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Summary

This paper builds on the available knowledge on what drives firms' production choices towards circular economy practices to shed new light on a so far quite neglected dimension: the role of organizational settings. Being the transition to a more circular economy systemic in nature, it draws not only on technological but also on organizational changes and new set-ups. Coherently, the paper investigates how certain organizational settings (such as practices of communication to employees on critical aspects of the life of the company, the implementation of new performance evaluation mechanisms and incentive-based payment methods and the implementation of changes in recruitment and training of (new) employees affect the adoption of circular economy innovation. The work is empirical, and it draws on a newly collected dataset representative for Italian manufacturing firms in 2017-2018. Results show new light on the role of such organizational set-ups, which are found to be making the transition towards a circular economy more effective.

Keywords: Circular Economy, Sustainable Production, Environmental Innovation, Organisational Change

JEL Classification: O30, O44, O55

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Innovation, Circular economy practices and organisational settings: empirical evidence from Italy

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Abstract

This paper builds on the available knowledge on what drives firms' production choices towards circular economy practices to shed new light on a so far quite neglected dimension: the role of organizational settings. Being the transition to a more circular economy systemic in nature, it draws not only on technological but also on organizational changes and new set-ups. Coherently, the paper investigates how certain organizational settings (such as practices of communication to employees on critical aspects of the life of the company, the implementation of new performance evaluation mechanisms and incentive-based payment methods and the implementation of changes in recruitment and training of (new) employees affect the adoption of circular economy innovation. The work is empirical, and it draws on a newly collected dataset representative for Italian manufacturing firms in 2017-2018. Results show new light on the role of such organizational set-ups, which are found to be making the transition towards a circular economy more effective.

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1. Introduction

Firms face multifaceted challenges coming from the current competitive environment. They need to innovate on ‘traditional’ forms of innovation (e.g. product and process), they need to answer environmental challenges (e.g. circular economy innovations) and they must be fit to sustain the technological changes and the persistent innovation activities, over different dimensions, through the adoption of appropriate organisational practices (organisational setting).

The contributions of recent and less recent works on the importance of the organisational setting/human resource management practices to support high economic performance (Caroli and Van Reenen, 2001; Laursen and Mahnke, 2001; Karlsson and Tavassoli, 2016; Arranz et al, 2019) and/or high innovative performance (Laursen and Foss, 2003; Ballot et al, 2015; Arranz et al., 2019) are abundant, but they still lack to provide an adequate focus on the organisational dimension, as pointed out by Arranz et al. (2019): “the technology-centric view of innovation continue to dominate” p.270). In addition, the complex set of relations among technological innovations and organisational practices is difficult to explore because of the usually lack of data on the organisation side of the nexus.

The main objective of this paper, in line with Carboni and Russu (2018), is to shed further light on the complex relation at firm level on product, process (Hullova, 2016) and organisational/human resource management practices (Bloom and Van Reenen, 2007), given the potential prominent role of the latter in designing the ground over which innovation flourish or struggle to come to light. In analysing the set of linkages we add, to the existing literature on the subject at stake, a perspective on specific typologies of innovations that enter in the realm of the circular economy, providing for the first time, at the best of our knowledge, evidence of original relations between organisational practices and circular economy innovations. The work bridges the literature concerning circular innovation with that one related to the firm’s organisational capabilities (see for the latter, Chiva et al., 2007; Presenza et al., 2017). The latter concerns several dimensions of the organisational structure, ranging from the types of knowledge sourcing adopted by the firm to the absorptive capacity provided by the human capital at the firm disposal. As it will be clear in the paper development, we mainly focus on organisational capabilities related to the employees and the organisation of labour at firm level: e.g. employees involvement; employees training.

To shed light on the main objective of the work we need to control for the main elements affecting firms’ choices towards circular practices. To this aim the paper draws extensively on the broad literature on environmental innovations’ determinants (for a review Barbieri et al. 2016) to select our core control variables, being circular economy a subset of those innovations. More precisely, both typologies of innovations are signalling firms strategic attention towards corporate social responsibility and sustainability objectives (Reif and Rexhäuser, 2018), both include those activities aiming at reducing the environmental impact of firms (Horbach and Rammer, 2020), and the former is definitely needed to drive the transition to a circular economy (de Jesus et al. 2018). This suggests that the drivers that extant literature has identified for environmental innovations do apply also for circular economy innovations, as confirmed in Cainelli et al. 2020. According to such literature (e.g., Rennings, 2000; Horbach, 2008 and Horbach et al. 2012) these main determinants can be grouped into: Market-pull (market conditions such as expectations of future turnover, previous economic performance, demand for new ecoproducts or consumer preferences); Technology-push (pertaining the knowledge-capital endowment, stimulated for instance by R&D activities and personnel); Regulation (i.e. any relevant policy that directs firms innovative activities towards a reduction in their environmental impacts, including either hard or soft measures) and a residual group of determinants pertaining firm specific factors (such as the size, the location, the internationalization of a firm).

However, and more interestingly in this context, different environmental innovations may heterogeneously affect the circular economy transition (Kiefer et al. 2021) and such transition needs more systemic innovations than "simple" technological changes, including service and organizational innovations (de Jesus et al. 2018), which the current paper tries directly to assess by looking at the role of organizational settings. In other words, this work enlarges the fourth group of determinants, i.e. firms specific factors, and it assesses whether certain organizational settings, which are firm specific, favour or not firms circular economy production choices.

Few antecedent studies analysed the relation between firm's internal factors, namely organisational changes, and environmental innovations. Hottenrott et al. (2016) highlight the importance of organisational changes as complementary practices to environmental technological innovation to productivity gains. Similarly, but in a study not involving the economic performance of the firms, Antonioli et al. (2013) analyse the complementary relation among different organisational practices and environmental innovation, as output variable. The latter study focuses on a general framework of analysis that may include the present one, which is however original in several respects. We add to the extant literature both the newness of perspective on circular economy innovations determinants and the original information at our disposal. In so doing we contribute to the debate concerning the circular model diffusion through the possibility to use a large set of circular economy innovations coupled with an equally large set of organisational practices, specifically detected by a unique questionnaire administered to a representative sample of Italian firms for the period 2017-2018. The main research question can be synthetically posed in this way: do organisational capabilities relate to circular innovations? In answering this question we intend to provide meaningful implications for managers about what we conceive to be a current and future crucial issue in the diffusion of circular business models: the relation between organisational capabilities and circular economy innovations.

The remaining of the paper is structured as follows. Section 2 provide a sketch of the on the vast literature on the determinants of innovations, with a focus on the internal strategic organisational dimensions; section 3 provides a description of the original dataset at our disposal and the methodology we are able to apply to answer the main research questions; section 4 shows the main results and provides a discussion on them; the last section is left to policy and managerial implications that can be drawn by the empirical results.

2. Data and methodology

Data for the empirical analysis have been collected from a survey on manufacturing enterprises in Italy. The survey has been conducted in 2020 at national level on those manufacturing companies with at least 10 employees, by the survey company Izi s.p.a.. This survey was configured as a CAWI (Computer Assisted Web Interview) survey through which a structured questionnaire was administered to companies. This questionnaire is made up of 4 main macro-sections: Business Characteristics; Innovation and Investment; CE; Organization, Training and Industrial Relations. Within each section, an appropriate set of questions allows for the collection of relevant information on the various themes. Although the questionnaire is complex, the objective of interviewing at least 4500 companies at national level has been achieved: the sample of responding companies is 4565, stratified on three dimensions - geographical location (macro area, Istat), sector (technological intensity, Eurostat), size (10-49 employees; 50-249 employees; 250+ employees). The period covered by the national survey is the two-year period 2017-2018. For the national economy it represents a two-year period of growth, which had already begun in 2015, but which showed a phase of slowdown in the transition from 2018 to 2019 (albeit still growth). In fact, to perform the analysis in this work the set of questions used encompasses general information on the enterprises (e.g., size, sector, turnover, finance, geography), information on R&D intensity at firm level and CE-related innovation adoption, as *control variables* in our specifications. As far as the main variables of interest are concerned the questionnaire offers a large number of organisational practices whose implementation and frequency within the firms are asked to the respondents (Table 4 in Appendix). Thanks to this articulated set of organisational practices, ranging from recruitment practices to employees involvement, we are able to capture different dimensions of the organisational capabilities each firm has.

Methodology

As already mentioned in the introduction, this work will be investigating to what extent the organizational setting of an enterprise influences the adoption of CE-related innovations within their production process. In order to answer this question, the empirical strategy will try to infer if those companies that have adopted CE innovations are also those that are implementing changes within their organization. Controls for the model comprise information on the size, the geographical area, technological intensity. The variables on geographical area and technological intensity at sector level have been constructed from the questions on province and sectorial manufacturing code (e.g., ATECO) respectively. There is also a specific set of variables reflecting the intensity of R&D within the enterprise through the number of (green) patent filed, the number of employees working in R&D and how much of the turnover of the firm has been destined to R&D (e.g., R&D investments). Correlation among relevant explanatory variables is presented in Table 5 of Appendix. The dependent variable has been constructed from the set of questions on adoptions of different innovations related to circularity. It takes value of 1 if the company has adopted an innovation related to material (including energy, electricity and water) reduction, waste reuse, reduction, transfer to other companies in order to be used in their production process, changes in product design to either reduce material inputs or maximize recycling. The variable takes value 0 if no such innovations have been introduced by the company.

For the relevant explanatory variables on organizational settings a set of 18 questions has been selected from the survey investigating the implementation of new methods for recruitment, employee communication and involvement in the life of the company, performance evaluation and incentive-based payment practices (Table 4 of the Appendix). Principal Component Analysis (PCA) has been applied to this set of variables to provide a more synthesized measure on organizational setting changes. Considering the nature of the variables, the PCA algorithm has been run on the matrix of polychoric correlation among the variables. Polychoric correlation is used to deal with categorical variables where it is assumed data follow an underlying normal distribution (Ekström 2011). On the other hand, the optimal number of components for the PCA has been chosen plotting the eigenvalues coming from the matrix of observed data with those coming from a random (polychoric) matrix of the same size as the original (e.g., parallel analysis). The optimal number of components, as suggested by the sample, would provide a sharp break in the plot. Once identified the suggested number of components (in this case 3), PCA has been run using the varimax method for the rotation of the matrix of components whereas scores have been computed using the regression method (DiStefano et al. 2009). In synthesis, after the PCA, the 18 questions have been reduced to 3 Principal Components providing information on the relevant organizational aspects subject to this analysis. The full PCA results are presented in Table 1.

Table 1. Results of the Principal Component Analysis.

Question	Principal components – Varimax rotation		
	Employee involvement	**Evaluation and pay for performance**	**Recrutiment and training**
Candidates upon hiring undergo structured interviews (questions related to the job, standardized for every candidate with objective measurement scale)	0,2162	0,1490	**0,7903**
Candidates upon hiring undergo formal tests (written test or simulations of problem solving of real cases)	0,1449	0,2596	**0,7488**
Employees receive professional training	0,4397	0,2076	**0,6076**
Results of performance evaluation are used to determine training needs of employees	0,3313	0,2604	**0,6820**
Employees are refunded for external training courses	0,2973	0,3355	**0,4963**
Employees receive formal evaluation of their performances	0,2772	0,4482	**0,5407**
Raises of salaries are based on employees' performances	0,3062	**0,6357**	0,3380
Employees receive bonuses, rewards linked to productivity, individual performances or other indicators	0,2575	**0,8091**	0,2445
Employees receive bonuses, rewards linked to productivity, group performances or other indicators	0,2347	**0,8422**	0,2244
Employees receive bonuses, rewards linked to productivity, company performances or other indicators	0,2482	**0,8213**	0,2236
Qualified employees have the opportunity to be promoted to positions with higher salaries and higher responsibilities	0,3916	**0,6163**	0,3273
Employees can express their concerns reasonably	**0,6969**	0,2248	0,3164
Employees are involved in formal paricitpatory processes (i.e., work group for quality enhancement, workgrous of problem solving, discussion panels, suggestion mechanisms)	**0,7238**	0,2896	0,3227
Employees communicate among departments/offices/organizational units for problem solving and compliance with deadlines	**0,7830**	0,1852	0,2654
Employees are informed by the company on organizational objectives	**0,8274**	0,2617	0,2455
Employees are informed by the company on operative performances (e.g., productivity, quality, client satisfaction)	**0,8194**	0,2895	0,2131
Employees are informed by the company on financial performances	**0,5847**	0,4934	0,1970
Employees are informed by the company on market performances (e.g., market share, strategies)	**0,5982**	0,4601	0,2211

A synthetic account of the variables employed in the empirical analysis along with main statistics is provided in Table 3 of the Appendix. The Equation below represents the baseline model that will be used for the analysis. For the single enterprise □

$$
\begin{aligned}
&\square\square\ \square\square\square\square\square\square\square\square\square\square\square_{\square} \\
&\quad = \square\square\square\square\ \square\square\square\square\square\square\square\square\square\square\square\square_{\square} + \square\square\square\square\ \square\square\square\ \square\square\square\ \square\square\square\square_{\square} \\
&\quad + \square\square\square\square\ \square\square\square\ \square\square\square\square\square\square\square\square_{\square} + \square\square\square\square_{\square} + \square_{\square} + \square_{\square}
\end{aligned}
$$

$\square\square\ \square\square\square\square\square\square\square\square\square\square\square_{\square}$ takes value 1 if the company has adopted a CE-related innovation. 0 otherwise

$\square\square\square\square\ \square\square\square\square\square\square\square\square\square\square\square\square_{\square}$ PC related to communication to and involvement of employees on critical aspects of the life of the company – as reported by a broad literature employees involvement may have a positive impact on the firm performance (e.g. Black and Linch, 2001; Caroli and Van Reenen 2001), but it may also influence the innovation adoption (Uhlaner et al., 2013; van Wijk et al., 2008)

$\square\square\square\square\ \square\square\square\ \square\square\square\ \square\square\square\square_{\square}$ PC representing the set of questions assessing the implementation of performance evaluation mechanisms and incentive-based payment methods – these practices are directly linked to higher employees' performance (Lucifora and Origo, 2015; Damiani and Ricci, 2011), which in turn (and in a dynamic perspective), through an indirect effect given by high economic performance and investments, may increase the capacity to innovate of the firm

$\square\square\square\square\ \square\square\square\ \square\square\square\square\square\square\square\square_{\square}$ = PC related to the implementation of changes in recruitment and training of (new) employees – the set of practices mainly explained by this components is related to the absorptive capacity of the firm, which is at the basis of the firm learning processes, and crucially shape the ability of the organisation to exploit external knowledge and (new) technologies (Presenza et al, 2017) as well as to increase the capability to experiment, taking risk, to set up participative decision making (Chiva et al, 2007)

The remaining variables have been constructed by drawing on extant literature on the drivers of environmental innovations adoption. More precisely:

$Inno_i$ captures a set of dimensions concerning R&D intensity e.g., number of (green) patents applications, number of employees in R&D, share of turnover destined to R&D. This variables account for the category of "Technology Push" set of determinants that extant literature has identified as relevant determinants of environmental innovations adoption.

X_i includes a set of controls concerning "Firm specific factors" and "Demand Pull" set of determinants, including the size of the enterprise (Large, Small, Medium), the Geographical Area (North-East, North-West, Center, South and Isles), as well as their sectorial technological intensity (High Tech, Medium-High Tech, Medium-Low Tech, Low Tech) and their exporting propensity.

ε_i is the error term.

Considering the nature of the dependent variable, the analysis will be performed applying a logistic framework (logit/probit). The empirical analysis will then focus on specific classes of enterprises related to dimension and technological intensity.

Being the focus on Italian manufacturing firms observed in a cross section, we do not add any specific policy variable to capture the dimension "Regulation" that extant literature has listed as a crucial determinant for environmental innovations adoption, being most of the core regulation towards circular economy set at a higher institutional level thus invariant in the same country-year. However, to be sure to rule out possible regional heterogeneities in policy stringency, we account for the location of the firms by means of the geographical area variables (North-East, North-West, Center, South and Isles), and for the potential presence of sector specific policies by means of the technological intensity variables (High Tech, Medium-High Tech, Medium-Low Tech, Low Tech).

3. Results and discussion

In what follows results (Table 2) of the empirical analysis are reported, on the whole sample (columns 1 and 2), split by the technological intensity of the sector (columns 3 to 6) and split by the size of the firm (column 7 and 8).

The way firms do organize internally matters in explaining their attitude to engage in circular economy practices: the three main components are all significantly and positively correlated to the dependent variable, throughout the different specifications. Involving employees directly into firms participatory processes, keeping them informed on the economic performance and the objectives of the firm (*EMPLOYEES INVOLVMENT*) help the firm reaching its objective of adopting circular economy innovations. In line with the literature that recognise in employees participation to decision making a way to increase the capacity of the organisation to produce new and better ideas (Thompson, 2003), the higher the employees involvement into firm’s strategic choices, the higher its probability to be successful in translating its strategy into an innovative outcome. Furthermore, investing into firm’s employees training or hiring qualified employees (*RECRUITMENT AND TRAINING*) also positively contributes to achieving firms’ innovative objectives: the better and more qualified a firm’s human capital, the higher its probability in being a successful circular innovator. In this case we meaningfully enter the dimension of capabilities related to the organisational learning and the firm absorptive capacity, with the strong positive implications they have for the innovative activity of the firm. Circular innovations as other types of innovations are likely to be adopted where the knowledge base of the firm is ready to exploit them, possibly providing competitive advantages in line with the Porter hypothesis. At the same time, employees need to be given the right level of incentives in order to experience this virtuous circle: firms undertaking mechanisms to reward more productive attitudes in their employees (*EVALUATION PAY PERFORMANCES*) face better (circular) innovative outcomes. This evidence pertaining organizational set-ups is consistent in the whole sample, but also for the different technological intensive sectors and across different firm sizes. The only exception pertains column (3) for high tech firms, whose number of observations is however too low to allow extrapolating reliable evidence.

Moving to the other explanatory variables, they seem to be only partly consistent to existing literature. The "Technology Push" helps explaining circular innovation adoption (EMPLOYEES R&D, R&D INVESTMENT and GREEN PATENTS are all positive and significant), while sectors and regions are confirmed to matter in explaining innovative activities (the associated dummy variables are mostly significant). Surprisingly in this context size does not seem to play any direct role neither as direct covariate nor when splitting the sample into column 7 and 8. Lastly, exporting firms are less likely to adopt those innovations than non-exporting ones, contrarily to existing evidence on environmental innovation adoption. Future research may help explaining this controversial result. For instance, Table 6 of the Appendix shows the results for the same baseline model as in Table 2, using the number of CE-related innovation introduced by the enterprise (CE Innovation Count).

Table 2 - Results of the baseline model- Dependent Variable: CE Innovation Adopotion

	Dependent variable:							
	CE Innovation Adoption							
	probit	*logistic*	*probit*					
			HTech	MHTech	MLTech	LTech	Small	Medium
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Employee Involvement	0.174***	0.291***	0.116	0.208***	0.178***	0.186***	0.168***	0.226***
	(0.024)	(0.040)	(0.157)	(0.058)	(0.039)	(0.038)	(0.025)	(0.083)
Evaluation Pay performances	0.205***	0.337***	-0.027	0.233***	0.181***	0.250***	0.199***	0.226***
	(0.024)	(0.040)	(0.125)	(0.057)	(0.037)	(0.042)	(0.026)	(0.074)
Recruitment and training	0.211***	0.347***	0.178	0.206***	0.247***	0.202***	0.206***	0.279***
	(0.024)	(0.040)	(0.146)	(0.058)	(0.038)	(0.042)	(0.026)	(0.077)
North-East	0.136**	0.223**	0.073	-0.362**	0.184	0.325***	0.147**	-0.094
	(0.069)	(0.113)	(0.446)	(0.177)	(0.116)	(0.105)	(0.072)	(0.240)

North-West	0.110	0.185*	-0.291	-0.244	0.247**	0.074	0.129*	-0.170
	(0.067)	(0.111)	(0.406)	(0.172)	(0.113)	(0.105)	(0.071)	(0.228)
South and Isles	0.177**	0.290**	0.113	-0.457*	0.200	0.327***	0.199**	-0.063
	(0.087)	(0.144)	(0.569)	(0.242)	(0.156)	(0.123)	(0.091)	(0.305)
Medium	0.503	0.816		1.578	0.605	0.497		
	(0.435)	(0.726)		(2.181)	(0.897)	(0.564)		
Small	0.320	0.523	-0.373	1.379	0.446	0.326		
	(0.431)	(0.720)	(0.354)	(2.178)	(0.893)	(0.551)		
Low Tech	0.619***	1.019***					0.630***	0.564*
	(0.139)	(0.232)					(0.156)	(0.332)
Medium-High Tech	0.388***	0.637***					0.402**	0.265
	(0.142)	(0.235)					(0.159)	(0.324)
Medium-Low Tech	0.517***	0.852***					0.530***	0.364
	(0.138)	(0.230)					(0.155)	(0.323)
Export	-0.266***	-0.430***	-0.637**	-0.250**	-0.190**	-0.329***	-0.223***	-0.671***
	(0.048)	(0.079)	(0.285)	(0.115)	(0.077)	(0.079)	(0.051)	(0.162)
Empolyees R&D	0.005**	0.008**	-0.012	0.002	0.012***	0.004	0.006**	-0.004
	(0.002)	(0.003)	(0.009)	(0.004)	(0.003)	(0.004)	(0.002)	(0.006)
R&D investments	0.019***	0.032***	0.020	0.008	0.022***	0.031***	0.020***	0.014

	(0.004)	(0.006)	(0.013)	(0.007)	(0.006)	(0.008)	(0.004)	(0.012)
Patents	-0.008	-0.018	-0.030	-0.055	0.082	-0.032	0.025	-0.126*
	(0.032)	(0.053)	(0.076)	(0.063)	(0.085)	(0.096)	(0.039)	(0.076)
Green Patents	0.544***	0.969***		1.279**	0.091	0.597	0.438**	1.091*
	(0.183)	(0.343)		(0.572)	(0.282)	(0.457)	(0.206)	(0.660)
Constant	-0.820*	-1.359*	0.848	-1.067	-0.661	-0.190	-0.600***	0.611
	(0.459)	(0.766)	(0.638)	(2.189)	(0.902)	(0.563)	(0.179)	(0.440)
Observations	3,284	3,284	107	650	1,331	1,196	2,883	391
Log Likelihood	-2,062.459	-2,061.442	-62.232	-403.242	-832.403	-736.577	-1,814.476	-235.134
Akaike Inf. Crit.	4,158.919	4,156.885	148.464	834.483	1,692.805	1,501.155	3,658.952	500.268
Note:								*p<0.1; **p<0.05; ***p<0.01

4. Conclusions

The transition to a circular economy is an imperative, driven by increasing policy attention, but at the same time it is far from being a simple goal to be reached.

At the firm level, such transition asks firms to transform their business models to embrace a number of new circular practices such as changing their raw resources in favour of regenerative, recyclable or reusable ones; making waste a resource; design longer lasting products; facilitating services such as pay per use (Stahel, 2013) they may have not been familiar with. To be able to adopt circular economy innovations, firms are thus actually required to change substantially their business models (Linder and Williander 2015). This evidence suggests that it is not only a matter of technological capacity of a firm. In line with a literature that recognise the organisational capabilities as strictly interconnected to the innovative capacity of the firm (Capriati and Divella, 2020) we explored, in this paper, the relations between different dimensions of the internal-to-the-firm organisation of labour, which imply different dimension of the organisational capabilities, and the adoption of circular innovations.

Moving from these premises, the paper adds to existing literature a new piece of evidence on how firms can heterogeneously respond to the challenges above and be successful circular innovators. By recognizing the complexity of such challenge, the current work tries to shed new light on the determinants of circular innovations adoption by looking at a so far quite neglected dimension: the role of organizational set-ups. The analysis, conducted on a new and recent dataset on Italian manufacturing firms, confirms a pivotal role for different practices firms may or may not embrace, confirming the expectations that organizational set ups have a role. The paper suggests that i) the higher is employees involvement into firms' activities and objectives, ii) the better qualified is firm's human capital and iii) the higher is the presence of rewarding schemes for employees good performance, then the higher is the probability for such firm to be a successful circular innovator when compared to its peers. The complexity of the circular economy transition not only requires technological capabilities, as previous literature has already well outlined, but also specific organizational capabilities that allow making such transition effective. Firms' managers must be aware of the importance of the organisational practices adopted as a potential ground for the adoption and implementation of circular innovation.

Appendix

Table 3 - Main descriptive statistics

Variable	Description	Statistics
Export	1: the enterprise is an exporter	47%
	2: the enterprise is not an exporter	53%
Employees R&D	Employees in R&D as a share of total employees: 2018	Min. : 0.0
		1st Qu.: 0.0
		Median : 0.0
		Mean : 4.4
		3rd Qu.: 2.0
		Max. :100.0
R&D Investments	share of turnover dedicated to R&D : 2018	Min. : 0.0
		1st Qu.: 0.0
		Median : 0.0
		Mean : 2.7
		3rd Qu.: 2.0

		Max. :85.0
Patents	Number of patents filed by the company	Min. : 0.00
		1st Qu.: 0.00
		Median : 0.00
		Mean : 0.13
		3rd Qu.: 0.00
		Max. :31.00
Green Patents	share of patents filed that reduce environmental footprint of the enterprise out of total patents filed	Min. : 0.000
		1st Qu.: 0.000
		Median : 0.000
		Mean : 0.026
		3rd Qu.: 0.000
		Max. :10.000
Employee Involvement	PC capturing the level of communication and involvement of employees in the life of the company	Min. :-3.43690
		1st Qu.:-0.56539
		Median : 0.08914
		Mean : 0.01487
		3rd Qu.: 0.68645
		Max. : 3.21594
Evaluation pay performances	PC capturing if the enterprise has	Min. :-3.262933

	implemented new evaluation performance methods and incentive-based practices	1st Qu.:-0.720674
		Median :-0.038944
		Mean : 0.009702
		3rd Qu.: 0.685826
		Max. : 2.590442
Recruitment and training	PC capturing if the enterprise has implemented changes in recruitment and training of (new) employees	Min. :-3.315364
		1st Qu.:-0.686889
		Median : 0.030158
		Mean : 0.008307
		3rd Qu.: 0.686449
		Max. : 4.211577
Geographical Area	Centre	18%
	North East	32%
	North West	39%
	South-Isles	11%
Size	Large	0,3%
	Medium	12%
	Small	88%
Technological Intensity	HighTech	3%

	LowTech	36%
	MediumHighTech	20%
	MediumLowTech	41%
CE Innovation adoption	0: the enterprise has not adopted CE-related innovation	57%
	1: enterprise has adopted CE-related innovation	43%

Table 4 – Organisational practices used in the Principal Component Analysis

Code	Question	Answer	Frequency
v4.2.1	Candidates upon hiring undergo structured interviews (questions related to the job, standardized for every candidate with objective measurement scale)	Never	17,97%
		Seldom	9,77%
		Sometimes	18,91%
		Often	22,53%
		Very often	13,92%
		Don't know	16,90%
v4.2.2	Candidates upon hiring undergo formal tests (written test or simulations of problem solving of real cases)	Never	55,82%
		Seldom	12,24%
		Sometimes	11,24%
		Often	3,99%
		Very often	2,44%
		Don't know	14,28%
v4.2.3	Employees receive professional training	Never	4,35%
		Seldom	4,66%
		Sometimes	22,08%
		Often	32,19%
		Very often	29,38%
		Don't know	7,34%
v4.2.4	Results of performance evaluation are used to determine training needs of employees	Never	18,97%
		Seldom	11,39%
		Sometimes	26,19%
		Often	18,15%
		Very often	7,95%
		Don't know	17,36%
v4.2.5		Never	18,06%

	Employees are refunded for external training courses	Seldom	4,96%
		Sometimes	10,69%
		Often	15,32%
		Very often	32,67%
		Don't know	18,30%
v4.2.6	Employees receive formal evaluation of their performances	Never	33,50%
		Seldom	12,79%
		Sometimes	18,15%
		Often	12,85%
		Very often	8,10%
		Don't know	14,62%
v4.2.7	Raises of salaries are based on employees' performances	Never	13,79%
		Seldom	9,14%
		Sometimes	22,69%
		Often	24,30%
		Very often	17,33%
		Don't know	12,76%
v4.2.8	Employees receive bonuses, rewards linked to productivity, individual performances or other indicators	Never	20,95%
		Seldom	13,52%
		Sometimes	26,86%
		Often	15,93%
		Very often	11,48%
		Don't know	11,27%
v4.2.9	Employees receive bonuses, rewards linked to productivity, group performances or other indicators	Never	34,77%
		Seldom	15,26%
		Sometimes	19,55%
		Often	10,23%
		Very often	6,97%
		Don't know	13,22%
v4.2.10	Employees receive bonuses, rewards linked to productivity, company performances or other indicators	Never	29,54%
		Seldom	14,89%
		Sometimes	21,44%
		Often	12,06%
		Very often	9,29%
		Don't know	12,79%
v4.2.11	Qualified employees have the opportunity to be promoted to positions with higher salaries and higher responsibilities	Never	11,69%
		Seldom	16,20%
		Sometimes	32,34%
		Often	18,76%
		Very often	8,89%
		Don't know	12,12%
v4.2.12		Never	2,25%

	Employees can express their concerns reasonably	Seldom	4,93%
		Sometimes	18,39%
		Often	35,96%
		Very often	30,09%
		Don't know	8,37%
v4.2.13	Employees are involved in formal paricitpatory processes (i.e., work group for quality enhancement, workgrous of problem solving, discussion panels, suggestion mechanisms)	Never	14,07%
		Seldom	14,83%
		Sometimes	25,15%
		Often	22,84%
		Very often	12,42%
		Don't know	10,69%
v4.2.14	Employees communicate among departments/offices/organizational units for problem solving and compliance with deadlines	Never	5,45%
		Seldom	6,36%
		Sometimes	20,92%
		Often	33,86%
		Very often	25,06%
		Don't know	8,34%
v4.2.15	Employees are informed by the company on organizational objectives	Never	8,31%
		Seldom	10,20%
		Sometimes	25,58%
		Often	29,29%
		Very often	18,03%
		Don't know	8,59%
v4.2.16	Employees are informed by the company on operative performances (e.g., productivity, quality, client satisfaction)	Never	9,59%
		Seldom	11,91%
		Sometimes	27,01%
		Often	26,92%
		Very often	15,41%
		Don't know	9,17%
v4.2.17	Employees are informed by the company on financial performances	Never	39,62%
		Seldom	22,20%
		Sometimes	16,81%
		Often	7,03%
		Very often	3,23%
		Don't know	11,11%
v4.2.18	Employees are informed by the company on market performances (e.g., market share, strategies)	Never	33,74%
		Seldom	20,46%
		Sometimes	20,31%
		Often	9,90%
		Very often	4,32%

		Don't know	11,27%

Table 5 - Correlation table relevant covariates

	Export	**Employees R&D**	**Investments R&D**	**Patents**	**Green Patents**	**Empl Involv**	**Evalu Perf**	**Recr Train**
Export	1	-0.146	-0.152	-0.115	-0.069	-0.053	-0.089	-0.061
Employees R&D	-0.146	1	0.374	0.103	0.109	0.025	0.091	0.046
Investments R&D	-0.152	0.374	1	0.100	0.054	0.079	0.092	0.060
Patents	-0.115	0.103	0.100	1	0.564	0.046	0.049	0.025
Green Patents	-0.069	0.109	0.054	0.564	1	0.029	0.059	0.033
Empl Involv	-0.053	0.025	0.079	0.046	0.029	1	-0.038	-0.025
Evalu Perf	-0.089	0.091	0.092	0.049	0.059	-0.038	1	-0.088
Recr Train	-0.061	0.046	0.060	0.025	0.033	-0.025	-0.088	1

Table 6 Results of the baseline regression model- Dependent variable: CE Innovation Count

	Dependent variable:						
	CE Innovation Count						
	Poisson						
		HTech	MHTech	MLTech	LTech	Small	Medium
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Employee Involvement	0.692***	-0.459***	0.523***	1.127***	0.392***	0.745***	0.206***
	(0.010)	(0.075)	(0.025)	(0.016)	(0.018)	(0.011)	(0.037)
Evaluation Pay performances	1.079***	0.126*	0.015	1.680***	0.433***	1.127***	0.306***
	(0.008)	(0.067)	(0.020)	(0.011)	(0.016)	(0.008)	(0.030)

Recruitment and training	1.486***	-0.111	0.290***	2.543***	0.133***	1.569***	0.332***
	(0.009)	(0.074)	(0.023)	(0.015)	(0.017)	(0.009)	(0.032)
North-East	0.794***	-0.462*	-1.101***	1.817***	-0.206***	0.806***	0.042
	(0.023)	(0.256)	(0.057)	(0.046)	(0.041)	(0.024)	(0.104)
North-West	-0.843***	-0.480**	-0.687***	-0.468***	-0.288***	-0.978***	0.351***
	(0.026)	(0.224)	(0.051)	(0.053)	(0.042)	(0.028)	(0.097)
South and Isles	-0.383***	1.240***	-1.269***	0.100*	-0.109**	-0.468***	0.465***
	(0.033)	(0.236)	(0.113)	(0.060)	(0.048)	(0.035)	(0.124)
Medium	0.424**		0.105	1.202***	0.672*		
	(0.211)		(0.456)	(0.321)	(0.358)		
Small	1.535***	-0.381**	0.017	2.350***	0.875**		
	(0.209)	(0.178)	(0.455)	(0.318)	(0.355)		
Low Tech	1.097***					1.216***	0.352***
	(0.066)					(0.078)	(0.136)
Medium-High Tech	0.649***					0.703***	0.489***
	(0.067)					(0.079)	(0.129)
Medium-Low Tech	1.562***					1.678***	0.130
	(0.065)					(0.076)	(0.133)
Export	-1.530***	-1.976***	-1.443***	-2.591***	0.132***	-1.603***	-0.533***
	(0.017)	(0.216)	(0.061)	(0.025)	(0.032)	(0.017)	(0.075)

Empolyees R&D	-0.040***	-0.006	-0.024***	-0.142***	0.013***	-0.049***	0.002
	(0.001)	(0.005)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
R&D investments	-0.015***	-0.006	0.010***	-0.040***	0.004*	-0.018***	0.028***
	(0.001)	(0.006)	(0.002)	(0.002)	(0.002)	(0.001)	(0.004)
Patents	-0.134***	0.028	-0.263***	-0.069***	0.034	-0.186***	-0.050***
	(0.015)	(0.036)	(0.042)	(0.025)	(0.035)	(0.025)	(0.016)
Green Patents	0.225***		0.396***	0.622***	0.285***	0.181***	0.168***
	(0.032)		(0.051)	(0.079)	(0.090)	(0.049)	(0.035)
Constant	0.105	3.639***	3.829***	-0.355	0.194	1.558***	0.996***
	(0.221)	(0.350)	(0.464)	(0.324)	(0.358)	(0.082)	(0.183)
Observations	3,283	107	650	1,331	1,195	2,883	390
Log Likelihood	-57,592.360	-309.948	-6,140.977	-28,506.410	-7,851.665	-53,966.460	-1,891.114
Akaike Inf. Crit.	115,218.700	643.897	12,309.950	57,040.810	15,731.330	107,962.900	3,812.228

Note: *p<0.1; **p<0.05; ***p<0.01

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