

Does the NRRP speed up firms' Twin Transition? Empirical evidence from Italy

by
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Abstract

In response to the environmental and social crises compounded by the COVID-19 pandemic, the European Union pursued the goal of accelerating a recovery that should be also resilient. Specifically, the European Green Deal (EGD) and NextGeneration EU (NGEU) programs bestowed great support to intensify socio-economic competitiveness and resilience. At the firm level that means speeding up the Twin Transition – i.e., Green Transition coupled with Digital Transition.

It becomes then very important to test whether those EU programs are effectively quickening the Twin Transition. To do that, we focus on Italy, the EU country whose National Recovery and Resilience Plan (NRRP) received the largest share of the overall NGEU's endowment.

Using a unique micro-level database of almost 3,000 firms, our econometric analyses find conspicuous support for the hypothesis that the NRRP is effectively speeding up the Twin Transition. Namely, we show that if a firm is activating NRRP projects four main results attain. First, this will impact the *extensive margin*, increasing the likelihood of starting the Twin Transition at firms which had never invested in it previously. Moreover, it will affect the *intensive margin*, raising the probability of enticing firms which had already invested in the Twin Transition to continue investing in it. Thirdly, it will bear on the *inclusive margin*, whereby the prospect of starting the Twin Transition at firms which had never invested in it previously will be boosted for firms belonging to disadvantaged entrepreneurial segments and areas. Lastly, engaging the Twin Transition improves not only society's wellbeing but also the performance at firm level. We should highlight as well that the bulk of the previous results is robust to adopting an instrumental-variables approach to tackle the issue of potential endogeneity.

Our findings are not trivial because: i) our survey might have come too early to grasp the full effects of the NRRP program, which spans from 2021 to 2026; ii) our interviews might be biased by extreme economic and political uncertainty due to the Russia-Ukraine war; iii) firms might hesitate to change their strategies if they believed that the NRRP provided only temporary incentives.

Overall, our results offer strong empirical support to the validity of the EU policies in terms of speeding up the firm-level Twin Transition in the country which provides the most important case study. Italy is, in fact, the country which benefited of the largest allotment of NGEU's funds. At the same time, the Italian economy hosts the largest and longest-lived fracture between the more affluent rest of the country and the less developed South. Hence, if the NRRP is working well in Italy, by strengthening the Twin Transition, this bodes well for the overall success of the EGD and NGEU policies of the European Union.

JEL: M14; O14; O32; O33; Q01; Q55; Q56; Q57.

Keywords: European Green Deal (EGD); Next Generation EU (NGEU); National Plan for Recovery and Resilience (NPRR); Twin Transition; Extensive Margin; Intensive Margin; Inclusive Margin.

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1. Introduction

Over the latest decades the European Union has progressively embarked in the Green Transition, which means moving to a new socio-economic model oriented towards sustainable development. The practical effects of that are already visible. For instance, by 2020 the share of renewable energy on total energy produced stood at 37.5 per cent in the EU (Renewable energy statistics by Eurostat, 2022) compared to 20.3 per cent in the US (US Energy Information Administration, 2022); Plastic waste per person per year stood at 105 Kg in the US vs 81 Kg in Germany and 56 Kg in Italy (Vetter, 2020); the average ESG (Environment, Social, Governance) ratings of top listed companies in the EU were found to be 14 per cent higher in the EU compared to the US (Ciciretti et al., 2022).

Against that background, in this paper we ask whether the acceleration imparted to the Green Transition by the European Green Deal (EGD) and NextGeneration EU (NGEU) programs may be paying off. Specifically, we investigate whether Italy's National Recovery and Resilience Plan (NRRP) – which carries to the Italian national level the NGEU program – is accelerating the Twin Transition – i.e., Green Transition coupled with Digital Transition at firm level. This evidence is particularly important to assess the success of EU's policies since Italy is the EU country whose NRRP received the largest share of the overall NGEU's endowment.

Using a unique micro-level database of almost 3,000 firms, our econometric analyses find conspicuous support for the hypothesis that the NRRP is effectively speeding up the Twin Transition. Namely, we show that if a firm is activating NRRP projects four main results attain. First, this will impact the *extensive margin*, increasing the likelihood of starting the Twin Transition at firms which had never invested in it previously. Moreover, it will affect the *intensive margin*, raising the probability of enticing firms which had already invested in the Twin Transition to continue investing in it. Thirdly, it will bear on the *inclusive margin*, whereby the prospect of starting the Twin Transition at firms which had never invested in it previously will be boosted for firms belonging to disadvantaged entrepreneurial segments and areas. Lastly, engaging the Twin Transition improves not only society's wellbeing but also the performance at firm level. We should highlight as well that the bulk of the previous results is robust to adopting an instrumental-variables approach to tackle the issue of potential endogeneity.

We should point out that these findings are not trivial for three main reasons. First, our survey data to verify the possible connection between the NRRP and the Twin Transition were collected in early 2022 (April-May) the time might still be insufficient to grasp the full effects of the NRRP program, which spans from 2021 to 2026. Second, since they were conducted after the start of the Russia-Ukraine war, the interviews might be biased by extreme economic and political uncertainty. Third, even disregarding the previous two possible aspects, firms might refrain from changing their

strategies if they believed that the drive towards the Twin Transition was only temporary and not a permanent policy by the EU.

Overall, our results offer strong empirical support to the validity of the EU policies in terms of speeding up the firm-level Twin Transition in the country which provides the most important case study. Italy is, in fact, the country which benefited of the largest allotment of NGEU's funds. At the same time, the Italian economy hosts the largest and longest-lived fracture between the more affluent rest of the country and the less developed South. Hence, if the NRRP is working well in Italy, by strengthening the Twin Transition, this bodes well for the overall success of the EGD and NGEU policies of the European Union.

To our knowledge, this is one of the first few empirical studies addressing the impact of the EU programs EGD, NGEU and NRRP at the firm level. While investigating the impact of the NRRP at the macro level appears somewhat more standard, we believe that it is more difficult and more meaningful studying this impact at the firm level.

In the rest of the paper, Section 2 presents the institutional background of Italy's NRRP. In turn, Section 3 describes how firms liaise with the NRRP in Italy. Next, in Section 4 we synthesize the literature review and spell out our research hypotheses. Thereafter, Section 5 describes the data and presents our empirical strategy, while Section 6 details on the data and the variables employed. Hence, Section 7 presents and discusses the main results achieved. Finally, in Section 8 we summarize the main findings and discuss possible research approaches for the future.

2. Institutional background

In July 2020, in response to the pandemic crisis, the European Council approved the Next Generation EU (NGEU), an ambitious economic transformation program to be implemented over six years (2021 to 2026). The Plan allocates 750 billion (390 billion in grants and 360 billion in long-term loans to be repaid by 2058) to member countries to support investment programs aimed to promoting the Twin Transition (digital and environmental) of the economy and society, within a framework of cohesion and inclusion.

As other EU member countries, Italy has also produced its own document called National Recovery and Resilience Plan (NRRP) that incorporates the EU approach. The plan consists of 6 missions (M) divided into 16 components (C) and 132 investments (I), which are associated with 58 strategic reforms necessary to achieve the set goals. More than half of the total planned resources (191.5 billion euros) is allocated to the first two measures, which are directly related to the Twin Transition issues (digital and environmental), demonstrating the relevance of these issues for Italy's future (Table 1).

Table 1 – NRRP breakdown by mission and component

MISSIONS and Components	EUR BILLION	SHARES (in %)
M1. DIGITALISATION, INNOVATION, COMPETITIVENESS, CULTURE AND TOURISM	40,32	21,1
M1C1 – Digitalisation, innovation and security in the public administration	9,75	5,1
M1C2 – Digitalisation, 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 creches 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 digitalisation of the national health service	8,63	4,5
TOTAL	191,50	100,0

Source: Italy's National Recovery and Resilience Plan

Proving the importance of this plan in the Italian economic, Di Bartolomeo and D'Imperio (2022) estimate the additional GDP contribution of NRRP between 2021 and 2026 (compared to a baseline scenario in the absence of the Plan) at 3.4 percentage points. This would result from an increase in domestic demand in the short run, followed by an improvement in business productivity. Firms play a central role within the plan, involved indirectly (as suppliers of semi-finished products, finished products and specialized skills needed for the transition of the entire economic system) and directly (by taking advantage of measures to reorganize production and organizational processes and invest in the dual transition). These measures can also be divided into transversal measures (accessed by all firms, regardless of their economic activity) and sectoral measures (aimed to specialized firms).

One of the most important cross-cutting measure of the plan is **Investment M1C2-1.1 (Transition 4.0)**, which allocates €13.38 billion to promote initiatives related to the digital transformation of production processes, improving and refinancing some measures already contained in the "Industry 4.0" Plan launched in the previous years. In particular, "Transition 4.0" aims to support private

investments in: 4.0 tangible capital goods (production machines controlled by computer systems, machines and systems for the control of products or processes, and interactive systems); 4.0 intangible capital goods (3D, intra-factory communication systems, artificial intelligence and machine learning software; systems, platforms and applications); standard intangible investment assets (software relating to business management); research, development and innovation activities for green, digital and design innovation; training activities related to relevant technologies (big data and data analysis, human-machine interface, internet of things, digital integration of business processes, IT security).

In turn, **Investment M1C2-1.5 (Supply Chain Industrial Policies and Internationalization)** promotes SMEs' competitiveness, internationalisation, innovation and sustainability with two lines of intervention:

- Refinancing Fund 394/81 currently managed by public agency SIMEST,⁴ providing financial support to enterprises, notably SMEs, to support their internationalisation through various tools such as programs to access foreign markets and development of e-commerce;
- Competitiveness and resilience of supply chains. It gives financial support to firms, through the instrument "Contratti di Sviluppo", for projects related to key strategic value chains, such as industrial development programs, environmental protection development programs, sustainable mobility and tourism activities.

A prominent measure related to the second mission (Green revolution and ecological transition) is **Investment M2C2-5.4 (Support to start-ups and venture capital active in the ecological transition)**, supporting the development of green transition start-ups via a €250 million fund (Green Transition Fund) to enable investments on key sectors connected with the green transition (renewables, circular economy, mobility, energy efficiency, waste management, energy storage, etc.). Research also includes interventions directly dedicated to business within Mission 4 (Education and Research). This applies in the first instance to some measures aimed to support innovation processes and technology transfer:

- Integrating the resources of the Important Projects of Common European Interest (IPCEI) fund (Art. 1 of Italy's 2020 Budget Law) to incentivize the participation of firms in strategic value chains by financing projects of significant relevance to the country's productive and technological development (**Investment M4C2-2.1 – Important Project of Common European Interest**);
- By supporting participation in research and innovation partnerships under the Horizon Europe program on strategic themes such as High Performance Computing, Key digital technologies, Clean

⁴ SIMEST is the public agency (owned by the Cassa Depositi e Prestiti Group) to support the growth of Italian companies through the internationalization of their business.

energy transition, Blue economy, Innovative SMEs (**Investment M4C2-2.2 – Horizon Europe partnerships**);

- By strengthening technology transfer centers (Competence Centers, Digital Innovation Hubs, Digital Innovation Points in terms of one-stop-shop) aimed to provide advanced technology and innovative services to firms on leading technologies and manufacturing specializations (**Investment M4C2-2.3: Strengthening and sectorial territorial extension of technology transfer centers by industry segments**).

Moreover, in order to enhance supportive conditions for research and innovation, the **Investment M4C2-3.3 (Introduction of innovative doctorates that respond to the needs of innovation by enterprises and promote the hiring of researchers by companies)** aims to better link research and firms by fostering the development of highly specialized skills (PhDs) on green and digital issues through the activation of 5,000 dedicated scholarships and by incentivizing the hiring of 20,000 research fellows or researchers. In addition, new financial instruments are planned to support SMEs' investment in research and innovation.

Alongside transversal measures, many investment lines focus on specific sectors such as, notably, those related to agribusiness. In fact, in order to develop a sustainable agrifood supply chain, the NRRP promotes projects for the digitization and innovation of machinery, in the bio-economy and circular economy, both for enterprises in the primary sector and those related to food processing (**Investment M2C1-2.3: Innovation and mechanization in the agricultural and food sectors**). In addition, part of the resources is dedicated to the development of more sustainable logistics and the creation of agrisolar parks that enable firms in the sector to produce photovoltaic energy (**Investment M2C1-2.2: Agrisolar park**) with an installed power equal to at least 375,000 kW in 2026.

Some “hard-to-abate” sectors are also affected by specific sectoral interventions. This is the case of the petrochemical supply chain, which will be able to take advantage of the resources provided by **Investment M2-C1.3.1 (Production of Hydrogen in brownfield sites)**, aimed at the conversion of brownfield sites into hydrogen valleys to support the decarbonization of the most energy-intensive production processes, which are disinclined to embrace electrification-related technologies.

Of all the analyzed sectors, one of the most affected by the NRRP is automotive and its components. Indeed, firms involved in the production of transportation equipment and its components will have to engage in a difficult transition to the production of zero-impact models. So, the Italian plan stimulates automotive firms with various measures like, e.g., **Investment M3C2.5 (Developing international, industrial and R&D leadership in key transition supply chains)**, which provides grants to reconfigure industries in the sector to support the growing demand for zero-impact buses, appropriately stimulated by the resources provided for **Investment M2C2.4 (Developing more**

sustainable local transport). Also the above mentioned **M2C2-5.1 Investment (Development of an international, industrial and R&D leadership in renewables and batteries)** partly regards the automotive sector, to develop gigafactories for the production of batteries for electric cars.

3. The firms' relationship with the NRRP

With the aim of understanding the response of the production system to the Italian plan, a survey of nearly 3,000 manufacturing enterprises was conducted. To start with, surveyed firms were asked: "Has your firm already activated (or expects doing so) to join projects connected with the NRRP?".

Table 2 - Manufacturing firms involved in NRRP projects (values and % shares)

	Numbers			Shares		
	Activated	Not activated	Total	Activated	Not activated	Total
Size cladd						
Micro (5-9 employees)	188	763	951	19,8	80,2	100,0
Small (10-49 employees)	365	941	1.306	27,9	72,1	100,0
Medium-Large (50+ employees)	396	327	723	54,8	45,2	100,0
Macro-regions						
North-West	291	653	944	30,8	69,2	100,0
North-East	294	645	939	31,3	68,7	100,0
Centre	183	419	602	30,4	69,6	100,0
South	181	314	495	36,6	63,4	100,0
Sector of economic activity						
Food and beverage	222	444	666	33,3	66,7	100,0
Personal and household goods	201	475	676	29,7	70,3	100,0
Machinery and equipment	280	607	887	31,6	68,4	100,0
Other manufacturing	246	505	751	32,8	67,2	100,0
Internationalization						
Exporting firms	636	972	1.608	39,6	60,4	100,0
Non-exporting firm	313	1.059	1.372	22,8	77,2	100,0
Foreign participation firms	82	87	169	48,5	51,5	100,0
Non-Foreign participation firms	867	1.944	2.811	30,8	69,2	100,0
Entrepreneurship						
Youth firms	147	449	596	24,7	75,3	100,0
Non-youth firms	802	1.582	2.384	33,6	66,4	100,0
Female firms	118	315	433	27,3	72,7	100,0
Non-female firms	831	1.716	2.547	32,6	67,4	100,0
Foreign firms	255	921	1.176	21,7	78,3	100,0
Non-foreign firms	694	1.110	1.804	38,5	61,5	100,0
Family ownership						
Family firms	821	1.749	2.570	31,9	68,1	100,0
Non-family firms	128	282	410	31,2	68,8	100,0
Total	949	2.031	2.980	31,8	68,2	100,0

Almost one-third (31.8 per cent) of the 2,980 surveyed manufacturing firms responded positively. Of these 949 “activated” firms, 280 are the mechanical supply chain, 222 in the food supply chain, 208 in the production of personal goods and services and the remaining 246 in other manufacturing activities. Notable differences emerge across firms based on their size and extent of international activities. Larger enterprises (396 enterprises) reach a 54.8 per cent activation rate, almost three times that of the 188 micro enterprises (19.8 per cent). Activation rates are relatively high also for firms with foreign participation (48.5 per cent) and exporting firms (39.6 per cent).

In general, more structured and better-organized firms seem keener to take the NRRP opportunities. This suggests a possible push for concentration in markets related to the production of goods and services. In other words, firms with higher technology and skills to interact with the plan's tools might have an advantage over micro and small businesses in the next years, showing more opportunities to transform their production processes, especially in the digital and environmental transition.

4. Literature review and research hypotheses

According to the New Institutional Economics, institutions play a key role by shaping the way an economy evolves and by contributing to determine its performance (North, 1989, 1990; 1994). In the presence of uncertainty (Knight, 1921) and imperfect and asymmetric information, institutions are essential to provide certainty and predictability. In fact, institutions facilitate the learning process and support a society’s willingness to undertake risk and exploit the innovation potential. Moreover, institutions reduce transaction costs concerning, e.g., information acquisition (Dobler, 2009), and contribute to remove market’s inefficiencies in knowledge allocation (Greenwald & Stiglitz, 2013). This role is crucial in times of change (including also unexpected exogenous or endogenous shocks) since these times require a strong dose of adaptive efficiency, defined as «an ongoing condition in which society continues to modify or create new institutions as problems evolve» (North, 2005, p. 169). In practice, adaptive efficiency concerns how the formal and informal rules of a society: i) shape over time its economic trajectory; ii) affect the direction of learning and the willingness of individuals or entrepreneurs to acquire knowledge and skills for developing innovation – with positive spillovers in terms of encouraging other individuals to strive for higher productivity; iii) provide incentives and favorable environment to innovation and entrepreneurial activity (North, 2005). These characteristics are determinant in assuring a stable and efficient institutional framework of an economic system allowing entrepreneurs to maximize opportunities, achieving successful economic change and good performance over time (North, 1990, 1994, 2005).

Deepening this issue by a firm-level microeconomic perspective, institutions help in sustaining the competitiveness of private companies, by providing firms with critical resources that they can use for

innovation and development (Li & Atuahene-Gima, 2001; Sheng et al., 2013; Shu et al., 2015). Rodrik (2008) highlights that industrial policy has to build on a productive dialog between the government and private sector, allowing information flows in both directions, good identification of the needs, well targeted policy instruments, and self-correction mechanism.

Indeed, according to the literature, institutions can create a local environment favorable to innovation in many ways: i) favoring the accessibility of valuable resources (Ács et al., 2014), improving cross-fertilization processes targeted to bridge knowledge between different sectors and actors, so favoring new practical implementation and opportunities for knowledge exchange (e.g., Doloreux & Parto, 2005) that help the integration of internal lacking skills and competencies; ii) generating consensus and avoiding conflicts of interests; iii) carrying a function of uncertainty reduction (Lundvall, 1992); iv) acting as a venture capitalist by providing financial resources for new business activities as well as facilitating the firm's credit access playing a role as guarantors of credit claims; v) increasing the level of trust which in turn favors the intensity and quality of resources that firms exchange (Molina-Morales et al., 2011); vi) supporting firm's networks for innovation upgrading (e.g., Schøtt & Jensen, 2016, find that institutional support for networking better the benefits of networking for innovation). Unsurprisingly, in the current era characterized by a radical change towards a new economic paradigm relying on digital and green transition (European Commission, 2022), institutions are viewed as key actors in defining and effectively implementing the policies requiring a multi-level governance and a multi-stakeholder approach (OECD, 2021; European Commission, 2020a; Italian Government, 2021), since the integration of digitalization and environmental sustainability involves a new policymaking method. Recent empirical studies, for the Italian case, found a positive moderator role of public institutions in supporting business models 4.0 innovation specifically for family-managed firms (Cucculelli et al., 2022) as well as in increasing the effectiveness of eco-innovation (Cassetta et al., 2022).

The Next Generation EU of the European Commission states that «Europe's recovery will be a team effort, from all of us as individuals, to social partners, civil society, business, regions, countries and institutions. This is Europe's moment and it is time to seize it together.» (European Commission, 2020a, p. 2). In the same vein, Italy's NRRP defined an organizational model that involves several actors (regions, local authorities, public bodies such as chambers of commerce) as actuators of the Plan measures for achieving the targets.

Most studies on Italy's NRRP describe the context, concept and challenges of the Plan emphasizing the determinant factors for achieving the most efficient results composed of efficiency of the Public administration related to the accountability mechanisms, excess of legislation, bureaucracy, right balance between procedures and effective results, mismatch between the Plan's timeframe and that

of the Italian electoral cycle (Fabbrini, 2022). In the same vein some scholars study also the great chance of improving Italian administration by building an administrative capacity suitable to sustain the investment effort contained in the NRRP itself (Polverari & Piattoni, 2022). Some works analyze specific missions of the Plan, such as Mission 2, «Green revolution and ecological transition» (Silvestri et al., 2022). Finally, others analyzed the content of the Plan under the lens of the Industrial policies objectives and needs (Lucchese & Pianta, 2021; Maranzano et al., 2021), such as radical innovations and production technologies and competencies developed within an endogenous process and with a mid-term vision.

Some descriptive studies compare the NRRPs across European countries by investigating differences in terms of balancing expenditure and reforms, finding that the more EU-funded grants governments receive, the more the balance shifts towards reforms (Bisciari et al., 2021).

Concerning empirical studies, we find investigations of the macroeconomic impact of NRRP in terms of GDP, private investments, total investments, imports and exports, by differentiating the estimates according to the public capital efficiency (Di Bartolomeo & D'Imperio 2022). In the same vein others estimate the spillover effects considering the diverse productivity of the public capital (Pfeiffer & Varga, 2021). Finally, other scholars estimate NRRP's impact in emissions reduction (Romani et al., 2022).

In view of the above, taking into account the potential key role played by the institutions, that is currently almost exclusively relied on the NRRP aimed at improving firms' competitiveness through the Twin Transition (digital and green), we posit the following hypotheses:

Hp.1. The activation on NRRP projects increases the likelihood of starting to invest in the Twin Transition for the firms which have never invested in it (extensive margin effect).

Hp.2. The activation on NRRP projects increases the likelihood of continuing to invest on the Twin Transition for the firms which has already invested on it (intensive margin effect).

Hp.3. The activation on NRRP projects contributes to reducing the gap between less competitive and more competitive firms (inclusive margin effect).

The importance of focusing on the Twin Transition derives from the fact that it represents a key push factor for firm's competitiveness as well recognized also at the European level. President Ursula von der Leyen underlined in her State of the Union speech (September, 2020) that the digital and green transition is the key priority of the European Commission, since it will be the determinant factor in

supporting the European Union economically, environmentally and geopolitically (European Commission, 2020b). Indeed, regarding green investments, several contributions find that environmental investments lead to innovation and technological change overcompensating the costs (Porter & van der Linde, 1995; Frondel et al., 2007) and positively influencing firm performance (for a review, see, e.g., Hojnik & Ruzzier, 2016; recently for the Italian case, Cassetta et al., 2022). As well as concerning digital investments, several scholars highlighted that the full potential of 4.0 technologies involves a radical transformation of the business models (Frank et al., 2019; Müller et al., 2018, 2020; OECD, 2017) boosting firm performance (Moeuf et al., 2017; for a detailed description about the benefits of technologies 4.0, see Büchi et al., 2020; recently for the Italian case, see Nucci et al., 2022), also with regard to post-Covid-19 recovery (recently for the Italian case, Cugno et al., 2022).

The significance of pooling together the green transition and the digital transition was underlined also by the Next Generation EU that further emphasized the importance of the Twin Transition stating that only through this it will be possible to strengthen Europe's competitiveness, resilience and position as a global player (European Commission, 2020a, 2022; for a review about the relationship between Industry 4.0 and environmental sustainability, see Kozlova et al., 2021).

In the light of these arguments, we posit the following hypothesis:

H_{p.4}. The firm's investments in the Twin Transition positively influence its economic performance (growth margin effect).

5. Data and empirical strategy

5.1 Data

The data used come from the special survey carried out by Centro Studi Tagliacarne-Unioncamere (Italian Union of Chambers of Commerce) in early 2022 on a representative sample of almost 3,000 Italian manufacturing firms with a number of employees between 5 and 499. These fresh data allow us to study firm's recovery capacity after the Covid-19 crisis.

The sample corresponds to 2.3% of the whole Italian population in terms of firms and 4.8% in terms of employees. Specifically, the sampling procedure ensured the statistical representativeness of the data following both exhaustive and random sampling criteria. The stratification considered three dimensions of firms: i) industry (several activities of the section C manufacturing sector of the Nace Rev.2 classification); ii) size class in terms of employees (5-9, 10-49, 50-249, 250-499); iii) geographical location (North-West, North-East, Center, South). The maximum sampling error was small ($e=1.8\%$; $\alpha=0.95\%$) indicating that the final sample is representative of the population. The

survey was conducted via the CATI (Computer-Assisted Telephone Interviewing) method by a professional contractor with the aim of gathering both qualitative and quantitative information on firm; several preliminary briefings have been held with the contractor aiming at explaining to interviewers the exact meaning of the issues of the questions, with particular reference to those concerning Industry 4.0 and green investments. The quality of the data was subsequently validated. Furthermore, according to Dorling and Simpson (1999), the quality of the data was also ensured by the fact that they came from a public agency confirming a high response rate and the representativeness of the population. The questionnaire submitted to the firms included several topics, besides digital and green investments, workforce characteristics, economic performance, cooperation. Information on firm characteristics (e.g., age, economic sector) came from the administrative archive.

5.2 Empirical strategy

We use different methods for measuring the various types of effects potentially attributable to the NRRP. Concerning the *extensive margin effect*, we estimate the probability that a firm starts to invest in the Twin Transition (both digital and green) in the period 2022-24. Since the dependent variable is binary we use a probit model that is the suitable econometric model in this case (Wooldridge, 2010, pp. 453-459). Focusing on the firms starting investments in the Twin Transition, we run regression on two types of subsamples: i) the subsample of firms that have never invested in the digital and green field (“Strong” version of the estimate); ii) the subsample of firms that have invested at most in only one transition (digital or green) or in none of the two.

Specifically, our probit model is as follows:

$$\text{Prob}(TWIN\ TRANSITION\ 2022 - 2024 = 1)_i = \Phi(\beta_0 + \beta_1 NRRP_i + \beta_2 C_i + \varepsilon_i) \quad (1)$$

where *TWIN TRANSITION 2022-2024* represents the probability that the firm *i* will invest in the Twin Transition (both in digital technologies and in environmental sustainability). The variable *NRRP* measures firm’s activation on NRRP projects (= 1 if the firm is activated in NRRP projects). *C* is a vector of control variables concerning human capital (*HC*), firm’s age (*Age*), firm’s size (*Micro* as reference category, *Small*, *Medium*), sector (*Sect_Food* as reference category, *Sect_P&H*, *Sect_Mech*, *Sect_Other*), and geographical location (*North-West* as reference category, *North-East*, *Center*, *South*). All control variables are binary except for *Human capital* and *Age* that are continuous or discrete. Φ is a standard normal cumulative distribution function. Finally, ε_i is the normally distributed random error with zero mean and constant variance $N(0, \sigma^2)$ that captures any other unknown factors. To know the effects of any explanatory variable on the response probability

$P(Y = 1|\mathbf{x})$ we calculated the marginal effects (average marginal effects). Marginal effect indicates «the effect on conditional mean of Y of a change in one regressor, say, x_j » (Cameron & Trivedi, 2010, p. 343).

For estimating the *inclusive margin effect* we use the same probit model but by running the regressions on different typologies of firms: micro-small (5-49 employees) vs medium-large (50-499 employees); or located in the Center-North vs in the South. This allows us to capture the potential different effects produced by firm's activation on NRRP projects at smaller- vs larger-sized firms, as well as at firms located in the Center-North vs those located in the (less developed) South.

The estimation of the *intensive margin effect* is conducted by applying Heckman sample selection correction (Heckman, 1979). Considering that the firms that continue to invest in the Twin Transition are only those which have already invested in it in the past, we control for a potential sample selection bias by running the Heckman correction. This method is based on a two-equation model: the first equation, selection equation, is a probit regression estimating the probability of a certain event (y_1^*) – in our case if the firm has invested in the Twin Transition in the period 2017-2021 –, while in the second one, the resultant outcome equation, y_2^* (the outcome of interest, in our case if the firm will invest the Twin Transition in the period 2022-2024) is observed only if $y_1^* > 0$. Since the main outcome variable is binary, we run a probit model with Heckman selection (command in STATA: *heckprobit*). The technique is similar to Heckman's (1979) two-step OLS sample selection model originally designed for continuous dependent variables estimated by linear regression, and it has been adapted for discrete dependent variables where both the selection equation and the outcome equation are binary choices (van de Venn & van Praag, 1981).

We imposed the exclusion restriction requiring that the selection equation must have at least one more exogenous variable that is excluded from the outcome equation. We included in the select equation further variables capturing if the firm exports and if the firm invested in R&D.

To assess the presence of a selection bias we use the value of the correlation between the error terms of the two equations $\rho = corr(\varepsilon_1, \varepsilon_2)$. In practice, in presence of a significant correlation between the errors (ρ is significant rejecting the null hypothesis $\rho = 0$) there is a selection bias implying the use of the selection model, since the standard regression based only on observed data for y_2 (namely on a non-random sample of the 'certain' respondents) would be subject to an omitted-variable problem; otherwise, if there is no correlation between the errors ($\rho = 0$), the standard regression provides the more and consistent estimates (Greene, 2003; 2006; van de Venn & van Praag, 1981).

6. Variables description

6.1 Dependent variable

Our dependent variable (*TWIN TRANSITION 2022-2024*) takes value 1 if the firm will invest in the period 2022-2024 both in digital technologies and in environmental sustainability (Table 3). We constructed it through the combination of the following two indicators. The first one, concerning digital investments, corresponds to a dummy variable taking value 1 if the firm invested in technologies related to Industry 4.0: (i) advanced manufacturing; (ii) augmented reality; (iii) Internet of things; (iv) big data; (v) cloud computing; (vi) cyber security; (vii) additive manufacturing; (viii) simulation; (ix) horizontal and vertical integration; (x) blockchain; (xi) artificial intelligence. These typologies are in line with those defined by Rüßmann et al. (2015), adopted by the Minister of Economic Development of Italy (2017), and taken into account also in recent studies for Italy (Büchi et al., 2020). Moreover, we also considered blockchain (Kayikci et al., 2020; Kimani et al., 2020) and artificial intelligence (Loureiro et al., 2020).

The second one, concerning green investments, corresponds to a dummy variable equal to 1 if the firm invested in the improvement or the introduction of new products and processes aimed at reducing the environmental impact of the business activity in line with a large strand of literature (Hofman et al., 2020; Arranz et al., 2019; Doran & Ryan, 2016; Sezen & Cankaya, 2013; Kemp et al., 2006; Rennings, 2000).

Furthermore, to further the analysis we used other two dependent variables measuring firm performance. The first concerns the dynamic of the sales taking value 1 if the firm reports a turnover increase in 2021 and 2022 (*Turnover growth*). The second, instead, tries to capture the concept of resilience: according to the literature defining resilience as the firm's recovery capacity from a negative shock (Timmerman, 1981; Herbane, 2019), we measured the resilience through a binary variable (*Resilience*) taking value 1 if the if the firm expects to pass to pre-Covid crisis level in 2022.

6.2 Independent variables

Our main independent variable (*NRRP*) takes value 1 if the firm is activating or has already activated on Italy's NRRP projects. We included a set of control variables that may affect the probability to invest in the Twin Transition. Several firm's characteristics have been taken into account. Since human capital is a factor potentially improving business process organization and IT adoption (Bresnahan et al., 2002; Falk, 2002) as well as green investments (Cuerva et al., 2014), we included a variable accounting for the share of employees with a university degree (*Human capital*). We control for the firm's age, by including a continuous variable measuring the years since firm's inception (*Age*), as innovation performance (in our case referred to digital and green) may depend on

the life stages of firms (Craig & Moores, 2006). More specifically, age captures the experience related to competences accumulated and embedded learning mechanisms within the company (Balabanis & Katsikea, 2003; Kumar & Saqib, 1996), potentially improving the innovation propensity, e.g., by allowing to manage green investments at lower cost (Mohana-Neill, 1995). Nevertheless, some scholars highlight that younger firms are more likely to innovate than the older ones (Kraiczy et al., 2014; Lewin & Massini, 2003).

Size is one of the most important determinants of innovation investments (Becheikh et al., 2006), even though the issue of whether small or large firms are the most innovative is still unsettled (Tsai & Wang, 2005). For instance, regarding green investments, the literature claims that larger firms have a higher sensibility for the sustainability issue (Sharma, 2000), they experience greater social pressure, and manage environmental issues more effectively (see Liao et al., 2015; de Villiers et al., 2011). Thus, we include three size class fixed effects: *Small*, *Medium*, *Large*, considering *Micro* as the reference group omitted in the regression to avoid overdetermination problems in the model.

Furthermore, we included industry manufacturing dummy variables to account for sectoral differences: Food (*Sect_Food*) (reference category); Personal and Households goods (*Sect_P&H*); Mechanical (*Sect_Mech*); Other manufacturing activities (*Sect_Other*).

Drawing on Camagni and Capello (2013), the different territorial features may influence the development of innovation and investments: the location advantages including knowledge-based asset, infrastructure and technology, could potentially affect firms' competitiveness. This is particularly relevant in Italy where differences between North, Centre and South in terms of infrastructures, endowments and economic growth are relevant (Svimez, 2021). So, we control for the area in which the firm is located including three area fixed effects: *North-East*, *Centre*, *South*, considering the first dummy (*North-West*) as the reference group.

Table 3 – Variables description

Variables	Type	Description
Dependent variable		
TWIN TRANSITION 2022-2024	Dummy	1 = if the firm will invest in the Twin Transition (both in 4.0 technologies and in the environmental sustainability) in the period 2022-24
Resilience	Dummy	1 = if the firm expects to pass the pre-Covid-19 production level in 2022
Turnover growth	Dummy	1 = if the firm states to register a turnover increase in 2021 and 2022
Main independent variables		
NRRP	Dummy	1 = if the firm is activating or has already activated on Italy's NRRP; 0 = otherwise
TT1721	Categorical	0 = if the firm has invested in the period 2017-21 in any transition (neither 4.0 technologies, nor environmental sustainability) (<i>TT1721_NO</i>); 1= if the firm has invested in the period 2017-21 in

only digital transition (4.0 technologies) (*Digital1721_only*); 2= if the firm has invested in the period 2017-21 only in green transition (environmental sustainability) (*Green1721_only*); 3= if firm has invested in the period 2017-21 in both digital and green transition (*TTI721*)

Control variables

Human capital	Continuous	Share of employees with tertiary degree (0-100)
Age	Discrete	Number of years since inception
Micro	Dummy	1 = if the firm has 5-9 employees
Small	Dummy	1 = if the firm has 10-49 employees
Medium	Dummy	1 = if the firm has 50-249 employees
Large	Dummy	1 = if the firm has 250-499 employees
Sect_Food	Dummy	1 = if the firm belongs to Food manufacturing sector
Sect_P&H	Dummy	1 = if the firm belongs to Personal and Households goods manufacturing sector
Sect_Mech	Dummy	1 = if the firm belongs to Mechanical manufacturing sector
Sect_Other	Dummy	1 = if the firm belongs to other manufacturing activities
North-East	Dummy	1 = if the firm is located in the North-East
North-West	Dummy	1 = if the firm is located in the North-West
Center	Dummy	1 = if the firm is located in the Center
South	Dummy	1 = if the firm is located in the South

Moderator

Social capital	Continuous	Number of blood donation per inhabitant (<i>Italian volunteers blood association and Istat</i>)
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Instruments

iv_training	Dummy	1 = if the firm carried out training courses by using external funds such as interprofessional funds, public regional funds, European funds
terrorist_relations	Dummy	1 = if the firm has strong and enduring relationships with territorial institutions (Government agencies, Chambers of commerce, etc.)
coop_banks	Continuous	Number of cooperative banks branches per 100,000 inhabitants (<i>Bank of Italy</i>)

Summary statistics

Table 4 displays summary statistics. The firms that will invest in the Twin Transition in the three-year period 2022-2024 are 30.4% of the total. So, about one third of the firms is activated on NRRP projects. The average share of employees with a tertiary degree is 9.7% and the average age is 32 years. The largest shares of firms correspond to the small (43.9%) and micro (32.0%) firms, representing together 75% of the total sample; the rest is mainly composed of medium firms (20.8%) while only 3.3% are large.

Almost one-third of the firms operate in the Mechanical manufacturing sector (29.7%); little more than one-fifth (22.3%) in the Food manufacturing sector as well as for in the Personal and Households goods manufacturing sector (22.7%); one fourth (25.2%) in Other manufacturing activities. From a geographical perspective, almost one third of the firms are located in the North-West (31.7%) and another one third in the North-East (31.5%), while the shares of both the Centre (20.2%) and the

South (16.6%) are smaller. Collinearity problems does not emerge since all values of Variance Inflation Factor (Table 4) are below of the critical value of 10 (Yoo et al., 2014).

Table 4 – Summary statistics

	Obs.	Mean	Std. Dev.	Min	Max
TWIN TRANSITION 2022-2024	2,972	0.304	0.460	0	1
NRRP	2,972	0.317	0.465	0	1
TT1721_NO	2,972	0.331	0.471	0	1
Digital1721_only	2,972	0.126	0.332	0	1
Green1721_only	2,972	0.271	0.444	0	1
TT1721	2,972	0.272	0.445	0	1
Resilience	2,972	0.271	0.444	0	1
Turnover growth	2,972	0.347	0.476	0	1
Human capital	2,972	9.720	14.719	0	100
Age	2,972	32.086	16.467	3	135
Micro	2,972	0.320	0.466	0	1
Small	2,972	0.439	0.496	0	1
Medium	2,972	0.208	0.406	0	1
Large	2,972	0.033	0.179	0	1
Sect_Food	2,972	0.223	0.417	0	1
Sect_P&H	2,972	0.227	0.419	0	1
Sect_Mech	2,972	0.297	0.457	0	1
Sect_Other	2,972	0.252	0.434	0	1
North-West	2,972	0.317	0.465	0	1
North-East	2,972	0.315	0.465	0	1
Center	2,972	0.202	0.401	0	1
South	2,972	0.166	0.372	0	1
Social capital	2,972	0.041	0.021	0.001	0.118
iv_training	2,972	0.379	0.485	0	1
terrorist_relations	2,972	0.364	0.481	0	1
coop_banks	2,972	2.627	4.020	0	35.281

Note: In this tables the summary statistics refers to the number of firms (2,972) slightly different from those reported in table 2 (2,980) because takes into account specifically the firms analyzed in the regression for which we have information to construct all control variables.

Table 4 – Variance Inflation Factor (VIF)

	VIF
NRRP	1.05
Human capital	1.06
Age	1.06
Small	1.08
Medium	1.12
Large	1.03
P&H_m	1.79
Mechanical_m	1.81
Other_m	1.68
North-East	1.40
Center	1.36
South	1.35

The VIF is calculated after OLS regression.

7. Results and discussion

7.1 Baseline results

Tables 5-1 through 5-5 report the results. To estimate the effect on the digital and green transition exerted by the NRRP we contrast the firms activating (already active or activating) on NRRP projects with those which do not plan activating on NRRP projects.

Concerning the *extensive margin effect*, we estimate the probability of starting to invest in the Twin Transition (both digital and green) in the period 2022-2024 by running a probit regression on the subsample of firms that have never invested in the Twin Transition. More specifically, we estimate two different versions of the effect: i) “strong” version, considering the subsample of firms that have made neither digital nor green investment; ii) “weak” version, adding to the “strong” subsample the firms that have made either digital or green investment (but not both).

We find that firms activating on NRRP projects have a higher probability to start to invest in the Twin Transition than those not activating (Table 5-1). Thus, *H_{p.1} is confirmed*. This applies both to firms that have never invested neither in digital nor green transition (“strong” version) and to firms that have invested at most in only one type of transition (“weak” version): the marginal effect of *NRRP* is positive and statistically significant both in the case of strong version (0.072, $p < 0.01$, Model A) and weak version (0.117, $p < 0.01$, Model B). These findings underline the critical role played by the NRRP in favoring the convergence of the entrepreneurial system on the Twin Transition by supporting the transition of the firms still not fully moved towards the green and digital frontier.

Table 5-1 – NRRP extensive margin effect: Marginal effects of the probit

Dependent variable: TWIN TRANSITION 2022-2024

	Extensive	
	Strong (A)	Weak (B)
NRRP	0.072*** (0.015)	0.117*** (0.015)
Human capital	0.000 (0.001)	0.000 (0.000)
Age	-0.000 (0.000)	-0.000 (0.000)
Small	-0.013 (0.013)	0.035** (0.014)
Medium	0.047 (0.037)	0.107*** (0.026)
Large	0.254 (0.166)	0.209*** (0.071)
Sect_P&H	-0.092*** (0.024)	-0.038* (0.020)
Sect_Mech	-0.069*** (0.025)	-0.002 (0.020)
Sect_Other	-0.074*** (0.025)	0.007 (0.021)
North-East	0.009	-0.010

	(0.016)	(0.017)
Center	-0.015	-0.000
	(0.016)	(0.020)
South	0.042*	0.034
	(0.023)	(0.023)
Obs	985	2,163
LR chi2	64.52***	123.77***
Pseudo R2	0.166	0.074

The table displays average marginal effects. Standard errors in parentheses. Likelihood ratio (LR) chi-square testing the joint significance of the explanatory variables. Reference categories are: Sect_Food with respect to sector variables; North-West with respect to geographical location variables. *** p < 0.01, ** p < 0.05, * p < 0.1.

The estimation of the *intensive margin effect* is conducted by applying the Heckman sample selection correction (Heckman, 1979) that allows to control for a potential sample selection bias due to the fact that a firm’s decision to invest in the Twin Transition in the period 2022-2024 could depend upon whether it has already invested on it previously (in our analysis considering the period 2017-2021). This method is based on the conditional expectation that the probability of investing in the Twin Transition in the period 2022-2024 is conditional on the decision of having already invested in the Twin Transition in the period 2017-2021. Also in this case, we estimate two different versions of the effect: i) for the “strong” version the model is conditioned to the firms that have already invested in both transitions (green and digital); ii) while for the “weak” versions the model is conditioned to the firms that have invested in only one transition (digital or green). Since our dependent variable is binary, we run Heckprobit.

We find that firms activating on NRRP projects have a higher probability to continue again to invest in the Twin Transition in the period 2022-2024 than those not activating (Table 5-2). Thus, *Hp.2 is confirmed*. This applies to firms that have already invested both in digital and green transition, as well as to firms that have invested in only one type of transition: the marginal effect of *NRRP* is positive and statistically significant both in the case of strong version (0.083, p<0.01, Model A) and weak version (0.218, p<0.01, Model B). By this perspective, the important role played by the NRRP relies on the fact that continuing to invest in the Twin Transition is crucial in light of the rapid technological progress requiring constant investment to preserve firms’ competitiveness.

Table 5-2 – NRRP intensive margin effect: Marginal effects of heckprobit

Dependent variable: TWIN TRANSITION 2022-2024

	Intensive	
	Strong (A)	Weak (B)
NRRP	0.083*** (0.033)	0.218*** (0.021)
Human capital	-0.001 (0.001)	-0.001 (0.001)
Age	0.000	0.000

	(0.001)	(0.001)
Small	0.009	0.041
	(0.033)	(0.032)
Medium	0.029	0.145***
	(0.050)	(0.046)
Large	0.045	0.196***
	(0.062)	(0.065)
Sect_P&H	-0.042	0.005
	(0.037)	(0.033)
Sect_Mech	-0.034	0.092***
	(0.028)	(0.030)
Sect_Other	-0.017	0.083***
	(0.027)	(0.030)
North-East	-0.027	-0.022
	(0.025)	(0.027)
Center	-0.034	-0.030
	(0.033)	(0.031)
South	0.001	0.040
	(0.028)	(0.033)
Observations	2,972	2,972
Selected	809	1,987
Non selected	2,163	985
Wald chi2	21.25**	105.86***
LR test chi2 (rho=0)	6.09**p.0136	16.97***

The table displays average marginal effects. Standard errors in parentheses. Wald chi-square testing the joint significance of the explanatory variables. LR test chi-square testing the correlation ($\rho=0$) between the error terms of the two equations: presence of a significant correlation between the errors (ρ is significant rejecting the null hypothesis $\rho=0$) there is a selection bias implying the use of the selection model. Reference categories are: Sect_Food with respect to sector variables; North-West with respect to geographical location variables. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To estimate the *inclusive margin effect* we compare the effects of the firm's activation on NRRP projects for micro-small firms vs medium-large firms, on one hand, and for firms located in the North-Central Italy vs in the South of Italy. As well known, Italy historically suffers of a major gap in the South with respect to the rest of the country in terms of economic development and infrastructural endowment (Svimez, 2021). Concerning the size, in literature (e.g., Pastore et al., 2020) is well documented about the gap of the small enterprises with respect to the larger ones because of many barriers that the former have to face.

The inclusive effect is estimated by deepening the extensive effect ("strong" version) on subsamples according to these two perspectives (size class and macro-regions).

The results (Table 5-3) show that NRRP exerts an inclusive effect since the marginal effects of the extensive effect is positive and significant for micro-small firms (0.67, $p < 0.01$ Model A) as well as for the medium-large ones (0.095, $p < 0.01$, Model B), however with magnitude rather similar. Also geographically, we find a positive and significant effect of the NRRP in supporting the Twin Transition in both macro-regions: further with a stronger magnitude in the South (0.142, $p < 0.05$) than in the Center-North (0.062, $p < 0.01$). Thus *Hp.3 is confirmed*. From this point view, these findings strengthen the key role of NRRP in favoring the convergence of the entrepreneurial system towards the Twin Transition by enticing less competitive firms in the same way as more competitive ones.

Table 5-3 – NRRP inclusive effect (based on extensive effect strong version): Marginal effects of probit

Dependent variable: TWIN TRANSITION 2022-2024

	Inclusive			
	Micro- Small (A)	Medium- Large (B)	Center- North (C)	South (D)
NRRP	0.067*** (0.022)	0.095*** (0.022)	0.062*** (0.015)	0.142** (0.055)
Human capital	0.000 (0.001)	0.000 (0.001)	-0.000 (0.001)	0.004** (0.002)
Age	-0.001 (0.001)	0.000 (0.001)	-0.000 (0.000)	-0.001 (0.001)
Small			0.008 (0.012)	-0.145*** (0.045)
Medium			0.063 (0.041)	0.014 (0.139)
Large			0.232 (0.220)	0.247 (0.319)
Sect_P&H	-0.079** (0.032)	-0.080** (0.032)	0.073*** (0.025)	-0.172*** (0.054)
Sect_Mech	-0.055 (0.035)	-0.061* (0.033)	-0.056** (0.026)	-0.088 (0.072)
Sect_Other	-0.066** (0.034)	-0.057* (0.034)	0.070*** (0.026)	-0.058 (0.068)
North-East	-0.028 (0.020)	0.038 (0.025)		
Center	-0.014 (0.023)	-0.017 (0.022)		
South	0.077** (0.038)	0.014 (0.029)		
Obs	484	501	829	156
LR chi2	35.84***	31.72***	36.60***	29.50***
Pseudo R2	0.200	0.151	0.138	0.264

The table displays average marginal effects. Standard errors in parentheses. Likelihood ratio (LR) chi-square testing the joint significance of the explanatory variables. Reference categories are: Sect_Food with respect to sector variables; North-West with respect to geographical location variables. *** p < 0.01, ** p < 0.05, * p < 0.1.

Moreover, following the long-debated social explanations – e.g., à la Putnam (1993) – of the North-South divide in terms of economic development in Italy, we explore the possible role of social capital as regards the ability of firms to engage in the Twin Transition. To be sure, differences in terms of social capital and social norms seem to persist still between the Center-North and the South of Italy. In practice, the Southern Italian environment seems less prone to stimulate cooperation (Bigoni et al., 2016), which seems essential for the Twin Transition that has also a component of production of the common good of sustainability. Yet, although it is lower on average than in the Center-North, the endowment of social capital and pro-cooperative norms varies across the various parts of Italy's South. As such, we might hypothesize that the interaction between the level of social capital and the NRRP stimulus could be a stronger determinant of the Twin Transition in the South vis-à-vis the

Center-North. The results of this estimation – again a probit model with the same structure than the models we have been commenting up to here – provide support for the hypothesis that social capital intensifies the effect of the NRRP activation in the South. Indeed, the interaction term NRRP*Social capital comes out very strong and significant only in the South (Table 5-4).⁵

Table 5-4 – NRRP inclusive effect (based on extensive effect strong version) the moderator role of the social capital: Marginal effects of probit

Dependent variable: TWIN TRANSITION 2022-2024

	Italy	Center-North	South
	(A)	(B)	(C)
NRRP	0.020 (0.033)	0.069* (0.040)	-0.103 (0.092)
NRRP*Social capital	1.316* (0.688)	-0.073 (0.740)	8.807*** (2.978)
Social capital	0.194 (0.374)	0.966** (0.423)	-3.956* (2.321)
Human capital	0.000 (0.001)	-0.000 (0.001)	0.004** (0.002)
Age	-0.001 (0.000)	-0.000 (0.000)	-0.001 (0.001)
Small	-0.013 (0.013)	0.006 (0.012)	-0.120** (0.048)
Medium	0.052 (0.039)	0.058 (0.039)	0.084 (0.162)
Large	0.306* (0.177)	0.195 (0.206)	0.351 (0.395)
Sect_P&H	-0.103*** (0.024)	-0.071*** (0.025)	-0.185*** (0.051)
Sect_Mech	-0.082*** (0.025)	-0.058** (0.026)	-0.089 (0.069)
Sect_Other	-0.078*** (0.026)	-0.068*** (0.026)	-0.070 (0.065)
North-East			
Obs	985	829	156
LR chi2	64.79***	44.61***	41.01***
Pseudo R2	0.166	0.169	0.368

The table displays average marginal effects. Standard errors in parentheses. Likelihood ratio (LR) chi-square testing the joint significance of the explanatory variables. Reference categories are: Sect_Food with respect to sector variables; North-West with respect to geographical location variables. *** p < 0.01, ** p < 0.05, * p < 0.1.

As the last step of this analysis, we study the effect of the Twin Transition on economic performance by differentiating the firms investing in only digital transition, in only green transition, and in Twin Transition (digital and green), to deeply test if green and digital investments are substitute or complementary – i.e., they tend to join and further reinforce each other – in affecting firm performance. We find that the Twin Transition has the highest effect on resilience than the two

⁵ The surprising evidence of a negative coefficient of Social capital per se can be downplayed by observing that the statistical significance of this relationship is low, only at the 10 per cent level.

transition singularly considered (Table 5-5). More specifically, with respect to the firms that have not invested in any transition in the period 2017-21 (reference category), the firms that have invested in the Twin Transition show the highest probability of passing the pre-Covid production level in 2023 (marginal effect: 0.199, $p < 0.01$ Model A) compared to the firms that have invested in only digital transition (marginal effect: 0.103, $p < 0.01$ Model A) as well as to the firms invested in only green transition (marginal effect: 0.052, $p < 0.05$ Model A). Thus *Hp.4 is confirmed*.

These findings are confirmed also by replacing the variable *Resilience* with the variable *Turnover growth* identifying the firms with turnover growth in 2021 and 2022: the highest marginal effect regards the firms that have invested in Twin Transition (marginal effect: 0.174, $p < 0.01$ Model B) compared to the firms that have invested in only digital transition (marginal effect: 0.113, $p < 0.01$ Model B) as well as to the firms invested in only green transition (marginal effect: 0.036, not statistically significant Model B).

These findings underline the importance of pointing on National Recovery and Resilience Plan because by transforming the production system towards the digitalization and the environmental sustainability, it fosters at the same time also the firm's performance.

Table 5-5 – Twin Transition effect on performance: Marginal effects of probit

Dependent variable at the top of the column of the table

	Resilience	Turnover growth
	(A)	(B)
Digital1721_only	0.103*** (0.028)	0.113*** (0.030)
Green1721_only	0.052** (0.021)	0.036 (0.022)
TT1721	0.199*** (0.024)	0.174*** (0.025)
Human capital	0.001 (0.001)	0.001 (0.001)
Age	0.000 (0.001)	-0.001** (0.001)
Small	0.040** (0.019)	0.016 (0.020)
Medium	0.085*** (0.026)	0.102*** (0.028)
Large	0.054 (0.048)	0.134** (0.053)
Sect_P&H	0.014 (0.024)	0.086*** (0.026)
Sect_Mech	0.031 (0.023)	0.058** (0.024)
Sect_Other	0.032 (0.024)	0.062** (0.025)
North-East	-0.001 (0.020)	0.017 (0.021)
Center	-0.016 (0.024)	0.012 (0.025)
South	-0.006 (0.025)	0.025 (0.027)

Obs	2,972	2,972
LR chi2	150.91***	139.53***
Pseudo R2	0.042	0.036

The table displays average marginal effects. Standard errors in parentheses. Likelihood ratio (LR) chi-square testing the joint significance of the explanatory variables. Reference categories are: Sect_Food with respect to sector variables; North-West with respect to geographical location variables. *** p < 0.01, ** p < 0.05, * p < 0.1.

7.2 Deepening the endogeneity of NRRP: instrumental variables approach

The probit estimates may be affected by reverse causality problems. Although our estimations control for several factors, it might be possible that there are some unobserved factors simultaneously affecting firm's activation on NRRP projects (*NRRP*) and the investments in Twin Transition (*TWIN TRANSITION 2022-2024*). Thus, we should control for potential endogeneity of NRRP using instrumental variables approach. We deepen the endogeneity on the extensive effect.

As known, instrumental variables approach is one of the most widely used econometric method (e.g., Wooldridge, 2010; Marra & Radice, 2011): it allows to control for a possible existence of one or more instruments that may influence the endogenous variable, are independent of unmeasured confounders, and do not directly affect the outcome (e.g., Angrist et al., 1996).

Since we are in presence of an endogenous variable with a binary outcome, we use a bivariate probit model (Heckman, 1978; Maddala, 1983): as well known, from both a theoretical and empirical point of view, that simultaneous likelihood estimation methods are superior to conventional two-stage instrumental variable procedures (e.g., Wooldridge 2010; Bhattacharya et al., 2006; Freedman & Sekhon 2010).

Considering NRRP endogenous, we can argue that the probability of a firm activating on NRRP projects is likely to be determined by other factors concerning the firm's openness towards especially public administration together to the degree of cooperation at the local level. So, we explored three different variables at the firm level which could be related to the firm's decision to activate on NRRP but not necessarily be related to the decision to invest in starting or accelerating the Twin Transition. Namely, we considered first whether the firm performed training activities by using external funds such as interprofessional funds, public regional funds, European funds (*iv_training*). Having undertaken this training could favor activating on NRRP but not necessarily push for the Twin Transition. The second variable was the firm's relationship with territorial institutions (Government agencies, Chambers of commerce, etc.; *terrist_relations*). Possibly, if this relationship is stronger and longer enduring, then activating on NRRP is more likely whereas this factor does not automatically strengthen the incentive towards the Twin Transition. Finally, the third variable is the presence of cooperative banks branches (*coop_banks*) which is another contextual factor that might favor activating on the NRRP but could be not strictly related to the Twin Transition. We consider the follow bivariate probit model:

$$\text{Prob}(TWIN TRANSITION 2022 - 2024 = 1)_i = \Phi(\beta_0 + \beta_{21}NRRP + \beta_{22}C_i + \varepsilon_i) \quad (2)$$

$$\text{Prob}(NRRP = 1)_i = \Phi(\beta_0 + \beta_{21}I_i + \beta_{22}C_i + \mu_i) \quad (3)$$

where I_i are the instrumental variables corresponding to the: i) firms training activities by using external funds such as interprofessional funds, public regional funds, European funds (*iv_training*); firm's relationship with territorial institutions (Government agencies, Chambers of commerce, etc.) (*terrist_relations*); presence of cooperative banks branches (*coop_banks*). C_i is a vector of the control exogenous variables in Eq. (1) and Eq. (2), and ε_i and μ_i are the normally distributed random errors with zero mean and constant variance $N(0, \sigma^2)$.

Eqs. (1) and (2) constitute the recursive bivariate probit model (Greene, 2018, pp. 855-856) aimed at estimating the effect of the firm's activation on NRRP projects (*NRRP*) on the probability of investing in the Twin Transition (*TWIN TRANSITION 2022-2024*) controlling for the endogeneity of the *NRRP*. The correlation between the unobserved determinants of investing in Twin Transition (subsumed in ε_i in Eq. 1) and the unobserved determinants of *NRRP* (subsumed in μ_i in Eq. 2) $\rho = \text{Corr}(\varepsilon_i, \mu_i)$ indicates the endogeneity degree of the variable *NRRP*.

If we reject the Hypotesis $\rho = 0$ then the variable *NRRP* is endogenous, the Eq. (1) is inconsistent and we have to estimate the two-equation system (Bivariate Eq. 1 and Eq. 1). If we do not reject the Hypotesis $\rho = 0$ the variable *NRRP* is not endogenous and we can just estimate Eq. (1). Our results (Table 5-6) confirm that the variable *NRRP* is endogenous since the Wald test $\rho = 0$ is rejected at the 1%. Nevertheless, also controlling for the endogeneity, the positive effect of *NRRP* on the probability of investing in the Twin Transition *NRRP* is positive and significant at the 1%.

Concerning the validity of the instruments, F statistics (on OLS regression) for the instruments' relevance is over 10 the instruments are not weak. More specifically, based on Stock and Yogo's (2005) tabulation of the critical values for the weak instruments test, we reject the null of a relative bias greater than 5%. The Sargan test (on OLS regression) is not significant, so we can consider the instruments to be exogenous. Overall, looking the coefficient of each instrument, all are statistically significant. Thus, the results of the IV approach (Table 5-6) corroborate the previous results (Table 5-1).

Table 5-6 – Instrumental variables approach: bivariate probit

	NRRP	TWIN TRANSITION 2022-2024
NRRP		1.911*** (0.370)
+ <i>controls</i>		
#iv_training	0.600*** (0.114)	
#terrorist_relations	0.344*** (0.111)	
# coop_banks	0.020* (0.011)	
$\rho = corr(\varepsilon_i, \mu_i)$		-0.598 (0.169)
Wald-test $\rho = 0$		6.841***
Instr. relevance, F-statistic		14.251***
Overidentification test, Sargan Chi2		1.110
Obs.		985
Wald chi-square		177.70***

The dependent variable is reported at the top of the column. The table displays coefficients of the bivariate probit regression. Standard errors in parentheses. Wald chi-square test of joint significance for all the explanatory variables is reported. The symbol # indicates the instrumental variable. Instruments relevance: F-test on OLS, significant with a F-value > 10 means to reject the hypothesis of irrelevance of the instrumental variables. Sargan test for the overidentification restriction on OLS, not significant means do not reject the hypothesis of exogeneity of the instrumental variables. *** p < 0.01, ** p < 0.05, * p < 0.1.

8. Conclusions

How can we judge the response to the environmental and social crises – aggravated by the COVID-19 pandemic – given by the European Union to accelerate a recovery that should be also resilient by means of the European Green Deal (EGD) and Next Generation EU (NGEU) programs? Otherwise said, we verified whether, at the firm level, EGD and NGEU are speeding up the Twin Transition – i.e., Green Transition coupled with Digital Transition. Ascertaining whether those EU programs are effectively quickening the Twin Transition acquires special relevance for Italy, the EU country whose National Recovery and Resilience Plan (NRRP) received the largest share of the overall NGEU’s endowment.

Using a unique micro-level database of almost 3,000 firms, our econometric analyses found conspicuous support for the hypothesis that the NRRP is effectively speeding up the Twin Transition. Namely, we showed that if a firm is activating NRRP projects four main results attain. First, this impacts the *extensive margin*, increasing the likelihood of starting the Twin Transition at firms which had never invested in it previously. Moreover, it could affect the *intensive margin*, raising the probability of enticing firms which had already invested in the Twin Transition to continue investing in it. Thirdly, it could bear on the *inclusive margin*, whereby the prospect of starting the Twin Transition at firms which had never invested in it previously will be boosted for firms belonging to

disadvantaged entrepreneurial segments and areas. Lastly, engaging the Twin Transition might improve not only society's wellbeing but also the performance at firm level. We showed also that the bulk of the previous results is robust to adopting an instrumental-variables approach to tackle the issue of potential endogeneity.

By and large, our findings gave robust empirical support to the validity of the EU policies in terms of speeding up the firm-level Twin Transition in the country which provides the most important case study. Italy is, in fact, the country which benefited of the largest allotment of NGEU's funds. At the same time, the Italian economy hosts the largest and longest-lived fracture between the more affluent rest of the country and the less developed South. Hence, if the NRRP is working well in Italy, by strengthening the Twin Transition, this bodes well for the overall success of the EGD and NGEU policies of the European Union.

Honesty requires recognizing some limitations of our study. In particular, we relied on the spot effect of the NRRP, since we could only observe the impact of a firm engaging itself with the NRRP onto its likelihood of investing in the Twin Transition. To improve on this weakness, future studies could examine the dynamic effects of the NRRP by observing a firm's behavior over a longer time period. Nevertheless, we should stress that our findings are not trivial since they are based on data collected in the first part of 2022, rather early since the NRRP spans until 2026. Moreover, the firms' responses might be thwarted by the extreme economic and political uncertainty caused by the Russia-Ukraine war. Finally, ignoring the previous two considerations, firms' strategy revisions might not follow the NRRP if the firms believed that the drive towards the Twin Transition was not a permanent policy by the EU.

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