the ecological perspective, the value chain should enter an “alternative stability domain” (Wieland & Durach, 2021) according to the changed environmental conditions. While this approach is in line with recent research that has conceptualized organizational resilience as a dynamic quality for MNEs (Napier et al., 2024; Grego et al, 2024), to the best of my knowledge, this is the first model to make this type of association in the GVC context based on empirical findings.

6. Concluding remarks

6.1 Theoretical implications

This study makes four contributions to the debate on value chain dynamics and tackles the ongoing debate on a “more or less globalized?” world (Thakur-Welgold & Miroudot, 2023).

First, data provide empirical support to the association of resilience to redundancy of suppliers, and network spillovers, in contrast with the contemporary narrative of cost-efficiency and optimization often proposed in the operations literature (Sanders & Wagner, 2011). The excessive focus on cost reduction does not consider value creation and resilience as outputs stemming from the network of the GVCs activities (Gereffi, 2020). This is evidenced by this multiple-case analysis: all of the MNEs included in the study have in fact recognized the value of multiple sourcing for resilience while acknowledging the trade-offs with cost efficiency. These aspects can be fruitfully analysed under the global factory perspective in IB (Buckley 2009; Buckley & Strange, 2015) which emphasises the fine slicing of activities and interconnections among them through vertical integration or outsourcing processes (Buckley & Ghauri, 2004; McCann & Mudambi, 2005).

The redundancy of supply sources contradicts the myth according to which leaner and more efficient supply-chains are more resilient. In response to shocks, diversifications of activities across different markets proves to be advantageous (Coveri et al., 2023). As argued by Tang (2006, 480) “spreading multiple suppliers among multiple countries [...] can make a supply chain more resilient during a major disruption”. The benefits are also acknowledged in the real option theory, according to which during COVID-19 having portfolios of activities across different countries enabled some companies to shift production and supply of key materials (Miroudot, 2020). However, by acknowledging the interactions between location and control decisions on matters of resilience, we contribute to the real option theory perspective on resilience by overcoming the limitation to the headquarter-subsidary

interactions and highlighting the role of inter-firm relationships and knowledge transfer practices within GVCs (Liu et al., 2020; Roxenhall & Ghauri, 2004).

Second, empirical findings contribute to the debate in IB about the supposed “more or less globalization” MNEs are facing in the current economic environment (see JIBS point and counterpoint by Contractor 2021 and Ciravegna & Michailova, 2021) by supporting a geographical diversification of value chain activities without limiting the existing global reach of MNEs. This diversification approach is not seen as replication of whole value chains across different regions, but as a decision that concerns each single disaggregated value chain activities.

Third, this study combines the multi-layer definition of resilience in IB as presented by Gereffi et al. (2020) with the need to acknowledge the processual and dynamic nature of resilience (Conz & Magnani 2020; Napier et al., 2024). Moreover, my contribution also consists in the introduction of the orchestrator’s business model as a framework of reference for further investigations of resilience in GVCs adopting a longitudinal perspective (Grego et al., 2024; Galkina et al., 2023).

Finally, this study constitutes a contribution to the emerging debate concerning synergies and tensions between resilience and sustainability in MNEs (Napier et al., 2023; Contractor, 2021; Nielsen et al., 2023; OECD, 2021c). The findings about resilience building mechanisms at the operational level include practices such as reuse and recycling of raw materials to minimize MNE reliance on the upstream value chain in times of disruptions. This contribution directly connects MNE resilience to environmental sustainability practices and it constitutes empirical evidence that environmental sustainability and resilience can present intrinsic synergic approaches that need further investigation.

6.2 Managerial implications

This study also has implications for management practice. Findings describe how resilience in GVCs can be, at least in part, determined by a multi-layered decision-making process by the MNE. In particular, with their location, control and operational decisions, orchestrators can design their business model (Onetti et al., 2012) with a strategic approach that contemplates resilience in GVCs as an outcome. In particular, this study uncovers how these three decision-making levels interact on matters of resilience and it can therefore guide managerial actions.

Moreover, this study also places emphasis on the role of GVC actors apart from the orchestrators for what concerns resilience. In particular, findings show to practitioners how the type of inter-firm relationships the orchestrator forms with suppliers, distributors and customers can have an impact on how the entire value chain is able to withstand disruptions.

6.3 Limitations and avenues for future research

Although the study presents both theoretical and managerial contributions, I need to address its limitations.

First, the multiple case study is contextualized in one industry and therefore the collected data are affected by specific dynamics that characterize this type of industry. Second, while findings have identified the significant role of inter-firm relationships for resilience in GVCs, data collection has been focused on the orchestrator.

Consequently, this study also introduces opportunities for future research.

First, the study could be replicated in different industries, in order to understand how different competitive and structural dynamics can affect the theoretical model. Second, further investigation adopting a quantitative methodological approach could test the theoretical model in order to confirm generalizability of findings. Moreover, because of the

role of inter-firm relationship, a longitudinal perspective along the value chain could be fruitful for future studies.

Finally, because of its relevance for practitioners and the interest by academics, this study encourages further investigation on the theme of tensions and trade-offs among resilience and sustainability for MNEs.

Appendix A2: Details about explorative interviews

Table 13. Interviews to MNEs

<i>nr.</i>	<i>Sector</i>	<i>HQ</i>	<i>Revenues (mln \$; 2022)</i>	<i>Role of the interviewee(s) (number of interviewees)</i>
1	Beverage Manufacturing	U.S.A.	43,004	Senior Executives (2)
2	Coffee Manufacturing	Costa Rica	N/A	CEO
3	Personal Care Products Manufacturing	Turkey	0,409	Senior Executives (3)
4	Semiconductor and Other Electronic Component Manufacturing	Switzerland	16,128	VP Head of Supply Chain
5	Oil and gas field machinery and equipment	U.S.A.	21,156	VP Global Supply Chain Chief Procurement Officer

Source: Orbis

Table 14. Interviews to consultants

<i>nr.</i>	<i>Area of expertise</i>	<i>Years of experience</i>
1	Market research in FMCG markets	28
2	International Business and Strategic Communications	29
3	Technology and telecom strategy	23

Table 15. Interviews to academics

<i>nr.</i>	<i>Area of expertise</i>	<i>Years of experience</i>
1	Procurement, logistics and supply chain management	23

Appendix B2: Interview protocol

1. Could you provide a brief description of your company's value chain?
 - a. The input-output structure of the value chain;
 - b. The geographical dispersion of the value chain activities (upstream and downstream);
 - c. The governance structure: which value chain activities are outsourced?
 - d. What are the main institutional factors (e.g. dependent on foreign and national governments, international institutions...) that influence the structure of the value chain?
2. What are the most important risks related to value chain activities that concern your company?
3. What have been the most important value chain disruptions in recent years?
4. Do you think that the geographic dispersion of value chain activities in your company has influenced how you have addressed these disruptions?
5. Do you think whether value chain activities are performed in-house or outsourced has influenced how you have addressed these disruptions?
6. Has technology influenced how your company has addressed these disruptions?
7. In recent years, have there been changes in your company's value chain regarding governance structure and/or geographic dispersion?
8. In your experience, what characteristics must a value chain possess to be "resilient" to unexpected events?
9. Are there external actors who have played a role in the resilience of your value chain?
10. In your experience, does the relationship with key suppliers influence the value chain's ability to handle unexpected events?
11. In your company's experience, what is the relationship between value chain resilience and costs?

Appendix C2: Single case histories

Amgen Inc.

The company

Amgen is an American biotech company that operates in a wide set of therapeutic areas, i.e. oncology, hematology, cardiovascular diseases, inflammatory diseases, osteoarticular diseases and nephrology. Amgen has a commercial presence in approximately 100 countries worldwide and reported a turnover of 26,323 million dollars for the 2022 fiscal year.

The value chain

For what concerns control of value chain activities, these are mostly internalized.

The company's R&D activities are carried out in owned facilities that are located in the U.S.A., Canada, Denmark, Germany, Iceland and the United Kingdom.

The manufacturing process is primarily carried out in eight company-owned plants, located in the U.S.A., Puerto Rico, Brazil, Ireland, The Netherlands, Singapore and Turkey. This internal manufacturing network has commercial production capabilities for bulk manufacturing, formulation, fill, finish, tableting and device assembly.

However, certain raw materials and components necessary for product manufacturing are provided by and are the proprietary products of unaffiliated third-party suppliers, certain of which are only sources for such materials. In addition, Amgen uses third-party contract manufacturers to supplement the capacity or capability of the internal manufacturing network.

Administrative offices and marketing & sales teams are mostly present in each of the major geographical markets that are targeted by Roche

Overall, company-owned distribution centers are located in the U.S.A., Puerto Rico, Brazil, Netherlands and Turkey. In the U.S.A., substantially all sales are to pharmaceutical wholesale distributors, which are the principal means of distributing products to healthcare providers.

Outside the United States, Amgen sells principally to healthcare providers and/or pharmaceutical wholesale distributors depending on the distribution practice in each country. On a combined basis, wholesalers accounted for 82% of worldwide gross revenues for 2021. Therefore, while manufacturing of product lines is global, distribution is regionalized, with regional hubs that serve individual country markets.

Resilience building mechanisms

At the operational level, Amgen has long invested in organizational capabilities to enhance responsiveness of the value chain. The company carried out targeted investments in infrastructure to ensure continuity of operations, such as technological improvements for constant 24/7 monitoring of inventory and stock levels of raw materials. However, on a more strategic level, Amgen addresses two pivotal aspects. First, the company considers valuable for value chain resilience the dual sourcing approach. Secondly, Amgen seems to highlight the positive implication that centralised control has over value chain resilience: they believe in the need for a function that oversees the value chain, which develops an overarching framework to take decisions and to understand whether those choices are beneficial for the customer.

Moreover, Amgen also considers the relationship with other value chain actors as relevant to build resilience in case of disruption. In the case of suppliers, this relationship is built with a long term approach, based on shared practices and provision of specialized training by Amgen. Moreover, according to the informants, the investments the company allots to build this relationship is conditional on how important the supplier is for the production continuity: this entails specific engagement programs to share forward looking ideas. This same approach is also associated with distributors, whose relationship with the company is considered crucial for developing a resilient value chain. This relationship is equally seen as collaborative and focussed on developing and sharing solutions.

Finally, according to Amgen's case, an adaptive value chain contributes to achieving resilience, in the sense that the orchestrator needs to be able to adapt certain value chain activities (e.g. distribution) in response to environmental changes.

GE Healthcare

The company

GE HealthCare is a spin-off of GE Company, a high-tech American industrial company. GE HealthCare operates in the industry of healthcare systems and pharmaceutical diagnostics in three key care areas: neurological disorders, cancer and industrial internet, i.e. creating and enabling technology and services which can help improve the way healthcare is delivered to patients globally. In 2022, GE Healthcare reported total profits for 18,341 million dollars.

The value chain

As in the previous case, except for raw materials, also the GE HealthCare value chain is vertically integrated. Sourcing, production, and distribution network is managed globally while products are manufactured at and distributed by facilities serving specific regions. GE HealthCare has 43 manufacturing facilities, of which 31 are owned and 12 are leased, inclusive of one facility that is part-owned and part-leased. 17 manufacturing facilities located in the U.S.A. and 26 located outside of the U.S.A., including in China, India, Israel, Mexico, Brazil, Austria, Denmark, France, Germany, Ireland, the Netherlands, Norway, Sweden, Finland, South Korea, and Japan. GE HealthCare deploys a global multi-channel commercial model consisting of 10,000 sales professionals and a network of approximately 5,200 indirect third-party partners. The company's commercial model is organized in global and regional marketing, regional inside sales teams, field-based sales teams, and sales agents

and distributors. The direct and indirect sales channels are integrated with end-to-end virtual sales teams.

Resilience building mechanisms

A first resilience building mechanism in the case of GE HealthCare is found in the type of relationships that the company develops with suppliers, distributors and customers.

For what concerns suppliers and distributors, the company's relationship with them is developed in partnerships, in order to leverage on each other's experience in times of disruptions. Specifically in the case of suppliers, the company recognizes multiple sourcing as strategic for building resilience in its GVC, because recent disruptions have highlighted how their single sourcing strategy in some areas has hindered their responsiveness.

For what concerns customers, the company develops a trust relationship by establishing intimacy based on honest interactions, in order to explain the reasons why the company, not by its own will, is not able to manage deliveries within the times required by the procurement contracts, therefore managing customer's expectations and allowing them to plan having full visibility.

Finally, in the case of GE HealthCare, resilience is also associated with product design. First, the company has a long-term strategic approach that is defined as "platforming" and, in practice, aims to make product families increasingly "compatible". While different products in the same product portfolio (e.g. CT-scans) have optional configurations, they have the same functional features (e.g. the mechanics, the electronics, the tubes, x-rays). This approach is believed to develop more resilience to face disruption in the supply chain. Moreover, for GE HealthCare, a resilient value chain is also one that exploits the life of a component. For example, in the case of an MRI, electronics and plastics are replaced while

the magnet, which is fundamental for the use of the machine, is derived from old machines. This approach translates into reduced risks in case of upstream disruptions.

Pfizer Inc.

The company

Pfizer is an American research-based biopharmaceutical company that specializes in the discovery, development, manufacture and wholesale of prescribed medicines offered under the brand name Pfizer. The company has a leading portfolio of products and medicines that support wellness and prevention, as well as treatment and cures for diseases across a broad range of therapeutic areas. Pfizer reported revenues for 100,330 million dollars for the 2022 fiscal year.

The value chain

Pfizer R&D activity is focused on both discovering new products and adding value to existing ones, i.e improving their effectiveness and ease of dosing and discovering potential new indications. The company's R&D activity is structured to deliver a highly differentiated product portfolio, also thanks to strategic partnerships that enhance creativity and flexibility and urgency to deliver innovation to patients as quickly as possible. While a significant portion of R&D is carried out internally, the company also seeks promising chemical and biological lead molecules and innovative technologies developed by others to incorporate into their products. To this end, Pfizer enters into collaboration, alliance and license agreements with universities, biotechnology companies and other firms as well as through acquisitions and investments. These forms of collaboration allow the company to share knowledge, risk and cost.

Raw materials essential to manufacturing are procured from numerous suppliers worldwide. The purchase of raw materials is partly managed locally by a local procurement service and

by the factory buyers, while another part of the purchases, more strategic or with greater volume, are managed at the corporate level, by the category manager. For global materials, the company refers to corporate suppliers, i.e. those that guarantee product quality and the required standards and that serve multiple sites globally.

The manufacturing of both products and packaging is carried out almost completely without outsourcing. Third parties' involvement in manufacturing is marginal and only related to specific products. Distribution is global too, in the sense that most wholly owned plants serve the global market: the company sells its products in over 125 countries, including emerging markets. In 2021, Pfizer revenues were so geographically distributed: about 37% in the U.S., 23% in Europe, 15% in the remaining developed countries, and 25% in emerging markets.

The company's prescription biopharmaceutical products are sold principally to wholesalers, but also directly to retailers, hospitals, clinics, government agencies and pharmacies.

Resilience building mechanisms

The company considers the procurement of raw materials the main issue in case of disruptions. According to the informant, for example, this issue emerged at the beginning of 2022, as the result of multiple events, such as the pandemic, the war in Ukraine and the increase of energy costs. The in-depth interview led to the uncovering of three aspects which contributed to Pfizer's GVC resilience in this circumstance: visibility along the value chain, information sharing, and product and supplier diversification on multiple levels.

First, it was critical for the company to have timely updates about the activities along the value chain, in order to re-plan production. In this sense, it was crucial for Pfizer to have an internally developed and customised digital architecture, to run simulations, identify issues and possible solutions in a timely manner. However, for the company it has been necessary not only to have this information, but also to be able to efficiently share it along the value

chain, both internally and externally. On the one hand, Pfizer created a cross-functional team when procurement risks arose, in order to have a single comprehensive source of information within the company to re-plan production. Moreover, sharing information among production sites allowed to compensate for the lack of raw materials that were instead available in other locations. In this circumstance, the company considers a benefit that value chain activities are mostly internalized.

At the same time, it became relevant to establish a different relationship with suppliers based on a more frequent communication with suppliers, i.e. weekly if not daily. In times of disruption the contact with suppliers has ceased to be a contact strictly based on a contractual relationship and it developed in a collaborative relationship for creating alternatives and sharing best practices.

Finally, the company considers product and supplier diversification relevant for GVC resilience. At the product level, the company enhanced the product portfolio flexibility by broadening the production range of the factory equipment, allowing for substitutability of raw materials. At the supplier level, the company recognizes that multiple sourcing can enhance GVC resilience in case of disruptions. In particular, in the last period Pfizer production plants proceeded to expand the supplier range by identifying alternative suppliers among those already verified and qualified at the corporate level.

Roche

The company

Roche is a Swiss health-care company active in the discovery, development, manufacture and marketing of products and services that address disease prevention, diagnosis and treatment. Roche has two operating divisions: the pharmaceuticals division and the diagnostics division. In the pharmaceuticals division, the company's portfolio of brands of self-medication

products is designed to meet the growing demand for non-prescription remedies. At the same time, Roche Consumer Health addresses the needs of a healthy lifestyle, protection against environmental stress factors and self-medication for minor complaints. In the diagnostics division, Roche offers a wide range of products and services in all fields of medical testing. Roche reported a turnover of 66,430 million dollars for the 2022 fiscal year.

The value chain

For what concerns control of value chain activities, these are mostly internalized. Roche only engages with contract manufacturers for cost advantage in case of marginal non-strategic activities or to manage demand peaks that cannot be satisfied by internal productive capacity. Overall, R&D, manufacturing of products and packaging, and distribution, are managed internally. However, Roche relies on third parties for production inputs. In 2021, the company's total spend with suppliers and service providers was approximately CHF 20.3 billion: CHF 15.3 billion by the Pharmaceuticals Division and CHF 5.0 billion for the Diagnostics Division. The spend with the top 1000 suppliers accounted for 81% of Roche's total spend. These expenses are so distributed: 60,6% in the EMEA region, 31,5% in North America, 5,9% in the APAC region and 2% in the LATAM region. Approximately 15% of the total spend was with suppliers in non-OECD countries. Manufacturing activities are carried out at the global level through wholly owned FDIs. Distribution is instead localized, with bigger wholly owned regional hubs.

Resilience building mechanisms

According to the informant, the main issue that Roche has faced during the phase after Covid 19 peak is the unexpected demand peak for specific elements in its product portfolio. In particular, the company faced excess demand compared to its manufacturing capacity during covid-19 pandemic. Three main insights on GVC resilience emerged from the company's experience. First, an adaptive value chain can enhance resilience. Resilience appears to be

determined by the orchestrator's ability to adapt value chain activities in case of altered circumstances. For example, for years Roche had tried to implement product distribution directly to the patient rather than intermediaries (e.g. pharmacies) for those products that allowed a correct administration at home. This became possible only during the Covid-19 pandemic, when access to hospitals was limited. At that time, Roche implemented a home delivery service for certain types of drugs. In this sense, by adapting its distribution channels, Roche was able to take advantage of an opportunity in the changing environment, therefore compensating for the impossibility to proceed normally with its operations.

The second insight is the need to collaborate with third parties in case of disruptions. In particular, in the case of Roche it was crucial to keep open communications with customers, managing their expectations and sharing timely information with them. This approach allowed customers to re-plan their operations and therefore minimize disruption along the value chain. For example, different formulation for the same drug allowed the company to allocate better its production based on the specific needs of the customer.

Finally, since value chain activities are mostly internalized, Roche manages the consequence of external disruptions through a centralized task force that manages resource allocation. This approach allowed more efficient decision making because of the higher level of visibility across the whole value chain by the decision-makers.

Medtronic

The company

Medtronic is a healthcare technology company headquartered in Ireland. The company operates in four segments that primarily develop, manufacture, distribute, and sell device-based medical therapies and services for four therapeutic areas, i.e cardiovascular, medical surgical, neuroscience, diabetes. Medtronic serves healthcare systems, physicians,

clinicians, and patients in more than 150 countries worldwide and reported a turnover of 31,686 million dollars for the 2022 fiscal year.

The value chain

Also in the case of Medtronic, the value chain is globally dispersed. Approximately 37% of the manufacturing or research facilities are owned by Medtronic and the remaining balance is leased. The company's largest manufacturing facilities by location are in the U.S.A., Puerto Rico, Mexico, China, Minnesota, Italy, Ireland, Dominican Republic, Switzerland, and France. Medtronic also maintains sales and administrative offices in the U.S. at five locations in five states and outside the U.S.A. at 129 locations in 62 countries. A majority of these locations are leased. The company purchases many of the components and raw materials used in product manufacturing from numerous suppliers located in various countries, some of which are necessarily sole suppliers. Moreover, manufacturing of product families is centralised in single locations. The Medtronic value chain is not perfectly vertically integrated: R&D is also carried out with collaborations with third parties and manufacturing - although mostly carried out in-house - is partially outsourced for specific processes.

Resilience building mechanism

In Medtronic case, the company leverages partnership with suppliers, distributors and unrelated third parties to achieve resilience in the GVC at times of disruption. Partnership with suppliers and distributors

Partnership with suppliers and distributors is based on trust and entails the sharing of risk and resources. Within these collaborative relationships, the company extends its mission to its partners, working together to find optimal solutions. In this way, MEDtronic buys a result rather than a service or a good from its partners. In order to achieve this kind of relationship, MEDtronic shares its goals, their strategy for improvement, and the same is done by the

partners. According to the company experience, this partnership guarantees the sustainability of the relationship and the flexibility required in these continuous changes. At the same time, at the moment of the disruption during covid, Medtronic also developed partnerships with parties outside of its value chain: for example Medtronic opened the door to an Italian-level working group, making available its spaces and capabilities to committing to the production of PPEs. This kind of partnership allowed MEDtronic to fill overcapacity in their production plants.

A second aspect that emerged in the Medtronic case is the need for a centralized decision making process, based on inter-company information flow along the value chain. The company, following the pandemic, has in fact restructured its value chain by creating a centralized team that takes care of the procurement for all plants worldwide. According to the company's experience, this approach gives a greater advantage by enhancing the visibility along the value chain and also in the negotiation with large suppliers.

Finally, recent disruption has highlighted how geographical dispersion of value chain activities is functional to GVC resilience. For a long time the company has choned to centralize worldwide production of product families in single locations for cost efficiency issues and IP protection. However, recent disruptions and specifically a hurricane in Costa Rica, have moved the company to rethink this strategy.

Appendix D2: Most representative quotes

Table 16. Most representative quotes

Most representative quotes	Second-order concepts
<p>All our production sites have business continuity plans [...] And this concerns all the actors in the value chain. Business continuity ensures that everyone is prepared. We conduct continuous updating courses on our procedures. In this case I make particular reference to production and distribution. There are definitely third parties involved. (Amgen)</p> <p>We have continuous meetings and business reviews with distributors. They have KPIs to achieve, we measure them. For example, we see how many days it takes to deliver, we check that there are no problems with delays, we take inventories. It's a continuous working together and finding solutions to improve the processes. (Amgen)</p> <p>In the end, if you are contracting it out you cannot say you are vulnerable for all kinds of shortages. It all depends on how your partnership is structured and how you are collaborating all together. (Amgen)</p> <p>Depending on how important the supplier is, also the supplier engagement program will differ. But, for sure, for the important suppliers there is an engagement program to share forward-looking ideas that Amgen has, and those of the supplier in turn. So there is a benefit from the relationship for both parties. (Amgen)</p> <p>Customers must be educated, we must establish intimacy, an honest interaction, explaining the reasons why the company, not by its own will, is not able to manage deliveries within the times required by the procurement contracts , for specific legal conditions, in the signed offers. (GE HealthCare)</p> <p>We had to make an emergency plan, finding the resources to manage all the orders to the factories, finding the resources to move the goods both internationally and also locally. We are lucky enough to work with a partner who has followed us for many years, he has the expertise to carry out certain delivery operations. (GE HealthCare)</p> <p>The medium-low range CT scan we produce was probably not available for 6-9 months and we said to customers: "if you really want it from us, you'll have to buy the higher-range machine". (GE HealthCare)</p>	<p>Establishment of partnerships along the value chain</p>

<p>A partnership was established with the suppliers, especially those who demonstrated the most difficulties (Pfizer)</p> <p>In managing the emergency, the patients for whom that drug is indicated or who were already on therapy had to be secured first. Then we tried to understand what the additional needs were and we tried to find containment measures to satisfy them. For example, if the intravenous formulation worked well for Covid, we tried to understand with doctors whether it was possible to move patients with rheumatoid arthritis to the subcutaneous formulation, in order to ensure that the intravenous formulation was available for Covid patients. (Roche)</p> <p>The better your partnership with your suppliers, the more you speak the same language, which allows for a very good understanding in times of stress [...] when you have a good partnership, you can actually solve your problems faster and also you know your suppliers will actually go the extra mile to help you out (Roche)</p> <p>I just take a look at multiple countries where we have a relationship with the warehousing and distribution suppliers in the countries. We're not thinking of buying them but we are sitting at the table and taking a look at, you know: "this is the new EU guidelines which are coming up. How can we blend together in the best way possible for the market?" (Roche)</p> <p>We were very open about what we could do and they were very open to what they actually needed to do. And then you see in times of stress everything becomes malleable. These relationships really, really help. (Roche)</p> <p>So for instance, the hospitals where we deliver our goods have the best insight of what's happening there and our partners, like suppliers, they know what's going on there. So anywhere in this chain of potential issues arise either in house or outsourced. Then you as a company or control tower or whatever needs to know. Because if we know that there's a potential issue somewhere, we can actually identify possible alternatives. For instance, If we have a week of delay, but the end customer is saying "oh, but we have a week of stock on the shelf", then it's still a problem, but it's not a big issue. (Roche)</p> <p>Partnership and also trust in partnership and sharing of risk and resources. Really plan what to do together. It is a sort of extending our mission to our partners, therefore to our suppliers. Those who work with us are part of our mission, of our objective. It's not "I need you to achieve my goal". Any supplier must feel part of the mission, the goal and share the result. By doing this I don't buy a service, I don't buy a good, but I buy a result together with you. Let's achieve a result together. Just as we share the goal, we also share the opportunities for improvement, and on the other side, the same thing is expected. Where can we improve? Where can we go? It must be a continuous and mutual search for improvement and also optimization. (Medtronic)</p>	
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<p>[the partnership with third party actors] also guarantees the sustainability of the relationship and the flexibility required in these continuous changes (Medtronic)</p> <p>We have established an open dialogue with suppliers, weekly but sometimes even daily. Contact with the supplier has ceased to be a contact strictly linked to a function of the plant and to a commercial relationship. It started to be a collaborative relationship for the creation of alternatives and sharing best practices (Pfizer)</p>	
<p>In the face of emergency events, such as earthquakes, fires, epidemics, etc., we continue to try to improve our supply chains with targeted investments in infrastructure, to ensure that production sites can always be operational, resisting emergency events or causes of force majeure. In production technology, centralized control (control tower) is aimed at maintaining constant 24/7 monitoring of inventory management in order to prevent any stock outages; even with the inventory, we manage the levels of stocks of both raw materials, always maintaining inventories adequate to what the sales and distribution forecasts are. (Amgen)</p> <p>I strongly believe in the collaboration with vendors and suppliers, together with manufacturing and supply chain. Because in that ecosystem there is still a lot that you can gain in efficiency from an information sharing point of view [...] We started a project that is called from a global point of view "supply chain transition". Basically, we want to put more emphasis on the visibility across all parties in the supply chain. To ensure that there is no information gap, that nothing is falling into the cracks, and that we can more easily plan what is needed (Amgen)</p> <p>Another important point is to anticipate the planning as much as possible. In the sense of giving visibility to both customers and factories of when we are going to execute the deal. (GE HealthCare)</p> <p>The digital tool itself is not enough: they have also set daily flow meetings along the entire value chain to highlight critical issues, align on priorities, explore together how to solve problems (Pfizer)</p> <p>you want to be sitting on the table and actually say: "you shouldn't hold that, you should be open to share, for instance, your forecast really openly, you should be able to share the demand structures and potential risks". The more people are open about potential risks, the more you can actually assist them to create value and then they counter-measures if needed (Roche)</p> <p>That being said, we're heavily investing and working on fair sharing of data. Fair sharing of data basically allows different parties to share their information very easily and have the AI systems integrated as well. But with a very good position for ownership of data. Ownership remains with the person who supplies it. (Roche)</p>	<p>Constant sharing of information & knowledge</p>

<p>The moment we see that we might have problems in satisfying the entire demand, the first thing we do is open a report to the regulatory agency, and we say "be careful because we could enter a critical situation and we could be called to limit our stock". This means that we cannot necessarily give the drug to everyone, but we will have to prioritize. [...] So we immediately inform the regulatory agency and the market to implement processes containment on the local market. This means that we collaborate with the pharmacist to ensure that short-term therapy needs are guaranteed and then replenish stocks once the critical situation has emerged. (Roche)</p>	
<p>If you are small, the raw material suppliers will not give you the highest priority. (Amgen)</p> <p>Asking a supplier who does it for you, I imagine, means making long-term business volume commitments. Because if I am a supplier to Fiat, who asks me "can you do this for me" and "can you do more for me", I say "yes, but to make you more I have to invest in my production capacity. What commitment do you make?". (GE HealthCare)</p> <p>If I want a value chain that is as resilient as possible, I must have, for example, as many suppliers as possible, which means not having the negotiating capacity "I give you 100% of my need for this component" but I have two-three suppliers. This gives me more flexibility, (GE HealthCare)</p> <p>A single demand, a single global forecast also gives us a greater advantage in negotiating with large suppliers. A demand split in four is different from a single demand with a much larger quantity. The supply capacity becomes stronger and also more secure. (Medtronic)</p> <p>By reducing the number of suppliers [and therefore achieving higher volumes for each supplier, editor's note] there is also the opportunity to improve negotiations with suppliers and therefore have greater efficiency in terms of costs, an improvement in terms of services and also an opportunity to stabilize the process more. (Medtronic)</p>	<p>Power-dependency dynamics with suppliers</p>
<p>The paper quality we needed was not available in the volumes that we needed and that was the first time in Amgen history. A thing like that never happened. Availability of paper? It was not a problem before. However it could impact our ability to supply to the patient. There was already the strategy to have multiple sources available, but even that was not sufficient in some locations. So the whole covid situation showed indeed that you need to have strategies in place, like multiple sources, so that you are less dependent on one single source. To be honest, that was already a strategy but this emphasizes that it was a good strategy and that you should not only go for efficiency only but that also reliability of your supply chain is a really important factor that you have to take into account. (Amgen)</p>	<p>Multiple sourcing</p>

<p>But the thing is we had at least dual sourcing, it was helpful. We were able to mitigate the disruption. One source will dry up. [...] We are doing risk mitigation: we spent effort and also money in it to ensure that we have the dual sourcing in place and that we can switch if needed or change volumes from one source to another source very quickly. (Amgen)</p> <p>We have a value chain which in many cases is unfortunately based on single suppliers. The multi-supplier - the primary, the secondary, the tertiary - would have allowed us, for example, during the pandemic to have more flexibility, to perhaps maintain live production rather than keeping them blocked by impediments of our single sourcing. (GE HealthCare)</p> <p>We have expanded the range of suppliers for the materials for which there was more difficulty: that is, searching for alternative suppliers for a product among those already verified and qualified (Pfizer)</p>	
<p>If you make use of redundancy throughout different geographical locations, you could actually significantly reduce the risk. [...] If you have a strategic product for which there's no alternative on the market, it pays for you to have a redundant production chain (Roche)</p> <p>We tend to do double sourcing. So we have two geographical locations, two production sites who are actually equipped to make the same drug (Roche)</p> <p>Even if it is too early to make accurate predictions, at this moment we do not foresee production disruptions, but if the war progresses... We are in northern Israel and I cannot rule out this happening. Having a single global production center for this type of equipment could obviously bring our production capacity and then sales to its knees tomorrow. Therefore the geopolitical risk is high where there is a centralization of production in a single location.</p> <p>In general, diversification of the localization of activities helps (Pfizer)</p> <p>Production is centralized in a single plant. Over the last few years, history has told us that it is a risk. It has been a problem in the past years to have centralized production, even if it is something that almost all multinationals have done in the last twenty years. For example, part of our production is in Costa Rica. In South America, hurricanes, earthquakes, fires... we have seen them all, and this has put a crisis in place, hitting a production plant. By targeting a manufacturing plant that generates finished distribution products that are also life-saving, produced in a single point globally for cost efficiency issues and having the know-how in a single point, allows you to grow much faster. But this is a risk that has been perceived during crises. The hurricane stopped the production plant in Costa Rica for months. (Medtronic)</p>	<p>Redundancy of value chain activities</p>

<p>It no longer is a normal inclusion in the planning and replenishment systems, but it is possible to create dedicated task forces which, if the criticality is on a global scale, somehow decide on a global scale to "allocate" the products correctly in the various countries , taking the required specifications, evaluating and re-assigning production. (Roche)</p> <p>When we have many production plants that make requests to many different suppliers, and perhaps some of these suppliers have difficulty finding material and others do not. In the first case, significant product shortages are generated in the value chain. [...] This is why Medtronic has overturned the concept of mega regions and created a single global region, except China: let's put all the demand together, starting from the demand for materials of the production plants. The company is reorganized into global functions: there is no longer EMEA logistics, but there is global logistics; there is no longer a regional or even plant-based supply chain, but a global team, which takes demand [from plants, editor's note] from all over the world, puts it together and searches for large suppliers. (Medtronic)</p>	<p>Efficient allocation of resources</p>
<p>Among the various things we did, when Covid began, in March we had already set up a home delivery process: delivery of some medicines directly to patients' homes via external suppliers. [...] We have given our contribution in terms of organisation, knowledge and process to some ASL (Local Health Authority, in Lombardy, Sicily and Lazio, editor's note). We simply provided a transporter that went to the ASL, picked up the drug and brought it to the patients. To clarify, the drugs had already been purchased by the ASL. (Amgen)</p> <p>We have a strategic approach to solving some of these weaknesses and one above all is “platforming”. In practice, we are trying, clearly with a long-term strategy, to make product families increasingly "compatible". I'll give you an example. [...]We don't have only one CT scan. There is a “basic” CT scan that is sold for 150,000 euros and we arrive at much more advanced models. It is not just a question of options. To simplify, I'll tell you that it's the same concept as the car: it's like saying that Fiat starts from the Panda and arrives at a more advanced model. Each of these models, then, has optional configurations. This comparison with the car is very apt because car chassis have become increasingly standardized, i.e. in common with even more families of car manufacturers. They have also made agreements between competitors to use the same platform to achieve economies of scale. This is clearly not our case, because at the moment we have unrelated products in our CT scan range. What we are now evaluating is: what do these machines have in common? The mechanics, the electronics, the tubes, x-rays. For each component, do they have common bases? It means lowering production costs and having more resilience in the face of supplier problems. (GE Healthcare)</p> <p>A resilient value chain is also one that exploits the life of a component. I give you the example of MRI. The heart of the machine is a magnet, a huge magnet, to simplify. And that magnet has an average life of 25 years, maybe even 30. [...] We have implemented procedures whereby we replace all the electronics, even the plastics for a more adequate "look and feel", but the heart, which is the</p>	<p>Operational flexibility built in the value chain</p>

<p>magnet, remains there. This certainly means having one less production and supply problem upstream of the magnet components. It's clearly a benefit. (GE HealthCare)</p> <p>Always adhering to the mandatory specifications to maintain quality, the production range of the machines has been expanded (in paper weight, mm of ribbons, etc...). This is to increase the range of materials that can be used with the machinery. (Pfizer)</p> <p>The person who was ill found it difficult to go to hospital, because every time he had a risk of infection. In this context, a need has arisen to ensure that for certain therapies the patient can not go to hospital but can be treated elsewhere, perhaps at home. This determined a first step that Roche implemented on certain types of drugs, creating a home delivery service. We had tried in the past for many years, but had never succeeded. (Roche)</p> <p>Also Medtronic's ability during the pandemic to say: I have R&D people, specialists, production sites with clean rooms, I can collaborate with other companies. So open the door and say: these are my technologies, we can improve them together, we can invest to create something new, to address this demand. This is something that Medtronic has done. [...] These are obviously smaller companies, which could also be acquired. For example, during the pandemic there were no masks. Medtronic opened the door to an Italian-level working group by saying: I have the spaces, the staff; if there is a mask manufacturer that already has a patent and the capabilities, we are ready to produce them. (Medtronic)</p>	
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CHAPTER 3. Two birds with one stone? An in-depth study on resilience and sustainability in a semiconductor Global Value Chain

Abstract

On January 1st, 2020, firms woke up into the “Decade of Action”: 10 years that should lead to achieving the Sustainable Development Goals (SDGs). In this context, multinational enterprises (MNEs) are regarded as playing an active role in establishing a sustainable development approach to the economy. Moreover, the challenges caused by environmental and social decay have made it imperative for MNEs to develop resilient production networks within their global value chains (GVCs). By addressing the underlying similarities between resilience and sustainability, the present study proposes to investigate whether MNEs can adopt synergistic approaches to achieve sustainable and resilient GVCs. The study develops an in-depth single-case study contextualized in the semiconductor industry.

Keywords: resilience; sustainability; global factory; semiconductors; global value chains

1. Introduction

At the end of 2023, the OECD updated its “Guidelines for Multinational Enterprises on Responsible Business Conduct”, introducing for the first time since 1976 the idea that multinational enterprises (MNEs) are directly responsible for climate change (OECD, 2023).

This is one of the many pieces of evidence that, nowadays, MNEs are regarded as playing an active role in relation to a wide range of issues, one being sustainable development (Eang et al., 2023; Ghauri, 2022; Ben Jaafar & Battikh, 2021).

First, the rise of MNEs as powerful economic actors with a global presence has had profound social implications. While MNEs have positively contributed to global economic growth and technological advancement (De Backer et al., 2019; Meyer, 2004), they have also been associated with negative social outcomes. MNEs have often faced criticism for exploiting labor, disregarding workers' rights, and perpetuating social inequalities along their value chain or for condoning the same practices by local suppliers, particularly in developing countries where labor regulations may be weaker or less effectively enforced (International Labour Organization, 2021; Doh, 2019).

Second, climate change is widely recognized as one of the most pressing challenges of our time (Brewer, 2005), whose most tangible consequence is the occurrence of extreme weather events and climate-related disasters (Oh & Oetzel, 2022). Environmental disasters have not only threatened ecosystems and human well-being but have also imposed significant economic burdens on nations and businesses worldwide (Marchant, 2019): value chains have been disrupted, infrastructure has been damaged, and productivity has been impacted (Swanson & Bradsher, 2022; Hallegatte et al., 2019; Grover, 2022). Hurricane Katrina (NBCnews, 2005), the 2003 European heatwaves (García-León et al., 2021) and Pakistan floods (The World Bank, 2022) are only a few of the extreme events that have impacted economic and productive systems.

As influential economic actors operating across borders, MNEs possess considerable power and influence over global production, consumption, and resource allocation (The World Bank, 2019). Their activities and decisions have far-reaching consequences for environmental sustainability, influencing among others greenhouse gas emissions (The World Bank, 2019) and the depletion of finite natural resources (International Resource Panel, 2020).

Nevertheless, the complex reality of global value chains (GVCs) has often made it difficult to hold MNEs accountable for their social and environmental practices (Bu et al., 2023).

With the awakening of a global conscience on the issue of sustainable development, various stakeholders, including civil society organizations, academics, and policymakers, have advocated for greater corporate responsibility and accountability of MNEs (European Parliament, 2022; Zhan, 2021). The rise of global initiatives and standards, such as the United Nations Global Compact in 2000 and the Sustainable Development Goals (SDGs) in 2015, reflects a growing consensus that MNEs must adopt responsible business practices and align their operations with sustainable principles (United Nations, 1999; 2015).

In parallel with sustainability challenges, resilience has recently emerged as a critical attribute for MNEs (Gereffi, 2020; Strange, 2020). Resilience in international operations has become a widespread concern not only because of the pressing challenges brought on by unsustainable practices -such as environmental disasters- but also to navigate the all-round complexity of an increasingly uncertain environment (Ku et al., 2020). Lately, the uncertainty that traditionally characterizes MNEs' activity has been exacerbated by a number of factors, including geopolitical tensions (Meyer et al., 2023), large scale conflicts (Ratten, 2022), and a global pandemic (Sharma et al., 2020).

In the last few years, resilience and sustainability have been separately receiving increasing attention in IB scholarship (Ku et al., 2020; Luo, 2022; Kolk & Van Tulder, 2010; Ghauri, 2022). However, even if these concepts have started to be associated, their connection has

been discussed almost exclusively at the conceptual level both by academics and practitioners (Napier et al., 2023; Contractor, 2021; Nielsen et al., 2023; OECD, 2021c), lacking however empirical investigation.

By acknowledging the rising call of conjoint research on resilience and sustainability (Ku et al., 2020; Luo & Van Assche, 2023; Luo, 2022) and recognizing their strategic role for MNEs in the matter (McKinsey, 2022b), the present study proposes to investigate whether MNEs can adopt shared approaches to realize sustainable and resilient GVCs. Therefore, leveraging the “global factory” framework (Buckley & Ghauri, 2004), I conceptualize the role of the MNEs as GVC orchestrator in tackling sustainability and resilience objectives. Specifically, the study takes a Resource Dependence Theory (RDT) perspective on the topic and it is contextualized within the MNE-supplier relationship dynamics.

Overall, the present study tries to answer the following research question: *how do power asymmetries between MNEs and suppliers influence the design of resilient and sustainable GVC?*

Because of the dynamic and complex phenomenon and the relevance of the context of investigation, the paper develops an in-depth single-case study, following the Extended Case Method (ECM). The present investigation is contextualized within the semiconductor industry: in particular, it analyses the practices of the biggest European semiconductor producer, i.e. STMicroelectronics.

2. Theoretical background

2.1 Sustainability and resilience in IB: two inescapable imperatives for MNEs

Sustainability and resilience represent two challenges that MNEs need to address in the short-to-medium term. Because of their nature as “inescapable imperatives”, they have

elicited the interest of academics, managers and policy makers, although with different intensities.

The issue of sustainable development has been a concern since long: it regards ensuring that humanity “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987: p.16), and it is generally interpreted as environmental and social sustainability. Environmental sustainability refers to ensuring that humanity operates within planetary boundaries (Steffen et al., 2015), i.e. by utilizing natural resources in a way that preserves the environment and guarantees its long-term viability. Environmental sustainability encompasses efforts to mitigate climate change, reduce pollution, conserve natural resources, and promote biodiversity (Pisani et al., 2019; Golgeci et al., 2021).

Social sustainability, on the other hand, is a wide concept that involves creating and maintaining durable circumstances for human well-being, particularly for susceptible persons or groups (Hollander et al. 2016). In this sense, social sustainability is concerned with issues such as poverty, inequality, human rights, fair labor practices, community development, and stakeholder engagement, with the aim of promoting long-term societal well-being (Lund-Thomsen & Lindgreen, 2014; Lee & Rammohan, 2017).

The recognition of MNEs’ responsibility in addressing sustainability challenges is long-standing, as it is testified by how the Sustainable Development Goals (SDG) have been designed: they are a set of 17 goals that promote the joint effort of MNEs, institutions, and local businesses for the improvement of environmental, social, and economic conditions (Ghauri et al., 2017). Resilience, on the contrary, has gained attention in IB research in the last few years, because of the increasingly uncertain environment MNEs face nowadays (Ku et al., 2021), and especially after the covid-19 pandemic (Barbieri et al., 2020; Gereffi, 2020; Strange, 2020; Buckley, 2021).

Resilience in IB is mostly defined as the “ability of a system to return to its original state or move to a new, more desirable state, after being disturbed” (Christopher & Peck, 2004: p. 4). Previous studies have addressed MNE resilience in the context of developing countries (Ali et al., 2011; Branzei & Abdelnour, 2010) or as a desired managerial capability (Fainshmidt et al., 2017; Al-Atwi et al., 2021). Following the pandemic, however, more recent studies have contributed to this stream of research by conceptualizing how resilience relates to the GVC context (Gereffi et al., 2022; Mouzas & Bauer, 2022; Dilyard et al., 2021). The GVC perspective, in fact, represents a telling setting to bring forward the coordination challenges that GVCs can face - and have faced - in case of disruptions (Philips et al., 2022).

2.1.1 A synergistic perspective

Researchers in the IB field have displayed a growing interest in exploring potential links between resilience and sustainability. They have particularly delved into the role of MNEs in striving for sustainable development that is also resilient (for example, Ghauri, 2022; van Zanten & van Tulder, 2018).

It is evident that pursuing both sustainability and resilience goals introduces specific challenges, contradictions, and trade-offs for MNEs (Carmin & De Marchi, 2023; Garrone et al., 2023). However, the present study argues that, from an IB perspective, resilience and sustainability, as strategic objectives, also present underlying similarities.

First, both sustainability and resilience aim at achieving the survival of a system (Mehrjerdi & Shafiee, 2021). Sustainability is focused on the long-term survival of a socio-environmental system, i.e. group of humans, social elements, and processes that interact with each other and nature (SESYNC, 2022). Resilience focuses on the survival of a

system, such as GVCs³, after a disruption. Moreover, I argue that, since GVCs are embedded in socio-environmental systems, they interact and influence each other.

With their GVC activities, MNEs directly influence social (e.g. quality employment, equal opportunities, poverty, promotion of inclusive economic growth) and environmental (e.g. transition to affordable and clean energy, ensurance of sustainable consumption and production patterns) processes globally (Ghauri, 2022).

Vice versa, the socio-economic environment can have an effect on how resilient a response to disruption is in GVC. For example, a well-developed technological infrastructure enhances connectivity, communication and coordination within the value chain, which it's crucial for responsiveness (Cai et al., 2016). Moreover, the education and skills of the workforce also can impact the resilience of GVCs: a well-educated and skilled workforce is better equipped to adapt to changes, innovate, and operate in a more efficient and flexible manner (Ibrahim et al., 2021). Additionally, sectoral resilience through learning in networks and GVCs has been highlighted, emphasizing the impact of inter-organizational learning on the resilience of value chains (Yoruk et al., 2023)

Second, both resilience and sustainability require a “systemic approach” (Bansal et al., 2021): their achievement is not the exclusive responsibility of single actors, but rather it depends on how these actors interact in a system (Carmin & De Marchi, 2023; Rašković, 2022).

This is particularly significant in the GVCs context, where MNEs interact with various actors, such as suppliers (Ang et al., 2017; De Marchi et al., 2019), buyers (De Marchi & Di Maria, 2019; Pereira et al., 2015), and institutions (Dallas et al., 2021; Ponte, 2019).

For example, from the operational perspective, the issue of environmental sustainability has been studied among researchers of sustainable supply chain (SSC) management (Vachon & Klassen, 2008; Green et al., 2012). It is not enough for MNEs to account for the

³ GVC can be classified as a system by the Oxford English Dictionary definition of system: “An organized or connected group of things”.

environmental impact of their purchasing strategy, manufacturing process, and distribution to build environmentally sustainable supply chains: they need to ensure that suppliers and customers adopt an environmentally friendly practices (Vachon & Klassen, 2008; Badi & Murtagh, 2019).

For resilience, recent studies have focused on the role of governance structures within GVCs (Ryan et al., 2022; Buckley, 2021). Choksy et al. (2022) has discussed how GVC resilience is dependent on supplier resilience - i.e. suppliers' abilities to respond to large-scale disruptions and return to normal operations (Rice & Caniato, 2003)- and how this can be influenced by supplier upgrading practices promoted by MNEs in a captive governance structure. Kano et al. (2022) conceptualized the role of *managerial governance* in achieving GVC resilience, i.e. “more fine-grained mechanisms within a broader governance structure, some of these being relational in nature, that encourage repeated, observable patterns of behavior by targeted units and individuals” (Verbeke & Fariborzi, 2019: p. 1215).

Therefore, as resilience and sustainability remain the grand challenges of our time (Zhan, 2021; Srinivasan & Eden, 2021) and in light of these underlying similarities as strategic objectives (i.e. scope and approach), this study proposes to investigate whether MNEs can adopt synergistic approaches to transit towards sustainable and resilient GVCs.

2.2 Resilience and sustainability in the global factory

As location and control decisions within the value chain appear to be intrinsically linked to both resilience and sustainability, this study is developed following a “global factory” perspective (Buckley, 2011). The “global factory” framework defines MNEs as GVC orchestrators, i.e. the entity that harmonizes value chain activities through ownership and location strategies, with the aim of responding efficiently to global economic conditions and adapting to changes in those conditions (Buckley & Ghauri, 2014).

Recent research has started to enquire how the orchestrator's choices in structuring the GVC can affect its resilience and sustainability.

For what concerns MNE's decisions on location, offshoring of value chain activities - i.e. their relocation to foreign locations, regardless of the ownership mode (Kinkel & Maloca, 2009) - has potential implications on both resilience and sustainability. The geographical configuration of value chain activities is already recognized to impact GVC resilience against disruptions (Gereffi, 1995). However, while reshoring or near-shoring strategies promote regionalization of value chain activities to enhance resilience (Barbieri et al., 2021), the redundancy of activities across multiple locations is also advocated to create responsive GVCs and mitigate overreliance on specific locations (Gereffi, 2020; Cohen et al., 2020; Strange, 2020). These strategic approaches proposed for GVC resilience are strictly related to the MNEs impact on the socio-environmental system. For example, it is important to consider the potential negative consequences of relocating value chain activities on the global society, as it may lead to economic and social hardships for countries heavily reliant on international trade and their unique competitive capabilities, therefore impacting social sustainability (Panwar et al., 2022; Assche et al., 2021). At the same time, from the perspective of environmental sustainability, previous studies have advocated for shorter value chains through the implementation of reshoring strategies in order to reduce GVCs negative environmental impacts (Gupta et al., 2021).

Overall, even if lacking general consensus, geographical dispersion of value chain activities is widely discussed in relation to sustainability and resilience debates in IB. It is different for control dynamics in GVCs, and how they relate to resilience and sustainability..

As orchestrators, MNEs decisions shape control and power relationships in GVCs and they allocate and regulate the flow of financial, material, and human resources within the chain (Gereffi, 1994). MNEs can choose to outsource certain or all of their value chain activities,

obtaining semi-finished products, finished products, or services from external companies, even if these activities were traditionally performed internally (Simchi-Levi et al., 2004). The choice of outsourcing is influenced by factors that are both endogenous (e.g. cost effectiveness; development of core competencies) and exogenous (e.g. presence of market failure; bargaining problems; dynamic aspects and entry deterrence; government policies) (Casson, 1986) to the firm.

In the case of outsourced value chain activities, relationships with subcontractors are mostly regulated through contractual agreements and the MNE has limited visibility and control over the outsourcee behaviour (Cox, 2001; Strange, 2011). Moreover, the value chain can also include suppliers beyond the first-tier, which have no formal relationship with the MNE but are still practically involved in the value creation, potentially exposing the MNE to serious social and environmental risks (De Marchi et al., 2019; Andersen & Skjoett-Larsen, 2009). Nevertheless, MNEs are increasingly held accountable for the adoption of sustainable practices of other actors within the “extended value chain”, i.e. value-creating activities - both primary and support - can extend beyond MNEs’ direct control (Vachani & Post, 2012). As orchestrators, MNEs are seen as the most impactful entity, and the promoters and facilitators of the sustainable practices cascade throughout the extended value chain (Villena & Gioia, 2020; Montiel et al., 2021; McKinsey, 2016; Castaldi et al., 2023).

For what concerns resilience, the interest in MNEs control decisions is more recent (Chatterjee et al., 2024; Choksy et al., 2022; Gölgeci et al., 2023). Kano et al. (2022) proposed how managerial governance mechanisms are associated with GVC resilience, including relationships among GVC actors (i.e. inter-firm adaptations) and relationships with actors outside of formal GVC boundaries (extra-GVC adaptations). In particular, recent work has highlighted how building supplier capabilities is relevant when addressing GVC resilience issues (Gereffi et al., 2022). Overall, while interest in the influence of control

dynamics in GVC over resilience is extremely recent, it is already acknowledged as relevant for sustainability, especially relating to suppliers.

Building on the presented argument of synergic relationship among resilience and sustainability in GVCs, the present study specifically focuses on control dynamics.

In particular, a prominent role in control dynamics for both GVC resilience and sustainability is coherent with the need to address both objectives with a “system approach” previously described, where the outcome is not the exclusive consequence of the actions of the single actors but also of these actors’ interactions.

We argue that this is particularly true for the relationship between MNEs and suppliers (Negri et al., 2021), by reason of the power asymmetries that regulate them.

Table 17. Sustainability and Resilience in the global factory: governance perspective

	Sustainability	Resilience
Ownership strategy	<ul style="list-style-type: none"> ● “Extended value chain”: value-creating activities can extend beyond MNEs’ direct control (Vachani & Post, 2012) ● Orchestrators are seen as the most impactful entity, and the promoters and facilitators of the sustainable practices cascade throughout the extended value chain (Villena & Gioia, 2020; Montiel et al., 2021) 	<ul style="list-style-type: none"> ● Managerial governance mechanisms associated with GVC resilience (Kano et al., 2022)

Source: Author’s elaboration

2.3 The role of power asymmetries in MNE-suppliers relationships

Power asymmetries are a distinctive characteristic of outsourcing relationships (Blois, 1997) that determine the choice of GVC governance structure by MNEs (Strange & Humphrey, 2019). According to Resource Dependence Theory (RDT), resource scarcity generates organizational interdependence between MNE and suppliers, that each party will try to modify by acquiring strategic resources (Cook, 1977; Pfeffer & Salancik, 1978).

These power asymmetries can be determined by various factors: (i) number of alternative suppliers available to lead firm; (ii) number of alternative buyers available to suppliers; (iii) potential switching costs for both entities; (iv) level of investments in relationship-specific assets (Magnani et al., 2019).

Because of this feature, orchestrators can outsource -i.e. relinquish ownership of- value chain activities whilst still retaining control over them (Hymer, 1972; Strange & Newton, 2006; Strange, 2011).

More importantly, power asymmetries between suppliers and MNE provide the latter with the capacity to influence suppliers behaviour. This capacity may be leveraged, for example, to capture more value from the value chain activities (Cox, 1999; Reimann & Ketchen, 2017; Strange & Humphrey, 2019), but also to get suppliers to abide by orchestrator requirements (Ulstrup Hoejmosé et al., 2013).

Since MNEs, as GVCs orchestrators, can leverage their power over suppliers to influence their behaviour, which in turn is relevant for both resilience and sustainability, I believe it to be a necessary investigation path.

Therefore, by adopting a RDT perspective, the present study tries to answer the following research question: *how do power asymmetries between MNEs and suppliers influence the design of resilient and sustainable GVC?*

3. Methodology

To answer the research question, the study acknowledges that the relationship between MNEs and suppliers does not exist in a vacuum: it is contextualized within a socio-environmental system, with which it interacts.

As a consequence of the intricate and multi-layered nature of the research question (Dyer & Wilkins, 1991), the study is developed using a qualitative approach and an in-depth single case study in particular.

As IB phenomena are often dynamic, complex and multidimensional, scholars have called for more frequent use of qualitative methods (Sinkovics et al., 2008)

Because of the primary role of the context in which the MNE-supplier relationship is embedded, the present study is designed following the extended case method (ECM) (Burawoy, 1998). This “contextualized explanation” approach considers context as explanatory rather than a boundary condition (Welch et al., 2022; Nguyen and Tull, 2022). In particular, the ECM proposes to bridge the explanatory power of the micro level, i.e. the initial standpoint and the interactions in the field site from which the researcher constructs their research object - the MNE - and the macro level, i.e. the abstract, often taken-for-granted, social structures that condition and surround that research object (Burawoy, 2009). Specifically, for the design of the present investigation I refer to the categorization by Tsang (2013), according to which contextualized research methods are characterized by strong emphasis on contextualization as well as a strong emphasis on theory development.

Following the analytical approach devised for ECM (Nguyen & Tull, 2022), the study is developed in six phases:

- (i) Theorized engagement, i.e. theory-led problematization and multi-level data collection across time and space where the authors are informed by the theories presented in the previous sections of the paper;
- (ii) Analysis of data by confronting theory with emerging data and identify anomalies, surprises, and complexities;

- (iii) Revisions and definition of themes, i.e. revisit and refine theorized storyline and distill a convincing theoretical story;
- (iv) Case extension, i.e. trace outwards and connect inwards to situate the case within the wider contexts;
- (v) Historization of the macro contexts to casually connect the micro and the macro level;
- (vi) Review, refine and evaluate themes and concepts.

In accordance with the contextualized explanation approach, the single case study is chosen according to its uniqueness to highlight anomalies and limits in existing theory (Burawoy, 1998).

3.1 Context of analysis

The in-depth single-case study features STMicroelectronics (ST), which is one of the world's largest semiconductor companies. The choice of this company fits with the proposed methodology because ST is a forerunner in the semiconductor industry with its commitment to sustainability: between 1991 and 1991, the company has won 31 awards for its environmental sustainability (ST, 1999). Moreover, at the height of the "semiconductor shortage", ST was recognized by Resilinc as ranking among the top 30 suppliers to the high-tech industry with the best risk programs in place (Resilinc, 2022)

Key facts about ST are presented in Table 18.

Table 18. STMicroelectronics: key facts

Foundation	1987
Headquarter	Geneva, Switzerland
Number of employees (2022)	51,370
Revenues (2022)	\$16,3 billion
Revenues by geographical area (2022)	41% Americas 30% Asia Pacific Region 29% EMEA region
Subcontracted manufacturing activity (% of total production value in 2021)	24%
Procurement by geographical area (2021)	49% Asia 44% Europe

Sources: ORBIS; STMicroelectronics

It is also important to acknowledge some macro-dynamics that affect the study.

First, the semiconductor industry has been severely impacted by both the Covid-19 pandemic (KPMG, 2021) and the war in Ukraine (Gartner, 2022), with a significant increase in the level of uncertainty players are subjected to. For example, following the first Covid-19 pandemic months, semiconductor revenue projection was reduced by \$55.0 billion, to \$415.4 billion, and annual growth for 2020 was reduced from 12.5% to 0.9% (Accenture, 2020). This already dire situation was then aggravated by the war in Ukraine: neon, one of the main raw materials for semiconductors, is widely sourced from both Russia and Ukraine, with the biggest Ukrainian producers located severely impacted area (Reuters, 2022)

Second, the semiconductor industry contributes to environmental pollution (Ahmad, 2007; Gopalakrishnan et al., 2010) and it has raised concerns in aspects of social sustainability (OHCHR, 2022).

Third, with a growing institutional interest in the semiconductor industry (The Economist, 2022; The White House, 2021), the analysis of this specific context could make more apparent how the micro and macro levels interact.

3.2 Data sources

Data collection lasted from April 2021 until February 2024 and it relied on three main sources:

1. Primary data collected through in-depth semi-structured interviews to both ST and two of its suppliers on resilience and sustainability of the GVC;
2. Author's observations and field notes ;
3. Documentary sources, both produced by the company and third parties.

Primary data consist of about 100 pages of transcripts collected over 7 interviews with 7 different executives across the three organizations.

The author also participated in three events, either organized by or featuring ST, that addressed sustainability and resilience as central themes. The study also relies on secondary sources. Data collection includes both annual financial reports and annual sustainability reports, published from ST and its suppliers separately. Moreover, newspaper articles and industry reports were included for a better understanding of the context. Overall, the study relies on five secondary sources:

- (i) news articles focused on the semiconductor industry and ST specifically and concerned with the themes of sustainability and resilience, which were retrieved from the NexisUni database;
- (ii) reports about semiconductor industry outlook published by independent parties;
- (iii) two monographies addressing the story of ST in the European semiconductor industry, and the recent climate of conflict in the global semiconductor industry;
- (iv) institutional documentation detailing governmental policies that directly affect the semiconductor industry;
- (v) scientific papers published in peer reviewed journals in the business and management area of research that feature ST.

Information about the interviewed ST suppliers is presented in Table 19 while details about data sources are available in Table 20. Interview protocols are reported in Appendix B3.

Table 19. Information about interviewed suppliers

	Linde (L)	GlobalWafers (GW)
Foundation	1879	2001
Headquarter	Ireland	Taiwan
Number of employees	65,010	N/D
Revenues (\$, 2022)	33,36 bil	1,29 bil
What the company supplies to ST	Raw materials: technical gasses	Raw materials: silicon for microelectronics applications

Source: Orbis database; Companies' reports

Table 20. Details on data collection

Category	Type	Details
Interviews	Interview with Supply Chain – Executive Vice President, STMicroelectronics	Theme: GVC resilience 14 pages, font size 12, Times New Roman, double-spaced
	Interview with <ul style="list-style-type: none"> ● Supply Chain – Executive Vice President, STMicroelectronics ● Supply Chain, Planning & Operations - Financial Controls and Compliance Director, STMicroelectronics 	Theme: how resilience and sustainability interact in the GVC; role of the relationship with suppliers 9 pages, font size 12, Times New Roman, double-spaced
	Interview with Supply Chain, Planning & Operations - Financial Controls and Compliance Director, STMicroelectronics	Theme: Clarification on how ST structures the relationships with suppliers for sustainability and resilience goals 13 pages, font size 12, Times New Roman, double-spaced
	Interview with Linde Executive Account Director	Theme: GVC resilience 10 pages, font size 12, Times New Roman, double-spaced
	Interview with Linde Executive Account Director	Theme: how resilience and sustainability interact in the GVC 14 pages, font size 12, Times New Roman, double-spaced
	Interview with <ul style="list-style-type: none"> ● VP of Marketing, EU and Singapore Regional Sales Director, GlobalWafers ● Procurement & Logistics Manager, Italy, Globalwafers 	Theme: GVC resilience 17 pages, font size 12, Times New Roman, double-spaced
	Interview with <ul style="list-style-type: none"> ● VP of Marketing, EU and Singapore Regional Sales Director, GlobalWafers ● ESG manager, MEMC Electronic Materials Spa, GlobalWafers 	Theme: how resilience and sustainability interact in the GVC 20 pages, font size 12, Times New Roman, double-spaced
	Interview with <ul style="list-style-type: none"> ● VP of Marketing, EU and Singapore Regional Sales Director, GlobalWafers ● Procurement & Logistics Manager, Italy, Globalwafers ● ESG manager, MEMC Electronic Materials Spa, GlobalWafers 	Theme: how resilience and sustainability interact in the GVC; the role played by relationships 16 pages, font size 12, Times New Roman, double-spaced

Corporate Reports	ST Sustainability reports	1998-2023, 1.995 pages
	ST annual reports	1995-2022, 5.092 pages
	GlobalWafers CSR/ESG reports	2017-2021, 427 pages
	GlobalWafers yearly Financial reports	2017 (first report available in English)-2023, 481 pages
	Linde Sustainable Development Reports	2017-2021, 596 pages
	Linde yearly Financial reports	2018-2022, 674 pages
Field Notes	Author's personal notes for the "ST Sustainability days" event in (4/05/2023)	Includes <ul style="list-style-type: none"> interaction with suppliers, clients and research institutions that were present at the event and ST Foundation Panel session featuring ST executives and stakeholders on the theme of sustainability
	Recording of the launch event for "Fondazione Chips.it", the Italian center for semiconductor integrated circuit design (03/11/2023)	71 pages, font size 12, Times New Roman, double-spaced Featuring: <ul style="list-style-type: none"> Institutional presence: Minister of Economy (Italy); Minister of Economic Development (Italy); Minister of University and Research (Italy); Director-General for Communications Networks, Content and Technology (European Commission) Executives presence: Infineon, Intel, Inventvm, Sony, and STMicroelectronics
	Author's personal notes for the lectio magistralis by Jean-Marc Chéry, President and CEO in STMicroelectronics, at the academic year opening event of University of Pavia (20/11/2023)	Theme: "Technology innovation addressing societal challenges"
Other Sources	Newspapers articles, retrieved from NexisUni	<i>"semiconductor*" AND "resilien*" AND "sustainab*"</i> <ul style="list-style-type: none"> Total results: 719 Timeframe: 1997-2023 Per geographical area: <ul style="list-style-type: none"> Africa: 0,8% Asia: 53,3% Australia: 1% Europe: 17,2%

		<ul style="list-style-type: none"> ○ Middle East: 1,7% ○ North America: 10,8% ○ South America: 13,4% ○ International: 1,3% <p><i>"semiconductor*" AND "government*" AND "sustainable development"</i></p> <ul style="list-style-type: none"> ● Total results: 348 ● Timeframe: 1995-2023 ● Per geographical area: <ul style="list-style-type: none"> ○ Africa: 3,5 ○ Asia: 57,1% ○ Australia: 0,3% ○ Europe: 6,9% ○ Middle East: 1,2% ○ North America: 12,4% ○ South America: 17,6% ○ International: 1,2% <p><i>"STMicroelectronics" AND "resilien" AND "sustainab*"</i></p> <ul style="list-style-type: none"> ● Timeframe: 2014-2023 ● Total results: 10 (only Asia and South America)
	Industry reports	<p>Deloitte (2022). “2022 semiconductor industry outlook”</p> <p>OECD (2019-12-12), “Measuring distortions in international markets: The semiconductor value chain”, OECD Trade Policy Papers, No. 234, OECD Publishing, Paris. http://dx.doi.org/10.1787/8fe4491d-en</p>
	Marco Bardazzi (2022). <i>“Silicon Europe”</i> . Rizzoli	The book details STMicroelectronics history from its origins and contextualizes it in the development of the European semiconductor industry.
	Chris Miller (2022). <i>“Chip War. The fight for the world’s most critical technology”</i> . Simon & Schuster	The book explains how the semiconductor came to play a critical role in modern life and how the US became dominant in chip design and manufacturing and applied this technology to military systems. In particular, the book takes a geopolitical perspective to the development of the semiconductors industry.
	“European Chips Act” documentation of the European Commission	<ul style="list-style-type: none"> ● European Chips Act Factsheet ● COMMISSION RECOMMENDATION (EU) 2022/210 of 8 February 2022 on a common Union toolbox to address

		<p>semiconductor shortages and an EU mechanism for monitoring the semiconductor ecosystem</p> <ul style="list-style-type: none"> ● COMMISSION STAFF WORKING DOCUMENT. A Chips Act for Europe. ● Proposal for a COUNCIL REGULATION amending Regulation (EU) 2021/2085 establishing the Joint Undertakings under Horizon Europe, as regards the Chips Joint Undertaking ● European Chips Survey Report ● European Chips Act - Questions and Answers ● PROPOSAL FOR A REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework of measures for strengthening Europe's semiconductor ecosystem (Chips Act)
	“Chips and Science Act” documentation of the U.S.A Congress	PUBLIC LAW 117-167—AUG. 9, 2022
	Other governmental sources	<ul style="list-style-type: none"> ● Dipartimento per la programmazione e il coordinamento della politica economics (Italy) (2023). “La Resilienza delle “Global Supply Chain”: Semiconduttori e Materie Prime Critiche” ● Ministère de l’Economie, des finances et de la souveraineté industrielle et numérique (France) (2023). “COMMUNIQUE DE PRESSE N°904” ● Ministero dell’Economia e delle Finanze (Italy) (2023). “Comunicato Stampa 0042”
	Policy documentation on semiconductors and sustainability	<ul style="list-style-type: none"> ● European Commission (2021). “2030 Digital Compass: the European way for the Digital Decade” ● European Commission (2022). “EU-US Joint Statement of the Trade and Technology Council” ● U.S. Department of Energy (2022). “U.S. Department of Energy Response to Executive Order 14017, “America’s Supply Chains”
Scientific papers	Scientific paper citing STMicroelectronics, retrieved from SCOPUS	<p>Search string: TITLE-ABS-KEY ("STMicroelectronics") AND (LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (SRCTYPE , "j"))</p> <p>1. Benassi, M., & Landoni, M. (2019). State-owned enterprises as knowledge-explorer agents. <i>Industry and Innovation</i>, 26(2), 218-241.</p>

		<ol style="list-style-type: none"> 2. Lutz, M., & Boucher, X. (2017). Data-driven decision-making for IT capacity: beyond statistical analyses. <i>Journal of Decision Systems</i>, 26(1), 1-24. 3. Kokshagina, O., Le Masson, P., Weil, B., & Coge, P. (2016). Portfolio management in double unknown situations: Technological platforms and the role of cross-application managers. <i>Creativity and Innovation Management</i>, 25(2), 270-291. 4. Baglieri, D., Cinici, M. C., & Mangematin, V. (2012). Rejuvenating clusters with 'sleeping anchors': The case of nanoclusters. <i>Technovation</i>, 32(3-4), 245-256. 5. Bhatti, K. M., & Khalid, S. (2021). Rent-seeking behaviour: knowledge transfer as informal control mechanism in high technology alliances. <i>International Journal of Business and Globalisation</i>, 27(1), 15-31. 6. Kokshagina, O., Gillier, T., Coge, P., Le Masson, P., & Weil, B. (2017). Using innovation contests to promote the development of generic technologies. <i>Technological Forecasting and Social Change</i>, 114, 152-164. 7. Cesaroni, F., & Piccaluga, A. (2013). Operational challenges and ST's proposed solutions to improve collaboration between IP and R&D in innovation processes. <i>California Management Review</i>, 55(4), 143-156. 8. Bricchi, M., Mandran, N., Gzara, L., Dupuy-Chessa, S., & Rozier, D. (2014). Wiki for knowledge sharing, a user-centred evaluation approach: a case study at STMicroelectronics. <i>Journal of Knowledge Management</i>, 18(6), 1217-1232. 9. Wang, C. C., Sung, H. Y., Chen, D. Z., & Huang, M. H. (2017). Strong ties and weak ties of the knowledge spillover network in the semiconductor industry. <i>Technological Forecasting and Social Change</i>, 118, 114-127. 10. Boucher, X., Chapron, J., Burlat, P., & Lebrun, P. (2011). Process clusters for information system diagnostics: an approach by Organisational Urbanism. <i>Production Planning and Control</i>, 22(1), 91-106. 11. Cassiman, B., Di Guardo, M. C., & Valentini, G. (2009). Organising R&D projects to profit from innovation: Insights from co-opetition. <i>Long range planning</i>, 42(2), 216-233.
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3.3 Data analysis

The analytical approach of the study is developed in accordance with best practices in management studies (Bjerregaard & Klitmøller, 2016; Fournier & Eckhardt, 2019; Danneels, 2011) and IB in particular (Geary & Aguzzoli, 2016). By adopting the ECM protocol, data analysis started with a first round of exploratory coding of collected data (recollections from the field, field notes, interviews, etc.), which allowed the identification of relevant themes. Subsequently, another round of coding of higher theoretical level of abstraction (Gioia, Corley, & Hamilton, 2013) was carried out, in which the author went back and forth between empirics and theory (i.e. global factory framework and resource dependency theory), in order to identify possible anomalies and variations from existing theory (Nguyen & Tull, 2022). Finally, findings were reviewed and refined through a process of contextualization in the macro-environment.

4. Findings

4.1 Touchpoints between resilience and sustainability

The first insight emerged from data analysis that confirms my assumption of a synergy between resilience and sustainability objectives is the presence of the “Resilience Management System” (RMS) in ST sustainability reports. In fact, the word “resilience” appears for the first time in 2018 in the reports, as an evolution of the business continuity concept, which has been present since 2014. The link between sustainability and resilience was hinted by ST in its Sustainability report:

«Sustainability is a driver of our resilience, competitiveness and long-term success. It empowers value creation while reducing risks for us and our stakeholders» (ST, Sustainability Report, 2020)

This overlap appear particularly evident for what concerns environmental sustainability:

«For example, by promoting energy and resource efficiency, STMicroelectronics and its suppliers have been able to reduce costs and improve their ability to manage fluctuations in energy and raw material prices. By promoting transparency and responsible sourcing practices, STMicroelectronics has been able to reduce the risk of supply chain disruptions and improve its ability to manage risks related to environmental and social issues». (ST)

The meaning of this very intertwined link between resilience and sustainability was actually made explicit during an interview with one of ST suppliers:

«The link between continuity of supply and the risk associated with a deviation from a sustainability are inevitable» (GW)

Therefore, it appears that it is actually the deviation from sustainable practices that would reduce resilience: not adhering to social and environmental standards in an ever-changing environment, where these standards are continuously updated, means to put at risk the business continuity of the value chain.

Moreover, in ST case, sustainability and resilience present an overlap for geopolitical issues that concern the semiconductor industry.

Being a sector of strategic importance, the semiconductor industry has been the center of interest of political debates in the last few years. As testified by the “European Chips Act” and “Chips and Science Act” in the U.S.A., governments are encouraging the regionalization of the semiconductor value chains because of the increasingly tense climate in international relationships. At the same time, the possible shortening of the semiconductor value chain is considered as benefiting the environmental sustainability cause.

However, in the case of ST, regionalization is not advisable, for two main reasons. First, Europe lacks necessary resources that would be needed for the regionalization of the semiconductor value chain:

«Europe is the one that certainly has excellence from an equipment point of view. [...] But then from the point of view of both production capacity and especially materials, Europe is not in a very good position. [...] Given the fragmentation of

the availability of materials, IP and equipment that have been built over the decades, no one can afford complete regionalization. [...] » (ST)

Therefore, an important issue is that different parts of the world have specialized in different value chain activities, rendering impossible regionalizations, at least in the short term.

Second, because of how it is structured, the semiconductor industry, that heavily relies on partnerships in order to reach very high levels of capital investments:

«Becoming completely integrated is impossible in a market like ours and unfortunately I must say that the more we continue with this regionalization discussion, the more growth will slow down, due to the impossibility of sharing what we are developing.» (ST)

The European Chips Act - which is the most relevant to ST, since it is a French-Italian company - does take into consideration this issue. In fact, the act proposes to encourage the “building [of] semiconductor international partnerships with like-minded countries”.

However, since the geopolitical environment has been extremely volatile, such a vague definition of investment scope (i.e. “like-minded countries”) makes it difficult for semiconductor companies to strategize with long-term capital commitments.

The lack of resources, at a global level however, is also evident in the shortage of skilled workers that have plagued the semiconductor industry for quite some time. On the one hand, this shortage represents a disruption risk. To provide a magnitude of the problem it is important to note that at the end of 2022 ST had over 5000 job openings unfulfilled. This poses a serious threat to business continuity in the long term. This aspect was specifically recognized by ST:

«Today more than ever, if a country or a continent does not invest decades in advance in human resources, it cannot think of supporting a high-tech market by deciding and investing only in production capacity.» (ST)

This aspect, especially in some parts of the world, is directly connected to social sustainability and specifically the SDG 4, i.e. to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Overall, resilience and sustainability present overlapping challenges for what concerns environmental and social issues. Moreover, they are both affected by geopolitical tensions.

4.2 Influence of supplier size

Data analysis supports my assumption on the need for a “systemic approach” to sustainability and resilience in the case of ST. For example, long-term sustainability goals are periodically identified and aligned in collaboration with third parties, i.e employees, customers, investors, suppliers, local partners, national and local authorities, academic entities, industry associations, and media. These goals are set by ST following a “materiality exercise”, where the company proposes potential issues and stakeholders rate their priority according to their experience through a survey. Moreover, also in the case of resilience, collaboration with third parties in the value chain appears crucial. Both during the pandemic and the outbreak of the Russia-Ukraine war, for example, the company activated a Corporate Crisis Team (CCT), whose functions included:

«adapting and executing our business continuity plans, actively managing the situation across our whole supply chain, and working closely with our customers, suppliers, and partners» (ST, Sustainability Report 2023)

The relationship with suppliers appears to be at the forefront in the analysis. It emerges as pivotal in the address of both resilience and sustainability goals for ST:

«By promoting sustainability and responsible business practices throughout its supply chain, STMicroelectronics has been able to build stronger relationships with its suppliers and contractors based on shared values and goals» (ST)

Overall, what emerged from data analysis is the need to develop well-rounded partnerships with suppliers - including subcontractors - to address both sustainability and resilience in the value chain. One example of how these partnerships are developed is the commitment of both parties in shared investments:

«[...] outsourcing can become something [in which] you co-invest. We are moving towards a partnership, where you can put in either money or technologies that

you make available to the foundry. There are more and more companies that are willing to do this. We share a certain technology, they provide a certain production capacity: the combination allows us to manage a part of the business with a production capacity, which they have, as well as being able to use the technology that is made available» (ST)

What emerged, in fact, is that ST believes there is a need to shift from a mere contractual relationship to more strategic partnerships with suppliers. This approach results functional not only to enhance value creation in the semiconductor industry, but also to achieve sustainability and resilience in the value chain.

In general, for what concerns sustainability, ST has enabled supplier engagement programs that:

« [...] promote sustainability and responsible business practices [...] this includes regular communication and collaboration on sustainability issues, as well as joint initiatives to improve sustainability performance throughout the supply chain.» (ST)

For what concerns resilience, ST shares its “Business Continuity Plans” with suppliers for increased coordination in case of disruption and supports them in case of disruptions by sharing best practices. For example, this was the case during the pandemic: the CCT developed the company’s global response by taking the lead of local crisis teams at regional, country and site levels to address the complexity of local conditions. In some cases, this meant training local partners to develop control and tracing techniques and reduce the spread of the infection, in order to ensure business continuity. The building of collaborative relationships and the sharing of best practices for resilience is complementary to the activity of training and resource sharing ST has developed for addressing sustainability issues with value chain actors.

However, data analysis revealed how, specifically for what concerns resilience and sustainability, ST adopts different approaches to these partnerships, according to the supplier's size, in terms of availability of resources.

According to ST experience, larger suppliers may have more resources and capabilities to implement comprehensive sustainability programs and they can also have more influence to direct the sustainability practices of their suppliers and contractors in turn.

This is also evidenced from Linde's experience:

«Customers usually require us to sign a code of conduct. [...] We believe we have a more advanced system than this, since they are very general systems. For sustainability there is one of the main indices which is the Dow Jones Sustainability Index. [...] I must say that today we - together with a few competitors - are the leaders. So, when customers say something [about signing the code of conduct], I just send them our various sustainability reports.» (L)

This quote also prefaces another finding that emerged for data analysis. In fact, ST employs the power-asymmetry in the relationship with the suppliers by requiring suppliers to achieve a set of internationally recognized certifications for both sustainability and resilience. In the case of sustainability, for example, ST requires suppliers to adhere to the Responsible Business Alliance (RBA) Standards. For resilience, ST encourage suppliers to achieve ISO certifications, such as ISO 22301 (i.e. Societal security – Business Continuity Management Systems) and ISO 31000 (Risk Management),

However, smaller suppliers may encounter more difficulties in adhering to ST requirements in terms of sustainability:

«smaller local companies may have fewer resources and less ability to implement comprehensive sustainability programs and may be less familiar with international sustainability standards and regulations. As a result, sustainability activities targeting local small businesses may need to be adapted to their specific needs and circumstances.» (ST)

This is also reported by Global Wafers experience:

«We don't have the internal skills, so we are somehow forced to look for external help. They are often not simple issues, also linked to regulatory evolution.» (GW)

Therefore, for these suppliers that often lack the necessary resources and knowledge, ST has developed responsible supply chain program -including both training and support - to help them improve their sustainability performance:

«this includes providing guidance on sustainability best practices and offering tools and resources to help suppliers measure and monitor their sustainability performance.» (ST)

In this sense, it is relevant to point out one instance of this support on behalf of ST that happened during the pandemic:

«At our Muar site (Malaysia), we granted salary advances to the most economically vulnerable categories of employees, in particular migrant workers, to anticipate their basic needs and enable them to better prepare for lockdown measures. We also made sure that similar protection measures were put in place by our direct suppliers in Malaysia, for whom we introduced a training program to increase awareness of our social standards.» (ST, Sustainability report, 2021)

This approach is replicated for what concerns resilience. In fact, resilience and sustainability are considered such synergies in ST value chain, that in 2022 the company set up a new organization under the procurement department, called Third-Party Management (TPM). This organization has dedicated resources for enhancing supplier onboarding, monitoring, and assessment capacities for both business continuity and sustainability risks. The benefits of this new governance structure include:

«more resources to support our responsible supply chain program, more synergies and leverage with procurement, more effective organization and consistent processes, and alignment across all organizations» (ST, Sustainability Report, 2023)

5. Discussion

The aim of the present study is to understand how sustainability and resilience interact in GVC as strategic objectives, consequently contributing to the nascent debate in IB literature (Napier et al., 2023; Contractor, 2021). In particular, the investigation focuses on how power asymmetries between MNEs and their suppliers influence the design of resilient and sustainable GVCs.

First, the study provides empirical support to the existing synergy between resilience and sustainability in GVCs. The findings propose that sustainability can be conceived as an antecedent of resilience in the GVC context: when MNEs encourage suppliers to implement

sustainable practices - social and environmental - both actors enhance their resilient responses in case of disruption.

This analysis is particularly evident in the case of geopolitical risks. For example, the choice of alternative energy sources along the value chain is an environmental sustainability practice, but at the same time it allowed the mitigation of the negative effects of disruption such as the Russia-Ukraine war. Therefore, I formulated the following proposition:

Proposition 1. The adoption of sustainable practices by the MNE and its suppliers before the disruption ($t-1$) is associated with their resilient response when confronted with disruptions (t).

In this sense, findings in this study further confirm the processual and dynamic nature of resilience that has been proposed at the organizational level (Conz & Magnani, 2020; Ambulkar et al., 2015). In particular, the findings propose that the synergy between sustainability and resilience in GVCs is developed before the disruption (i.e. at time $t-1$), with the enactment of sustainable practices along the value chain that contribute to its resilience.

Moreover, the findings are directly associated with the preparedness perspective of GVC resilience (Ali et al., 2022; Orlando et al., 2022).

Second, findings propose that power-asymmetries between the orchestrator and the suppliers play a role in achieving sustainability and resilience at the GVC level. It is important to note how the semiconductor industry is very concentrated, with a relatively small number of producers interfacing with a large number of suppliers. In fact, findings show how the orchestrator may pose the signature of a code of conduct for resilience or the achievement of a business continuity certification as a condition for the contractual relationship. Therefore, findings recognize as relevant for both resilience and sustainability in GVCs the RDT construct according to which the stronger party in the relationship can influence the behaviour of the other (Cox, 1999; Reimann & Ketchen, 2017; Strange & Humphrey, 2019).

With this premise, the second proposition follows:

Proposition 2a. MNEs can exploit contractual power vis-a-vis their suppliers to positively influence their implementation of sustainable practices, which enhance resilient responses of both parties to disruptions in the value chain.

This insight is contextualized within the MNE-supplier power dynamics literature and it widens the ways in which MNEs can exert power over their suppliers by controlling the terms of the relationship (Murphree & Anderson, 2018). In particular, this study integrates the signature of code of conduct to a list that already includes negotiation of favourable terms with suppliers, such as lower prices, longer payment terms (Brito & Miguel, 2017; Crook & Combs, 2007; Pfeffer & Salancik, 1978)

However, findings also show that the orchestrator's influence over supplier behaviour for the adoption of sustainable practices is effective only if the supplier possesses the resources to implement them. In fact, suppliers - especially smaller firms, like SMEs - may lack the necessary resources or capabilities (e.g. know-how) to abide by the orchestrator's requirements. Therefore, I formulated a third proposition, directly connected to the previous one:

Proposition 2b. The relationship between the MNE's contractual power over the supplier behaviour and the supplier's implementation of sustainable practices is moderated by supplier's resources and capabilities.

Therefore, while the RDT perspective remains relevant, findings show that it does not provide a complete representation of the GVC mechanisms that associate sustainability and resilience. According to RDT, larger suppliers have more resources and capabilities, which can make them less dependent on any particular MNE customer: this can give them more bargaining power in negotiations with MNEs, as they have more alternatives for selling their products or services (Provan & Gassenheimer, 1994). On the other hand, smaller suppliers may be more dependent on MNEs for their revenue and survival (ibid): this can give MNEs more power in their relationships with smaller suppliers, as they may have fewer alternatives for selling their products or services. While this study confirms this fundamental prescription,

it also integrates the issue of smaller suppliers lacking the means to implement MNEs requirements. In fact, findings show that knowledge exchanges (e.g. training, exchange of best practices, direct support) between the MNE and the suppliers are crucial for enhancing supplier's capabilities for the implementation of sustainable practices and, consequently, a resilient response to disruption for both parties. Therefore, findings associate resilience to inter-organizational learning processes within GVCs (Mohr & Segupta, 2002; March, 1991).

On this basis, I formulate one last proposition:

Proposition 3. Inter-organizational learning occurring between the MNE and its suppliers positively influences suppliers' capabilities for the adoption of sustainable practices, enhancing resilient responses of both parties to disruptions in the value chain.

It is important to note how these findings are related to the theme of supplier upgrading in the GVCs (Choksy et al, 2022; Sinkovics et al., 2018). According to previous studies, participating in GVCs provides suppliers with the opportunity to learn new techniques, develop more sophisticated products and perform more value added activities (Humphrey & Shmitz, 2000). Upgrading has been increasingly associated with sustainability, posing that, through learning in their inter-organizational relationships in GVCs, suppliers might change their activities to achieve higher sustainability performance (Gereffi, 2019). By showing that in this approach resilience and sustainability are synergistic in GVCs, findings propose that supplier upgrading should be also included in the investigation of GVC resilience.

Finally, this last proposition also contributes to clarifying the existing link between supplier upgrading - which has been consistently linked to sustainability - and inter-firm managerial governance adaptations - which have been recently associated with GVC resilience (Kano et al., 2022).

6. Concluding remarks

6.1 Theoretical implications

The contribution of this study to literature is twofold

First, to the best of my knowledge, this is the first study to empirically lay out the links between sustainability and resilience in the value chain (Ghauri, 2022).

The debate surrounding the interaction of resilience and sustainability for MNEs is a topic of significant interest in the IB field. Both scholars (Ku et al., 2020; Luo & Van Assche, 2023; Luo, 2022) and practitioners (WTO, 2023; Forbes, 2023) have engaged in discussions to understand the complex relationship between these two crucial aspects within the context of MNE operations. In particular, a recent debate has emerged revolving around how MNEs can effectively integrate resilience and sustainability into their strategies and operations. On the one hand, there is the belief that a strong focus on sustainability can enhance resilience by fostering stakeholder trust, mitigating risks, and ensuring long-term viability (Sindhwani et al., 2024; Nobre, 2024). On the other hand, there is the belief that resilience measures, such as robust supply chain management and crisis response mechanisms, can indirectly contribute to sustainability by safeguarding operations and minimizing negative impacts on the environment and society (Corrales-Estrada et al., 2021). The present study contributes to this ongoing debate by providing empirical evidence that supports sustainability practices as antecedents of value chain resilience. Moreover, sustainable practices can be considered as part of the GVC design before the disruption, contributing to the GVC preparedness to react to a disruption. In so doing, this study also constitutes empirical support to the dynamic and processual perspective of resilience (Conz & Magnani, 2020; Napier et al., 2024)-

Secondly, a key contribution of the study is its adoption of a RDT perspective, as advocated by Pfeffer and Salancik (2015). This theoretical lens offers a nuanced understanding of the power dynamics, resource disparities, and capabilities among stakeholders in the value chain

(Pfeffer & Salancik, 2015). By emphasizing these aspects, the research underscores the importance of addressing power imbalances and resource discrepancies in fostering both sustainability and resilience.

Moreover, findings show how, on matters of resilience and sustainability in the GVC, the RDT perspective should be integrated with two additional concepts: inter-organizational learning processes and supplier upgrading.

On the one hand, findings associate resilience to inter-organizational learning processes within GVCs (Mohr & Segupta, 2002; March, 1991). In particular, this study supports knowledge exchanges in the form of training, exchange of best practices, and direct support in the MNE-supplier relationships for the implementation of sustainable practices which, in turn, determine a resilient response to disruption for both parties.

On the other hand, this study emphasizes the link between supplier upgrading and resilience and sustainability within GVCs (Choksy et al, 2022; Sinkovics et al., 2018).

Supplier upgrading has been increasingly tied to sustainability, as suppliers can enhance their sustainability performance by modifying their activities through learning in GVCs' inter-organizational relationships (Gereffi, 2019). By demonstrating that resilience and sustainability are interconnected and mutually reinforcing in GVCs, this study suggests that supplier upgrading should be considered in the investigation of GVC resilience. This approach highlights the significance of integrating sustainability and resilience in supplier upgrading to improve the overall performance and resilience of GVCs

6.2 Managerial implications

The present study also presents practical contributions for managers.

First, since sustainability is recognized as an antecedent of resilience, the commitment companies make for sustainability could start to be considered less functional, i.e. to the achievement of required standards, and more strategic, i.e. to the company's performance. In

particular, the introduction of sustainable standards across the extended value chain, such as the signature of a code of conduct by suppliers, can be associated with the enhancement of resilience within GVCs.

Second, the study also conveys how sustainability and resilience are strategic objectives that can be addressed using complementary practices in the management of third parties in the value chain. In particular, the present study encourages the adoption of supplier upgrading and inter-firm knowledge transfer practices as strategies that MNEs can implement in order to address sustainability and resilience challenges across the value chain.

6.3 Limitations and avenues for future research

Being an exploratory investigation, the present study also presents a number of limitations. First, the choice of the Extended Case Methodology has been functional to the identification of relevant themes in the study of such an intricate issue. However, the contextualization of the analysis in one company in a single sector inevitably limits the transferability of findings. Moreover, since according to the adopted methodology the environment has an explanatory power over the phenomenon, the single case investigates company embedded in the European context a. Therefore, future studies could explore the issue using a multiple case study methodology, addressing a larger number of firms in order to identify possible partners that are shared among different organizations

Appendix A3: STMicroelectronics

The single-case study features STMicroelectronics (ST), which is one of the world's largest semiconductor companies. ST is a French-Italian company that designs, develops, manufactures, and markets a broad range of products for four main markets, i.e. automotive, industrial, personal electronics and communications equipment, computers, and peripherals. Moreover, the company's products are employed in Smart Mobility applications, and in Internet of Things ("IoT") technologies. In 2022, the company served more than 200,000 clients. ST is an R&D-intensive company, as signalled by the high number of registered and pending patents (18,500) and by the number of employees that operate in the R&D division (17,5% of the total).

The company's value chain is organized in a matrix structure, with geographic regions interacting with product groups. Both geographic regions and product groups are supported by shared technology and manufacturing operations and by central functions. Because of its strategic role, R&D is carried out in-house, within innovation centers that allow the company to quickly and cost-effectively introduce new products in the market. These innovation centers are located in North America, Europe, and South-East Asia. Moreover, ST value chain involves three critical types of suppliers: (i) equipment suppliers; (ii) raw materials suppliers; (iii) external silicon foundries and back-end subcontractors to outsource parts of wafer manufacturing and assembly and testing of finished products. Nevertheless, ST directly operates 7 front-end and 7 back-end manufacturing sites, which are located in Europe, Asia, and North Africa. Overall, ST procures materials, goods, and services from approximately 6,500 tier 1 suppliers of various types and sizes. Sales and marketing activities are organized as a combination of regional and key account coverage. The three regional sales units report to the headquarters and are located in the Americas, South-East Asia, and EMEA regions.

Finally, distribution is carried out by third parties, i.e. distributors and sales representatives.

ST is an unique case for this investigation for two reasons: first, sustainability is one of its strategic pillars and the company has significantly addressed sustainability challenges for at least three decades, which is unique in the semiconductor industry; second, the company governance structure features a dedicated “Audit, ERM & Resilience” which reports to the Chairman of the Supervisory Board Audit Committee and dotted line to the CEO, highlighting how resilience constitutes a relevant strategic area for ST.

Appendix B3: Interview Protocols

STMicroelectronics

First interview

1. Could you provide a brief description of your company's value chain?
 - a. The input-output structure of the value chain;
 - b. The geographical dispersion of the activities of the upstream and downstream value chain);
 - c. The governance structure: which value chain activities are outsourced? To whom? In which countries? Why? Are they strategic activities for the company? Why?
 - d. What are the main institutional factors (e.g. dependent on foreign and national governments, international institutions...) that influence the structure of the value chain?
2. What are the most important risks related to value chain activities that concern your company?
3. What have been the most important value chain disruptions?
4. Do you feel that the geographic dispersion of value chain activities in your company has influenced how you have addressed these disruptions? If yes, in what way?
5. Do you think the governance structure (i.e. whether activities are performed in-house versus outsourced) of value chain activities in your company influenced how you addressed these disruptions? If yes, in what way?
6. Does your company adopt digital technologies to monitor value chain activities? If so, do you think they had an impact on how your company dealt with these disruptions?
7. Have there been any changes in your company's value chain pandemic regarding governance structure and/or geographic dispersion, following a disruption? If so, do you think these changes are short, medium or long term?
8. Have there been any other changes in the value chain to report?
9. According to company experience, what characteristics must a value chain possess to be "resilient" to unexpected events?
10. What is the role of other actors involved in the value chain, including small businesses (SMEs) to which your company outsources activities? Have these actors played a role in the resilience of your value chain?
11. More generally, according to company experience, does the relationship with key suppliers influence the value chain's ability to manage unexpected events? If yes, in what way?
12. In your company's experience, can creating a resilient value chain have an impact on company performance?

Second interview

1. What is value chain sustainability for STMicroelectronics?

2. The theme of resilience has been present in the ST Sustainability reports for years. In your experience, why should resilience be included in a company's sustainability approach?
3. Focusing on suppliers/subcontractors, what sustainability activities does ST carry out?
4. How have these types of activities influenced the type of relationship that ST has with suppliers/subcontractors?
5. Is there a difference in how these activities are carried out based on the size of the company they relate to? (e.g. if the supplier is another large multinational or a smaller local company)
6. In ST's experience, have the activities the company carries out in the field of sustainability in any way affected the value chain's ability to react to external shocks? If yes, in what way?

Suppliers

First interview

1. Could you provide a brief description of your company's value chain?
 - a. The input-output structure of the value chain;
 - b. The geographical dispersion of the activities of the upstream and downstream value chain);
 - c. The governance structure: which value chain activities are outsourced? To whom? In which countries? Why? Are they strategic activities for the company? Why?
 - d. What are the main institutional factors (e.g. dependent on foreign and national governments, international institutions...) that influence the structure of the value chain? What type of relationship does your company have with STMicroelectronics?
2. What are the most important risks related to value chain activities that concern your company?
3. What have been the most important value chain disruptions?
4. Do you feel that the geographic dispersion of value chain activities in your company has influenced how you have addressed these disruptions? If yes, in what way?
5. Do you think the governance structure (i.e. whether activities are performed in-house versus outsourced) of value chain activities in your company influenced how you addressed these disruptions? If yes, in what way?
6. In your experience, which aspects (formal and informal) of your company's relationship with STMicroelectronics have influenced operational continuity?
7. Does your company adopt digital technologies to monitor value chain activities? If so, do you think they had an impact on how your company dealt with these disruptions?

8. Have there been any changes in your company's value chain as a result of disruptions regarding governance structure and/or geographic dispersion? If so, do you think these changes are short, medium or long term?

9. Have there been any other changes in the value chain to report?

10. According to company experience, what characteristics must a value chain possess to be "resilient" to unexpected events?

11. In your company's experience, can creating a resilient value chain have an impact on company performance?

Second interview

1. What is value chain sustainability for your company?

2. How are the company's sustainability objectives chosen?

3. How are the company's sustainability objectives contextualized within the value chain?

4. In the company's experience, have the activities carried out in the field of sustainability in any way influenced the ability of the value chain to react to external shocks? If yes, in what way?

Third interview

A third interview was conducted only for GlobalWafers. The interview followed the same themes as the second one and was needed for further clarifications.

CONCLUSION

The present doctoral dissertation aims at contributing to both theory and practice.

1. Theoretical contributions

As a result of my doctoral dissertation, each chapter provides contributions to theory.

The systematic review tries to contribute to GVC literature by developing a conceptual framework for GVC resilience that could represent the basis for further theoretical and empirical developments in the field. Overall, this chapter's contribution is tripartite. First, it provides a definition of resilience that applies to the GVC context, taking into consideration both governance structure and geographical dispersion (Buckley, 2004), which is lacking at the moment. Second, it identifies the actors and measurement approaches addressed by existing literature, complementing the organizational perspective of resilience (Hillmann & Guenther, 2021). This contribution is significant in pointing out the need to enlarge the investigation scope outside organizational resilience and address resilience in IB using a more systemic approach (Bansal et al., 2021). Third, by addressing the touchpoints between SC and IB literature, it reconciles resilience with the meanings of flexibility, robustness, adaptability, and agility, providing a theoretical framework applicable in future research.

In the second chapter, my investigations associates the topic of GVC resilience to the business model perspective, by adopting the Onetti et al. (2012) framework. This approach allows to disentangle the different levels of analysis and to achieve a better visibility in the study of the phenomenon. Moreover, findings allowed to detect how governance structure and geographical dispersion of the GVC can interact for what concerns GVC resilience. To the best of my knowledge, this is the first empirical investigation that testifies the interaction between the two structural dimensions of GVCs. Finally, by highlighting the relevance of resource-dependency dynamics in association with GVC resilience (Pfeffer & Salancik,

2015), the study also acknowledges how an industry specific characteristic can affect GVC resilience and, particularly, how this dynamic is connected to costs.

The third chapter empirically lays out sustainability and resilience can be addressed in a synergy in the GVC context. In particular, findings evidenced how a Resource Dependency Theory perspective is relevant when addressing both objectives, because of the role played by power asymmetries between parties and specifically differences in resources and capabilities (Pfeffer & Salancik, 2015). Finally, the study also conveys how both resilience and sustainability should be addressed in the debate about supplier upgrading in GVCs (Lee & Gereffi, 2015; Choksy et al., 2022; Pasquali, 2021).

I am aware that the present doctoral dissertation only partially covers the underlined research problems and gaps. However, I do hope that my contribution has offered significant insights for future research to take further steps in extending and improving the definition and conceptualization of GVC resilience in the international business field from theoretical, methodological, and empirical points of view.

2. Managerial contributions

The study also presents contributions to practitioners. First, by differentiating the GVC resilience building mechanisms according to the *modus*, *locus* and *focus* framework, the present study provides managers with a clear understanding of how resilience building mechanisms relate to each other and how they can be contextualized in their firm's GVC. Moreover, since sustainability is recognized as being relevant for resilience, the commitment companies make to sustainability could start to be considered in connection to the company's performance rather than an issue of compliance to standards. Finally, the study also conveys how sustainability and resilience are strategic objectives that can be addressed using complementary practices in the management of third parties in the value chain.

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