Chapter 1

OUTSOURCING IN TIMES OF DISRUPTION

SUMMARY: 1.1. Introduction. – 1.2. In search of a supply chain in times of disruption. – 1.2.1. Disruption from digital technologies. – 1.2.2. Disruption from social and environmental sustainability. – 1.2.3. Disruption from the Covid-19 pandemic and war in Ukraine. – 1.3. The Gruppo Schiano case study: How shifts in customer behaviour drive innovation in the bicycle industry manufacturing paradigm and supply chain. – 1.3.1. Introduction. – 1.3.2. Highlights of the bicycle market. – 1.3.3. The history of the bicycle industry. – 1.3.4. The company profile. – 1.3.5. From mass production to mass customization. – 1.3.6. Conclusions and implications for management.

1.1. Introduction

In the past, outsourcing decision-making was synonymous with the term "make-or-buy" and was primarily based, albeit not exclusively, on evaluating the market price/internal cost trade-off. The importance of cost economies in outsourcing decisions is largely based on the Transaction Cost Economic Theory (TCET), developed first by Coase (1937) and updated revised, almost fifty years later, by Williamson (1981).

More recently, outsourcing has rapidly spread throughout the business world, involving several high-tech and other industries (Mohiuddin et al., 2017; Cohle, 2019; Stanko and Calantone, 2011; Calantone and Stanko, 2007; Chiesa et al., 2004; Carson, 2007). It has been applied to several activities along firms' value chains, not only at the operational (Boulaksil and Fransoo, 2010; McIvor et al., 2009) but also at the strategic level (Edvardsson et al., 2019; McIvor, 2008; Gottfredson et al., 2005; Shy and Storbacka, 2003; Baden-Fuller et al., 2000; McIvor, 2000; Sislian and Satir, 2000; Targett & Hunt, 2000; Quinn, 1999, 2000; Quinn and Hilmer, 1994). This has made outsourcing an interesting topic for the academic community and managerial practice alike (Gewald and Schäfer, 2017).

Outsourcing is a growing phenomenon in industries where firms are mainly committed to redefining their operating model and updating competitive advantage through product innovation development involving intense collaborative relationships between buyers and suppliers (Slot et al., 2019; Cantone et al., 2018; Handley and Benton, 2013). The strategic potential of outsourcing has encouraged firms to involve not only the non-core activities along the value chain but also those strategically relevant for innovation and competitive advantage, as well as those relating to new product development.

Demand for product innovation is increasing across the board: customers want better-performing products with new features better customised to their needs. At the same time, the spread of new digital technologies opens up new opportunities to innovate value propositions and operating models, sometimes shaping the form of disruptive innovation.

Bringing innovative products to the markets requires capabilities across several complementary technologies. In addition, firms must address rapid changes to technology and organisation, transforming many of their longstanding technologies and introducing new R&D processes. These pressures drive firms to increase supplier participation in innovation projects despite the difficulties of involving them in new and successful forms of collaboration, which requires time and significant mutual commitment.

Firms do not always possess all the necessary capabilities to develop innovation internally by themselves, nor do they have the necessary effective resources to create them internally. When it comes to innovation, any activity along a firm's value chain might be outsourced if there are suppliers able to carry them out more efficiently and effectively when forced to do so by their competitors. However, firms adopt varying levels of outsourcing policy.

Some firms outsource activities not directly connected with their core business. Others outsource the primary and/or support activities along the value chain that they deem essential for a competitive advantage and to create value. In interfirm networks relying on high-intensive knowledge and innovation, some firms, generally seen as "focal firms" (Sharma et al., 2020; Lorenzoni and Lipparini, 1999), assume the role of "network orchestrator" (Häcki and Lighton, 2001; Brown et al., 2002). This term denotes a focal firm in an actor's business network. Being endowed with vast relational capabilities (Lorenzoni and Lipparini 1999; Capaldo, 2004), it can coordinate multiple, repeated, and trust-based outsourcing relationships with key suppliers (relationship or partnership-based outsourcing).

Table 1. – The primary responsibilities of the "focal firm" within the supply chain.

1. Selecting the actors of the tier-1 supply network, establishing the criteria for selecting tier-2 and tier-3 suppliers.
2. Defining fair incentives for the tier-1 suppliers.
3. Defining the routine for exchanging information, such as the criteria for assessing tier-1 supplier performance.
4. Defining business processes by involving tier-1 suppliers to increase the effectiveness and efficiency of the supply network.
5. Managing communication flows with tier-1 suppliers to facilitate learning processes and the supply-chain business target.
6. Monitoring the evolutionary trajectories of knowledge and competency innovation of key business processes in order to improve innovativeness and performance within the supply chain.

7. Managing customer relationships to monitor changing needs.
8. Managing all relationships with tier-1 suppliers.
9. Assuming responsibility towards customers for the final product/service.

Source: The Authors.

As we mentioned earlier, firms generally supplement their internal resources and capabilities with a selected set possessed by the suppliers. These can share solutions, services, and their usual activities, which would otherwise be difficult or impossible to substitute or imitate. Integrating know-how is therefore essential and depends on the cost structure and capabilities of potential suppliers, market conditions, technological development, and a firm's personal vision. The main task of those deciding to outsource extensively, such as pure network orchestrators, is to build supplier networks and manage the relational processes along the supply chain. However, building and managing supplier relationships can be time-consuming, needing substantial relation-specific investments. It also requires the ability to select suppliers, define the goals of the outsourcing relationship and key performance indicators, and set up a system to measure them and distribute the benefits resulting from the outsourcing relationships. Furthermore, it is necessary to establish suitable interfaces and organisational routines, investing in digital and intelligence-based technologies to manage the relationships, and so forth.

Widespread recourse to outsourcing in business systems arises from several trends (Table 2; Figure 1).

1. The *globalisation of supply markets* and consequent increased market efficiency (i.e., a greater variety of market offerings, specialization, and supplier reliability, along with more competitive prices).
2. A *growing knowledge-based economy* requiring more specialised knowledge in designing, producing, and delivering products and services.
3. *Firms focusing on core business and core competencies*. The result is the deconstruction of the value chain. A firm focuses its investments and energies on activities embedding its organisational capabilities, on which current and future competitive advantage will depend. At the same time, it can access capabilities and knowledge, establishing vertical and/or horizontal and/or intersectional relationships with actors in the business ecosystem and exploiting the advantages of network economies (variety, speed, learning, and quality economies).
4. *The spread of digital technologies*. This makes it possible to build extended value networks, to separate the physical flows of goods from

the relative information flows to explore new kinds of cognitive division of labour, to absorb the competencies and knowledge (innovation economies) available on an increasingly borderless market, and to reduce interaction costs. The spread of digital networks over the last decade has led to significant growth in platform business models, with both "asset control" (i.e., Amazon and Zalando) and "peer-to-peer-provided assets" (i.e., Airbnb and Uber), constituting an increasing threat to traditional pipeline businesses (Wirtz et al., 2019; Modul et al., 2019). However, according to Modul et al. (2019: 695), there is a "convergence" of business models, i.e., "there are several examples of pipeline and platform businesses adopting each other's business model characteristics". Thanks to digitalization, platform businesses can leverage the activities and resources available within the ecosystem (Fehrer et al., 2018; Rangaswami et al., 2020; Wirtz et al., 2019) and the competitive advantages of network effects (Hagiu and Rothman, 2016; Modul et al., 2019).

5. *Decreasing interaction costs* associated with exchanging products, services, ideas, data, information, and knowledge (Hagel III and Singer, 1999; Walters et al., 2011). These costs, particularly substantial in high-intensity innovation businesses, create frictions between the economies and affect how the firms organise their internal activities and establish relationships with the actors within the business system. Changing interaction costs, therefore, determine fast (and vast) transformations in conventional business models in industries. Digital technologies, and the setting up of interactive digital networks, make it possible to share and exchange data, information, and codified knowledge more effectively, more quickly, and at a lower cost.

These five trends are closely interrelated. An economy based on digital and intelligent technologies – splitting flows of goods (manufacturing, stocking, handling and transportation of goods) from flows of information (data and information processing and transfer) – encourages interfirm relationships (Doan et al., 2021; Valdani, 2000), broadens the space-time options in interfirm collaboration, and lowers interaction costs. The new information and communication technologies also enable the adoption of more efficient and effective modes of dividing cognitive labour, thus overcoming the limitations arising from relationships based on the physical location of business partners.

Involving suppliers in innovation can provide several overall benefits and allow firms to create new sources of value, such as leveraging and applying specific technologies already adopted and end-tested by suppliers, which would be difficult or impossible to replicate in-house. Firms can also

pursue new business opportunities from scratch; they may develop new products and services and optimise costs from the earliest stages of innovation development (with shorter development times, greater design effectiveness, reorganising manufacturing operations and supply chain, investing more effort and commitment in preventing and solving problems, etc.). In addition, they may share data, information, objectives, strategies and actions to build new value propositions and operating models. Lastly, supplier involvement can create new competitive advantages.

When innovation incorporates specific products and/or process technologies, and when pressure from competition reduces time-to-market (TTM), outsourcing innovation offers benefits and advantages otherwise unavailable.

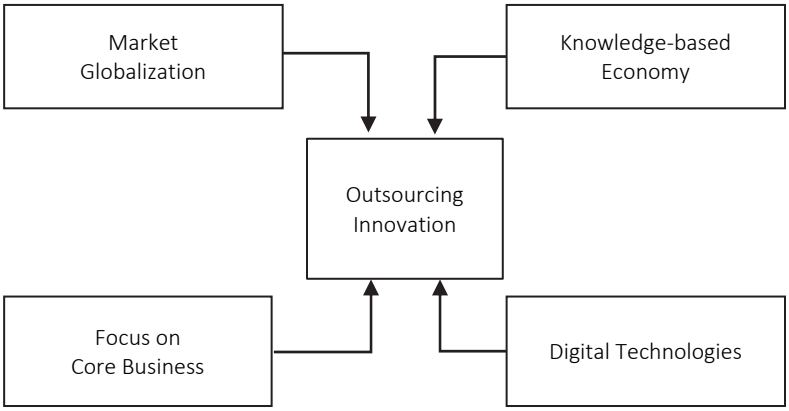
Innovations arising from the early involvement of suppliers vastly reduce time-to-market compared with home-grown efforts. This is often because the suppliers already have partial experience in terms of the resources, capabilities, and technologies on which the innovation is based. In fact, suppliers can have significant experience in using innovative firm-specific technologies, opening up new opportunities for problematic in-house product innovation (for an example, see the mini-case of collaboration between Aston Martin and Flexsys, below).

Table 2. – Some reasons for outsourcing innovation activities.

Extending organizational resources and capabilities in terms of:
Focus on core competencies and improvement of strategic execution.
Transforming the firm's business model, especially the effectiveness and efficiency of the operating model.
Increasing the flexibility and agility of the firm, coherently with the strategic change of the competitive environment (customer needs, technologies, competition games rules, and so forth).
Extending and integrating the firm's resources and competencies.
Improving managerial systems.
Enhancing innovation capability.
Improving competitive performance in terms of:
Operating performance (quality, time-to-market, time to profit, return on investment, etc.).
Value proposition for customers.
Economic value for shareholders.
Business-risk mitigation through sharing (financial, industrial and market risk).
Enhancing visibility, effectiveness, and efficiency in the supply chain.
Accelerating business growth using the strategic and operating capabilities in the supply network.

Source: Author's elaboration.

Figure 1. – Some drivers for outsourcing innovation.



Source: The Authors.

Illustrative mini-case: Aston Martin and FlexSys

UK carmaker Aston Martin joined forces with Aerospace technology company FlexSys Inc., applying their advanced FlexFoil™ technology to Aston Martin's latest ultra-high-performance vehicle. Aston Martin intends to incorporate FlexFoil™ shape-adaptive wing technology to the rear wing of the new AM-RB 003 hypercar.

FlexSys Inc. has worked with Aston Martin over several years to develop technologies ranging from the AM-RB 003 morphing wing to the Valkyrie windscreen wiper system, which enables rain clearance throughout the entire sweep of a highly complex windscreen. David Hornick, President and COO of FlexSys Inc., describes Aston Martin as being "laser-focused from the start of our relationship, achieving technical perfection in performance car systems and aerodynamics".

The shape-adaptive rear wing on the AM-RB 003 allows the car's downforce to be modified without changing its mounting position, resulting in a seamless design with high performance, improved efficiency, and reduced wind noise. In addition, the turbulence and associated drag increase found in current "state of the art" active wing designs is virtually eliminated.

FlexSys, a Michigan-based company, has been developing advanced aircraft wing technologies with the United States Air Force Research Laboratories for the past 18 years and has validated its seamless shape-adaptive wings' fuel savings and noise reduction benefits through extensive NASA flight testing on a modern aircraft. The patented technology uses variable-geometry control surface mechanisms that exploit the inherent flexibility of aerospace materials to continuously reshape wing profiles for optimal performance throughout the flight.

FlexSys Inc., an Ann Arbor Michigan-based company, was founded in 2000 by Dr Sridhar Kota to develop and commercialise his patented shape-morphing adaptive control surface design for an aerofoil. As a professor of Mechanical Engineering at the University of Michigan (1987 to date), Dr Kota started researching compliant mechanisms in the 1990s and pioneered the bio-inspired concept of Distributed Compliance for designing powerful and flexible one-piece machines. FlexSys developed proprietary software to create and optimise compliant systems and successfully demonstrated the application of compliant design methods for aerospace, automotive, and other applications over the years. Today, FlexSys is an established world leader in shape-adaptive structures.

Source: The Authors' reworking of the information on the company website.

Since the nineties, several studies have highlighted the role of strategic conditions and factors affecting outsourcing choices. From a strategic perspective, a firm's outsourcing decision-making process not only emphasises the effects in terms of transaction costs but also in terms of impact, extending and integrating internal resources, capabilities, and the knowledge base.

Increasing efficiency through cost reduction and accessing new resources and capabilities to extend a firm's competitive potential are not alternative goals of outsourcing decisions. There are circumstances in which these choices seek prevalently, if not exclusively, to obtain scale economies on activities that specialised external business partners can perform, significantly reducing unit costs. For example, in the commercial aircraft industry, outsourcing components and parts incorporating mature and straightforward technology with predominantly quantitative technical features aiming to meet this kind of goal. Similarly, there are circumstances where cost reduction is less significant since the aim of the outsourcing is essentially strategic, seeking access to the unique and specific resources and capabilities of specialised external suppliers. This occurred, for example, in the design and manufacture of components and subassemblies of the Boeing 787 Dreamliner[1], an all-new, mid-sized, advanced, and efficient commercial aircraft with an innovative fuselage in carbon fibre and some titanium parts. For the first model (B787-8), the project owner of this innovative commercial aircraft, Boeing, outsourced a large share (70%) of the design and manufacturing activities of this innovative aircraft to a global network of top-tier (or tier-1) specialised suppliers (14 partners located in several countries: Japan, China, Sweden, Australia, USA, Italy, France, South Korea). There were many reasons for this. Reducing the cost of project development and sharing the risks of the related investments, access to the technology and innovation capabilities of a skilled global network of suppliers, especially for new materials technologies (titanium and carbon fibre for the airframe structures), and reducing time-to-market, all increase the flexibility and quality of the new product development process.

Increased use of outsourcing to remodel strategic business processes is correlated to several general trends. The primary reason is an ever increasing and increasing uncertainty about the environment. In fact, to absorb

[1] The Boeing 787 Dreamliner is designed and is built in three versions: the 787-8 Dreamliner seating 210-250 passengers, the 787-9 seating 250-290 passengers, and the 787-10 seating 290-310 passengers. The 787-3 Dreamliner would have accommodated 290-330 passengers. But this project was cancelled on December 2010 for lack of orders. See www.boeing.com. Here we will use the terms "Boeing 787 Dreamliner", "B-787 Dreamliner", "787 Dreamliner", "B787 Dreamliner", "787" and "Dreamliner" interchangeably. When necessary, we will specify the model in question.

the sources of uncertainty – technology and market changes – firms extend their relationships with external organisations and pursue closer cooperation with trusted and skilled supply partners (Lorenzoni and Lipparini, 1999). According to the vast set of resource-based theories – Resource-based Theory (Penrose, 1959; Rumelt, 1984; Wernerfelt, 1984; Grant, 1991; Barney, 1991; Peteraf, 1993), Competence-based Competitive Theory (Hamel and Prahalad, 1996; Hamel, 1994), Strategic Assets Theory (Amit and Schoemaker, 1993), Knowledge-based Theory (Nonaka and Takeuci, 1991, 1995; Nonaka, 1994; Grant and Baden-Fuller, 1995; Liebeskind, 1996; Grant, 1997; Nonaka and Konno, 1998), Dynamic Capability Theory (Teece and Pisano, 1994; Teece, Pisano and Shuen, 1990, 1997) – in the industries characterised by high-intensity competition and technological product innovation, the creation and development of a firm's competitive advantage stem from the resources, competencies, and knowledge portfolio it owns and/or can access through collaboration with selected external organisations.

Access to the complementary resources and capabilities of specialised strategic suppliers – imperfectly imitable, mobile, reproducible, and substitutable – is a way of sustaining technological innovation for new product development and the future growth of a firm (Hagedoorn, 1993, 1995, 2002; Hagedorn and Schakenraad, 1994; Lorenzoni and Baden-Fuller, 1995; Ragatz et al., 1997; Handfield et al., 1999; Howells, 1999; Narula, 1999; Das and Teng, 2000; Quinn, 2000; Zhao and Calantone, 2003; Engardio et al., 2005; Carson, 2007; Rundquist, 2008; Griffith et al., 2009). This managerial approach is particularly effective in industries experiencing high-intensity product innovation. These include the following sectors: automotive (Wasti and Liker, 1997; von Corswant and Fredriksson, 2002; Mikkola, 2003); aircraft (Amesse et al., 2001); pharmaceutics (Piachaud, 2002; Chang, 2003); biotechnology (Powell, 1998; Powell et al., 1996; Pisano, 1991); and information and communication technology (Lee, 2001; Sturgeon, 2002).

Numerous studies in the literature have addressed the issue of outsourcing new product development (NPD) or R&D processes (Becker and Zirpoli, 2017; Liao et al., 2010; Rundquist, 2008; Song and Di Benedetto, 2008; Stanko and Calantone, 2011; Calantone and Stanko, 2007; Petersen et al., 2005; Zhao and Calantone, 2003; Wynstra et al., 2001, Carson, 2007; Chiesa et al., 2004). "New product development" refers to a firm's innovation process yielding new products. From a consolidated perspective, this means that the products may be new to the market and/or the firm. The degree of newness may also vary, so on the one hand, products can be radically new, while on the other, they may merely represent improvements to

existing ones (Garcia and Calantone, 2002). The term "outsourcing of innovation activities", instead, concerns outsourcing activities that are an "innovative part" of a new product and therefore have substantial implications for the innovation process (Rundquist, 2008).

Given the importance and complexity of innovation projects, many are undertaken in very close collaboration with the partners involved (Schamberger et al., 2013; Barczak et al., 2009). The supply partners are thus considered a potential source of innovativeness since their involvement permits access to the specialised technological capabilities of external organisations and to sustain NPD activities more effectively and efficiently (Carson, 2007; Engardio et al., 2005; Quinn, 2000; Howells, 1999; Narula, 1999; Griffith, Harmancioglu and Deoge, 2009). The success of NPD programmes depends on several factors, which may be internal – for example, linking portfolio decision-making to strategy and decentralising NPD portfolio-planning decision-making (Carbonell and Escudero, 2016), adopting effective human resources management practices (Aagaard, 2017) – and external, such as implementing a practical approach to selecting external partners (Guertler and Lindemann, 2016).

As the longitudinal case study presented later in this volume shows, innovation-based outsourcing underscores the importance of a firm's relational capabilities (Lorenzoni and Lipparini, 1999). These represent the "strategic centre" of an innovative value constellation (Lorenzoni and Baden-Fuller, 1995) to create, manage, and develop relationships with the network of firms along the supply chain, and to learn, absorb (Cohen and Levinthal, 1989, 1990), and integrate complementary resources, capabilities and knowledge, which are otherwise imperfectly imitable, mobile, reproducible, and replaceable (Grant, 1996).

Conversely, the central tenets of *Transaction Cost Economics Theory-TCET* (Williamson, 1979; Walker and Weber, 1984) and outsourcing decision-making involving NPD and/or R&D processes (Becker and Zirpoli, 2017; Cantone and Testa, 2012; Hsuan and Mahnke, 2011; Stanko and Calantone, 2011; Ambos and Ambos, 2011; Quinn, 2000; Veugelers and Cassiman, 1999) not only affect cost economies (design, production, and transaction costs) but also impact on the extension and integration of internal assets, resources, capabilities, and the knowledge base. Thus, NPD outsourcing must be interpreted in accordance with *Resource-Based Theory – RBT* (Wernefelt, 1994; Barney, 1991; Grant, 1991; Collis and Montgomery, 1995) and other epistemologically related theories, such as *Competence-Based Competition Theory – CBCT* (Prahalad and Hamel, 1990; Hamel, 1991; Sanchez et al., 1996), *Knowledge-Based Theory – KBT* (Grant and Baden-Fuller, 1995; Nonaka and Takeuci 1991; Grant, 1996), *Strategic*

Assets Theory – SAT (Amit and Schoemaker, 1993), Dynamic Capabilities Theory – *DCT* (Teece et al., 1997; Day, 1994). Furthermore, *Network Theory – NT* (Gulati et al., 2000; Gulati, 1998), and *Supply Network Theory – SNT* (Mena et al., 2013; Hearnshaw and Wilson, 2013; Galaskiewicz, 2011; Häkansson and Persson, 2004; Mills et al., 2004) also contribute to the general theoretical background.

NPD outsourcing activities based on collaborative relationships within the supply network bring several benefits to both firms and their suppliers. These benefits may be listed as follows: 1. the optimization of returns from shared investments, such as specific assets, which are not available or easy to develop in-house, focusing on the resources and capabilities of each partner (Narula, 2007); 2. access to the specialised and complementary resources of the supply partners (Dyer and Ouchi, 1993), in accordance with the open-innovation paradigm (Chesbrough, 2003); 3. the opportunity for partners to increase relational advantages arising from inter-firm cooperation within the innovation process (Hagedoorn, 2002; Dyer and Singh, 1998); 4. the opportunity to absorb and transfer capabilities, such as tacit and imperfectly transferable knowledge (Saenz et al., 2014; Azadegan et al., 2008); 5. the creation of new knowledge and competences for use during the innovation process, which could otherwise not be possible by merely leveraging the internal capabilities of the individual partners (Wu, 2008); 6. sharing the risk of relation-specific investments; 7. improving supply chain flexibility (Scherrer et al., 2014), performance (Cao and Zhang, 2011; Jang et al., 2006; Mikkola, 2003), and efficiency along the supply chain; 8. overcoming financial limits within the innovation projects (Song and Di Benedetto, 2008); 9. the opportunity for buyers and suppliers to capture mutual interest in both the short and long term (Vitasek and Manrodt, 2012; Van Echtelt et al., 2008).

Nevertheless, some case-based study research highlights that integrating suppliers into NPD projects could potentially give rise to costs, risks, and ineffective performance in terms of quality (Shirouzu, 2006) and lead-time delays (Lunsford, 2007), both of which may hugely outweigh the benefits. There is also a risk that innovation competencies may be lost (Becker and Zirpoli, 2017). Such consequences primarily arise from the complexity of buyer-supplier interdependency during the design and manufacturing phases (Salvador and Villena, 2013). A possible solution, to mitigate these adverse effects, may be the use of modular architecture product design (Lau et al., 2010; Chesbrough, 2008; Mikkola, 2003), or distinguishing between types of product innovation projects and applying dynamically different approaches over time (Becker and Zirpoli, 2017).

The issue of how outsourcing decisions in the NPD process can best be

undertaken has not been fully addressed in the literature (Stanko and Calantone, 2011). The factors influencing the decision to opt for innovation outsourcing most likely still need to be understood in current research.

As it stands, the existing literature takes accounts for neither a complete set of decision-making dimensions nor the specificity of the NPD process, especially when a disruptive technology fosters product innovation. Although several studies have analysed the antecedents of innovation outsourcing (Gooroochurn and Hanley, 2007; Bertrand and Mol, 2013; Griffith et al., 2008; Mol et al., 2005; Fill and Visser, 2000; Stanko and Calantone, 2011), the decision-making dimensions are not taken into account in an integrated multidimensional decision-making model, which considers the inter-related effects of their simultaneous evaluation. There are, therefore, significant gaps in the literature, which this book intends to fill.

This volume examines how organisations approach outsourcing decisions relating to NPD activities in technology-intensive industries and the implications of these decisions for performance. The context is that of industries characterised by a) high-intensity product innovation, b) high technological product complexity as a result of specific technologies developed and supplied by several organisations belonging to the supply chain, c) high value added by suppliers in the innovation development process in terms of quality, cost, and lead time, which contributes both to the final product and to value chain competitiveness, and d) a global supply chain, geographically dispersed among several countries (Mol et al., 2005).

The multidimensional and integrated decision-making model for outsourcing NPD activities proposed in this book is especially suited to situations in which disruptive technology drives product innovation. According to Danneels (2004: 249), disruptive technology "is a technology that changes the base of competition by changing the performance metrics along which firms compete". The same author explains that "a particular technology has performance constraints which limit the current product attributes set […] disruptive technologies introduce a dimension of performance along which products did not compete previously". The multidimensional and integrated decision-making model proposed in this book brings together, from an inter-related perspective, six key dimensions theoretically embedded in influential firm theories, offering a broader set of guidelines and directions for outsourcing decisions. The dimensions of our analysis work synchronously in order to consider the effects of their interrelations on the outsourcing decision. Therefore, even if "bounded rationality" limits the degree to which managers are perfectly rational in making decisions (Simon, 1955, 1959), it is necessary to develop a "satisfying" decision model (Simon, 1955, 1959), able to provide more effective guidance for manag-

ers when making outsourcing decisions (de Boer et al., 2006). To improve the reliability and success of an NPD outsourcing decision, all possible factors must be considered and thoroughly investigated. One of the causes of failure or ineffectiveness of the decision-making process is the difficulty in isolating the drivers influencing the decision. Therefore, in order to prove more effective, the proposed model considers the effect on the decision of all the relevant dimensions at the same time.

In line with the aims we described earlier, we will discuss the findings of empirical research exploring an embedded in-depth longitudinal case study, namely the Boeing 787 programme, starting with the first B787-8 Dreamliner model. This new aircraft constitutes disruptive technology product innovation within the industry as it adopts new material technologies enabling it to meet future customer needs (Christensen, 2013). The programme has radically changed the partnership model adopted in the industry's supply chain. This study aims to verify how the proposed model works to investigate outsourcing strategies related to the Boeing 787 Dreamliner programme. Therefore, the main research question that we aim to answer is: *what strategic dimensions in a decision-making model can extensively and thoroughly address the outsourcing decisions relating to NPD activities, given the hypothesis that a disruptive technology fosters product innovation?*

The book is organised as follows. It begins with a focus on the major transformations in supply chains during the fast-changing and adverse times we live through. A case study involving Gruppo Schiano highlights how customer behaviour shifts drive innovation in the bicycle industry's manufacturing paradigm and supply chain, now adopting digital technologies. The chapter on the case study was written by Mario Schiano, CEO of the company. There follows a presentation of theories of the firm and their implications for strategic outsourcing, after which we present a review of existing models in the literature addressing decision-making for strategic outsourcing and highlighting the notable gaps in the literature. Then, after discussing the methodology, we introduce a case study regarding the Boeing 787 Dreamliner programme (starting from the early B787-8 programme and tracking it throughout its product life cycle with the launch of the new B787-9 and B787-10 models). Next, we illustrate the proposed outsourcing decision-making model for NPD activities to describe the fundamental dynamics behind strategic decisions. A discussion of the empirical research findings on the embedded and in-depth longitudinal case study validates the stated research question and propositions set out in this volume. The case study concludes with some suggested implications for management and its limitations, as well as some opportunities for future research. Final-

ly, the afterword of this book – written by Vincenzo Caiazzo, former Chief Operating Officer at Alenia North America & former Chairman of the Board at Global Aeronautica – judiciously outlines an insider's perspective of the supply chain in the aviation industry.

1.2. In search of a supply chain in times of disruption

This section discusses three main disruption phenomena impacting on the supply chain, and its current and future organisation, relationships, and performance.

Supply chains have become intensely global and highly sophisticated. Globalisation has made supply chains more vulnerable to operational and macro-environmental disruption risks. In the light of such disruption occurring across industries worldwide, firms have to face the new challenges of managing supply chains efficiently in an age of disruption.

The main forces of disruption are the following: 1. widespread use of digital technologies; 2. an urgent need for business objectives and strategies to address environmental and social sustainability issues in accordance with ESG (Environmental, Social, and Governance) principles; 3. the Covid-19 pandemic (implications for supply chains in postpandemic era), and the most recent war in Ukraine.

Few firms and supply chains are currently prepared to address these overwhelming disruptions through resilient strategies, culture and organisation. Therefore, to survive in the 'new normal' age, they have to build a resilient supply chain, *a.* leveraging digital and intelligent technologies, to transform the traditional linear supply chain into a digital supply chain, *b.* implementing an environmentally and socially sustainable supply chain, and *c.* overcoming the turmoil created by the global health pandemic over the last two years and the most recent war in Ukraine, caused by Russia invasion. Building resilient supply chains enables firms to be proactive, agile, and flexible, as well as environmentally and socially responsible. They can engage with the supply ecosystem while being collaborative, visible, authentic, trustworthy, and digitally interconnected.

Digital technologies are enablers of resilience at every node of the supply chain. In the next section, we describe the three disruptive forces that particularly affect the supply chain.

1.2.1. Disruption from digital technologies

Disruption from digital technologies (DITs) influences society, relationships, and interactions between people and organisations, as well as the business models of firms. This disruption makes the latter much more difficult to manage (Kanarachos et al., 2018). As outlined by Queiroz (2018: 3), writing on the seminal idea developed by Legner et al. (2017), "there is some confusion regarding the difference between the terms digitization and digitalization. According to Legner et al. (2017), digitization refers to the process associated with converting analogue signals (physical activities) into a digital model, while digitalization refers to the impact of these technologies, caused by adoption and operation, in organizational and societal perspectives". Therefore, "digitization is a subset of the concept of digitalization". In what follows, we will use the terms interchangeably, although the discussion mainly regards the impact of digitalization on firms' strategic and operating models and, therefore, supply chain management.

One of the business model components with a direct impact on its operating model is the structure of the supply chain, how it is organised, and how relationships are formed within the supplier network (Queiroz et al., 2018). Digitalization and the evolution of information communication technologies in intelligent learning systems have enabled the *Fourth Industrial Revolution*, known as Industry 4.0, which encompasses several technologies (Hecklau et al., 2016; Qin et al., 2016; Lee, 2015; Schumacher et al., 2016; Xu et al., 2018), many of which stem from the field of Artificial Intelligence (AI), such as Machine Learning, Deep Learning, Robotics, Natural Language Processing, and Computer Vision.

Further enabling and advanced technologies are transforming society, people, and business, such as IoT – Internet of Things (Bibri, 2018; Kumar et al., 2016; Ben-Daya et al., 2017; Majeed and Rupasinghe, 2017), BDA-Big Data/Analytics (Kache and Seuring, 2017; Strandhagen et al., 2017; Chen et al., 2015), CPS-Cyber-Physical System Technologies (Bibri, 2018; Kumar et al., 2016; Qin et al., 2016), 3D Printing-Additive Manufacturing (Kapetaniou et al., 2018; Mohr and Khan, 2015), CCI-Cloud Computing Infrastructures (Korpela et al., 2017; Vazquez-Martinez et al., 2018; (Jede and Teuteberg, 2015; Giannakis, 2019; Maqueira et al., 2019), Nanotechnologies, Advanced Robotics/Robotics Process Automation (Barreto et al., 2017; Oyekan et al., 2017), Sensors, Blockchain (Korpela et al., 2017; Li et al., 2018), Augmented Reality (Rejeb et al., 2020), and Quantum and Edge Computing (Porambage et al., 2018).

As leading multinational consulting companies have pointed out (McKinsey, 2016; Boston Consulting Group, 2016; Deloitte, 2016; Bain &

Company, 2018; AT Kearney, 2015; Accenture, 2016), these DITs – spurred on by their data-driven and analytics powered capabilities – blur the borders between the physical and the virtual worlds. They activate an interactive and circular physical-to-digital-to physical loop, using data gathered from many physical and digital sources such as locations through sensors and other networked intelligent machines. They apply advanced and human learning algorithms to automate decision-making. They are influencing organisations in every industry (i.e., Retail, Finance, Media, Gaming and Entertainment, Health care, Education, Data analytics, Apparel, Innovative industries), as well as the management of every activity in a firm's value chain (i.e., Operations, Procurement, Logistics, R&D, Marketing), and the management of relationships among business actors in the business systems (supply-chain management relationships). They also permit real-time access to large amounts of data gathered from multiple sources. DITs have changed the value creation processes (i.e., how products are manufactured and services are produced and delivered, emphasising quality, safety, time, customization, and other elements in performance), as well as how this value is delivered to customers and exchanged within the supply chain. For example, IoT, blockchain, drones, wearable technologies, and so forth open up new potential for (mass) customising the customer experience (Srai et al., 2016). They improve effectiveness and efficiency along the supply chain, leveraging micro-scale distributed manufacturing plants and new manufacturing models (Holmström and Partanen, 2014; Zhou, 2013; Luz Martín-Peña et al., 2018), as well as more instantaneous tracking and digitally connected delivery systems). Lastly, they have changed the way customers and other supply-chain partners engage in the value co-creation process (Queiroz et al., 2018).

DIT disruption is, and will continue in the near future to be, driven by several factors (The Economist Intelligence Unit, 2020), such as – just to cite those with more significant impact – *a.* widespread internet access, increasing use of mobile and connecting devices in society, *b.* more company investment in interactive and connective technologies for big data analysis, *c.* more government investment in the digital economy, cybersecurity, and info-structure technologies, *d.* more private and public investment incentives for innovative start-ups, *e.* improved digital regulations and tax regimes for new digital enterprises, *f.* more education programmes on digital capabilities.

Another critical factor is the sharp decline in the cost of bandwidth, storage and computing on the one hand with significant growth of computing power and technological capabilities, on the other. This growth means that even small and medium-sized enterprises can invest in new interactive DITs,

which can process greater amounts of data and establish wider and deeper business relationships than ever before. In other words, they allowed, and will increasingly allow, supply chains to shift from traditional and linear configurations to multidirectional and dynamic digitally networked ones (Deloitte, 2016). Decision-making (i.e., planning) and operational (i.e., manufacturing, warehousing, delivering, buying, communication, and so forth) processes, involving the actors of the supply chains, are becoming more intelligent, smarter, more synchronised, more dynamically adaptive, and better connected in real-time. Lastly, industry 4.0 and digital transformation technologies strongly facilitate the information-sharing and decision-making process along the whole supply chain (Preindl et al., 2020).

In line with our previous remarks, we may add that the potential advantages of a digitalised supply chain supported by DITs become clear through some of the most appropriate definitions of the Digital Supply Chain (DSC). According to Ageron et al. (2020: 133), DSC "can be defined as the development of information systems and the adoption of innovative technologies strengthening the integration and the agility of the supply chain and thus improving customer service and sustainable performance of the organization". According to Büyüközkan and Göçer (2018: 165), DSC is "an intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronize interaction between organizations by making services more valuable, accessible and affordable with consistent, agile and effective outcomes". The backbone of a DSC is represented by advanced analytics and data-management technologies, capabilities, and capacities that make it possible to support the interactive and circular physical-to digital-to-physical loop relying on AI machines and a broad set of human learning algorithms. This allows firms to increase (Ageron et al., 2020) their end-to-end visibility and flexibility, as well as collaboration and real-time realignment at every stage of the supplier network. This, in turn, enables more cost-effective operational decision-making as well as the discovery of hidden insights for better strategic decisions regarding operational excellence (e.g., order management, performance management, logistics flow management, planning, end-to-end collaboration) and supply chain management (dynamic supply chain redesign, micro-segmentation of supply chains, end-to-end collaboration throughout the entire supply chain, and so on). It also enables process and product optimization, risk management, organisational capabilities, and new product-process innovation performance (agility, flexibility, quality, cost). As Garay-Rondero et al. (2019: 899) put it, the main differences regarding DSC compared with the traditional and linear SC involve several dimensions, such as accelerated,

adaptable, smart, real-time data gathering, and the fact that they are transparent, globally-connected, scalable, clustered, front-edge, inventive, and sustainable. Thanks to these qualities, DITs can enhance supply chain processes, ensuring actor responsiveness.

If the digitalization of a supply chain is to have a real impact on a firm's value proposition – improving and customising the offer system with the agility and flexibility needed to respond to changing customer needs – what is required is a profound transformation of firms' organisational culture and operating models (i.e., the structure of the supply chain, how interrelations within and outside the value chain are managed, in addition to organisational and cost structures). Digitalization will most likely drive a firm to reimage and innovate its business model (Kane et al., 2015); it will redefine its reasoning to build up a competitive advantage. In this disrupted organisational context, the competencies and capabilities of employers and managers also change. Beyond technology and big-data-driven competencies, other key capabilities must be developed and rethought, such as (Ageron et al., 2020; Queiroz et al., 2018) continuous human learning, critical thinking, decision-making, business process management, the engagement and management of external partners, negotiation, data science for developing analytical solutions and algorithms, digital translation (interfacing between business and analytics), collaboration and platform-based information-sharing at scale, the continuous redefinition of the collaborative relationships between humans and machines, and managing broader ecosystems comprising organisations belonging to multiple industries. Of course, not all competencies can be developed and managed inside a firm, so, following the open innovation paradigm (Chesbrough, 2003a), they join partnerships with others who can integrate their distinctive competencies with the "best of the breed" capabilities available in the broader business ecosystem.

As we will argue in greater detail later on, digitalization and automation technologies offer an excellent opportunity to achieve sustainability and apply circular economy models within the supply chain.

To conclude, Queiroz et al. (2018: 7) propose a framework of capabilities to manage a DSC. These are basic capabilities grouped into "ICT policies, worker policies, supplier integration, customer integration, warehouse capabilities, transportation and smart production". Then there are six enablers: Big Data Analytics, Blockchain, Analytical Intelligence, Cyber-Physical Systems, Cloud Computing, and the Internet of Things; these support the basic capabilities and permit a high level of integration and coordination with other players along the supply chain.

1.2.2. Disruption from social and environmental sustainability

Environmental and social issues have led to increasing awareness in society at large and impact the business world in terms of their economic relevance. Many companies are effectively addressing these issues; however, many others have yet to do so. The firm's stakeholders – shareholders, customers, employers, communities – are increasingly demanding vast and concrete commitments to these themes in order to match business practice with environmental and social needs. It is no understatement to affirm that the sustainability of a business is increasingly linked to its ability to integrate environmental and social issues into its own strategies and business models so as to create a competitive advantage. These issues are relevant because they have a direct impact on supply-chain management, and practices in this regard have been addressed in the literature for some time (Marshal et al., 2014; Pfeffer, 2010; Dey and Cheffi, 2013; Camarinha-Matos and Afsarmanesh, 2012; Klassen and Vereecke, 2012; Awaysheh et al., 2010; Chaabane et al., 2011; Pagell and Wu, 2009). Indeed, according to various studies (Reuter et al., 2010; Zimmermann and Foerstl, 2014; Pullman et al., 2009), adopting sustainable-oriented supply-chain management practices can create a unique competitive advantage if they effectively meet – radically or gradually – the needs of aware customers by changing – again radically or gradually – a firm's resource set. The need to involve the whole supply chain in reducing emissions has been brought to light in a worldwide study published by the Boston Consulting Group (March 2021). In fact, eight global supply chains (Food, Construction, Fashion, FMCG, Electronics, Automobile, Professional Services, and Other Freights) cause more than 50% of annual greenhouse gas emissions, and only a small proportion of these are produced during the final manufacturing phase; the rest comes from the supply chain partners. In addition, in all the supply chains analysed in the BCG study, full decarbonization (a net-zero supply chain) would have a low impact on the end consumer prices (rising no more than 4%).

Supply-chain sustainability refers to the systemic commitment of all the actors in the supply chain to pursuing environmental and social benefits (Jabbarzadeh et al., 2018; Taylor and Vachon, 2017).

Contrary to previous studies in the literature (Pfeffer 2010; Pullman et al., 2009; Barreto 2010; Kleindorfer et al., 2005) – breaking down the sustainability of supply-chain practices into environmental and social components in order to measure and analyse the effects on its outcomes more accurately – Marshal et al. (2015: 675), argue "that sustainability should not be a single overarching concept but should be deconstructed into environ-

mental sustainability and social sustainability to allow researchers to explore the differences". The sustainability of a supply chain in terms of environmental issues entails all the actors becoming involved in the supply chain of processes and products designed to protect the environment, minimise resources, recycle material, and use smart and more efficient technologies.

The social sustainability of a supply chain, on the other hand, means that all those involved in the supply chain of management and human-centric organisational practices must work to protect the long-term health and well-being of the workforce, in compliance with the national and international regulations. They must combat discrimination, be inclusive of any kind of diversity, ensure fair compensation for work, and reject any form of labour that deprives anyone, especially children, of their dignity and cultural, social, and economic growth. This means relationships within the supply chains have to be monitored beyond the conventional performance metrics – costs, time, and quality – foregrounding employees' social and individual well-being. Enhancing efforts in terms of the health, well-being, and welfare of all those making up the supply chain is a core responsibility of any business, especially focal firms. These must encourage the supply chain to adopt ESG (Environmental, Social, Governance) metrics when evaluating suppliers; they should also adopt DEI (Diversity, Equity, Inclusion) analytics to promote a more inclusive corporate culture and organisational environments.

Pursuing social sustainability involves, first of all, a firm's culture, namely its core values, shared by all the players along the supply chain, and will condition their behaviours. However, a firm's culture is influenced by – and influences – other elements that foster social sustainability. These are the firm's vision, its organisational and management systems (planning systems, control systems, communication and information systems, reward systems, etc.) (Pfeffer, 2010).

The focal firm in a supply network has a crucial role in creating a socially and environmentally aware supply chain. The role of the focal firm is essential when selecting suppliers capable of creating sustainability within the supply chain; they will monitor suppliers' sustainable practices over time, encouraging them to adopt and transfer the best solutions. To guarantee the sustainability of the chain, focal firms in supply chains with environmental and social objectives must add ESG and DEI to their supply partners' business models, including these metrics in their scorecards to evaluate the performance of the supply chain as a whole and that of any partners. As we will see, the Covid-19 pandemic has accelerated the need to invest in the environmental and social sustainability of supply chains.

Marshal et al. (2015) – starting from Klassen and Vereecke's classification (2012) and extending to those of Vachon and Klassen (2006) – have catalogued and measured four supply-chain sustainability practices. 1. *Environmental process practices*, focusing on monitoring suppliers' adoption of environmental management systems over time. This means the role of the focal firm should be to encourage suppliers to adopt and update sustainability-inspired processes. 2. *Environment market practices*, introducing new product- and process-development practices, and reconfiguring the supply chain. The former entail redesigning products and/or production processes to benefit the environment (lower resource consumption, less waste, greater use of recycled materials, etc.). The latter pursues a different supply chain configuration to minimise resources by recycling waste for this purpose. Implementing circular supply chains or closed-loop supply chains could be a way to redefine the supply chain and pursue its environmental sustainability. 3. *Social process practices* through which focal firms monitor suppliers' social sustainability practices and implement social management systems (i.e., health and safety systems; well-being programmes; fair wages; education programmes for developing capabilities; diversity). 4. *Social market practices* aiming to design and produce new products or processes whereby suppliers can improve the health and safety of workers along the supply chain and provide fair margins for suppliers (Waage, 2007).

Undoubtedly, it is a long and arduous task for an organisation to enable a supply chain to solve disruptive environmental and social tensions. However, some leading initiatives might be of help: 1. planning and sharing ambitious environmental and social targets (i.e., reduction of CO^2 emissions to zero, gender parity, inclusivity, and so on) with suppliers – starting with tier-1 suppliers and critical material/parts; 2. redesigning the organisation, processes, and products/services to achieve the expected environmental and social targets; 3. working with suppliers to reach the expected environmental and social targets; 4. redesigning the value and supply chains in the light of environmental and social targets; 5. sharing best-in-class ESG/DEI actions along the supply chain; 6. integrating environmental and social metrics in the vendor rating systems, rewarding the best performers and scaling up best practices throughout the supply chain.

1.2.3. Disruption from the Covid-19 pandemic and war in Ukraine

Causing lockdowns around the world, the Covid-19 pandemic has accelerated the spread of digitalization in businesses across various sectors (retail, finance, healthcare, entertainment, and so forth), bringing unique economic and organisational challenges in terms of both supply and de-