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Manufacturing and environmental practices in the Spanish context

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ABSTRACT

Manufacturers have become progressively more aware of their operations' impacts on the triple bottom line (social, environmental and financial), and they are under increased pressure to account for their resource consumption and environmental footprint. These challenges are forcing companies to implement and combine different management approaches, such as “green” and “lean”, to meet the needs of the ever-changing market demand. Using semi-structured interviews in 58 different companies, this paper shows how manufacturing companies carry out manufacturing and environmental practices. This study contributes to the current debate in the literature on environmentally friendly manufacturing by arguing that companies with advanced manufacturing practices do not engage in proactive participation in environmental management with tactical and strategic practices inside their organizations. Following that, some considerations for correctly measuring the environmental efficiency in companies are presented. The findings and recommendations of this study can be used to fully utilize the potential of environmental practices to simultaneously improve manufacturing productivity and environmental performance and to identify trends in organizational development.

1. Introduction

The activities of the manufacturing industry have contributed significantly towards strengthening the economy of many nations, including developing countries, and they play a vital role in the global economy by supplying goods and services. However, it is crucial for manufacturers to prevent the overuse of resources. According to the International Energy Agency (IEA, 2009), the manufacturing industry contributes 38% of CO2 emissions worldwide. Given the detrimental impact on the environment (e.g. global warming, changes in weather patterns, formation of acid rain and air pollution) and the potential for affecting human health and disrupting the natural balance of the ecosystem, it is essential that industry reduce CO2 emissions. Otherwise, in the absence of positive environmental initiatives, manufacturing activities will lead to the creation of enormous amounts of waste, the exploitation of natural resources and the overconsumption of energy (Abdul-Rashid et al., 2017).

The advancement of the concept “sustainability”, first introduced in 1987 (Brundtland, 1987), can be witnessed in the subsequent emergence and adoption of environmental practices and standards, either in relation to production (life cycle analysis, green building standards, etc.) or to management procedures (environmental management system) in industry. Many studies have highlighted the drivers, drawbacks, and benefits of implementing these new practices, with some drawing attention to the strategic implications of adopting such practices (Chen et al., 2016). The term “sustainability” can be defined as expanding the corporate perspective to one that considers environmental, social and economic aspects (i.e., triple bottom line) (Abdul-Rashid et al., 2017). However, this study will focus on environmental and economic aspects of sustainability.

After the international community received a wakeup call from the Brundtland Report (1987), issues such as global warming and environmental impacts have become key concerns for many companies around the globe. Governments and business communities have devoted their resources and efforts to improving ecological performance over the last four decades (Kang and Lee, 2016), and manufacturing managers have adopted various strategies to limit the impact of their operations and products on the natural environment (Vachon and Klassen, 2008). Given this context, companies' environmental performance and disclosure become increasingly important factors in their competitive success (Lu and Taylor, 2016). However, the return on investment for the

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implementation of environmental technical solutions has become one of the biggest challenges for manufacturing companies.

As some industrial performance metrics requirements are shifting from measures of economic-centric performance to measures of environmental performance (Abdul-Rashid et al., 2017), the relationship between environmental practices and financial performance has been the object of numerous debates and discussion in the literature due to the heterogeneous results found (Miras-Rodríguez et al., 2015). The most popular issue in environmental sustainability development studies is the causality between environmental strategy and company performance, and whether the relationship has a positive or negative influence (Kang and Lee, 2016).

Due to different perceptions, it is crucial to gain an understanding of how environmental practices influence manufacturing performance (Abdul-Rashid et al., 2017). In addition, Alayón et al. (2017) point out that a better understanding of the empirical reality surrounding the adoption of environmental principles in organizations is required. Furthermore, Kang and Lee (2016) showed that the majority of studies on this topic have been conducted using data from the USA (e.g., Vachon, and Klassen, 2008), are focused on a single country, have utilized a resource-based view, and have analyzed mixed industries. Thus, as research has provided considerable insights into our understanding of the benefits of the interaction between the environment and operations, very little attention has been devoted to the underlying contextual factors that may affect such an interaction and characterize it (Galeazzo et al., 2014b). As qualitative studies are often only applicable to a single company, a single sector, a single country or a single function, more empirical studies are required to test transferability and to explain the distinctions between environmental management practices among countries.

Based on the scenario of challenges and opportunities described above, this article intends to analyze the implementation of environmental practices in the Basque Country and quantify the relationships between advanced manufacturing practices and environmental practices in manufacturing companies. In addition, this research contemplates non-conventional manufacturing sectors unusually explored in the sustainability literature (Despeisse et al., 2012). Because the integration of environmental management into operations is context-dependent (Galeazzo et al., 2014b), the specific aim of this paper is to identify and analyze production and environmental practices within manufacturing companies. This study provides empirical data that supports using the potential of environmental practices in simultaneously improving manufacturing productivity and environmental performance. This is done by analyzing data acquired from 58 different manufacturing companies in the Basque Country, a region located in the north of Spain.

This paper is organized as follows. Section 2 presents a review of relevant literature. Section 3 is devoted to describing the proposed research method and results are presented in Section 4. A discussion about correctly measuring environmental efficiency in companies is in Section 5. Section 6 closes out the paper by presenting some concluding remarks and highlighting some opportunities for further research.

2. Literature review

2.1. Environmental management

Traditionally, environmental management has attracted little support from conventional management, which puts emphasis on cost leadership, profitability and resource efficiency without considering the natural environment (Christmann, 2000). However, a notable transition has been observed over the last decade as many modern consumers tend to be concerned about green products and ways to identify them. At the same time, people seem to expect higher quality from these kinds of products (Prieto-Sandoval et al., 2016). This trend is supported by personal values and the wealth of positive feelings that people have when they choose products with an environmental label (Kang and Lee, 2016).

According to Martínez León and Calvo-Amodio (2017), external environmental pressure on companies stems from laws and regulations, stakeholders, customers and suppliers, the scarcity of fossil fuels, and competition and global reputation. Internal pressure, in contrast, stems from reducing operational costs despite the rising costs of materials, energy use and waste disposal, and the risk of not being held liable or found negligent for accidents or environmental damage, etc. As environmental issues affect all levels of the organization, including the business, functional, and operational levels (Rothenberg et al., 2001), company commitment to environmental protection is emerging as an important strategic issue in the business world (Aguilera-Caracuel et al., 2011).

Consequently, green management has emerged as a philosophy and management approach that reduces the negative ecological impact of an organization's products and services and improves the environmental efficiency of their operations, while still achieving their financial objectives (Duarte and Cruz-Machado, 2013, 2017; Galeazzo et al., 2014a; Garza-Reyes, 2015). This management approach demands the commitment of all members of the corporation, from senior management down to the shop floor (Taylor, 1992).

2.2. Environmental practices

Green management is operationalized through green initiatives or practices (Digalwar et al., 2013) that include: environmental collaboration with suppliers, environmentally friendly purchasing practices, working with designers and suppliers to reduce and eliminate product environmental impact, minimizing waste, sourcing material from environmentally and ethically friendly sources, ISO 14001 certification, reverse logistics, environmental collaboration with customers, eco-design, environmentally friendly packaging, etc. (Raghu-Kumar et al., 2016; Duarte and Cruz-Machado, 2017). Previous studies have indicated that recycling, waste reduction, remanufacturing, environmental design, and market surveillance for environmental issues are the environmental practices that most strongly affect company performance (Montabon et al., 2007).

These environmental practices can be classified into two groups: active (proactive or prevention) and passive (reactive or control) (Rothenberg et al., 2001; Xie et al., 2016). Active practices include all the practices that change the structure of the process and adopt more environmentally friendly resources (Galeazzo et al., 2014a) in order to reduce environmental impact. These practices are often “value added” for the firm since they reduce costs through material use reduction or through the avoidance of waste management costs (Rothenberg et al., 2001). In this active approach, companies introduce environmental objectives into their tactics and strategy (Ormazábal, 2013). In contrast, passive practices entail the entire end-of-pipeline approach that recognizes, captures, and disposes of the emissions caused by the production process, without any structural intervention (Galeazzo et al., 2014a). As there is no structural intervention, those practices could be categorized as operational-level activities. Furthermore, passive practices are often required by external requirements from the market, the government, and repeated media exposure, among others (Rothenberg et al., 2001; Xie et al., 2016).

Recognizing that environmental management practices have

different scopes and potential impacts, Montabon et al. (2007) classified these practices as operational, tactical or strategic (see Fig. 1). As mentioned above, passive practices solve environmental problems in order to comply with external requirements without any structural intervention, while active practices introduce environmental objectives into the tactics and strategy of the company. Consequently, operational-level practices could be linked with a passive approach and tactical and strategic-level practices with an active approach. González-Benito and González-Benito (2008) concluded that incorporating measures of proactivity at different levels and functions of the company could help to more precisely define the relationships between environmental and manufacturing practices.

Linking Montabon et al. (2007) and the active-passive classification could help to identify a company's commitment to its environmental impact, even though both classifications are not completely related. The more internalized the environmental issues, the more practices expected at all levels of the company.

It is expected that by using these environmental practices, companies will improve their environmental performance. According to Carvalho et al. (2017), researchers agree that companies can achieve a greater competitive advantage by making their businesses more environmentally friendly. Environmental management practices may improve the ecological efficiency and competitiveness of a company by reducing its environmental risks and impacts (Zhu et al., 2007).

However, despite the importance of the environmental problem, many companies are still skeptical about the business benefits, and the rate at which environmental practices are being implemented is not keeping pace with the rapid global expanse of the manufacturing industry. Even though many success stories have proven this point, it seems most managers still see environmental waste minimization not as a competitive opportunity but as a "necessary evil", simply to avoid legal sanctions (Tilina et al., 2014).

Environmental practices are seen as a cost, as something that would be good to do for the environment or to tick the 'green' box of a customer contract rather than a fundamental component of doing business (Skellern et al., 2017). Miras-Rodríguez et al. (2015) concluded that managers do not, generally speaking, perceive that environmental practices have any significant impact on performance. Nevertheless, to fully meet expectations, manufacturing companies need to enhance their environmental management by taking the initiative (being active) in integrating environmental management into corporate culture and business planning in all levels of the company (Santos et al., 2017).

2.3. Environmental performance measurement

Organizations are faced with increasing pressure to engage in sustainable development and to integrate environmental dimensions into their traditional performance metrics (Hajmohammad et al., 2013). Furthermore, a growing number of companies are pursuing environmental goals by incorporating green initiatives into their business practices (Abdul-Rashid et al., 2017). Thus, the interest in environmentally-friendly manufacturing has encouraged a lot of research on the development of decision-making tools, metrics and environmental measurement systems (Esmaeilian et al., 2016). Selecting meaningful and effective measures for environmental performance is becoming increasingly important due to the increased costs of environmental activities (Montabon et al., 2007). The issue of how to address the performance of environmental practices may be a costly endeavor if a number of important economic factors are not taken into consideration (Simpson and Power, 2005).

Fig. 1. Environmental practices classification. Adapted from Montabon et al. (2007).

Investigators who rely on financial reporting typically have many standardized sources of data available primarily due to governmental reporting requirements. For environmental performance data, however, the situation is very different (Montabon et al., 2007). Overall, the main means by which a large number of organizations and researchers evaluate environmental performance is the ecological footprint method (Xie et al., 2016). The recent emergence of environmental reporting has provided an opportunity for more consistent evaluation of a firm's environmental performance. However, the implications of disclosed information can be opaque due to inconsistencies in reporting, the use of vague rhetoric, the inclusion of anecdotal evidence, and reference to data sources that are proprietary to the reporting firm (and hence not publically available) (Chen et al., 2016).

There is a lack of agreement on how to define and measure environmental company performance. (Montabon et al., 2007). Environmental measurement requires baseline information and temporal and spatial patterns to evaluate the status of environmental health and well-being (Burger, 2008). Previous articles have explored environmental evaluations, environmental indicators, and the relationship between environmental management and performance from the point of view of the country, region, city or ecosystem, while ignoring the point of view of the manufacturing industry (Xie et al., 2016).

Hajmohammad et al. (2013) concluded that a suitable route for facilitating the implementation, adoption and measurement of environmental practices and to improve the plant's environmental performance is by establishing an adequate operating context based on manufacturing practices such as lean. Yang et al. (2011) explored the relationship between manufacturing practices and environmental management. The results of this research proposed that the implementation of environmental management practices alone had a negative effect on competitiveness in the market and on financial performance. Hajmohammad et al. (2013) suggested that advance manufacturing activities provide means for encouraging environmental actions that can then lead to improved environmental performance. In addition, Domingo and Aguado (2015) pointed out that:

a) Manufacturing and environmental practices are different approaches and have different impacts on business performance outcomes.
b) It is essential that companies understand the consequences of their actions on environmental management via the existing discussion about their environmental and economic objectives.
c) Further research into the synergy between production and environmentally-friendly systems will offer the greatest potential to improve their effectiveness.

Furthermore, evidence from meta-analyses suggests that it is more likely that there is a positive relationship between environmental and financial performance. However, this positive relationship also depends on the analysis methods, the variables used,

the time period and the countries in which the information for the sample was collected (Chen et al., 2016). Given the above, it is important to measure the environmental performance from the manufacturing industry's viewpoint in order to improve the effectiveness of environmental practices and their integration with overall company performance.

3. Research method

In this study, we used a qualitative data collection method, as qualitative data gives the researcher in depth of understanding in terms of the inner workings of human organizations (Hessler, 1992). This study includes companies from 22 different sectors: automotive, plastics, machinery, metal, office furniture, weapons, etc. More than 90 manufacturing companies from the Basque Country were contacted. Specifically, in the European Union small and medium enterprises represent 99% of all enterprises (Filipe et al., 2016) However, as small and medium companies are the ones that have the greatest difficulty reaching a stage of management and environmental development due to their limited resources (Shi et al., 2008), only 58 companies completed the study. A list of sectors in the sample is presented in Table 1. Note that these manufacturing sectors differ from the usual sectors explored in the sustainability literature (Despeisse et al., 2012). This is significant because in order to evaluate environmental performance within manufacturing companies generally, more studies that focus on the unexplored areas of the globe and industry are needed (Kang and Lee, 2016).

The companies surveyed are located in the Basque Country, a region in northern Spain whose industry is a reference for the rest of the country. Traditional manufacturing sectors in this region, such as metallurgy and automotive production, represent a solid base for industrial development. In fact, the gross domestic product (GDP) of the Basque Country is the fifth highest in Spain (2015). Data collection was primarily conducted using semi-structured interviews (Burgess, 1984) and open-ended surveys with operations managers that inquired into manufacturing and environmental practices inside their company. In order to ensure that all interviewees had the same understanding of the context of the study, they were given some examples and explanations of well-known manufacturing and environmental practices. Additionally, it was sometimes necessary to standardize interviewees' answers according to the academic literature regarding manufacturing and environmental practices. Physical business characteristics such as company age, size (number of employees) and business sector were also noted.

Triangulation was sought by using other data collection sources: insights from factory visits, direct observation, and information from company websites. The data from the interviews and visits were collected in 2016. The nature of the study made it appropriate to use a non-probabilistic purposive sample. Thus, this paper does not attempt to draw statistical generalization from the results, and instead it presents empirical evidence about how manufacturing companies in the Basque Country carry out production management and environmental practices. It should be mentioned that this study merely focuses on the type of practices used and does not look into their implementation process. Fig. 2 summarizes some interesting data from the sample. It is important to note that the sample is well distributed among different manufacturing sectors and almost evenly distributed between company size: small, medium and large.

Table 1
Number of manufacturing companies per sector.

Sector	# of Companies
Motor vehicle part manufacturing	7
Machinery manufacturing	7
Plastic product manufacturing	6
Foundries	5
Fabricated metal product manufacturing	5
Boiler, tank, and shipping container manufacturing	4
Architectural and structural metals manufacturing	4
Pulp, paper, and paperboard mills	3
Coating, engraving, heat treating, and associated activities	2
Office furniture manufacturing	2
Railroad rolling stock manufacturing	2
Other	11
Grand Total	**58**

4. Results

This section presents the empirical findings and discusses the environmental and manufacturing practices found in the manufacturers that were evaluated.

4.1. Manufacturing practices

Advanced manufacturing practices can be defined as the activities established or the processes adopted by a company to achieve its goals by implementing well-known manufacturing models. These manufacturing practices include manufacturing resource planning, flexible manufacturing systems, group technology, total quality management (TQM), just-in-time delivery (JIT), lean production (LP), concurrent engineering, continuous improvement, etc. From our data, we identified which companies apply some manufacturing practices and classified them according to company size (see Fig. 3). Thirty-eight percent of the companies evaluated apply some of the aforementioned manufacturing practices. In considering practices by company size, large companies (47%) undertook more advanced manufacturing practices than the smaller companies did. The rationale here is that large companies need a common framework to spread a shared corporate culture for continuous improvement practices, as Toyota did with its Toyota Production System. Note that there is a directly proportional relationship between company size and the use of advanced manufacturing practices.

Fig. 4 shows which manufacturing practices are used in the evaluated companies. The two practices most frequently reported by companies are ‘continuous process improvement’ (which inside companies evaluated is mostly based on the plan-do-check-act cycle) and ‘lean production’. However, it is important to note that the other reported practices (i.e., 5S, JIT, kanban, SMED, TPM, etc.) are well-known Kaizen tools (continuous process improvement) (Imai, 1986) and/or lean thinking (Santos et al., 2014). On the other hand, 62% of companies report that they do not use any of the advanced manufacturing practices. That does not mean that companies are not concerned about their performance, but they use their own (empirical) methods to respond to their needs. These companies use their own metrics and indicators to evaluate their production.

4.2. Environmental management practices

Similarly, we identified and classified the environmental management practices used in the companies evaluated (see Fig. 5). The majority of the companies had implemented environmental practices, and those companies were asked what kind of environmental practices they used in their companies.

Several insights can be derived from the results. First, 85% of companies applied environmental practices in at least one of the

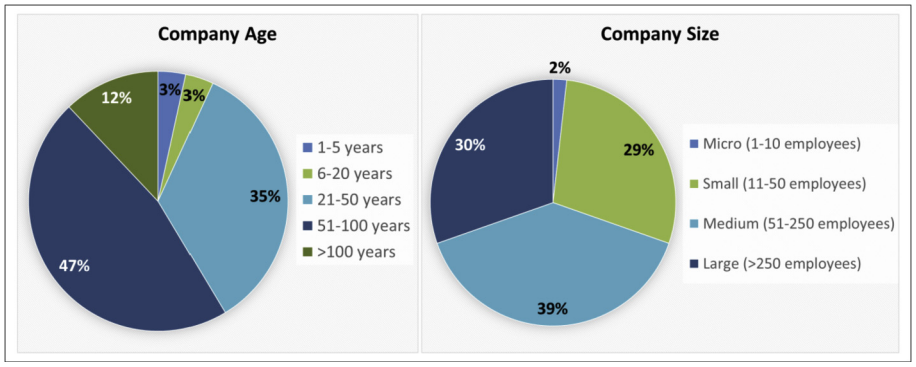

Fig. 2. Age and size of manufacturing companies.

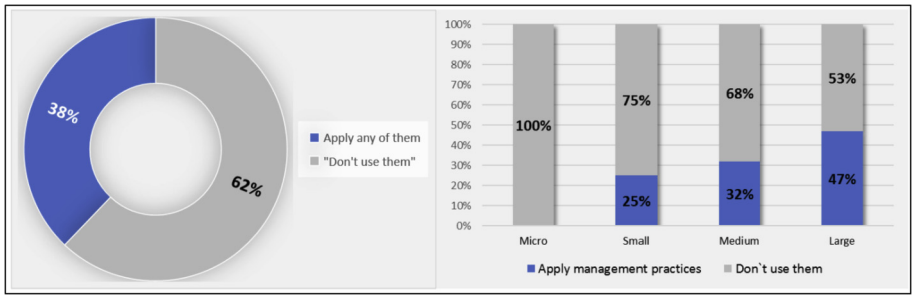

Fig. 3. Manufacturing practices in the companies evaluated.

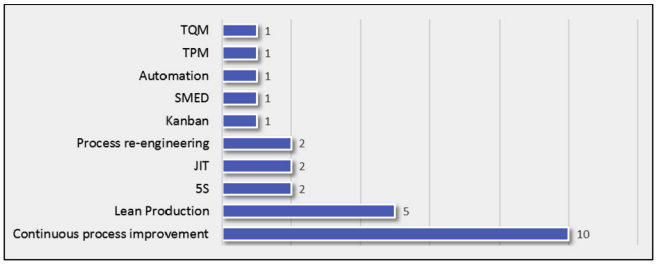

Fig. 4. Count of advanced manufacturing practices in the companies evaluated.

three levels (operational, tactical or strategic). However, most companies (84%) apply only operational-level practices. This represents the companies' motivation to develop environmental practices, but in a passive way; in other words, they use an "end-of-pipe" approach (Kang and Lee, 2016).

Only 33% and 5% of companies applied tactical or strategic environmental practices, respectively. That is, firms are trying to understand the benefits of an active approach to environmental policies as a means of using of resources more efficiently and improving their corporate image. Despite this intuitive argument, many companies are reluctant to take a more proactive approach to environmental practices due to a perceived lack of evidence that the benefits exceed the costs of pursuing these initiatives (Montabon et al., 2007). On the other hand, a small percentage of companies (9%) provided no information about their environmental practices. These findings are also consistent with the study by D'Amico et al. (2014), which argues that there is a low level of disclosure of environmental information by company employees because of incorrect environmental management inside

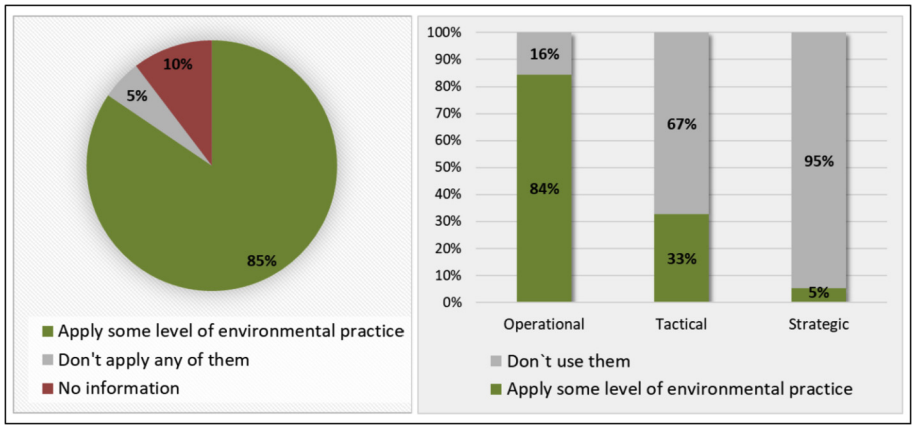

Fig. 5. Environmental level practices in the companies evaluated.

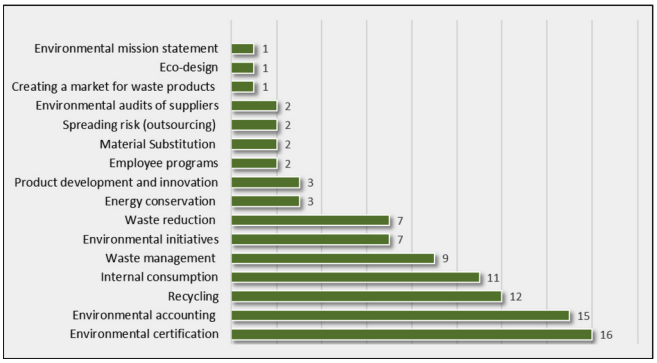

Fig. 6. Count of environmental practices in the companies evaluated.

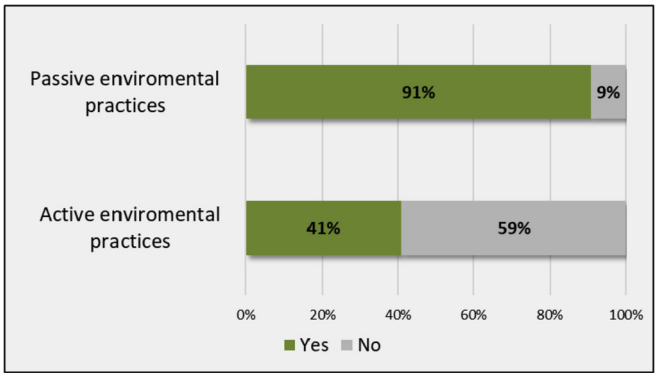

Fig. 7. Environmental practices (passive/active/) in companies with advanced manufacturing practices.

companies. The remaining 5% of companies reported that they are not concerned about their environmental impact.

Fig. 6 shows the complete list of environmental practices applied in the companies as gathered from the surveys and factory visits. Note that 16 companies (28% of all companies) report the tactical practice of 'environmental certification'. The most common environmental certification was the ISO 14001. Since the release of this standard in the fall of 1996, there has been additional pressure on some industry supply chains to address environmental performance through the use of environmental management systems (Montabon et al., 2007). By using ISO 14001, companies seek to merge environmental programs into one coherent system to manage all environmental activities efficiently (Habidin et al., 2017). This ISO 14001 certification can be effectively used as a predictor of the environmental awareness of a manufacturer (González-Benito and González-Benito, 2008). Other common and important environmental practices are environmental accounting and recycling, reported by 26% and 21%, respectively, of all companies.

With regard to environmental accounting, monitoring is vital to understanding the impact of the alternatives adopted. Companies must have performance measurement systems and assess performance through key performance indicators throughout the company (Duarte and Cruz-Machado, 2017). Besides the companies with ISO 14001 certification, only 15 (i.e. 26% of the sample) indicated that they had an environmental accounting practice. However, most of the accounting was for energy and water consumption. The interviewees' responses and comments seem to indicate that they recognize the link between monitoring energy, resource consumption and costs but they do not recognize the direct impact on productivity improvement. The general objective of these environmental consumption indicators was to reveal if the objectives established by the company or by the regulation were being fulfilled. There was no evidence of environmental-productivity measures being taken in an integrated approach in any of the companies studied. Therefore, environmental indicators could not be used as an effective tool to improve productivity.

4.3. Relationship between manufacturing and environmental management practices

According to King and Lenox (2001), potential complementarities exist among manufacturing and environmental practices, and thus firms should consider adopting these practices in bundles. For example, Pojasek (2008) showed that lean production practices adhere to environmental practices, such as the ISO 14001 standard. Yang et al. (2010) argued that environmental management is partially an extension of advanced manufacturing practices, continuous improvement and supplier management, since a significant portion of environmental programs are based on the foundations of manufacturing practices.

In this context, it is assumed that companies with advanced manufacturing practices have developed strong active participation in environmental management inside their organizations, and vice-versa (González-Benito and González-Benito, 2008). That is, they have tactical and strategic environmental management practices, where environmental gains will not be achieved through an end-of-pipe treatment (King and Lenox, 2001). In the case under study here, Fig. 7 shows that 41% of companies with advanced manufacturing practices have developed tactical and strategic environmental management practices (i.e., active environmental approach). Nevertheless, 91% of the same companies (i.e., companies with advanced manufacturing practices) have operational environmental practices. Note that a company could apply operational-level practices and tactical- and strategic-level practices simultaneously.

These results show that even companies with advanced manufacturing practices do not present a proactive approach in environmental development. That is, less than half of these manufactures have developed tactical and strategic practices inside their companies, while a large majority apply operational-level practices.

5. Discussion

As noted in the previous sections, companies seek to merge environmental programs into one coherent system to manage all environmental activities efficiently (Habidin et al., 2017). Thus, an integrated system for managing productivity and efficiency and environmental aspects in order to promote active participation in the environmental management of companies is very much needed. It is important that the appropriate decision-making tools which support environmental management in the manufacturing industry be developed. In this sense, monitoring, measurement and analysis ensure that all processes are carried out under control specifications and closely follow the required regulations (Mustapha et al., 2017). Any kind of monitoring process must ensure that the output is according to plan. These measurements and analyses allow decision-makers to find opportunities for improvement or validate those opportunities that have already been implemented.

Unlike financial and production reporting, which have many standardized sources of data available, environmental data suffers from a lack of consensus regarding how information should be presented, what indicators should be used, and how they are

interpreted (Chen et al., 2016). A rich and progressively standardized environmental methodology can establish a clearer context for evaluating the environmental performance of a company and provide a valuable source of data (metrics) for environmental studies (Dragomir, 2012).

However, as maximizing profit is the ultimate purpose of a company, this subject must be considered to be the most important aspect in environmental management studies (Kang and Lee, 2016). That is, efficiency in a company's environmental management cannot be measured independently of production efficiency or isolated from the company's context. Thus, monitoring, measurement and analysis play a significant role in integrating environmental and economic elements. Furthermore, the Industry 4.0 paradigm will enhance the high degree of environmental measurement in the factories of the future through the implementation of technological issues (Lasi et al., 2014). Any proposal for implementing monitoring, measurement and analysis in the factory should consider this paradigm. Selecting meaningful and effective tools for measuring production and environmental efficiency is important due to the aforementioned perception that implementing environmental options and complying with regulatory and public pressures increases costs (Montabon et al., 2007).

The following components could be taken into account in order to generate methodologies that correctly evaluate and measure the environmental performance in companies. Additionally, some alternatives for overcoming the identified barriers are suggested.

a) Location of the company: The environmental performance of a company greatly depends on where it is located. On the one hand, local environmental legislation sets requirements that affect how the company performs certain processes. On the other hand, the environmental culture of the workers sets their level of environmental commitment. It is important to measure the level of compliance with regulations and certifications. In addition, to align environmental initiatives with the organizational culture, companies could design appropriate training programs to develop the necessary skills in employees, such as environmental engagement (Santos et al., 2017).
b) Value chain: Customers and suppliers also affect the environmental efficiency of a company, for example by setting new restrictions on packaging, transportation, etc. In order to improve the efficiency and effectiveness of urban logistics systems, decision-makers have been led to consider collaborative strategies to reduce the overall cost of the supply process (Montoya-Torres et al., 2016). These strategies allow companies to rationalize the use of resources, such as the use of transportation vehicles.
c) Raw materials: The efficient use of raw materials should have a specific metric. As the production of raw materials entails an environmental impact, an indicator could exploit its use efficiently. Implementing strategies related to the circular economy would improve this indicator, thereby improving resource productivity and eco-efficiency (Yuan et al., 2008)
d) Production process: This process is often the one that has the greatest environmental impact. Clearly, this is where the company can best manage its environmental impact. As environmental efficiency should not be treated independently of productive efficiency, consumption (energy, water, etc.) should be monitored simultaneously with production. For example, an increase in water and energy consumption is not obtrusive when production increases. However, it could be critical if the increase occurs in cleaning processes, a task that is necessary but does not add value to the product. Several projects, including LIFE MCUBO, aim to engage industry in efficient resource management through new methodologies, models and wireless technologies, allowing them to simultaneously measure the productive and environmental efficiency of their manufacturing processes (LIFE MCUBO, 2016).

6. Conclusions and perspectives

Through the data collected from the semi-structured interviews carried out with a group of companies, this study has identified and analyzed the production and environmental practices within manufacturing companies. In this study, we used several aspects (i.e., industry sector, size, manufacturing practices and environmental practice level) to categorize and identify the current status of environmental management in the manufacturing field in a region which can be considered representative of the most advanced regions in Spain. Like some previous work focused on environmental management from the point of view of a country or region, this study extends previous studies by taking the perspective of the manufacturing industry. This study contributes to the current debate in the literature on environmentally friendly manufacturing by arguing that companies with advanced manufacturing practices do not engage in proactive participation in environmental management at the tactical and strategic levels of practice inside their organizations.

The introduction of new estimation methodologies with a single reporting metric is greatly needed in this area. That is, performance measures are aligned with environmental management by changing the design of the performance measurement system. To do this, certain considerations are suggested for responding to the informational needs regarding environmental management for decision-makers, government and/or investors. These considerations are important for correctly developing quantitative methods for relating the effects of environmental practices to manufacturing performance.

Finally, while this study provides some evidence about environmental management within manufacturing companies, future studies should investigate other methodologies to help companies adopt proactive environmental activities. For instance, training activities related to environmental security could increase the acceptance of environmental management, since companies that often arranged internal environmental training were more likely to adopt proactive environmental activities. This alternative could enhance the effectiveness of the proposed approach for integrating production and environmental efficiency.

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