February 2022

FONDAZIONE ENI ENRICO MATTEI

Working Paper

06.2022

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Summary

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Keywords: Circular Economy, Sustainable production, Environmental Innovation; Cluster analysis, Firm profile

JEL Classification: O30; O44; O55

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Abstract

Applying clustering techniques, this paper identifies homogeneous groups of enterprises within the heterogeneous landscape of the italian manufacturing tissue. The algorithm will be fed with data from a survey on a cross-section of SMEs in 2019. The set of questions span from economic and financial performances to innovation adoption (product, process, organization), to circular economy implementation and environmental protection. Clustering has been chosen to identify groups of firms with respect to multiple and diverse characteristics without any pre-existing hypothesis on a possible relationship among the variables. Results will group profiles of enterprises considering the information on multi-dimensional aspects of a firm. Indeed, the overarching aim of this work is to single out common characteristics among the diverse landscape of enterprises within the manufacturing sector. This will in turn support (local and national) policy makers in better designing and targeting an appropriate set of policy instruments with respect to the relevant areas (i.e., circular economy, environmental protection, eco-innovation) of the ecological/sustainability transition. If the one-size-fits-all has not been proved a viable approach in policy making, a more targeted intervention at policy level tackling the consistent heterogeneity of the manufacturing tissue might improve the effectiveness of (sectorial) policies.

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Introduction

The European commission, in 2015, enacted its ambitious action plan for the circular economy (CE), which aimed at fostering sustainable development through several different channels, among which: resource efficiency; prolonged product life-cycle; growth of green jobs, and an overall boost in competitiveness by the creation of new and innovative business opportunities (EC, 2015, 2019). More specifically, an economy can be considered as circular if: "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised" (EC, 2015, p 2). When moving from theory to practice, it is clear that, a transition from a traditional (linear) production structure to a circular one, require both a transformation of the production systems – through the lever of eco-innovation – and a profound socio-organisational transformation. Often, in fact, circular economy practices require agreement between players before products are on the market, in order to create the virtuous mechanism whereby the by-product (or waste) of one actor can become the productive input of another. Consequently, the understanding of these and other relevant aspects poses ample scope for economic research.

So far, the scientific literature has mainly focused on three aspects: the determinants of CE practices, its economic consequences and the impact on the labour market. As regards the determinants, starting from the literature on environmental innovation, some recent studies have shown that circular economy practices are strongly dependent on market demand (G. Cainelli, et al., 2020), environmental policies (Robaina et al., 2020; G. Cainelli, et al., 2020) and public production activities (Rainville, 2021). Regarding economic impacts, although early studies show that a transition to a circular production paradigm brings numerous benefits, including greater environmental sustainability – through more efficient use of natural resources – and the creation of new green job opportunities (Ghisellini et al., 2016; LourdesMoreno-Mondéjar et al., 2021), the literature is still scarce and can be deepened in several areas.

Thanks to a new dataset originated from a survey we conducted in 2020 in Italy, including a sample of 4500 firms, representative of the whole spectrum of national manufacturing companies with at least 10 employees, in this work we group – with a cluster analysis – national firms based on the type and intensity of their innovation activities, with a special focus on CE-innovation.

As a result, we obtain a first picture of the inner characteristics of the actors of the circular economy transition – the firms – which allow us to typify innovators and deeply understand their structure. This process has at least two important implications. On the one hand, a better understanding of the structure of innovators is a useful information for policy makers who want to adopt targeted policies to support the transition to a circular economy. A correct typification of companies, in fact, allows a correct targeting of industrial policy intervention (or of green public procurement programmes). On the other hand, this typification can be the basis for future studies aimed at assessing whether, and to what extent, the structure of innovators (i.e., belonging to a certain cluster or another) influences business performance.

Literature review

Assessing the economic consequences of circular economy practices is crucial for policy making, especially if we consider the increasing interest of the recent EU policy packages in this field (Circular Economy package, European Green Deal and Recovery Fund).

Since the seminal contribution by Porter and Van der Linde (1995) and Jaffe and Palmer (1997), the economic literature highlights that environmental regulation is not necessarily detrimental for firms' performance; on the contrary, well-design policies may induce environmental innovation (EI) practices that can generate long term positive effect on firm performances and competitiveness – a theory often known as Porter hypothesis. This idea has been verified empirically by a broad strand of empirical literature, which generally agrees that the economic return of sustainable consumption and production practices – the old question: "does it pay to be green?" – is highly context and sector specific and cannot be generalised (For a review see Barbieri et al., 2016).

Among recent studies, Telle (2006) concludes that the real question is understanding when (i.e. under which context), or for whom it can pay to go green. In fact, the academic literature has found both positive (Cheng et al. 2014; Salama 2005; Manello, 2017; Costantini and Mazzanti, 2012), null (Peneder et al. 2017; Rubashkina et al., 2015; Elsayed and Paton 2005; Amores-Salvadó et al. 2014) and negative effect (Greenstone et al., 2012; Rexhäuser and Rammer, 2013; Sarkis and Cordeiro 2001; Wagner et al. 2002) of different green practices on firm competitiveness. An attempt to summarise and synthesise this literature has been made by the meta-analysis by Horváthová (2010), which finds that 55% of studies find a positive effect of green practices on firms' outcomes, 30% no effect and 15% negative effect

A standard economic explanation for the positive effects comes from the idea that firms start to adopt green practices when facing resource depletion. These practices generally translate into new business strategies – like access to new markets, or cost reductions driven by increased resource efficiency –, which, eventually, are later associated to higher economic returns (Hart and Dowell 2011; Ambec et al. 2008, Porter and Kramer 2002, 2006). However, studies show that this mechanism is not homogeneous across sectors (Soltmann et al. 2015) and tend to vanish in energy-intensive ones (Riillo, 2017). Finally, Marin (2014) and Marin and Lotti (2017) show that productivity returns of green practices are smaller than the ones related to non-green ones, because environmental innovation tend to crowd out non-environmental innovations, which may be more profitable.

While many empirical studies have focused on the economic effects of environmental innovation, there is still little empirical evidence on the impact of circular economy practices on the performance of firms and economic systems – a topic more in line with this study. However, there is much need to study this new topic because, while EI and CE are closely related, such that achieving CE without EI is unlikely, not all EI are related to CE. For instance, circular economy practices differ from standard EI, because CE do not only require technological changes, but also service innovations and novel organisational set-ups (de Jesus et al. 2018).

Given these premises, there are at least two open lines of research which deserve further investigation. Firstly, a recent strand of literature analysis the development and adoption of circular economy practices by considering several aspects like: the contextual factors in which a firm operates; the technical-scientific aspects that may facilitate a transition to the CE (for instance, digital technologies); the acquisition of “circular” product, processes and business models (Centobelli et al., 2020). Secondly, little is known about the economic impact of circular economy practices at firm level.

In addition to the above-mentioned complexity, which still deserves further investigation, little is known on the economic returns of CE-related technologies. If, on the one hand, the aim of sustainable and circular economy practices is not to boost company profits, on the other hand, given the costs involved in introducing these practices, and the difficulty, at times, of communicating them to consumers, it is clear that understanding the economic return of CE becomes crucial to their future development. On this issue, the recent study by Horbach and Rammer, (2020) found – exploiting the German Community Innovation survey (2014) – that firms which introduced CE innovations have higher sales and employment growth (particularly in lower-median quantiles of the growth distribution), and have higher financial standing (particularly for high-growth firms in the upper quantile). Similarly, Ghisetti and Rennings

(2014), by dividing CE-innovation in its sub-categories, found that input-reducing innovation activities (either energy or materials) has lead to short-term profit gains which may eventually lead to a reduced price per product that may increase its demand. For the other categories of CE-innovation, such as energy- substitution in favour of renewables, the results are less clear, and may depend on who is producing the renewable energy and its costs for the firm. Flachenecker and Kornejew (2019), by exploiting the Community Innovation Survey (2008), found that competitiveness return are correlated to innovation for the reduction of material use, but only for firms that received public financial support for these practices.

Overall, the scant literature in this field highlights that a CE transition require costly changes for the firms, not only in physical capital investments, but also in intangibles innovation-related activities and in organizational changes. However, this literature has generally focussed on the whole manufacturing sector, often neglecting firm-specificity and considering all firms to be equal. In this paper, by clustering firms in their sub-group and analysing their characteristic, we fill this gap.

Data and Methodology

Data

The source of data to feed the clustering algorithm is 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, reference market, income, finance) along with all those dimensions related to innovation (product, process, organizational), eco-innovation, environmental performances and circular economy. A total of 93 questions have been selected to run further analysis. The choice of the questions has been operated considering the focus of this work and the nature of the information provided by the answers.

Methodology

The empirical strategy consists of two steps of analysis: the first step involves the application of an Exploratory Factor Analysis (EFA

[1]) on the sample of questions. This technique provides a first layer of analysis exploring interrelationship among variables through factors. Each factor represents a set of dimensions of the data that is highly correlated. EFA can be either employed to merely reduce the number of variables in a large dataset or to describe dimensions that cannot be explained by the single variables (Hair et al. 2009). In this work, EFA will be employed as a way to find factors that represent broader conceptual dimensions of the survey with respect to the single variables. As already mentioned, EFA aggregates variables considering their correlation. In fact, after preliminary analysis on the matrix of correlation for the whole sample of questions it was possible to perform the EFA excluding some variables from the full set. The final number, as already mentioned in the Data section, was 93. Apparently, the reason was that those questions were not allowing the correlation matrix to be fully ranked. The factors have been estimated using Ordinary Least Squares (OLS) to find the minimum residual solution (e.g., minres). The matrix of the factors has been rotated using the oblique rotation that allows for variables to be correlated (e.g., non-orthogonal). The number of factors has been determined by comparing the scree plot of the successive eigenvalues of the factors coming from the observed data with that of a random matrix of the same size as the original (e.g., parallel analysis). Any sharp break in the plot, suggests the number of factors to extract. On the other hand, factor scores have been estimated using a regression method. This technique does not only take into account correlation within factors and between factors and observed data, but also correlation between observed data and oblique factors (DiStefano, Zhu, and Mîndrilã 2009). The second step entails the proper cluster analysis on the enterprises using the factor scores computed out of the EFA. Following the approach in (Marin and Vona 2019) the choice of the optimal number of clusters

[1] EFA has been performed using the R package psych. Further information are available at https://cran.r-project.org/web/packages/psych/index.html

(e.g., stopping rule[2]) has been conducted adopting a hierarchical clustering algorithm (e.g., average linked algorithm) on the whole dataset. Then, the clusters have been formed using a non-hierarchical (e.g., k-means[3]) method. Average linkage is an agglomerative hierarchical clustering technique that employs the average of the Euclidean distance among two points when computing the group of clusters. Since by computation hierarchical clustering does not require defining a specific number of clusters in advance, those algorithms can be used to set up the optimal number of clusters (Hair et al. 2009). On the other hand, k-means is a non-hierarchical clustering algorithm based on partitioning the dataset data according to a specific number of clusters k in order to minimize the distance among the data points around the so-called centroids (Kaufman and Rousseeuw 2005). The process of choosing the optimal number of clusters involved the computation of various indexes[4]. This first step provided the support to pick the number k that produced interpretable clusters considering the specific aim of the work as also suggested by (Kaufman and Rousseeuw 2005).

Results

A summary of the results of the factor analysis are represented in Table 1. The first eight factors reflect different type of Circular Economy innovation, ranging from material saving activities, to design innovation and process and product innovation; factors nine to twelve include other relevant green innovation; factors 13 includes non-green innovation; factors 14 to 16 reflect different type and aspect of R&D activities; factors 17 and 18 includes investment and financing activities; factors 19 and 20 cost of waste management; factors 21 and 22 are waste costs while the other three factors reflect organisational innovation, public procurement and export.

Table 1: Exploratory Factor Analysis Results

Factor 1	Design for recycling and reuse Innovation
Factor 2	Waste Prevention Innovation
Factor 3	innovations to promote the reuse of waste from another production process
Factor 4	Material Saving Innovation
Factor 5	Innovation for reuse activities
Factor 6	Green Process Innovation
Factor 7	Green Product Innovation

[2] To perform the analysis for the stopping rule the R package NbClust has been employed. For further information, see https://search.r-project.org/CRAN/refmans/NbClust/html/NbClust.html
[3] K-means algorithm has been run employing the basic stats R package. For further information, see https://www.rdocumentation.org/packages/stats/versions/3.6.2/topics/kmeans
[4] The algorithm has been run for all the indexes available in the R package NbClust.

Factor 8	Other CE Innovation
Factor 9	Other Type of Design Innovation
Factor 10	GHG Reducing Innovation
Factor 11	Renewable Energy Innovations
Factor 12	Electricity Saving Innovation
Factor 13	Non-Green Innovation
Factor 14	Employment in R&D activities
Factor 15	R&D Expenditure
Factor 16	R&D Expenditure for Environmental Protection
Factor 17	Green Investments
Factor 18	Source of Financing
Factor 19	Cost of Waste Management
Factor 20	Waste Cost Expectations
Factor 21	Sales (National)
Factor 22	Sales (EU)
Factor 23	Organisational Innovation
Factor 24	Public Procurement
Factor 25	Export

Results from the cluster analysis are presented in Table 2, for the two-cluster solution, and in Table 3, for the three-cluster solution. Interestingly, the two results are coherent, and draw a clear picture on how firm are organized with respect to their innovative performance both in green and non-green technologies.

The two-cluster solution produce a simple and clear-cut result, which can be summarized as follow: Cluster 1 are green innovators; Cluster 2 are non-green innovators. The two groups can be typify as follow:

Cluster 1 – Green innovators: This first group includes a set of firms which have a higher-than-average level of all factors summarized in Table 1, except for non-green innovation and organizational innovation. By comparing this result with Table 4, we see that firms in this cluster are specialised in most of the green innovation – and particularly CE-practices –, among which: reduction and reuse of waste; design innovation for the circular economy; innovation for GHG reduction. With respect to cluster 2, in cluster 1 firm are generally involved in low-tech and medium-low tech sectors, and there is a higher share of small firms.

Cluster 2 – Standard innovators: Firms in this cluster are characterised by being slightly bigger compared to cluster 1, and by belonging to medium-high and high-tech sectors. Moreover, they are mainly specialised in non-green technological innovation and in organisational innovation (with a few exception, like “electricity” and “material use saving innovation” – two type of green-innovation in which firms in cluster 2 show an higher-than-average performance).

Overall, the picture is clear, and show that CE-innovation are more diffused in small med-tech firms belonging to medium-low and low-tech sectors, while standard technological innovation is more common in big firms in high-tech sectors.

Table 2. Two Cluster Solution

Factors	**Cluster 1**	**Cluster 2**
Design for recycling and reuse Innovation	0.6993	-0.2183
Waste Prevention Innovation	13.073	-0.4081
innovations to promote the reuse of waste from another production	0.7199	-0.2247
Material Saving Innovation	0.2274	-0.0710
Innovation for reuse activities	0.0588	-0.0184
Green Process Innovation	0.0840	-0.0262
Green Product Innovation	0.1185	-0.0370
Other CE Innovation	0.0541	-0.0169
Other Type of Design Innovation	0.1045	-0.0326
GHG Reducing Innovation	0.8096	-0.2527
Renewable Energy Innovations	0.7856	-0.2452
Electricity Saving Innovation	0.9977	-0.3114
Non-Green Innovation	-0.2873	0.0897
Employment in R&D activities	0.1957	-0.0611
R&D Expenditure	0.4908	-0.1532
R&D Expenditure for Environmental Protection	0.2067	-0.0645
Green Investments	0.0847	-0.0264
Source of Financing	-0.2592	0.0809
Cost of Waste Management	0.3665	-0.1144
Waste Cost Expectations	0.6320	-0.1973
Sales (National)	11.102	-0.3466
Sales (EU)	0.1206	-0.0376

Organisational Innovation	-0.6645	0.2074
Public Procurement	0.3413	-0.1065
Export	0.2131	-0.0665
Number of firms	2270	2295

Despite the two-cluster solution is preferred from a statistical viewpoint, it does not provide many new insights on how to interpret the structure of Italian firms. Among all the other possible cluster analysis, the four-cluster solution present the best compromise between statistical soundness and economic interpretation. Its results can be described as follows:

Cluster 1 – Low-tech, small and non-innovative firms: This group of firms shows low performances both in green (CE and non-CE) and non-green innovation. The 94% of firms are small, and nearly the 85% belongs to medium-low and low-tech sectors.

Cluster 2 – Medium sized firms with a high incidence of CE-innovation: This is a small group of firms – about the 10% of the full sample – which are highly specialised in green and circular economy innovation. The incidence of non-green and organisational innovation is very low. Interestingly, it is not that easy to identify this group with technological intensity level, and there is a high incidence of medium-sized firms.

Cluster 3 – Non green innovators: This is the largest group (nearly 3000 units) which includes firms of a bigger size compared to other clusters, and is very similar to cluster 2 of previous analysis. This group is characterised by a higher incidence of medium-high and high-tech sectors, and a higher-than-average specialisation in non-green innovation and organisational innovation. The incidence of CE innovation and green innovation is minimal.

Cluster 4 – Low tech, small firms with a certain degree of circular economy practices: This is the second cluster in term of numerosity, including about the 20% of total firms, and it is the group with the highest incidence of low-tech and small firms. Despite that, and in line with the result of the two-cluster solution, these firms have a high incidence of CE and green innovation. In most cases, as shown in table 4, this is the second group when it comes to the incidence of CE practices, after cluster 2.

Table 3. Four Cluster Solution

Factor	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Design for recycling and reuse Innovation	0.2020	0.9531	-0.2410	0.3317
Waste Prevention Innovation	-0.2692	12.252	-0.4516	11.784
innovations to promote the reuse of waste	-0.1395	0.6538	-0.2994	0.8260
Material Saving Innovation	0.6837	0.1686	-0.1618	0.1363
Innovation for reuse activities	-0.0160	0.2464	-0.0178	-0.0316
Green Process Innovation	-0.0498	0.3492	-0.0224	-0.0406
Green Product Innovation	0.0693	0.2193	-0.0463	0.0333
Other CE Innovation	-0.0162	0.1893	-0.0175	-0.0090
Other Type of Design Innovation	-0.0735	0.2113	-0.0424	0.0960
GHG Reducing Innovation	-0.2554	33.770	-0.2658	-0.3387
Renewable Energy Innovations	-0.2500	0.9040	-0.2621	0.6531
Electricity Saving Innovation	-0.1961	11.194	-0.3716	0.9115
Non-Green Innovation	0.0868	-0.2118	0.0904	-0.2663
Employment in R&D activities	0.1483	15.379	-0.2406	-0.0200
R&D Expenditure	0.5351	14.521	-0.3190	0.1332
R&D Expenditure for Environmental	-0.1460	0.1606	-0.0496	0.1779
Green Investments	-0.0129	0.0360	-0.0280	0.0874
Source of Financing	0.1219	-0.1894	0.0930	-0.3020
Cost of Waste Management	13.876	0.4039	-0.2684	0.0470
Waste Cost Expectations	-0.1981	0.6779	-0.2452	0.6610
Sales (National)	0.0503	10.936	-0.4053	0.9119
Sales (EU)	0.2284	0.0510	-0.0762	0.1233
Organisational Innovation	0.0802	-10.688	0.2323	-0.3979
Public Procurement	0.0162	0.7555	-0.0981	0.0189
Export	0.2171	0.2644	-0.0865	0.0774
Number of firms	349	435	2924	857

Discussion and conclusion

This analysis presents a result partly unexpected and certainly new to the literature: EC-innovations are mainly adopted by companies smaller than average and belonging to low-tech sectors, while, as expected, non-green and organizational innovations are more common in large and high-tech companies.

This result has important implication for national policy making, and, more generally, for the outlining of strategies for the development and promotion of circular economy practices, such as, for example, green public procurement projects. Large companies, already engaged in non-green innovative activities, do not seem to be interested (or seem less so) in investing in circular economy practices, while smaller innovative companies – at the moment the most interested in CE activities – still represent a small proportion of the national production system, that is not sufficient to promote the green transition so much advocated by the EU.

Possible public interventions in support of CE-innovation must consequently take into account these differences, in order to be tailored as best as possible to the characteristics and needs of companies.

This empirical exercise, is still to be considered as only a preliminary analysis, which can be extended in various directions: first, it could be interesting to assess whether and how much belonging to a cluster or another is correlated with different economic performance; second, it could be interesting to replicate this analysis after a few years to see if, and to what extent, these results depend on the specific phase of development of CE-innovation in which we are (in the early stage of its development), or if it is a structural element that depend on the intrinsic characteristics of CE technologies.

Table 4. Two and four cluster solutions – main descriptive statistics.

Questions	Answer	Two Cluster		Four Cluster			
		1	2	1	2	3	4
Is the company an exporter?	yes	44,8%	49,0%	24,6%	60,3%	67,7%	48,7%
Has the company introduced any type of innovation related to the Industry 4.0 programme in 2017-2018?	yes	19,3%	22,1%	13,8%	36,2%	20,7%	23,9%
Scope of innovation introduced: material reduction in the production process	yes	16,8%	18,1%	4,3%	67,6%	9,8%	16,2%
Scope of innovation introduced: electricity reduction	yes	22,4%	22,7%	10,2%	72,3%	14,1%	21,6%
Scope of innovation introduced: reduction of waste generated	yes	20,0%	17,9%	4,9%	79,5%	7,4%	17,0%
Scope of innovation introduced: re-use of waste in the production process	yes	13,2%	11,5%	4,6%	46,3%	5,5%	11,7%
Scope of innovation introduced: waste transfer to other companies that will use it in their production process	yes	18,4%	14,5%	8,4%	48,8%	9,9%	17,5%
Scope of Innovation introduced: change in product design for material reduction	yes	10,9%	9,7%	2,4%	36,6%	6,9%	11,2%
Scope of innovation introduced: changes in product design to maximize recycling	yes	9,5%	7,5%	1,0%	38,6%	3,8%	6,3%
Scope of innovation introduced: changes in the production process to reduce GHGs emissions	yes	7,8%	6,8%	1,1%	39,0%	1,2%	2,5%
Reuse of water in the production process: indicate if this innovation is	New for the firm	15,0%	15,8%	4,2%	58,3%	8,8%	14,7%
	New for the market	1,5%	1,9%	0,2%	7,9%	0,8%	1,5%
	New for the world	0,3%	0,3%	0,0%	1,4%	0,2%	0,0%

Re-use of materials: indicate if this innovation is	New for the firm	13,7%	10,7%	6,2%	36,8%	8,5%	9,6%
	New for the market	0,8%	0,5%	0,2%	3,1%	0,2%	0,3%
	New for the world	0,1%	0,2%	0,0%	1,0%	0,0%	0,0%
Re-use of electricity (whatever source): indicate if this innovation is	New for the firm	20,9%	20,8%	9,7%	64,7%	13,3%	20,8%
	New for the market	1,3%	1,4%	0,4%	5,8%	0,6%	0,8%
	New for the world	0,2%	0,5%	0,1%	1,7%	0,1%	0,0%
Reduction of waste: indicate if this innovation is	New for the firm	18,0%	16,2%	4,6%	70,2%	7,2%	15,7%
	New for the market	1,7%	1,4%	0,4%	7,6%	0,0%	1,3%
	New for the world	0,3%	0,3%	0,0%	1,7%	0,0%	0,0%
Waste transfer to other companies that will use it in their production process : indicate if this innovation is	New for the firm	16,6%	13,3%	8,1%	43,2%	9,3%	15,2%
	New for the market	1,5%	0,9%	0,3%	4,1%	0,0%	2,0%
	New for the world	0,3%	0,3%	0,0%	1,6%	0,0%	0,3%
Changes in the design of products to maximize its recycling : indicate if this innovation is	New for the firm	7,3%	5,9%	1,0%	30,2%	2,5%	4,8%
	New for the market	1,9%	1,3%	0,0%	7,0%	1,1%	1,3%
	New for the world	0,3%	0,3%	0,0%	1,4%	0,1%	0,3%
Changes in the production process for reduction of GHGs emissions: indicate if this innovation is	New for the firm	6,7%	6,1%	1,1%	33,3%	1,2%	2,5%
	New for the market	0,8%	0,5%	0,0%	4,1%	0,0%	0,0%
	New for the world	0,3%	0,2%	0,0%	1,6%	0,0%	0,0%
Have the investments in R&D been directed to pollution reduction and env. protection	yes	8,9%	9,6%	2,4%	34,1%	5,8%	8,9%
Tech Intensity	HighTech	2,5%	3,9%	1,9%	2,9%	5,6%	2,0%
	LowTech	39,7%	33,5%	39,0%	39,3%	30,3%	40,4%
	MediumHighTech	16,4%	22,8%	13,8%	20,0%	29,3%	14,2%
	MediumLowTech	41,4%	39,7%	45,3%	37,8%	34,8%	43,4%
Size	Large	0,3%	0,3%	0,2%	0,4%	0,6%	0,0%
	Medium	11,4%	12,4%	4,9%	20,2%	16,1%	12,9%
	Small	88,4%	87,3%	94,9%	79,5%	83,3%	87,1%

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