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Management and sustainability: Creating shared value in the digital era

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Full Papers

a cura di

Alberto Pastore, Federico Testa, Gennaro Iasevoli e Marta Ugolini

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Al Lettore,

questo volume accoglie i full paper del Convegno Sinergie-SIMA 2019 *Management and sustainability: Creating shared value in the digital era*, Sapienza Università di Roma, Roma, 20-21 giugno 2019.

La sostenibilità è senza dubbio uno dei temi sfidanti dell'epoca contemporanea. Lo sfruttamento delle risorse naturali legato alla crescente domanda di beni e servizi ha messo in evidenza quanto i modelli economici esistenti siano limitati. Un sistema di produzione e consumo basato su una logica lineare ove le risorse naturali sono estratte e trasformate per la produzione di beni e servizi è chiaramente non sostenibile. Inoltre, l'iniquità sociale, la povertà, e la fame nel mondo sono problemi sociali che devono essere globalmente affrontati.

Lo scopo del Convegno è discutere dei modelli di business sostenibili e delle necessarie evoluzioni strategiche come sfide per la gestione dell'impresa nel prossimo futuro. Un focus particolare è rivolto allo sviluppo di modelli di business e strategie basate su paradigmi di co-creazione di valore e alle opportunità oggi offerte dalle tecnologie digitali.

Alberto Pastore, Federico Testa, Gennaro Iasevoli e Marta Ugolini

Cari Lettori e Convegnisti,

il *call for paper* del Convegno Sinergie-SIMA 2019 *Management and sustainability: Creating shared value in the digital era* ha previsto la possibilità di presentare *extended abstract* oppure *full paper*. In totale sono pervenuti in redazione 102 *extended abstract* e 51 *full paper*.

Per gli *extended abstract*, la valutazione dei contributi ricevuti è stata operata dal Comitato Scientifico in base alla coerenza con il tema del Convegno e/o con gli studi management secondo i Gruppi Tematici SIMA, alla chiarezza e alla rilevanza (anche potenziale) dei contenuti proposti.

Per i *full paper*, la procedura di valutazione dei contributi è stata condotta secondo il meccanismo della *peer review* da parte di due referee anonimi, docenti universitari ed esperti dell'argomento, scelti all'interno dell'Albo dei Referee della rivista *Sinergie*.

In particolare, i referee hanno seguito i seguenti criteri nella valutazione dei contributi:

- chiarezza degli obiettivi di ricerca,
- correttezza dell'impostazione metodologica,
- coerenza dei contenuti proposti con il tema/track del convegno e/o con gli studi management,
- contributo di originalità/innovatività,
- rilevanza in relazione al tema/track del convegno e/o agli studi management,
- chiarezza espositiva,
- significatività della base bibliografica.

L'esito del referaggio ha portato a situazioni di accettazione integrale, accettazione con suggerimenti e non accettazione. In caso di giudizio discordante la decisione è stata affidata alla Direzione Scientifica. Ogni lavoro è stato poi rinviato agli Autori completo delle schede di referaggio per la valutazione delle modifiche suggerite dai referee, verificate in seguito dalla Redazione della rivista *Sinergie*.

A seguito del processo di valutazione sono stati accettati 41 *full paper* e 97 *extended abstract*, pubblicati in due distinti volumi. In questo volume dedicato ai *full paper*, i contributi sono articolati nelle seguenti gruppi:

- *Management and sustainability: Creating shared value in the digital era*
- *Management studies*

Tutti i *full paper* di questo volume sono stati presentati e discussi durante il Convegno e pubblicati *online* sul portale della rivista Sinergie (***www.sijm.it***).

Nel ringraziare tutti gli Autori per la collaborazione ci auguriamo che questo volume contribuisca a fornire un avanzamento di conoscenze sui modelli di business sostenibili e sulle necessarie evoluzioni strategiche come sfide per la gestione dell'impresa nel prossimo futuro.

La Direzione e il Comitato Scientifico

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Management studies

Determinants of business model innovation: the role of proximity and technology adoption

MATTEO DEVIGILI[*] ELENA CASPRINI[•] TOMMASO PUCCI[♠] LORENZO ZANNI[**]

Abstract

Objectives. *This paper investigates the non-technological and technological determinants of BMI, focusing on the role of proximity dimensions and technology adoption (TA). In particular, the paper looks at whether technological (TP), organizational (OP) and social proximities (SP) influence TA and BMI, while geographical proximity (GP) moderates these relationships. Then, a mediation effect of TA over TP, OP, and SP on BMI is also tested.*

Methodology. *Based on a unique sample of 123 firms, the impact of the technological, organizational and social proximities over TA is tested by an OLS regression analysis. Then, a logit regression is adopted to test the impact of independent variables on BMI. Finally, a mediation analysis - obtained through g-computation formula - is adopted to look at the mediation effect of TP.*

Findings. *For both TA and BMI, TP has a positive influence and GP acts as moderator of SP. Moreover, while GP negatively influences TA, it has an inverted U-shaped impact on BMI. Lastly, TA has a positive influence on BMI, and it is able to mediate the effect of TP over BMI.*

Research limits. *The study does not consider the multi-dimensional nature of each proximity dimension.*

Practical implications. *This study suggests that firms should invest in TA if they want to innovate their business model, but also be careful at collaborating with too much socially proximate partners that may hinder BMI. However, when these partners are geographically close, their negative influence is mitigated.*

Originality of the study. *This is the first quantitative study on the role of proximity dimensions on BMI.*

Key words: *business model innovation; geographical proximity; organizational proximity; technological proximity; social proximity; technology adoption*

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1. Introduction

In a complex scenario made of heterogeneous actors, where firms boundaries are blurred and innovation lies in networks (Doganova and Eyquem-Renault, 2009; Chesbrough and Schwartz, 2007), it is crucial to understand if and how firms should develop and innovate their approach to making business. To tackle this issue, several academics from management areas such as entrepreneurship (Zott and Amit, 2007; Doganova and Eyquem-Renault, 2009; Berbegal-Mirabent, 2012), innovation (Teece, 2010; Chesbrough, 2010; Casprini *et al.*, 2018), and strategy (Baden-Fuller and Mangematin, 2013; Magretta, 2002) employed *business model* (BM) as unit of analysis.

Unfortunately, no agreement can be found among scholars on BM definition (Zott *et al.*, 2011). So, while several researchers defined the BM as "*the content, structure, and governance of transactions*" (Amit and Zott, 2001, p. 511) or as "*the combination of a firm's business strategy, organization, and capabilities and the resulting financial structure*" (Casprini *et al.*, 2014, p. 176), others as "*the heuristic logics that connects technical potential with the realization of economic value*" (Chesbrough and Rosenbloom, 2002, p. 529). Nevertheless, the following BM features are undeniable: "*the model must link the workings inside the firm to outside elements*" (Baden-Fuller and Mangematin, 2013, p. 413) and it is influenced by the context where the firm operates (Casprini *et al.*, 2014; Pucci, 2016). Therefore, whatever a BM is named (architecture, conceptual tool, description, etc.) or defined, it should explain "*how an organization is linked to external stakeholders, and how it engages in economic exchanges with them to create value for all exchange partners*" (Zott and Amit, 2007, p. 181). For example, defining a cooperation and partnership strategy, the BM may enable firms to gather new knowledge from outside, and generate a market outcome (Zott *et al.*, 2011).

The literature on BM has underlined its ability to enhance or hinder firm's competitive advantage (Markides and Charitou, 2004; Teece, 2010), economic performance (Pucci *et al.*, 2017a; Zott and Amit, 2007), internationalization (Casadesus-Masanell and Ricart 2010; Onetti *et al.*, 2012), and innovation (Chesbrough, 2010; Loon and Chik, 2018). For these reasons and for the daily usefulness, practitioners more than academicians recognized its economic value (Doganova and Eyquem-Renault, 2009). Today, much more discussion has been devoted to business model innovation (BMI), underlining its positive impact on firms' performances (Lambert and Davidson, 2013). Indeed, entrepreneurs constantly looks for new ways of doing business, thus new BMs, in order to overturn the existing competitive rules leading the market (Ireland *et al.*, 2001). Therefore, the literature investigated those factors enabling BMI, highlighting technological and market related forces as possible causes (Lambert and Davidson, 2013; Casprini *et al.*, 2018). However, even though BM is undeniably tied to external factors, the social, spatial, cognitive, and cultural determinants have been largely overlooked (Mason and Chakrabarti, 2017).Our research aims to contribute to the literature answering the following research questions: (1) *How does technology adoption effect business model innovation?; (2) How do socio-cognitive relational structures influence business model innovation?* Indeed, to the best of our knowledge, no paper has investigated quantitatively to what extent technological proximity, organizational proximity and social proximity influence business model innovation and what is the role of geographical proximity in moderating these relationships.

As the BM is a "*cognitive instrument*" defined by the "*understanding of causal links*" (Baden-Fuller and Mangematin, 2013, p. 412), we expect socio-cognitive dimensions to influence the process of BMI, thus swaying how actors cognize new causal links. To test this relationship, we employ the proximity framework (Boschma, 2005; Knoben and Oerlemans, 2006), that has been applied by several management scholars (Lazzeretti and Capone, 2016; Geldes *et al.*, 2017; Mason and Chakrabarti, 2017). Indeed, proximity has been understood as a pre-condition for innovation, nurturing knowledge and technology transfer among actors (Gertler, 1995; Knobben and Oerlemans, 2006; Pucci *et al.*, 2017b): this corroborates its suitability in answering our second research question.

The paper is structured as follow: section two provides a review of the relevant literature and the conceptual model; section three discusses methodology and sample characteristics; section four provides the research findings; section five presents discussion, conclusions and limitations of this research.

2. Literature review and conceptual model

2.1 Business model innovation

Defining BMI presents two levels of complexity. A first level is linked to the fact that literature still debates about *what* a BM is (Zott *et al.*, 2011). If in its broadest terms a BM refers to the ways a company creates, delivers and captures value (Teece, 2010), a BMI could be simply defined as innovating a firm's BM. A second level of complexity is linked to its potential *dynamic* nature. Indeed, whether BM *per se* has been treated as a static concept, BMI may refer to either a completely new BM, as in the case of AirBnB (Mikhalkina and Cabantous, 2015), or to the evolution of an existing BM (Casprini *et al.* 2014, Bohnsack *et al.*, 2014). This implies that BM can be considered either as an *outcome* or as a *process* (Foss and Saebi, 2017). Referring to the former, literature has looked at two main aspects: the intensity and the audience of BMI. For what concerns the intensity, we can distinguish between incremental and radical BMI, on the basis of how much a BM is different from an existing one (Foss and Saebi, 2017). For example, Amit and Zott (2012) specify that a BMI could happen in several ways such as the addition of new activities or the change of parties performing one/more of the activities. For what concerns the audience, a BM may be novel for the firm or the industry (Casprini, 2015; Foss and Saebi, 2017). Referring to BMI as a process, literature is very heterogenous and has focused on several aspects such as the exploration and exploitation phases an established company could face in innovating its BM (Sosna *et al.*, 2010), the learning mechanisms in the BMI trajectories (Berends *et al.*, 2016), and the barriers - such as the resistance to modify asset configuration - to be faced in changing a BM (Chesbrough, 2010).

Beyond the definitional aspects, a crucial element is linked to understanding what drives BMI or, in other terms, its determinants. In particular, the drivers of BMI can be summarized in two broad categories: technological vs. non-technological factors. *Technology* represents undoubtedly a key driver of BMI (Gambardella and McGahan, 2010; Johnson *et al.*, 2008), as also evidenced by the fact that BM literature has flourished following the advent of ICTs (see Zott *et al.*, 2011 for a literature review). Additionally, research has also investigated the impact of sustainable technologies - as those applied in the case of electric vehicles (Bohnsack *et al.*, 2014) - as the starting point of BMI for all, established and entrepreneurial businesses. More recently, the diffusion and adoption of industry 4.0 technologies has also posited new challenges for established firms that are trying to integrate 3D printing, could computing and robotics in their activities (Müller *et al.*, 2018). Overall, it is evident that digitalization has enabled firms to innovate the way they create and capture value, both in the case of manufacturing firms (Coreynen *et al.*, 2017) and services (Casprini *et al.*, 2018; Remane *et al.*, 2017). *Non-technological factors* have been less investigated or jointly investigated with technological ones. Among the drivers of BMI we can cite the economic conditions and legislation (Ghezzi *et al.*, 2015; Murray and Scuotto, 2016; Sosna *et al.*, 2010), disruptive changes factors such as changes in customer habits and competitor strategy change (Ghezzi *et al.*, 2015; Murray and Scuotto, 2016), proximity (Mason and Chakrabarti, 2017), and the cognitive antecedents (Osiyevskyy and Dewald, 2015). For example, among the disruptive factors, we can mention sustainability. Many firms are changing their business models in order to be more sustainable not only from an economical, but mainly from a social and environmental point of view (see Bocken *et al.*, 2014 for a recent literature review on sustainable business model). Indeed, as Foss and Saebi (2017)'s literature review evidences, identifying and understanding the determinants of BMI is an important gap to address.

2.2 Proximity dimensions

The relationship among proximity, learning, knowledge creation, and innovation has largely attracted academic attention (Torre and Gilly, 2000; Boschma, 2005; Knoben and Oerlemans, 2006) and several scholars have recently highlighted proximity as a driver able to foster knowledge transfer among actors (Fitjar *et al.*, 2016; Capone and Lazzeretti, 2018; Rodrìguez *et al.*, 2018). A great issue within the proximity literature has always been the conceptualization and definition of such a complex variable, thus leading to many divergences, overlaps and ambiguities (Knoben and Oerlemans, 2006). Nevertheless, the literature agrees on proximity multidimensionality, thus distinguishing at least five dimensions: cognitive, institutional, organizational, social, and geographical (Boschma, 2005; Fitjar *et al.*, 2016; Capone and Lazzeretti, 2018). Recently, a technological facet has also been accepted (Cantù, 2010; Enkel and Heil, 2014; Isaksson *et al.*, 2016).

Geographical Proximity (GP) looks purely at the physical distance among actors (Boschma, 2005), known as a channel able to foster knowledge transfer across face-to-face interactions (Bindroo *et al.*, 2012; Fernandes and Ferreira, 2013). Indeed, the transfer of complex and strategic knowledge, both tacit and explicit, is facilitated by close proximity among actors and organizations (Torre and Gilly, 2000; Knoben and Oerlemans, 2006). Though, GP is neither a necessary nor a sufficient condition for knowledge transfer, but it may act as a catalyst fostering the development and influence of other proximity dimensions (Boschma, 2005; Geldes *et al.*, 2017).

Bounded rationality influences not only the ability to search for new knowledge, but also the way in which actors do structure and perform that search (Simon, 1995; Boschma, 2005). In such a cognitive constraint, at least two dimensions of proximity should be considered: *Cognitive* (CP) and *Technological Proximity* (TP). CP is defined as the affinity or distance in individual perceptions and cognition of phenomena (Knoben and Oerlemans, 2006), that is determined by both absorptive capacity and learning potentials (Boschma, 2005). Conversely, TP looks at the knowledge base that is at actors' disposal to acquire or exchange a specific technology (Zeller, 2004; Knoben and Oerlemans, 2006). So, while CP looks at efficient communication, TP "*refers to the extent to which actors can actually learn from each other*" (Knoben and Oerlemans, 2006, p.78).

Organizational proximity (OP) "*consists of shared organizational principles, rules, and codes, including a corporate identity and a corporate philosophy (Blanc and Sierra 1999, 196), to promote a certain coherence within a firm and compatibility among collaborating firms*" (Zeller, 2004, p. 88). Therefore, OP looks both to the inner-firm logic of belonging/similarity (see also Torre and Rallet, 2005), and to the inter-firms compatibility (see also Boschma, 2005).

Institutional proximity (IP) refers to both formal and informal "*humanly devised constraint*" (North, 1991, p. 97) that are likely to influence socio-economic interactions. Therefore, not only the "*rules of the game*" governing economic actors, but also cultural habits and values (Boschma, 2005). Thus, IP is likely to foster knowledge transfer decreasing transaction complexity through the sharing of common rules and values.

Social proximity (SP) is able to decrease risk of opportunism felt by economic actors resorting to trust mechanism (Hansen, 2015). Indeed, it "*refers to the strength of social ties between agents at the micro-level resulting from friendship, family relations or previous work-related interactions*" (ibid., 2015, p. 1674). This concept is rooted in the Granovetter's embeddedness, thus highlighting the ability of "*concrete personal relations and structures (or "networks") of such relations in generating trust and discouraging malfeasance*" (1985, p.490).

Perhaps counterintuitively, it should be underlined that higher proximity does not simply bring higher innovation. As emphasized by Boschma (2005), both too high and too low proximity may negatively affect innovation: also known as the "*proximity paradox*" (Broekel and Boschma, 2012). Indeed, an insufficient proximity between actors is likely to prevent learning, knowledge transfer, and innovation, while a too high proximity may generate a lock-in effect, thus redundancy of information and knowledge. This intuition has been empirically supported, thus highlighting that actors at the right distance outperform those in lower or higher proximity positions (Fitjar *et al.*, 2016).

2.3 Conceptual model and hypothesis

As previously highlighted, proximity is able to foster knowledge flow among actors both across formal and informal relationships, thus enhancing the sharing of technical advices, technology adoption and the development of innovation (Lazzeretti and Capone, 2016; Capone and Lazzeretti, 2018). Therefore, proximity dimensions are not only able to influence collaboration *per se*, but also the output of that collaboration (Werker *et al.*, 2019).

Gertler (1995) was among the first authors to investigate the impact of proximity dimensions over technology adoption (TA), thus highlighting that physical, organizational, and cultural "*closeness*" are important factors for the adoption of advanced technologies. More recently, Feldmann *et al.* (2015) analyzed rDNA technologies diffusion, showing the crucial role of social and cognitive proximity in fostering TA. Still, to understand how proximity dimensions may affect TA is an open topic of inquiry, calling for further understanding since "*technology diffusion will vary across industries, regions and time periods and for incremental rather than for radical technological breakthroughs*" (Feldman *et al.*, 2015, p. 814). The importance of studying technology adoption is crucial especially in this moment of transition towards the Fourth Industrial revolution. Several new technologies such as 3D printing, big data, robotics are becoming more diffused and easier adopted thanks to their lower costs, improved performance (Schmidt *et al.*, 2015; Strange and Zucchella 2017), and public investments (e.g. the so-called Piano Calenda in Italy). However, contrary to previous industrial revolutions, Industry 4.0 highlights the importance of technology adoption by the several partners along their supply chain in order to fully realize its potential value. Indeed, it is not the sole adoption of a technology within a firm, but the adoption and integration of multiple technologies across several partners that make the difference between a simple operational improvement and a new business model. In order to contribute to this debate, this study considers GP, TP, OP, and SP as determinants of TA. Indeed, it does not investigate: IP, as differences in formal institutions are not relevant on this research contest and informal institutions are likely to overlap the notion of OP (Knobben and Oerlemans, 2006); CP, since we are investigating specific technologies and their related knowledge. Therefore, looking at formal and informal relationships among supply chain partners, our first hypothesis is:

HP.1: Technological, organizational and social proximity foster technology adoption.

As highlighted by the literature (Kirat and Lung, 1999; Boschma, 2005; Knobben and Oerlemans, 2006), GP is not a sufficient condition to foster knowledge transfer. Indeed, GP "*may enhance interactive learning and innovation more indirectly, most likely by stimulating the other dimensions of proximity*" (Boschma, 2005, p. 71). Geldes *et al.* (2017) tried to empirically test this intuition investigating the ability of GP to moderate the impact of non-spatial proximity over inter-organizational cooperation, obtaining a not significant effect. Also, Guan and Yan (2016) investigated the ability of GP to moderate TP influence over re-combinative innovation. Again, the empirical results did not support the theoretical intuition. Lastly, through a qualitative analysis, Letaifa and Rabeau (2013) found that geographical proximity may decrease the likelihood of social proximity development.

Given the divergent and scarce research on this challenging theoretical/empirical debate, we aim to test the following:

HP.2: Geographical proximity is able to positively moderate the impact of technological, organizational and social proximity on technology adoption.

In addition, as we have seen, TA is one of the main drivers of BMI. Indeed, the introduction of new technologies in a firm's existing BM may change the way the firm creates and captures value. Literature is plenty of examples describing how new technologies have influenced many industrial sectors such as logistic (Alberti-Alhtaybat, *et al.*, 2019) and shared mobility (e.g. Casprini *et al.*, 2018) and empirical evidence is cumulating about the impact of digital (Li, 2018), 3D printing (Rayna and Striukova, 2016) and more in general industry 4.0 technologies (Müller *et al.*, 2018) on BMI. Consequently, our third hypothesis is:

HP.3: Technology adoption fosters business model innovation.

Furthermore, a recent qualitative research (Mason and Chakrabarti, 2017) looks at the role of proximity in the process of business model design. In particular, it proposes an analytical framework combining Boschma's (2005) proximities with the three BM elements of technology, market offering and network architecture, showing "*how managers and entrepreneurs organize their business activities to connect to business networks and markets*" (Mason and Chakrabarti, 2017: p. 78). To the best of our knowledge, no paper has investigated quantitatively to what extent TP, OP and SP influence BMI. Nonetheless, proximity may be considered as a potential non-technological determinant of BMI. Henceforth, our fourth hypothesis is:

HP.4a: *Technological, organizational and social proximity influence business model innovation.*

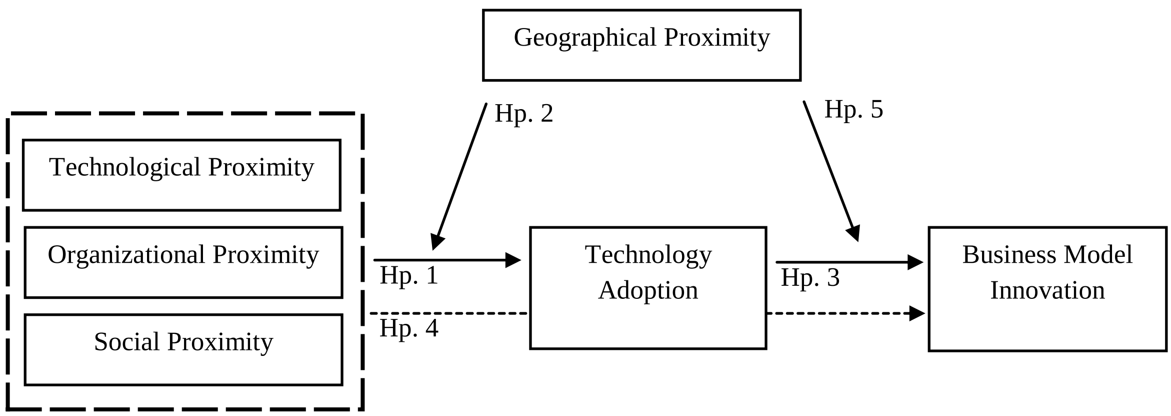
Moreover, since we have hypothesized that TP, OP and SP influences TA, we also suggest that:

HP.4b: *Technology adoption mediates the impact of technological, organizational and social proximity on business model innovation.*

Finally, as previously shown, the debate on the ability of GP to stimulate the other proximity dimensions is still open (Boschma, 2005; Guan and Yan, 2016; Geldes *et al.*, 2017). Therefore, we aim to test the following:

HP.5: Geographical proximity moderates the effect of technological, organizational and social proximity on business model innovation.

Fig. 1: Conceptual Model



Source: our elaboration

3. Methodology

Data were collected through a structured survey submitted to a sample of Italian manufacturing firms during July and November 2018. Particularly, we gathered answers from firms involved mainly in B2B transactions, such as machinery, equipment, and components producers. Indeed, B2B firms offer a relevant case and suitable sample to test the relevance of proximity determinants, receiving both upstream, downstream, and horizontal stimuli from their supply chain partners. Meanwhile, the choice of an Italian sample was led by convenience, but we acknowledge the significance of an international comparison, leaving space for further research.

The collection process has been performed in two steps. Firstly, the questionnaire (introduced by a presentation letter) was sent by email to a sample of 467 Italian manufacturing firms. Secondly, a printed version of the survey was administered to entrepreneurs and managers during several practitioner conferences organized by ADACI (Italian purchasing and supply management association). From the first step we collected 31 survey answers, while from the second one we gathered 107 answers. Further, we deleted observations containing missing values, thus the final sample is composed by 123 complete and usable survey answers. Finally, we employed data from the Chamber of Commerce to collect information regarding firm’s age and employees.

On the basis of number of employees, the final sample is composed as follow: 38 micro firms (1-9 employees); 32 small firms (10-49 employees); 34 medium firms (50-249 employees); 19 large firms (≥ 250 employees).

3.1 Measures

To test our conceptual model, we operationalized the variables as follow.

Dependent Variable. BMI is a dummy variable operationalized asking firms if they have changed or not their BMs, therefore those organizational and strategical structures allowing firms to generate value and achieve a competitive advantage (Pucci, 2016).

Independent Variables. Geographic [a], Technological [b], Organizational [c], and Social [d] Proximities are operationalized asking respondents to assess from 1 “no impact” to 5 “high impact” what is the influence on the relationships with their supply chain partners of: [a] geographic proximity; [b] existence and sharing of digital infrastructures; [c] share of a similar organizational culture; [d] trust based on long term relationships.

Mediating Variable. For what concerns TA, firms were asked to indicate if they have introduced during the period 2015-2017 the following technologies: (1) advanced manufacturing solutions, (2) additive manufacturing, (3) augmented reality, (4) simulation, (5) horizontal/vertical integration, (6) industrial internet, (7) blockchain, (8) cloud, (9) cyber-security, (10) big data and analytics (Piano Calenda, 2015). Each item is operationalized as a dummy variable (1 = “introduced” or 0 = “not-introduced”), thus TA was obtained as the arithmetic mean of the previous ten dummies.

Control Variables. To control for firms’ Age and Size, we used the natural logarithm of the number of years since firm’s establishment and number of employees, respectively. Furthermore, we asked firms to state if they are family firms (dummy = 1) or not (dummy = 0). Lastly, R&D was operationalized asking respondents to state the percentage of R&D over the total turnover.

Table 1 summarizes variables features.

Tab. 1: Measures description

Variables	Items	Source
Business Model Innovation (dummy, 1 0 "selected")		Our processing and adaptation starting from Pucci (2016)
Proximity Dimensions	*What is the impact of the following factors on the relationships among the actors of your supply chain?*	
Geographical Proximity (Likert scale 1-5)	Actors' geographical propinquity	
Technological Proximity (Likert scale 1-5)	Existence and sharing of digital infrastructures	
Organizational Proximity (Likert scale 1-5)	Share of a similar organizational culture	
Social Proximity (Likert scale 1-5)	Trust based on long term relationships	
Technology Adoption (dummy, 1 = "selected")	(1) Advanced Manufacturing Solutions; (2) Additive Manufacturing; (3) Augmented Reality; (4) Simulation; (5) Horizontal/Vertical Integration; (6) Industrial Internet; (7) Blockchain; (8) Cloud; (9) Cyber-security; (10) Big Data and Analytics	Piano Calenda, 2015
Control variables		
Age (log)	Natural logarithm of the number of years since the constitution	
Size (log)	Natural logarithm of the number of employees	
Family	Dummy, 1 = Selected	
R&D	Percentage of R&D expenditure on total turnover	

Source: our elaboration

3.2 Econometric Strategy

To test the impact of the independent variables over TA, we employed an OLS regression analysis since TA (obtained through the arithmetic mean of ten dummies) can be treated as a continuous variable. Whereas, BMI is regressed over the independent variables employing a Logit model since BMI is a dichotomous variable.

Mediation analysis is obtained through g-computation formula (Daniel *et al.*, 2011). We employed Model 1 for TA (see Table 3) and Model 6 (controlling also for the interaction term among TP and TA) for BMI (see Table 4), thus estimating the following regressions:

[1] $TA = \alpha_1 Age(log) + \alpha_2 Size(log) + \alpha_3 Family + \alpha_4 R\&D + \alpha_5 TP + \alpha_6 GP + \alpha_7 OP + \alpha_8 SP$

[2] $BMI = \beta_1 Age(log) + \beta_2 Size(log) + \beta_3 Family + \beta_4 R\&D + \beta_5 TA + \beta_6 TP + \beta_7 GP + \beta_8 (GP)^2 + \beta_9 OP + \beta_{10} SP\ (log) + \beta_{11} TA*TP$

To explain what g-formula package estimates, it is easier to decompose mediation analysis with counterfactuals (Daniel et al., 2011). Let's assume that X is a binary exposure variable, M a binary mediator, and Y an outcome variable. I our case, the formula gives three outcomes: the total causal effect (TCE), the natural direct effect (NDE), and the natural indirect effect (NIE). TCE compares E(Y[x, M(x)]) for different values of x:

TCE = E(Y[1, M(1)]) - E(Y[0, M(0)])

NDE is a comparison of E(Y[x, M(x_0)]) for different values of x, while x_0 is fixed at the baseline value:

NDE(0) = E(Y[1, M(0)]) - E(Y[0, M(0)])

Lastly, the NIE is obtained comparing E(Y[x, M(x0)]) for different values of x_0, while keeping x fixed: NIE(1)= E(Y[1, M(1)]) - E(Y[1, M(0)])

The g-formula infers TCE as described above, while for NDE and NIE it combines several simulations of M under different hypothetical values of X. Therefore, if X is binary, M is simulated for both X=1 and X=0.

In our case, X is not binary, but it is a categorical variable with baseline value equal to 1. In this case, the package compares this baseline value with the distribution of X. Additionally, it enables to control for confounders in both exposure-outcome and mediator-outcome relationships.

Computations were performed through Stata 14.2.

4. Results

Table 2 provides descriptive statistics and correlation analysis and Appendix 1 displays VIF scores and Tolerance levels. Low correlation levels (all lower than 0.5 in absolute value), together with low VIF scores (all equal or lower than 1.60) and good Tolerance levels (all greater than 0.62) guarantee the absence of multicollinearity among model variables (Kunter *et al.*, 2004).

Tab. 2: Descriptive Statistics and Correlation Analysis

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
[1] BMI	1.000									
[2] Age (log)	0.054	1.000								
[3] Size (log)	0.211	0.497	1.000							
[4] Family	0.003	0.059	-0.153	1.000						
[5] R&D	0.021	-0.274	-0.034	-0.219	1.000					
[6] Tech. Adoption	0.280	0.173	0.323	-0.205	0.167	1.000				
[7] Technological Prox.	0.232	0.111	0.161	-0.054	0.126	0.396	1.000			
[8] Geographical Prox.	0.003	-0.043	-0.032	0.065	-0.074	-0.140	0.153	1.000		
[9] Organizational Prox.	0.129	0.146	0.172	-0.076	0.051	0.175	0.389	0.029	1.000	
[10] Social Prox.	-0.069	0.224	0.047	0.046	-0.025	0.072	0.220	0.222	0.094	1.000
Mean	0.398	2.772	3.474	0.447	0.072	0.226	3.350	2.935	3.545	3.870
SD	0.492	1.065	2.119	0.499	0.101	0.186	1.287	1.158	1.073	1.116
Min	0	0	0	0	0	0	1	1	1	1
Max	1	4.796	10.215	1	0.8	0.7	5	5	5	5

Notes: N=123. Correlation coefficients greater than 0,2 in absolute value are statistically significant at 95%.

Source: our elaboration

4.1 Regression model

Table 3 displays results of TA regressed over the explanatory variables. In Model 0 only control variables are introduced, thus highlighting both Size and R&D to have a positive and significant influence on the dependent variable. Then, Model 1 introduces the independent variables: TP shows a positive and highly significant influence, while GP has a negative and significant effect. Moreover, while the effect of Size remains significant and positive, the coefficient of R&D loses both magnitude and significance. Both OP and SP have an effect not statistically significant. So, Hp.1 is partially supported as SP and OP do not have a direct effect on TA. Furthermore, we tested the ability of GP to moderate the effect of TP, OP, and SP on TA. As shown in Model 2, only the interaction term GP*SP has a significant and positive effect on the dependent variable. Hence, Hp.2 is partially supported since GP is not able to positively moderate TP and OP. Lastly, both Model 1 and Model 2 show good levels of R^2, thus highlighting a good model fit.

Tab. 3: Regression Analysis on Technology Adoption

	Technology Adoption		
VARIABLES	Model 0	Model 1	Model 2
Age(log)	0.0175	0.00874	0.00892
	(0.0172)	(0.0170)	(0.0170)
Size(log)	0.0228**	0.0195**	0.0197**
	(0.00878)	(0.00821)	(0.00813)
Family	-0.0499	-0.0461	-0.0496
	(0.0329)	(0.0305)	(0.0307)
R&D	0.320**	0.191*	0.203*
	(0.127)	(0.113)	(0.108)
Technological Prox.		0.0532***	0.0578***
		(0.0119)	(0.0123)
Geographical Prox.		-0.0282**	-0.108***
		(0.0117)	(0.0361)
Organizational Prox.		-0.00439	0.000115
		(0.0123)	(0.0127)
Social Prox.		0.00309	-0.0512*
		(0.0117)	(0.0279)
Geo. Prox. * Soc. Prox.			0.0204**
			(0.00926)
Constant	0.0979**	0.0490	0.225**
	(0.0474)	(0.0684)	(0.102)
Observations	123	123	123
R-squared	0.157	0.290	0.307

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: our elaboration

Table 4 summarizes the logit analysis obtained regressing BMI over the explanatory variables. In Model 3 BMI is regressed over the four proximity dimensions. Only TP shows a positive and significant effect on the likelihood of having BMI, while GP, OP, and SP display a not significant effect. In Model 4 TA is introduced, thus showing a positive and significant coefficient. Moreover, it should be noted that TP coefficient loses its magnitude and the standard error increases, thus suggesting a mediation effect of TA over TP on BMI. In Model 5 and 6 we take into account nonlinear effects for GP and SP, improving the Pseudo R^2 from 0.109 to 0.165 and 0.166. Here, GP shows a strong inverted U-shaped effect over the likelihood of having BMI, while SP shows a negative linear effect improved in terms of significance after the log transformation. Here, TP acquires a positive and significant effect if compared to Model 4, while TA coefficient loses magnitude and the standard error increases. Thus, Hp.3 is supported, while Hp.4a is partially supported. Lastly, we investigated the moderating ability of GP over TP, OP, and SP: as shown in Model 7, only the interaction term GP*SP is statistically significant and curvilinear. Indeed, Figure 2 shows that for extreme values of spatial distance or proximity, the effect of SP on BMI is negatively moderated, while for medium-low to medium-high values of spatial proximity, the effect of SP on BMI is positively moderated. Hence, Hp.5 is partially supported.

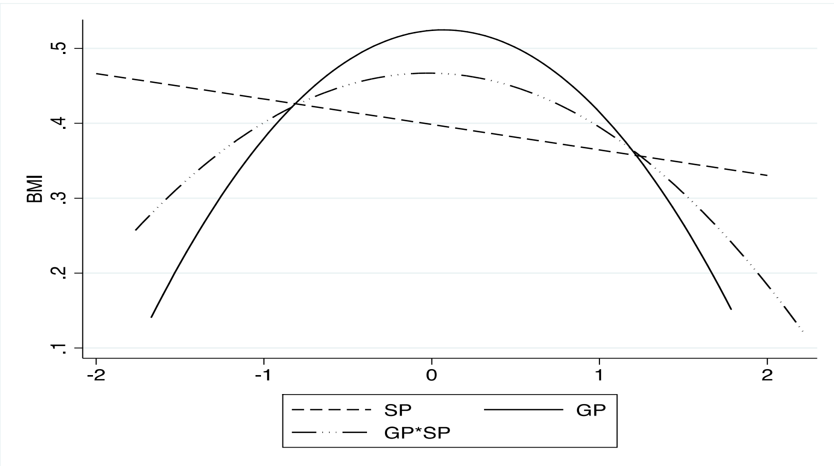
Tab. 4: Logit Regression Analysis on Business Model Innovation

	Business Model Innovation				
VARIABLES	Model 3	Model 4	Model 5	Model 6	Model 7
Age(log)	-0.134	-0.158	-0.157	-0.141	-0.148
	(0.230)	(0.229)	(0.253)	(0.255)	(0.256)
Size(log)	0.228**	0.188*	0.157	0.158	0.158
	(0.111)	(0.112)	(0.121)	(0.122)	(0.122)
Family	0.266	0.394	0.450	0.451	0.538
	(0.414)	(0.417)	(0.429)	(0.431)	(0.434)
R&D	-0.187	-0.654	-0.701	-0.614	-0.478
	(1.966)	(2.129)	(2.186)	(2.177)	(2.348)
Tech. Adoption		2.497**	2.448*	2.454*	2.534*
		(1.222)	(1.356)	(1.353)	(1.353)
Technological Prox.	0.405**	0.287	0.351*	0.370*	0.374*
	(0.174)	(0.191)	(0.202)	(0.205)	(0.214)
Geographical Prox.	-0.0204	0.0517	2.979**	3.019**	7.729**
	(0.168)	(0.180)	(1.163)	(1.182)	(3.062)
Geo. Prox. SQD			-0.484***	-0.490***	-1.336**
			(0.177)	(0.179)	(0.533)
Organizational Prox.	0.0950	0.106	0.107	0.0854	0.0724
	(0.199)	(0.199)	(0.211)	(0.211)	(0.217)
Social Prox.	-0.257	-0.276	-0.368*		
	(0.179)	(0.185)	(0.200)		
Social Prox. (log)				-1.092**	3.321
				(0.557)	(3.050)
Geo. Prox. * Soc. Prox. (log)					-3.674*
					(2.197)
Geo. Prox. SQD * Soc. Prox. (log)					0.653*
					(0.377)
Constant	-1.640	-1.820*	-5.441***	-5.557***	-11.13***
	(1.006)	(1.019)	(1.865)	(1.842)	(4.077)
Observations	123	123	123	123	123
Pseudo R2	0.0843	0.1096	0.1656	0.1662	0.1764

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: our elaboration

Fig. 2: Interaction effect on BMI



Source: our elaboration

4.2 Mediation analysis

Table 5 shows mediation analysis obtained through g-computation formula (Daniel *et al.*, 2011).

Tab. 5: Mediation Analysis

	G-computation estimate	Bootstrap Std. Err	z	P>|z|	Normal-based [95% Conf. Interval]	
TCE	.423	.054	7.90	0.000	.318	.528
NDE	.171	.057	3.01	0.003	.059	.282
NIE	.252	.066	3.79	0.000	.122	.382

Source: our elaboration

The mediation analysis results show that both total causal effect (TCE), natural direct effect (NDE), and natural indirect effect (NIE) are significant. From TCE, we can conclude that TP has a causal effect on BMI. Indeed, if TP is equal to 1 (baseline value), the likelihood of having BMI would decrease of 0.423; a large part of this reduction is mediated by TA, 0.252. Therefore, we can conclude that TA is able to mediate the effect of TP on BMI.

We tested mediation also for SP and OP, obtaining not significant results. Consequently, Hp.4b is supported only in the case of TP.

5. Discussion and conclusion

Focusing on the role of both technological and non-technological factors, this research offers some intriguing findings for both theory and practice.

For what concerns TA, having a strong relation (SP) with supply chain partners *per se* is a not sufficient condition. However, if that relationship goes with face-to-face contact, its effect becomes relevant. Indeed, the introduction of new technologies is negatively influenced by long-term relationships, but if that exchange of knowledge or advices happens in close proximity, the negative effect is smoothed. This result is in contrast with Feldman et al (2015) that emphasized the crucial role of social connections in fostering technology diffusion. Additionally, sharing similar digital infrastructures (TP) with supply chain actors enhances firms' ability to adopt new technologies. Indeed, to use such infrastructures, firms need a specific technical knowledge and practical understanding of that knowledge. Hence, having in common such a specific knowledge and experience base enables firms reciprocal understanding (Zeller, 2004). Moreover, a strong negative effect on TA is exerted by spatial closeness (GP). This result suggests that actors facing high GP with partners are less likely to introduce new technologies, falling in a lock-in effect and technological redundancy.

For what concerns BMI, its relationship with technological and non-technological variables is more complex, involving both linear and non-linear effects. Having adopted new technologies, firms are more prone to modify their BM to efficiently tackle the technological challenge faced. This result is in line with previous researches on BMI (Rayna and Striukova, 2016; Li, 2018; Müller *et al.*, 2018). Additionally, actors that share too strong relationships with supply chain partners are less likely to engage in modification of their BM. This negative effect is partially smoothed by face-to-face contacts and only for medium values of both SP and GP. This negative effect may be explained by bounded rationality of actors that push them to search for new knowledge and technical advices among socially closer partners, that are more likely to share similar values, knowledges, and routines. This unconscious custom may increase the likelihood of lock-in effect, knowledge redundancy, thus hindering innovation. Moreover, actors that share digital infrastructures are more likely to engage in the reshaping of their BM. However, this effect is largely indirect, thus driving BMI across the introduction of new technologies. Therefore, TP is beneficial for both TA and BMI. Lastly, actors displaying too high or too low values of spatial closeness with supply chain partners are less likely to innovate their BM. This inverted U-shaped effect fits perfectly the theoretical assumption discussed by the literature (Boschma, 2005).

Sharing a final thought on the effect of OP, thus the sharing of a similar organizational culture, it is worth. Indeed, OP has a not significant effect on both TA and BMI, something unexpected if compared to previous results on collaboration networks and innovation (Marrocu *et al.* 2013; Geldes *et al.*, 2017). The reason for this may depend on the timing of this research. Indeed, as underlined by Feldman *et al.* (2015) the impact of proximity dimensions may change not only over industry but also over time. Indeed, we are facing the first steps towards a digitalization process that is calling economic actors to completely reshape not only their organizational structure, but also values, customs, culture, and so forth. Therefore, OP may result not significative for TA and BMI, since firms are unconsciously facing a modification process that is ongoing. Perhaps, to share a common organizational culture is still a latent firms' need for cooperation and partnership agreements, that may become expressed when digitalization and Industry 4.0 will actually spread. We leave this topic open for further research.

This paper provides interesting contributions to theory and literature on business model innovation. First, studies on business model innovation in Industry 4.0 are still in their embryonic stage and, albeit initial evidence has emerged, it is mainly qualitative in nature. Hence, our paper presents some first empirical quantitative evidence treating BMI as the *outcome* (Foss and Saebi, 2017), rather than a process (e.g. Sosna *et al.*, 2010), and showing whether a technological determinant, i.e. Industry 4.0 technologies adoption, has an impact on BMI. Then, we looked at an under researched non-technological *determinant* of BMI, that of proximity dimensions. This provides a first quantitative evidence of the influence of proximity on BMI, thus enriching the previous qualitative contribution of Mason and Chackrabarti (2017). Thirdly and foremost, this research gives a partial support to the theoretical intuition of Boschma (2005), showing that being geographically close or distant could influence the effect of at least SP. This provides an interesting contribution in the context of Industry 4.0 and requires further investigation. As a matter of fact, whether on the one side technologies 4.0 may express their full potential once adopted along the entire supply chain., our results suggest that companies need to pay attention to being too much geographically close and socially proximate. Indeed, having strong relationships with upstream and downstream partners is not enough in adopting new technologies and it leads to lower business model innovation. However, geographical proximity plays an important role in influencing these relationships. It is only when social relationship goes with face-to-face contact, that its effect becomes relevant as shown by our findings. Companies face lot of internal obstacles in adopting new technologies even when adopted by their partners. One of the reasons may reside on their perception as highly risky technologies, especially in the case of smaller firms. However, when socially proximate companies are also geographically close, the adoption of new technology may be facilitated. In other terms, when companies are able to touch and see their partners' technologies, having face-to-face contact with their partners, they are more prone to adopt them. In addition, being too little (much) geographically close and too little (much) socially proximate could damage business model innovation. To the best of our knowledge this is the first contribution that emphasizes the importance of balancing proximities dimensions in improving business model innovation.This research has also some crucial managerial implications. Firstly, in a changing technological environment that is going towards a deep modification of the industrial system (fourth industrial revolution), firms should invest on knowledge. Hence, economic actors should try to acquire that knowledge both outside firm boundaries (e.g. collaborations with Universities or research centers; hiring highly skilled and well-trained employees) and inside (e.g. training courses for both managers and employees). Secondly, firms should invest on new technologies, thus boosting internal stirring and avoiding falling in myopia and inertia. Thirdly, actors should avoid looking for knowledge and technological advices solely among socially close partners. Indeed, overcoming this cognitive constraint may enhance the access to new and strategic knowledge that will translate in organizational renewal. Lastly, even though globalization and transport improvements lowered the significance of physical boundaries, economic actors should still pay attention to maintain both local relationships and distant ones strategically crucial. Therefore, firms should actively manage their relationship balancing not only local and distant relations, but also local and distant knowledge.

Nonetheless, this research has also some policy implications. A first consideration is linked to the relationship between size and technology adoption: our findings suggest that larger firms have a higher propensity to adopt new technologies than smaller ones. This evidence supports the need to develop regional policies in favor of small and medium-sized firms (that constitute the main business archetype of Italy), thus enabling them to catch up with the latest technological challenges. Furthermore, since technological proximity results from investments in education and, in particular, in the so-called STEM (Science, Technology, Engineering and Mathematics) disciplines, policy makers should direct higher investments towards education and learning. Finally, the new challenge offered by Industry 4.0 and digitalization is calling not only for capable managers, but also for public administrators able to understand and lead local context towards this challenge. Supporting education and boosting collaboration among local and distant stakeholders is a "must" for local administrators.

This research is not without limitations. Indeed, our study does not consider the multi-dimensional nature of each proximity dimension since our operationalization relies on single-item scales. Moreover, our firms belong to multiple sectors and we have not employed sector dummies to control for sectoral specificities. Lastly, the choice of an Italian sample represents a limitation that may hinder generalizability, thus calling for a comparison at international level.

Appendix

Appendix 1: VIF and Tolerance levels

	TA Regression		BMI Logit	
Variable	VIF	Tolerance	VIF	Tolerance
Business Model Innovation			1.16	0.8634
Technology Adoption	1.41	0.7103	1.46	0.6857
Age (log)	1.59	0.6288	1.60	0.6265
Size (log)	1.50	0.6659	1.53	0.6518
Family	1.12	0.8951	1.13	0.8887
R&D	1.20	0.8367	1.20	0.8359
Technological Proximity	1.47	0.6786	1.50	0.6673
Geographical Proximity	1.14	0.8782	1.14	0.8773
Organizational Proximity	1.21	0.8294	1.21	0.8284
Social Proximity	1.16	0.8590	1.18	0.8463

Mean VIF = 1.31 Condition Number: 17.5181 (TA Regression); 18.0623 (BMI Logit)

Source: our elaboration

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