Business model innovation and ambidexterity in Industry 4.0

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Abstract

Framing of the research. *The Fourth Industrial Revolution (I4.0) is dramatically affecting firms' strategies, disrupting their business models. In particular, a bunch of digital technologies like IoT (Internet of Things), cloud platforms, big data, artificial intelligence and data analysis are offering firms the possibility to manage products functions, remotely and globally, kick-starting the design of innovative business models.*

Purpose of the paper. *Using studies that have analyzed the link between business model innovation and ambidexterity as theoretical background, the aim of the paper is to investigate how incumbent BtoB manufacturing firms develop an I4.0 disrupting business model by addressing the related duality between exploration and exploitation (ambidexterity).*

Methodology*. The paper fulfils its purposes by the means of a qualitative investigation, discussing empirical evidence coming from a cross-case analysis of 25 Italian SMEs and medium-large enterprises, selected crossing secondary data and indications coming from a specific panel of ten industry experts.*

Results*. The impact of I4.0 technologies on firms' business models depend heavily on the access to user-firms' data. 21 firms are involved in non-disruptive modifications of the business model; 4 firms are conducting more sophisticated experimentations in result-oriented product-service systems. These firms, that we have named "challengers", are in a privileged position in order to unleash the potential of I4.0, introducing advanced services directly related to the customers' needs. All these challengers adopt a particular form of contextual ambidexterity in which the exploration activities involve specifically selected (key) customers.*

Practical implications*. Managers need to understand which are the pace and extent of change for the various components of the corporate business model to innovate during each specific step of transition towards I4.0 technologies.*

Research limitations. *The main limitation of the study is because the investigated companies were going through a transition phase: therefore, we can't tell what the outcome of this evolutionary journey will be, and if it will be the same for every firm.*

Originality of the paper*. The paper proposes an original framing that contributes theoretically to the literature interfacing business model innovation and ambidexterity management. In particular, the study enhances our knowledge about contextual ambidexterity, a concept as rich in charm as poorly explored in practice.*

Key words: *business model innovation; ambidexterity; I4.0; BtoB manufacturing firms; Italy*

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1. Introduction

The Fourth Industrial Revolution (Industry 4.0, I4.0) is dramatically affecting firms' behaviors and strategies, transforming products design, manufacture, operations and services. This disruption is in particular linked to a series of digital technologies within the I4.0 framework that will dramatically change the way firms operate in their markets (Meindl *et al.*, 2021). Among I4.0 technologies, a set of outward-oriented, front-end set of technological streams - IoT (Internet of Things), cloud platforms, big data, artificial intelligence and data analysis - are transforming business markets landscapes, offering firms the possibility to monitor, optimize and automatize product's functions, remotely and globally (Paiola and Gebauer, 2020). These technologies are at the core of a radical transformation of manufacturing, changing firms' business models with the expansion of service innovation opportunities.

The interplay of sensors and the development of the internet is central to I4.0: IoT enables data gathering from smart and connected devices, providing firms with strategic information input (Laudien and Daxböck, 2016; Santos *et al.*, 2017). IoT is therefore playing a critical role within I4.0 technologies (Arnold *et al.*, 2016). In particular, in this paper we refer to the IoT applied in industry, or the Industrial IoT (IIoT), where software-embedded intelligence is integrated in industrial devices, products and systems (Paschou *et al.*, 2020; Rymaszewska *et al.*, 2017).

By enabling communications with and among things, IoT has opened the possibility to gather fine-grained real-time data coming from relatively inexpensive sensors and actuators embedded in objects and devices from all over the world. This potentially enormous flow of data (big data) poses unprecedented challenges in collection, storage, processing and analysis (Santos *et al.*, 2017). This challenge involves also industrial services (Gebauer *et al.*, 2020), since data can be leveraged in order to enhance products and design innovative product-service systems (Belvedere *et al.*, 2013), optimize customer segmentation, positioning and pricing strategies and modify business models' component configurations over time (Santos *et al.*, 2017).

Overall, new and disruptive business models are emerging in the I4.0 landscape, posing big challenges to entire industries (Stock and Seliger, 2016). The aim of this paper is to investigate this phenomenon from the point of view of incumbent BtoB manufacturing firms, whose traditional strategies are not suitable for dealing with the ongoing digital revolution (Paiola and Gebauer *et al.*, 2020; Laudien and Daxböck, 2016; Müller *et al.*, 2018). Specifically, using studies that have analyzed the link between business model innovation and ambidexterity as theoretical background, our research question is: how do incumbent BtoB manufacturing firms engaged in the digital transition develop a disrupting business model by addressing the related duality between exploration and exploitation, that is, the ambidexterity dilemma? This question has not yet been addressed by empirical research, as indicated by the very recent review of the literature on ambidexterity and disruptive business model innovation conducted by Stoiber *et al.* (2023). The empirical section involves 25 Italian BtoB

manufacturing firms, whose strategic shifts related to I4.0 technologies are described and analyzed in relation to business model innovation.

The paper proposes an original framing that contributes to the literature interfacing business model innovation and ambidexterity management: capitalizing on previous studies and on the empirical evidence, the paper investigates a so far overlooked topic, related to the circumstance in which incumbent firms in given industries disruptively innovate their own current business models. Moreover, findings allow us to explore the circumstances under which contextual ambidexterity may represent a superior strategy and a viable perspective for firms facing disruptive technological change as is the case in the I4.0 scenario.

2. Theoretical background

2.1 The impact of I4.0 on business models: new services and revenue models

Despite the noteworthy role of technology in I4.0, scholars maintain that it is only part of the picture (Arnold *et al.*, 2016). In fact, firms have to work hard on their business models in order to exploit technological opportunities and avoid disruption, since "a mediocre technology pursued within a great business model may be more valuable that a great technology exploited via a mediocre business model" (Chesbrough, 2010, p. 355).

Even if a thorough review of business model literature is far beyond the aim of this paper, some further considerations regarding the concept of business model may be useful in order to properly introduce the importance of business model innovation and to better understand the scope of the ongoing transformation. Essentially, a business model summarizes the architecture and logic of a business (Baden-Fuller and Morgan, 2010): either explicitly or implicitly, whenever a firm is established, it employs a particular model that describes "the design or architecture of the value creation, delivery, and capture mechanisms it employs" (Teece, 2010, p. 172), that is fundamental functions in the strategic life of a firm.

Therefore, business model innovation is a process through which firms realize changes in the activities and functions within their business models and explore new architectural designs: it consists in exploring new possibilities related to value proposition definition, value creation, distribution and capture for customers, suppliers and partners (Casadesus-Masanell and Zhu, 2013).

Given this, an important aspect that literature has dealt with - that is connected to the definition itself of business model innovation - is related to the magnitude of the change, or the circumstances under which we can define that a modification in the business model is an innovation (Loebbecke and Picot, 2015). In fact, modifications in the business models can pose serious challenges to firms, impacting heavily on their efficiency, complementarities, lock-in, novelty and the linkages among them (Amit and Zott, 2001). At this regard, literature on business model innovation presents two conflicting approaches, i.e., incremental versus radical (disruptive) innovation (Wahyomo, 2018).

The circumstance is particularly important here, since it refers directly to the question whether I4.0 calls for an adjustment or a radical change in the business model. At this regard, literature has highlighted some of the main consequences of I4.0 technologies on firms' strategies (Ritter and Pedersen, 2020): for instance, Laudien and Daxböck (2016) describe how a "full utilization of IIoT" requires a radical innovation of the firms' business model. Innovative firms are now encouraged to leverage on services in order to create entirely new business models, finally migrating from product-centric approaches to service-oriented ones (Coreynen *et al.*, 2017). In fact, counting on hundreds or thousands smart and connected devices installed at the premises of final-user firms is something that can change the rules of the competition, making space for brand new data-based service-oriented business models (Raddats *et al.*, 2022).

Consequently, I4.0 technologies affect the design and development of the offering, in the direction of a dramatic expansion of service innovation opportunities, increasing the relevance of the transition of manufacturing firms toward service-based strategies. The connection between I4.0 technologies and service development is so firm that, recently, a growing research stream has begun to study technology as an enabler for servitization, triggering "digital servitization" as a specific research stream (Paschou *et al.*, 2020).

Thus, thanks to technologies, manufacturing firms can unlock the supply of product-service systems (PSSs) (Pirola *et al.*, 2020): firms' value propositions shift gradually away from pure products toward pure services, in the form of use-oriented and result-oriented offerings, gradually changing the focus towards advanced forms of market relations in which a solution is being purchased and paid for. While a product-oriented PSS is perfectly fit for the manufacturing firm's classical repertoire, use-oriented and result-oriented ones are more distant from traditional business models adopted and call for major redefinitions of the firms' business models.

In fact, I4.0 is both able to "boost" traditional industrial services (like maintenance), and to be the starting point of a potential disruption of traditional BtoB business models. In particular, IoT-based use-oriented and result-oriented PSSs imply a radical shift in the fundamental revenue models of the firms, introducing usage-based, performance-based and value-based revenue models (Adrodegari and Saccani, 2017). Capital equipment manufacturers that are used to achieve profitability from conventional services such as spare parts are therefore beginning to change their value propositions toward PSSs (Hypko *et al.*, 2010; Kohtamaki *et al.*, 2021), and to look to those new revenue models (Rymaszewskaa *et al.*, 2017). This is changing the mechanisms of revenue generation (along with costing structures, risk assessment and reciprocal liabilities among partners) from a transactional perspective to a relationship-based one (Gaiardelli *et al.*, 2014).

If we consider that "the more challenging the revenue architecture, the greater the changes likely to be required to traditional business models" (Teece, 2010, p. 186), we can assume that those changes will not be trivial. A particularly problematic scenario is present whether a relevant change in the business model core elements is expected, and when furthermore the

changes might lead the existing business models to become obsolete and uncompetitive, putting organizational structures and culture at stake (Bock *et al.*, 2012). Those challenging problems will be the object of the following section, that deals with business model innovation crucial questions that are relevant for our research.

2.2 Business model innovation and ambidexterity: a critical review

The literature on business model innovation has shed light on important issues (Spieth *et al.*, 2014; Wahyono, 2018). But when it comes to considering the crucial question of how an incumbent firm in a given sector disruptively innovates its own business model, we realize there is still a sizable area to explore (Paiola *et al.*, 2022). The perspective of ambidexterity, in the sense of exploration-exploitation à la March (1991), clearly seems to be the most appropriate for framing cases of business model innovation of disruptive type because developing a radically new business model demands an exploratory process that is particularly onerous from the point of view of the resources required. But the link between ambidexterity and business model innovation has only recently begun to attract scholarly attention (Khanagha *et al.*, 2014; Markides, 2013; Ricciardi *et al.*, 2016; Sosna *et al.*, 2010).

In this interfacing literature, the contribution from Markides (2013) serves as a useful starting point in order to arrive at our research question, which is the previous one specified in the emerging scenario of the I4.0. He claims that the simultaneous management of dualities such as exploration and exploitation, efficiency and flexibility, or low cost and differentiation, has been framed as an ambidexterity issue. From this starting point, the problem the author wishes to analyze is how a firm can compete with two conflicting business models simultaneously, that is one additional type of duality a firm may face. More precisely, in certain circumstances firms must develop a new and disruptive business model, that it is conflicting with the extant one. For this ambidexterity challenge, Markides identifies three possible solutions: 1) spatial separation, 2) temporal separation, or 3) contextual ambidexterity.

In the first, two business models are physically separated into two distinct organizations, or organizational units within the same organization (O'Reilly and Tushman, 2004). Instead, the temporal separation strategy means that a firm starts out by putting the new (and conflicting) business model "in a separate unit but reintegrate it in the main business over time (i.e., phased integration strategy)" (Markides, 2013, p. 315). The discriminatory variable between spatial separation and phased integration is the (perceived) strategic relatedness between the market for the established business model and the market for the new one. If this relatedness is weak, then firms will opt for separation; if it is strong, they will choose phased integration, or a simpler and manageable transition to duality (Visnijc *et al.*, 2021). In the latter case, a firm aims to exploit synergies between the new market and the existing business, but prefers to "separate for a period of time and then slowly merge the two concepts so as to minimize the disruption from the conflicts" (Markides, 2013, p. 25).

While using the former two solutions the conflicts between two business models are solved by managing them separately (in the early stages, at least), the third solution (contextual ambidexterity) involves managing the business models simultaneously. Following Gibson and Birkinshaw (2004, p. 210), this kind of ambidexterity is achieved "by building a set of processes or systems that enable and encourage individuals to make their own judgments about how to divide their time between conflicting demands for alignment and adaptability", i.e., between exploitation and exploration. In this case, every individual working in a given organizational context is ambidextrous (Birkinshaw and Gibson, 2004). However, in Markides (2013) and other authors (Hu and Chen, 2016; Lavie *et al.*, 2010; Spoiler *et al.*, 2023; Winterhalter *et al.*, 2016), the meaning of contextual ambidexterity is broadened, providing a multifaceted construct that indicates more than one way to handle two business models within the same organizational context. Accordingly, contextual ambidexterity includes those cases where some employees manage the relationships with demanding clients whose complex needs require a superior exploration investment (Bednarek *et al.*, 2016; Im and Rai, 2008). However, as Markides (2013, p. 317) points out, it is by no means easy to create an organizational context suitable to manage two conflicting business models simultaneously: "On one hand, it [the firm] has to create enough distance between the two business models that they don't suffocate each other; on the other, it has to keep them close enough to exploit synergies between the two".

The ambidexterity considered in Markides's typology concerns the duality between conflicting business models. But it can also be interpreted in the sense of an ambidexterity revolving around the classic dichotomy of March's exploration-exploitation (1991), bearing in mind that research on ambidexterity seems to have converged mainly on this type of duality (Birkinshaw and Gupta, 2013; Junni *et al.*, 2013; Stadler *et al.*, 2014). However, we simply need to acknowledge, according to some authors (Bröring and Herzog, 2008; Gerdoçi *et al.*, 2018; Sun and Lo, 2014), that exploration and exploitation may hardly be completely separated. Therefore, in the cases of a dual business model considered by Markides, the new business model is distinctive for its strong focus on the exploratory activity, whereas exploitation amply prevails in the extant business model. In the case of contextual ambidexterity, the old and new business models - which differ considerably in their balance of exploration and exploitation, and (partly for this reason) are also in conflict with one another to some degree - must coexist and interact in the context of the same organizational structure, posing contrasting demands to management (Andriopoulos and Lewis, 2009). On the other hand, spatial separation or temporal separation of the two business models are variants of structural ambidexterity, in the sense of the ambidexterity that can be achieved by creating dual structures (Altuna *et al.*, 2015; Bröring and Herzog, 2008; Gibson and Birkinshaw, 2004; Raisch and Birkinshaw, 2008).

Having clarified this point, the contribution from Markides (2013) serves as an important reference when dealing with the topic of disruptive business model innovations. His concept of business model duality can be further refined by explicitly considering the presence of a strategic

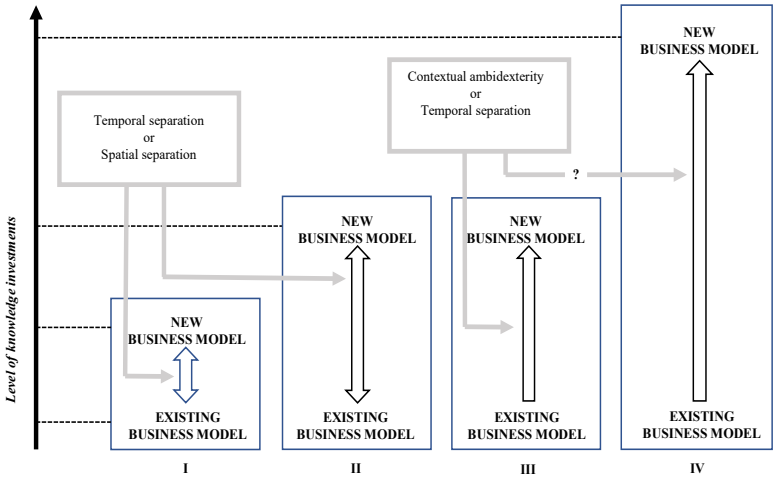
innovator in the market. In the paper that inspired the first two solutions envisioned in Markides (2013), Markides and Charitou (2004) wrote that the problem of how a firm can adopt two different business models in the same market "has become particularly pressing for an increasing number of established companies that have recently come under attack from 'strategic innovators' - companies that attack the established players by using radically different business models" (p. 22). But unfortunately, this is not the problem that Nestlé (one of the exampled mentioned by the authors) faced when introducing Nespresso to the market. In this case (as in others), Nestlé was the strategic innovator.

Therefore, distinguishing the situations in which there is a strategic innovator serving as a reference for the focal firm from those where the latter develops its own disruptive business model, is of uttermost importance for our discourse. To do that, we can think in terms of the investments in exploration, i.e. of the investments in knowledge needed to embark on the exploratory activity. The level of such investments correlates with the degree of uncertainty inherent in the exploratory process, and it is lower if there is a strategic innovator, and higher without it. In the former case, there is indeed a sort of "template" - to borrow a concept used in studies on the replication of organizational routines (Winter and Szulanski, 2001) - that the follower can use to speed up the process of exploration learning, and reduce the related costs and uncertainties. For instance, it may recruit some of the strategic innovator's key employees, who have experience of the new business model (Wezel *et al.*, 2006). Figure 1 shows the differences in the two above-described types of disruptive business model innovation (I and II), together with the spatial and temporal separation strategies that may be feasible in both situations, but under different circumstances.

The double arrow connecting the existing business model with the new one in Figure 1 indicates that the two business models are destined to coexist within the scope of the firm, even if they demand a temporary or permanent separation on the organizational level. This prerogative is shared by all the cases of structural ambidexterity contemplated in Markides (2013)'s framework: online trading systems; internet banking and internet brokerage; budget, no-frills flying; and others (Markides and Charitou, 2004). We frequently find such cases in the literature on business model *Innovation,* which has flourished in the last 15 years largely thanks to advances in ICT, and to the fact that many e-businesses are based on new business models (Amit and Zott, 2012; Casadesus-Masanell and Ricart, 2010; Shafer *et al.*, 2005). The adoption of a cloud business model by Telco, studied by Khanagha *et al.* (2014), also belongs to this typology, as an example of temporal separation. More in general, spatial or temporal separations are typical of strategies to develop a new market segment, as illustrated by the case of Nestlé. Consequently, the main source of conflict between the two business models derives from a cannibalization between the corresponding market segments (Markides and Charitou, 2004; Velu and Stiles, 2013).

sinergie
italian journal of management
Vol. 42, Issue 1, 2024

Fig. 1: Disruptive business-model innovations: a typology



Source: our elaboration

But what happens when an existing business model has to be switched to a new one (type III in Figure 1)? There are numerous anecdotal accounts of such a situation, but - to the best of our knowledge - only Sosna *et al.* (2010) have proposed an interpretation through the dual lens of business model innovation and exploration-exploitation ambidexterity. Their in-depth study concerned a Spanish dietary products company that was converted from a foodstuffs wholesaler into a franchisor managing the international retailing network Naturhouse. The strategy adopted by the firm to complete its business model "metamorphosis" (as the authors named it) involved what Markides (2013) called a temporal separation. However, the final solution didn't entail an integration of the two business models - which remained distinct (as in type II) - but a dissolution of the old model, which was replaced by the new one (type III). Actually, even contextual ambidexterity is a theoretical option in case of type III, whereas spatial separation - by definition - makes no sense in such cases.

At this point, we can set the stage for our study, which certainly differs from the above-mentioned one (type III) in that the exploratory process entails a higher level of investments in knowledge. This is because I4.0 is an even more broadly open scenario, rich in opportunities, but also burdened with uncertainties. In particular, exploring opportunities in I4.0 demands the ability to master different knowledge domains and be able to combine them together. Facing such a level of exploration breadth[1] clearly means raising exploration investments (type IV in Figure 1). But then, in the current phase at least, firms that advance on the I4.0 frontier should all be seen as pioneers, i.e., they cannot draw on successful prior experiences of strategic innovators that they might observe and imitate (as

[1] The concept of exploration breadth draws on that of knowledge breadth, which refers to the range of fields over which a firm has knowledge (Prabhu *et al.*, 2005).

in III). Moreover, their goal may be not to juxtapose two business models, but to transition from one to another (as in III). Finally, the choice of which strategy to adopt - temporal separation *versus* contextual ambidexterity - clearly remains an open question, that our study attempts to answer. At the same time, bearing in mind the abovementioned broad definition of contextual ambidexterity, we also look into the solution adopted by each firm to manage its metamorphosis.

3. Methodology and empirical setting

As I4.0 is still an emerging and puzzling phenomenon, we designed an explorative qualitative investigation, implementing a cross-analysis of different companies, coherently with well-known specific literature on qualitative research and collective case-study (Eisenhardt, 1989; Yin, 1994).

Consistently, instead of aiming at building a statistically representative sample we preferred to focus on diversity, designing a setting able to describe the different situations and challenges facing firms in the I4.0 scenario described above (Miles and Huberman, 1994). In a preliminary investigation phase, using a semi-structured interview template, we interviewed 10 industry experts selected on the base of their specialization in the field and their expertise using secondary data, personal and professional contacts.

Their indications and suggestions have been critical in the subsequent phase of selecting the sampled firms. We constructed a preliminary list of firms as coming from the experts' suggestions and started to contact top managers belonging to the different companies, targeting both top managers (CEOs, and GMs) and specific function managers presumably directly involved in the transformation elicited by I4.0 (like CTOs, CIOs, etc.). Once the contact was established, a first personal phone call by the researchers was managed in order to explain the nature and aims of the research, to assess the firm's willingness to participate in the investigation and identify which managers/professionals was specifically to be involved in the interviews. Between the beginning of 2017 and mid-2018, we collected data coming from several in-depth face-to-face semi-structured interviews with firms' key-informants and top managers in charge of technological or specifically IoT-related activities, like Chief Executive Officers, General Managers, and others.

Tab. 1: Empirical cases, firms' characteristics and interviews outline

Company	Industry	Rev. (mio)	Emp.	Value system*	Sales model°	Product type (prevalent)	Digital technologies^	Interviews, roles, total duration§
1	Professional equipment	3	8	OEM	Indirect	Standard	IOT	1, SM, 2h
2	Machine tools	8	26	OEM	Direct	Custom	IOT	2, CEO, 2,5h
3	Professional equipment	6	30	OEM	Indirect	Standard	IOT, Cloud	2, CEO, CTO 3h
4	Mechanical components	8	34	OES	Indirect	Standard	IOT, Cloud, DA	2, CEO, 2,5h
5	Packaging machines	20	84	OEM	Direct	Custom	IOT	2, CEO, CMM, 2h
6	Packaging machines	50	120	OEM	Direct	Custom	IOT, Cloud, DA	2, BD, 3,5h
7	Inspection machines	37	143	OEM	Direct	Custom	IOT	1, CTO, COO, 2h
8	Professional equipment	105	150	OEM	Indirect	Standard	IOT, cloud	2, CEO, 2,5h
9	Heating control systems	48	195	OES	Indirect	Standard	IOT, Cloud	3, CTO, CMO, 4h
10	Heating devices	61	233	OEM	Indirect	Standard	IOT, Cloud, DA	3, CEO, 4h
11	Food machines	150	250	OEM	Indirect	Standard	IOT, Cloud, DA	3, SM, CTO, 5h
12	Home automation	130	410	OEM	Indirect	Standard	IOT, Cloud	2, CTO, 2h
13	Diagnosis machinery	90	458	OEM	Indirect	Custom (modular)	IOT, Cloud, DA	1, CMM, CTO, 2h
14	Heating control systems	166	602	OES	Indirect	Standard	IOT, Cloud	4, CTO, CIO, 5h
15	Machine tools and plants	202	652	OEM	Direct	Custom	IOT, Cloud, DA	3, CTO, CHRO, 5h
16	Retail equipment	240	697	OEM	Direct	Standard (modular)	IOT, DA	2, CTO, 3h
17	Off-road automation	157	743	OES	Indirect	Standard	IOT, Cloud	4, CEO, CTO, 4h
18	Water management devices	278	761	OEM	Indirect	Standard	IOT, Cloud	1, SM, CTO, 5h
19	Heating components	276	801	OES	Indirect	Standard	IOT, Cloud	3, CEO, CTO, 3h
20	Heating equipment	235	820	OES	Indirect	Custom (modular)	IOT, Cloud	3, CEO, SM, CTO, 4,5h
21	Coffee and coffee machines	381	842	OEM	Indirect	Standard	IOT, Cloud, DA	2, CTO, 4h
22	Retail equipment	225	975	OEM	Direct	Standard (modular)	IOT, Cloud, DA	1, CMM, 2h
23	Packaging machines	219	1005	OEM	Direct	Custom	IOT, Cloud, DA	3, GM, 5h
24	Home automation	211	1058	OEM	Indirect	Standard	IOT, Cloud	4, CMM, 4h
25	Packaging machines	239	1263	OEM	Direct	Custom	IOT	1, CTO, 1,5h

* OES: Original Equipment Supplier, OEM: Original Equipment Manufacturer.

° Direct: prevalent direct relations with customers; Indirect: prevalent use of distribution channels.

^ DA: Data Analysis.

§ BD: Business Developer; CHRO: Chief Human Resources Officer; CIO: Chief Information Officer; CMO: Chief Marketing Officer; COO: Chief Operations Officer; CTO: Chief Technology Officer; GM: General Manager; SM: Service Manager.

Source: our elaboration

In many cases, two or more people have been involved in the interviews, for a total duration of approximately 77 hours. The aim of the field research was to get detailed information on the type of technologies used by the firms, the current and potential use of those technologies and the resulting changes in the business model. Table 1 portraits an outline of the sample: the total number of interview sessions, roles of the interviewees, total duration of the interviews.

Interviews were registered, transcribed, and coded to be able to better understand differences and similarities among companies. Follow-up meetings and calls have been arranged to deal with any unclear topic and avoid any misinterpretation. Main results of the investigation have been shared with interviewees in the form of an accurate presentation of the findings to have a first and direct feedback regarding the accuracy of the data.

As Table 1 shows, the empirical investigation has involved 25 Italian firms in various degrees involved in digital transformation processes. All

the firms are located in the North of Italy (in particular: Emilia Romagna, Friuli, Lombardy, Veneto), a geographical location that - in terms of manufacturing production - has a long and acknowledged tradition and a world-class standing, being the most advanced industrial regional system in the country and one of the most relevant in UE (De Marchi and Grandinetti, 2017).

The sampled firms cover a large array of industrial specializations that are heavily involved in technological evolutions related to I4.0, like the production and manufacturing of machine tools and plants, mechanical components, packaging machines, food processing machines, inspection and diagnosis machines, water management devices, professional cooking equipment, retail equipment, heating control systems and devices, off-road automation devices, home automation. Therefore, the empirical sample was set to provide sketches of strategies, problems and challenges of different firms in different contexts, in order to facilitate the emersion of a differentiated portfolio of technology utilization and business model innovations.

In fact, selected firms have different value chain positions (19 OEMs and 6 OESs) and sales models (9 firms sell prevalently directly to their final-user firms, while 16 have a mainly indirect access to the customers). One firm is below 20 employees and qualifies as very small, whether a core group of 11 enterprises are SMEs, employing a range of 20-500 people. A final group of 13 firms are medium- to large-enterprises, with a total number of employees above 500. In line with Laudien and Daxböck (2016), no large multinational corporation has been included in the investigation, and only two firms in the sample have more than 1.000 employees.

Firms' competitive strategies are frequently characterized by segment or niche focalization, with a consequent specialization of resources, capabilities, products and services: 10 firms prevalently customize their products and solutions on customer's needs, while standard products are mainly produced in low to medium batch sizes. Very often, firms are leaders in the respective niche / industry, testifying for a tradition of good managerial capabilities and successful strategic alignment with the environment. Nonetheless, they are looking at the present technological transformation with great attention and caution, with the consciousness that the change could be both an opportunity and a threat.

On the whole, the sampled firms are trying to figure out how to use technology in order to modify their value propositions, conveying new services and nurturing new relations. Every firm has invested in technologies able to make its products smart and connected (i.e., IoT) but not in every case the digitalization is complete: only 8 firms out of 25 have deployed solutions that involve all the technologies we deem critical for I4.0 (IoT, Cloud platforms, Data analysis) and have started to gather and analyse data coming from the installed base (in various degrees and with different time spans).

While every company has a clear idea of what I4.0 technologies can do for basic services that are traditionally offered by BtoB manufacturing firms (such as maintenance and assistance), on the other hand, radical changes have been projected, analyzed and acted in very few cases. The

introduction or testing of disruptive value propositions and business models is consequently very uncommon. In particular, as we will see in the proceeding of the work, the circumstance whether the firm has a direct contact with the final user is critical in shaping its strategy.

4. Value proposition shifts and business model changes

Table 2 represents basic features of business model changes caused by I4.0 in the sampled firms, especially as regards the change of the value proposition toward advanced services. All the firms are exploring the possible uses of I4.0 for sustaining their value propositions, aiming at enhancing services already provided or introduce new ones, as in the cases of maintenance ticketing, warranty management or Remote Condition Monitoring. If, on the one hand, those service-oriented uses of I4.0 may be technically challenging, on the other they remain within the domain of product-oriented PSS enhancements. Therefore, in most cases (21) it is a matter of non-disruptive modifications of the firms' business models that fundamentally are comfortably rooted in the currently prevalent product-orientation culture that permeates all the manufacturing firms of the sample (see: low and low- medium business model conflicts in Table 2).

Tab. 2: Business model changes in the investigated firms

Company	Industry	Rev. (mio)	Value system	Sales model	Sales model changes	Value proposition orientation	Value proposition shift (PSS)	BM change scope	BM conflicts	Ambidexterity management
1	Professional equipment	3	OEM	Indirect	=	Product		Limited	Low	
2	Machine tools	8	OEM	Direct	=	Product		Limited	Low	
3	Professional equipment	6	OEM	Indirect	=	Product		Limited	Low	
4	Mechanical components	8	OES	Indirect	=	Product		Limited	Low	
5	Packaging machines	20	OEM	Direct	=	product		Limited	Low	
6	Packaging machines	50	OEM	Direct	=	Product	To result-oriented	Wide	Medium-high	Contextual
7	Inspection machines	37	OEM	Direct	=	Product		Limited	Low	
8	Professional equipment	105	OEM	Indirect	To direct	Product		Limited	Low-medium	
9	Heating control systems	48	OES	Indirect	=	Product		Limited	Low	
10	Heating devices	61	OEM	Indirect	To direct	Product		Limited	Low-medium	
11	Food machines	150	OEM	Indirect	=	Product		Limited	Low	
12	Home automation	130	OEM	Indirect	=	Product		Limited	Low	
13	Diagnosis machinery	90	OEM	Indirect	To direct	Product		Limited	Low	
14	Heating control systems	166	OES	Indirect	=	Product		Limited	Low	
15	Machine tools and plants	202	OEM	Direct	=	Product		Limited	Low	
16	Retail equipment	240	OEM	Direct	=	Product	To result-oriented	Wide	Medium-high	Contextual
17	Off-road automation	157	OES	Indirect	To direct	Product		Limited	Low-medium	
18	Water management devices	278	OEM	Indirect	=	Product		Limited	Low	
19	Heating components	276	OES	Indirect	To direct (planned)	Product		Limited	Low-medium	
20	Heating equipment	235	OES	Indirect	To direct (planned)	Product		Limited	Low	
21	Coffee and coffee machines	381	OEM	Indirect	=	Product		Limited	Low	
22	Retail equipment	225	OEM	Direct	=	Product	To result-oriented	Wide	Medium-high	Contextual
23	Packaging machines	219	OEM	Direct	=	Product	To result-oriented	Wide	High	Contextual
24	Home automation	211	OEM	Indirect	=	Product		Limited	Low	
25	Packaging machines	239	OEM	Direct	=	Product		Limited	Low	

Source: our elaboration

This situation is related to the fact that I4.0 technologies' impact on new business models depend heavily on the access to user-firms' data. Firms with a direct relation with final-user firms (that is firms with a direct sales model in Tables 1 and 2) are very well to offer new services destined to the final-user firms' processes, while in case of an indirect relationship that option is out of reach. That is why firms that belong to the latter case (OEMs with an indirect relation with final user firms or first/second tier OESs) are stuck in a position that only a very difficult downstream move can change: as one can see in Table 2, only 6 out of the 16 firms having an indirect access to user firms' data are making (or planning) such a step.

However, four firms are aimed at more sophisticated explorations: they are experimenting result-oriented PSS, challenging the established business model with performance-based contracting via IoT-based remote condition monitoring. These "challengers" - all OEMs with a custom or modular product and a direct sales model (see Table 2) - are in a privileged position in order to unleash the potential of I4.0, introducing advanced services directly related to the customers' needs instead of the mere product-oriented ones. As one can easily understand, those firms are truly facing a disruptive new business model: new forms of contractual agreements that move away from the ownership-based transactional sale of products represent a big challenge since the new offer is directly cannibalizing established sales, dangerously conflicting with the current business strategy. Let's consider, for instance, the revenue model implied in outcome-based contracts: here the billing mechanism is benchmarked on equipment's efficiency (i.e., uptime level) or to the actual rate of utilization of the product, suggesting firms to be very careful in approaching the topic (in particular, in industries in which the amount of capital expenditure underlying product manufacturing is significant).

In those cases, as we'll see, the critical capability firms have to master is to manage the conflicts that may arise between traditional and emergent business models. In particular, this is the area in which firms will have to succeed in managing duality and be ambidextrous, matching the exploration of the new and the exploitation of the old: the following sections will describe in depth the specific forms of ambidexterity management adopted by the sampled firms.

5. Business model innovation and contextual ambidexterity in Industry 4.0

To make a step further, in this section we'll focus on the challenger firms, adding some further information (see Table 3). In order to better understand the context in which challengers act, in the following paragraphs a more detailed description will be provided.

Company A is a small firm that produces machines and solutions for the packaging of tissue products, with strong capabilities related to innovation and service development. According to UCIMA (Italian Packaging Machinery Manufacturers' Association), the automatic packaging machinery industry is one of the most dynamic Italian industries: it counts

around 200-250 industrial companies with a total turnover of more than €7 billion, of which more than 80% comes from export. A employs 120 people, has a turnover of €50mio and is located in the so-called "Packaging Valley" in Emilia Romagna, a region with the highest concentration of packaging companies in the world (along with Lombardy, Piedmont and Veneto).

Company B belongs to the same industry, although to a different niche: located in Lombardy, it is a leader company in producing complete packaging systems and lines, especially for dried food. It is a medium-large enterprise that employs 1005 people in 4 different production locations in the world, with a total turnover of €219mio[2], with a strong and long-standing reputation in quality, innovation and customer service.

Company C and D are both medium to large firms belonging to the same industry. They are leader companies in the design, manufacturing, and installation of complete equipment for the retail sector: the production of commercial refrigerated furniture, systems and solutions is indeed an industry in which Italian firms can boost a long-standing tradition and reputation. Company C, located in one of the industrial clusters in the Veneto region, is now a global company that employs 697 people worldwide and totalizes €240mio revenues. C is renowned for its flexibility and its extensive product range, constantly updated in line with the evolution of big retail chains.

Company D is located in Lombardy and employs 975 people, totalizing €225mio revenues. It belongs to a dynamic group of firms focused on the production of furniture for the commercial sector, working with the world's grocery and FMCG (fast-moving consumer goods) leaders, to whom it offers personalized systems and turn-key solutions. As final remark - that as we'll see is connected to the way challengers manage ambidexterity in I4.0 - we must underline that all the companies operate in highly competitive markets facing international and global customers, that in many cases are MNEs with sophisticated needs and big bargaining power.

As we have seen previously, these firms started to manage the relation with key customers in a completely new way than in the past, linking (partially or totally) the revenues of the equipment supplied to the performance levels reached by their user-firms in their typical operations. In order to face those non-trivial changes, and protecting their extant business model from the potential disruptiveness of the change, challenger firms in our sample are adopting a contingent solution that is different from those envisioned by previous research: they are implementing a sort of "hidden" dual business model, since it is a particular form of exploration of the strategic duality related to digital technologies in which the new business model is acted in protected and bounded contexts. In fact, in order to contain the conflicts, controlling the potential disruptiveness and exploiting synergies among the extant and the new business model, our

[2] In this case, due to administrative balance sheet consolidation policies within corporate groups, we couldn't report facts and figures related specifically to the packaging system division within the firm's corporate group. For that reason, while the selected product line represents most of the business, facts here reported encompass also different divisions and product areas.

challengers are encapsulating the exploration space into selected supplier-customer relations, developing the new value proposition and the new business model only for selected customers (key customers).

As we'll see in detail, this solution entails specific forms of ambidexterity management that pertain to the broadened concept of contextual ambidexterity introduced earlier: to better understand this point, let's compare similarities and differences of the highlighted cases, to better investigate the reasons of this circumstance.

Table 3 reports challengers' data regarding the main traits the literature has highlighted in order to understand how to manage dual business models. Notwithstanding the unavoidable differences in industries, market conditions and firms' resources and capabilities, the cases share some similarities.

Tab. 3: Ambidexterity management mechanisms in challenger firms

Case	Industry	Rev. (mio)	Emp.	Categorial framing of BM innovation			Urgency of the BM change	Markets strategic relatedness	Potential disruptiveness of the new BM	Template of the new BM	Exploration breadth	Mechanism to exploit synergies	Type of customer	Strategic management of duality
				Threat *versus* opportunity	Proactive versus reactive	Short term versus long term								
A	Packaging machines	50	120	Opportunity	Proactive	Long	Low	High	High	None	High	Focus on key customers	Large MNE	"Hidden" dual business model
B	Packaging machines	219	1005	Opportunity	Reactive	Long	Low	High	High	None	High	Focus on key customers	Large MNE	"Hidden" dual business model
C	Retail equipment	240	697	Opportunity	Proactive	Long	Low	High	High	None	High	Focus on key customers	Large MNE	"Hidden" dual business model
D	Retail equipment	225	975	Opportunity	Reactive	Long	Low	High	High	None	High	Focus on key customers	Large MNE	"Hidden" dual business model

Source: our elaboration

Firstly, all the firms are facing extremely high levels of exploration breadth, since no template and no previous experience is present in relation to an experimental business model whose potential hostility to the established one is extreme. Moreover, all "pilot" projects involve key customers, being in fact sponsored by very large, sophisticated, and culturally advanced firms facing global markets, often leaders in their respective industry. In case B the trigger for exploring a new business has been the demand of a large firm concerned about the poor efficiency performance shown by its operations and looking for suppliers that are capable of helping to solve the problem. Company D started its business model innovation with one of its clients, a large multinational corporation with a great installed base and with specific needs related to the use of IoT technologies that did not find a proper solution. Cases A and C, on the contrary, show a more proactive strategic move, using selected customers for the piloting of new versions in order to have functional feedback.

Finally, all the firms share the same categorical framing regarding the role of digital technologies and I4.0 in their strategies: they classify the challenges they face prevalently as opportunities (even if they are completely aware of the risks) and adopt a long-term strategic horizon in order to evaluate actions and returns of the investments.

5.1 The inception of the new business model

Our challenger firms have begun a journey that has not yet ended, which is in line with the developmental character of I4.0 strategies, particularly those of digital servitization (Baines *et al.*, 2020; Zighan and Abualqumboz, 2022). An interesting difference that seems to emerge regards the inception of the project, or - so to say - the trigger that initiated the path. In fact, in the case of Company B the initial trigger for exploring a dual business model is an extant customer: a large firm operating in the food and beverage industry, worried of the bad efficiency performances showed by its operations and looking for suppliers capable to help to solve the problem and possibly to take over the entire process on its behalf.

Company D has started an important project with one of its clients, a key customer that, in this case, is the trigger of the exploration: a large MNE of the food and beverage industry with a huge installed base and with very specific needs related to the use of I4.0 technologies that haven't found a proper solution yet.

Cases A and C, on the contrary, show a more proactive strategic move: company A is conducting explorations in the possible uses of digital technologies since 2016, actively investing for the design of a possible new service solution; gradually the project becomes well-defined and larger, involving also external firms for the provision of the most technological requirements. Then, starting approximately from 2017, the company starts scouting its account portfolio in search of a suitable customer to test the system and "go live". As the company A's Business Development Manager says: "we are trying to invent new services that affect directly the customer's business; in a sense we are creating our future customer".

Company C is involved in an ongoing pilot experiment oriented to a specific niche of its market identified as possible target of a new value proposition. A large-scale retailer is the key customer involved in the project of envisioning a complete result-oriented solution capable of relieving the customer from any direct responsibility and direct activity on the machines during the use. "Finding out the right customer and the right way to explain the solution is the most difficult part", says the company C's Chief Technology Officer, recognizing that its market in general is not so prepared and sensitive, mainly for cultural reasons, even if first signs of dynamism are present. It is important to underline, however, that the difference between proactive and reactive approaches doesn't have to be neither overlooked nor overrated: in fact, companies B and D were being investigating possible new services to put in the offering for a while, and the call to action coming from a sophisticated and relevant customer occurred just at the right time, finding them "prepared" to seize it.

5.2 The context: people and organization

As far as organizational choices are concerned, reactive and proactive approaches show interesting differences in how the firm allocates resources on the projects.

Proactive approaches firstly identify a person, in general an internal professional coming from the sales department, that may be appointed to be the "Digital Transformation Manager" (DTM); at the beginning the structure at her/his disposal is quite lean, even if she/he has a blank proxy on the strategic exploration activities related to the new technological applications, regarding which she reports directly to the CEO. She can use some resources (human and physical) pertaining to internal offices (like, typically, the technical office, and the ICT department) negotiating duration and intensity with the specific manager in chief. Few stable resources are allocated initially to the venture, and the specific budget is quite limited. Progresses in the project, envisioned applications and the opportunity to develop internally some adaptations of off-the-shelf technologies can change this initial situation, mainly thanks to the abnegation and ability of the manager in chief (the DTM). Consequently, some specific professionals may be then allocated to the project: in case B, for example, a senior and a junior engineer compose the DTM's team. Further additions of people generally follow the gradual acceptation of the new "group" and the new project within the organization (especially at high strategic levels) and are related to competences and technologies necessary to implement mobile applications and data analysis (and in particular its most advanced evolutions of artificial intelligence and machine learning).

In the case of reactive approaches, the stakes at play are much clearer from the beginning and the company reacts promptly to the customer's request allocating resources in order to solve problems and find viable solutions as soon as possible. In case D for example, a new office (not a new division nor a new company) inside a pre-existent organizational structure (and the traditional business model) has been set up in order to face the challenge of I4.0: it is an "Innovation Centre" composed of 8 people with different competences, that interact with the R&D department in order also to give input for new product development activities. In case B, even if the in-house team is very small (2 people and the DTM), it is regularly connected to a larger group (10 people) that operates directly at the customers' premises and manages some of the operative tasks necessary to implement the result-oriented PSS. In that case, periodic meetings in-house can play as organizational integration mechanisms in order to align the whole team on the experimentation's developments.

Both approaches end up reserving the same treatment to organization and human resources when the exploration has reached a certain level of maturity. "At a certain point you have to go internally", says company A's Business Development Director, explaining the choice of hiring an expert in data analysis and business intelligence coming from the Apple Academy.

5.3 The client-supplier relation as a prototype

As we mentioned, no previous experience related to the main strategic challenges posed by the new business model is retrievable in the company's past or in the industry at large. A high level of uncertainty connotes the adopted solutions and their outcomes, putting firms in a highly risky situation: consequently, a high level of cooperation between supplier and

customer is a common trait of the cases. That cooperation takes different forms.

Firstly, in performance-oriented PSS the actual performances depend also from the customer's cooperation and ability in doing its part of the job. This result is consistent with findings in other studies on business model innovation based on I4.0 technologies (e.g., Müller, 2019; Paiola *et al.*, 2021). Secondly, the sustainability of the new business model may depend on the availability of the partners to share totally or partially the risks. In case B, for instance, the unprecedented features of contracts (conditions, service-level agreements, prices) and the disrupting shift in the revenue model, induced the key customer to agree to pay up-front the equipment involved in the pilot project. "That was the only way to make the outcome-based contracting economically sustainable for us" says the company B's CEO. Regarding the sustainability question, one important relational feature that every company underlines regards the length of supply contracts, whose duration must be consistent with the total value of the equipment.

A last aspect that is important to highlight relates to the metamorphosis of the firm's business model. As far as the outcome of the initial incubation phase and the further use of the experience gathered in the pilot experimentations is regarded, all the four firms testify for a common evolution of business model innovation towards a proactive approach, that involves a sort of replication of the experience for other customers. The search for more customers for the new PSS may also cross the boundaries of the firm's established market, as in case B: "We are trying to move towards new markets and fields of application … and I have to say that when we show our services and solutions to them, they say the product is interesting" (CEO).

6. Concluding remarks

This study seeks to shed light on how companies that are exploring the disruptive scenario of I4.0 are dealing with the duality posed by business model *Innovation,* in line with directions suggested by the literature on the subject (Meindl *et al.*, 2021).

6.1 Theoretical contribution

A first theoretical contribution is made by validating and refining the typology introduced in Figure 1 and regards the topic of disruptive business model innovations. In fact, in the I4.0 scenario: the exploratory process requires higher investments in knowledge, as there is no prior experience to exploit or imitate, and the exploration breadth is high; among the strategies hypothesized by Markides (2013), contextual ambidexterity is currently prevailing in the investigated firms, while at present we cannot foresee the evolution of the experimentation in subsequent phases: a prosecution of the contextual ambidexterity, a spatial separation or an ending of the duality through a business model metamorphosis (see type

IV in fig. 1); the innovation impacts directly on the firm's business model (Paiola and Gebauer, 2020; Paiola *et al.*, 2022), and may eventually consist in a metamorphosis of the old business model rather than the addition of a new one.

A further theoretical contribution of the paper concerns contextual ambidexterity, a concept as rich in charm as poorly explored in practice. The main finding of the empirical investigation is that all the challenger firms of our sample adopt a particular form of contextual ambidexterity, that differs from the one hypothesized by Gibson and Birkinshaw (2004) - according to which ambidexterity must be a quality of each individual in the organization - but is aligned with the recent evolution of the construct in the literature (Hu and Chen, 2016; Lavie *et al.*, 2010; Markides 2013; Winterhalter *et al.*, 2016). In fact, our challenger firms have made a selective choice, giving some employees (individually or in groups) the task of exploring the new opportunities through cooperation projects with the most advanced and important customers, maintaining a variable but always important connection to extant resources and competences in the organization. Since exploration involves specifically and uniquely key customers, this solution is a way of "hiding" the new business model inside a dyadic client- supplier relationship. This "hidden" dual business model is clearly a noteworthy strategy in terms of risk management and effectiveness, and cannot be defined as a second-best option for facing I4.0 disruptiveness.

Finally, our results are in line with those studies showing that some clients may be more useful than others in supporting the company's exploration process (Bednarek *et al.*, 2016; Im and Rai, 2008). A high level of cooperation between supplier and customer is a common trait of the cases. In addition to this evidence, our results show that exploration, since it involves specifically and uniquely key customers, becomes a way of "hidding" the new business model inside a dyadic client-supplier relationship. This "hidden" dual business model is clearly a noteworthy strategy in terms of risk management and effectiveness, and cannot be defined as a second-best option for facing I4.0 disruptiveness. Indeed, over time all the four firms follow a common evolutionary path of business model innovation towards a proactive approach, planning or trying somehow to replicate their initial experience also with other customers.

6.2 Managerial implications

In line with other recent studies (e.g., Frank *et al.*, 2019; Müller *et al.*, 2018; Paiola *et al.*, 2021), our research shows that firms that live up to meet the I4.0 challenge are still limited to few "fortunate" cases. However, making the title of one of those contributions our own, "fortune favors the prepared" (Müller *et al.*, 2018), underlining the role of strategic culture in preventing firms to make "fortune" with I4.0 (Paiola *et al.*, 2021).

Specifically, the results of our study indicate a main critical implication for managers of B2B manufacturing companies willing to achieve enterprise development via contextual ambidexterity within I4.0. Such companies tend to carry out an evolutionary, long-period and proaction-oriented

strategic approach which takes into account how customers' needs and industry requirements change over time, in particular after the progressive introduction and implementation of I4.0 technologies at the industry level. Therefore, managers need to understand which are the pace and extent of change for the various components of the corporate business model to innovate during each specific step of transition towards I4.0 technologies. For instance, the investments of specific resources, the development of new technology-based value propositions and the revision of the corporate value design could be incremental processes in those industrial contexts where customers and other suppliers are more laggards and reactive in the adoption and implementation of new technologies. In other words, the pace of disruption and the choices between a) proactiveness and reactiveness and b) exploration and exploitation should be also made by carefully considering the strategic approach of the main corporate customers and suppliers.

6.3 Limitations and further research

This study has three main limitations owing to its explorative nature. First, we have investigated firms involved in a transition phase: in particular, we can't tell what the outcome of the metamorphosis will be, and if it will be the same for every firm. Second, we didn't observe how contextual ambidexterity works in depth, for example regarding the role of individuals and groups, such as strategic managers (middle- and top-level) and top management teams. Third, BtoB manufacturing firms are only a portion, however relevant, of the I4.0 landscape. Clearly, each of these limitations would only be overcome by further research on the relationship between I4.0 and business model innovation.

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