February 2022

Fondazione Eni Enrico Mattei

Working Paper
05.2022

The economic returns of circular economy practices

Davide Antonioli, Claudia Ghisetti, Massimiliano Mazzanti, Francesco Nicolli

The economic returns of circular economy practices

By Davide Antonioli, Department of Economics and Management, University of Ferrara and SEEDS – Centre for Sustainability, Environmental Economics and Dynamics Studies
Claudia Ghisetti, Università degli studi di Milano Bicocca
Massimiliano Mazzanti, Department of Economics and Management, University of Ferrara and SEEDS – Centre for Sustainability, Environmental Economics and Dynamics Studies
Francesco Nicolli, Department of Economics and Management, University of Ferrara and SEEDS – Centre for Sustainability, Environmental Economics and Dynamics Studies

Summary

Assessing the economic consequences of sustainable production choices aimed at reducing environmental negative externalities is crucial for policy making, in light of the increasing interest and awareness experienced in the recent EU policy packages (Circular Economy package; European Green Deal and Recovery Fund to support sustainable transition). This assessment is one of the goal of the current work, which tries to provide new empirical evidence on the economic returns of such choices, drawing on previous literature on the underlying determinants of greener production choices, which are stated to differ from standard technological innovations as they are subject to a knowledge and an environmental externality. Using an original dataset on about 3000 Italian manufacturing firms we provide evidence on the relations among innovations related to the Circular Economy concept and economic outcome in the short run. The evidence shows that in the short run it is difficult to obtain economic gains, especially for the SMEs.

Keywords: Circular Economy, Sustainable Production, Environmental Innovation, Economic Effect

JEL Classification: O30, O44, O55

Address for correspondence:
Francesco Nicolli
Department of Economics and Management
University of Ferrara
Via Voltapaletto 11 - 44121 Ferrara (Italy)
E-mail: francesco.nicolli@unife.it

The economic returns of circular economy practices

Davide Antonioli[*], Claudia Ghisetti[†], Massimiliano Mazzanti*, Francesco Nicolli*[‡]

Abstract

Assessing the economic consequences of sustainable production choices aimed at reducing environmental negative externalities is crucial for policy making, in light of the increasing interest and awareness experienced in the recent EU policy packages (Circular Economy package; European Green Deal and Recovery Fund to support sustainable transition). This assessment is one of the goal of the current work, which tries to provide new empirical evidence on the economic returns of such choices, drawing on previous literature on the underlying determinants of greener production choices, which are stated to differ from standard technological innovations as they are subject to a knowledge and an environmental externality. Using an original dataset on about 3000 Italian manufacturing firms we provide evidence on the relations among innovations related to the Circular Economy concept and economic outcome in the short run. The evidence shows that in the short run it is difficult to obtain economic gains, especially for the SMEs.

1. Introduction

The literature on the economic returns of sustainable production choices is already very rich. However, it still does not lead to any conclusive evidence pertaining its economic consequences.

One of the first contribution arguing in favor of the potential positive effects of environmental innovation (EI) comes from the seminal paper by Porter and Van der Linde (1995), that postulates that environmental regulation is not necessarily detrimental for firms' performance. When environmental policies are well designed, regulation-induced innovation may generate positive effects in the long-run, leading to "win-win" solutions that counterweight the costs of compliance. Jaffe and Palmer (1997) articulate the hypothesis in its narrow, weak and strong characterizations, and it is only under the latter that efficiency gains achieved by the "induced innovation" can completely offset the loss of competitiveness that has been caused by compliance (to policy) costs. A broad strand of empirical literature has been focused on assessing the competitiveness effects of environmental regulation, or, in other terms, the strong version of the Porter Hypothesis, which indirectly or directly passes through innovation, or more precisely, environmental innovation (EI) adoption, and this is where the current work is positioned. Likewise, the natural-resource-based view of the firm hypothesizes that firms' profitability and competitiveness can be positively affected by EI through the competitive advantages that are created once accounting for the natural environment surrounding the firm.

Overall, existing literature agrees that the question "does it pay to be green?" needs to be better qualified in terms of the sustainable production choice that is considered. Leaving environmental policy behind the scenes of the empirical analysis, given the focus on one single country (Italy), the current work focuses on innovation activities directed towards circular economy practices to understand whether there exist short term economic gains (or losses) associated to those activities.

[*] Department of Economics and Management, University of Ferrara and SEEDS – Centre for Sustainability, Environmental Economics and Dynamics Studies.
[†] Università degli studi di Milano Bicocca.
[‡] Corresponding author: francesco.nicolli@unife.it.

More precisely we answer the question of which type of green practices has to be adopted to generate positive economic returns among environmental innovation for circular economy (CE-related environmental innovation). We contribute to a very recent and still developing literature, needing confirmation and empirical evidence, on the potential benefit of the circular economy for firms (Dey et al, 2020; Khan et al, 2021). We aim to fill the gap in the research area on the relation between CE-related environmental innovation and economic performance and, contextually, we shed further light on the more general relation between environmental innovation and firms' economic performance. To do that we rely on a unique dataset for a sample of about 3000 Italian manufacturing firms.

The organisation of the paper is as follows. The next section discusses the general conceptual modes via which EIs and CE influence firms' economic performance., developing the research questions. Section 3 illustrates the empirical strategy and discusses the results. The last section is left to the conclusions.

2. Economic returns and environmental and circular economy innovation

Recent literature agrees that mixed findings are found when studying the economic returns of greener production choices. Telle (2006) concludes that the real challenge would be to unveil when or for whom it can pay to go green, rather than posing the too general question whether it pays or not to be green, as negative (Greenstone et al., 2012; Rexhäuser and Rammer, 2013; Sarkis and Cordeiro 2001; Wagner et al. 2002), null (Peneder et al. 2017; Rubashkina et al., 2015; Elsayed and Paton 2005; Amores-Salvadó et al. 2014) and positive (Endrikat et al, 2014, Cheng et al. 2014; Dowell et al. 2000; Russo and Fouts 1997; King and Lenox 2001; Salama 2005; Lanoie et al. 2011; Manello, 2017; Costantini and Mazzanti, 2012) competitiveness or profitability returns have been empirically depicted in the literature. As reported in Barbieri et al. (2016), "EI may influence in an asymmetric way short-term measures of profitability (e.g. stock market returns, profits) and long-term performance (e.g. productivity, international competitiveness, survival, and firm growth)" (Barbieri et al. 2016: 609).

The meta-analysis of the literature by Horváthová (2010) summarizes that 15% of the studies found a negative return of going green, 55% a positive return, and 30% found no significant effect.

An economic explanation on positive findings comes from the natural-resource-based view of the firm: the inclusion of environmental aspects is a pro-active reaction to resources depletion which may be threatening firm's resources (Hart and Dowell 2011). This reaction is, in turn, able to foster the development of strategic resources and dynamic capabilities (Aragon-Correa and Sharma 2003; Hart and Milstein 2003) that are later associated to positive economic returns (Hart 1995via a better market's evaluation of the firm, access to new markets or cost reduction driven by increased resource efficiency (Ambec et al. 2008; Margolis and Walsh 2003; Orlitzky et al. 2011; Porter and Kramer 2002, 2006) and innovation(Martinez-Conesa et al. 2017) or the derived demand for green technologies induced by regulation that increases innovative firms' market value (Colombelli et al. 2020).

However, negative returns may also be explained. For instance Soltmann et al. (2015) perform a sectoral analysis on 12 OECD country-sectors (Austria, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States) in the period 1980–2009 and approximating EI through patent applications and suggest for the presence of an U-shaped relation between environmental patents and value added. Forr most industries, increases in EI negatively affect performance, whilst for others it improves performance. This would suggest strong sectoral heterogeneities, which have been also confirmed by, Riillo (2017) on Italian SMEs with a focus on labor productivity, leading the author to conclude that greener firms in energy-intensive sectors show no significant difference in performance than other firms. Mixed findings can also be explained with the lenses of economic growth. Leoncini et al. 2019 focus on a panel of Italian firms finding that their growth is more affected by green technologies than non-green ones, with the exception of struggling and rapidly growing firms, and firm's age plays a key role in shaping such relation. Marin and Lotti (2017) assess the effects of environmental patents on productivity on a panel of Italian manufacturing firms showing that the productivity returns of EI are smaller than the ones related to non-environmental technologies. In fact, EI tend to crowd out non-environmental innovations which may be even more profitable (Marin 2014).

The reason why it is important to make such distinction in the types of innovation considered and to better qualify the question is that firms' profitability depends on whether firms choose to introduce end-of-pipe technologies or to redesign their production processes and services. The first are not associated to any changes in firms' resources nor capabilities and are thus not expected to produce any positive economic return in the short run (Russo and Fouts, 1997; Cleff and Rennings, 1999). Ghisetti and Rennings (2014) for instance show, on a sample of German firms, how different typologies of EI may lead to heterogeneous profitability effects: EI aimed at improving resource and energy efficiency have a positive influence on financial performance, but, on the other side, those aimed at reducing externalities, such as harmful materials and air, water, noise and soil pollution, are associated to a worsening of the financial performance. Miroshnychenko et al. (2017) provide a novel and global empirical overview on the financial returns of green practices by analysing a panel of publicly-traded companies in 58 countries over 13 years, showing that what they define as internal green practices (pollution prevention and green supply chain management) are the major drivers of financial performance, whereas product development is secondary and the adoption of environmental management schemes (namely ISO 14001) negatively impacts financial performance.

Whereas a vast number of contributions, as reported above, has focused on understanding the economic returns of innovation and sustainable production choices, such a broad picture of the innovative potential and returns for CE-related technologies is still lacking. Having clarified the need to better understand the economic returns of different innovative practices, it is quite unfortunate not to have such unpacking available for CE specific technologies. Clearly, environmental technologies and CE-related ones are deeply connected. CE related practices and innovations can be meant as signal of firms' attention toward corporate social responsability and sustainability (Reif and Rexhäuser, 2018). EI, and technology, cover a broader set of activities though, i.e. all the activities aiming at reducing the environmental impact of firms, including end-of-pipe technologies (Horbach, et al 2012; Horbach and Rammer, 2020). Eco-innovation is a key element for driving a transition to a circular economy but, at the same time, it has been stressed that the CE transition is found to be contingent on "systemic" EI, requiring not only technological changes but also service innovations and novel organisational set-ups (de Jesus et al. 2018).

De Jesus et al. 2018 highlight that EI and CE are closely related, such that achieving CE without EI is unlikely, but also not all EI are related to CE. Consequently the impacts of different EIs may be heterogeneous on the different spheres of CE, as also emphasised by Kiefer et al. (2021): different typologies of EI contributes differently to the various levels of CE (e.g. micro – companies and consumers, etc…; meso – interfirm networks, etc…; macro – province, regions, nations, etc…).

Still, a better understanding of the EI-CE linkages is needed and it "requires, as a precondition, a deeper investigation of the potential drivers of those dimensions of EI that are more relevant for a CE transition" (Cainelli et al. 2020; 3) and of those EI characteristics that may spur or hamper a CE transition (Kiefer et al., 2021).

We may expect that the increasing policy attention towards circular economy (EC, 2015) and sustainable transition (European Green Deal; Recovery Fund) can create the right incentives for their uptake and pose the basis for their economic returns. The integration of EI in sustainable and innovative business models, such as circular business models, is complex. The multidimensional aspects that a recent literature takes into consideration for the analysis of circular business models (Centobelli et al., 2020) go from contextual factors (environmental factors in which a firm operates) to cross dimensional practices (practices that favour the transition towards a circular economy, e.g. emerging digital technologies), passing through circular business model dimensions and practices for value creation and value capture (dimension connotating the definition and execution of firms' business model and practices related to the value creation and acquisition of product and processes).

In addition to the above-mentioned complexity, which still deserves further investigation, little is known on the economic returns of CE-related technologies. While the purpose of CE is not per se to spur firms' growth of firms, Horbach and Rammer, (2020) conclude that it is important to know whether firms that invest in CE activities will benefit or suffer in terms of their growth prospects and labor demand, motivating the need to study CE economic returns extensively. The two authors consistently analyse, using the German Community Innovation survey (2014), whether firms that engage in CE innovations experience positive or negative results in their sales growth and employment. The study finds a confirmation that sales and employment growth have increased in firms having adopted CE-related innovations, especially in lower-median quantiles in the growth distribution, and have increased firms financial standing especially for high-growth firms in the upper quantile. However, the study does not unpack for the different typologies of CE innovation, as it only focuses on the aggregated category of CE (any-type) adoption. On the latter point, we recall that Ghisetti and Renings (2014) show that innovation activities that are associated to a reduction in input use (energy or materials) per unit of outputs lead to short-term profit gains which may eventually lead to a reduced price per product that may increase its demand. Less clear-cut are the economic returns of other CE activities, such as those associated to a substitution of energy to favour the use of renewables, as it depends on the who is producing the renewable energy and its costs for the firm; or to waste reduction or waste recycling or material reuse, as those activities may be costly to the firms whereas, by contrast, they cannot outweigh the lower cost of virgin materials. Overall, a CE transition for the firm will always require costly changes, not only in physical capital (investments), but also in intangibles (R&D activities) and in organizational changes. Flachenecker and Kornejew (2019) focus on a cross section retrieved from the Community Innovation Survey (2008) and find support of a correlation between innovations that reduce material use and the competitiveness returns, for firms that received public financial support to these activities

Provided that the research on the relationship between CE-related innovations and firms' economic performance is still scanty, we aim to answer the following research questions:

R1: Do CE related innovations correlate with better economic performance?

What is yet to be ascertained is whether the nature of the innovation itself (product, process or organisational nature), or its type (e.g. energy reduction; raw material reduction; design to promote durability, etc…) affect its economic short term rerturns. This is what this work tries to shed light on.

R2a: Does the relation between CE-related innovations and firms' economic performance depend on the nature of CE innovations (product, process or organisational nature)

R2b: Does the relation between CE-related innovations and firms' economic performance depend on the type of CE innovations (e.g. energy reduction; raw material reduction; design to promote durability, etc…)

Lasty we test whether the joint adoption of multiple innovations, i.e. bundles of CE related innovations, shape performance.

R3: Does the adoption of bundles of CE related innovations correlate more robustly to firms' economic performance than the adoption of single or sparse CE related innovations?

3. Empirical strategy

The empirical analysis draws on an original firm-level data of a survey conducted in 2020 by IZI spa for the University of Ferrara, on a stratified (size, region and sector) representative sample of more than 4500 manufacturing Italian firms.

Overall, 43% of the firms in the sample declared having introduced at least one of the possible CE-innovations listed in Table 1.

Table 1 provides an overview on the distribution of CE related practices in the representative sample of Italian firms, as already reported in Zoboli et al. (2021). The largest share of CE- innovations adopters pertains the domain of Waste, including innovations that allow the re-use of waste into owns or others production processes (23% of firms have adopted such innovations in the period 2017-2019) but also the domain of Energy reduction, including innovations that reduce firm's energy use (23% of adopters). Then it follows the category of: Innovations that reduce raw materials (incl. energy); Innovations that change the design to minimize energy use or maximize products' recyclability; Innovations towards renewable energy use. Lastly come innovations precisely aimed at reducing water use and innovations aimed at abating greenhouse gas emissions (although most of the GHG abatement will be captured by innovations at abating energy use, being energy consumption responsible for most GHG emissions).

Table 1: Distribution of CE-Innovations on the whole sample of respondent firms

CE-Innovation by:	%	*Description of the binary variables*
Innovation type		
CE_dummy	43	1 if at least one CE innovation is adopted; 0 otherwise
CE_Prod	22	1 if a CE product innovation is adopted; 0 otherwise
CE_Proc	30	1 if a CE process innovation is adopted; 0 otherwise
CE_Org	20	1 if a CE organisational innovation is adopted; 0 otherwise
CE_bundle	16	1 if the firm introduced at least 5 CE innovations; 0 otherwise
Environmental Target		
WATER	8	1 if the firm introduced CE innovations to reduce water usage; 0 otherwise
RAWMAT	18	1 if the firm introduced CE innovations to reduce the use of raw materials; 0 otherwise
RENEN	13	1 if the firm introduced CE innovations to increase the usage of renewable energy; 0 otherwise
ENERGY	23	1 if the firm introduced CE innovations to reduce energy consumption; 0 otherwise
WASTE	30	1 if the firm introduced CE innovations to reduce waste; 0 otherwise
WASTE_RE	23	1 if the firm introduced CE innovations to reuse waste; 0 otherwise
ECO_DES	15	1 if the firm introduced CE innovations to change the design in order to increase reparability and recyclability; 0 otherwise
GHG	8	1 if the firm introduced CE innovations to reduce GHG emissions; 0 otherwise

In order to assess the economic returns associated to CE activities, the original dataset has been combined with balance sheet data from Bureau van Dijk AIDA dataset, leading to a sample loss of one quarter due to missing information. We extracted from AIDA information on the last available year's annual revenues of the firm (2019) and on its costs of production (2019). After the merging and the cleaning procedure of extreme values

[1], likely due to some measurement errors or firm specific conditions (e.g. company liquidation), we end up with around 3100 observations, which still are distributed in terms of size, geography and Pavitt sectors (Scale intensive; Science-Based; Specialised Suppliers; Supplier Dominated) as the original sample.

[1] We use trimmed values for the performance variables in the subsequent analysis

The two measures of economic performance are more likely than others (e.g. profits) to be affected in the short run by innovations introduced in the biennium 2017-2018. Moreover, the first variable, revenues, is focused on gains, while the second on costs, since the CE-related innovations may impact on both the dimensions of the economic performance of the firms and we aim to single out the relations of CE innovations to the two dimensions considered,revenues and production costs. Indeed, several scenarios may emerge: e.g. in the aftermath of the CE innovation adoption increasing revenues may be offset by increasing costs or increasing revenues may be associated with decreasing costs (the best scenario for a firm) or, again, mixed scenarios may be revealed by the analysis.

A first way to empirically assess for the potential economic impact of CE strategies, is to perform a sample t-test on group differences on different outcome variables. The t-test compares the difference in the means of the selected economic log transformed revenues (Revenues per employee) and costs (Costs of production per employee) variables of the two groups: to one group belong those firms having introduced a certain CE innovation and to the other group belong those firms that have not introduced such innovations.

Results of the statistical test are reported in Table 2. The statistical analysis allows establishing an association between the outcome variable of interest and the introduction of certain CE-related innovations. It can however not allow establishing any direction of causality for such association and it does not take into account other relevant factors.

Tab.2 – T-tests on innovators (EC=1) and non-innovators(EC=0)

	Mean EC=0	Mean EC=1	Diff: EC=0-EC=1	t value	p value
LnRevenuesEmp					
CE_dummy	11.613	11.736	-.123	-3.2	.002
CE_Prod	11.633	11.79	-.156	-3.4	.001
CE_Proc	11.607	11.797	-.19	-4.65	0
CE_Org	11.665	11.682	-.017	-.35	.719
CE_bundle	11.643	11.8	-.157	-3.05	.003
WATER	11.651	11.854	-.204	-3	.003
RAWMAT	11.648	11.758	-.111	-2.25	.024
RENEN	11.654	11.761	-.107	-1.9	.055
ENERGY	11.630	11.79	-.161	-3.55	.001
WASTE	11.640	11.729	-.088	-2.15	.033
WASTE_RE	11.645	11.744	-.1	-2.2	.026
ECO_DES	11.654	11.754	-.1	-1.85	.068
GHG	11.661	11.76	-.1	-1.4	.164
LnCostEmp					
CE_dummy	11.618	11.739	-.12	-3.25	.001
CE_Prod	11.616	11.861	-.245	-5.65	0
CE_Proc	11.616	11.791	-.175	-4.45	0
CE_Org	11.664	11.705	-.042	-.9	.357
CE_bundle	11.639	11.834	-.194	-3.95	0
WATER	11.655	11.851	-.196	-3	.003
RAWMAT	11.643	11.793	-.149	-3.2	.002
RENEN	11.654	11.789	-.135	-2.5	.012
ENERGY	11.655	11.726	-.071	-1.65	.1
WASTE	11.637	11.748	-.111	-2.8	.005
WASTE_RE	11.645	11.758	-.113	-2.65	.009
ECO_DES	11.639	11.864	-.225	-4.35	0
GHG	11.653	11.891	-.238	-3.55	.001

As we can appreciate there is some evidence in favour of a relation between the adoption of CE-related innovations and the two measures of performance, normalised by the firm size in terms of employees, leading us to further analyse the relations to provide answers at the research questions posed above.

As t-tests cannot allow controlling for additional factors, the second step of the analysis consists of testing econometrically for such association, controlling for variables that may affect it. The following equation is estimated:

$$LnY_{i,2019} = \beta \quad CE_{i,2017-2018} + \gamma \quad CON\acute{T}ROLS_{i,2017-2018} + \lambda \quad + \nu \quad + e_i$$

where i indexes the 3078 Italian firms, Y signals an economic output variable, either revenues (log-transformed) or profits (log-transformed), CE indexes any of the CE-related innovations, λ accounts for 4 Pavitt-based sectoral dummies, ν for 21 regional dummies[2], ε is the error term. Among the CONTROLS, the following variables are accounted for (Tab.3): SME, a dummy taking value one in case the firm is small or medium; GROUP, a dummy that equals one if the firm belong to a group; EXPORT, a dummy that equals one if the firm undertakes exporting activities; RD_HC, a continuous variable that measures the share of employees in R&D activities; two dummy variables capturing the introduction of process or product innovations (PROD, PROD).

Table.3: Descriptive statistics of controls and dependent variables

Variable	Obs	Mean	Std. dev.	Min	Max	Description
Controls						
GROUP	3,078	.1536712	.3606919	0	1	Binary variable=1 if the firm belong to a group; 0 otherwise
EXPORT	3,078	.5204678	.4996621	0	1	Binary variable=1 if the firm export part of its products; 0 otherwise
RD_HC	3,078	4.88564	13.14379	0	100	Share of employees in R&D activities
SME	3,078	.9850552	.1213516	0	1	Binary variable=1 if the firm is a small or medium firms in terms of the number of employees according to the Eurostat definition; 0 otherwise
Regional dummyes	\	\	\	0	1	Regional dummies (20) that capture the geographical location of a firm at NUTS2 level
Sector dummyes	\	\	\	0	1	Pavitt-based sectors dummies (4): Scale intensive; Science-Based; Specialised Suppliers; Supplier Dominated
PROD	3,078	.4031839	.4906168	0	1	Binary variable=1 if the firm introduced a product innovation in the biennium 2017-2018; 0 otherwise
PROC	3,078	.4353476	.495883	0	1	Binary variable=1 if the firm introduced a process innovation in the biennium 2017-2018; 0 otherwise

[2] The Trentino Alto Adige region is split in its two autonomous provinces: Bolzano and Trento

Dependent variables						
LnRvenuesEmp	3,078	11.67	1.07	6.94	14.22	Log of the revenues per employee
LnCostEmp	3,049	11.67	1.01	7.07	14.04	Log of the production costs per employee

Tables 4a,b,c,d reports the main econometric results obtained by estimating the previous equation by means of robust OLS for both the two dependent variables considered in this work.

Starting from the first dependent variable – LnRevenuesEmp – we notice that among the controls, GROUP and EXPORT are positively associated to the revenues per employee in all the specifications (Tab4a,b). In terms of sectors, the Science Based firms have significantly higher revenues than Scale intensive firms (reference category), while the opposite holds for Specialised Suppliers and Supplier Dominated firms. Moving to the main variables of interest, we observe a specific pattern across the different CE-related variables. Among all of them, only the CE-related process innovations are positively associated to higher revenues; the remaining CE-related types of innovations are not (Tab.4a). The latter result holds also when we look at the specific typologies of effects targeted by the innovations introduced (Tab.4b): they are not leading to any positive or negative short-term return in terms of revenues per employee.

We can answer positively to our second research questions (R2b), but only in terms of process innovations. The idea that bundles of CE-related innovations, adopted according to a general strategy of reducing the environmental impact contextually to increasing the economic performance is not supported by the evidence, which, however, lack to take into consideration potential demand factors that may influence the firms revenues.

Table 4a – Dependent variable: LnRevenuesEmp

	(1)	(2)	(3)	(4)	(5)
GROUP	0.411***	0.411***	0.408***	0.412***	0.411***
	(0.052)	(0.053)	(0.052)	(0.052)	(0.052)
EXPORT	0.315***	0.315***	0.312***	0.317***	0.315***
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
RD_HC	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SME	-0.051	-0.053	-0.029	-0.064	-0.054
	(0.179)	(0.179)	(0.179)	(0.180)	(0.178)
Science Based	0.171*	0.171*	0.178**	0.162*	0.169*
	(0.088)	(0.088)	(0.087)	(0.088)	(0.087)
Specialized Suppliers	-0.136**	-0.136**	-0.127**	-0.142**	-0.137**
	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Supplier Dominated	-0.100**	-0.100**	-0.097**	-0.103**	-0.101**
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
PROD	0.060	0.059	0.056	0.068	0.062
	(0.047)	(0.049)	(0.047)	(0.047)	(0.047)
PROC	0.035	0.037	0.015	0.047	0.038
	(0.045)	(0.044)	(0.046)	(0.044)	(0.045)
CE_dummy	0.013				
	(0.040)				
CE_Prod		0.014			
		(0.051)			
CE_Proc			0.084**		
			(0.043)		

CE_Org				-0.066	
				(0.048)	
CEbundle					0.005
					(0.055)
_cons	12.286***	12.287***	12.222***	12.327***	12.295***
	(0.290)	(0.293)	(0.301)	(0.277)	(0.287)
N	3078	3078	3078	3078	3078
r2	0.082	0.082	0.083	0.082	0.082
F	10.452	10.580	10.640	10.643	10.424
df_m	30.000	30.000	30.000	30.000	30.000

Robust standard errors in parentheses; Regional dummies included; Reference category for Pavitt sectors: Scale intensive.
No collinearity among the controls: mean VIF=1.07
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Tab.4b – Dependent variable: LnRevenuesEmp

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROUP	0.409***	0.414***	0.411***	0.410***	0.412***	0.411***	0.412***	0.412***
	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
EXPORT	export	0.316***	0.314***	0.314***	0.316***	0.315***	0.317***	0.315***
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
RD_HC	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SME	-0.048	-0.060	-0.051	-0.033	-0.059	-0.054	-0.056	-0.056
	(0.178)	(0.179)	(0.179)	(0.179)	(0.179)	(0.179)	(0.178)	(0.177)
Science Based	0.167*	0.168*	0.170*	0.174**	0.167*	0.170*	0.166*	0.169*
	(0.088)	(0.088)	(0.088)	(0.087)	(0.088)	(0.088)	(0.087)	(0.087)
Specialized Suppliers	-0.132**	-0.139**	-0.136**	-0.134**	-0.139**	-0.136**	-0.138**	-0.137**
	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Supplier Dominated	-0.098**	-0.102**	-0.101**	-0.100**	-0.102**	-0.100**	-0.101**	-0.101**
	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)
PROD	0.062	0.066	0.061	0.056	0.064	0.062	0.070	0.063
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
PROC	0.033	0.042	0.036	0.027	0.040	0.037	0.041	0.039
	(0.045)	(0.045)	(0.044)	(0.045)	(0.044)	(0.044)	(0.044)	(0.045)
WATER	0.058							
	(0.071)							
RAWMAT		-0.028						
		(0.050)						
RENEN			0.031					
			(0.057)					
ENERGY				0.065				
				(0.045)				
WASTE					-0.011			
					(0.042)			
WASTE_RE						0.007		
						(0.046)		
ECO_DES							-0.043	
							(0.059)	
GHG								-0.005
								(0.078)
_cons	12.271***	12.310***	12.285***	12.260***	12.309***	12.292***	12.310***	12.301***
	(0.294)	(0.281)	(0.290)	(0.297)	(0.286)	(0.288)	(0.278)	(0.284)
N	3078	3078	3078	3078	3078	3078	3078	3078
r2	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
F	10.390	10.493	10.428	10.569	10.440	10.421	10.501	10.451
df_m	30	30	30	30	30	30	30	30

Robust standard errors in parentheses; Regional dummies included; Reference category for Pavitt sectors: Scale intensive.
No collinearity among the controls: mean VIF=1.07
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

When we perform the same analysis on the costs of production as dependent variable, we find the same results as above for the control variables, but for the Specialised Suppliers that do not show a worse performance in terms of costs of production with respect to the Scale Intensive. Moreover, when we focus the attention on the variables of interests (Tab.4c), we notice again that CE-related process innovation impact on costs, increasing them, and CE-related product innovations have the same impact on costs. Introducing these types of innovations increases the costs of production in the short run because they are likely to request a different production process, potentially new workers recruited to fill internal competences gaps to deal with new products and new processes, new suppliers and/or more expensive intermediate products or materials. The absence of any relation with cost of production is instead shown when we disaggregate the CE-related innovation according to their impact: in this case only the innovation introduced to reduce the GHG emissions, which is somewhat less related to the circular economy concept than others here analysed, is positively associated to the cost of production (tab.4d): new technologies adopted to reduce the GHG emissions are likely to increase costs for the sample firms.

Again, as for the revenues per employee, for the costs variable we are able to positively answer to the second research question posed above (R2b): the type of CE-related innovation introduced influences the cost of production, in particular the short-term cost of production seems to rise when CE-related product or process innovations are adopted.

Tab.4c – Dependent variable: LnCostsEmp

	(1)	(2)	(3)	(4)	(5)
GROUP	0.314***	0.309***	0.310***	0.314***	0.310***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
EXPORT	0.354***	0.350***	0.351***	0.356***	0.354***
	(0.039)	(0.039)	(0.038)	(0.039)	(0.039)
RD_HC	0.002	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SME	-0.135	-0.119	-0.113	-0.142	-0.129
	(0.164)	(0.164)	(0.164)	(0.163)	(0.163)
Science Based	0.192**	0.201**	0.199**	0.186**	0.192**
	(0.080)	(0.079)	(0.080)	(0.080)	(0.079)
Specialized Suppliers	-0.073	-0.070	-0.064	-0.077	-0.071
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
Supplier Dominated	-0.119**	-0.113**	-0.117**	-0.121**	-0.118**
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
PROD	0.074	0.049	0.069	0.079*	0.070
	(0.045)	(0.046)	(0.045)	(0.045)	(0.045)
PROC	-0.005	-0.010	-0.024	0.002	-0.010
	(0.043)	(0.042)	(0.043)	(0.042)	(0.042)
CE_dummy	0.010				
	(0.039)				
CE_Prod		0.107**			
		(0.046)			
CE_Proc			0.078*		
			(0.041)		
CE_Org				-0.041	
				(0.046)	

CEbundle					0.052
					(0.052)
_cons	11.442***	11.418***	11.403***	11.450***	11.442***
	(0.401)	(0.396)	(0.392)	(0.401)	(0.401)
N	3049	3049	3049	3049	3049
r2	0.088	0.089	0.089	0.088	0.088
F	11.141	11.506	11.209	11.235	11.317
df_m	30.000	30.000	30.000	30.000	30.000

Robust standard errors in parentheses; Regional dummies included; Reference category for Pavitt sectors: Scale intensive.
No collinearity among the controls: mean VIF=1.07
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Tab.4d – Dependent variable: LnCostsEmp

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROUP	0.310***	0.312***	0.313***	0.315***	0.313***	0.313***	0.312***	0.313***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
EXPORT	0.354***	0.354***	0.353***	0.355***	0.354***	0.354***	0.351***	0.354***
	(0.038)	(0.039)	(0.038)	(0.039)	(0.039)	(0.038)	(0.039)	(0.038)
RD_HC	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SME	-0.128	-0.134	-0.126	-0.149	-0.130	-0.133	-0.137	-0.104
	(0.163)	(0.164)	(0.164)	(0.163)	(0.164)	(0.163)	(0.164)	(0.164)
Science Based	0.187**	0.192**	0.192**	0.187**	0.194**	0.197**	0.196**	0.198**
	(0.079)	(0.080)	(0.080)	(0.079)	(0.080)	(0.080)	(0.079)	(0.080)
Specialized Suppliers	-0.069	-0.073	-0.072	-0.075	-0.070	-0.067	-0.072	-0.069
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
Supplier Dominated	-0.117**	-0.119**	-0.120**	-0.120**	-0.118**	-0.116**	-0.119**	-0.117**
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
PROD	0.075*	0.073	0.072	0.079*	0.072	0.072	0.060	0.070
	(0.044)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)	(0.046)	(0.045)
PROC	-0.010	-0.005	-0.009	0.003	-0.007	-0.008	-0.009	-0.013
	(0.042)	(0.042)	(0.042)	(0.042)	(0.043)	(0.043)	(0.042)	(0.042)
WATER	0.078							
	(0.070)							
RAWMAT		0.019						
		(0.049)						
RENEN			0.066					
			(0.054)					
ENERGY				-0.035				
				(0.046)				
WASTE					0.026			
					(0.041)			
WASTE_RE						0.039		
						(0.044)		
ECO_DES							0.088	
							(0.056)	
GHG								0.137*
								(0.073)
_cons	11.438***	11.441***	11.428***	11.456***	11.436***	11.442***	11.439***	11.417***
	(0.401)	(0.401)	(0.397)	(0.401)	(0.400)	(0.401)	(0.397)	(0.402)
N	3049	3049	3049	3049	3049	3049	3049	3049
r2	0.088	0.088	0.088	0.088	0.088	0.088	0.089	0.089
F	11.183	11.134	11.098	11.235	11.153	11.152	11.152	11.331
df_m	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000

Robust standard errors in parentheses; Regional dummies included; Reference category for Pavitt sectors: Scale intensive.

No collinearity among the controls: mean VIF=1.07
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The evidence so far leads to consider as almost absent a relation between CE-related innovations and firms' economic outcomes in terms of revenues and costs[3], in line with part of the literature on environmental innovations and firms' economic performance. In particular, R1 and R3 do not find a positive answer: the types of CE-related innovation and the adoption of bundles of CE-related innovations are not related to the outcome variables here considered. In addition, we can state that for CE-related process innovations we are in a scenario in which the increased revenues are 'counterbalanced' by the increased costs of production associated to the same type of innovation. This 'neutral' (in terms of economic advantages for the firms) short term scenario may turn in a positive one in the medium-long run, when the production costs do not further increase (on the contrary some efficiency gains may be captured) while revenues do.

Although we are bounded to work with cross section data, with some sensible diachrony between balance sheets data and survey data, it is possible to refine the analysis in order to capture potential specific relationships between the economic variables and the CE-related innovations, as reported in the next sub-sections.

3.1 Searching for different relations over different portions of the dependent variables distribution

In order do deeply delve in the relation between firms' economic performance and the CE-related environmental innovations we look at the results over different quantiles of the dependent variable distributions, to search for specific relations in accordance with the firm performance distribution. The simultaneous quantile regressions we settled provide results for three levels of the dependent variables distributions: first quartile (.25), median (.5) and last quartile (.75). In so doing we can test for the presence of significant differences among the coefficients of the CE-related variables for the first and last quartile. When the differences are significant it means that the CE innovations differently relate to the outcome variables according to the portion of the outcome variables distribution we analyse[4]. The simultaneous quantile regressions are based on bootstrapped standard errors, for which we set 150 repetitions, a number of repetitions high enough to maintain quite stable the F tests we perform to detect differences in the coefficients between the 25th and 75th percentile of the distribution. In our sample, only the CE_BUNDLE; ECO_DES; GHG innovation produce coefficients that tend to be significantly different for the firms located in the 25th and 75th percentiles of the distribution of revenues per employee. Adopting bundles of CE-related innovations, introducing changes in the product design in order to increase the durability and recyclability of the product itself and introducing innovation to reduce GHG emissions seem to generate more gains for the high performing firms with respect to the low performing ones. We can speculate that the high performing firms are likely to be better equipped in terms of financial wealth and workers competences to bear a quick and full deployment of the activities needed to revise the production process as requested by the introduction of complex innovations (eco-design and GHG ones) or by the introduction of bundles of innovations and start to gain in the short-run. The research questions R2b and R3 seem to hold for a limited number of high performing firms.

In addition to the results of the F tests on the simultaneous quantile regressions we run quantile regressions for each quartile at a time: 25th and 75th percentiles, which produce the following interesting results (Tab.6, only significant results for the 25th and/or 75th percentiles are reported).

---

[3] We also tried other shor term performance variables, such as returns on sales (ROS), but there is no evidence of significant relations with CE-related innovations.

[4] The regressions results are not reported for space constraints, but they are available from the authors upon request.

Tab.6 – Quantile regressions for the .25 and .75 quantiles of the outcome variables distributions

	LnRevenuesEmp			LnCostsEmp							
	.75	.75	.75	.25	.25	.25	.25	.25	.75	.75	.75
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CE_PROD				0.093** (0.045)					0.064* (0.035)		
CE_PROC	0.080* (0.041)				0.088** (0.037)						
CE_BUNDLE						0.067* (0.040)					
WASTE_RE		0.083** (0.042)									
GHG			0.177* (0.095)				0.143*** (0.048)			0.176** (0.069)	
RENEN								0.095* (0.052)			
ECO_DES											0.102** (0.044)
N		3078					3049				
PseudoR2	0.074	0.074	0.075	0.066	0.066	0.065	0.066	0.076	0.076	0.077	0.076

Robust standard errors in parentheses; All the controls used for the baseline specifications are included.
No collinearity among the controls: mean VIF=1.07
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The CE-related process innovations and those aimed to reuse the waste produced and to reduce GHG emissions are linked to the 'high-revenues' firms; while for the 'low-revenues' firms the CE innovations are not relevant. When we turn to production costs firms characterised by high production costs relate to product innovations, innovation in the design of the product and again in GHG, while for firms with low level of production cost many of the CE innovations are significantly positive. In the short run, the CE-related innovations seem to 'influence' the high performing firms, both in terms of revenues and in terms of costs (in the latter case the high performing firms are those with low levels of production costs). Although these results may be confounded by some un-captured heterogeneity or by some other sources of endogeneity, they nonetheless point to a positive 'impact' of CE-related innovation on the firm economic performance in specific regions of the economic variables distributions.

3.2 SMEs and CE-related innovations

Since most of the firms in our sample, as it is in the population, is constituted by SMEs, we carried out the same analysis as in tables 4 above for this subsample of firms.

The results[8] show that CE-related organisational innovations are negatively linked to the revenues, while no other significant impact emerges. In terms of production costs, on the contrary, we register a positive relation with product and process types of innovations and with innovations aiming at reducing GHG emissions and those targeted to increase durability and recyclability through product re-design. Hence, when CE-related innovations are introduced we do not register a potential short-run positive impact; on the contrary, it seems manifestly clear the difficulty of SMEs, that incur in cost increase in the short-run without being able to compensate for it through revenues increases.

It emerges the necessity to sustain CE-related innovations adoption in SMEs with targeted policies, in addition to an overall policy strategy to strongly push the shift towards circular business models in Italian manufacturing firms.

4. Conclusions

The work aimed at shedding light on the expected economic returns associated to circular economy practices and business models, by entailing a micro firm-level approach. It proposed an empirical analysis based on original and updated dataset on Italian manufacturing firms that has the advantage, compared to other similar existing datasets, of allowing appreciating the different typologies of CE-related activities a firm may be willing to embrace. As a matter of fact, such dataset has allowed the current analysis to reveal the economic returns associated to a general category of CE activities, as well as to other specific types of circular innovation and specific environmental targets addressed through such innovations, from energy, materials, to waste and water. This dataset has been combined with balance sheet information from AIDA, allowing to obtain objective and not self-reported information on the main economic outcomes of interest in the short run: revenues and production costs.

The main findings of the work are that CE-related innovations tend to be scarcely related to revenues and to production costs. CE process innovations are positively associated to revenues pointing to their potential influence in increasing them, although they are also positively related to production costs together with CE-related product innovations: as the firms introduce these types of innovation they experience production costs increases.

Looking to the quantiles of the performance variables distributions we obtain some interesting results. Different typologies of CE innovations positively relate to high performing firms on revenues, while several

[8] The regressions results are not reported for space constraints, but they are available from the authors upon request.

other typologies of CE innovations positively associate to high performing firms in terms of production costs (low levels of production costs): in the short run the firms that introduce CE innovations tend to benefit in terms of revenues, but tend also to have a detrimental effect in terms of increasing costs of production. The evidence confirms the heterogeneity in circular economy business models and practices already discussed in Zoboli et al. (2021), which gets translated into different economic impacts.

Finally, when the SMEs subsample is considered, we find mainly no associations or negative economic impacts by the introduction of CE-related innovations, pointing to the potential difficulties and obstacles the SMEs experience in the adoption of circular practices.

The evidence obtained in the present work suggests some policy and managerial implications. In terms of policies, it emerges the need for sustaining the introduction of CE innovations in the SMEs, in order to cope with the potential short-term negative impacts they are likely to experience through the adoption of CE practices. At the same time the degree of awareness on CE business models should be increased in the managerial staff to generate the capabilities to construct/design profitable circular business models, since the introduction of single practices may be sufficient neither for strong environmental effects nor for the economic performance of the firms, with potentially detrimental effects at least in in the short run. We may argue that the main obstacle to achieve these policy and managerial goals lies in the still blurriness of the narrative surrounding the concept of circular economy (and circular economy business models), which does not provide a clear framework for policy makers and managers to implement and design appropriate actions and tools (see on this issue D'Amato and Korhonen, 2021), calling for more holistic approaches of analysis and for further empirical evidence.

The current analysis presents some weaknesses that could not be solved and constitute a limitation for the work. The main weakness is that the empirical analysis cannot make any causal claim, rather it can only be read in terms of robust associations. So far, the current analysis cannot establish whether higher revenues lead to better capability to invest in R&D and innovative activities and consequently to higher CE-related innovations adoption or, by contrast, whether CE-related activities lead to higher revenues. Furthermore, the dataset, although rich and original, is a cross-section. The time dimension would be very precious to be explored in order to better assess when and for how long such economic returns may occur and when, by contrast, they may diminish or vanish. Lastly, the evidence collected so far holds for Italian manufacturing firms, and it cannot be extended and generalized to other firms.

References

Ambec, S. and P. Lanoie (2008), ‘Does it pay to be green? A systematic overview,’ Academy of Management Perspectives, 22(4), 45–62.

Amores-Salvadó J., Martín-de Castro G.,. Navas-López J. (2014), Green corporate image: moderating the connection between environmental product innovation and firm performance, Journal of Cleaner Production, 83, 356-365

Aragón-Correa, J. A. & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. Academy of Management Review, 28(1), 71-88.

Barbieri, N., C. Ghisetti, Gilli M., Marin G., Nicolli F. (2016), ‘A survey of the literature on environmental innovation based on main path analysis,’ Journal of Economic Surveys, 30(3), 596–623.

Barney J., Ketchen D., Siegel D., Wright M., McWilliams (2011), Creating and Capturing Value: Strategic Corporate Social Responsibility, Resource-Based Theory, and Sustainable Competitive Advantage, Journal of Management, 37, 1480-1495

Cainelli, G., D’Amato A., Mazzanti, M. (2020) Resource efficient eco-innovations for a circular economy: Evidence from EU firms, Research Policy 49.

Centobelli P, Cerchione R, Chiaroni D, Del Vecchio P, Urbinati A. Designing business models in circular economy: A systematic literature review and research agenda. Bus Strat Env. 2020;29:1734–1749

Cheng B., Ioannou I., Serafeim G. (2014), Corporate social responsibility and access to finance, Strategic Management Journal, 35, 1-23

Cleff T. and Rennings K. (1999), Determinants of environmental product and process innovation, Environmental policy and governance, 9, 191-201

Colombelli, A., Ghisetti, C., & Quatraro, F. (2020). Green technologies and firms’ market value: a micro-econometric analysis of European firms. Industrial and Corporate Change, 29(3), 855-875.

Costantini, V. and M. Mazzanti (2012), ‘On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports,’ Research Policy, 41(1), 132–153.

D’Amato D. and Korhonen J. (2021), Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework, Ecological Economics, 188, 107-143

De Jesus, A., Antunes, P., Santos, R., Mendonça, S. (2018). Eco-innovation in the transition to a circular economy: An analytical literature review. Journal of cleaner Production, 172, 2999-3018.

Dey PK, Malesios C, De D, Budhwar P, Chowdhury S, Cheffi W. Circular economy to enhance sustainability of small and medium-sized enterprises. Bus Strat Env. 2020;29:2145–2169

Dowell, G., Hart, S., Yeung, B. (2000). Do Corporate Global Environmental Standards Create or Destroy Market Value? Management Science, 46(8), 1059-1074.

Elsayed K., Paton D. (2005), The impact of environmental performance on firm performance: static and dynamic panel data evidence, Structural Change and Economic Dynamics, 16, 395-412

Endrikat J., Guenther E., Hoppe H. (2014),Making sense of conflicting empirical findings: A meta-analytic review of the relationship between corporate environmental and financial performance,European Management Journal, 32, 735-751

European Commission (2015), Closing the loop - An EU action plan for the Circular Economy. Brussels, 2.12.2015 COM(2015) 614

Flachenecker, F., and Kornejew, M. (2019). The causal impact of material productivity on microeconomic competitiveness and environmental performance in the European Union. Environmental Economics and Policy Studies, 21(1), 87–122.

Ghisetti, C. and K. Rennings (2014), 'Environmental innovations and profitability: how does it pay to be green? An empirical analysis on the German innovation survey,' Journal of Cleaner Production, 75, 106–117.

Marin G. and Lotti F., 2017. "Productivity effects of eco-innovations using data on eco-patents," Industrial and Corporate Change, Oxford University Press, vol. 26(1), pages 125-148.

Greenstone, M. and List, J. A. and Syverson, C. (2012), The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing. MIT Department of Economics Working Paper No. 12-24

Hart, S. and Dowell, G. (2011). A Natural-Resource-Based View of the Firm: Fifteen Years After. Journal of Management. 37. 1464-1479

Hart, S. L. (1995), 'A natural-resource-based view of the firm,' Academy of Management Review, 20(4), 986–1014.

Horbach J., Rammer C., Rennings K. (2012), Determinants of eco-innovations by type of environmental impact — The role of regulatory push/pull, technology push and market pull, Ecological Economics, 78, 112-122

Horbach, J. and Rammer, C. (2020) Circular economy innovations, growth and employment at the firm level: Empirical evidence from Germany. Journal of Industrial Ecology, 24, 615–625.

Horváthová E., (2010), Does environmental performance affect financial performance? A meta-analysis, Ecological Economics, 70, 52-59

Jaffe, A. B. and K. Palmer (1997), 'Environmental regulation and innovation: a panel data study,' Review of Economics and Statistics, 79(4), 610–619.

Johnstone, N., I. Hashic, J. Poirier, M. Hemar and C. Michel (2012), 'Environmental policy stringency and technological innovation: evidence from survey data and patent counts,' Applied Economics, 44(17), 2157–2170.

Khan, S. A. R., Razzaq, A., Yu, Z., & Miller, S. (2021). Industry 4.0 and circular economy practices: A new era business strategies for environmental sustainability. Business Strategy and the Environment, 1–14

Kiefer CP, del Río P, Carrillo-Hermosilla J. (2021), On the contribution of eco-innovation features to a circular economy: A microlevel quantitative approach. Bus Strat Env.;30:1531–1547

King, A.A. and Lenox, M.J. (2001), Lean and Green? An empirical examination of the relationship between lean production and environmental performance, Production and Operations Management, 10: 244-256

Lanoie P. Lucchetti J., Johnstone N. Ambec S. (2011), Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis, Journal of Economics and Management Strategy, 20, 803-842

Leoncini, R., A. Marzucchi, S. Montresor, F. Rentocchini and U. Rizzo (2019), 'Better late than never': the interplay between green technology and age for firm growth,' Small Business Economics, 52(4), 891–904.

Manello, Alessandro, 2017. "Productivity growth, environmental regulation and win–win opportunities: The case of chemical industry in Italy and Germany," European Journal of Operational Research, Elsevier, vol. 262(2), pages 733-743

Margolis, J., and Walsh, J. (2003). Misery Loves Companies: Rethinking Social Initiatives by Business. Administrative Science Quarterly, 48(2), 268-305

Marin, G. (2014), 'Do eco-innovations harm productivity growth through crowding-out? Results from an extended CDM model for Italy,' Research Policy, 43(2), 301–317.

Martinez-Conesa I., Soto-Acrosta P., Placios-Manzano M. (2017), Corporate social responsibility and its effect on innovation and firm performance: An empirical research in SMEs, Journal of Cleaner Production, 142, 2374-2383

Miroshnychenko, I., Barontini, R., Testa, F. (2017). Green practices and financial performance: A global outlook. Journal of Cleaner Production. 147. 340-351

Orlitzky, M, Siegel D., Waldman D. (2011), Strategic Corporate Social Responsibility and Environmental Sustainability, Business and Society, 50, 6-27.

Peneder M., Arvanitis S., Rammer C., Stucki T., Wörter M. (2017), Competitiveness and Ecological Impacts of green Energy Technologies: Firm-Level Evidence for the DACH Region (Working Paper No. 544). WIFO Working Papers

Porter M and van der Linde C. (1995), "Toward a New Conception of the Environment-Competitiveness Relationship," Journal of Economic Perspectives, 9, pp. 97–118

Porter M. and Kramer M. (2006), 'Strategy & Society: The Link Between Competitive Advantage and Corporate Social Responsibility', Harvard Business Review, December, pp. 79-92

Porter M., and Kramer M. (2002) "The Competitive Advantage of Corporate Philanthropy." Harvard Business Review, 80, 56–69.

Reif, C., and Rexhäuser, S. (2018). Good enough! Are socially responsible companies the more successful environmental innovators? In J. Horbach & C. Reif (Eds.), New developments in eco-innovation research, sustainability and innovation (pp. 163–192). Cham, Switzerland: Springer.

Rexhauser S. and C. Rammer (2014), 'Environmental innovations and firm profitability: unmasking the porter hypothesis,'Environmental and Resource Economics, 57(1), 145–167.

Riillo, C. (2017), Beyond the question "Does it pay to be green?": How much green? and when?, Journal of Cleaner Production, 141, 626-640

Rubashkina, Y., M. Galeotti and E. Verdolini (2015), 'Environmental regulation and competitiveness: empirical evidence on the Porter hypothesis from European manufacturing sectors,' Energy Policy, 83, 288–300.

Russo, M. V. and P. A. Fouts (1997), 'A resource-based perspective on corporate environmental performance and profitability,'Academy of Management Journal, 40(3), 534–559.

Salama A. (2005), A note on the impact of environmental performance on financial performance, Structural Change and Economic Dynamics, 16, 413-421

Sarkis, J. and Cordeiro, J. (2001). An empirical evaluation of environmental efficiencies and firm performance: Pollution prevention versus end-of-pipe practice. European Journal of Operational Research. 135. 102-113.

Soltman C., Stucki T., Woerter M. (2015), The Impact of Environmentally Friendly Innovations on Value Added, Environmental and Resource Ecoomics, 62, 457-479

Stuart L. Hart and Mark B. Milstein, (2003), Creating sustainable value. Academy of Management, 17, 56–67

Telle, K. (2006) "It Pays to be Green" – A Premature Conclusion?. Environ Resource Econ, 35, 195–220.

Wagner, M., Van Phu, N., Azomahou, T. and Wehrmeyer, W. (2002), The relationship between the environmental and economic performance of firms: an empirical analysis of the European paper industry. Corp. Soc. Responsib. Environ. Mgmt, 9: 133-146

FONDAZIONE ENI ENRICO MATTEI WORKING PAPER SERIES
"NOTE DI LAVORO"
Our Working Papers are available on the Internet at the following address:
http://www.feem.it/getpage.aspx?id=73&sez=Publications&padre=20&tab=1

"NOTE DI LAVORO" PUBLISHED IN 2022

1. 2022, Daniele Crotti, Elena Maggi, Evangelia Pantelaki, Urban cycling tourism. How can bikes and public transport ride together for sustainability?
2. 2022, Antonio Acconcia, Sergio Beraldo, Carlo Capuano, Marco Stimolo, Public subsidies and cooperation in research and development. Evidence from the lab
3. 2022, Jia Meng, ZhongXiang Zhang, Corporate Environmental Information Disclosure and Investor Response: Empirical Evidence from China's Capital Market
4. 2022, Mariagrazia D'Angeli, Giovanni Marin, Elena Paglialunga, Climate Change, Armed Conflicts and Resilience
5. 2022, Davide Antonioli, Claudia Ghisetti, Massimiliano Mazzanti, Francesco Nicolli, The economic returns of circular economy practices

Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italia

Tel. +39 02.520.36934
Fax. +39.02.520.36946

E-mail: letter@feem.it
www.feem.it

Fondazione Eni Enrico Mattei