Reconfiguring International Manufacturing Networks in Times of Uncertainty: Towards a New Theoretical Framework

Abstract:

Purpose – Research on multinational enterprises (MNEs) is now more relevant than ever, as the world economy experiences financial stress spilling over into the real sector from the credit-constrained private sector, large trade imbalances from low public saving, and high volatility in energy prices. Concerns have emerged regarding resilience and agility in sustainable supply chains, prompting calls for MNEs to reconfigure their international manufacturing networks (IMNs) to respond to external disruptions in times of uncertainty. This paper addresses two critical research questions: *What is the impact of new external systems on IMNs? How can IMNs respond to the new external systems for dealing with the global economic crisis?*

Design/methodology/approach – The study adopts a qualitative case study approach by engaging with three MNEs based in Europe. Following a systematic thematic analysis process, we utilise a Context-Intervention-Mechanism-Outcome framework to develop our propositions.

Findings – The paper proposes a new theoretical framework to capture the interactions between IMNs and their external systems, namely, their international business environment. It provides six important IMN network reconfiguration mechanisms - E2E connection, vertical integration, localisation, diversification, simplification and streamlining, and building redundancy, alongside specific operating methods. The functions of the mechanisms result in enhanced IMN controllability, agility, resilience, and sustainability.

Originality – In addition to providing the important insights into the recent debate in the operations and supply chain management and international business literature. our case-based approach offers the core guiding/controlling principles for IMNs to deal with uncertainty.

Keyword: *International manufacturing networks, global supply chains, resilience, reconfiguration*

1. Introduction

The last decade has seen increasingly more complexity in the international business (IB) environment and concerns about climate change. Moreover, the recent global uncertainty driven by the pandemic and heightened geopolitical tensions and the ensuing disruptions of global supply chains have significantly altered the dynamic balance between globalisation and de-globalisation (Enderwick and Buckley, 2020; Luo and Tung, 2025). Indeed, the crises and challenges have highlighted the need to understand how firms' business processes and manufacturing networks are affected by external shocks. This is particularly relevant in multinational enterprises (MNEs) as these firms tend to face additional vulnerabilities that aggravate their responses to global shocks (Luo and Tung, 2025).

The impact of IB environment on the manufacturing industry is a well discussed topic in the supply chain and operations management literature. Notably, the term international manufacturing network (IMN) is used to describe a coordinated network of intra-firm factories located in different places (Cheng et al., 2021; Rudberg and Olhager, 2003; Shi and Gregory, 1998; Ferdows, 1997; Hayes and Whellwright, 1984). However, past research in its approach to analysing the IB environment originates in systems theory and appears to date back to a framework proposed by Skinner (1964). In particular, the framework identifies four **external systems**, namely, technical, economic, cultural, and political systems, as well as an **internal configuration**. The former (external systems) can be extended to the IB context, whereas the latter (internal configuration) refers to the structure and pattern of the manufacturing systems, later known as IMNs, affected by the external systems. Since then, many studies have focused on the impact of a specific external system (e.g. technology systems) on manufacturing processes in the context of globalisation (Badasjane et al., 2025; Birkel and Muller, 2025). There are also detailed IMN process and typologies (Cheng et al., 2021; Feldmann and Olhager, 2019; Shi and Gregory, 2005). However, existing studies often overlook the dynamic nature of economic conditions, particularly the role of the dynamics generated by transitions and crises in IMN efficiency and effectiveness (Fleish and von Dzengelevski, 2024; Shi et al., 2024).

Indeed, the IB environment is increasingly evolving and influenced by new information technologies, policy, and ethical concerns (Cohen and Lee, 2020; Ferdows, 2017; Luo and Tung, 2025; Witt *et al*., 2023). This requires a new theoretical understanding of agility and resilience in global supply chains (Gölgeci and Gligor, 2022; Islam and Lee, 2004; Witt *et al*., 2023). A series of recent papers have separately addressed some of these issues, including the analysis of the consequences of digital technologies for manufacturing operations (see Ahi *et al*. 2022; Badasjane et al., 2025; Birkel and Mulle, 2025) as well as an investigation on the impact of geopolitical uncertainties on business environments (see Li *et al*., 2022; Yang et al., 2025). Meanwhile, there are increasingly more studies that focus on sustainability transformations which are capable of changing institutional and market conditions (see Hu et al., 2025; Marano et al., 2024).

Nevertheless, the connection between internal and external systems in times of uncertainty remains as a gap in the literature. Current studies motivating the conceptualising of external systems for reconfiguring manufacturing networks have not considered a unifying framework featuring MNEs and the variation in the amount of uncertainty faced by decision makers. There is a lack of in-depth empirical studies in relation to global coordination, as recent debates emphasise a range of views over the new features of globalisation and the variations in its effects with respect to economic responses (Li *et al*., 2022; Luo and Tung, 2025). It is crucial to develop theoretical and practical insights regarding the MNEs' reaction to the current

disruptions (Buckley, 2022; Xu *et al*., 2023; Luo and Tung, 2025; Saretz and Friedli, 2024). Specifically, we need to understand the new principles to design IMN in order respond to the changing external systems (Buckley, 2023; Saretz and Friedli, 2024; Wieland *et al*., 2023).

To fill this gap, we ask the following research questions: *What is the impact of new external systems on IMNs? How can IMNs respond to the new external systems for dealing with the global economic crisis?* Based on data from multiple case studies, we propose a new theoretical framework that captures the dynamic interactions between IMNs and the evolving external systems. The novelty of our paper lies in the application to IMNs, the emphasis on identifying the external systems in the face of high uncertainty, and the study of decision makers' behaviour in an extended framework characterised by a well-articulated mechanism for supply and manufacturing network configuration. In addition, our case-based approach enables qualitative analysis supplemented by careful conceptualising of a framework that allows us to examine the mechanism through which global shocks impact on manufacturing systems, while gauging the real-world relevance of the impact of shocks. Similar studies are, to our knowledge, non-existent.

2. Literature Review

2.1 External Systems and Internal Configuration

Initially outlined in Skinner's (1964) framework, a manufacturing network is affected by four **external systems**: technical, economic, cultural, and political systems. Since the 1980s, the scope of external system has been expanded to the International Business (IB) context as the manufacturing sector has moved towards to a transnational phase. In recent years, technological advances such as Industry 4.0 technologies, big data analytics, and Internet-of-Things are transforming international trade, and thus MNEs' practice and business processes (Ahi *et al*., 2022; Badasjane et al., 2025; Birkel and Muller, 2025; Fang et al., 2023; Szelagowski and Berniak-Wozny, 2024). Meanwhile, green energy transition, decarbonisation, and resource constraints are forming a new system of driving forces for MNEs to redesign their manufacturing systems (Elia et al., 2021; Hu et al., 2025; Marano et al., 2024). Furthermore, the world has recently seen a rise in protectionism, turbulent geopolitical relations, and interventionism in national policies. The trade war for global leadership between the US and China has affected international trade and industrial policies, which has raised a growing attention in the IB research community in terms of global value chains and innovations and how MNEs can react (Vertinsky *et al*., 2023; Yang et al., 2025). Luo and Tung (2025) propose a multipolar geo-strategy framework for MNEs to adapt to specific needs of geopolitical regions. However, this conceptual framework has not been validated in an empirical context. Most recently, Miller et al. (2025) examine the impact of the US tariffs on global supply chains, highlighting the increase in the adjustment costs of MNEs' response to the tariffs.

Whilst external systems are changing, the concept of **internal configuration**, meaning the configuration of IMNs affected by the external systems also evolves. Manufacturing system is originally regarded as a factor level input-output transformation model (Hayes and Wheelwright, 1984). However, since the 1980s, with the internationalisation of MNEs and their supply network. For one thing, MNEs have developed their geographically dispersed factories by co-ordinating them into a synergetic network (Ferdows, 1997; Shi and Gregory, 1998; Cheng et al., 2021). For another, it becomes popular for companies to downsize and outsource their non-core business tasks and to set-up inter-firm collaborations, and thus forming global supply networks (Lamming et al., 2000). Accordingly, IMN literature also concerns network

capabilities and types. For instance, Shi and Gregory (1998) highlight four IMN capabilities, which are strategic resource accessibility, thriftiness, manufacturing mobility, and learning capability. This is recently advanced in a survey-based study that defines five distinct types of IMNs according to their capabilities: externally focused, unfocused, low-capability, internally focused, and all-round networks (von Dzengelevski et al., 2024). Through multiple case studies, Feldmann and Olhager (2019) categorise linear, divergent, convergent, and mixed structures as the taxonomy of IMNs. A follow-up study indicates that plant roles affect the effectiveness of IMN structures (Olager and Feldmann, 2022). Nevertheless, current IMN studies mainly concern network efficiency and effectiveness in a predictable condition without sufficiently consider IB policy changes and extreme external shocks (Fleish and von Dzengelevski, 2024; Shi et al., 2024). Still, tools and mechanisms are needed to mitigate the external risks that IMNs are facing (Saretz and Friedli, 2024).

2.2. Network Reconfiguration in Times of Uncertainty

The global fragmentation of supply chains creates more complexity and uncertainty, whereby calling for more research on network reconfiguration in the forms of regionalisation, and pursuing sustainability and resilience. Location decision is a key factor to global value chain efficiency and resilience (Buckly, 2004). The term is expanded to regionalisation, as researchers have examined an increasing reshoring trend (Cohen and Lee, 2020; Witt et al. 2023; Sacco et al., 2025) to centralise control. Indeed, intra-regional trade in global supply chains is far more regionalised than the label “global” suggests (Kano et al., 2020). However, this increases the risks of building regional technology walls (Elia et al., 2021) and is confronted to the limits of lack of local infrastructure, knowledge or qualified labour, the loss of ecosystem synergies that previously existed with global value chains and moving the reliance on global value chains further upstream, the increased cost of foreign sales and the exposure to domestic economies (Enderwick and Buckley, 2020). An empirical study focuses on the relationship between production footprint and profitability, indicating manufacturing in low-cost countries is not necessarily the best choice (von Dzengelevski and Netland, 2023). Most recently, Sacco et al. (2025) argue that reshoring approach has not necessarily enhance global value chain resilience, whereas different disruptions require different geographic configuration.

Meanwhile, sustainability has notably become another emerging topic with a focus on green supply chain management and the ecological impact of business processes globally (Abdallah and Al-Ghwayeen, 2019; Couckuyt and Van Looy, 2019; Hu et al., 2025). The transformation toward supply chain sustainability is affected by macro factors such as legal and societal pressures, alongside micro-process of bargaining power, managerial sensemaking, and transparency in shaping relationships between MNEs and their suppliers (Marano et al, 2024). To this end, two governance approaches are effective to promote supply chain sustainability: 1) assessment, meaning to evaluate supplier's compliance with sustainability standards, and 2) collaboration with suppliers to improve sustainability performance (Marano et al., 2024). Most recent empirical studies also highlight an integrated decision concerning organisational behaviour, technology and network changes to achieve decarbonisation and sustainability (Hu et al., 2025).

Furthermore, to achieve supply chain reliance, responsiveness and agility, useful toolsets include using redundant suppliers, bringing or keeping production in-house, and other supply-chain initiatives (Chopra and Sodhi, 2004). Namdar et al. (2022) propose four strategies to achieve supply chain resilience: acceptance, inventory slack, volume flexibility,

responsiveness and having capacity reserves. Diversification, meaning using multiple sourcing, is another method to mitigate risks of currency adjustment and supply chain disruptions (Cohen and Lee, 2020). Through multiple case studies, Bastl et al. (2025) identify entrepreneurial orientation as a critical factor to improve supply chain agility in times of uncertainty. It is suggested that companies should actively seek for new solutions for reducing lead time, developing new products and engaging with customers. From a focal firm aspect, organisational forecasting inaccuracies and organisational resistance to change are main obstacles to IMN resilience, whereas vertical integration and strong IT capabilities can be enablers Fleisch and von Dzengelevski (2024). From a developing country perspective, Islam and Chadee (2024) articulate the needs of adaptive governance in global supply chains to deal with exogenous shocks such as Covid-19. By investigating a medical device project during the Covid-19, Shi et al. (2024) argue that companies should rely on wider business ecosystem resource and relations to form a 'transformative' supply chain, to response to extreme conditions. Drawing on the theory of dynamic capabilities, Nikookar et al. (2025) highlight supply chain visibility, responsiveness, flexibility, and collaboration are essential important to resilience. It is noted that the study of supply chain resilience also needs to factor in social-ecological systems (Nikookar et al., 2025; Wieland *et al*., 2023).

3. Methods

The nature of this research requires the in-depth understanding of an emerging phenomenon, and key elements including details of external systems and internal configuration are understudied or unclear. Such a requirement is associated with a qualitative approach, and specifically multiple case studies can explore a nascent topic and extract the theoretical and practical insights from the data collected (Eisenhardt, 1989). The case selection criteria are: 1) the case organisations are MNEs which perform the production or coordinate manufacturing networks at an international level; 2) the case organisations have made changes in their international manufacturing footprint ; 3) changes involve the management of supply chain partners; 4) there is good access to data, e.g. interviewees, business reports that trace the companies' key IMN changes. Accordingly, three Europe-based manufacturing MNEs from the electrical equipment industry (see Appendix 1) are selected for in-depth investigation. As articulated by Eisenhardt (1989), theoretical sampling is a key principle in multiple case studies, meaning that cases are deliberately selected according to their potential to inform or refine a theory. These three cases all show the features of being disrupted by the external environment (e.g. tariff, sustainability regulations, digital transformation) in the recent 10 years, and they have all redesigned their manufacturing networks (e.g. production relocation, new supplier involvement) to enhance resilience. Thus, the three cases can provide rich theoretical and practical insights, serving a reasonably common representation of the industry (Badasjane et al., 2024). Findings can potentially be applicable to broader scenarios i.e. IMNs that face challenges from uncertain IB environment in their global supply chain and operations.

For data collection, semi-structured interviews were conducted with the case companies from January 2022 to July 2023. We engaged with people in the positions of global supply chain manager etc. to capture an understanding of the company's IMN from various aspects. Each interview lasted around 60 minutes, generating a transcript of approximately 5500 words. The interview questions were guided by a research protocol (see Appendix 2). We continued the interviews until various aspects of had been covered, indicating reaching theoretical saturation point (Glaser & Strauss, 1999). Accordingly, 11 interviews were conducted covering business unit, regional (Europe) and global level IMN practices (see Appendix 1).

For data analysis, we followed thematic analysis to identify patterns in the data leading to specific theoretical accounts (Braun and Clarke, 2006). Specifically, the process had six steps: 1) each researcher read the transcripts and secondary data; 2) independently, each researcher generated initial codes concerning activities, elements, and process relating to the external systems and internal configuration. With team discussion, codes were confirmed. 3) collectively, we searched for similar patterns between the codes, interpreted the aggregated meanings, and generated themes; 4) we reviewed the themes, considering relationships among the codes that informed each theme, ensuring the logic and coherence; 5) we defined and named the themes, making sure they were theoretically meaningful. 6) we repeated the previous steps until there were no more new themes emerging and thus theoretical saturation was reached. This resulted in the generation of four themes of the external systems and six themes of the internal configuration (see Table 1). Afterwards, we adopted a Context-Intervention-Mechanism-Outcome (CIMO) framework (Denyer et al., 2008) to develop important propositions.

Table 1. Codes and themes (Source: Authors own work)

Codes/sub-themes	Themes	Contributing to
- Equilibrating differences in relative cost (C1,2,3) - Inflation (C2) - Yuan appreciation (C2)	Economic system	External systems
- Protectionism (C1,3) - FDI policy changes (C1,2,3) - Conflicts (C1)	Geopolitical system	
- Inventory (C1,2,3) - Digitalisation (C1,2,3)	Technical system	
- Risk-aversion (C1) - ESG awareness (C1,2,3)	Cultural system	
- Carbon footprint (C1,2,3) - Material scarcity (C1,2,3) - Climate catastrophise (C2)	Environmental system	
- E2E visualisation (C1,2,3) - Communication with stakeholders (C1,2,3) - Knowledge sharing with low-tier suppliers (C1,2,3)	E2E connection	Internal configuration
- Elimination of low-value suppliers (C2,3) - Long-term partnership (C1,2,3) - Concentrating steps of production (C2)	Vertical integration	
- Developing regional supply networks (C1,2,3) - Local sourcing (C1,2,3) - Circular economy implementation (C1,2,3)	Localisation	
- Multiple sourcing (C1,2,3) - Developing alternative products (C1,2)	Diversification	
- Simplifying product design (C2,3) - Digital platform (C1,2,3) - Standardisation of components (C1,2,3)	Simplification and streamlining	
- Increasing inventory (C1,2,3) - Duplication of manufacturing sites (C1,2,3) - Plant utilisation optimisation (C1,2)	Building redundancy	

To improve research rigor, the following actions were taken. We collected secondary data including companies' internal quarterly and annual results presentations, companies' annual reports, social media posts, company website, and news releases. This can ensure data

triangulation (Eisenhart, 1989), helping us to examine the changes and trends of companies' global production footprint, events and performance in the past 10 years, verify findings from primary data, and thus enhance the quality and reliability of the research. The adaptation of the CIMO framework enhanced the clarity and practical relevance of our propositions (Denyer et al., 2008). We repeatedly compared our empirical findings with the literature (Karttunen *et al*., 2023), looking for the explanations and reasonings (Harley and Cornelissen, 2022).

4. Case Analysis

4.1 Case One (C1)

C1 specialises in digital automation and energy management solutions, having around 200 plants in around 40 countries. The company has a "multi-hub" organisation: global strategy designs are applied in each hub, and each region has its own capabilities e.g. R&D. Since 2019, C1's focus is re-equilibrating in favour of developed countries, which leads to regionalisation of trade around the US, China, Russia, Europe and India. There have been challenges in the past five years due to the increased complexity of products and their integration with digitisation. An increase of regional government regulations and policies, notably a decoupling around regulations and standards about electrical equipment and digitisation, requires duplication and redundant efforts. The acceleration in regional trade and implementation of trade barriers to encourage national-oriented trade also impacts the business. The company recently noted their exposure to supply chain dependency and business continuity risks. For example, C1 relies heavily on its cluster of plants in Southeast Asia. Supplies from this region contributes to a multi-billion-euro business line. Learning from the COVID disruption in logistics, C1 leverages the multi-hub organisation, rebalancing the manufacturing footprint regionally, which targets increased resilience, moving from "just-in-time" to "just-in-case". For instance, it develops a 'power-of-two' industrial strategy: a double source of supply and manufacturing in at least two regions. C1 felt the impact of competing industries on natural resources, and addresses sustainability at strategic level.

4.2 Case Two (C2)

C2 is a global specialist in electrical and digital infrastructure. It exports products to nearly 180 countries and has around 120 manufacturing sites in 30 countries. It is essentially positioned in developed countries, with sales in Europe and North & Central America representing each 40% of the group sales. The recent challenges C2 has faced are supply chain disruptions, caused by COVID. Indeed, getting its hands on materials, mitigating single-source supplier failures and unreliability as well as finding transportation capacity are most challenging for the company. Moreover, C2 has acknowledged its dependence on China for electronic components and raw materials. To deal with the external disruptions, C2 has reinforced their regional organisation and follows a local strategy to expand market and to be compatible with the local regulations. It builds more inventory and diversifies its supply within the same region or different regions, and redesigns parts to have wider accessibility. Nonetheless, C2 has a "hub-like" organisation to leverage cost and productivity differentials between geographic locations. For instance, its Europe zone leverages low-cost manual labour in Eastern Europe, Turkey, and Northern Africa. The company still has a certain amount of inter-regional trade. Indeed, there is a strong percentage of the workforce based in the "rest of the world" region, even if that region represents 20% of sales.

4.3 Case Three (C3)

C3 is a leading global technology company that operates in more than 100 countries. To explore the regional market growth opportunities, C3 operates regionally, meaning developing its production and suppliers within the same region, e.g. Europe, China, North America. C3 is organised in 20 independent business units, in 4 major businesses, to best seize opportunities for its positioning and therefore grows through acquisitions, but also divestments. In terms of manufacturing footprint and supply chain management, all business areas are independent, but still have a share of common group purchases for synergy reasons (<20%). C3 has prioritised best quality and price ratio for selecting suppliers, and sometimes source from suppliers who not located in the region of C3's manufacturing and selling. Similarly, C3 claims that it normally concentrates orders with suppliers to benefit from scale-effects. To focus on their core skills, C3 has developed supplier ecosystems to better manufacture parts, and at a lower cost. However, recently challenges include COVID and the China-US trade war, that confronted it with this cost-based strategy. In response, C3 has considered decentralisation as a success factor and strengthened their already regional approach. They build on this organisation to make it more resilient by multiplying the interconnections and the alternatives – within the region of manufacturing or not, especially with suppliers.

5. Findings and Propositions

As shown in Table 1, codes and themes are identified from the case studies. To further develop propositions, a CIMO framework is adopted and illustrated as Figure 1, which brings in themes together as blocks and highlights their interactions as arrows.

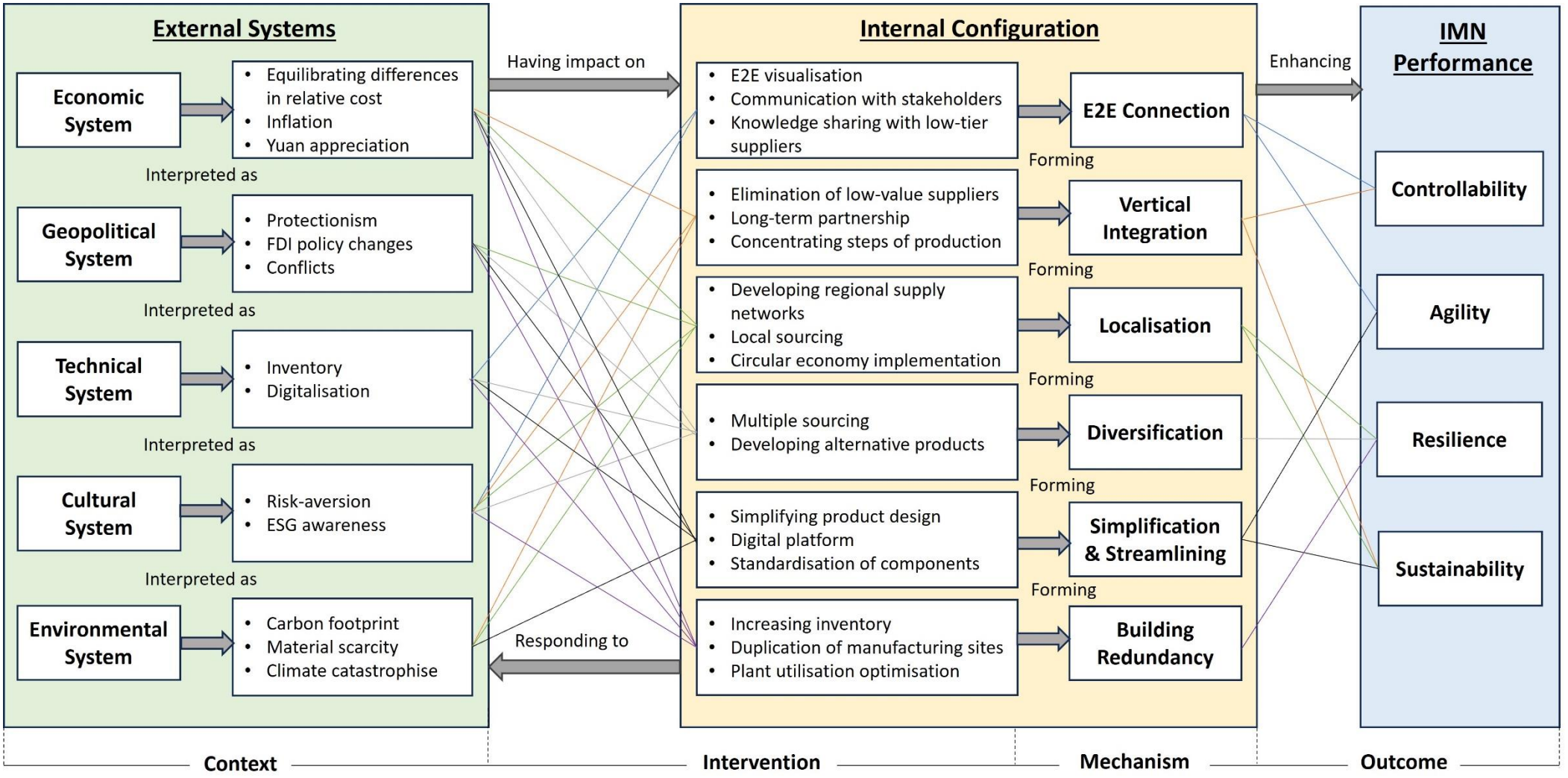

Figure 1. Context-Intervention-Mechanism-Outcome analysis (Source: Authors own work)

The left side of Figure 1 is the **context**, meaning the settings and external factors that an IMN is operated in. Specifically, the context is described by the interviewees as 'uncertain', 'disruptive', 'changing', 'dynamic', and 'highly unpredictable'. This can be interpreted as the external systems consisting of economic, geopolitical, technical, cultural, and environmental systems.

Next, context influences management decisions which lead to a series of **interventions**, meaning activities and changes. Interventions reflect the impact of external systems on internal configuration. Specifically, interventions are E2E visualisation, communication with stakeholders, knowledge sharing with low-tier suppliers, elimination of low-value suppliers, long-term partnership, concentrating steps of production, developing regional supply networks, local sourcing, circular economy implementation, multiple sourcing, developing alternative products, simplifying product design, digital platform, standardisation of components, increasing inventory, duplication of manufacturing sites, and plant utilisation optimisation.

With the combination and reinforcement of interventions over time, **mechanisms** are formed and reinforced, which are consistent with the aggregated themes of internal configuration, namely E2E connection, vertical integration, localisation, diversification, simplification and streamlining, and building redundancy.

The functions of mechanisms result in **outcomes** in terms of the enhanced IMN performance, which is claimed by the interviewees as 'more resilient', 'quick response', 'improved adaptability', 'better control', 'flexible', 'green', and 'sustainable'. This can be summarised as controllability, agility, resilience and sustainability, shown on the right side of Figure 1.

5.1 Context

As Table 1 summarises, our data are categorised as five external systems. First, for the ***economic system***, the cases highlight the impact of **equilibrating differences in relative costs** due to the increases in labour costs in developing countries. Meanwhile, there is a growing impact of **Inflation** pressures, with increase in material, production and transportation cost. In addition, the Chinese **Yuan appreciation** in recent years (Lyons, 2025) has influenced MNEs' location decision. This is highlighted by C2 as it highly depends on raw materials and electronic components suppliers from China. Therefore, the Yuan appreciation makes sourcing from the Chinese suppliers even more expensive. Accordingly, relying solely or in majority on a Chinese ecosystem that has been built over the past 20 years is being invalidated.

Second, all cases reveal a ***geopolitical system***. **Protectionism** is highlighted as a change in the economic situation has pushed governments to reconsider their openness to international trade. According to C1, the Trump administration and relationship with Mexico and especially China (Zahan, 2025) is most pressing geopolitical drivers to reconfigure corporate networks. However, as pointed out by C3, other regions show similar signs of "national preference", such as European countries or India, resulting in companies rethinking their geographic footprint. There is also a concern of **FDI policy changes** from all cases, which can affect companies' location decision, e.g. moving to a more stable country. Furthermore, there is recent emphasis on regional **conflicts**. For instance, the Russia-Ukraine war (WTO, 2023) has unmounted the belief of managers that conflicts could not severely impact developed countries. The conflicts have contributed to disruptions in supply chains and increased the cost of production. The disruption is global wise affecting all case companies, especially C1 who has regional trade in Russia.

The third external system is the ***technical system***. All cases demonstrate two dominant technical factors in recent years, inventory and digitalisation. Frequency, timing, and order size are the key factors in **inventory**. Related technical tools are constantly changing. Companies C2 and C3 consider the benefits and disadvantages of just-in-time system. Moreover, digitalisation is a notable phenomenon as all case companies are involved in digital transformation, affected by the technology advancement e.g. automation and digital twins. This has impact on their internal operations and supply networks.

Fourth, regarding the ***cultural system***, all cases indicate the transition towards risk-aversion and Environmental, Social and Governance (ESG) awareness. According to C1, **risk-aversion** means companies anticipating more frequent disruptions and factors in overall costs i.e. the incurred costs of disruptions rather than costs of products made in normal times. As for **ESG awareness** and business ethics, all cases highlight that the ESG criteria are increasingly important for business decisions, as it will influence the companies' reputation. It will also affect the supply chain e.g. sourcing more ethical and sustainable.

Finally, an ***environmental system*** is identified. All cases emphasise the concern about **carbon footprint** in their IMN. According to C1, decarbonisation mainly consists of shortening supply chains at strategic level. CO_2 prices, and 'green' electricity are considered. Also, all cases companies are aware of **scarcity of materials.** There is pressure on resource extraction in their OSCM. In addition, due to increase of climate catastrophes, disruptions have increased over time and become more frequent. This poses challenges to companies as many "low-cost" production sites are already or will be in at-risk zones. Even in Europe, climate-related disruptions e.g. floods in Germany in 2021 (Krischanitz, 2022) and the cold wave in Texas in 2021 (Albert et al., 2022) impacted hugely on the steel and plastic manufacturing, as seen in C2.

It is worth noting that the above five systems are interconnected. For example, ESG awareness highlighted in the cultural dimension also interprets the motivation of addressing environmental factor. The pricing of carbon emissions, a key indicator of environmental system, whether it is internal or external, adds a new element to the cost analysis, thus it can also be part of the economic system. Tax and tariff as seen in protectionism as well as FDI policy changes can also influence economic system.

5.2 Intervention, Mechanism, and Outcome

Mechanism 1: E2E connection

This refers to the connection among supply chain stages, including product design, procurement to production, warehousing, distribution, and service. All case companies implement **end-to-end (E2E) visualisation** approach in their supply chain. The objective is to increase knowledge and transparency. C1 for example leverages its own products and software, uses this digital tool that is overarching to the manufacturing, logistics, procurement functions, bringing the information back to a global level where it can then be processed using data analytics, robotic process automation and AI to extract valuable insights from such a mass of data. Moreover, all case companies have increased **communication with stakeholders**. For example, C2 holds monthly-calls with the most at-risk suppliers to ensure orders arrive on-time or therefore can react by finding alternatives. C2 places orders very early to ensure that the supplier will be ready for it: they now order up to 18-24 months in advance, when it used to be

on 9-10-month cycles. Moreover, C2 are transparent in their needs, not trying to have a tactical approach. In addition, all three companies are involved in **knowledge sharing with lower-tier suppliers**. Indeed, C1 tries to increase regionalisation as "*the biggest difficulty is having a regional value chain*" (C1-I1) and "*there is nothing worse than creating a new site in a region if the suppliers are all on another continent*" (C1-I2). Looking further upstream enables us to better prevent disruptions. For example, C3 is looking at tier-2 and sometimes tier-3 suppliers to ensure there is also a dual-sourcing at that level.

Overall, E2E visualisation shows the incorporating of digitalisation (technical system). This in turn contributes to long-term supply chain relationships and strategic planning (controllability). The frequent communication with stakeholders and knowledge sharing with lower-tier suppliers show a risk-aversion attitudes (cultural system). Using digital tools (technical system), communication becomes transparent. This enables real-time coordination and quick reaction (agility). Accordingly, we generate the following proposition.

> *Proposition 1: Through E2E connection mechanism, MNEs can improve their IMN controllability and agility, whereby effectively reacting to the new cultural and technical systems.*

Mechanism 2: Vertical integration

This mechanism means more control, merging, and integration of plants and suppliers. On this point, one way to **eliminate low value-added suppliers**. For example, C3 is moving towards concentrating on their core skills. They also consider re-insourcing some activities to ensure that they have material and priority. This is because some suppliers in developing countries e.g. China become more expensive recently, which adds little value and more uncertainty in the supply chain. C2 has removed some suppliers in China due to their poor performance to meet delivery time. Also, all cases show **long-term partnership** with suppliers. This is emphasised in this industry due to the large number of suppliers that exist but the low number of suppliers for each part, given the size and specificity of that industry. For example, C1 moves "*from a tactical to a strategic approach with suppliers*" (C1-I1). C2 has also ensured their approach is "ethical" with suppliers, as "*We don't launch orders to 10 different suppliers and when we get one, cancel the 9 order orders. We work towards developing trust and strategic relationship, as this relationship goes both ways*" (C2-I2). Meanwhile, to shorten supply chain for a set of different reasons including costs, additional risks of disruption and carbon emissions, C2 is **concentrating steps of production** in the same site or sites nearby.

It is noted that the elimination of low value-added suppliers helps companies to respond better to the equilibrating relative costs, inflation, and yuan appreciation (economic system). The long-term partnership and co-investment can reduce lead-time, thus IMNs are more controllable and sustainable. This effectively addresses equilibrating relative costs (economic system) and carbon footprint concern (environmental system). The emphasis on ethical issues demonstrates ESG awareness (cultural system). This can be combined with the concentrating steps of production to tackle carbon footprint challenges (environmental system). This further leads to the sustainable development of IMNs. Accordingly, we generate the following proposition.

> *Proposition 2: Through vertical integration mechanism, MNEs can improve their IMN controllability and sustainability, whereby effectively reacting to the new economic, cultural and environmental systems.*

Mechanism 2: Localisation

This mechanism refers to companies sourcing materials, components, and services from local suppliers. When there are no regional suppliers, companies are actively **developing regional supply networks**. According to C2, "*suppliers won't develop until the company brings back production, but the company won't bring back production if there are no suppliers*" (C2-I1). Similarly, C1 is developing a whole ecosystem in India. It has implemented several initiatives, that are based on developing a strategic relationship with their suppliers: co-investing with suppliers, giving them projects even if it is not competitive yet, helping them ramp up capacity, capabilities, and competences to reach quality and levels of production required. **Local sourcing** is another method adopted by all case companies. C1 has a China-for-China strategic plan. In 2020, 92% of the supplied goods came from the same region as its manufacturing sites, and 80% of the sales were produced in the same region as its customers. According to C3, procurement and supply chains functions were evaluated on their capacity to reduce costs. Therefore, C3 was sourcing at the lowest cost possible, not always in the region of manufacturing. However, a "majority" of their suppliers were regional. The above elements have pushed them to increase their local sourcing. C1 highlights that their objective is to move from 80% to 90% of regional sourcing. Furthermore, all case companies are keen on **circular economy implementation**. C1 for instance is working on maintaining and prolonging life of current products, whilst promoting reuse and redistribution, refurbishing and remanufacturing with its "waste-to-resource" programme, and recycling locally, aiming to use 50% of green materials in its products, instead of mining and extracting them. Circular economy should represent up to 15-20% of the company's business.

Findings indicate companies accelerating their regionalisation trend to react to carbon emissions, transportation cost, FDI policy changes and increase in tariff (geopolitical system). Developing local suppliers not only reduces product cost (economic system) but also enables resilience. The implementation of circular economy shows the concerns on raw material scarcity and carbon footprint (environmental system), and indicates risk-aversion and ESG awareness (cultural system). Thus, the following proposition is generated.

> *Proposition 3: Through localisation mechanism, MNEs can improve their IMN resilience and sustainability, whereby effectively reacting to the new economic, geopolitical, cultural and environmental systems.*

Mechanism 4: Diversification

This mechanism involves spreading sourcing and manufacturing footprint across multiple suppliers and locations. Indeed, **multiply sourcing** is a key to avoids having "*all their eggs in the same basket*" (C2-I2). This is also addressed as "*The main element for the supply chain is not localise to reduce risk, rather build up alternatives, find sources to meet the surging demand*" (C3-I2). C3 works with suppliers outside their region of manufacturing for two main reasons: (1) the supplier has the required capacity; (2) C3 wants to de-risk the supply chain and diversify its exposure to geopolitical tensions e.g. switching from suppliers in Ukraine to other countries. Indeed, they had three suppliers for a particular component, but all three were located within 50km of each other, and impacted by a same climate-related event. Another method is **developing alternative products.** They increase the number of components that have the same function. For example, due to demand deficiencies, C1 has redirected resources to develop, engineer and quality new alternatives or materials. C1 and C2 rethink the overall design of their

products to have several designs and differences in parts and suppliers used, therefore minimising the number of failure points.

Overall, multiple sourcing shows a reaction towards economic (i.e. relative cost) and geopolitical factors (i.e. conflicts, policy changes). It helps companies to reduce risk and achieve resilience in times of crisis. This shows a culture of risk-aversion. By developing alternative product design, companies also solve inventory problems (technical system). Thus, the following proposition is generated.

> *Proposition 4: Through diversification mechanism, MNEs can improve their IMN resilience, whereby effectively reacting to the new economic, geopolitics, and technical systems.*

Mechanism 5: Simplification and streamlining

This mechanism concerns simplifying, standardising, and streamlining processes to minimise delays and improve coordination between various parts of the supply chain. To minimise the costs or speed of qualification, C2 and C3 **simplify the product design**. In the past, they were answering to specific customer needs that created silos and complexity. At present, they ask their engineers to "go to the point", and only design new parts when needed. C2 "*doesn't want to over-spec, as it would increase costs and supply chain tensions*" (C2-I2). Meanwhile, all case companies have created **digital platforms** across the supply chain. This enables them to not only share parts and suppliers for a certain number of parts but also minimise the regional differences coming from specific standards or regulations. Therefore, it "*limits the risks of silos or isolation due to regionalisation*" (C1-I3). This for example enables the power-of-two for C1 to "*work even better and be competitive*" (C1-I1). Similarly, **standardisation of products and components** enables better interconnectedness and having suppliers and plants that can redirect their supplies from one region to another. As explained by C3, diversification and having back-ups is easier using the same footprint and suppliers. This also enables companies to "*reduce costs and weigh-in more with suppliers*" (C2-I2).

It is evident that simplification of product design and standardisation can reduce cost and materials. Thus, IMNs become more sustainable. Digital platforms help companies to incorporate technical factors, streamline process, and thus react quickly (agility) to economic and geopolitical uncertainty. Standardisation is effective to reduce cost and carbon footprint. Accordingly, the following proposition can be developed.

> *Proposition 5: Through simplification and streamlining mechanism, MNEs can improve their IMN agility and sustainability, whereby effectively reacting to the new economic, geopolitics, technical, and environmental systems.*

Mechanism 6: Building redundancy

This mechanism means companies intentionally creating backup capacity in their productions. All companies are **increasing inventory**, compared to their past strategies. For C1, 84% of the top risks are secured with strategic stock-hoarding and "*investing in specific modelisation tools to optimise its strategic inventories volume & location in order to reduce time to survive to a business continuity event*" (C1 2021 Annual report). C2 has seen "*a very strong increase in strategic stock*" (C2-I2). The increased inventory enables them to not only respond to supply-side shocks, but also be less exposed to volatile price fluctuations as a main factor in the

economic system. Furthermore, **duplication of manufacturing sites** is considered by all cases. For example, C1 started in 2020 a "Power-of-two" programme, meaning that they have production in at least two relevant regions. This stands in opposition to their previous strategy which was reducing the number of sites. Moreover, they have plants that are already too big which limits their efficiency. Therefore, C1 split a large plant in two and create a new line in the second biggest market, creating more and smaller plants and therefore increasing resilience. Nevertheless, C2 and C3 are not actively building new capacities to have redundancy. They can leverage acquisitions, but the industrial footprint of a target is not a crucial criterion. Still, C3 implemented a redundancy-strategy in regions where "*tariffs go on and off for certain categories or segments in some countries*" (C3-I2), demonstrating its concern of economic factors (i.e. tariff). Meanwhile, to better develop resiliency and increase speed of reactions, C1 and C2 have the maximum possible number of plants that are multi-BU, meaning **plant utilisation optimisation**. For C1, this enables them to keep a critical mass and have more alternatives on what to produce and keeping the buffer capacity. For C2, this translates into sharing lines and capacities with other BU to switch lines and products, giving them more flexibility.

Overall, these interventions have effectively mitigated risk. Through manufacturing site duplication, a failure in one regional supply chain has little impact on the business in other regions. Thus, the IMNs become resilient. This effectively manages disruption and uncertainty caused by geopolitical and economic factors (e.g. tariff, inflation, conflict). Also, plant utilisation optimisation shows companies incorporating technical elements relating to inventory management. The redundancy mechanism demonstrates a culture toward risk-aversion. Hence, the following proposition is generated.

> *Proposition 6: Through building redundancy mechanism, MNEs can improve their IMN resilience, whereby effectively reacting to the new economic, geopolitics, cultural and technical systems.*

6. Discussion and Implication

6.1 Discussion: Towards A New Framework

Synthesised from the above findings, we propose a new framework (Figure 2) to capture the new external systems and their connection to IMNs.

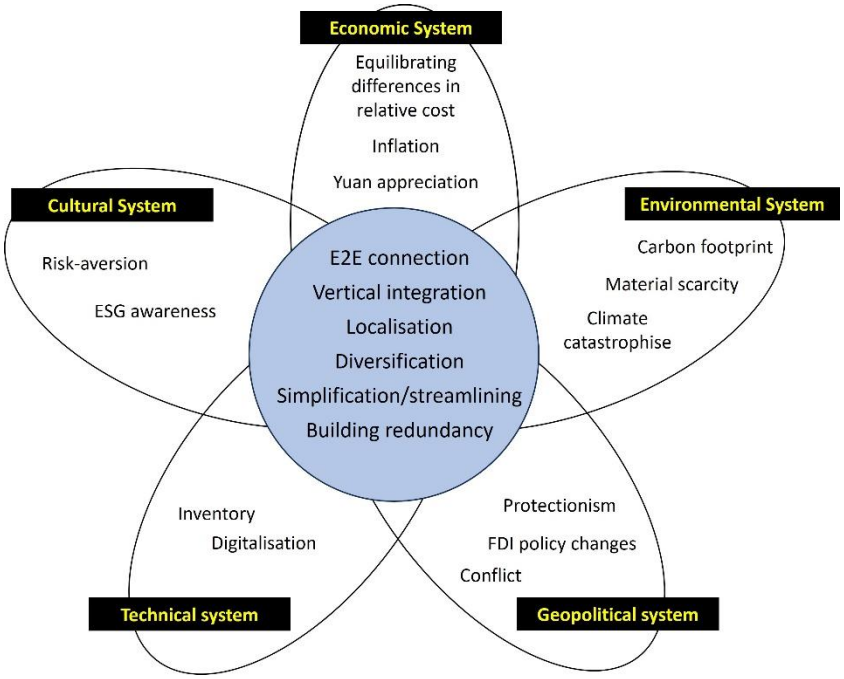

Figure 2. A new framework of external systems and internal configuration (Source: Authors own work)

Consistent with the layout of Skinner's (1964) model, the outside of Figure 2 represents **external systems**. Whist the traditional **economic system** factors e.g. cost of production, taxes, and economic instability remain important, our findings highlight emerging cost during international trading such as Yuan appreciation and inflation. **Geopolitical system** is extended from political system that concerns government stability, business law, remain important in the current debate of IB and IMN literature (Cohen and Lee, 2020; Luo and Tung, 2025). For instance, protectionism and FDI policies can influence the degree of globalisation and de-globalisation in the IMN configuration (Enderwick and Buckley, 2020). Our findings have captured additional geopolitical issues. For example, the US-China trade war affects European MNEs to consider developing supply networks in less affected countries such as India. Also, the Ukraine-Russia war results in companies developing alternative supply networks outside the conflict areas, but still in the same region, that is Europe. In the **technical system**, apart from inventory and other production related technology, we highlight automation as part of the ongoing digital transformation (Ahi et al., 2022; Badasjane et al., 2025; Birkel and Muller, 2025; Fang et al., 2023; Szelagowski and Berniak-Wozny, 2024). **Cultural system** refers to values, assumptions, motivating factors, customs etc. Among them, risk-aversion, and business ethics are increasingly important. Notably, the "environmental system" is a new system identified from the case study, concerning climate change, material scarcity and carbon footprint. It emphasises that the design of IMN should further encompass the environmental sustainability requirement (Marano et al., 2024). Furthermore, our study reveals that the **environmental system** is interconnected with the other four systems. Carbon price is emerging in recent years, which influences both economic and environmental systems (Hu et al., 2025).

The core of Figure 2 represents the IMN configuration. Here, six mechanisms enable IMNs to cope with the uncertainty and complexity of external systems. It is noted that the mechanisms can cover various levels. For instance, simplification and streamlining concerns digital platform across a supply chain, as well as product design simplification at a product level. Nevertheless, changes in product design can affect manufacturing process and footprint e.g.

reducing capacity in some manufacturing sites or removing suppliers. These ultimately will influence IMNs.

6.2 Implications

The framework (Figure 2) has several implications for IMN and global value chain theories. First, whilst existing literature has identified IMN typologies e.g. externally focused networks (von Dzengelevski et al., 2024), coordination of geographically dispersed factory network (Cheng eta l, 2021; Shi and Gregory, 1998), studies mainly concern IMN efficiency and effectiveness (von Dzengelevski et al., 2024; Feldmann and Olhager, 2019; Shi and Gregory, 2005) which can be achieved in a relatively stable condition. In other words, current models are conceptualised under the assumption that supply and demand patterns are predicable or can be optimised. Our study factors in the unpredictability of external systems that affect IMN configuration, and highlights the growing trends of achieving controllability, adaptability, sustainability and resilience (Dolgui et al., 2020; Shi et al., 2024; Nikookar et al., 2025), which are beyond the traditional IMN capabilities e.g. cost-efficiency.

Second, our findings confirm the validity of some existing mechanisms to achieve the newly required IMN capabilities. For instance, this study supports the argument that IMNs should restructured toward better controllability to cope with policy changes and technology advancement (Cohen and Lee, 2020). This requires vertical integration in production and supply chains (Cohen and Lee, 2020; Fleisch and von Dzengelevski, 2024). We enrich the IMN literature by identifying detailed interventions, such as eliminating low-value suppliers, building long-term partnership, and concentrating production steps. Further, our research illustrates a move back in time, for instance in terms of inventory, volume and production flexibility (Chopra and Sodhi, 2004; Namdar *et al*., 2022). Companies are increasingly collaborating, multiple sourcing, and being transparent, enabling better response and recovery capacities in case of a disruption, confirming literature insights (Cohen and Lee, 2020; Huo *et al.*, 2017). Moreover, we argue that companies can utilise digital tools to share knowledge with stakeholders and low-tier suppliers to achieve better controllability. This provides empirical support to the recent insight that digitalisation can improve supply chain prediction and reaction, while enabling continuity and visibility in real-time (Badasjane et al., 2024; Ivanov and Dolgui, 2021).

Third, our findings contribute to the ongoing debate around resilience in the global value chain literature. We highlight the importance of regionalisation, a concept associated with ‘location decision’ in global factory theory (Buckley, 2009; 2023) that suggests that relocation of value-chain activities a build global value chain resilience (Sacco et al., 2025). Furthermore, we highlight regionalisation, a concept associated with ‘location decision’ in global factory theory (Buckley, 2009; 2023) that suggests that relocation of value-chain activities can build global value chain resilience (Sacco et al., 2025). The research indicates that geographic fragmentation increases the risk of adoption of regional standards and technologies. Moreover, regional organisation would not only be less effective in countering global problems (Enderwick and Buckley, 2020; Luo and Tung, 2025) but also reduce investment in global disaster risk awareness and management (Elia *et al*., 2021). Our empirical studies illustrate that companies mitigate such elements through creation of a global industrial and supply chain strategy that is deployed regionally. Companies are looking to being more regional from E2E but increase their interconnectedness: they duplicate the number of alternatives if a node in the network fails, by sourcing or manufacturing from another region, which is also partly possible through standardisation and platforms and increased inventory.

Finally, Figure 2 provides a holistic view of IMN consisting of macro-(global) and micro-(firm) levels of concerns, and the external systems represent the complexity and uncertainty of the IB environment affecting IMNs (Witt *et al*., 2023). Whilst our framework contributes to the recent IB debate around the impact of geopolitical issues on MNE strategies (Li et al., 2022; Luo and Tung, 2025), we argue that the decision is a balance of global and regional strategies. Our study enriches the relatively small amount of OSCM literature that focuses on the management of global operations especially under the complex situation (Ferdows, 2017), providing empirical contexts to support the social-ecological systems view of supply chain resilience (Nikookar et al., 2025; Wieland et al., 2023).

6.3 **Limitation and Future Research Avenues**

There are some limitations of the study. From a theoretical perspective, this study seeks to link IMN and IB literature, by focusing on the interaction between macro concepts (e.g. technical system) and IMN changes. The study has not included organisational-level theoretical lens e.g. dynamic capabilities (Nikookar et al., 2025). Thus, it can be hard to determine if the IMN reconfiguration is associated with other variables e.g. organisational learning, resource and capabilities. From empirical aspect, the paper is based on three case studies from the European electrical equipment industry. There can be a lack of generalisability from a small number of cases to other regions. Also, each industry sector has its unique characteristics and global supply chain patterns (Sacco et al. 2025). Thus, the specific context of electrical equipment industry is difficult to replicate or verify in other industry settings (e.g. fashion industry), limiting its empirical validity. From an analytical and methodological perspective, our qualitative case studies rely on interview-based primary data collection. Though taking account measures on data triangulation, there can still be bias and inaccurate information provided from the interviewees. Also, as a qualitative study, we focus on the interpretation of the data, seeking for patterns, similarities and differences among the IMN configurations. This method is ineffective in terms of measuring or quantifying the impact of external systems on IMNs.

The above limitations provide avenues for future research. First, the analysis could be enriched by considering MNEs from a different sector or region to obtain comparable results. For instance, MNEs from emerging and less-developed countries can have different adaptive governance in their global supply chains (Islam and Chadee (2024). Second, quantitative methods can used to validate the findings, measuring the correlation between external variables and specific reconfiguration mechanisms. In addition, future study can bring in more organisational level theoretical lens, exploring the resource and capabilities required during IMN transformation. Process-oriented research can also be conducted to identify the evolving stages. In addition, geographic dispersions and cross-firm boundary collaborations have transformed the industrial systems towards ecosystems (Shi et al., 2024). More research is needed to test whether the traditional system-oriented thinking can be used to capture the important features of ecosystem in the IB environment.

7. Conclusion

This paper aims to explore the new external systems that influence IMNs and identify important approaches to respond to the shock. Based on three case studies, the paper found ample evidence in favour of emerging external systems in times of high uncertainty. By answering to the research questions set earlier, our findings show the impact of economic, geopolitical, technical, cultural, and environmental systems on IMNs. Through the mechanisms of E2E

connection, vertical integration, localisation, diversification, simplification and streamlining, and building redundancy, IMNs can effectively respond to the external systems. Our findings advance the understanding of the interaction between the changing IB environment and MNE's resilience (Dolgui et al., 2020; Fleishch and von Dzengelevski, 2024; Witt *et al*., 2023). We identify specifical operational approaches based on empirical evidence. As for the managerial implication, Figure 2 provides OSCM managers directions to reconsider factors that can impact their business. We navigate companies in a less stable and certain environment through an identification of best practices, as seen in the case companies. The six mechanisms can provide companies capacity to absorb shocks and disruptions. This ultimately can inform a global strategy that is deployed regionally. For instance, they can adopt digital technologies to share information with partners including low-tier suppliers, which in turn can mitigate risk and enhance IMN controllability and agility. Companies will also need to consider carbon price and adopt a comprehensive view of cost and IMN performance by sourcing more locally.

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Appendices

Appendix 1. Overview of the case companies

Case Company	Interviewee position	Geographic Scope	Business Scope	No. of interviews
Case One (C1)	Head of Supply Chain (C1-I1)	Global	Group	2
	Head of Supply Chain Strategy & Performance (C1-I2)	Global	Group	1
	Head of Supply Chain Strategy Deployment (C1-I3)	Europe	Group	1
Case Two	Chief Operating Officer, and Head of Performance & Projects (C2-I1)	Global and Europe	Group and Business Unit	1
	Head of Supply Chain & Industrial Planning (C2-I2)	Global	Business Unit	2

Case Three	Head of Global Business Development (C3-I1)	Global	Group	1
	Head of Procurement and Supply Chain (C3-I2)	Global	Business Unit	1
	Head of Procurement (C3-I3)	Global	Business Unit	2

Appendix 2. Interview protocol

Introduction
Representation of the "past" IMNs - *What was your supply chain strategy five years ago?* - *What were the prioritised regions?*
"Current" drivers pushing the IMN reconfiguration - *Are there any changes in your supply chain and production strategies recently?* - *What drives the changes?* - *Are there any external events that affect your supply chain most?* - *What other factors affect your supply chain and production strategies?*
Changes in manufacturing footprint - *In terms of your production systems, what are the main changes?* - *Why do you change these?* - *In terms of products, what are the changes to cope with growing uncertainty?* - *How did you make the changes firstly?* - *Can you give me an example?* - *What are the outcomes of the changes?* - *Do the changes affect the your supply chains?*
Change in supply chain - *What are the changes in your supply chains?* - *Why do you change these?* - *Who are involved in the changes?* - *What have been achieved so far?* - *What are the challenges?* - *Can you give me an example?*
Wrap-up and conclusion