DESIGN-MANUFACTURING COORDINATION: PROXIMITY, INTEGRATION AND BEYOND, TOWARDS OMNISHORING

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ABSTRACT

Recent research argues that when innovation is embedded in the manufacturing process, design and manufacturing need to be integrated and geographically close to secure current and future innovation. However, process-embedded innovative industries such as fashion (Pisano & Shih 2012) have massively outsourced and/or offshored for decades. Our research aims to understand how innovative firms in the fashion industry manage design-manufacturing coordination in terms of proximity and integration. Examining 18 European fashion firms, our work uses an abductive approach to understand how firms manage their design-manufacturing coordination and specifically the role played by proximity and integration in such coordination. The analysis reveals that there is a range of coordination modes that go beyond geographical proximity and vertical integration. We also argue that proximity and integration are complex notions and not independent options. Finally, we demonstrate the concept of *omnishoring,* as coordination strategies are often managed simultaneously and complement each other.

INTRODUCTION

The existing literature has long stressed not only the importance but also the difficulty of coordinating design and manufacturing activities, specifically in innovative contexts (Kessler & Chakrabarti, 1999; Swink, 1999; Barton, Love & Taylor, 2001; Olausson, Magnusson and Lakemond, 2009). In parallel, geographical proximity (Alcacer, 2006; Alcacer & Chung, 2007; Nachum, Zaheer, & Gross, 2008; Pisano & Shih, 2012; Berger, 2013) has been argued to play a key role in facilitating design-manufacturing coordination and enhancing innovation. Additionally, vertical integration is understood as keeping the manufacturing of a given part or product internally, i.e., within the boundaries of the firm rather than outsourcing (Monteverde and Teece, 1982), reduces the complexity of coordination between design and manufacturing through lower transaction costs (Williamson, 1975) and an easier leverage of core competencies (Holcomb and Hitt, 2007).

Based on these findings, innovative firms should favour proximity and vertical integration to protect and enhance innovation (Chesbrough and Teece, 2002; Pisano & Shih, 2012; Berger, 2013). For this reason, manufacturing proximity has been central to political campaigns and has been presented as a priority of elected governments in several countries, such as France and the United States, for a decade. The recent COVID-19 crisis has further revealed limits of distant manufacturing (Barbieri et al., 2020). Similarly, vertical integration and a strengthened control of different steps of the value chain should be favoured by innovative firms (Pisano & Shih 2012). However, despite such recommendations based on research and government incentives, as well as broadly advertised cases in which manufacturing is brought to the home country (in proximity to design), such as the Adidas smart factory launched in 2016 and 2017, macroeconomic data and large-scale studies cannot confirm this trend (Martinez-Mora & Merino, 2014; Rice & Stefanelli, 2014; Brennan et al., 2015; Dachs et al. 2019). Even the Adidas emblematic example has shown its limits, as the sportswear leader decided to close its

German and North American speed factories and relocate related robotic technologies in its Asian factories. Process-embedded innovative industries such as fashion are still extensively offshored, i.e., outsourcing manufacturing in distant locations. Fashion is a process-embedded innovation industry (Pisano and Shih, 2012) and as such poses questions regarding the need for proximity and vertical integration versus the need for offshoring.

In this context and based on this apparent contradiction, we pose the following research question: How do innovative firms coordinate design and manufacturing? We will analyse it from a geographical proximity and vertical integration perspective. To answer this question, we start with a literature review on design-manufacturing coordination and show the role of proximity and integration choices to highlight the research gap and justify our study. We then describe our empirical field and abductive methods before presenting our results and discussion.

THEORETICAL BACKGROUND

Coordination, defined as "managing dependencies between activities" (Malone and Crowston, 1994, p. 90), has long been studied by organization theory, which has evidenced different types of interdependencies (Thomson, 1967) suggesting different modes of coordination. More specifically, abundant literature on design-manufacturing coordination has been developed since the 1990s in the organizational theory field to emphasize the role and benefits of such coordination in new product development (NPD). At the same time, however, research on design-manufacturing coordination has placed little emphasis on the role of proximity and vertical integration.

Design-manufacturing coordination

The organization and operations literature has a long and extensive tradition of analysing design-manufacturing coordination (Dekkers, Chang & Kreutzfeld, 2013) and, more broadly, the benefits of cross-functional integration for innovation through the organizational lens (Adler, 1995; Olausson, Magnusson & Lakemond, 2009; Turkulainen & Ketokivi, 2012). Coordination has been extensively studied by organization and management scholars (Lawrence & Lorsh, 1967; Mintzberg, 1979; Adler, 1995) as a way to resolve “the task dependencies in a complex work setting” (Hong, Pearson & Carr 2009)

Design-manufacturing coordination is a specific case of such task dependency and was alternatively referred to as a design-manufacturing relationship (DMR) (Adler, 1995) or design-manufacturing integration (DMI), defined as “interaction and collaboration between design/engineering and manufacturing managers, who work together to arrive at mutually acceptable outcomes for their organization” (Thomé & Sousa, 2016). Different forms of design-manufacturing coordination have been argued to derive different types of benefits—decreased time to market, quality enhancement, cost reduction, etc.—specifically in contexts of high complexity, uncertainty and innovation (Adler 1995; Kessler & Chakrabarti, 1999; Swink, 1999; Barton et al., 2001; Olausson, Magnusson & Lakemond 2009). Cross-functional integration between manufacturing and design has been shown to improve innovation (Brettel et al., 2011); conversely, poor coordination may lead to major issues and disruption, as demonstrated by the example of the Boeing 787 Dreamliner (Hong, Pearson & Carr 2009).

According to Thomson (1967), there are three types of interdependencies in coordination: i) pooled, i.e., when activities share common resources, ii) sequential, i.e., when activities depend on the completion of others, and iii) reciprocal, i.e., when activities feed their work back and forth. These types suggest different coordination mechanisms, which can be formal or informal. More recent research (Hong, Pearson & Carr, 2009) has extended these theories and highlighted two critical coordination dimensions: i) the information processing structure, including means and mechanisms to facilitate information exchange and processing, and ii) locus of control, which is related to the person in charge of decision-making.

Overall, smooth and regular communication between design and manufacturing helps alleviate integration barriers (Vandevelde & Van Dierdonck, 2003), including personality, cultural, language, organizational and physical barriers (Ripamonti & Peraboni, 2010), and therefore improves design-manufacturing coordination. Building on the organization literature (Adler, 1995), recent research (Twigg, 2002; Vadevelde & Van Dierdonck, 2003; Hong, Pearson and Carr 2009; Dekkers, Chang & Kreutzfeld, 2013; Thomé & Sousa, 2016) has tried to conceptualize different types of mechanisms. Specifically, a matrix of four coordination mechanisms has been elaborated (Hong, Pearson & Carr, 2009) based on the type of information processing structure (programming vs. feedback) and locus of control (centralized vs. decentralized). These different mechanisms emphasize the need for information sharing and processing as well as the efficiency and effectiveness of decision-making. Existing research also highlights the needed complementarity between pure information and data exchanges and more informal and intangible dimensions such as social ties and knowledge sharing (Ripamonti & Peraboni, 2010). The complementarity between design and manufacturing knowledge is essential for design manufacturing integration (Abecassis-Moedas & Ben Mahmoud-Jouini, 2008).

Following this path, other works (Abecassis, Caby & Jaeger, 2000; Twigg, 2002; Vandevelde & Van Dierdonck, 2003; Dekkers, Chang & Kreutzfeld, 2013; Thomé & Sousa, 2016) have further analysed how to improve information sharing, processing and decision-making. They have identified different mechanisms grouped into two main categories: i) organizational and ii) technological mechanisms. Organizational mechanisms include organizational practices such as direct contacts, job rotation, organizational choices, and colocation; technological mechanisms encompass collaborative information technologies and software. These two groups of mechanisms are presented as independent, while information technologies will be particularly critical when direct contacts are less frequent and will not always be successful (Bal & Foster, 2000). This has been shown to be specifically true in the case of virtual enterprises (Ripamonti & Peraboni, 2010). Despite its abundance, this literature has remained mainly conceptual and difficult to connect with real cases and overall business trends towards global and complex value chains.

The role of proximity and integration in design-manufacturing coordination

Interestingly, while existing works focus on the need to coordinate design and manufacturing efficiently, they rarely analyse the impact of the organisational setting (geographic proximity, governance mode, etc.) on the success of such coordination. Specifically, most of the literature on design-manufacturing coordination has focused on interdepartmental interdependence and has not covered the possibility for design and manufacturing functions to be managed in different companies (Adler, 1995, Vandevelde & Van Dierdonck, 2003, Thomé & Sousa, 2016) or in a geographically distant setting. Only recently have some authors analysed cross-functional coordination issues in contexts of manufacturing outsourcing (Bengtsson, von Haartman & Dabhilkar, 2009; Olausson et al., 2009) or organizations with multiple suppliers (Hong, Pearson & Carr, 2009).

Among organizational mechanisms, proximity has been argued to facilitate information sharing and integration (Adler, 1995) and provides quicker decision-making and issue resolution, specifically when the product and process are interdependent (Thomé & Sousa, 2016). Additionally, when activities are complex, coordination involves cultural control mechanisms (Eisenhardt, 1985) that will be more efficiently achieved through face-to-face meetings than email or phone calls (Nickerson & Zenger 2002). Therefore, proximity allows us to avoid quality issues (Gray, Roth & Leiblein, 2009). While colocation can be beneficial when complexity is high, it can also be detrimental when complexity is low (Thomé & Sousa, 2016). Despite these examples, proximity is rarely analysed per se in the design-manufacturing coordination literature and is strictly limited to geographical proximity.

Similarly, organizational design and practices play a key role in information transfer and influence coordination. In the case of multidivisional firms, information sharing and processing from one division to another, which are critical to fostering innovation, may be difficult to achieve (Kleinbaum & Tushman 2009). Additionally, vertical integration facilitates information sharing between design and manufacturing and may clarify decision-making. Higher vertical integration improves coordination between design and manufacturing. Therefore, manufacturing competence should be kept in-house when the degree of innovation is high (Olausson, Magnusson & Lakemond, 2009). Outsourcing massively has shown several limits despite the development of information technologies (Chesbrough & Teece, 2002). Although rarely explicitly studied in the case of design-manufacturing coordination, vertical integration has been shown to help alleviate barriers and improve coordination (Vandevelde & Van Dierdonck, 2003; Olausson Magnusson & Lakemond, 2009). This is particularly true when innovation is systemic, i.e., when it involves different functions and activities (Chesbrough & Teece, 2002). Indeed, when design and manufacturing belong to the same organization, coordination and information sharing are facilitated through common rules and organizational routines.

Manufacturing location and proximity

Independently from design-manufacturing coordination, a significant stream of research in operations and supply chain management literature has focused on the role and impact of distant or close manufacturing. More specifically, several authors (Abecassis-Moedas, 2007; Gray, Roth & Leiblein, 2009; 2011; Ellram, 2013; Ellram et al, 2013; Di Mauro et al. 2018) have studied the impact of locating manufacturing facilities far from the headquarter and the main markets, whether insourced or outsourced and qualified such a phenomenon as “offshoring”. These works have specifically highlighted their negative consequences on supply chains.

Building on these outcomes, more recent research (Kinkel & Maloca, 2009; Ellram, 2013; Ellram et al, 2013; Gray et al, 2013; Kinkel, 2014; Fratocchi et al, 2014; Fratocchi et al, 2016) have analysed reshoring and backshoring (i.e. bringing manufacturing closer and back home after offshoring). They tried to assess such trends and conclude they are growing phenomenon –though cases remain relatively rare- and driven by different motives including quality and supply chain issues, correction versus previous erroneous choice, evolutions in host countries conditions. These studies were recently complemented by a regulatory perspective to forster closer manufacturing in a post pandemic world (Elia et al. 2021). While these works never focused on the role of innovation in manufacturing proximity decision nor on a better coordination between design and manufacturing, recent research (Dachs et al, 2019) shows that innovation plays a role in backshoring decisions, though more minor than other factors.

Location, proximity and innovation

Independently, another stream of research grounded in economics has analysed the role of location and proximity in resource creation and development, often relative to innovation. These works include the literature on clusters and deal with concepts such as colocation, agglomeration economies, and questions concerning where to locate based on a set of factors, including the location of resources, competitors, customers and suppliers (Alcacer, 2006; Nachum et al., 2008; Alcacer & Zhao, 2012; Alcacer & Delgado, 2013). These studies mainly focus on concentration, i.e., location as a relative choice with regard to competitors or business partners, to foster knowledge spillovers and innovation, and they are mostly static.

Other works have focused on the location of the research and development (R&D) function. A few scholars, mainly in economics (Cardinal & Hatfield, 2000; Lahiri, 2010) and economic geography (Sonn & Storper, 2008), have demonstrated that the location, proximity and distribution of R&D centres in absolute terms, and relative to headquarters and plants, influence innovation. These works show complex linkages between the geographic dispersion of R&D and innovation, as dispersion not only provides an opportunity for knowledge variety but also incurs risks in knowledge sharing and transfer. They highlight the need for knowledge transfer and sharing between different R&D entities and between R&D and other functions (headquarters, manufacturing, etc.). Therefore, companies need to make a trade-off between location proximity and concentration (favouring knowledge transfer and coordination) and distance and dispersion (favouring the diversity of new ideas and resources). Other authors (Knoben & Oerlemans, 2006; Coughlan, 2014) have built on the literature on clusters to further analyse the role of distance and proximity in enhancing innovation. They specifically show the benefits for innovation of combining geographical proximity with other kinds of proximity (cultural, virtual and technological proximity).

Finally, recent research investigates the possible relationship between manufacturing proximity and innovation in different contexts, among which industry 4.0. (Durach, Kurpjuweit and Wagner, 2017; Ancarini & Di Mauro, 2018; Ancarani, Di Mauro & Mascali, 2019; Dachs, Kinkel & Jäger, 2019 a. & b.; Stentoft et al. 2020; Butollo, 2020). Overall, they fail to demonstrate a clear correlation between innovation and local manufacturing, as the results are contrasted and rarely fully conclusive (Dachs et al. 2019). In other contexts, research fails to evidence higher level of industry 4.0 technology adoption among closer manufacturing cases - assessed through reshoring- (Ancarini & Di Mauro, 2018). Recent research (Butollo, 2020) shows a more complex picture and predicts new fragmentation forms of supply chains rather than manufacturing proximity with the development of digitization and industry 4.0.

As shown, the literature on design-manufacturing coordination, on the one hand, and the literature on the role of proximity in innovation, on the other hand, are mostly disconnected. However, the debate on innovation has recently led a few authors (Pisano & Shih, 2012; Berger, 2013) to call for a "manufacturing renaissance" in the United States, arguing for the benefits of geographical proximity and vertical integration between design and manufacturing. More specifically, they have developed arguments on the negative impact of distant and outsourced manufacturing (specifically in far-off and low-cost countries) on current and future corporate and national innovation. In particular, the more innovation embedded in the manufacturing process, the more critical it is to locate manufacturing close to R&D, including process and product design (Pisano & Shih, 2012). They also suggest vertically integrating the two activities. According to Pisano & Shih (2012), the interconnectedness between design and manufacturing is industry- and product-specific. To determine the extent to which R&D and manufacturing are interdependent, they developed a two-by-two matrix with the two following variables: the degree of modularity between R&D and manufacturing, defined as the ability of these two activities to operate independently of each other, and the maturity of the manufacturing process technology. Their matrix provides four categories of innovation. When the degree to which information about product design can be separated from the manufacturing process (i.e., modularity) is low, the colocation of manufacturing and R&D is critical. In such cases, current and future innovation is strongly related to regular exchanges, tight collaboration and coordination between the manufacturing process and design.

Despite their analysis and the long tradition of literature arguing for the benefits of design-manufacturing coordination, most industries, including innovative industries such as fashion and electronics, practice offshoring, i.e., distant and outsourced manufacturing (Rice & Stefanelli, 2012; Kinkel, 2014; Dachs et al. 2019).

Based on this apparent contradiction, we aim to bridge the gap between these two literature streams and to better understand the complex ways in which innovative firms manage coordination between design and manufacturing from a proximity and integration perspective. Our research question is: How do innovative firms manage their design-manufacturing coordination from a geographical proximity and vertical integration perspective?

RESEARCH SETTING AND METHOD

The aim of the research is to better understand how innovative firms manage their design-manufacturing coordination from a geographical proximity and vertical integration perspective. Given that the literature on design-manufacturing coordination and on location, proximity and innovation already offers theoretical frameworks, our aim is to use a case research approach as theory elaboration (Ketovi & Choi, 2014). As such, it is not inductive as a theory generation approach or deductive as a theory testing perspective. It is abductive in a theory elaboration perspective. This work is framed within the theoretical frameworks of design-manufacturing coordination and of proximity, integration and innovation. Our aim is to explore the question of design-manufacturing coordination from the perspective of both proximity and integration.

For that purpose, we developed a field-based study in the European fashion industry. Below, the research setting, data collection and analysis method are presented. We are exploring this question to better understand the relationship among concepts of proximity and integration that were not previously looked at together.

Research setting

The research focuses on design-manufacturing coordination from a geographical proximity and vertical integration perspective. The researchers investigated the European fashion industry as the empirical setting because of its specific features, which make it particularly appropriate for this research. First, it is a very innovative and dynamic industry but was not chosen by previous research on design-manufacturing coordination, which focused on high-technology industries such as electronics or aircraft manufacturing. As shown by Cappetta, Cillo & Ponti (2006) and Macchion et al. (2015), innovation, through style and design, plays a fundamental role in the fashion industry. Then, in the fashion industry, innovation mostly relies on design (Abecassis-Moedas, 2006; Abecassis-Moedas & Benghozi, 2012; Benghozi & Salvador, 2015), which makes it ideal to study design-manufacturing coordination. Therefore, we focus on the design function hereafter and study design-manufacturing coordination. Because of the specificities of the fashion industry, this coordination between design and manufacturing has proven to be critical, calling for geographical proximity and vertical integration between the two functions (Pisano & Shih, 2012). In particular, Pisano and Shih (2012) used the fashion industry as an illustration of a process-embedded innovation.

Second, the fashion industry is the archetype of both an internationalized industry with distant offshore manufacturing (Buxey, 2005; Jin, 2004) and a localized industry, as illustrated in the concept of industrial districts in Prato (Piore & Sabel, 1984) or in garment centres in London, New York and Paris. Because fashion is labour intensive and products are easy to transport, Western fashion manufacturing operations have been widely offshored to low-wage environments. On the other hand, several industry leaders, such as Zara or Zegna, have chosen to locate their manufacturing in their home country, reflecting alternative strategies (Verdu et al., 2012). For these reasons, it is a very interesting industry to study, as exemplified by previous work (Cardeal, Abecassis-Moedas and Antonio, 2014; Jin, 2004; Verdu et al., 2012; Macchion et al., 2015; Martinez-Mora & Merino, 2014).

Research methodology and protocol

To explore the research question, exploratory qualitative multiple case study-based research was conducted. The methodology follows the items essential to qualitative research as discussed by Barratt, Choi & Li (2011). The phenomenon studied is the coordination between design and manufacturing. This method is appropriate to "provide freshness to an already researched topic" (Eisenhardt, 1989). A multiple case study methodology was adopted because it allows comparison of findings across a range of situations, strengthens the validity of the findings and helps draw out contextual differences. The number of cases studied (18) corresponds to the range proposed by Miles and Huberman (1994) in a multiple-case study (between 15 and 30). The case studies were selected following theoretical sampling, and they were not chosen for statistical reasons (Eisenhardt, 1989).

The sample is composed of 18 European fashion firms from different countries, sizes and segments. The case selection aimed to cover several segments of the industry, except luxury (because the issue is specific and already known for luxury), different sizes and different European nationalities, as both design-manufacturing coordination (Engelen, Brettel & Wiest 2012) and proximity choices are impacted by culture (Ghemawat 2001). To that end, we worked with industry experts who helped select cases in all these categories. The unit of analysis is the firms and their design-manufacturing coordination in terms of geographical proximity and vertical integration. Our final sample is composed of a broad range of European actors in the fashion industry with companies originating from different countries (France, Italy, Spain, the United Kingdom, Germany, Switzerland and Denmark). They also represent a broad range of sizes, from 30 million to over 6 billion euros in sales. Additionally, different market segments are included (mass market, sportswear, premium, underwear, fast fashion, mid-market, etc.). Combined, the 18 firms in the sample represent 20 billion euros in sales. A full list of the interviewed companies and their key characteristics is provided in Table 1 below. For reasons of confidentiality, the company names are omitted.

Insert Table 1 around here

Data Collection

Data were collected through semi-structured interviews with the CEOs or top managers of the 18 European fashion firms: eight CEOs, two sourcing directors, three supply chain directors, one category director and four innovation directors. In addition to these major informants, we had the opportunity to complement these interviews with access to annual reports and articles on all of these firms. The use of multiple sources is a way to address the issue of a single respondent approach and to triangulate data. The authors wrote memos and notes about several case studies. The interviews ranged from one to two hours, and they were recorded and transcribed. The objective of the interviews was to address the following subjects: (1) the proximity and integration of design and manufacturing and (2) the relationship between design and manufacturing and the coordination modes used by the firm.

After presenting the research goal as the coordination between design and manufacturing, the interviews followed an interview guide encompassing the following topics. First, the interviewee was asked to describe the general profile of the firm, its characteristics, its general performance, the markets targeted, and its global organization. The following themes were addressed: the structure of the supply chain and value chain, the organization and location of design, and the organization and location of manufacturing and its proximity to design. Respondents were asked what proportion of their activity was located where and what proportion of their manufacturing was integrated. Respondents were also asked to explain how design and manufacturing were organized and coordinated.

Data Analysis Process

The data analysis process followed two iterations: first, understanding the proximity and vertical integration between design and manufacturing activities for each case and then, analysing the coordination mechanisms between design and manufacturing for each case. The different design-manufacturing coordination modes were listed separately by each author and then compared to improve the reliability of the analysis. Finally, through multiple iterations between the two authors, a number of coordination modes between design and manufacturing emerged. Some of those coordination modes were proximity and vertical integration (different levels of each of these dimensions were observed), and then others (beyond proximity and vertical integration) emerged.

The first step of the data analysis process was to report the geographical proximity and vertical integration between design and manufacturing for each of the cases (see details in Table 2 and 3). In the second step of the data analysis, we analysed how design and manufacturing were coordinated to better understand the other coordination mode beyond proximity and integration. These results are reported in Table 4 and 5.

RESULTS

The data was analysed according to the protocol detailed above and is reported below. First the results are structured in terms of geographical proximity and vertical integration and then in terms of coordination modes.

Geographical proximity and vertical integration as ways to coordinate design and manufacturing

As fashion has been analysed as a process-embedded innovation industry, it is predicted that for firms to better innovate, design should not be separated from manufacturing (both from a geographical proximity and vertical integration perspective) (Pisano & Shih, 2012). Our empirical analysis confirms the benefits of design-manufacturing coordination:

"Overall, the link between creation and manufacturing is crucial". Company B

"For me, it is crucial, absolutely crucial. We need to move forward, do our job and push the limits, but the designers must know the manufacturing process". Company N

In Table 2, we report the proportion of activity in three proximity categories (home country proximity, home region proximity and no proximity) and in three vertical integration categories (design and manufacturing integrated, design in-house and manufacturing outsourced in a partnership and design in-house and manufacturing outsourced).

Insert Table 2 around here

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1. **Home country proximity**. This first coordination mode resides in the proximity that is presented in the literature. Pure colocation is a very efficient coordination mechanism. There is only one case in our sample, case M. Eight cases in our sample carry out some manufacturing in the home country, often in very small proportions.
2. **Home region proximity**. This coordination mode resides in proximity but is broader than the colocation of design and manufacturing in the home country. The distinction between close and distant manufacturing is clear for firms. In Europe, Western European manufacturing takes place in a minority of companies (only one in our sample, in Italy). Italy is the most cited country in Western Europe, where companies choose to manufacture because of its specific competencies and its fabric and production quality. Portugal is also an interesting location due to its quality/price/proximity balance, and for several of the companies interviewed, it is growing. Eastern Europe is expanding, particularly Romania

(five companies in our sample) and, to a lesser extent, Poland and Bulgaria. The close locations cited also include North Africa (Tunisia and Morocco), Turkey and Israel. Turkey benefits from reasonable costs, growing expertise and access to raw materials.

French companies have massively invested in Tunisia and Morocco, and German fashion firms have long-lasting and strong relationships with suppliers in Eastern Europe. In these cases, coordination is made easier, as the cultural distance is lower than the geographical distance. Beyond geographical proximity between design and manufacturing itself, economic, cultural and administrative proximity also facilitates coordination.

3. **No proximity**: design in home location and manufacturing in distant location: a majority of companies in our sample manufacture in distant locations such as Asia, especially in China. There are many companies that are in that configuration.

Regarding proximity, we find that proximity is more complex than just geographical proximity, and cultural proximity also matters, almost as if it could reduce physical distance. Additionally, companies consider home region proximity as proximity (and not only home country). Finally, there are two cases (D and F) where proximity is used differently. Instead of manufacturing being located close to design, it is design that is located close to manufacturing, often in the Far East. The main coordination mode is still geographical proximity but not in the home country.

"We have design teams in the countries where we manufacture, including China, India, Bangladesh, Turkey and Italy". Company D

In terms of vertical integration, there are three options: design and manufacturing integrated, design in-house and manufacturing outsourced in a partnership and design in-house and manufacturing outsourced.

4. **Design and manufacturing integrated** is a coordination mechanism used by eight companies in our sample.
5. **Design in-house and manufacturing outsourced to partners**: four companies in our sample use this model.
6. **Design in-house and manufacturing outsourced** is used by 14 cases in our sample.

The three levels of vertical integration show that integration is more complex and subtle than integrated or outsourced. Partnerships allow for more "closeness".

Our empirical analysis shows a very broad variety of proximity and degrees of vertical integration between design and manufacturing, both among the companies in our sample and within a single company. In Table 2 and throughout this analysis, it emerges that most companies have a portfolio approach and use a mix of proximity and vertical integration. What also emerges is that the two dimensions of proximity and vertical integration might not be totally independent. The data are presented in a matrixial way in Table 3, crossing the dimensions of proximity and vertical integration.

Insert Table 3 around here

In Table 3, we can see that proximity and vertical integration can be alternative coordination modes or can be used in combination. In some cases, distant manufacturing is performed in internal plants. When manufacturing is geographically distant from design, the firm's own internal plant is perceived as less distant. Indeed, coordination between design and manufacturing is made easier because both functions share the same values, identity, organization and information systems. Alternatively, when the relationship between the fashion firm and its preferred suppliers is strong through a strategic partnership, dedicated investments can be made, and coordination between manufacturing and design is facilitated.

As a result, it is almost as although the manufacturing base were an internal plant, and easier coordination between design and manufacturing is allowed, the geographical distance notwithstanding. For this reason, several companies from our sample decided to have their own plants or to build strong partnerships with their suppliers.

> *"Overall, 40% of our underwear manufacturing takes place in our own plant in the Philippines. It works really well".* Company F

Overall, it is interesting to see that most companies use a mix of proximity and distance and a mix of integration and outsourcing. When we cross the two dimensions, as in Table 3, we can see that proximity and integration are related. Proximity and distance are not independent.

Coordination modes beyond proximity and integration

A second iteration of data analysis consists of identifying other coordination modes between design and manufacturing used by firms beyond geographical proximity and vertical integration. The options are as follows. For details, see Table 4 below.

Insert Table 4 around here

Simple coordination. Overall, several companies manage geographical distance by reducing its impact through the use of other coordination modes, such as regular trips by the designers and product developers involved or specialized and highly skilled intermediaries. Intermediaries appear to form the connection between distant design and manufacturing (product managers, buyers or the sourcing team).

> *"So, then, the designs will be sent to agents in the locations. It could be in India, it could be in Bangladesh, it could be in China".* Company E

"Designers go to China on a regular basis". Company G

"We basically don't have our own plants. We use other plants, but our own designers go and visit and basically develop a little bit of the product with them". Company N

Segmented coordination. In some fashion companies, the first batches of products are manufactured locally or very close; later, batches are managed in more distant locations. As first batches are considered to be at the core of design-manufacturing coordination, this kind of organization allows innovation to be enhanced, while a large share of manufacturing is managed in distant locations.

"We have all the ultrasonic bonding; some special machines are installed in Portugal, in this so-called tech center. Sometimes, people, developers, product managers, and designers go down to Portugal just to do trials and mockups and to see what can be done. We mostly do the prototypes in Portugal because we have a lot of experienced people there and machines. They're also people who are very important. And, then, the full production side is mainly done in Romania or China". Company O

"It is part of our culture; we do the samples and prototypes in our own atelier here in Paris. Designers like to have prototyping here". Company P

Virtual coordination: Beyond geographical proximity and vertical integration, a new coordination mode is emerging, virtual coordination (facilitated by the use of technology). Therefore, instead of reducing the geographical distance per se, companies choose to substitute geographical proximity with other forms of proximity: ICT-enabled proximity. Overall, several companies manage geographical distance by reducing its impact through the use of communication technologies. Numerous firms have sophisticated information and communication technologies (ICTs) in place (e.g., product lifecycle management (PLM) systems) between design and manufacturing locations. In a way, technology reduces geographical distance, as it allows manufacturing and design teams to better communicate and coordinate through electronic exchanges and virtual reality tools such as 3D modelling.

> *"So, then, the designs will be sent to agents in the locations. It could be in India, it could be in Bangladesh, it could be in China". (…) "Because of the technology, it is clear how many centimetres there are to the left and how many stitches there are to the right. There can never be a misunderstanding about that".* Company E

These options are not exclusive to one another, and quite a few players adopt more than one of these coordination modes, as shown in Table 5.

Insert Table 5 around here

In the data analysis, we identified that geographical proximity and vertical integration are broader concepts: home country, home region and no proximity and integrated, outsourced with partners and purely outsourced. However, cultural distance can also reduce geographical distance, and design and manufacturing can be close, even colocated, but not always in the home country. Then, we found that there are other coordination modes beyond proximity and integration: simple coordination (trips and intermediaries), segmented coordination (using proximity for first batches only), and virtual coordination. Finally, we observed that companies have a portfolio approach and that they mix and match the different coordination modes: proximity, integration, simple coordination, segmented coordination, and virtual coordination. We see emerging the concept of omnishoring.

DISCUSSION

As predicted by Pisano & Shih (2012), the value of keeping design and manufacturing vertically integrated and geographically close is high in the fashion industry. Our research also confirms the overall need to have strong coordination between design and manufacturing. However, few of our cases actually use geographical proximity and vertical integration, at least not for all their products, as they need to cope with other types of constraints such as the availability of raw materials and competences, lower costs and large scale, or an existing network of suppliers. In many cases, they neither integrate vertically nor colocate design and manufacturing. Therefore, our results challenge Pisano & Shih's (2012) model, as they refine the understanding of proximity and integration and propose that there are alternative ways to coordinate the two activities beyond geographical proximity and vertical integration.

Overall, we contribute to the long tradition of the DMI literature, providing an analysis of coordination mechanisms in the context of global and extended value chains, as called for by experts in the field (Dekker et al., 2013). Specifically, we demonstrate several mechanisms that companies deploy to coordinate manufacturing and design beyond geographical proximity and vertical integration. Specifically, we demonstrate that a variety of mechanisms can be leveraged to overcome traditional barriers to coordination, such as physical, organizational and cultural distance (Vandevelde & Van Dierdonck, 2003). These mechanisms reflect and refine the organizational and technological mechanisms previously demonstrated by research on design-manufacturing coordination (Abecassis et al., 2000; Twigg, 2002).

Proximity, integration and innovation

First, we suggest that distance is a multidimensional concept. An in-depth understanding of this concept results in innovative paths to better coordinate design and manufacturing and to refine Pisano & Shih's analysis. As shown in other contexts (Ghemawat, 2001; Coughlan, 2014), distance and proximity are complex concepts. Therefore, geographical distance should be complemented with administrative, economic and cultural distance (Ghemawat, 2001) to understand the actual impact of distance or proximity on innovation. Similarly, proximity can be achieved not only geographically but also culturally, cognitively or technologically. Therefore, we suggest that these dimensions (geographic, cultural, cognitive, organizational and technological proximity) could enrich Pisano & Shih's matrix. For example, the impact of distance on management also varies based on the level of control and the similarities between business processes or practices. Previous research has shown that large companies can benefit from "epistemic communities" that help them overcome the issues raised by long distances (Hakanson, 2005). We provide additional support for this concept, showing that it facilitates the management of distance within the same company. Our results can also partly explain why backshoring remains anecdotic (Dachs et al. 2019) and further reinforce the potential of more complex moves such as the "relocation of second degree" (Barbieri et al. 2019) or new forms of supply chain fragmentations (D'Aveni, 2018; Butollo, 2020; Elia et al, 2021).

Our findings confirm and extend existing work on the impact of proximity on innovation (Coughlan, 2014; Sonn & Storper, 2008). In our case, coordination between design and manufacturing—a key step in the innovation process—not only concerns reducing geographical distance (as originally assumed by Pisano & Shih, 2012) but also may be achieved through different means when the two activities are distant.

Our work makes another important contribution to design-manufacturing coordination: proximity and vertical integration are interdependent. Too often, these two dimensions are viewed and analysed as independent or are combined in an ambiguous manner (McIvor, 2013). Only recently have issues of proximity and vertical integration been analysed together (Buckley & Strange, 2015). According to our work, some geographical distance can be managed through vertical integration. As shown previously, managing the coordination between design and manufacturing when they are distant is facilitated when they belong to the same company, i.e., when they are vertically integrated. Therefore, we provide evidence that these two dimensions are not independent.

Multiple coordination modes and omnishoring

Overall, we observed that companies tend to use more than one coordination mechanism at the same time. In our sample, all firms used some geographical proximity; additionally, they used other coordination mechanisms. We argue that European fashion companies develop *omnishoring* strategies, i.e., a combination of proximity and distance and of vertical integration and outsourcing, and they leverage the complementarity between these different modes. For example, some of them test the first small manufacturing batch of a given newly designed product in their own local workshop before launching large-scale manufacturing in an outsourced plant in Asia. For the same product, later in the season, they may even complement smaller batches manufactured in nearby subcontractors to ensure replenishments. Additionally, some products are better fitted to some types of suppliers (internal vs external) and some types of proximity (close vs far). Balancing between different options helps companies meet the challenges that they are facing, including innovation. It illustrates "structural flexibility" (Brennan et al., 2015; Christopher & Holweg, 2011), defined as "the ability of the supply chain to adapt to fundamental changes in the business environment" (Christopher & Holweg, 2011, p.70). This observation also goes beyond the traditional dichotomy between offshoring and reshoring (Ellram, Tate & Petersen, 2013; Gray, Roth & Leiblein, 2011; Kinkel & Maloca, 2009; Dachs et al. 2019) and between make and buy (McIvor, 2009). First, the chosen coordination modes are not binary but could be positioned on a continuum, both for the extent of geographical proximity (between close and far, several intermediate distances exist such as nearshoring or relocation to a second degree as evidenced previously –Barbieri et al. 2019-) and for the degree of vertical integration (between make and buy, different types of partnerships are possible). They are also combined differently (e.g., outsourced close vs. outsourced distant or insourced distant or insourced close). Second, we show that companies use proximity and distant sourcing as well as vertical integration and outsourcing simultaneously as they adjust the coordination mode to the type of product (very fashionable vs more basic), to its level of development (prototypes or first batches vs latest), or its intended market. We define as "omnishoring" such a combination and complementarity of coordination modes based on those two dimensions – extent of geographical proximity and degree of vertical integration – within a single company.

We develop the concept of omnishoring as an analogy to omnichannel retailing (Verhoef, Kannan & Inman, 2015), where different sourcing options (regarding the extent of geographical proximity and vertical integration) are combined. Like omnichannel, these options also build on their complementarities to facilitate the achievement of different objectives simultaneously and seamlessly thanks to sophisticated information technology. In this view, omnishoring blurs the lines between offshoring and reshoring and goes beyond relocation to a second degree (Barbieri et al. 2019). It also blurs the lines between outsourcing and vertical integration, as different options are used simultaneously by the same company leveraging their complementarities. Omnishoring finally solves the trade-off between innovation and agility versus low-cost and distant sourcing, as it helps coordinate manufacturing and design through different means that complement each other, the geographical proximity and vertical integration level notwithstanding. Additionally, as in the case of omnichannel, information systems and technology should play a key role in coordinating the different modes, optimizing efficiency and offering a seamless experience to users. At this stage, among the surveyed companies, piloting between different modes is still in its infancy. As envisioned by D'Aveni (2018), future manufacturing titans such as Jabil could act as a control tower to further leverage complementarities and precisely pilot manufacturing based on geographical, qualitative and quantitative needs for a more responsible and efficient industry.

CONCLUSION

This research reveals that there are a range of mechanisms to coordinate design and manufacturing that go beyond geographical proximity and vertical integration, including simple, segmented and virtual coordination modes. It also shows that the two dimensions of geographical proximity and vertical integration are not independent. Our work provides an explanation for the apparent paradox of distant and outsourced manufacturing in an innovative industry and reconciles the two perspectives of geographical proximity and vertical integration that are usually apprehended independently.

Beyond its theoretical implications, it also offers managerial implications because it helps companies approach their sourcing strategy as a portfolio and understand how it is possible to preserve or enhance innovation despite distant and outsourced manufacturing. Additionally, it coins the term *omnishoring*, which may be further analysed in the future. Because geographical proximity and vertical integration may be difficult to achieve based on existing networks and constraints, omnishoring can represent a smart alternative for companies to coordinate design and manufacturing.

Despite its many contributions, our work also has some limitations. First, due to the use of an abductive methodology, our results cannot be fully generalized, and further research is necessary to test our findings in a context broader than the fashion industry. Second, our focus was European and at one point in time. Recent developments and research in additive manufacturing may pave the way for new trends in supply chain organizations and design-manufacturing coordination modes (Hohn & Durach, 2021). We hope to extend this research in time and scope in the future. The pertinence of this work might be increased by the COVID-19 crisis that has made reshoring more key and that has impacted global supply chains (Barbieri et al., 2020). Finally, while we provide interesting insights into the different ways that companies can use to coordinate design and manufacturing, we could not relate the different coordination modes to the level or type of innovation. We believe that doing so could be an attractive avenue for future research in the field.

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TABLES

Firm	Nationality	Sales (M euros)	Market segment
A	UK	90	Mass market
B	France	100	Sportswear
C	France	1500	Mass market
D	Denmark	2700	Fast fashion
E	Germany/ the Netherlands	6500	Mass Market
F	France	700	Underwear
G	Spain	828	Mid-market
H	France	1400	Premium sportswear
I	Germany	85	Mid-market
J	France	890	Mass market
K	France	28	Premium
L	France	600	Mass market
M	Italy	70	Premium
N	Italy	650	Premium
O	Switzerland	117	Underwear/sportswear
P	France	600	Premium
Q	UK	2000	Mass market
R	France	180	Premium

TABLE 1. Descriptive Statistics

	Geographical proximity between design and manufacturing			Vertical integration between design and manufacturing		
Firm	1. Home country proximity	2. Home region proximity	3. No proximity	4. Integrated in-house	5. Outsourced with partnership	6. Manufacturing outsourced
A		50%	50%	50%		50%
B	40%	50%	10%	40%		60%
C		20%	80%		100%	
D		20%	80%			100%
E		30%	70%			100%
F	30%	10%	60%	48%	52%	
G		20%	80%			100%
H	15%	85%		50%		50%
I		90%	10%	20%	80%	
J		5%	95%			100%
K		90%	10%			100%
L		30%	70%			100%
M	100%			50%		50%
N	20%	60%	20%	5%	95%	
O		80%	20%	66%		33%
P	3%	65%	32%			100%
Q	1%	23%	76%			100%
R	5%	65%	30%			100%

TABLE 2. Geographical proximity and vertical integration between design and manufacturing

	Home country proximity			Home region proximity			No proximity		
Firm	Integrated	Partnership	Outsourced	Integrated	Partnership	Outsourced	Integrated	Partnership	Outsourced
A				50%					50%
B	40%					50%			10%
C					20%			80%	
D						20%			80%
E						30%			70%
F	30%			10%			10%	50%	
G						20%			80%
H	10%		5%	40%		45%			
I				20%	70%			10%	
J						5%			95%
K						90%			10%
L						30%			70%
M	50%		50%						
N	5%	15%			60%			20%	
O				66%		14%			20%
P			3%			65%			32%
Q			1%			23%			76%
R			5%			65%			30%

TABLE 3. Geographical proximity and vertical integration between design and manufacturing (matrix perspective)

Firm	1. Simple coordination	2. Segmented coordination	3. Virtual coordination
A			
B			X
C			X
D			
E	X		X
F		X	
G	X		
H			
I			
J	X		
K			
L	X		
M			
N	X		
O		X	X
P	X	X	
Q	X		
R			

Table 4: Other coordination modes for each case beyond proximity and integration

Firm	Proximity (home country)	Integration (in-house)	Simple coordination	Segmented coordination	Virtual coordination
A		X			
B	X	X			X
C					X
D					
E			X		X
F	X	X		X	
G			X		
H	X	X			
I		X			
J			X		
K					
L			X		
M	X	X			
N	X	X	X		
O		X		X	X
P	X		X	X	
Q	X		X		
R	X				

Table 5: Coordination modes between design and manufacturing