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Managerial training and business transformation in Italian manufacturing firms. The Role of the National Recovery and Resilience Plan

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ABSTRACT

This paper explores the role of the National Recovery and Resilience Plan (NRRP) as a driver for the reconfiguration of companies' business profile in the Italian economy. Using a unique database containing information on 1779 Italian manufacturing firms, we find that the NRRP has stimulated a significant reconfiguration of their business profile. Interestingly, companies that invest in managerial training are more likely to fully leverage the opportunities created by the NRRP. In contrast, no effect is found for firms investing in general training or those with a high proportion of white-collar workers. These findings highlight the importance of managerial capabilities in enabling firms to navigate transformations and reshape their business profile accordingly.

1. Introduction

In July 2020, the European Council approved the *Next Generation EU* (NGEU) program, an ambitious six-year initiative (2021–2026) designed to drive economic transformation across Member States. In line with this framework, Italy developed its own *National Recovery and Resilience Plan* (NRRP), allocating substantial resources to support the digital and green transitions - particularly through investments in innovative intangible assets such as cloud computing, data analytics, the Internet of Things (IoT), and related technologies - aimed at strengthening the competitiveness of the national productive system.

In a rapidly evolving economic landscape, firms must continuously innovate to remain competitive. Among the various forms of innovation, digital transformation stands out as a key driver of change, encompassing product, process, and - most critically - business model innovation (BMI). Unlike product or process innovation, BMI entails a deeper reconfiguration of a firm's value creation and capture mechanisms, often requiring a strategic overhaul of organizational structures and capabilities. When aligned with digital transformation within the Industry 4.0 paradigm, this evolution is referred to as Business Model Innovation 4.0 (BMI 4.0), where firms leverage digital technologies to reshape their business models in response to new competitive dynamics (Frank et al., 2019; Muller et al., 2018, 2021; Matarazzo et al., 2020).

Although the NRRP does not explicitly target business model innovation (BMI), it creates a fertile environment for its development by promoting the adoption of digital technologies across industries. Notably, a substantial portion of NRRP resources - €40.32 billion - is allocated to investments in "Digitalization, Innovation, Competitiveness, Culture, and Tourism" highlighting the strategic importance of these areas. From a business perspective, the implementation of the NRRP is expected to significantly enhance the competitiveness of the Italian economy and to play a central role in supporting companies that innovate and invest.

By directing resources toward specific economic sectors that drive growth (Herrendorf et al., 2014), the NRRP serves as a catalyst to enhance firms' innovative capacity. Several scholars have highlighted the positive impact of public policy interventions - including initiatives like the NRRP - on firms' innovation capabilities (Marlin and Geiger, 2015; Moretti and Wilson, 2014; Bronzini and Piselli, 2016) and business strategies (Matarazzo et al., 2020). However, most research has

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focused either on the Plan as a public policy instrument (Bisciari et al., 2021; De Pascale et al., 2024; Lucchese and Pianta, 2021; Polverari and Piattoni, 2022; Silvestri et al., 2022) or on its effects on firms' digital transformation (Ferri et al., 2023; Maranzano et al., 2021), leaving the influence on changes in firms' organizational and business profiles largely unexplored.

This paper aims to address this gap by examining whether the NRRP has prompted firms to redesign their business models in response to the evolving competitive environment. Specifically, it first examines whether the NRRP has served as a catalyst for reshaping the business profiles of Italian companies in a manner aligned with the broader digital transformation. Then, it explores the internal factors enabling this transformation, with a focus on workforce composition and managerial training as key mediators. Specifically on this second point, the paper contributes to the literature by emphasizing the role of human capital in mediating the relationship between public policy and the change in the business profile of the company (Baumol, 2002). The rationale lies in the centrality of knowledge stock and targeted investments in training, upskilling, and qualified personnel to enhance firms' capacity to seize innovation opportunities (Burlina et al., 2025; Bourke and Roper, 2017; Evangelista and Savona, 2003; Protogeou et al., 2017; Sheehan et al., 2025; Wu et al., 2025). Within this line of research, Bourke and Roper (2017), Doran and Ryan (2014), and Evangelista and Savona (2003) highlight how strategic training strengthens absorptive capacity and innovation performance. Burlina et al. (2025) and Protogeou et al. (2017) underscore the particularly strong effect of on-the-job managerial training in transition economies, while Sheehan et al. (2025) show that training supports innovation through firm-level human capital and is further amplified in knowledge-sharing contexts.

To investigate these dynamics, we analyse a micro-level dataset of 1779 firms surveyed in 2023 by the Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce). This dataset offers unique insights into the reconfiguration of companies' business models toward digital-oriented structures, reflecting the broader digital transformation of the productive sector driven by the adoption of the Plan. Survey data have been matched with financial information from Moody's Bureau van Dijk to provide a comprehensive view of the companies' financial profiles.

Our findings show that the NRRP indeed serves as a catalyst for the digital-oriented reconfiguration of Italian firms' business profiles. Companies engaged in NRRP-related projects are more likely to innovate their business models, an effect that is significantly strengthened when managerial training is involved. In contrast, other human capital factors - such as general employee upskilling or overall educational attainment - do not appear to significantly support BMI adoption. This indicates that the strategic vision and opportunity-seizing capabilities of managerial staff, strengthened through managerial training, are critical for transforming digital investments into meaningful organizational renewal.

The paper is organized as follows. Section 2 provides an overview of the institutional background of the Italian NRRP, while Section 3 reviews the relevant literature. Sections 4 and 5 describe the dataset and present the empirical strategy, respectively. Section 6 discusses the empirical results, Section 7 offers additional evidence on specific cases, and Section 8 concludes the paper.

2. Institutional background

The National Recovery and Resilience Plan (NRRP), the formal document required to access NGEU funds, outlines strategies for the post–Covid-19 recovery with a focus on digitalization, green initiatives and economic cohesion. With investments of €191.5 billion spread across six missions and 134 components, the Plan aims to increase GDP growth by up to 3.6 percentage points between 2021 and 2026,[1] incentivizing private investment through tax credits for research, innovation and training (a full description of the NRRP can be found in Appendix A).

Beyond financing innovation in digitalization and green transition, the NRRP sets long-term trajectories, reduces uncertainty, and drives firms to anticipate shifts, reshape their organizations, and adjust their strategic outlook (Amit and Zott, 2012; Casadesus-Masanell and Zhu, 2013). This effect is especially relevant for Italian manufacturing, where many firms operate in mature sectors that undergo strategic renewal (Abernathy and Clark, 1985; Christensen, 1997). In these contexts, innovation is less about radical new products and more about the reconfiguration of business models. By aligning firms' strategic expectations with digital and green priorities, the NRRP functions as a catalyst for business model transformation, encouraging firms to rethink value creation, organizational design, and external relationships.

Concrete examples illustrate how these mechanisms connect to the objectives of this study. The most significant case is M1C2-I1 – Transizione 4.0, which allocates €13.4 billion to support the digital transformation of companies, complemented by additional tax credits for a total of over €34 billion. These resources do not merely finance the adoption of single technologies such as cloud platforms, IoT or data analytics, but set a structural direction that pushes firms to reorganize production processes, integrate digital supply chains, and reconfigure customer interaction models. In this sense, the funding acts as a lever for reshaping the overall business profile rather than simply updating equipment. More recently, this investment has evolved into Transizione 5.0, which brings an additional €6.3 billion toward projects combining digital and energy-efficient innovation. Under the new scheme, support is extended to investments in energy efficiency, renewable self-production, and training tied to the green transition, thus reinforcing the transformative pressure on firms to redesign business models that integrate competitiveness and sustainability.

Complementing this technological push, M4C2-I1 – Extended partnerships in research on Key Enabling Technologies allocates more than €1.6 billion to create large public–private research networks that connect universities, research centres and enterprises in strategic domains. By fostering collaborative R&D and encouraging firms to open their innovation processes, this measure leads companies to adjust their business models toward more network-based and knowledge-intensive strategies. Taken together, these initiatives show how the NRRP not only lowers the cost of adoption but also sends powerful signals that drive firms to reconfigure their structures and strategic positioning in line with emerging technological and institutional ecosystems.

2.1. From public policy to firm behaviour

Firms often underinvest in innovation due to high costs associated with - as costs frequently exceed the resources of private firms (Link and Siegel, 2007) - and uncertainties about long-term returns (Martin and Scott, 2000). This prompts demand for public intervention and public policy support that becomes essential to foster innovation in the private sector (Link and Siegel, 2007; Wang, 2018).

The literature has identified multiple mechanisms through which public support enhances firms' innovative capacity, especially in SMEs, which often face significant financial constraints (Czarnitzki and Lopes-Bento, 2013). Financial instruments mitigate the risks associated with innovation projects (Zona, 2012) and reduce the burden of investment through cost-sharing arrangements (Roper et al., 2008). Public subsidies and incentives also generate positive effects on innovation

[1] Details on https://www.mef.gov.it/en/focus/The–National–Recovery–and–Resilience–Plan–NRRP/.

outputs (Bronzini and Piselli, 2016; Marlin and Geiger, 2015; Moretti and Wilson, 2014), particularly in under-developed regions (Castellacci and Archibugi, 2008; Zehavi and Breznitz, 2017).

Beyond product and process innovation, public policy has also been shown to affect BMI directly, by disrupting incumbent business models and encouraging firms to reconfigure them around new technologies and societal needs (Bidmon and Knab, 2018; Wainstein and Bumpus, 2016; Wesseling et al., 2020).

In this context, the NRRP represents the major public policy intervention to accelerate firms' digitalization. Importantly, the NRRP is not only designed to promote the adoption of digital technologies but also to act as a catalyst for business model transformation, particularly in sectors where innovation depends less on technological breakthroughs and more on organizational and strategic reconfiguration (Baden-Fuller and Morgan, 2013). Thus, the NRRP enables firms to move beyond technology uptake and redesign their business profiles, especially when a new paradigm such as digitalization emerges. However, the extent to which firms can seize these opportunities largely depends on managerial capabilities. Skilled managers are better positioned to interpret policy signals, identify viable strategic adjustments, and translate them into organizational change. These aspects will be further discussed in the following sections, which also briefly present the hypotheses to be tested

3. Literature background and hypotheses

3.1. Business model innovation and industry 4.0

BMI represents a key lever of competitiveness across industries. While in high-tech sectors innovation often stems from radical technological advances, in mature industries technological progress tends to generate diminishing returns and innovation relies more on reconfiguring business models, organizational forms, and processes (Abernathy and Clark, 1985; Tushman and Anderson, 1986; Christensen, 1997). In such contexts, BMI becomes particularly relevant as it allows firms to adapt to market saturation, shifting demand patterns, and disruptive changes, even when the technological frontier no longer provides strong opportunities for differentiation (Teece, 2010; Zott and Amit, 2010).

At the same time, BMI is also critical in high-tech and digital-intensive sectors. Here, firms face accelerated disruptions and rapidly evolving technologies, which demand continual rethinking of how value is created, captured, and delivered. BMI, defined as "designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss and Saebi, 2017) ,[2] has thus been recognized as a fundamental source of competitive advantage, a determinant of organizational resilience, and a driver of long-term survival (Amit and Zott, 2012; Casadesus-Masanell and Zhu, 2013), especially under a digital technology paradigm: Industry 4.0 shapes BMI along three dimensions (Cucculelli et al., 2022; Muller et al., 2018, 2021): value creation, by digitalizing processes and enabling smart manufacturing to boost efficiency (Bogers et al., 2016; Kiel et al., 2017; Rachinger et al., 2019); value capture, by improving connectivity with suppliers and customers (Bogers et al., 2016; Cozzolino et al., 2021; Khanagha et al., 2022; Muller et al., 2018); and value offer, by using analytics to deliver customized, high-quality products (Li, 2020; Muller et al., 2018). Table 1 presents details about these three dimensions.

Overall, digital technologies and Industry 4.0 transformations have reinforced the centrality of BMI. Digital technologies enable continuous strategic transformation to navigate digital disruptions effectively

[2] Several definitions of BMI exist in literature: (i) as the discovery of a fundamentally different BM within an existing organization (Markides, 2006), (ii) as the search for new logics and approaches to revenue generation (Casadesus-Masanell & Ricart, 2010), and (iii) as a deliberate and observable change in the BM elements and/or architecture of an organization (Foss & Saebi, 2017; Khanagha et al., 2014).

Table 1
Potential benefits from digital technologies on BMI.

Pillars of BMI	Positive effect generated by investment in digital technologies	Source
Value Creation		
Enhanced customer experience	Digital technologies allow businesses to create highly personalized and engaging experiences, fostering stronger connections with customers. This result gives companies a competitive edge and meeting evolving market demands	Muller et al. (2018, 2021) Kiel et al. (2017)
Flexibility in decision process	The adoption of digital technologies, such as cloud computing, provides businesses with the agility to scale operations on–demand. This enhances efficiency and allows quick adaptation to changing market dynamics	Dedehayir et al. (2017)
Internationalization	Digital technologies eliminate geographical constraints, enabling businesses to transcend borders. E–commerce platforms, coupled with targeted digital marketing, empower companies to reach a global audience and diversify their customer base	Chesbrough (2010) Sainio (2004)
Value Offer		
Product customization	Leveraging advanced analytics and artificial intelligence, firms can understand individual customer preferences and deliver tailor–made products and services. This level of personalization enhances customer satisfaction and loyalty	Kiel et al. (2017) Li (2020) Muller et al. (2018) Rachinger et al. (2019)
Digital products and services	The integration of digital technologies allows businesses to create entirely new categories of products and services by catering the modern consumer needs and preferences	Bogers et al. (2016) Khanagha et al. (2014, 2022)
Value Capture		
Change of revenue model	The flexibility provided by digital technologies enables companies to experiment with innovative revenue models. Subscription–based services, freemium models, and digital marketplaces offer diversified and efficient avenues for revenue generation	Casadesus–Masanell & Ricart (2010)
Data–value	The wealth of data generated by digital interactions presents businesses with opportunities for monetization. Businesses can capitalize on the intrinsic value of data. Social media platforms, online marketplaces, and affiliate marketing create additional revenue streams	Muller et al. (2018, 2021)
Cost–structure reduction	Digital technologies streamline operations, leading to significant cost reductions. Automation and optimization improve profit margins, allowing businesses to invest resources strategically and capture more value from business operations	Wu et al. (2013)

(continued on next page)

Table 1 (*continued*)

Pillars of BMI	Positive effect generated by investment in digital technologies	Source
Firm's interconnection	Digital technologies facilitate the creation of interconnected business ecosystems. This allows seamless integration of products and services, offering customers a comprehensive and cohesive experience across various touchpoints customers	Muller et al. (2018) Cozzolino et al. (2021) Khanagha et al. (2022)

Source: our own elaboration.

(Warner and Wäger, 2019; Rachinger et al., 2019) by improving efficiency, flexibility, and customization capabilities (Dedehayir et al., 2017; Porter and Heppelmann, 2014) and are acknowledged as vital drivers of BMI (Baden-Fuller and Haeflinger, 2013; Chesbrough, 2010; Kiel et al., 2017; Khanagha et al., 2014; Warner and Wäger, 2019). The introduction of Industry 4.0 makes the shift toward new business models not optional but necessary for competitiveness (Frank et al., 2019; Muller et al., 2021). Through BMI, firms can reduce transaction costs, enhance profitability (Wu et al., 2013), and quickly realign products, services, processes and networks with dynamic market needs (Sainio, 2004).

Given the support provided by the National Recovery and Resilience Plan (NRRP) for digital transition and technology adoption, we formulate our first hypothesis:

Hypothesis 1 (H1): Participation in an NRRP project increases a firm's likelihood of implementing an Industry 4.0–driven business model innovation.

3.2. Business model innovation and managerial skills

A growing literature emphasizes that managerial training is a strategic accelerator for enhancing firms' innovation capabilities, particularly in the context of BMI. The literature widely investigates the effect of managerial upskills on innovation capabilities, confirming positive relation both in developing countries (Chen and Huang, 2009; Caloghirou et al., 2018) and developed countries (Protogerou et al., 2017; van Uden et al., 2017).

At firm level, managerial training is often conceptualized as an accelerator for innovation. Targeted investments in training improve firms' absorptive capacity and innovation performance (Doran and Ryan, 2014; Evangelista and Savona, 2003), especially when combined with external knowledge sourcing (Bourke and Roper, 2017). Evidence from transition economies further suggests that on-the-job training—particularly in managerial and communication skills—is more effective than classroom-based approaches (Burlina et al., 2025).

Beyond technical skills, managerial competencies play a crucial role in enabling firms to adapt their business models. Top managers influence strategic decision-making, resource coordination, and the implementation of innovation-oriented strategies (Casadesus-Masanell and Ricart, 2010; Marvel and Lumpkin, 2007; Sirmon et al., 2011). Managers embedded in value networks can mobilize internal and external resources, foster connectivity, and promote innovation across organizational boundaries (Hock-Doepgen et al., 2021; Zott and Amit, 2010). Recent studies also emphasize the importance of knowledge acquisition and learning processes in enhancing managerial effectiveness. The distinction between general and specific training is relevant: generalist managerial experience supports both incremental and radical innovation, particularly in resource-rich environments (Sheehan et al., 2025; Wu et al., 2025).

While some contributions focus on product and process innovation as drivers of organizational reconfiguration (Cozzarin and Percival, 2023; Dostie, 2018), the literature increasingly recognizes that managerial human capital is essential for enabling BMI, especially in the context of Industry 4.0. Here, technological adoption must be accompanied by organizational transformation (Kiel et al., 2017; Schneider, 2018): managers are uniquely positioned to integrate new technologies with business processes, explore emerging opportunities, and drive strategic renewal (Gao et al., 2008; Shalley et al., 2015).

Taken together, these studies suggest that managerial skills—particularly when supported by structured training—are not merely complementary to technological change, but necessary for enabling the reconfiguration of the business profile of the company, i.e., BMI. They serve as a strategic interface between external incentives and internal transformation processes, allowing firms to interpret, absorb, and act upon innovation opportunities. Therefore, we formulate our second hypothesis:

Hypothesis 2 (H2): The likelihood of implementing an Industry 4.0–driven business model innovation increases when firms invest in managerial training or workforce upskilling.

4. Data

4.1. Survey design

The data used in this study come from a survey conducted in 2023 by Centro Studi Tagliacarne – Unioncamere (the Italian Union of Chambers of Commerce). The survey was designed to investigate firms' behaviour across multiple dimensions. Its primary aim was to collect information to support policymaking by national institutions (e.g., the Ministry of Enterprises and Made in Italy, and the Ministry of Economy and Finance) in key areas of industrial policy: digital transition, green transition, internationalization (export expectations and strategies), entrepreneurship (e.g., family governance), credit access, supply chains, and economic outlook. Within this framework, a specific section of the survey focused on firms' participation in NRRP projects, particularly those related to the digitalization of firm organization and the adoption of Industry 4.0 technologies—a topic closely connected to the role of these technologies in driving business model innovation (BMI).

The survey targeted a large sample of Italian manufacturing SMEs and, after excluding incomplete or unusable questionnaires, resulted in a final working sample of 1779 manufacturing firms with between 5 and 499 employees. This constitutes the sample used in the empirical analysis, and it represents about 2.1 percent of the total Italian business population. The sampling procedure ensured the statistical representativeness of the data by combining both exhaustive and random sampling methods (see in Appendix B for more technical details). Three dimensions were considered for stratification: i) sector (nine industries within Section C of the Nace Rev. 2 classification of manufacturing industry); ii) size class in terms of employees (5–9, 10–49, 50–499); and iii) geographical location (North-West, North-East, Centre, South). The survey was conducted by a professional contractor using CATI (Computer-Assisted Telephone Interviewing) to collect both qualitative and quantitative data. Several preliminary meetings were held with the contractor to clarify the exact meaning of the questions, especially those related to digital technologies and the participation of companies in NRRP projects.

In terms of company size, 44.2 % of firms in the final sample are micro enterprises (5–9 employees), 49.9 % are small enterprises (10–49 employees), and 5.9 % are medium or medium-large enterprises (50–499 employees). Geographically, 18.7 % of firms are located in the North-West, 37.3 % in the North-East, 25.4 % in the Centre, and 18.6 % in the South of Italy.Regarding sectoral distribution, 14.5 % of firms operate in *Food products, beverages, and tobacco*, 15.2 % in *Textiles, apparel, leather, and related products*, 7.8 % in *Wood and paper products, and printing*, 6.4 % in *Chemicals, pharmaceuticals, rubber, and plastics products*, 12.9 % in *Furniture and other manufacturing*, and 4.1 % in *Non-metallic mineral products*. A substantial share belongs to the mechanical industry, including 23.2 % in *Basic metals and fabricated metal products*, 4.8 % in *Computer, electronic, optical products, and electrical equipment*, and 11.1 % in *Machinery and transport equipment*.

4.2. Dependent variable

To test our hypotheses, we use Business Model Innovation (BMI) as the dependent variable. We adopt a definition of BMI rooted specifically in the digital transformation paradigm of Industry 4.0 (Muller et al., 2018). Within this paradigm, digital technologies associated with Industry 4.0 shape BMI along three dimensions: value creation, value offer, and value capture. Regarding value creation, Industry 4.0 technologies enhance data availability, accelerate decision-making, and improve operational efficiency through advanced process digitization. In terms of value offer, these technologies broaden product portfolios and enable customization; higher-quality, tailored solutions and service extensions—such as predictive maintenance and retrofitting—enhance customer value. Finally, concerning value capture, Industry 4.0 technologies facilitate automated platforms that streamline transactions, reduce costs, and increase transparency. They also support pay-per-use models and foster closer supplier–customer integration, with customers directly involved in product design (for a more detailed explanation, see Muller et al., 2018).

In the section of the survey devoted to digital technologies, firms were asked the following question:

"How does the introduction of digital technologies affect your company in terms of BMI? Please select all that apply."

Respondents could select among four strategic areas: i) Technological structure and product/service portfolio; ii) Sales methods and marketing of products/services; iii) Internal organization of the company and production processes; iv) External relationships of the company, including integration and collaboration with suppliers and/or customers; v) None of the above.

Our dependent variable, BMI, is a dummy equal to one if digital technologies have influenced the business model in at least two of the four strategic areas described above, and zero otherwise. This definition captures a subset of BMI—those innovations explicitly driven by digital adoption, which aligns with the NRRP's strategic priorities. In the robustness analysis, we vary the threshold for the dependent variable (from one to three out of the four strategic areas) to ensure the consistency of our BMI measure. Overall, 16.6 % of the sample companies have innovated their business model. Innovation intensity is higher among medium and large companies, and is particularly prevalent in sectors such as Chemicals, pharmaceuticals, rubber and plastics products, together with computer, electronic, optical products and electrical equipment. Notable differences also emerge based on international profile of the company: 21.0 % of exporting companies adopt BMI, compared to 12.3 % of non-exporting companies (Table 2).

4.3. Independent variables

To assess the effect of the NRRP on BMI, we create a dummy variable (*NRRP*) to identify companies that have already activated NRRP-related projects. Specifically, the variable *NRRP* takes the value one if the company has activated one or more NRRP projects and zero otherwise.

According to the survey, around 10.1 percent of manufacturing companies are involved in NRRP projects related to digital transformation and digital technologies. Participation is higher among medium–large firms (21.6 percent) than small and micro companies (11.4 and 7.2 percent respectively). Export–oriented companies (12.4 percent) and companies in Southern regions (11.4 percent) show a high level of participation, confirming the role of the Plan in maintaining international competitiveness and reducing territorial inequalities (Table 3).

With respect to human capital, we construct four categorical variables: NRRP_Managers, NRRP_StockManagers, NRRP_UpReskill, and NRRP_Graduates. NRRP_Managers captures whether firms invested in managerial training during 2020–2022. It is coded as 0 if the firm did not participate in the NRRP, 1 if the firm participates or has participated in the NRRP, and 2 if the firm participates or has participated in the NRRP and invested in managerial training. NRRP_StockManagers captures the proportion of high-level managers in the company, defined as firms in the third tercile of the sample distribution of managers per employee. It is coded as 0 if the firm did not participate in the NRRP, 1 if the firm participates or has participated, and 2 if the firm participates or

Table 2
Business model innovation by firms with different characteristics (percentage on total firms by characteristic).

	BMI		
	(BMI=0)	(BMI=1)	
Size class			
Micro (5–9 employees)	90.7	9.3	100.0
Small (10–49 employees)	79.5	20.5	100.0
Medium–Large (50+ employees)	61.8	38.2	100.0
Geographical location			
North–West	84.8	15.2	100.0
North–Est	83.2	16.8	100.0
Centre	83.9	16.1	100.0
South	81.8	18.2	100.0
Manufacturing industries			
C10–C11: Food products, beverages, and tobacco	84.3	15.7	100.0
C13–C15: Textiles, apparel, leather, and related products	81.2	18.8	100.0
C16–C18: Wood and paper products, and printing	86.4	13.6	100.0
C19–C22: Chemicals, pharmaceuticals, rubber, and plastics products	74.6	25.4	100.0
C23: Non-metallic mineral products	85.3	14.7	100.0
C24–C25: Basic metals and fabricated metal products	84.6	15.4	100.0
C26–C27: Computer, electronic, optical products, and electrical equipment	80.4	19.6	100.0
C28–C30: Machinery and transport equipment	84.4	15.6	100.0
C31–C33: Furniture and other manufacturing	85.0	15.0	100.0
Internationalization			
Exporting firms	79.0	21.0	100.0
Non - Exporting firms	87.7	12.3	100.0
Age (by years since inception)			
Under 20 years	84.5	15.5	100.0
20 years and more	83.0	17.0	100.0
Family ownership			
Non–family firms	84.6	15.4	100.0
Family firms	83.2	16.8	100.0
TOTAL	83.4	16.6	100.0

Source: Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) survey, 2023.

Table 3
Manufacturing firms activated by the NRRP on projects related to digital transition by firm characteristics (percentage on total firms by characteristic).

	Activated	Not activated	Total
Size class			
Micro (5–9 employees)	7.2	92.8	100.0
Small (10–49 employees)	11.4	88.6	100.0
Medium–Large (50+ employees)	21.6	78.4	100.0
Geographical location			
North–West	8.1	91.9	100.0
North–Est	10.8	89.2	100.0
Centre	9.8	90.2	100.0
South	11.4	88.6	100.0
Age (by years since inception)			
Under 20 years	11.1	88.9	100.0
20 years and more	9.8	90.2	100.0
Internationalization			
Non–exporting firms	7.9	92.1	100.0
Exporting firms	12.4	87.6	100.0
TOTAL	10.1	89.9	100.0

Source: Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) survey, 2023.

has participated and belongs to the third tercile in managerial density. NRRP_UpReskill measures investment in upskilling or reskilling of non-managerial employees. It is coded as 0 if the firm did not participate in the NRRP, 1 if the firm participates or has participated, and 2 if the firm participates or has participated and has invested in employee retraining programs.

Finally, NRRP_Graduates captures the proportion of college-educated employees, coded as 1 if the firm is in the third tercile of college graduates per employee in the sample. It takes the value 0 if the firm did not participate in the NRRP, 1 if the firm participates or has participated, and 2 if the firm participates or has participated and belongs to the third tercile in workforce education.

4.4. Control variables

We include several control variables to account for internal and external factors that may affect a firm's likelihood of reconfiguring its business profile. First, we control for digital intensity, i.e., the extent of digital technology adoption within the firm. Digital technologies have a profound impact on firm activities and processes, shaping mechanisms of value creation, value capture, and value offer. The Digital Intensity variable is a continuous variable that ranges from 0 to 12, based on the number of digital technologies adopted by the firm.[3]

As innovative performance may depend on the firm's life stage (Craig and Moores, 2006), we include a continuous variable Age, measuring the number of years since the firm's founding. Age also captures accumulated experience, competencies, and embedded learning mechanisms (Balabanis and Katsikea, 2003; Kumar and Saqib, 1996).

Firm size is another key determinant of innovation investment (Becheikh et al., 2006). We use the number of employees as a proxy for size (Size) (Becheikh et al., 2006; Syverson, 2011).

To account for sectoral differences, we include nine industry dummy variables (Sector): "Food products, beverages, and tobacco"; "Textiles, apparel, leather, and related products"; "Wood and paper products, and printing"; "Chemicals, pharmaceuticals, rubber, and plastics products"; "Non-metallic mineral products"; "Basic metals and fabricated metal products"; "Computer, electronic, optical products, and electrical equipment"; "Machinery and transport equipment"; and "Furniture and other manufacturing."

Following Camagni and Capello (2013), we consider territorial characteristics that can influence innovation. Locational advantages—including knowledge-based assets, infrastructure, and technology—can affect competitiveness, particularly in Italy where regional disparities are significant. We therefore include three NUTS-1 dummy variables for firm location: North-East, Centre, and South, with North-West as the reference group.

We also control for the ownership structure of the company, namely family ownership. A family firm is defined as a firm owned by an individual or family (Miller et al., 2007) and is measured with a dummy variable (Family) equal to 1 if family-owned and 0 otherwise.

Finally, we account for firm profitability, which is known to enhance innovation (Audretsch, 1995). We consider return on sales (ROS) and return on assets (ROA), both measured as deviations from the sector average with respect to the corresponding NACE 4-digit sector, firm size and NUTS-3 region. Table 4 presents the full list of variables used in the analysis, along with their definitions.

[3] The 12 technologies included in the survey are: Big data analytics, Internet of Things (IOT), Robotics, Cloud computing, Additive manufacturing, Supply chain integration software, Augmented and virtual reality, Simulation between connected machines, Cyber security (cyber security), Blockchain, Artificial Intelligence, Machine learning

Table 4
Variables description.

Variables	Type	Description
Panel A – Dependent variable		
BMI	Dummy	1 = if the firm carries out BMI; 0 = otherwise
Panel B – Main independent variables		
NRRP	Dummy	1 = if the firm has activated a project for the NRRP; 0 = otherwise
NRRP_Managers	Categorical	0 = if the firm has not activated a project for the NRRP (NNRRP); 1= if the firm has activated a project for the NRRP but has not invested in managerial skills training (YNRRP_NManagers); 2= if the firm has activated a project for the NRRP and has invested in 2020–2022 in managerial skills training (YNRRP_YManagers). Firms with managerial training activity are those that invested in this activity in 2020–2022.
NRRP_StockManagers	Categorical	0 = if the firm has not activated a project for the NRRP (NNRRP); 1= if the firm has activated a project for the NRRP but has a low–level of managerial stock within the firm (YNRRP_NStockmanagers); 2= if the firm has activated a project for the NRRP and has a high share of managers within the firm (YNRRP_YStockmanagers). Firms with a high share of managers are those in the third tercile of the distribution of firms by managers per employee.
NRRP_UpReskill	Categorical	0 = if the firm has not activated a project for the NRRP (NNRRP); 1= if the firm has activated a project for the NRRP but has not invested in upskilling/reskilling of employees (YNRRP_NUpReskill); 2= if the firm has activated a project for the NRRP and has invested in 2020–2022 in upskilling/reskilling of employees (YNRRP_YUpReskill). Firms with upskill/reskill activity are those that invested in these activities in 2020–2022.
NRRP_Graduates	Categorical	0 = if the firm has not activated a project for the NRRP (NNRRP); 1= if the firm has activated a project for the NRRP but has not a high share of graduated employees (YNRRP_NGraduates); 2= if the firm has activated a project for the NRRP and has a high share of graduate employees (YNRRP_YGraduates). Firms with a high share of graduates are those in the third tercile of the distribution of firms by graduates per employee.
Panel C – Control variables		
Digital Intensity	Categorical	0 = if the firm has not adopted any digital technology; 12 = if the firm has adopted all digital technologies in 2020–2022; varies between 1 and 11 if the firm has adopted only certain technologies in 2020–2022 based on the number of digital technologies taken
Age	Continuous	Number of years since inception
Size	Continuous	Number of employees
Sector	Dummies	Dummies according to 9 manufacturing industries
North–East	Dummy	1 = if the firm is located in the Nort–East
North–West	Dummy	1 = if the firm is located in the Nort–West
Centre	Dummy	1 = if the firm is located in the Centre
South	Dummy	1 = if the firm is located in the South
Family	Dummy	1 = if the firm is family–owned firm
ROS	Continuous	Return on sales. Difference from average ROS defined at Nace 4–digit – size and – Nuts3
ROA	Continuous	Return on asset. Difference from average ROA defined at Nace 4–digit – size and – Nuts3

Source: Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) survey, 2023.

4.5. Descriptive analysis

The descriptive analysis reveals that the share of firms adopting BMI is higher among firms participating in NRRP compared to those non-participating (28.7 percent vs 13.0 percent) (Fig. 1– Panel A). Likewise, in the group of firms active on NRRP projects, the share of firms reconfiguring their business model is higher among those that have had managerial training (*YManagers*) compared to firms that have not (*NManagers*) (37.9 percent vs 26.9 percent) (Fig. 1– Panel B).

Table 5 shows the distribution of companies that implemented additional managerial training measures during 2020–2022 (YManagers). Regarding firm size, >90 % of small and micro enterprises did not implement any additional managerial training measures (NManagers). By sector, companies in "Non-metallic mineral products," "Computer, electronic, optical products, and electrical equipment," and "Machinery and transport equipment" show a significantly higher uptake of managerial training compared to other sectors, with 14.6 %, 12.9 %, and 11.5 %, respectively, versus the sample average of 8.9 %. Differences also emerge when comparing exporting and non-exporting firms. Firms with a high degree of internationalization are more active in implementing executive training programs: 12.4 % of exporting companies introduced such programs, compared to 5.5 % of non-exporting firms. Finally, ownership appears to influence the adoption of managerial training. Among family businesses, 8.2 % invested in executive education, compared to 13.0 % of non-family businesses.

5. The empirical model

To test H1, we run the following probit model:

$$BMI_i = \alpha_0 + \alpha_1 NRRP_i + \alpha_2 X_i + \varepsilon_i \quad (1)$$

Where, for each firm *i*, the dependent variable BMI_i is dummy variable equal to one if the firm has reconfigured its business model according to digital technologies, as defined in Section 4.2, and zero otherwise. The variable $NRRP_i$ takes the value one if the company has activated a NRRP project and zero otherwise. The coefficient of interest, α_1, captures the effect of the NRRP on the likelihood of innovating the business model. This permits to test H1. Since the opportunity to access the program and start a project under the NRRP is open to "all companies located in the national territory, including permanent establishments of non–residents, regardless of their legal form, economic sector, size, accounting system and tax profit determination system", the risk of selection bias due to entry restrictions is negligible. In other words, the program's eligibility criteria do not impose systematic barriers that could have excluded *ex ante* specific categories of firms.[4] Moreover, our sample includes both firms that engaged in BMI and those that do not, allowing for an implicit control group within the sample of firms. This mitigates concerns related to sample selection, as it enables a comparison between firms that benefit from the NRRP and those that do not, under similar observable conditions.

To test H2, we use the following probit model:

$$BMI_i = \beta_0 + \beta_1 HC_i^k + \beta_2 X_i + u_i \quad (2)$$

The variable HC_i^k includes the managerial training variables, where *k* alternatively refers to the variables *NRRP_Managers, NRRP_Stockmanagers, NRRP_UpReskill* or *NRRP_Graduates.*

To assess H2, we focus on the coefficient β_1 and expect that firms engaging in the NRRP project are more likely to innovate BMI when investing in managerial training or up-skilling. Models in Eq. (1) and Eq. (2) include the full set of control variables – firm, sectoral and geographical controls–in vector X_i (see Section 4.4). Standard errors (ε_i) and (u_i) are clustered at firm level.

6. Results

6.1. The influence of the NRRP on BMI

Table 6 reports the marginal effects for Eq. (1), which estimates the effect of NRRP participation on the likelihood of engaging in BMI. In Column 1, the baseline specification includes core firm-level controls. The coefficient on NRRP is positive and statistically significant, indicating that firms participating in NRRP projects are 17.2 percentage points (pp) more likely to adopt BMI compared to non-participating firms. This result does not reject Hypothesis 1, which posits that NRRP participation enhances the likelihood of business model reconfiguration.

Among the controls, firm size is positively associated with BMI, suggesting that larger firms are more likely to engage in business innovation. Return on sales (ROS) also shows a positive and significant effect, indicating that more profitable firms are more inclined to innovate their business models. Columns 2 and 3 introduce sectoral and macro-area controls, respectively, to account for industry-specific and regional heterogeneity. The coefficient of the NRRP variable remains stable and significant, confirming the robustness of the main result. In Column 4, we consider the firm's digital intensity. The inclusion of this variable substantially increases the model's explanatory power (Pseudo R^2 rises from 0.064 to 0.225). The marginal effect of digital intensity is positive and highly significant, confirming that firms with greater digital engagement are significantly more likely to undertake BMI. The coefficient on NRRP decreases to 5.9 pp but remains statistically significant, suggesting that the effect of NRRP participation persists even after accounting for the intensity of digital technology adoption.

Overall, the results consistently show that NRRP participation increases the likelihood of BMI, even after controlling for firm characteristics, sector, region, and digital readiness.

6.2. The effect of managerial training on BMI

The analysis further examines whether managerial training amplifies the effect of NRRP participation on BMI, as indicated in Hypothesis 2. Column 5 of Table 6 reports the results from Eq. (2), distinguishing between (i) firms that have activated neither NRRP projects nor managerial training (No NRRP), (ii) those that have activated NRRP projects without managerial training (Yes NRRP_No Managers), and (iii) those that have activated NRRP projects and also conducted managerial training (Yes NRRP_Yes Managers). The coefficient for Yes NRRP_Yes Managers is positive and statistically significant: ceteris paribus, firms combining NRRP participation with managerial training are approximately 9.1 percentage points more likely to engage in BMI compared to firms participating in NRRP without training. This result does not reject Hypothesis 2 and underscores the importance of managerial training in shaping the effect of public policy on innovation.

Columns 6–8 of Table 6 extend the analysis to other dimensions of human capital beyond managerial training, including the share of high-level managers (NRRP_StockManagers), the implementation of upskilling and reskilling programs (NRRP_UpReskill), and the proportion of graduate employees on total workforce (NRRP_Graduates). None of these variables show statistically significant coefficients, suggesting that the mere presence of managerial personnel or general workforce training does not substantially influence the likelihood of BMI adoption. Instead, it is the targeted investment in managerial training—that leverages strategic and organizational competencies—that appears critical for enabling firms to capitalize on NRRP incentives.

Finally, across all specifications (columns 5–8), the coefficients for No_NRRP are negative and statistically significant, indicating that the absence of participation in NRRP projects markedly reduces the likelihood of business model innovation.

These findings contribute to the literature on the role of managerial

[4] For more details see: https://www.mimit.gov.it/it/incentivi/credito–dimposta–per–investimenti–in–beni–strumentali

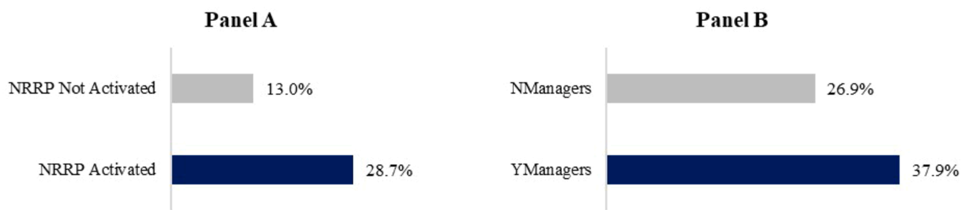

Fig. 1. Percentage of manufacturing firms innovating the business model, by NRRP participation (Panel A) by managerial training status (Panel B). Note: Panel B: with reference to the firms activated in NRRP projects. Source: Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) survey, 2023.

Table 5
Firms that carried out training activities on managerial skills in 2020–22. Manufacturing firms by characteristics (percentage on total firms by characteristic).

	NManagers	YManagers	Total
Size class			
Micro (5–9 employees)	94.0	6.0	100.0
Small (10–49 employees)	90.8	9.2	100.0
Medium–Large (50+ employees)	72.4	27.6	100.0
Geographical location			
North–West	90.1	9.9	100.0
North–Est	90.2	9.8	100.0
Centre	92.6	7.4	100.0
South	91.8	8.2	100.0
Manufacturing industries			
C10–C11: Food products, beverages, and tobacco	93.7	6.3	100.0
C13–C15: Textiles, apparel, leather, and related products	93.5	6.5	100.0
C16–C18: Wood and paper products, and printing	91.4	8.6	100.0
C19:C22: Chemicals, pharmaceuticals, rubber, and plastics products	92.2	7.8	100.0
C23: Non-metallic mineral products	85.4	14.6	100.0
C24–C25: Basic metals and fabricated metal products	90.1	9.9	100.0
C26–C27: Computer, electronic, optical products, and electrical equipment	87.1	12.9	100.0
C28–C30: Machinery and transport equipment	88.5	11.5	100.0
C31–C33: Furniture and other manufacturing	92.0	8.0	100.0
Age (by years since inception)			
Under 20 years	91.0	9.0	100.0
20 years and more	91.1	8.9	100.0
Family ownership			
Non–family firms	87.0	13.0	100.0
Family firms	91.8	8.2	100.0
Internationalization			
Exporting firms	87.6	12.4	100.0
Non-exporting firms	94.5	5.5	100.0
TOTAL	91.1	8.9	100.0

Source: Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) survey, 2023.

capabilities in supporting innovation processes (Marvel and Lumpkin, 2007; Tang et al., 2012), reinforcing the view that managerial training serves as a strategic complement to policy-driven innovation. By enhancing firms' ability to interpret, absorb, and act upon external incentives, managerial training strengthens the impact of programs like the NRRP. The results also carry important policy implications: initiatives aimed at promoting innovation through public investment should consider pairing financial support with targeted managerial training, as this combination appears to substantially increase the effectiveness of policy interventions in fostering BMI.[5]

7. Heterogeneity

In this section, we examine two potential sources of heterogeneity that may influence the impact of managerial human capital on BMI. Specifically, we assess the moderating role of technological intensity and firm size on the four variables capturing managerial human capital: managerial training, managerial staff, upskilling and reskilling activities, and the share of graduates. For each of these four variables, we explore variations across technological intensity (low-tech vs. high-tech industries) and firm size categories (micro, small and medium–large enterprises). We also conducted a heterogeneity analysis with respect to the four geographical areas: North-West, North-East, Centre, and South but with no relevant differences that could alter the results (see Appendix C). The same heterogeneity analyses for Hypothesis 1 are reported in Table D.1 and Table D.2 in Appendix D.

7.1. Managerial training

Table 7 shows that the effect of the NRRP on BMI varies across sectors with different levels of technological intensity (columns 1–2). Specifically, we consider sectors C20-C21, C26-C30 as high technological intensity industries and sectors C10-C19, C22-C25, C31–33 as low technological intensity industries. In low-tech sectors (Column 1), the coefficient *No NRRP* is negative and statistically significant, indicating that firms not involved in NRRP initiatives are significantly less likely to adopt BMI. Conversely, the coefficient for *Yes NRRP_Yes Managers* is positive and significant, suggesting that managerial training supports innovation even in low-tech sectors.

In high-tech sectors (Column 2), the coefficient for *Yes NRRP_Yes Managers* is positive, statistically significant, and larger in magnitude than in low-tech sectors. This implies that managerial training amplifies the effect of NRRP on BMI more strongly in high-tech industries. However, the coefficient for *No NRRP* is not significant: firms in high-tech sectors are more prone to innovate due to their technological capabilities and market dynamics, and thus less reliant on external policy *stimuli.*

These results have two key implications. First, they confirm that NRRP initiatives combined with managerial training have a positive effect on BMI in both low- and high-tech sectors, although the magnitude is greater in the latter. Second, the absence of NRRP support penalizes low-tech firms more severely, while high-tech firms remain relatively unaffected due to their intrinsic innovation potential.

Columns 3–5 of Table 7 focus on company's size. Moving from micro

[5] To corroborate our results and show that the relevant dimension is *Managers* rather than *StockManagers, UpReskill*, or *Graduates*, we also estimated models including multiple human capital variables and their interactions with the NRRP variables in a single specification. The results remain unchanged, and the presence of *Managers* alongside another variable does not increase the likelihood of doing BMI, confirming that the key dimension is *Managers*.

Table 6
The effect of NRRP and human capital on BMI.

Dep. variable	BMI (1)	BMI (2)	BMI (3)	BMI (4)	BMI (5)	BMI (6)	BMI (7)	BMI (8)
NRRP	0.172***	0.170***	0.172***	0.059***				
	(0.021)	(0.021)	(0.021)	(0.020)				
No NRRP					–0.036*	–0.076***	–0.097***	–0.079***
					(0.023)	(0.027)	(0.031)	(0.026)
Yes NRRP_No Managers (r.c.)					-			
Yes NRRP_Yes Managers					0.091**			
					(0.016)			
Yes NRRP_No StockManagers (r.c.)						-		
Yes NRRP_Yes StockManagers						–0.031		
						(0.034)		
Yes NRRP_No UpReskill (r.c.)							-	
Yes NRRP_Yes UpReskill							–0.026	
							(0.038)	
Yes NRRP_No Graduates (r.c.)								-
Yes NRRP_Yes Graduates								–0.046
								(0.034)
Age	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	0.001	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Size	0.001***	0.001***	0.001***	0.000**	0.000**	0.000***	0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Family	0.002	0.001	0.002	0.012	0.012	0.010	−0.031	0.010
	(0.024)	(0.024)	(0.024)	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)
ROS	0.007**	0.007**	0.007**	0.002	0.002	0.002	0.000	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ROA	−0.003	−0.003	−0.003	0.001	0.001	0.001	0.002	0.001
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Digital intensity				0.158***	0.157***	0.158***	0.252***	0.159***
				(0.008)	(0.008)	(0.008)	(0.011)	(0.008)
Sectoral Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1779	1779	1779	1779	1779	1779	1779	1779
Pseudo R^2	0.059	0.062	0.064	0.225	0.228	0.225	0.341	0.226
Wald Chi–square	127.00***	134.10***	138.38***	343.53***	355.80***	341.15***	238.05***	344.09***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Sectoral and macro-area dummies are used as controls. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

firms - where the coefficient *Yes NRRP_Yes Managers* is negative and significant, to small firms (positive but not significant), and finally to medium-large firms (positive and significant), it becomes evident that the combination of NRRP and managerial training is most effective in firms with greater size. In fact, the positive coefficient for *NRRP* participation combined with managerial training in column 3 suggests that larger firms benefit substantially from the synergy between policy support and managerial capabilities. This result suggests that larger firms better undertake the NRRP interventions, particularly when supported by trained management.

Overall, the results confirm that managerial capabilities are a critical transmission channel through which public policy can foster BMI, even if with some differences in terms of intensity.

7.2. *Managerial staff*

In Column 1 of Table 8, firms operating in low-tech sectors that do not participate in NRRP projects are significantly less likely to engage in BMI. This confirms the relevance of NRRP in less innovative sectors. However, *Yes NRRP_Yes StockManagers* is not statistically significant, suggesting that the presence of stock managers does not enhance the effectiveness of NRRP in these contexts, as confirmed in Section 6.2 (Hypothesis 2). In high-tech sectors (Column 2), the coefficients *No NRRP* and *Yes NRRP_Yes StockManagers* are not significant, confirming that no differences arise in high-tech environments either.

Size heterogeneity is shown in columns 3–5 of Table 8. The disaggregated results for micro, small and medium-large firms reveal nuanced patterns. In small firms (Column 4), the *Yes NRRP_Yes StockManagers* coefficient is negative and highly significant, indicating that the presence of stock managers may even hinder the effectiveness of NRRP on BMI. In contrast, no effects exist in medium-large companies. These findings suggest that in smaller firms, the presence of stock managers may reflect rigid structures that are less prone to innovation, particularly when responding to external policy programs. On the other hand, the stock of managers (number) does not have a role in bigger firms.

Overall, the results suggest that the presence of stock managers does not constitute an effective accelerator for NRRP in innovating business models.

7.3. *Upskill and reskill activities*

The results in Table 9 about *UpReskill* within low- and high-tech sectors closely mirror those observed for *StockManagers*, leading to the same interpretations (columns 1–2). Only in low-tech sectors, firms not benefiting from NRRP interventions exhibit a significant negative effect on BMI, while the coefficients *Yes NRRP_Yes UpReskill* are not significant.

Columns 3–5 reveal variation in the effect of NRRP across different firm sizes. Despite one would expect training initiatives to enhance innovation outcomes, no significant effects are observed, and the coefficient for *Yes NRRP_Yes UpReskill* is not statistically significant across specifications (Columns 3–5, Table 9), indicating that general upskilling/reskilling measures do not substantially influence BMI.

7.4. *Graduates*

Table 10 presents the effect of the share of graduates across different levels of technological intensity. In low-tech sectors, the results reveal a significant negative effect both for *No NRRP* and *Yes NRRP_Yes Graduates*

Table 7
The effect of *NRRP_Managers* on BMI: breakdown by technological intensity and by firm size.

Dep. variable	Sectors		Size		
	Low-tech	High-tech	Micro	Small	Medium-Large
	BMI	BMI	BMI	BMI	BMI
	(1)	(2)	(3)	(4)	(5)
No NRRP	−0.061**	0.048	0.018	−0.035	−0.023
	(0.028)	(0.043)	(0.044)	(0.039)	(0.033)
Yes NRRP_No Managers (r. c.)	-	-	-	-	-
Yes NRRP_Yes Managers	0.079*	0.120*	−0.074*	0.059	0.123***
	(0.047)	(0.065)	(0.039)	(0.088)	(0.045)
Firms' Controls	Yes	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes	Yes
Observations	1.327	452	232	545	999
Pseudo R^2	236.50***	146.28	0.379	0.23	0.193
Wald Chi–square	0.209	0.284	56.06***	105.71***	187.42***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Low-tech sector: C10-C19, C22-C25, C31–33; High-tech sector: C20-C21, C26-C30. Micro firms: 5–9 employees; Small firms: 10–49 employees; Medium–Large firms: 50+ employees. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

coefficients (column 1). This suggests that firms operating in these industries are particularly vulnerable to innovation stagnation when targeted policy lacks. Moreover, also the mere presence of graduates, even in combination with NRRP-related projects, is not sufficient to offset structural disadvantages. In high-tech sectors, both coefficients are instead not significant. High-tech firms are less reliant on policy *stimuli* due to stronger internal R&D capabilities and better access to innovation (column 2).

Focusing on different firm size, the results in columns 3–5, Table 10, follow the same patterns of those related to *StockManagers*. While small firms involved in NRRP projects with high share of graduated employees are less likely to innovate their business model, differences among medium-large companies are not significant. More specifically, the negative result in column 4 shows that smaller firms may face organizational *inertia* or lack the managerial structures to effectively integrate advanced human capital into innovation processes.

8. Conclusion

In this paper, we examine the effect of the NRRP on the reconfiguration of Italian firms' business profiles. By promoting digital and green transitions, the NRRP represents a significant opportunity for firms to invest in innovation and adapt their business models along the lines of the digital technologies.

Using a unique micro-database of 1779 firms from Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce), we provide evidence supporting the hypothesis that the NRRP effectively accelerates the transformation of Italian firms' business profiles in line with the digital transformation framework. Our results indicate that firms participating in NRRP projects are more likely to invest in BMI than non-participating firms. Moreover, we find that this effect is not driven by the mere presence of human capital, but specifically by the professional development of managers. In other words, targeted managerial training increases the likelihood of reshaping the business profile of the company, as it equips firms to better recognize and strategically exploit emerging opportunities.

Overall, our research contributes to the understanding of the interplay between the NRRP, digital transformation, and BMI, providing useful guidance for policymakers, managers, and researchers alike. From a policy perspective, these findings underscore the importance of designing interventions that not only provide financial support but also enhance firms' managerial capabilities. Several policy implications emerge from our results. First, given that a large proportion of Italian companies are family-run firms—which appear less prone to BMI—it is crucial to encourage their participation in NRRP projects to maximize the program's impact on this type of ownership. Second, the NRRP's driving role should also extend to more mature companies, as they may be particularly receptive to business model transformation as a means of maintaining competitiveness. Third, it may be advisable to complement NRRP-driven initiatives with labour-market interventions aimed at strengthening managerial skills and competencies. Finally, as the NRRP approaches its final stage, its implementation can serve as a valuable reference for designing future policy frameworks to foster innovation in the private sector.

The present study has several limitations that could be addressed in future research. First, the cross-sectional design does not allow for causal

Table 8
The effect of *NRRP_StockManagers* on BMI: breakdown by technological intensity and by firm size.

Dep. variable	Sectors		Size		
	Low-tech	High-tech	Micro	Small	Medium-Large
	BMI	BMI	BMI	BMI	BMI
	(1)	(2)	(3)	(4)	(5)
No NRRP	−0.101***	0.041	0.022	−0.079*	−0.063
	(0.030)	(0.059)	(0.040)	(0.043)	(0.041)
Yes NRRP_No StockManagers (r.c.)	-	-	-	-	-
Yes NRRP_Yes StockManagers	−0.051	0.051	-	−0.175***	0.004
	(0.042)	(0.065)		(0.056)	(0.046)
Firms' Controls	Yes	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes	Yes
Observations	1.327	452	228	545	999
Pseudo R^2	0.209	0.279	0.381	0.24	0.187
Wald Chi–square	226.63***	142.91***	52.51***	99.33***	178.53***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Low-tech sector: C10-C19, C22-C25, C31–33; High-tech sector: C20-C21, C26-C30. Micro firms: 5–9 employees; Small firms: 10–49 employees; Medium–Large firms: 50+ employees. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table 9
The effect of *NRRP_UpReskill* on BMI: breakdown by technological intensity and by firm size.

Dep. variable	Sectors		Size		
	Low-tech BMI (1)	High-tech BMI (2)	Micro BMI (3)	Small BMI (4)	Medium-Large BMI (5)
No NRRP	−0.088***	−0.029	0.014	−0.019	−0.100***
	(0.033)	(0.051)	(0.053)	(0.046)	(0.038)
Yes NRRP_No UpReskill (r.c.)	-	-	-	-	-
Yes NRRP_Yes UpReskill	−0.013	−0.068	−0.019	0.039	−0.064
	(0.040)	(0.058)	(0.061)	(0.060)	(0.043)
Firms' Controls	Yes	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes	Yes
Observations	1.327	452	232	545	999
Pseudo R^2	0.208	0.280	0.374	0.23	0.189
Wald Chi–square	230.29***	141.92***	49.25***	101.17***	181.77***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Low-tech sector: C10-C19, C22-C25, C31–33; High-tech sector: C20-C21, C26-C30. Micro firms: 5–9 employees; Small firms: 10–49 employees; Medium–Large firms: 50+ employees. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table 10
The effect of *NRRP_Graduates* on BMI: breakdown by technological intensity and by firm size.

Dep. variable	Sectors		Size		
	Low-tech BMI (1)	High-tech BMI (2)	Micro BMI (3)	Small BMI (4)	Medium-Large BMI (5)
No NRRP	−0.105***	0.027	0.014	−0.076*	−0.073**
	(0.029)	(0.054)	(0.050)	(0.042)	(0.036)
Yes NRRP_No Graduates (r.c.)	-	-	-	-	-
Yes NRRP_Yes Graduates	−0.079*	0.034	−0.04	−0.122**	−0.016
	(0.041)	(0.061)	(0.054)	(0.061)	(0.045)
Firms' Controls	Yes	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes	Yes
Observations	1.327	452	232	545	999
Pseudo R^2	0.210	0.278	0.376	0.235	0.187
Wald Chi–square	231.78***	138.40***	49.69***	108.35***	178.64***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Low-tech sector: C10-C19, C22-C25, C31–33; High-tech sector: C20-C21, C26-C30. Micro firms: 5–9 employees; Small firms: 10–49 employees; Medium–Large firms: 50+ employees. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

inference, providing only an assessment of associations between the variables. Second, although we adopt a literature-based definition of business model innovation, further research could explore alternative definitions and operationalizations of the variables, including the type and intensity of managerial training. Third, despite including multiple controls for digital intensity and other potential confounders, we acknowledge the possibility of indirect overlaps—for example, NRRP-funded digital projects may be intertwined with BMI initiatives. Finally, the research could benefit from larger-scale surveys and cross-country analyses conducted in diverse entrepreneurial systems.

Author statement

All authors have contributed substantially to the conception, design, and execution of the research, as well as to the writing of the manuscript. Marco Cucculelli coordinated the research project, contributed to the conceptual framework, and supervised the empirical analysis and manuscript development. Noemi Giampaoli contributed to data management, empirical analysis, and manuscript drafting. Mirko Menghini provided expertise on public policy design and contributed to the analysis and interpretation of results related to the NRRP framework. Marco Pini contributed to the construction and validation of the firm-level dataset, to the econometric modeling and analysis and to the policy discussion. Matteo Renghini contributed to econometric modeling, robustness analysis, and manuscript drafting and revision. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CRediT authorship contribution statement

Marco Cucculelli: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Noemi Giampaoli:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Mirko Menghini:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Marco Pini:** Writing – review & editing, Validation, Methodology, Investigation, Data curation, Conceptualization, Formal analysis. **Matteo Renghini:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing Interest

The authors declare that they have no competing financial or personal interests that could have influenced the results or interpretation of this research. This work has not been published previously and is not under consideration for publication elsewhere.

Appendix A. The National Recovery and Resilience Plan

The National Recovery and Resilience Plan (NRRP) is the document that each Member State must prepare to access Next Generation EU (NGEU) funds, the policy instrument introduced by the European Union for recovery following the Covid–19 pandemic. The primary objective of the Plan is to support growth by maintaining high income dynamics in the coming years and ensuring the transition of the economy to digitalized, green, and cohesive models. According to estimates by the MEF, based on the European Commission's QUEST model, GDP could grow by up to 3.6 percentage points more than in the baseline scenario (between 2021 and 2026), due to an initial demand effect from the implementation of investments and a medium–term increase in potential GDP from the higher stock of public capital.

Under the NRRP, €191.5 billion will be invested in a wide range of sectors, divided into six missions, 16 components, and 134 investments (see Table A.1). More than half of the total budget is earmarked for the first two missions related to Twin Transition (digital and green).

Table A.1
NRRP breakdown by mission and components.

Missions and components	€ billion	Shares (in %)
M1. Digitalization, innovation, competitiveness, culture and tourism	40.32	21.1
M1C1 – Digitalization, innovation and security in the public administration	9.75	5.1
M1C2 – Digitalization, innovation and competitiveness in the production system	23.89	12.5
M1C3 – Tourism and culture 4.0	6.68	3.5
M2. Green revolution and ecological transition	59.47	31.1
M2C1 – Circular economy and sustainable agriculture	5.27	2.8
M2C2 – Energy transition and sustainable mobility	23.78	12.4
M2C3 – Energy efficiency and renovation of buildings	15.36	8.0
M2C4 – Protection of land and water resource	15.06	7.9
M3. Infrastructure for sustainable mobility	25.40	13.3
M3C1 – High speed rail, rail network capacity and road safety	24.77	12.9
M3C2 – Intermodality and integrated logistics	0.63	0.3
M4. Education and research	30.88	16.1
M4C1 – Strengthening the provision of education services: from nurseries to universities	19.44	10.2
M4C2 – From research to business	11.44	6.0
M5. Inclusion and cohesion	19.81	10.3
M5C1 – Employment policies	6.66	3.5
M5C2 – Social infrastructure, households, the community and the third sector	11.17	5.8
M5C3 – Special interventions for territorial cohesion	1.98	1.0
M6. Health	15.63	8.2
M6C1 – Local networks, facilities and telemedicine for local healthcare	7.00	3.7
M6C2 – Innovation, research and digitalization of the national health service	8.63	4.5
TOTAL	191.50	100.0

Source: Italy’s National Recovery and Resilience Plan.

In particular, Mission 1 (Digitization, Innovation, Competitiveness, Culture and Tourism) is the most interesting for firms, with €24.8 billion (out of a total of €40.3 billion) allocated for the digital transition of the production system (Fig. A.1).

Within Mission 1, €13.4 billion is earmarked for the "Transition 4.0″ plan as part of the M1C2 component (Digitalization, innovation and competitiveness in the production system). These funds were complemented by an additional €5.1 billion from the National Fund for Complementary Investments (Legislative Decree No 56/2021), which accounted for more than half of the total plan funds available to companies as tax credits (€34.2 billion).

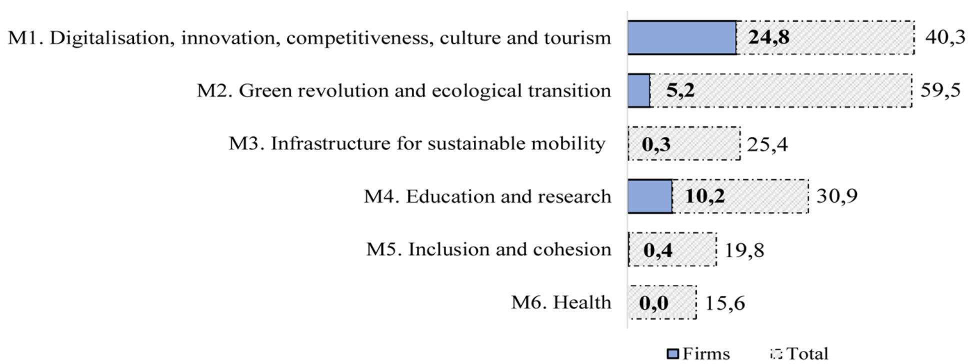

Fig. A.1. NRRP resources for firms by mission (values in € billion). Source: ministry of economy and finance.

The measure builds on the previous "Industry 4.0″ and "Enterprise 4.0" plans and aims to promote the digital transformation of companies by stimulating private investment in digital technologies through a system of tax credits. Specifically, “Transition 4.0″ is divided into the following sub-investments:

(i) Industry 4.0 tangible capital goods (production machines controlled by computer systems, machines and systems for product or process control, and interactive systems).
(ii) Industry 4.0 intangible capital goods (3D technologies, intra-factory communication systems, artificial intelligence, machine learning software, systems, platforms, and applications).
(iii) Industry 4.0 standard intangible investment assets (business management software).

(iv) Tax credits for research, development, and innovation activities (including green, digital, and design innovation; training related to relevant technologies such as big data and data analysis, human–machine interfaces, the Internet of Things, digital integration of business processes, and IT security).
(v) Tax credits for training activities related to the skills necessary for "Industry 4.0″ enabling technologies.

Appendix B. The centro studi guglielmo tagliacarne (CST) survey

The Centro Studi Guglielmo Tagliacarne (CST) survey is based on a stratified simple random sampling design by cross-classifying 4 macro-regions, 4 size classes of employed persons, 9 economic sectors and the Medio Banca Register (MBR) membership variable. The number of sampled enterprises is 22,297 defined by considering the accuracy of the main estimates, the budget constraint and the expected response rate, according to the observed one in the previous CST survey. The aim is to collect about 2500 complete interviews. The CST stratum sample allocation gives greater sampling fractions to the strata with higher expected sampling variabilities of the main estimates. The allocation is carried out by the solution of a multi-variate, multi-domain optimization problem (Falorsi and Righi, 2015). Strata with units belonging to the MBR are take-all strata. The data collection, implemented with CATI technique, defines a starting sub-sample of enterprises to be contacted with uniform contact rate among the strata. Then, the contact rate increases when the observed response rate decreases. The survey respondents have been 2448. The contact rate has been the 44.5 %. The 8.3 % units were out of the target population, and the response rate of the remaining units has been equal to 24.6 %. The CST survey used a calibration estimator (Deville and Särndal, 1992). The base weights (inverse of the inclusion probabilities) have been adjusted by the contact and non-response rate (Särndal and Lundström, 2005), assuming a non-response Missing At Random mechanism (Little and Rubin, 2019). The calibrated weights reproduce the number of enterprise distribution by macro-regions, size classes of employed persons and economic sectors. Finally, the estimation variance has been performed by Taylor linearization variance estimation method (Deville and Särndal, 1992).

Appendix C. Heterogeneity by geographical area

Tables C.1–C.4 explore geographical heterogeneity in the relationship between NRRP participation, managerial and human capital dimensions, and the adoption of BMI across Italian macro-areas.

A first notable result emerges in the South (Table C.1), where firms participating in the NRRP and simultaneously investing in managerial training are 21.5 pp more likely to adopt BMI. This suggests that the combination of policy support and active managerial trading can have a transformative effect in regions characterized by lower innovation intensity. By contrast, no significant effects are detected in the North-West, North-East and Centre, indicating that in more developed areas NRRP-related managerial training does not translate into differential BMI adoption.

Consistently across macro-areas, Table C.2 shows that the stock of managers does not significantly mediate the effect of NRRP participation on BMI. This result suggests that it is not the mere availability of managerial resources, but rather their active upgrading that matters for enhancing the effect of NRRP on BMI.

Tables C.3 and C.4 highlight a different pattern in the North-West. In this macro-area, the absence of NRRP support is systematically associated with a significant reduction in the likelihood of adopting BMI, pointing to a strong dependence of innovation performance on public policy support in highly industrialized contexts. However, the interaction between NRRP participation and upskilling/reskilling activities (Table C.3), as well as the presence of graduates (Table C.4), does not generate positive effects and, in some cases, is even associated with negative coefficients. This may indicate diminishing returns or coordination frictions between policy support and firm-level human capital in more advanced regions. In the remaining macro-areas (North-East and Centre), no robust effects emerge across specifications, while in the South NRRP interactions with graduates and upskilling/reskilling remain insignificant. This suggests that, although NRRP combined with managerial training can foster BMI in lagging regions, other forms of human capital accumulation may not be sufficient to overcome deeper structural constraints to innovation.

Table C.1
The effect of *NRRP_Managers* on BMI: breakdown by geographical area.

Dep. variable	Geographical area			
	North-West BMI (1)	North-East BMI (2)	Centre BMI (3)	South BMI (4)
No NRRP	−0.040	−0.047	−0.019	−0.002
	(0.037)	(0.043)	(0.056)	(0.065)
Yes NRRP_No Managers (r.c.)	-	-	-	-
Yes NRRP_Yes Managers	0.081	0.062	0.118	0.215*
	(0.061)	(0.066)	(0.095)	(0.117)
Firms' Controls	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes
Observations	659	615	301	200
Pseudo R^2	0.262	0.214	0.265	0.249
Wald Chi–square	159.80***	127.49***	61.35***	55.14***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table C.2
The effect of *NRRP_StockManagers* on BMI: breakdown by geographical area.

Dep. variable	Geographical area			
	North-West BMI (1)	North-East BMI (2)	Centre BMI (3)	South BMI (4)
No NRRP	−0.059	−0.052	−0.089	−0.083
	(0.047)	(0.050)	(0.056)	(0.067)
Yes NRRP_No StockManagers (r.c.)	-	-	-	-
Yes NRRP_Yes StockManagers	0.001	0.024	−0.108	−0.103
	(0.057)	(0.061)	(0.082)	(0.101)
Firms' Controls	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes
Observations	659	615	301	200
Pseudo R^2	0.260	0.213	0.265	0.235
Wald Chi–square	156.79***	127.85***	62.91***	48.70***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table C.3
The effect of *NRRP_UpReskill* on BMI: breakdown by geographical area.

Dep. variable	Geographical area			
	North-West BMI (1)	North-East BMI (2)	Centre BMI (3)	South BMI (4)
No NRRP	−0.117**	−0.062	−0.042	−0.072
	(0.048)	(0.048)	(0.067)	(0.078)
Yes NRRP_No UpReskill (r.c.)	-	-	-	-
Yes NRRP_Yes UpReskill	−0.093*	0.004	0.022	−0.025
	(0.054)	(0.059)	(0.080)	(0.089)
Firms' Controls	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes
Observations	659	615	301	200
Pseudo R^2	0.264	0.213	0.260	0.232
Wald Chi–square	160.07***	126.75***	62.71***	49.19***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table C.4
The effect of *NRRP_Graduates* on BMI: breakdown by geographical area.

Dep. variable	Geographical area			
	North-West BMI (1)	North-East BMI (2)	Centre BMI (3)	South BMI (4)
No NRRP	−0.068*	−0.074	−0.100	−0.055
	(0.040)	(0.047)	(0.064)	(0.066)
Yes NRRP_No Graduates (r.c.)	-	-	-	-
Yes NRRP_Yes Graduates	−0.024	−0.021	−0.114	0.023
	(0.056)	(0.061)	(0.078)	(0.106)
Firms' Controls	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes
Observations	659	615	301	200
Pseudo R^2	0.262	0.214	0.266	0.231
Wald Chi–square	158.11***	126.77***	61.75***	48.73***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Appendix D. Heterogeneity results for the baseline specification (H1)

Table D.1
The effect of NRRP on BMI: breakdown by technological intensity and by firm size.

Dep. variable	Sectors		Size		
	Low-tech BMI (1)	High-tech BMI (2)	Micro BMI (3)	Small BMI (4)	Medium-Large BMI (5)
NRRP	0.077***	0.006*	−0.028	0.041	0.064**
	(0.023)	(0.040)	(0.044)	(0.034)	(0.028)
Firms' Controls	Yes	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes	Yes
Observations	1327	452	232	545	999
Pseudo R^2	0.208	0.278	0.374	0.229	0.187
Wald Chi–square	228.05***	138.86***	49.42***	102.58***	177.96***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Low-tech sector: C10-C19, C22-C25, C31–33; High-tech sector: C20-C21, C26-C30. Micro firms: 5–9 employees; Small firms: 10–49 employees; Medium–Large firms: 50+ employees. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Table D.2
The effect of NRRP on BMI: breakdown by geographical area.

Dep. variable	Geographical area			
	North-West BMI (1)	North-East BMI (2)	Centre BMI (3)	South BMI (4)
NRRP	0.058**	0.062**	0.051	0.058
	(0.031)	(0.036)	(0.051)	(0.060)
Firms' Controls	Yes	Yes	Yes	Yes
Sectoral Controls'	Yes	Yes	Yes	Yes
Macro-area Controls	Yes	Yes	Yes	Yes
Digital intensity	Yes	Yes	Yes	Yes
Observations	659	615	301	200
Pseudo R^2	0.260	0.213	0.259	0.231
Wald Chi–square	156.35***	126.58***	61.05***	48.31***

Note: The dependent variable is BMI. Controls: firm's digital intensity, age, size, sector, geographical position, type (family), ROS and ROA. Table displays Average Marginal Effects (AME) of the Probit regression. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Elaborations on Centro Studi Tagliacarne – Unioncamere (Italian Union of Chambers of Commerce) data.

Data availability

Data will be made available on request.

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