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Keywords: Environmental policy, green investments, firm performance
JEL Classification: D24, L25, Q50, Q58

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Green Investments and Firm Performance[1]

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Abstract

This paper examines the impact of firms' green investments on a range of performance outcomes including the growth of output, employment, productivity, export intensity, and energy intensity. The analysis uses firm-level data from Ireland's industry sector over the period 2008-2016. To identify causal effects, a difference-in-difference propensity score matching is implemented. In addition to average effects across all firms, we identify and quantify heterogenous effects for different groups of firms. Our results indicate that in the medium-term green investments have positive and statistically significant effects on firms' performance. Taking into account firm heterogeneity, we find that the effects are stronger for firms which are larger, foreign-owned, more productive, and in low-tech industries. Taken together, this evidence suggests that environmental quality and firm performance go together.

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1 Introduction

Do environmental quality and firm performance go together? International evidence reviewed recently by Dechezleprêtre et al. (2019) suggests that while environmental regulations tend to improve environmental performance, their causal effect on firm performance is not clear cut. Understanding how environmental policy impacts on firm performance is important for the design of policies aimed at improving environmental quality and the acceptability of such policies.

Earlier contributions to the literature reflected the conventional view of many economists that environmental regulations lead to increased costs and lower productivity due to constrains on an optimal allocation of resources. A number of studies attempted to link the productivity slowdown in the US in the 1970s to environmental regulations (see for example Gray 1987; Barbera and McConnell 1990; Gollop and Roberts 1983; Smith and Sims 1985). However, these studies are considered not robust enough given data limitations in terms of time coverage and difficulties with empirical identification (Jaffe et al. 1995; Albrizio, Kozuk and Zipperer 2017). More recent studies on the effects of environmental regulations on aggregate productivity based on longer time series or case studies find positive or no effects (Alpay et al. 2002; Hamamoto 2006; Yang et al. 2012).

Several country-specific studies have examined the impact of firms' investment in pollution abatement technologies, taken as a proxy for environmental performance, on firms' productivity and find weak negative effects (Ayerbe and Gorriz 2001-in the case of Spain; Broberg et al. 2013 – for Sweden; Sanchez-Varga et al. 2013- for Mexico) or insignificant effects (in the case of the US: Gray and Shadbegian 2003; Shadbegian and Gray 2005). Another literature strand has found that environmental regulations result in short-term costs that are outweighed by benefits in the longer term (Lanoie et al. 2008 - in the case of Canada; Khanna and Damon 1999 – for the US; Horváthová 2012 – for the Czech Republic).

Another literature strand points to a positive relationship between environmental regulations and firm performance. This latter literature strand has been initiated by Porter (1991) and developed further by Porter and van der Linde (1995), Ambec and Lanoie (2008) and Acemoglu et al. (2012). The key outcome of this literature is that environmental regulations incentivise firms to innovate and that this policy-induced innovation improves both the environmental quality and firm performance via two channels: (i) increased revenue due to better access to certain markets; differentiated products; sales of new cleaner technologies; and

(ii) reduced production costs including: the cost of materials, energy, services; the cost of capital; the cost of labour.

Against this background, this paper examines the impact of firms' green investments on a range of performance outcomes including the growth of output, employment, productivity, export intensity, and energy intensity. The analysis uses firm-level data from Ireland's industry sector over the period 2008-2016. To identify causal effects, a difference-in-difference propensity score matching is implemented. In addition to average effects across all firms, we identify and quantify heterogenous effects for different groups of firms and industries. Our results indicate that green investments have positive and statistically significant effects on firms' performance. However, these effects vary over time across the measures of performance outcomes considered. Further, taking into account firm heterogeneity, we find that the effects are stronger for firms which are larger, foreign-owned, more productive, and in low-tech industries. The output and productivity performance of firms with green investments in the food industry is better than the average performance of all firms. Taken together, this evidence suggests that environmental quality and firm performance go together. Heterogenous effects indicate that not all firms benefit equally from green investments.

The remainder of the paper is structured as follows. Section 2 presents the empirical methodology to identify and quantify the impact of green investment on firms' performance. Section 3 describes the data used in the empirical analysis and discusses summary statistics of the key variables. Section 4 discusses the results and Section 5 concludes.

2 Empirical Methodology

To assess the impact of green investments on firms' performance, we need to know what their performance would have been had they not invested. However, this counterfactual performance is not observed. To overcome this analytical challenge, we use the difference-in-difference propensity score matching methodology (see Blundell and Costa Dias 2000). The basic idea is that if there exist two firms having similar characteristics, one of which reports green investments ("treated" firm) and the other one does not ("control" firm), the difference in their performance change before and after green investments would be likely induced by green investments ("treatment"). This empirical approach allows us to compare the performance of firms which are similar before "treatment" (green investment) and to eliminate the impact of temporary unobserved firm-specific shocks to firm performance that might bias our results.

We define the treated group as firms with green investments in a given year *t*, i.e., if a given firm *i* invests in year *t* but not in *t+1*. The control group consists of firms that never invested during the analysed time period. This definition implies that if a firm invested in a given year *t* but not in any other years it would not be considered as a potential control firm.

There are several methods to match a treated firm to a firm with similar characteristics in the control group (see for example Wooldridge 2002; Siedschlag et al. 2014). For the purpose of this analysis we use the one-to-one nearest neighbour matching with replacement. The empirical estimation of the effects of green investment on firm performance is carried out in three steps. First, we estimate the propensity that a given firm engages in green investment in each year, $P(GINV_{it} = 1)$, conditional on its characteristics one year prior to investment, X_{it-1}:

$$P(GINV_{it} = 1) = F(X_{it-1}, I_j, T_t) \quad (1)$$

I_j, T_t denote industry and time fixed effects.

Second, we match each firm that invests to a firm with similar characteristics in the same year and in the same sector that never invested (the closest "neighbour", a firm having a similar propensity to invest).

The validity of the matching procedure depends on whether each independent variable is "balanced" i.e. it does not differ significantly between the firms with green investments (the "treated" group) and the matched firms without green investments (the "control" group). To verify that this balancing condition holds we use a range of tests used in the recent literature (see for example, Smith and Todd 2005; Bandick, Görg and Karpaty 2014).

Third, we compare the average performance of the "treated" and of the "control" group before (one year before) and up to five years after the green investment. The difference in the performance change of the "treated" and "control" groups captures the impact of green investment, β:

$$\beta = \sum_{i \in GINV} [\Delta y_i - \sum_{j \in C} (p_i, p_j) \Delta y_j] \quad (2)$$

p_i denotes the predicted probability for a given firm *i* in the "treated" group (*GINV*) to engage in green investments (using the estimates obtained with Eq. 1), p_j is the predicted probability for firm j in the "control" group (C) to engage in green investments, Δy_i is the log difference between the average firm performance outcome before and after green investment for a given

firm i in the treated group, Δy_j is the log difference between the average firm performance outcome over the period for the matched firm in the control group.

A caveat related to the available data is to be noted. The available data starts in 2008 and we do not have information about prior green investments. As a consequence, we cannot identify the first time firms engaged in green investment. Our analysis captures the effects of green investments on firm performance assuming that these are independent from previous green investments.

3 Data and Summary Statistics

The data we use comes from the Census of Industrial Production (CIP) Survey carried out by Ireland's Central Statistics Office (CSO). The survey covers industrial enterprises with three and more persons engaged. According to the CSO (2016), enterprises with three and more persons engaged account for 97% of the total industrial turnover and enterprises that responded to the survey represented 92% of total employment. Therefore, the CIP data has a good representation of Ireland's industry sector. In this paper, our analysis focuses on the manufacturing and utilities sectors.

However, even though the data has a good coverage, the response rate to the survey may differ by firm size, which may potentially affect the representativeness of the sample of the overall industries. To have an idea of the full population, we refer to the Business Register (BR) data, which is also provided by the CSO. The Business Register data includes all firms that are registered in Ireland. It provides information on firms' primary activity industry (NACE Rev. 2 classification), date of birth, location and employment. The BR data is matched with CIP data based on a common firm identifier. To be consistent with the CIP survey, only firms with three and more persons engaged are used to construct the considered population of firms.

We define a sample stratum by a firm's primary sector, year and its four size groups of persons engaged (3-19; 20-49; 50-249; and 250+). When comparing the sample size in the CIP to the population of firms in the BR data in each stratum, it seems that larger firms have a higher response rate to the CIP survey than smaller firms. The response rate for firms with 50 and more persons engaged is over 80%, while it is 30% for firms with 3-19 persons engaged. To account for the potential bias introduced by various response rates from different strata, we weigh our estimates with relative weights. The idea is that a higher weight should be given to

strata with a lower response rate because there would be a larger number of firms in the survey if their response rate were as high as other strata.

Table 1: Survey response rates and sampling weights by firm size, 2008-2016

Number of people engaged (size)	Response rate	Absolute weight	Relative weight
3-19	0.30	3.74	2.41
20-49	0.65	1.57	1.01
50-249	0.82	1.24	0.80
250+	0.90	1.12	0.72
Overall	0.72	1.55	1

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: The response rate equals the number of firms in the CIP survey (sample) divided by the total number of firms in the Business Register data (population) in each size-sector-year stratum.

The relative weights are calculated as follows. First, we compute the absolute weight of a size-sector-year stratum as the number of firms in the population from the Business Register over the number of firms in the CIP survey in each stratum. Second, we compute the overall absolute weight over all firms (with three and more persons engaged) in all sectors and years. The relative weight is the ratio of the absolute weight of a stratum over the overall absolute weight. The relative weight is applied to each firm-year observation with firm-year observations in the same stratum having the same weight. Table 1 summarizes the response rates, and the absolute and relative weights by firm size over the analysed period, 2008-2016. The response rates and absolute weights by year are shown in Table A1 in the Appendix. The annual response rates range from 69 to 77 per cent.

We define green investments as the sum of investment (capital expenditures) in plant and equipment for the purposes of pollution control (PC) and investment in plant and equipment linked to cleaner technologies (CT). The investment figures are obtained from reported information on changes in capital stocks. Accounting these expenditures as capital expenditures is based on the effects they produce over more than one year. In contrast, current expenditures on environmental production are accounted as intermediate consumption (they do not have effects beyond the year in which they take place).

However, not all enterprises are required to report capital expenditures including green investments as defined above. Firms with less than 20 persons engaged are sent a shorter survey questionnaire (Form C) and are required to report a more limited amount of information (e.g., turnover, total persons engaged, change in total capital assets, foreign or local firm and few additional variables). Larger firms, with 20 and more persons engaged, are sent a more detailed survey questionnaire (Form F) and are required to report more information, including

investment in plant and equipment for pollution control and investment in plant and equipment for clean technologies. These enterprises represent around 49% of the total number of enterprises in the data set and we only include these firms in our analysis.[2] We exclude from the analysis firms which have negative gross value added, around 2% of total observations. The resulting sample consists of 9,295 firm-year observations over the period 2008-2016.

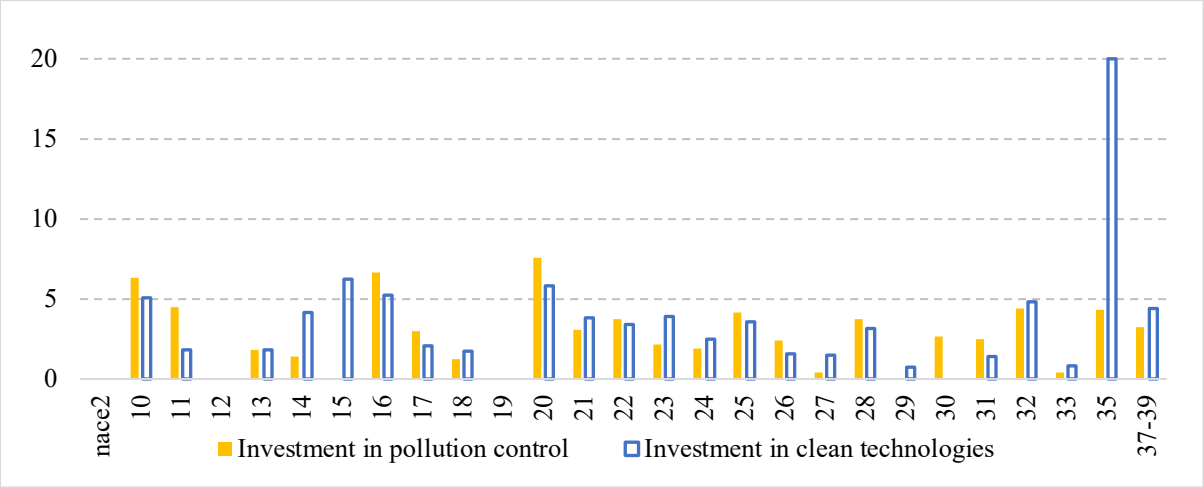
Figure 1 presents the proportion of firms with investment in environmental protection by industry, where an industry is defined at 2 digit NACE Rev.2. classification. On average, only 3.9% of firms invested in equipment for pollution control in a year and only 3.7% of firms invested in equipment linked to cleaner technologies. These results are similar to the investment rates found by Haller and Murphy (2012). Using data for 2006 and 2007, they found that only 5.4% of firms in manufacturing invested in equipment for pollution control. However, these investment rates are much lower than figures reported by Anderson et al. (2011), as they use data from a survey which included a much smaller number of firms than the number of firms in the CIP data set.

As shown in Figure 1, in comparison to manufacturing, the energy sector has a much higher rate of investment in equipment linked to cleaner technologies, around 20% in the analysed data set. This result is not surprising given the strong regulations on emissions in place in this sector.

Figure 2 shows that the rates of green investments are similar across different regions in Ireland. Among all firms, the rate of investment in equipment for pollution control or for investment in equipment linked to cleaner technology is lower than 5.5%. In comparison to firms in other regions, firms located in Midlands have a slightly higher investment rate in the case of investment in equipment linked to cleaner technologies, while they invest less in equipment for pollution control. Firms in South-East have high investment rates in the case of both green investments. In contrast, firms in the South-West and West regions have low investment rates in both green investments.

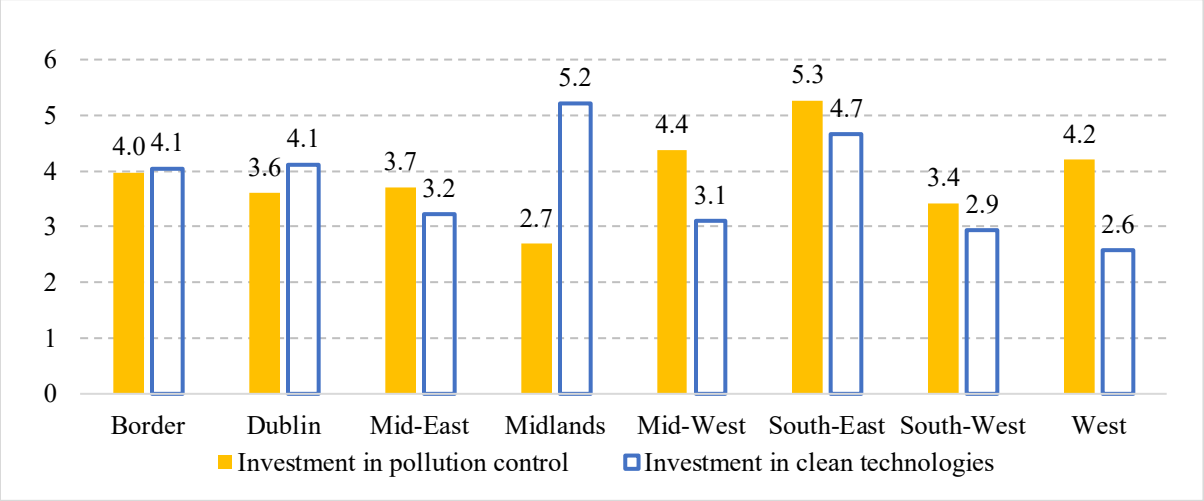
[2] However, not responding to Form F does not mean the enterprise does not invest in environmental protection. The censoring of data may potentially induce selection bias if we only consider enterprises that respond to Form F. Ideally, one may use the Heckman selection model to account for data censoring. However, such selection correction is difficult to incorporate with the propensity score matching method and thus, we do not consider it in this paper. In a separate paper, we show that such a selection bias does not have a significant impact on results (Siedschlag and Yan 2020).

Figure 1: Green investment rates by industry, 2008-2016



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: The NACE Rev. 2 classification codes are as follows: 10 Manufacture of food products; 11 Manufacture of beverages; 12 Manufacture of tobacco products; 13 Manufacture of textiles; 14 Manufacture of wearing apparel; 15 Manufacture of leather and related products; 16 Manufacture of wood and products of wood and cork; except furniture; manufacture of articles of straw and plaiting materials; 17 Manufacture of paper and paper products; 18 Printing of reproduction of recorded media; 19 Manufacture of coke and refined petroleum products; 20 Manufacture of chemicals and chemical products; 21 Manufacture of basic pharmaceutical products and pharmaceutical preparations; 22 Manufacture of rubber and plastic products; 23 Manufacture of other non-metallic mineral products; 24 Manufacture of basic metals; 25 Manufacture of fabricated metal products, except machinery and equipment; 26 Manufacture of computer, electronic and optical products; 27 Manufacture of electrical equipment; 28 Manufacture of machinery and equipment n.e.c.; 29 Manufacture of motor vehicles, trailers and semi-trailers; 30 Manufacture of other transport equipment; 31 Manufacture of furniture; 32 Other manufacturing; 33 Repair and installation of machinery and equipment; 35 Electricity, gas, steam and air conditioning supply; 37 Sewerage; 38 collection, treatment and disposal activities; materials recovery; 39 Remediation activities and other waste management services.

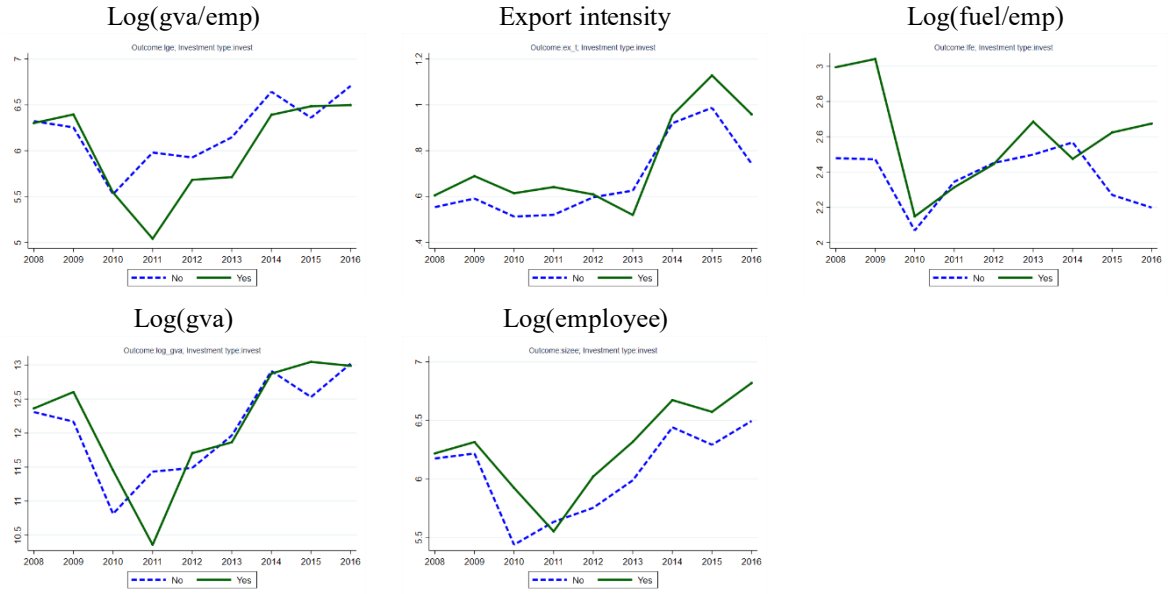
Figure 2. Green investment rates by region, 2008-2016



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

To have a basic idea of the differences of performance between firms that have green investment or not, Figure 3 shows the evolution over 2008-2016 of the five performance outcome variables for firms that *ever* invest versus firms that *never* invest. The green solid line represents firms that invest at least once in equipment for pollution control or in equipment linked to cleaner technologies (treatment), and the blue dotted line represents firms that never invest (control group). The five output variables are labour productivity, export intensity, energy intensity, gross value added and employment. The shown values are weighted averages, using absolute weights.

Figure 3. Trends of outcome variables by firms' participation, green investment



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Notes: The green solid line represents firms that ever invest in pollution control or clean technologies, and the blue dotted line represents firms that never invest. The outcome variables are weighted.

The performance of treated firms and firms in the control group over time have similar trends. For both groups, their performance drops initially before 2011 and then start to recover. The initial drop might be due to the financial crisis in 2007 and the "post-2008 Irish economic downturn". Despite such similarities, firms with green investments tend to have higher energy intensity and a larger firm size.

Table 2 shows summary statistics of the performance outcome variables and co-variates used in the empirical analysis for all firms in our analysis.

Table 2: Summary statistics, all firms, 2008-2016

Variables	Description	N	mean	median	sd	min	max
Log(gva/emp)	Gross value added in 1000 euro per employee (log)	9295	3.98	4.02	1.15	0.00	7.81
Export intensity	Percent of export sales in total turnover	9295	0.43	0.23	0.43	0.00	1.00
Log(fuel/emp)	Fuel consumption in 1000 euro per employee (log)	9295	1.54	1.38	0.90	0.00	4.89
Log(gva)	Gross value added in 1000 euro (log)	9295	7.76	7.77	2.03	0.69	15.66
Log(employee)	Number of total persons engaged (log)	9295	3.90	3.69	1.05	1.10	8.94
Log(employee)^2	Number of total persons engaged squared (log)	9295	16.28	13.61	9.26	1.21	79.88
Log(wage)	Labour cost in 100 euro per employee (log)	9295	3.73	3.73	0.41	0.00	4.96
Importer	Dummy = 1, if the firm imports in a year	9295	0.81	1	0.40	0	1
Exporter	Dummy = 1, if the firm exports in a year	9295	0.67	1	0.47	0	1
Supply chain link	Dummy = 1, if the firm supplies material to affiliates	9295	0.22	0	0.42	0	1
Irish-owned	Dummy =1, if the firm is Irish-owned	9295	0.31	0	0.46	0	1

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Values above the 99.5th percentile are set to the value of the 99.5th percentile to eliminate the influence of outliers. The summary statistics are weighted.

Table 3. Summary statistics for firms with and without green investments, 2008-2016

	Firms with no green investments						Firms with green investments					
	N	mean	median	sd	min	max	N	mean	median	sd	min	max
Log(gva/emp)	8689	3.97	4.01	1.15	0.00	7.81	606	4.22	4.13	1.19	0.01	7.81
Export intensity	8689	0.42	0.21	0.43	0.00	1.00	606	0.52	0.52	0.43	0.00	1.00
Log(fuel/emp)	8689	1.52	1.37	0.89	0.00	4.89	606	1.84	1.61	1.04	0.00	4.89
Log(gva)	8689	7.71	7.73	2.01	0.69	15.66	606	8.54	8.46	2.24	0.69	15.26
Log(employee)	8689	3.86	3.66	1.03	1.10	8.93	606	4.41	4.14	1.28	1.61	8.94
Log(employee)^2	8689	15.98	13.42	8.88	1.21	79.82	606	21.11	17.17	13.02	2.59	79.88
Log(wage)	8689	3.73	3.73	0.41	0.00	4.96	606	3.81	3.77	0.43	2.56	4.96
Importer	8689	0.80	1	0.40	0	1	606	0.90	1	0.30	0	1
Exporter	8689	0.67	1	0.47	0	1	606	0.78	1	0.42	0	1
Supply chain link	8689	0.22	0	0.41	0	1	606	0.32	0	0.47	0	1
Irish	8689	0.31	0	0.46	0	1	606	0.34	0	0.47	0	1

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Values above the 99.5th percentile are set to the value of the 99.5th percentile to eliminate the influence of outliers. Summary statistics are weighted.

Table 3 shows the summary statistics for the treated and control groups. The monetary variables are deflated by the industry-specific producer prices indices in each industry from the Eurostat and are in constant 2015 prices. The top 0.5% of each variable is winsorized to eliminate the influence of outliers.[3] In general, firms that ever invested in equipment for pollution control or for clean technologies have a better performance in terms of gross value added, export intensity and labour productivity than firms that never have green investment. They are also larger in size, are more likely to be part of a corporation-group (supply materials to affiliates) and are

[3] Values above the 99.5th percentile are set to the value of the 99.5th percentile.

more likely to engage in international business (importer or exporter). On the other side, they consume more fuel per employee than other firms.

4 Empirical Results

In this section, we first show the results from the difference-in-difference propensity score matching for all firms. We then examine the impact of green investments by groups of firms.

4.1 Average effects across all firms

The co-variates we use to calculate the propensity scores are gross value added, firm size, firm size squared, importer, export, supply chain link and ownership (Irish or foreign-owned).[4] All co-variates are lagged by one year to alleviate potential endogeneity. We also include year dummies and sector dummies, and ensure that a treated firm is matched to a control firm in the same year and in the same sector. Table 4 shows the estimates of the first stage probit model. Coefficients are listed in column (1) and marginal effects are shown in column (2). The results suggest that larger firms are more likely to invest. Importers and firms which are part of a corporate group are more likely to invest. The effect of firm size shows an inverted-bell shape, suggesting that smaller and larger firms are more likely to invest than firms of medium size. The turning point is at around 36 employees. Moreover, controlling for other factors, local firms are more likely to invest.

Table 4: Determinants of firms' propensity to engage in green investments

	Beta (1)	Marginal effects (2)
Log(gva)	0.063**	0.009**
	(0.027)	(0.004)
Log(employee)	-0.487**	-0.066**
	(0.228)	(0.030)
Log(employee)^2	0.068***	0.009***
	(0.023)	(0.003)
Importer	0.425***	0.057***
	(0.166)	(0.022)
Exporter	0.055	0.007
	(0.097)	(0.013)
Supply chain link	0.291***	0.039***
	(0.082)	(0.012)
Irish-owned	0.295***	0.040***
	(0.101)	(0.014)
Constant	-1.427***	

[4] These co-variates are selected as they produce a good balance of the treated and control groups. We show the balancing tests later in this section.

	(0.524)
Observations	5402
Pseudo R^2	0.10
Log likelihood	-1451

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Co-variates are lagged by one year. Year dummies and sector dummies are included. Robust standard errors in parentheses are clustered at NACE Rev2. 3-digit level. *** p<0.001, ** p<0.05, * p<0.1. Estimates are unweighted.

The main results of the impact of green investments on firms' performance are shown in Table 5. We show the impact year by year from the year when a firm invests (year=0) up to 5 years after investment, as we believe that, the impact might be immediate for some performance outcome indicators while it would take a longer time for effects to emerge for others. We also compute the three years and five years average effects. The number of matched green investors is also shown in this table. The longer the time post-investment, there are fewer matched cases. All performance indicators are weighted by the relative weights. p-values are reported in parentheses based on robust standard errors and the bias of all continuous co-variates are adjusted as suggested in Abadie and Imbens (2006, 2011, 2012).

Overall, our results suggest that green investments have positive effects on firms' performance. To facilitate the reading of the results, we take the impact of green investments on labour productivity as an example. In the investment year (year=0), the growth rate of labour productivity is 8.6% higher for firms with green investment than for firms without. This difference becomes larger, 13.8% in the 3rd year after green investment. The average effect over 3 years after the first investment is 13.4%, and 12.4% over 5 years.

Moreover, the results show an interesting pattern. Indeed, green investments have immediate and short-run impacts on some performance outcomes, while their effects on other performance outcomes takes longer to materialize. For example, green investments led to a higher output growth (measured by gross value added) from the time of investment to up to three years post-investment, while the effect disappears from the 4th year. The growth rate of firms with green investment is 13.8% higher than for firms without such investment in the year of investment. The growth differential is 23.8% in the 3rd year after the investment. The increasing difference is likely to be due to cumulative effects of green investments, as investors may invest in consecutive years. On the other hand, the effects of green investment take longer to appear in the case of energy intensity and employment growth. In both cases, the impacts start to emerge from the second year after investment. In the second year after green investment, the energy intensity reduction differential for firms with green investment is 6.4% compared to firms

without green investment, and the employment growth differential for investors is 3.9% higher than in the case of non-investors.

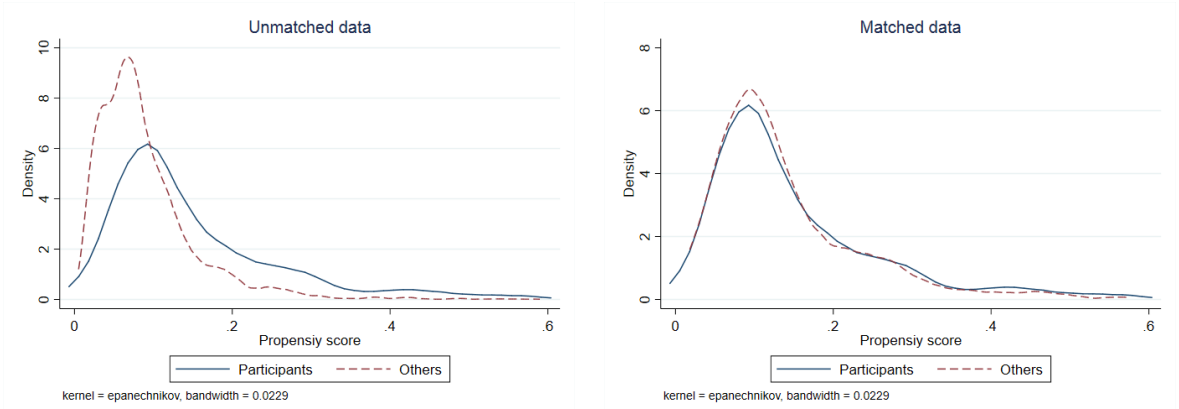
Table 5: The effects of green investments on firm performance

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	426	339	282	225	166	113	426	426
Log(gva/emp)	0.086	0.094	0.155	0.138	-0.057	-0.049	0.134	0.124
	(0.098)	(0.082)	(0.013)	(0.067)	(0.339)	(0.499)	(0.005)	(0.008)
Export intensity	0.007	0.015	-0.01	0.02	0.011	-0.01	0.01	0.005
	(0.678)	(0.429)	(0.647)	(0.433)	(0.722)	(0.785)	(0.591)	(0.757)
Log(fuel/emp)	-0.005	-0.03	-0.064	-0.125	-0.14	-0.109	-0.047	-0.059
	(0.834)	(0.347)	(0.042)	(0.000)	(0.000)	(0.036)	(0.06)	(0.022)
Log(gva)	0.138	0.129	0.223	0.238	0.018	0.055	0.206	0.196
	(0.086)	(0.104)	(0.011)	(0.026)	(0.841)	(0.608)	(0.005)	(0.006)
Log(employee)	0.018	0.014	0.039	0.054	0.091	0.114	0.026	0.033
	(0.107)	(0.349)	(0.063)	(0.023)	(0.002)	(0.003)	(0.048)	(0.021)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses based on robust standard errors.

The validity of our results depends on the explanatory variables for the control and treated groups being balanced after matching. The estimated balancing tests for the matching are shown in Figure 5 and in Table 6. Figure 5 shows that the distributions of estimated propensity scores are similar for treated and control groups after matching. Table 6 indicates that the distributions of co-variates are also similar for treated and control groups after matching. These post-matching tests reassure our estimates presented in Table 5.

Figure 5: Balancing test, unmatched and matched data of green investment



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

Table 6: Balancing tests for firms' propensity to engage in green investment

	Treated	426	Control	3969
	Standardized differences		Variance ratio	
	Raw	Matched	Raw	Matched
Log(gva)	0.495	0.089	1.080	1.275
Log(employee)	0.513	0.052	1.652	1.151
Log(employee)^2	0.515	0.064	2.056	1.167
Importer	0.253	-0.009	0.543	1.028
Exporter	0.292	-0.006	0.664	1.012
Supply chain link	0.376	0.039	1.379	1.018
Irish	0.079	-0.005	1.058	0.997

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

4.2 Firm heterogeneity

Having estimated the average impacts of green investment on investors' performance outcomes, one interesting question is whether such impacts differ for different groups of firms. We therefore investigate the heterogeneous impacts of green investments for groups of firms which vary by firm size (small, medium-sized, large), ownership (Irish and foreign-owned), productivity (low and high labour productivity), energy intensity (low and high energy intensity), technology intensity (low, and medium and high technology intensity). We further analyse industry-specific effects of green investments in the food industry, one of the industries with a high pollution intensity.

A firm is defined as small and medium-sized (SME) if it has less than 250 employees or if its annual turnover does not exceed 50 million euros. A firm is defined as small if it has less than 50 employees or if its annual turnover does not exceed 10 million euros. To classify a firm as having high or low labour productivity, we compute the average labour productivity of a firm between 2008 and 2016. A firm is defined as having high labour productivity if its labour productivity is higher than the median of all firms in the same sector. This approach avoids the mixture of firms across sectors, as some sectors tend to have higher labour productivity than others. Firms with higher/lower energy (fuel consumption) intensity are defined in a similar way relative to the median energy intensity for all firms in the same sector. To classify firms by technology intensity, we use the Eurostat's aggregation of manufacturing industries based on NACE Rev. 2.[5]

[5] The classification is available from the Eurostat at the following web link: https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf.

Table 7 summarizes the number of observations and the average investment rate for each of the groups of firms considered. Green investment rates vary across these groups of firms. Overall, larger firms (medium and large or large firms) have higher investment rates than smaller firms.[6] More productive firms and firms with a higher energy intensity are more likely to invest in environmental protection.

Table 7: The proportion of firm groups in the total number of firms and investment rates

SME	% obs	0.90	Large	% obs	0.10
	Invest	0.06		Invest	0.13
Small	% obs	0.57	Medium and Large	% obs	0.43
	Invest	0.05		Invest	0.09
Irish	% obs	0.28	Foreign	% obs	0.72
	Invest	0.07		Invest	0.06
Higher labour productivity	% obs	0.55	Lower labour productivity	% obs	0.45
	Invest	0.08		Invest	0.05
Higher fuel intensity	% obs	0.52	Lower fuel intensity	% obs	0.48
	Invest	0.08		Invest	0.05
Higher-medium tech industries	% obs	0.53	Low tech industries	% obs	0.38
	Invest	0.06		Invest	0.07
Food industry	% obs	0.22			
	Invest	0.09			

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. The categories are created based on average values of a firm between 2008 and 2016. A firm is defined as SME if it has less than 250 employees or if its annual turnover does not exceed 50m euros. A firm is defined as Small if it has less than 50 employees or if its annual turnover does not exceed 10m euros. A firm is defined as a higher half if its index is higher than the median of that sector.

Tables 8a to 8c present the results of the effects of green investments on firm performance by firm group obtained with the difference-in-difference propensity score methodology. We list the average effects of green investments on firm performance over three and over five years. The year-by-year effects are shown in Tables A7-A16 in the Appendix. The results suggest that medium and large firms may benefit more from green investment than small firms. For example, relative to non-investors, the productivity growth differential in the case of medium and large investors is 9.4% on average over three years after investment and 9.6% on average after five years, while the difference is not significant for small investors. The impacts of green investments on energy intensity, gross value added, and employment growth are also only significant for medium and large firms but not for small firms.

[6] Ideally, one would separate firms into SME and non-SME. However, for non-SMEs we have very few observations in the data, therefore, we combine Medium sized firms with Large size, and compare it with small sized firms.

Foreign-owned firms appear to benefit more than local firms from green investments. The effects of green investments on the performance of Irish-owned firms do not appear to be statistically significant. We also find that green investors in the group of firms with a higher labour productivity have a significantly better performance with respect to the growth of labour productivity, output and the reduction of energy intensity than green investors with lower productivity. If firms are split by their energy intensity, green investors in the group of firms with high energy intensity have larger performance gains with respect to the growth of output, and labour productivity than green investors with low energy intensity. However, the impact of green investment does not appear to be significant in the case of energy intensity and employment growth. On the other hand, green investments do not have significant effects on the performance of firms with low energy intensity.

Table 8a. Differential effects of green investments on firm performance by firm size and ownership

	Small		Medium and Large		Irish		Foreign	
Cases	128		209		144		255	
Years' mean	3	5	3	5	3	5	3	5
Log(gva/emp)	0.17	0.155	0.094	0.096	0.061	0.061	0.19	0.17
	(0.112)	(0.134)	(0.061)	(0.047)	(0.474)	(0.474)	(0.002)	(0.005)
Export intensity	0.054	0.045	-0.005	-0.007	-0.001	-0.001	0.019	0.012
	(0.22)	(0.294)	(0.811)	(0.742)	(0.972)	(0.972)	(0.193)	(0.405)
Log(fuel/emp)	0.014	0.00	-0.092	-0.108	-0.027	-0.027	-0.067	-0.087
	(0.784)	(0.996)	(0.001)	(0.000)	(0.587)	(0.587)	(0.009)	(0.001)
Log(gva)	0.179	0.15	0.163	0.171	0.046	0.046	0.307	0.284
	(0.284)	(0.343)	(0.025)	(0.015)	(0.728)	(0.728)	(0.001)	(0.001)
Log(employee)	-0.046	-0.043	0.037	0.042	-0.01	-0.01	0.049	0.06
	(0.089)	(0.131)	(0.026)	(0.02)	(0.647)	(0.647)	(0.006)	(0.002)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology p-value reported in parentheses based on robust standard errors.

Table 8b. Differential effects of green investments on firm performance by firm productivity and energy intensity

	Higher labour productivity		Lower labour productivity		Higher energy intensity		Lower energy intensity	
Cases	256		97		241		118	
Years' mean	3	5	3	5	3	5	3	5
Log(gva/emp)	0.195	0.187	0.008	0.007	0.194	0.192	-0.064	-0.072
	(0.001)	(0.001)	(0.911)	(0.919)	(0.00)	(0.00)	(0.438)	(0.378)
Export intensity	-0.008	-0.01	0.058	0.048	0.019	0.012	-0.005	0.002
	(0.729)	(0.694)	(0.085)	(0.137)	(0.357)	(0.549)	(0.898)	(0.967)
Log(fuel/emp)	-0.058	-0.061	-0.037	-0.068	-0.034	-0.045	0.001	-0.014

	(0.055)	(0.046)	(0.468)	(0.197)	(0.305)	(0.182)	(0.983)	(0.725)
Log(gva)	0.283	0.277	0.048	0.048	0.288	0.286	-0.098	-0.101
	(0.001)	(0.001)	(0.724)	(0.686)	(0.00)	(0.00)	(0.491)	(0.48)
Log(employee)	0.025	0.032	0.026	0.03	0.018	0.023	-0.008	-0.001
	(0.164)	(0.089)	(0.256)	(0.224)	(0.243)	(0.176)	(0.767)	(0.98)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: p-value reported in parentheses based on robust standard errors.

Furthermore, green investments have significant impacts only on the performance outcomes of investors in low tech industries, but not on that in high or medium technology industries. This result may be due to the fact that low tech industries have heavier pollution, and hence, reducing pollution might stimulate their performance. Last but not least, green investments improve the performance of firms in the food industry.

Table 8c. Differential effects of green investments on firm performance by industry group technology intensity and for firms in the food industry

	Medium and high tech		Low tech		Food industry	
Cases	184		198		158	
Years' mean	3	5	3	5	3	5
Log(gva/emp)	0.043	0.052	0.197	0.168	0.246	0.217
	(0.441)	(0.356)	(0.006)	(0.013)	(0.005)	(0.009)
Export intensity	0.004	0.008	0.029	0.017	0.046	0.037
	(0.851)	(0.725)	(0.343)	(0.561)	(0.191)	(0.277)
Log(fuel/emp)	0.001	-0.004	-0.065	-0.082	-0.103	-0.124
	(0.98)	(0.904)	(0.062)	(0.022)	(0.004)	(0.001)
Log(gva)	0.051	0.072	0.313	0.277	0.396	0.355
	(0.531)	(0.387)	(0.005)	(0.008)	(0.004)	(0.005)
Log(employee)	0.016	0.021	0.035	0.043	0.039	0.046
	(0.354)	(0.253)	(0.090)	(0.050)	(0.112)	(0.077)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology p-value reported in parentheses based on robust standard errors.

5 Conclusions

This paper examines the impact of green investments on a range of firm performance outcomes in Ireland. To this purpose, we use data from the Census of Industrial Production over 2008-2016 made available by Ireland's Central Statistics Office. We employ a difference-in-difference propensity score matching methodology to identify the causal effects of green investments on the growth of labour productivity, export intensity, gross value added, employment and the reduction of energy intensity measured by fuel consumption per employee.

After carefully matching of green investors to non-investors with similar characteristics in the same year and industry, we find that on average, across all firms, green investments have positive effects on a range of firms' performance outcomes. Green investments appear to increase the growth rates of labour productivity, gross value added and employment and reduce energy intensity, which means they increase the energy efficiency of investors. However, we do not find a significant impact of green investment on how much firms export. Our results also reveal that some impacts are immediate (i.e. on the growth of output and labour productivity), while other effects take longer to emerge (i.e. on energy intensity and employment growth).

Furthermore, our results uncover differential effects of green investments by firm groups. Green investments have significant impacts on performance outcomes for firms which are larger, foreign-owned, with high labour productivity and firms in low-technology industries. Green investments do not have significant effects on the performance of small firms, local firms, firms with low labour productivity, and firms in industries with high and medium technology intensity. Moreover, although green investments can help energy intensive firms to grow their gross value added and labour productivity, they do not impact significantly on their energy intensity. Finally, green investments by firms in the food industry improve their performance with the exception of export intensity.

Taken together, our results suggest that environmental quality and firm performance go together. However, we find that not all firms benefit equally from green investments. This result suggests that in the medium term not all firms have the capacity to generate substantial benefits from green investments to overweigh the associated costs. Such benefits could be larger for all firms in the long term. Longer time series when available would allow the extension of this research.

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Appendix

Table A1. Survey response rate and sampling weight by year

Year	Response rate	Absolute weight
2008	0.68	1.57
2009	0.69	1.63
2010	0.77	1.38
2011	0.79	1.52
2012	0.77	1.49
2013	0.75	1.53
2014	0.69	1.62
2015	0.70	1.57
2016	0.68	1.66
Average	0.72	1.55

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: the response rate is equal to the number of firms in the CIP survey (sample) divided by the total number of firms in the Business Register data (population) in each size-sector-year stratum. The absolute weight is the total number of firms in the population of firms in the Business Register over the number of firms in the CIP survey.

Table A2. Determinants of firms' propensity to invest in equipment for pollution control and in equipment linked to cleaner technologies

	Pollution control		Cleaner technologies	
	Beta	Marginal effects	Beta	Marginal effects
	(1)	(2)	(3)	(4)
Log(gva)	0.053*	0.004*	0.072*	0.006*
	(0.028)	(0.002)	(0.037)	(0.003)
Log(employee)	-0.585**	-0.044**	0.139**	0.011**
	(0.268)	(0.018)	(0.062)	(0.005)
Log(employee)^2	0.079***	0.006***		
	(0.029)	(0.002)		
Importer	0.544***	0.041***	0.208	0.017
	(0.198)	(0.015)	(0.162)	(0.012)
Exporter	-0.044	-0.003	0.209**	0.017*
	(0.102)	(0.008)	(0.112)	(0.009)
Supply chain link	0.317***	0.024***	0.251**	0.020**
	(0.099)	(0.008)	(0.101)	(0.009)
Irish	0.318***	0.024**	0.414***	0.033***
	(0.121)	(0.009)	(0.118)	(0.01)
Constant	-1.417**		-3.34***	
	(0.633)		(0.323)	
Observations	5850		5848	
Pseudo R^2	0.11		0.08	
Log likelihood	-1015		-1012	

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Co-variates are lagged by one year. Robust standard errors in parentheses are clustered at NACE Rev. 2 3-digit level.
*** p<0.001, ** p<0.05, * p<0.1.

Table A3. The effects of investment in equipment for pollution control on firm performance

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	229	177	136	107	75	56	229	229
Log(gva/emp)	0.062	0.063	0.223	0.263	0.149	0.015	0.114	0.126
	(0.397)	(0.399)	(0.017)	(0.05)	(0.117)	(0.892)	(0.073)	(0.037)
Export intensity	0.035	-0.003	0.028	0.042	-0.008	-0.059	0.037	0.026
	(0.086)	(0.924)	(0.323)	(0.249)	(0.847)	(0.202)	(0.073)	(0.196)
Log(fuel/emp)	-0.029	-0.031	-0.09	-0.104	-0.042	-0.065	-0.072	-0.079
	(0.287)	(0.420)	(0.028)	(0.021)	(0.432)	(0.458)	(0.009)	(0.005)
Log(gva)	0.081	0.063	0.258	0.366	0.268	0.028	0.154	0.17
	(0.458)	(0.548)	(0.040)	(0.059)	(0.086)	(0.867)	(0.101)	(0.053)
Log(employee)	0.008	-0.009	0.009	0.026	0.025	-0.004	0.015	0.016
	(0.486)	(0.666)	(0.716)	(0.363)	(0.498)	(0.94)	(0.316)	(0.312)

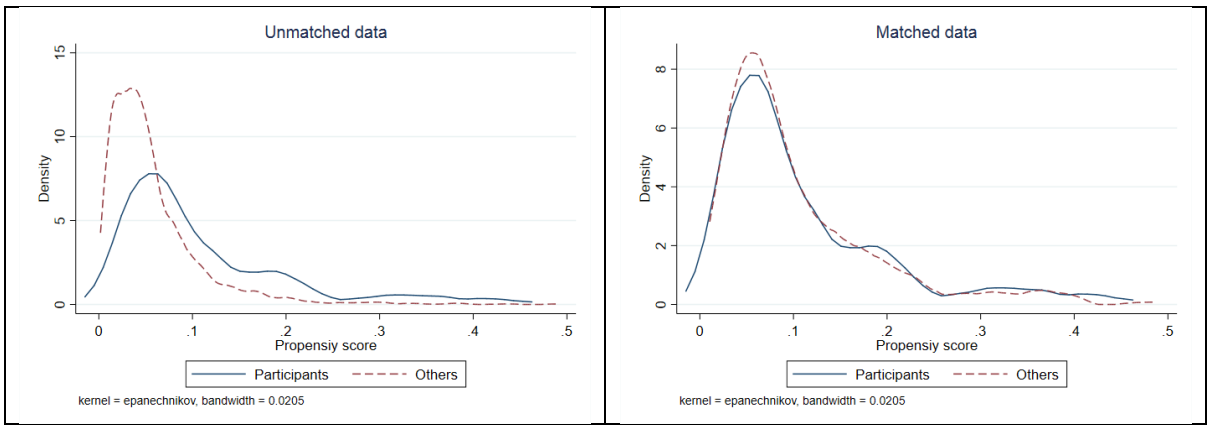
Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A4. The effects of investment in equipment linked to cleaner technologies on firm performance

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	216	179	150	114	88	55	216	216
Log(gva/emp)	0.006	0.063	0.031	0.103	-0.144	-0.122	0.034	0.021
	(0.913)	(0.409)	(0.708)	(0.262)	(0.117)	(0.27)	(0.432)	(0.651)
Export intensity	-0.003	0.008	-0.015	-0.044	0.025	-0.048	-0.015	-0.018
	(0.936)	(0.767)	(0.563)	(0.276)	(0.439)	(0.33)	(0.604)	(0.532)
Log(fuel/emp)	0.003	-0.052	-0.025	-0.102	-0.125	-0.059	-0.044	-0.056
	(0.925)	(0.191)	(0.559)	(0.069)	(0.006)	(0.245)	(0.221)	(0.125)
Log(gva)	0.002	0.09	-0.028	0.187	-0.187	-0.144	0.026	0.007
	(0.983)	(0.439)	(0.826)	(0.163)	(0.149)	(0.354)	(0.695)	(0.915)
Log(employee)	0.009	0.009	-0.009	0.018	0.018	0.028	-0.001	0.001
	(0.421)	(0.598)	(0.776)	(0.666)	(0.510)	(0.462)	(0.963)	(0.939)

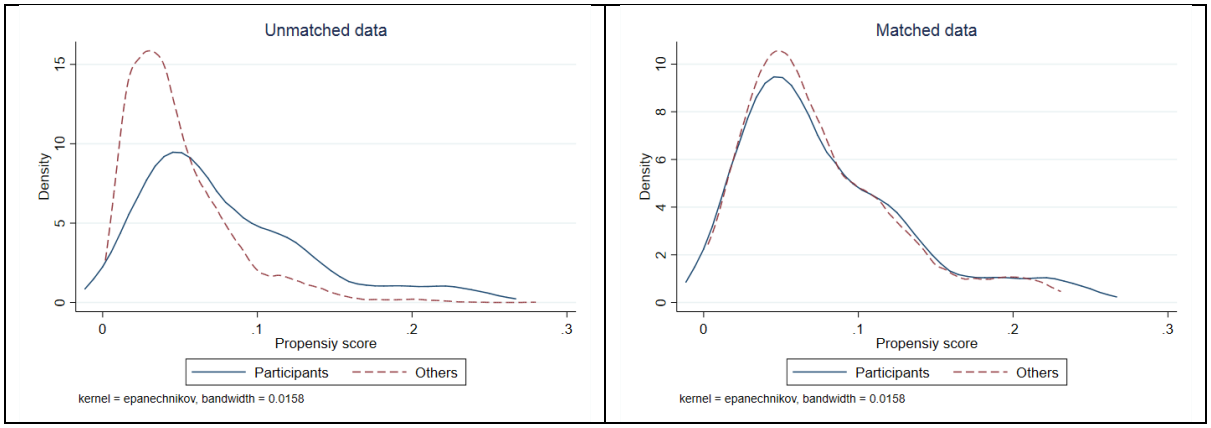
Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Figure A1. Balancing test for firms' propensity to invest in equipment for pollution control



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

Figure A2. Balancing test for firms' propensity to invest in equipment for cleaner technologies



Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

Table A5. Balancing tests for the propensity score matching, investment in equipment for pollution control and equipment linked to cleaner technologies

	Pollution control				Cleaner technologies			
	Treated	229	Control	3181	Treated	216	Control	3638
	Standardized differences		Variance ratio		Standardized differences		Variance ratio	
	Raw	Matched	Raw	Matched	Raw	Matched	Raw	Matched
Log(gva)	0.483	0.023	0.993	1.147	0.501	0.106	0.921	1.233
Log(employee)	0.526	0.021	1.680	1.127	0.459	0.083	1.468	1.135
Log(employee)^2	0.533	0.033	2.099	1.127				
Importer	0.309	-0.019	0.437	1.072	0.188	0.000	0.637	1.000
Exporter	0.211	-0.012	0.744	1.021	0.404	0.000	0.518	1.000
Supply chain link	0.409	0.044	1.386	1.018	0.431	0.009	1.382	1.003
Irish	0.076	0.009	1.043	1.004	0.080	-0.010	1.056	0.995

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.

Table A6. Year by year effects of green investments on firm performance, small firms

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	128	94	68	61	41	31	128	128
Log(gva/emp)	0.045	0.072	0.35	0.251	-0.195	-0.11	0.17	0.155
	(0.733)	(0.595)	(0.029)	(0.221)	(0.236)	(0.57)	(0.112)	(0.134)
Export intensity	0.034	0.081	0.068	0.053	-0.036	-0.023	0.054	0.045
	(0.463)	(0.039)	(0.156)	(0.37)	(0.612)	(0.803)	(0.22)	(0.294)
Log(fuel/emp)	0.073	0.008	-0.035	-0.112	-0.052	-0.052	0.014	0
	(0.11)	(0.912)	(0.669)	(0.135)	(0.566)	(0.601)	(0.784)	(0.996)
Log(gva)	-0.016	0.057	0.473	0.397	-0.213	-0.065	0.179	0.15
	(0.935)	(0.775)	(0.025)	(0.169)	(0.404)	(0.818)	(0.284)	(0.343)
Log(employee)	-0.052	-0.034	0.022	0.077	0.106	0.128	-0.046	-0.043
	(0.029)	(0.292)	(0.649)	(0.123)	(0.067)	(0.069)	(0.089)	(0.131)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-values are reported in parentheses.

Table A7. Year by year effects of green investments on firm performance, medium and large firms

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	209	177	155	111	80	44	209	209
Log(gva/emp)	0.068	0.076	0.094	0.168	0.063	0.068	0.094	0.096
	(0.155)	(0.234)	(0.262)	(0.076)	(0.413)	(0.55)	(0.061)	(0.047)
Export intensity	-0.006	-0.015	-0.018	0.011	0.072	0.009	-0.005	-0.007
	(0.78)	(0.535)	(0.531)	(0.759)	(0.067)	(0.832)	(0.811)	(0.742)
Log(fuel/emp)	-0.059	-0.061	-0.107	-0.176	-0.192	-0.206	-0.092	-0.108
	(0.031)	(0.027)	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)	(0.000)
Log(gva)	0.133	0.144	0.133	0.317	0.192	0.281	0.163	0.171
	(0.07)	(0.135)	(0.275)	(0.015)	(0.069)	(0.114)	(0.025)	(0.015)
Log(employee)	0.026	0.031	0.037	0.063	0.079	0.15	0.037	0.042
	(0.049)	(0.099)	(0.166)	(0.058)	(0.075)	(0.034)	(0.026)	(0.02)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A8. Year by year effects of green investments on firm performance, Irish-owned firms

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	144	97	57	31	No match	No match	144	144
Log(gva/emp)	0.016	-0.011	0.19	0.295			0.061	0.061
	(0.845)	(0.921)	(0.244)	(0.195)			(0.474)	(0.474)
Export intensity	-0.014	0.007	-0.034	-0.026			-0.001	-0.001
	(0.764)	(0.888)	(0.642)	(0.721)			(0.972)	(0.972)
Log(fuel/emp)	-0.005	-0.003	-0.053	-0.101			-0.027	-0.027
	(0.929)	(0.969)	(0.566)	(0.404)			(0.587)	(0.587)
Log(gva)	0.001	-0.043	0.117	0.23			0.046	0.046
	(0.99)	(0.788)	(0.587)	(0.405)			(0.728)	(0.728)
Log(employee)	0.005	0.007	0.022	0.009			-0.01	-0.01
	(0.801)	(0.791)	(0.594)	(0.845)			(0.647)	(0.647)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology p-value reported in parentheses.

Table A9 Year by year effects of green investments on firm performance, foreign-owned firms

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	255	230	214	185	166	113	255	255
Log(gva/emp)	0.141	0.102	0.172	0.126	-0.057	-0.049	0.19	0.17
	(0.053)	(0.089)	(0.01)	(0.123)	(0.339)	(0.499)	(0.002)	(0.005)
Export intensity	0.02	0.019	-0.001	0.03	0.011	-0.01	0.019	0.012
	(0.13)	(0.254)	(0.959)	(0.3)	(0.722)	(0.785)	(0.193)	(0.405)
Log(fuel/emp)	-0.012	-0.046	-0.059	-0.123	-0.14	-0.109	-0.067	-0.087
	(0.603)	(0.104)	(0.065)	(0.000)	(0.000)	(0.036)	(0.009)	(0.001)
Log(gva)	0.219	0.161	0.292	0.263	0.018	0.055	0.307	0.284
	(0.051)	(0.072)	(0.002)	(0.029)	(0.841)	(0.608)	(0.001)	(0.001)
Log(employee)	0.028	0.023	0.048	0.067	0.091	0.114	0.049	0.06
	(0.05)	(0.215)	(0.054)	(0.013)	(0.002)	(0.003)	(0.006)	(0.002)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A10. Year by year effects of green investments on firm performance, firms with highlabour productivity

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	256	213	172	125	81	54	256	256
Log(gva/emp)	0.151	0.161	0.237	0.177	-0.039	-0.092	0.195	0.187
	(0.017)	(0.016)	(0.007)	(0.147)	(0.666)	(0.394)	(0.001)	(0.001)
Export intensity	-0.01	0.017	-0.021	0.045	0.059	-0.008	-0.008	-0.01
	(0.686)	(0.508)	(0.51)	(0.237)	(0.233)	(0.899)	(0.729)	(0.694)
Log(fuel/emp)	-0.023	-0.045	-0.094	-0.135	-0.086	-0.021	-0.058	-0.061
	(0.385)	(0.298)	(0.018)	(0.004)	(0.076)	(0.786)	(0.055)	(0.046)
Log(gva)	0.23	0.219	0.351	0.322	0.08	0.035	0.283	0.277
	(0.016)	(0.022)	(0.002)	(0.066)	(0.539)	(0.811)	(0.001)	(0.001)
Log(employee)	0.015	0.025	0.065	0.084	0.135	0.152	0.025	0.032
	(0.354)	(0.191)	(0.022)	(0.008)	(0.001)	(0.008)	(0.164)	(0.089)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A11. Year by year effects of green investments on firm performance, firms with low labour productivity

Year	0	1	2	3	4	5	3 years average	5 years mean
Cases	97	70	59	51	47	34	97	97
Log(gva/emp)	-0.125	-0.022	0.09	0.265	-0.128	0.111	0.008	0.007
	(0.145)	(0.873)	(0.513)	(0.032)	(0.295)	(0.394)	(0.911)	(0.919)
Export intensity	0.046	0.024	0.003	-0.006	-0.05	0.043	0.058	0.048
	(0.178)	(0.464)	(0.943)	(0.907)	(0.318)	(0.508)	(0.085)	(0.137)
Log(fuel/emp)	-0.008	-0.014	-0.068	-0.165	-0.232	-0.306	-0.037	-0.068
	(0.854)	(0.856)	(0.232)	(0.004)	(0.001)	(0)	(0.468)	(0.197)
Log(gva)	-0.213	0.047	0.223	0.489	-0.061	0.285	0.048	0.048
	(0.154)	(0.84)	(0.335)	(0.006)	(0.761)	(0.182)	(0.724)	(0.686)
Log(employee)	0.009	0.026	0.068	0.066	0.054	0.095	0.026	0.03
	(0.6)	(0.366)	(0.098)	(0.101)	(0.216)	(0.109)	(0.256)	(0.224)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A12. Year by year effects of green investments on firm performance, firms with high energy intensity

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	241	188	157	127	91	58	241	241
Log(gva/emp)	0.099	0.195	0.242	0.186	-0.008	0.057	0.194	0.192
	(0.119)	(0.009)	(0.003)	(0.105)	(0.923)	(0.598)	(0)	(0)
Export intensity	0.019	0.049	0.009	-0.006	0.012	-0.034	0.019	0.012
	(0.371)	(0.054)	(0.774)	(0.865)	(0.766)	(0.574)	(0.357)	(0.549)
Log(fuel/emp)	0.001	-0.025	-0.042	-0.137	-0.137	-0.119	-0.034	-0.045
	(0.969)	(0.5)	(0.321)	(0.002)	(0.008)	(0.083)	(0.305)	(0.182)
Log(gva)	0.153	0.291	0.35	0.321	0.095	0.19	0.288	0.286
	(0.108)	(0.01)	(0.002)	(0.053)	(0.462)	(0.285)	(0)	(0)
Log(employee)	0.015	0.019	0.029	0.05	0.101	0.114	0.018	0.023
	(0.258)	(0.349)	(0.313)	(0.122)	(0.01)	(0.033)	(0.243)	(0.176)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A13. Year by year effects of green investments on firm performance, firm with low energy intensity

Year	0	1	2	3	4	5	3 y average	5 y average
Cases	118	92	74	54	34	28	118	118
Log(gva/emp)	0.006	-0.173	-0.041	0.117	-0.069	-0.042	-0.064	-0.072
	(0.954)	(0.067)	(0.756)	(0.331)	(0.655)	(0.699)	(0.438)	(0.378)
Export intensity	-0.025	-0.035	-0.026	0.072	0.041	0.034	-0.005	0.002
	(0.542)	(0.304)	(0.456)	(0.085)	(0.521)	(0.558)	(0.898)	(0.967)
Log(fuel/emp)	0.03	-0.006	-0.035	-0.11	-0.18	-0.218	0.001	-0.014
	(0.365)	(0.901)	(0.485)	(0.074)	(0.011)	(0.002)	(0.983)	(0.725)
Log(gva)	0.01	-0.271	-0.059	0.179	-0.059	0.049	-0.098	-0.101
	(0.952)	(0.052)	(0.774)	(0.29)	(0.786)	(0.676)	(0.491)	(0.48)
Log(employee)	-0.027	-0.001	0.053	0.066	0.086	0.091	-0.008	-0.001
	(0.23)	(0.948)	(0.101)	(0.084)	(0.092)	(0.173)	(0.767)	(0.98)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A14. Year by year effects of green investments on firm performance, firms in industries with medium and high technology-intensity

Year	0	1	2	3	4	5	3 years average	5years average
Cases	184	148	122	92	69	47	184	184
Log(gva/emp)	-0.017	0.101	0.036	0.101	0.046	-0.037	0.043	0.052
	(0.777)	(0.235)	(0.656)	(0.254)	(0.462)	(0.604)	(0.441)	(0.356)
Export intensity	0.009	0.004	-0.006	0.06	0.053	0.114	0.004	0.008
	(0.684)	(0.886)	(0.826)	(0.076)	(0.142)	(0.04)	(0.851)	(0.725)
Log(fuel/emp)	0.039	-0.003	-0.025	-0.032	-0.097	-0.006	0.001	-0.004
	(0.223)	(0.937)	(0.565)	(0.447)	(0.033)	(0.945)	(0.98)	(0.904)
Log(gva)	-0.014	0.119	0.036	0.169	0.112	-0.019	0.051	0.072
	(0.866)	(0.343)	(0.755)	(0.214)	(0.122)	(0.827)	(0.531)	(0.387)
Log(employee)	0.023	-0.006	0.034	0.022	0.035	0.015	0.016	0.021
	(0.152)	(0.775)	(0.221)	(0.537)	(0.402)	(0.783)	(0.354)	(0.253)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A15. Year by year effects of green investments on firm performance, firms in industries with low technology intensity

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	198	156	133	109	85	63	198	198
Log(gva/emp)	0.155	0.111	0.245	0.175	-0.134	-0.066	0.197	0.168
	(0.057)	(0.175)	(0.02)	(0.177)	(0.196)	(0.609)	(0.006)	(0.013)
Export intensity	0.009	0.042	-0.001	0.025	-0.012	-0.075	0.029	0.017
	(0.779)	(0.168)	(0.979)	(0.574)	(0.807)	(0.181)	(0.343)	(0.561)
Log(fuel/emp)	-0.02	-0.043	-0.083	-0.168	-0.152	-0.183	-0.065	-0.082
	(0.551)	(0.335)	(0.08)	(0.001)	(0.005)	(0.005)	(0.062)	(0.022)
Log(gva)	0.234	0.183	0.403	0.353	-0.03	0.075	0.313	0.277
	(0.071)	(0.136)	(0.007)	(0.055)	(0.854)	(0.7)	(0.005)	(0.008)
Log(employee)	0.014	0.042	0.074	0.123	0.16	0.166	0.035	0.043
	(0.443)	(0.058)	(0.025)	(0.000)	(0.000)	(0.002)	(0.09)	(0.05)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.

Table A16. Year by year effects of green investments on firm performance, firms in the food industry

Year	0	1	2	3	4	5	3 years average	5 years average
Cases	158	124	106	91	71	52	158	158
Log(gva/emp)	0.159	0.154	0.352	0.241	-0.114	0.011	0.246	0.217
	(0.116)	(0.109)	(0.006)	(0.126)	(0.34)	(0.94)	(0.005)	(0.009)
Export intensity	0.009	0.054	0.015	0.028	-0.009	-0.017	0.046	0.037
	(0.808)	(0.102)	(0.663)	(0.543)	(0.861)	(0.739)	(0.191)	(0.277)
Log(fuel/emp)	-0.039	-0.075	-0.115	-0.23	-0.173	-0.248	-0.103	-0.124
	(0.221)	(0.147)	(0.028)	(0.000)	(0.003)	(0.000)	(0.004)	(0.001)
Log(gva)	0.252	0.261	0.568	0.419	-0.057	0.177	0.396	0.355
	(0.116)	(0.065)	(0.001)	(0.059)	(0.766)	(0.419)	(0.004)	(0.005)
Log(employee)	0.017	0.048	0.094	0.119	0.139	0.157	0.039	0.046
	(0.414)	(0.061)	(0.014)	(0.002)	(0.001)	(0.01)	(0.112)	(0.077)

Source: Authors' estimates based on data from the Census of Industrial Production, Central Statistics Office.
Note: Estimates are obtained with a difference-in difference propensity matching methodology. p-value reported in parentheses.