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THE EFFECTS OF DOMESTIC AND EU INCENTIVES ON CORPORATE INVESTMENT TOWARD ECOLOGICAL TRANSITION: A PROPENSITY SCORE MATCHING APPROACH

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The Effects of domestic and EU incentives on corporate investment toward ecological transition: a propensity score matching approach

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Abstract

We investigate the effects of domestic and EU incentives on different types of corporate investments in ecological transition on a large representative sample of Italian firms including the universe of companies above 250 employees. We perform propensity score matching tests exploiting revealed information of firms that declare to use the incentives for specific ecological transition investments compared to a synthetic counterfactual of "twin" companies matched on selected characteristics. Our findings show that domestic and EU incentives significantly increase green investments, and more so if we consider investment in energy saving plants and for greenhouse emissions reduction.

Keywords: EU incentives, green investment, propensity score.

JEL Classification: H23, H25, Q58.

1.Introduction

Ecological transition is the main challenge of the global economic system for the oncoming years. Manufacturing (especially in the hard-to-abate-sectors), agriculture, mobility and transport, energy production and house efficiency require a dramatic change if we want to meet the Paris agreement limits on the rise of global temperature and avoid the risk of a climate disaster. Some facts and figures help to understand the extent of the challenge. In 2019 global emissions reached around 53 billion tons of C02 equivalent (GtCO2) at global level while the EU sets the ambitious goal of net zero emission in 2050 and of a 55 percent reduction by 2030. However the marginal abatement cost curve tells us that with the existing technology the marginal cost of ecological transition is sharply upward sloping after the first half of the road toward net zero emissions (De Cara and Jayet,

2011; Kesicki and Strachan, 2011). However, every year the curve shifts to the right due to the ongoing technological progress in emission reduction. This is why ecological transition requires strong and effective policy actions that promote innovation and economies of scale in the installation of new technology. Beyond changes in corporate and household behavior given the existing technological vintage, most of the transition is in fact incorporated into new environmentally sustainable investment and innovations (such as those including, among others, installation of new energy saving plants, efficient water management, reused/recycled inputs, combined heat and power or combined cooling, heating and power generation, etc.) where more energy efficient capital gradually replaces the existing less efficient capital stock. Domestic and EU fiscal policies can therefore play a crucial role in this direction by fostering corporate investment for ecological transition.

Our research paper aims to provide a contribution in this direction by testing whether domestic and EU subsidies have a significant impact on corporate decisions to adopt ecologically sustainable investments. To this aim we use the Italian National Statistical Institute Multiscopo Survey containing data for a large representative sample of Italian firms below 250 employees and the universe of Italian firms above that threshold.

As is well known there are many other factors beyond public funds and subsidies (ie. the pressure of financial investors, internal corporate strategies, increasing managerial awareness that environmental sustainability is a competitive factor of the future) that can nonetheless stimulate corporate investment in ecological transition. The main methodological question on the effectiveness of subsidies is therefore the comparison with the counterfactual that is, whether companies would have nonetheless invested in ecological transition without the subsidy. We aim to provide an answer to this question by creating a synthetic counterfactual with a propensity score matching approach and testing the effect of domestic and EU subsidies on many different types of ecological transition investments. Our stratified and representative Multiscopo survey allows as well to test whether subsidies impact differently according to geographical areas and size classes.

Our paper contributes to a vast literature including theoretical and empirical analyses on drivers of eco-investment and innovation. A benchmark theoretical reference is that of directed technological change (Acemouglu et al. 2012) where it is shown that green taxes/subsidies redirecting innovation toward more ecological friendly productive processes are crucial to achieve sustainable growth. The empirical literature on drivers of environmental friendly innovation identifies the following main dimensions: i) *firm specific factors* including size, location, sector, age and employees training and education; *ii) technological conditions and Innovations,* depending on the knowledge-capital endowment of firms, R&D investment, organizational capabilities and organizational innovations, co-operation with public and private entities, and acquisition of capital assets and external knowledge; iii) *absorptive capacity* (Cohen et al. 2000), related to the notion that the ability to exploit external knowledge is crucial to corporate innovation capabilities; iv) *market condition*s (such as expectations of future turnover, previous economic performance, demand for new eco-products, or consumer preferences); v) *environmental regulatory policies*, including government legislation such as laws, acts, and directives changing the relative prices of production factors or setting new (environmental) standards, acting bilaterally on both the supply (push) and the demand (pull) side.

Detailed reviews of this literature can be found in Barbieri et al. (2016), De Jesús Pacheco et al. (2016), Del Rio et al. (2016), Hojnik and Ruzzier (2016), Siedschlag et al. (2019).

The effects of all the above mentioned factors on the adoption of environmental friendly innovation are also conditional to the type of eco-innovation adopted (Kedou,2011; Horbach et al,2012). Several empirical analyses on specific topics for eco-innovations have used the Community Innovation Survey (Horbach 2016; Bossle et al., 2016; Rogge and Schleich, 2018; Caianello et al.,2020), recent works rely on the analysis of randomized samples (Maruf et al. 2018 and Jove-Llovis 2017) and a great number of empirical analyses use patents as a measure of

innovation (Brunnermeier and Cohen 2003, Laurens et al. 2017, Montobbio and Solito 2018, Nameroff et al. 2004, Wagner 2007, Aiello et al. 2019, Griliches, 1990, Hall et al. 1986, Archibugi and Pianta 1996, Haščič and Migotto 2015, Fusillo et al. 2019, Aiello et al., 2019).

Within this literature our paper contributes to the subfield of the specific role of domestic and EU subsidies and incentives on green investment and innovation. Among previous contributions Cainelli, Mazzanti, and Borghesi (2012) find that local public funding and group membership are the most relevant determinants of the introduction of radical green innovations for firms based in Italy. Cainelli, and Mazzanti (2013) show that public funding played an important role for the introduction of innovation with environmental benefits in the areas of carbon abatement and energy efficiency in the Italian service industries. On the opposite, Borghesi, Cainelli, and Mazzanti (2015) find no effect of public funding on the innovation performance of firms in the sectors under the EU Environmental Trading System (ETS) regulation. Castellacci and Lie (2017) show that public funding is an important determinant of innovation with environmental benefits in the area of waste and carbon dioxide reduction in South Korea. Peñasco, del Río, and Romero-Jordán (2017) show that international public subsidies do not increase the likelihood of introducing green innovations in Spain, whereas national public funding does. In contrast to these results, Rogge and Schleich (2018) find that public funding to German firms matters for the introduction of green innovations conditional on firms' accessibility to both domestic and EU funding. Using data from 16 EU countries, Jaumotte and Pain (2005) find that green innovations in small firms are dependent on the availability of finance and co-operation to a larger extent than in larger firms. Cecere et al. (2020) find that access to public funds or incentives play a complementary role to private funds, mainly in small firms, because they are effective in improving corporate ability to introduce eco-innovations only when the firm is not short of either internal or external sources.

We aim to give an additional contribution to this specific strand of literature by investigating the effect of domestic and EU financial support to ecological transition friendly investment in Italy. More specifically the typologies covered are investment that reduce energy consumption, energy efficient building retrofit, installation of electric energy plants using renewable sources, thermic energy plans using renewable sources, investment in combined heat and power or combined cooling, heating and power generation, purchase of electric or hybrid vehicles for the corporate car fleet and other investments for efficient and sustainable energy and transport management. To this aim we use a special section of the Italian National Statistical Institute Multiscopo Survey realized on September 2018**.** The advantage of our research is that it covers a very large and representative sample of the Italian firms (including the Italian Universe of firms above 250 employees) and an extremely detailed series of environmental innovations. The richness of our sample allows us to test the effect of subsidies and incentives on the overall sample compared with that on the small (3-50 employee) size firms and in the less developed area of South of Italy. In addition to it, the propensity score matching approach brings us closer to the comparison with the counterfactual comparing green investment of subsidised companies with that of a control group represented by "twin" companies without the subsidy.

Based on the literature described above we therefore formulate three research hypotheses on the significant effect of subsidies on green investment and on the stronger impact of them in the South and in the small firm subsample. Our main findings show that EU funds increase significantly (in range between 5 and 15 percent according to different subsidies and investment typologies) environmentally sustainable corporate investment.

The magnitude of the effect is much higher for general energy efficient investment (leading to greenhouse emissions reduction), while smaller but significant for more specific technologies such as combined heat and power or combined cooling, heating and power generation. The impact remains strong and tends to be larger for firms located in the Italian Mezzogiorno and for small businesses even though we do not find evidence that the difference between subsamples is statistically significant. We therefore find support for the first but not for the other two research hypotheses.

The paper is divided into five sections including Introduction and Conclusions. In Section 2 we highlight our research hypotheses, in section 3 we describe the dataset and the methodology used. In Section 4 we present and discuss our descriptive and econometric findings. Section 5 concludes.

2. Research hypotheses

Green investment has relevant innovation characteristics and the understanding of such characteristics requires knowledge in different (natural science related) disciplines going beyond standard financial knowledge, in an economic approach that considers interdependences among physical, human and natural capital. More specifically, and differently from the past, if we consider as reference the EU Taxonomy on green investment,[1] environmental sustainability requires an understanding of the impact of investments on carbon footprint, water footprint, biodiversity, climate adaptation and mitigation, quality of air and circular economy. The latter consists of developing new products/processes with the goal of increasing the share of recycled/reused material as input and, in any case, a more sustainable use of production and consumption waste (thereby avoiding landfill disposal). In many cases this requires an entirely new design of "cradle to cradle" products. The high innovative content of ecologically sustainable investment is likely to increase informational asymmetries between investors and financers (Guiso, 1998; Zhang and Vigne, 2021). As is well known in the literature, informational asymmetries translate into higher costs of external finance as a consequence of higher screening and monitoring costs and/or the higher risk of the investment, up to forms of credit rationing (Myers and Mailuf, 1984). This is why we assume in our research hypothesis that domestic or EU subsidies can have intensive or extensive effects on corporate green investment. This is the case if internal finance is not sufficient to cover green investment costs and its innovative content makes informational asymmetries high enough to lead to excess cost of external finance or credit rationing having a negative impact on investment decisions

H_O1: *domestic and EU subsidies have a significant impact on ecologically sustainable investment*

The Italian Mezzogiorno suffers from a significantly lower rate of economic development than the rest of the country. Guiso et al. (2004) show that the lower financial development in the Mezzogiorno turns into higher financial constraints for households and businesses. Data from Bank of Italy show that in the year of our survey the lending rate gap between the two areas has been markedly high (3.59% in the Nord versus 5.33% in the

[1] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

South of Italy for medium term loans). Lending rates in this area are on average higher as they reflect the higher risk of economic activity due to poor quality of transport infrastructure (ie. almost non existing high speed railway and far less developed highway routes) and to the role played by criminal organizations charging an informal "tax" on economic activities. As a consequence it is reasonable to assume that all these factors (lower financial development, higher financial constraints and higher investment risk) reflect into higher excess cost of external finance and credit rationing.

We therefore expect that the positive impact of subsidies on green investment can be higher in this area.

Ho2: domestic and EU subsidies have a relatively higher impact on companies located in less developed areas.

As is well known in the literature several theoretical studies and empirical analyses, in agreement with the theoretical model of asymmetric information of Stiglitz and Weiss (1987), have revealed that the credit market for small firms often displays patterns and features not commonly found in large firms. In particular, i) interest rates are much higher on average than bank interest rates, and also show significant dispersion; ii) the probability of partial or total credit rationing is higher with borrowers unable to borrow all they want, or some loan applicants are unable to borrow at all. Other authors in the literature go in the same direction showing that informational asymmetries and credit rationing can be related to some traditional a priori factors – such as firm size, age and location – and lenders' rational decisions based on their credit risk models. Evidence on the inverse relationship between financing constraints and firm size is provided on US, UK and Italian data (Fazzari et al. 1988; Chirinko, 1993; Becchetti et al. 2010). The authors show that small firms (that were denied credit can realize only a limited share of their projects and this provides evidence supporting the hypothesis that their statistically significant investment-cash flow relationship originates from credit rationing. Given the highest incidence of screening and monitoring costs (fixed for any investment project) on bank interest gains on smaller size investments, informational asymmetries are more likely to create credit rationing or unsustainable extra costs of external finance for small firms vis-à-vis large firms. This is why we expect that, beyond the informational asymmetry related to the innovative content of green investment, small firms suffer particularly from it and therefore can finance a significantly higher amount of green investment in presence of domestic or EU subsidies

H_O3: *domestic and EU subsidies have a significant impact on corporate ecologically sustainable investment, especially for small and medium sized firms ~~and younger firms~~*

3. Dataset description

The Multiscopo Survey on the Italian Statistical Institute Census of companies involves a sample of about 280,000 firms with 3 and more employees, representing the Italian universe of just over a million units. The Multiscopo sample corresponds to 24.0% of Italian companies, which however produce 84.4 % of the national added value, employ 76.7% of all Italian workers (12.7 million including artisans and self-employed) and up to 91.3% of dependent workers. The survey includes the universe of companies above 250 employees, while it is a representative sample of the firm population in the 3-250 employees size interval. The Census survey was carried out between May and October 2019, the reference year of the data acquired by the companies being 2018. More

than half of the companies are active in the North (29.2% in the North-West and 23, 4% in the North-East), 21.4% in the Center and 26.0% in the South, and most of the companies are controlled by an individual owner or a family, without major differences from a sectoral and geographical point of view. Census data from the Multiscopo survey show that between 2016 and 2018, 34.6% of Italian companies experienced at least one business development and innovation. In 2018, self-financing is the most widespread source of financing (used by 74.5% of sample companies). Seven out of 10 companies are engaged in "sustainable" actions: from the environment to parenting. In particular, in 2018 66.6% of Italian companies with at least 3 employees carried out actions to reduce the environmental impact of their productive process.

Descriptive findings related to variables used in our empirical analysis show that around 2.4 percent of companies in the sample obtain EU funds (Tablet 1 in the Appendix). Given the large size of our sample this share corresponds to a considerable amount of companies (around 40,000). The share is higher for public incentives (3.12 percent) and lower for public funds (1.4 percent). The presence of a very large sample of firms not receiving incentives or subsidies creates a a largestock where we can identify control firms and build our synthetic counterfactual with the propensity score matching approach. The difference between public funds and public incentives is that the latter include tax credits and accelerated depreciation, while the first are limited to grants and soft loans.

Descriptive findings on environmental friendly investment show that 36.5 percent of sample companies have done in the last three years investment that reduce energy consumption, around 13.1 percent energy efficient building retrofit, 8.4 percent installation of electric energy plants using renewable sources, 3.8 percent thermic energy plans using renewable sources, 2.9 percent investment in combined heat and power or combined cooling, heating and power generation 5.9 percent purchase of electric or hybrid vehicles for the corporate car fleet and 13.9 percent other investments for efficient and sustainable energy and transport management. In the section that follows we test our research hypotheses evaluating whether EU or domestic public funds and incentives significantly contributed to these investments.

4. The propensity score matching model

To take into account the problem of endogeneity when testing the effect of subsidies on green investment we run propensity score matching (PSM) estimates (Rosenblaunm and Rubin, 1983). PSM aims to reduce or eliminate endogeneity bias in observational studies in order to estimate the causal effect of a treatment on an outcome by comparing units that do not participate to the treatment, but otherwise share the same characteristics as units participating to it.

As is well known, the propensity score is used to build a synthetic counterfactual by identifying “twin” companies in the treatment group (in our case firms having public funds or subsidies) and in the control group (firms not having public funds or subsidies) based on a propensity score calculated with a logistic regression where we use as X-variables relevant corporate characteristics.

The PSM approach we apply to our research therefore consists of three steps: i) identifying and estimating a logit specification to calculate the propensity score for each firm in the sample; ii) selecting a matching algorithm, testing for balance in characteristics in the treatment and control groups; iii) estimating the treatment effect and interpreting the results. We therefore start our econometric analysis by calculating the propensity score with the following logit specification

$$(1)\quad EU\ Fund_i = \alpha_0 + \alpha_1 Size_i + \alpha_2 Age_i + \alpha_3 VA/employee_i + \alpha_4 TechInvest_{ix} + \alpha_5 LabourForceGrowth_{ix} + \alpha_6 GeneratChange_i + \alpha_7 EU\text{-}Competitor_i + \alpha_8 Extra\text{-}EU\text{-}Competitor_i + \sum_d \gamma_d\ DIndustry_{i,t} + \sum_f \delta_f\ DMacroarea_{i,t} + \varepsilon_i$$

where controls selected as relevant matching characteristics include the number of firm employees (*Size*), the time distance from firm's year of birth (*Age*), firm value added per employee (*VA/employee*) plus a series of (0/1) dummies capturing firms that invested in digitalisation technology (*TechInvest*), companies that increased their workforce in the 2016-2018 period (*LabourForceGrowth)*, underwent a changein ownership in the 2016-2018 period *(GeneratChange)*, had competitors located in EU countries or, alternatively, in countries outside the EU (*EU Competitor* and *non EU competitor* respectively). We finally add to the specification 5 (minus one) macroareas and 17 (minus one) (NACE1) industry dummies. The possibility of introducing them and therefore controlling accurately also for firm location and industry characteristics is given by the extension of our sample allowing to find large numbers of "control twins" for treated firms at macroearea and NACE1 industry level.

The specification shown in Table 2 (see the Appendix) is related to a specific dependent variable (circular economy). Results are similar in terms of sign and significance when using the other green investment dependent variables since the number of companies answering the different question items representing our green investment typologies is roughly the same (they are omitted for reasons of space and available upon request). The propensity score estimate shows that companies who experienced an increase in the workforce in the last three years and have higher value added per worker are more likely to take EU subsidies. This is an important finding as it suggests that the PSM approach allows us to control and correct for the higher "quality" of companies taking the subsidies when evaluating their effects on green investment decisions. From a geographical point of view the share of companies from the South (North-West) is relatively higher (lower) in the unmatched than in the matched treatment sample showing that EU and domestic subsidy recipients and fund are geographically imbalanced.

In Tables 3.1-3.3 (see the Appendix) we report, for each type of domestic or EU financial support, tests showing that the propensity score matching creates a sample of treatment and control firms with balanced properties (ie. there are not significant differences in average values of characteristics between treatment and control group). If we consider size, the wide unmatched average difference between companies taking and not taking the subsidy is of 15 employees (with the treatment sample of companies taking the subsidy being as expected larger). The propensity score matching reduces the difference to 1.5 workers, with treatment and control group being not significantly different in size. Another important characteristics in treatment and control group selection is the share of companies that increased their workforce in the last year. As mentioned above the share is significantly higher in the unmatched sample for companies getting the subsidy (89 against 74 percent). We

can interpret this result by assuming that an unobservable variable such as the idiosyncratic quality of the management is positively correlated with both the likelihood of employment growth and success in obtaining the domestic or EU subsidy. In the matched sample the difference becomes no more significant (89 percent of firms reporting a workforce increase in the last year in both treatment and control groups) so that the propensity score matching analysis that follows in the next section can control for the spurious effect of these factors. Other three factors that matter when comparing unmatched treatment and control samples are the event of a generational change in the last three years, the share of companies that compete globally (ie. having competitors beyond EU) and that of those doing high tech investment. The share is higher among those getting the subsidy but becomes insignificant when corrected with the propensity score matching. To resume with, companies getting the subsidy are in general larger, more involved in global competition, more likely to have lived a generational change, increased their workforce and invested in technology in the last three years. The propensity score matching however corrects for these biases selecting a subsample of companies in the control group being not different from those of the treatment group in terms of these characteristics.

In Tables 4.1-4.4(see the Appendix) we report values of ATE (average treatment effect) for all the different green investment considered. The results on the average treatment effects show that companies with otherwise not significantly different characteristics in terms of factors selected in the propensity score estimate have a significantly higher probability of green investment when they receive external funding. The ATE is significant for almost all investment and public subsidy/fund types.

When we look at the impact of EU funds we find that the largest effect we measure is related to the installation of energy saving plant/machinery that rises by 13.7% in the treatment sample with respect to the control sample. The effect is larger in the subsample of companies located in the South (17.3%) (Table 4.1 in the Appendix). The difference between the impact on the overall sample and the small and South subsamples is however not significant since confidence intervals overlap.

All other effects are significant and contained between 3-7 percent without significant differences among the overall sample and those of small firms and firms of the South.

With regard to investment in circular economy we find that the impact on investment in reused/recycled production waste as input for new production tends to be smaller than that on the more general use of waste management for all of the three types of domestic and EU intervention. Hence the most successful effect of public funds/incentives in circular economy concern the second type of investment.

As well, impact of domestic and EU subidies/public funds on Plants for thermic production from renewable sources and combined heat and power (CHP) generation, combined cooling heating and power (CCHP) generation tends to be small (around 3 percent for EU funds, while around 1.2 percent for public funds and subsidies in both cases).

5. Conclusions

Climate change is the main global challenge of the next decades and it requires dramatic changes in consumption and production habits in order to reduce greenhouse gases emissions and tackle the climate warming threat. Since most of green technological advancement occurs when incorporated in new vintage technologies green investment plays a crucial role in this challenge. The upward sloping margin abatement cost curve of carbon tells us that the costs of corporate investment toward ecological transition are extremely high and grow as far as we make progress toward the goal. This is why the role of public subsidies can be crucial to win the challenge.

In this perspective "blended green finance" involving public-private partnership is crucial for the success of ecological transition. Additionality (activation of private investment that would have not occurred otherwise), mobilisation of private capital and demonstration effect to unleash energies toward ecological transition are crucial attributes of its success (Tonkonogy et al. 2018). In our empirical analysis we test additionality in terms of ecological transition of the most traditional form of blended green finance represented by domestic and EU incentives.

Based on these considerations the research question of our paper is whether EU subsidies and domestic subsidies and public incentives have a significant impact on corporate green investment with special focus on circular economy, waste management and emission reduction. We test our hypothesis on a large representative sample of Italian companies including the universe of companies above 250 employees with a propensity score matching approach that compares companies taking the subsidy with a synthetic counterfactual.

Our findings show that EU subsidies, and with them domestic subsidies and public incentives, significantly increase green investment, with the magnitude of the effect ranging between 5 and 15 percent, the impact being stronger in the installation of energy saving machinery. When focusing on companies located in the Italian Mezzogiorno the impact tends to be larger, consistently with the hypothesis of higher informational asymmetries and cost of external finance in this area even though we do not find a clear-cut significant difference here from the overall sample.

Our results focus on the year 2018 since this is the only year in which the detailed information of Indagine Multiscopo is available. Further research on this topic in other samples and countries could verify for the existence of time substitution and dynamic effects around the EU subsidy-green investment nexus and could calculate cost-effectiveness of the public resources used for the subsidy. The policy implication of our research is that subsidies to green investment are an important policy measure that can foster environmental technological change and contribute to speed up ecological transition.

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APPENDIX

Table 1 Descriptive statistics of the variables used in the empirical analysis

Variable	Obs.	Mean	St. dev.	Min	Max
Incentive variables					
EU subsidies	196,981	0.024	0.154	0	1
Public incentives	196,981	0.014	0.117	0	1
Public funds	196,981	0.031	0.173	0	1
Controls					
N. of employees	196,981	38.501	448.366	3	137,372
Value added/ worker	195,796	47729.19	89704.7	-5,415,981	1.23e+07
Eu competitor	196,981	0.989	0.106	0	1
Non Eu competitor	196,981	0.094	0.291	0	1
Firm age (years)	196,981	21.608	14.985	0	187
Labor force growth	196,981	0.031	0.173	0	1
Tech Investment	196,981	0.625	0.484	0	1
Generational Change	196,981	0.120	0.325	0	1
North-East	196,983	0.262	0.440	0	1
North-West	196,983	0.305	0.460	0	1
Centre	196,983	0.205	0.404	0	1
South	196,983	0.156	0.363	0	1
Isles	196,983	0.071	0.257	0	1
NACE1 Industries					

Mineral extraction	196,983	0.0038	0.061	0	1
Manufacturing	196,983	0.031	0.461	0	1
Water and waste management	196,983	0.015	0.121	0	1
Building	196,983	0.085	0.279	0	1
Retail and wholesale trade	196,983	0.193	0.345	0	1
Transport	196,983	0.063	0.243	0	1
Hotels and restaurants	196,983	0.064	0.244	0	1
Information and communication	196,983	0.039	0.192	0	1
Real estate	196,983	0.014	0.116	0	1
Professional activities	196,983	0.062	0.241	0	1
Leasing, travel and other industrial services	196,983	0.064	0.246	0	1
Education	196,983	0.012	0.110	0	1
Health and social assistance	196,983	0.036	0.186	0	1
Sport and recreational activities	196,983	0.019	0.138	0	1
Other services	196,983	0.021	0.144	0	1
Green investment typologies					
Emission reduction	196,983	0.31	0.463	0	1
Circular economy	196,983	0.83	0.374	0	1
Wastewater reuse/recycle to reduce polluting emission	196,983	0.086	0.279	0	1

Saving raw materials in production processes	196,983	0.449	0.497	0	1
Use of reused/recycled production waste as input for new production	196,983	0.202	0.401	0	1
Progress in separate waste collection	196,983	0.798	0.402	0	1
Waste management aimed to reduce emissions	196,983	0.506	0.500	0	1
Installation of energy saving plant/machinery	196,983	0.001	0.287	0	1
Termic isolation and/or more energy efficient buildings	196,983	0.039	0.193	0	1
Plants for electricity production from renewable sources	196,983	0.044	0.020	0	1
Plants for thermic production from renewable sources	196,983	0.015	0.122	0	1
Combined heath and power (CHP) generation, Combined Cooling Heating and Power (CCHP) generation	196,983	0.010	0.098	0	1
Electric hybrid corporate fleet of vehicles	196,983	0.015	0.121	0	1
Other green investment	196,983	0.034	0.182	0	1

Table 2. Propensity score estimates

VARIABLES	EU funds	Public funds	Public incentives
N. of employees (th.)	0.058	0.103	0.027
	(0.065)	(0.054)	(0.074)
Firm age	0.0054***	0.010***	0.0068***
	(0.0014)	(0.001)	(0.0011)
Value added/ worker	8.10e-07***	5.85e-07***	9.87e-07***

	(2.21e-07)	(3.08e-07)	(2.02e-07)
Eu competitor	0.469**	1.328***	0.433**
	(0.192)	(0.416)	(0.173)
Non Eu competitor	0.450***	0.619***	0.318***
	(0.056)	(0.084)	(0.051)
Labor force growth	0.939***	0.735***	0.994***
	(0.066)	(0.086)	(0.059)
Tech Investment	0.502***	0.395***	0.560***
	(0.050)	(0.066)	(0.042)
Generational Change	0.227***	0.278***	0.244***
	(0.054)	(0.076)	(0.046)
NACE1 industry dummies	Yes	Yes	Yes
Macroarea dummies	Yes	Yes	Yes
Pseudo R^2	0.065	0.048	0.064
LR (χ^2)	1529.95	638.41	1891.08
Observations	94140	94140	94140

Dependent variable: (0/1) dummy taking value one if the firm invested in circular economy in the 2016-2018 period. Robust standard errors in parentheses. *** p<0.01. ** p<0.05. * p<0.1

Table 3.1 Balancing properties in unmatched and matched samples:main covariates

(Balancing Properties of Nace01Industries arecomitted for soace and available upon request)

Eu subsidies – overall sample

		Treatment	Control	Bias	T- stat
N. of employees	Unmatched	90.102	37.22	3.6	8.04
	Matched	49.90	48.56	0.1	0.21
Value added/ worker	Unmatched	57442	47491	13.6	9.03
	Matched	58275	56691	2.2	0.35
Eu competitor	Unmatched	0.987	0.989	-1.6	-1.12

	Matched	0.988	0.988	0.0	0.00
Non Eu competitor	Unmatched	0.189	0.091	28.3	22.76
	Matched	0.199	0.201	-0.8	-0.25
Firm age	Unmatched	23.53	21.56	12.9	9.03
	Matched	24.57	24.41	1.0	0.35
Labor force growth	Unmatched	0.883	0.685	49.6	29.27
	Matched	0.896	0.892	1.1	0.50
Tech Investment	Unmatched	0.765	0.621	31.6	19.19
	Matched	0.762	0.758	0.9	0.36
Generational Change	Unmatched	0.172	0.119	15.0	8.68
	Matched	0.179	0.173	1.6	0.52
lsles	Unmatched	0.078	0.071	2.7	1.89
	Matched	0.075	0.074	0.4	0.16
North-East	Unmatched	0.321	0.261	13.2	9.30
	Matched	0320	0.315	1.0	0.36
North-West	Unmatched	0.230	0.361	-17.5	-11.43
	Matched	0.224	0.218	1.2	0.47
South	Unmatched	0.176	0.156	5.4	3.78
	Matched	0.189	0.203	-3.9	-1.30
Center	Unmatched	0.174	0.206	-8.3	--6.20

Table 3.2 balancing properties in unmatched and matched samples:main covariates

(Balancing Properties of Nace01Industries arecomitted for soace and available upon request)

Public funds – overall sample

		Treatment	Control	Bias	T- stat
N. of employees	Unmatched	97.78	37.65	8.4	7.01
	Matched	57.179	38.461	2.6	3.44
Value added/ orker	Unmatched	55544	47618	10.0	4.59
	Matched	58734	51436	3.7	1.53
Eu competitor	Unmatched	0.993	0.989	5.6	2.59
	Matched	0.995	0.994	12.8	7.24

Non Eu competitor	Unmatched	0.134	0.093	-0.3	-0.05
	Matched	0.172	0.173	1.7	0.54
Firm age	Unmatched	23.003	21.588	9.1	4.96
	Matched	24.308	24.129	1.1	0.28
Labor force growth	Unmatched	0.846	0.688	38.1	17.88
	Matched	0.869	0.854	3.5	1.04
Tech Investment	Unmatched	0.743	0.623	25.9	2.59
	Matched	0.741	0.626	3.1	12.05
Generational Change	Unmatched	0.160	0.120	11.7	0.81
	Matched	0.175	0.159	6.2	1.07
Isles	Unmatched	0.088	0.071	3.6	3.38
	Matched	0.078	0.088	4.6	-0.87
North-East	Unmatched	0.247	0.262	-3.6	-1.86
	Matched	0.233	0.231	0.4	0.09
North-West	Unmatched	0.244	0.306	-3.6	-1.86
	Matched	0.254	0.247	0.4	0.09
South	Unmatched	0.224	0.155	17.5	9.81
	Matched	0.239	0.230	2.1	0.47
Center		0.174	0.206	-8.3	--6.20

Table 3.3 balancing properties in unmatched and matched samples:main covariates

(Balancing Properties of Nace01Industries arecomitted for soace and available upon request)

Public incentives – overall sample

		Treatment	Control	Bias	T- stat
N. of employees	Unmatched	76.13	37.28	3.0	6.68
	Matched	48.10	56.06	0.6	-1.13
Value added/ worker	Unmatched	58039	47397	12.6	9.13
	Matched	58511	57174	1.6	1.16
Eu competitor	Unmatched	0.987	0.989	-1.2	-0.93
	Matched	0.989	0.990	-0.8	-0.35
Non Eu competitor	Unmatched	0.170	0.091	23.5	20.81

	Matched	0.180	0.173	2.3	0.82
Firm age	Unmatched	23.70	21.54	14.3	11.21
	Matched	25.00	24.51	13.2	1.26
Labor force growth	Unmatched	0.875	0.684	47.1	31.89
	Matched	0.903	0.904	-0.2	-0.12
Tech Investment	Unmatched	0.767	0.620	32.4	22.05
	Matched	0.769	0.756	2.1	0.94
Generational Change	Unmatched	0.177	0.118	16.7	11.29
	Matched	0.183	0.179	1.2	0.47
Isles	Unmatched	0.075	0.071	1.3	1.03
	Matched	0.062	0.068	-2.4	-1.03
North-East	Unmatched	0.279	0.262	4.0	3.11
	Matched	0.282	0.282	0.0	0.00
North-West	Unmatched	0.259	0.307	-10.7	-8.03
	Matched	0.275	0.276	-0.2	-0.08
South	Unmatched	0.214	0.155	15.3	12.58
	Matched	0.205	0.200	1.3	0.51
Center	Unmatched	0.174	0.206	-8.3	--6.20

Table 4.1 Average treatment effect of the treated per green investment type – EU funds

Green investment type	All firms	South	Small firms
Emission reduction	0.065 (0.0173)***	0.087 (0.035)***	0.062 (0.0178)***
Circular economy	0.0561 (0.0101)***	0.098 (0.015)***	0.033 (0.013)**
Wastewater reuse/recycle to reduce polluting emission (2)	0.0333 (0.0112) ***	0.057 (0.020) **	0.017 (0.09)
Saving raw materials in production processes (3)	0.0576 (0.0164)***	0.063 (0.032)***	0.30 (0.018)
Use of reused/recycled production waste as input for new production (4)	0.0466 (0.0134) ***	0.045 (0.018) ***	0.027 (0.012) **

Progress in separate waste collection (5)	0.0509 (0.0122)***	0.098 (0.016)***	0.024 (0.014)
Waste management aimed to reduce emissions (6)	0.064 (0.0159)***	0.096 (0.035)**	0.048 (0.018)**
Installation of energy saving plant/machinery	0.137 (0.0185)***	0.173 (0.028)***	0.140 (0.019)***
Thermic isolation and/or more energy efficient buildings	0.0628 (0.0119)***	0.036 (0.016)**	0.068 (0.014)***
Plants for electricity production from renewable sources	.0658 (0.0091)***	.0622 (0.016)***	.064 (0.011)***
Plants for thermic production from renewable sources	0.0332 (0.0087)***	0.033 (0.013)**	0.031 (0.009)***
Combined heath and power (CHP) generation, Combined Cooling Heating and Power (CCHP) generation	0.0352 (0.0067)***	0.011 (0.011)	0.012 (0.006)*
Electric hybrid corporate fleet of vehicles	0.0201(0.0097)*	0.007(0.010)	0.014(0.007)
Other green investment	0.0477 (0.0142)***	0.035 (0.019)	0.044 (0.015)***

Small firms: firms below 50 employees. T statistics in parenthesis.

Table 4.2 Average treatment effect of the treated per green investment type – Public funds

Green investment type	All firms	South	Small firms
Emission reduction	0.098 (0.024)***	0.104 (0.033)***	0.110 (0.026)***
Circular economy	0.040 (0.017)**	0.096 (0.020)***	0.068 (0.016)***
Wastewater reuse/recycle to reduce polluting emission (2)	0.057 (0.015)***	0.054 (0.027)*	0.028 (0.016)
Saving raw materials in production processes (3)	0.071 (0.022)***	0.085 (0.036)***	0.067 (0.026)**
Use of reused/recycled production waste as input for new production (4)	0.004 (0.016)	0.019 (0.028)	0.019 (0.028)
Improvement in differentiated waste (5)	0.034 (0.016)**	0.087 (0.024)***	0.067 (0.017)***
Waste management aimed to reduce emissions (6)	0.059 (0.022)**	0.085 (0.040)*	0.096 (0.024)***
Installation of energy saving plant/machinery	0.158 (0.016)***	0.200 (0.033)***	0.172 (0.020)***

Termic isolation and/or more energy efficient buildings	0.099 (0.014)***	0.088 (0.025)***	0.096 (0.017)***
Plants for electricity production from renewable sources	0.054 (0.012)***	0.115 (0.026)***	0.051 (0.010)***
Plants for thermic production from renewable sources	0.040 (0.012)***	0.041 (0.017)*	0.034 (0.012)***
Combined heath and power (CHP) generation, Combined Cooling Heating and Power (CCHP) generation	0.023 (0.007)***	0.012 (0.009)	0.019 (0.007)**
Electric hybrid corporate fleet of vehicles	0.025 (0.007)***	0.064 (0.023)**	0.017 (0.007)**
Other green investment	0.057 (0.012)***	0.030 (0.020)	0.065 (0.018)***

Small firms: firms below 50 employees. T statistics in parenthesis.

Table 4.3 Average treatment effect of the treated per green investment type – Public incentives

Green investment type	All firms	South	Small firms
Emission reduction	0.106 (0.016)***	0.105 (0.012)***	0.095 (0.017)***
Circular economy	0.076 (0.011)***	0.091 (0.027)***	0.070 (0.014)***
General interest	0.075 (0.015)***	0.091 (0.022)***	0.079 (0.016)***
Wastewater reuse/recycle to reduce polluting emission (2)	0.026 (0.0079)	0.0133 (0.0147)	0.024 (0.0096)**
Saving raw materials in production processes (3)	0.084 (0.016)***	0.114 (0.293)***	0.072 (0.018)***
Use of reused/recycled production waste as input for new production (4)	0.032 (0.011)**	0.049 (0.024)**	0.040 (0.013)***
Improvement in differentiated waste (5)	0.073 (0.013)***	0.079 (0.017)***	0.068 (0.0155)***
Waste management aimed to reduce emissions (6)	0.092 (0.016)***	0.073 (0.026)***	0.082 (0.018)***
Installation of energy saving plant/machinery	0.164 (0.012)***	0.179 (0.025)***	0.160 (0.014)***
Termic isolation and/or more energy efficient buildings	0.039 (0.007)***	0.041 (0.011)***	0.050 (0.009)***
Plants for electricity production from renewable sources	0.045 (0.009)***	0.074 (0.017)***	0.048 (0.011)***

Plants for thermic production from renewable sources	0.018 (0.005)***	0.016 (0.007)**	0.022 (0.007)***
Combined heath and power (CHP) generation, Combined Cooling Heating and Power (CCHP) generation	0.010 (0.004)**	0.019 (0.010)*	0.009 (0.006)
Electric hybrid corporate fleet of vehicles	0.012 (0.006)**	0.021 (0.014)	0.002 (0.004)
Other green investment	0.033 (0.007)***	0.044 (0.011)***	0.039 (0.007)***

Small firms: firms below 50 employees. T statistics in parenthesis.