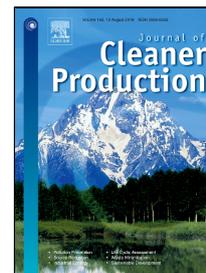


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**Sustainable innovation through management systems integration**

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## Sustainable innovation through management systems integration

### Abstract

In an increasingly competitive world driven by fast changes, companies are challenged to pursue sustainable development through innovation. This matter has led to the discussion about how organizations manage innovate in a way that they meet the demands of sustainability. Recently, researchers have identified the integration of management systems (IMS) as a potential practice to support both innovation and sustainability. This research aims to contribute to this field by exploring the relationship between IMS and sustainable innovation. European and Latin-American countries are included to contribute to the still scarce empirical evidence analyzing developed and less developed countries. Results suggest that IMS provides the managerial support to foster the adoption of cleaner production technologies. The latter is of particular relevance towards the development of sustainable products that deal with the technical, environmental and social impacts of new products. However, the role of IMS towards sustainable product innovation is not significant. Moreover, no significant differences in terms of sustainable innovations are evidenced among candle manufacturers in Europe and Latin-America. Bigger companies are found more innovative in terms of the adoption of cleaner production technologies, but no significant differences are observed in terms of sustainable product innovation. All in all, this is one of the first articles to relate IMS, the adoption of cleaner production technologies and sustainable product innovation studying a sample of companies allocated in countries of diverse economic backgrounds.

**Keywords:** Management systems integration; innovation; sustainability; cleaner production.

**Paper type:** Research paper

## 1. Introduction

The global concern about environmental care, social awareness and sustainability has increasingly caught the attention of practitioners and researchers (Gianni et al., 2017; Oskarsson and Malmborg, 2005). In light of the current business situation, sustainable development emerged as a new competitive advantage, including sustainable initiatives and a wider perspective of profitability, that involves environmental and social values (Sroufe, 2017). The inclusion of these parameters within the strategic management of organizations poses the basis for sustainability (Elkington, 1997). To this end, companies are required to innovate, change their organizational structure and integrate their strategies to overcome barriers and become more sustainability-oriented (Kennedy et al., 2017; Lozano et al., 2016).

To meet the challenge of innovating effectively and maximizing the value of sustainability demands, it is necessary to have well-structured management systems (MSs) (Wagner, 2007). According to the International Organization for Standardization (ISO) MSs are ‘the way in which an organization manages the inter-related parts of its business in order to achieve its objectives’ (ISO, 2018). Depending on the specific objectives, MSs are classified as quality (QMS), environmental (EMS), occupational health and safety (OHSMS), corporate social responsibility (CSR), among others (Jørgensen et al., 2006). Towards sustainability, their most relevant limitation lays on the fact that the sole implementation of an isolated MS cannot cover all the sustainability dimensions since MSs are too narrow and focus only on specific kinds of issues (Darnall et al., 2008). For this reason, organizations that aim to implement sustainability best practices might require adopting more than one MS, harness their synergies and integrate them (Mustapha et al., 2017).

The integration of management systems (IMS) allows organizations to be simultaneously coherent and consistent in satisfying the demands of sustainability in an optimal way (Rebelo et al., 2016; Salomone, 2008). This argument has led IMS to be acknowledged as a relevant sustainable management approach (Gianni et al., 2017; Jørgensen, 2008; Mustapha et al., 2017; Rebelo et al., 2016; Siva et al., 2016). As such, IMS has been positively related to innovations in general based on theoretical frameworks (Bernardo, 2014) and empirical statistical evidence (Hernandez-Vivanco et al., 2016; Simon and Petnji Yaya, 2012). However, how IMS is related to sustainable innovation (rather than innovation in general) remains a major research gap (Nunhes et al., 2016), which will be explored in this article.

Companies in pursuit of sustainability reflect this approach through the improvement and creation of new processes and products (Boons et al., 2013). The Cleaner Production (CP) framework has

been recognized as a remarkable voluntary corporate initiative towards sustainability (Lozano, 2012). This strategy seeks to continuously applicate integrated preventive actions to increase companies' efficiency and reduce at the source any environmental and social risks (UNEP DTIE, 1996). To this end, companies utilize technological solutions to minimize the environmental and social impacts of their operations before they leave a production process (Kemp and Volpi, 2008; UNEP DTIE, 1996; Vieira and Amaral, 2016). This objective is in line with sustainable product innovations, which seek to reduce, from the design, the environmental and social impacts over their entire life cycle (Rebelo et al., 2016; UNEP DTIE, 1996). Despite the substantial literature devoted to study sustainable process and product innovations, the empirical evidence in middle-income and developing countries is still under-researched (del Río et al., 2016). Therefore, this study will explore the relationship between the adoption of CP technologies and sustainable product innovation through a sample of companies based in countries with diverse economic backgrounds.

To sum up, the aim of this article is to contribute to the state-of-the-art by exploring whether IMS acts as a driver of sustainable innovation, within the framework of cleaner production. This research will explore these relationships based on empirical evidence of a specific industry in countries with different levels of economic development.

## **2. Theoretical framework**

In this section, firstly sustainable innovation is analyzed in the context of CP to relate the adoption of CP technologies and sustainable product innovation. Then, the relationship between IMS and the adoption of CP technologies, and sustainable product innovation are analyzed.

### *2.1. Sustainable process and product innovations*

According to the OECD (2005), both process and product innovations have different objectives; the former is related to the implementation of a new or significantly improved production or delivery methods. The latter is related to significant changes in the capabilities of goods or services. To become sustainably oriented, such innovations must benefit the TBL with measurable improvements (Sroufe, 2017). Thus, companies are challenged to manage the existing trade-offs between the economic, environmental and social impacts so that process and product innovations do not have (negative) consequences between them or in another area (Rocha et al., 2007). To this end, companies should implement radical innovations embedded in the companies' wider socio-economic context (Boons et al., 2013).

From the operations standpoint, Muñoz-Villamizar et al. (2018) suggested that, in order to assess and improve their sustainable performance, companies should consider four factors: i) complying

with their location's regulations and certifications, ii) rationalizing their resources across the value chain, iii) improving their raw materials through the implementation of circular economy strategies, and iv) improving their production processes. According to the authors, the latter is often the factor that has the greatest environmental impact since this is what companies can best manage directly. As a consequence, companies aiming to become sustainability-oriented seem to prefer beginning their transition from process innovations and then move forward to the other factors. In this line, Sroufe (2017) discussed that process improvements that enable energy conservation as well as waste reductions at source are necessary to bring new sustainable products to the market. According to the author, such new products would be designed using ecological and less hazardous new materials.

Given the strategic importance of adopting a sustainable management approach, Boons et al. (2013) identified that companies should be forthcoming to make great efforts to successfully achieve the required transitions. This means that, the more innovations related to the technical and sustainability attributes of new products, the larger the effort that companies must make. Thus, as long as creating sustainable products is profitable and customer oriented, companies ought to invest in such innovations and in actions to preserve the environment (Ramos et al., 2018). Such approach would foster, from the design, waste and emissions reductions, as well as the minimization of risks to the environment and society, in accordance with CP (Kemp and Volpi, 2008; UNEP DTIE, 1996; Vieira and Amaral, 2016).

Adopting a new technology, in particular if it is CP oriented, requires a great effort and a strong strategical commitment since it might implicate changing radically the companies' operations (Boons et al., 2013). According to the CP framework, such changes would be related to both: process and product innovations. Thus, it can be expected that companies that adopt CP technologies in pursue of sustainability will also introduce sustainable product innovations aiming to benefit the TBL, as stated in H1:

H1: The adoption of cleaner production technologies is positively related to sustainable product innovation.

## *2.2. The integration of managements systems and the adoption of cleaner production technologies*

Companies are continuously challenged to comply with the different requirements of the multiple stakeholders. To this end, they implement individual MSs –such as QMS, EMS, OHSMS and CSR– aimed to respond to their specific demands. In the course of this process, companies are faced with

a “puzzle” of MSs that should be integrated into a unique and more efficient integrated MS (Rebelo et al., 2016). For this purpose, companies must firstly give the same (high) importance to all the MSs (certified or not) within the organization (Bernardo et al., 2017; Gianni et al., 2017; Zeng et al., 2007). To analyze how IMS is related to the adoption of CP technologies, the contributions of each MS are analyzed as follows.

EMSs are adopted to deal with the environmental dimension of the companies’ operations, with the advantage that it promotes the better use of resources, which usually leads to cost reductions (Lozano, 2012). To reach this benefit, companies have to necessarily change and improve their current operations, so they must modify or introduce new processes (Lim and Prakash, 2014). When such innovations occur in the framework of an EMS strategy, companies aim to eliminate any potential environmental risk at source, which promotes the adoption of CP technologies (Radonjić and Tominc, 2006).

Even if the environmental motivations seem to be clear for implementing CP technologies, companies are usually more conscious about the quality dimension of their operations (Ramos et al., 2018). Interestingly, and from the QMSs’ perspective, pollution could be considered as a ‘quality defect’ that should be reduced or eliminated at the source instead of just being controlled (Khanna et al., 2009). Although this objective is in line with the CP approach, it also demands companies to step further. To effectively obtain process innovations oriented to improve quality, the latter should be considered beyond the limited scope of control and inspection. Its adoption should be widened to the strategic vision of continuous improvement (Moreno-Luzon et al., 2013).

Besides fostering environmental care, CP technologies should also pursue the minimization of risks posed to society, including workforce (UNEP DTIE, 1996). Thus, OHSMSs have a relevant role. Since adopting a new technology usually implicates new or different workforce risks, OHSMSs are useful to provide companies of the necessary means to manage them (Santos et al., 2013). Simultaneously, OHSMSs contribute to the reduction of wastes and the improvement of quality, which complements the contributions of the other MSs (Lo et al., 2014).

Moreover, CSR is in line with EMSs and OHSMSs’ goals, but expanding its frontiers outside the organization, so it takes place under the aegis strategic management (Lozano, 2012). Thus, it is not surprising that CSR and EMS are being increasingly adopted and integrated due to both, internal motivations (higher effectiveness) and external demands calling for more information regarding environmental and social performance (Oskarsson and Malmberg, 2005). According to the latter study, the adoption of CSR and EMS could foster innovation if (and only if) companies act proactively rather than just responding to the legal demands or the demands in the standards.

Otherwise, such MSs might hinder instead of promote innovation (Oskarsson and Malmborg, 2005). Henceforth, companies dealing with such proactive approach regarding environmental and social practices are replacing other companies with more traditional strategies such as low-price oriented. Thus, it seems that CSR, besides being aligned to the CP framework, reinforces the other MSs providing the organization of a more holistic strategy that includes sustainability priorities (Longoni and Cagliano, 2015). As a result, the CSR adoption seems to act a strategical support to promote the adoption of CP technologies through its sustainability-oriented framework.

By giving a high importance to all MSs, IMS captures their synergies to promote process innovations (Bernardo, 2014; Hernandez-Vivanco et al., 2016; Simon and Petnji Yaya, 2012). Moreover, IMS provides a sound focus and clear insights towards sustainability goals (Mustapha et al., 2017); i.e., to use efficiently resources/costs and minimize environmental and social impacts (Gianni et al., 2017) through innovation (Rebelo et al., 2016). Thus, IMS seems to give companies the necessary managerial support to adopt CP technologies (Mustapha et al., 2017; Ramos et al., 2018; Vieira and Amaral, 2016) as stated in H2:

H2: The integration of management systems is positively related to the adoption of cleaner production technologies.

### *2.3. The integration of management systems and sustainable product innovation*

Mustapha et al. (2017) recognized IMS as a sustainable green MS that stimulates companies to move towards a sustainability approach through the optimization of costs and time. The authors attributed such IMS benefits to the abatement of redundancies and the simultaneous enhancement of productivity. According to the conclusions of that study, it seems that IMS is more related to sustainable process innovation rather than product innovation.

In spite of the direct relationships between IMS and process innovations, sustainability professionals are well aware of the imperative need of applying this strategy across the value chain and involving both processes and products (Rebelo et al., 2016; Sroufe, 2017). On this basis, sustainable innovation is required not only to meet with the internal (process) CP requirements, but also to attend the needs of the different stakeholders across the value chain (Muñoz-Villamizar et al., 2018). It is in this process that IMS becomes crucial by its purpose of attending equally the needs and goals of the diverse stakeholders across the value chain (Jørgensen, 2008). Thus, the relationship between IMS and (sustainable) product innovation is plausible (Bernardo, 2014), but it

seems not to be direct. Thus, the path of the relationship between IMS and sustainable product innovation has to be further developed.

Although IMS and innovation have been generally positively related (Bernardo, 2014; Gianni et al., 2017), most studies have focused on a general definition of ‘innovation’ rather than the specific types of innovation proposed by the OECD (2005). Simon and Petnji Yaya (2012) present one of the first studies attempting to disentangle the IMS effects on the different types of innovations, namely process, organizational and marketing innovations. According to the authors, the better use of systems resulting of IMS fosters all three types of innovation, which in turn, improve customer satisfaction. These effects might be intrinsically attributed to new and improved products (innovation). Although this last argument was not empirically tested in Simon and Petnji Yaya (2012), the significant relationship between IMS and product innovation was later found in Hernandez-Vivanco et al. (2016). The authors conclude that IMS improves the odds of innovating in both processes and products, but they also observe that companies must be open to collaborate with external parties –including the stakeholders of the supply chain– so that both process and product innovations are positively related; otherwise, process innovations might hinder product innovations. Thus, it seems that a previous relationship between IMS and process innovations is required so that both contribute to create new or improved products. This indirect relationship could be suspected to maintain when focusing on sustainable innovations.

To create sustainable products and achieve excellence, organizations must be proactive regarding continuous improvement and should implement organizational and process innovations (Rebelo et al., 2016). In this line, IMS not only that is a relevant an organizational innovation that endorses organizational efficiency (Bernardo, 2014), but it also fosters the adoption of sustainable process innovations, namely CP technologies (Mustapha et al., 2017; Ramos et al., 2018; Vieira and Amaral, 2016). The latter, as previously discussed, promotes sustainable product innovations, which integrate the technical, environmental and social dimensions of the new products (Rebelo et al., 2016). As a result, it can be hypothesized that IMS is significantly related to sustainable product innovations, but its relationship is mediated by the adoption of CP technologies. Hence, hypothesis H3 is stated as follows:

H3: The adoption of cleaner production technologies mediates the positive relationship between the integration of management systems and sustainable product innovation.

To sum up, Figure 1 shows the studied relationships:

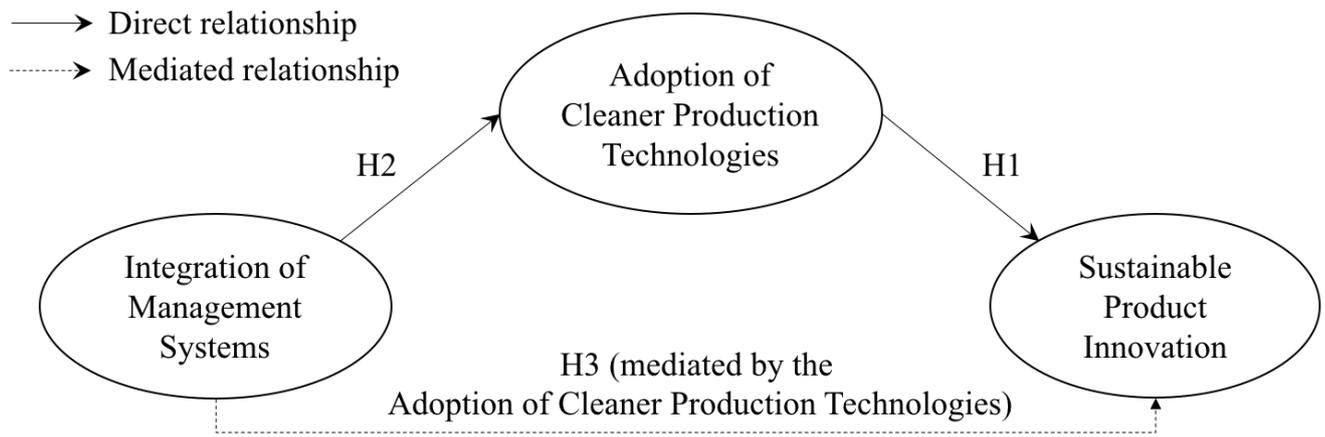


Figure 1. Model relating IMS and sustainable innovation

### 3. Research methodology

This section presents the methodological approach to test the hypotheses of this research. To this end, firstly the target population and sample selection is presented. Then, a statistical model is selected. Finally, the measurement of the selected variables is described.

#### 3.1. Population and sample selection

The candle industry is of special interest to this study for three main reasons. Firstly, because from the ancient times candles have been involved in the debate of their potential indoor pollution and health effects (Karataş and Gülder, 2012), which degree of danger depends on the process and raw materials used in their elaboration (Derudi et al., 2012; Manigrasso et al., 2017; Orecchio, 2011). Secondly, due to its traditional consumption among human history (Nordhaus, 1996), being nowadays widely used in the worldwide population. This allows studying countries in different stages of economic development. More specifically, it is estimated that half of Europeans use candles at least once a week (ComRes/AECM, 2015), while in the US, the annual retail sales are estimated at \$2 billion (Derudi et al., 2012). Finally, there are few official reports concerning the candle sector (Knight et al., 2001), and the scientific literature studying these issues from a managerial perspective is almost anecdotal.

To have a significant sample of the sector, this study surveyed the top-management of companies related to the most representative candle associations. Namely, the Latin American Candle Association (ALAFAVE), the European Candle Association (ECA), the Association of European Candle Makers (AECM) and the National Candle Association of the United States (NCA) allowed us to contact their members for this research. All contestants were part of the top-management, and their companies had a direct link with one of the abovementioned associations. The total number of

candle manufacturers that met both requirements was 174: 61 linked to ALAFAVE, 22 to ECA, 64 to AECM and 27 to NCA. However, only European and Latin-American firms were willing to participate in this study.

The questionnaires were mainly based on the structure of the Community Innovation Survey (CIS, 2012) and the Spanish Innovation Panel (PITEC, 2007), both following the OECD (2005) guidelines. A version in English and in Spanish was prepared using Survey Monkey. It was firstly assessed by the candle associations' board. Then it was improved and pre-tested in five firms that validated it, so no further changes had to be done. The questionnaire is presented in the Appendix. It was sent via email in three rounds between October 2016 and February 2017, obtaining 40 valid answers: 20 Latin-Americans and 20 Europeans. The valid answers resulted in an overall response rate of 27.21% with a response error of  $\pm 8.0\%$  at 95% confidence. Table 1 summarizes the descriptive statistics of the sample. As it can be evidenced, candle associations may include companies from diverse sizes and ages. Therefore, there are no major concerns regarding the representability of this sample towards the candle industry in the studied regions.

Table 1. Descriptive statistics of the sample.

Location	N	Age in 2015		Average Revenues during 2014/15 <sup>a</sup> (thousand euros)				Average Employees during 2014/15					
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
<b>Latin-America</b>	<b>20</b>	<b>26.213</b>	<b>17.206</b>	<b>2</b>	<b>69</b>	<b>2,976.101</b>	<b>3,243.521</b>	<b>55.711</b>	<b>10,884.920</b>	<b>38.971</b>	<b>37.184</b>	<b>3.500</b>	<b>155</b>
Argentina	2	17.500	9.192	11	24	845.162	700.098	350.118	1,340.206	14.500	1.414	13.500	15.500
Colombia	5	23.200	13.312	2	36	3,348.206	3,363.646	1,017.133	9,137.886	65.936	28.333	20	98
Ecuador	1	32	(.)	(.)	(.)	2,030.269	(.)	(.)	(.)	29	(.)	(.)	(.)
Guatemala	1	4	(.)	(.)	(.)	2,728.548	(.)	(.)	(.)	34.541	(.)	(.)	(.)
Paraguay	1	35	(.)	(.)	(.)	3,357.296	(.)	(.)	(.)	42.500	(.)	(.)	(.)
Peru	5	17	13.565	4	40	408.067	546.575	55.711	1,353.548	14.315	8.071	3.500	26
Dominican Republic	2	40	41.012	11	69	4,321.359	6,107.273	2,864.695	8,639.854	91.250	90.156	27.500	155
Venezuela	3	41	9	32	50	6,769.904	4,115.016	2,654.889	10,884.920	19.727	6.621	12.500	25.500
<b>Europe</b>	<b>20</b>	<b>77.580</b>	<b>65.260</b>	<b>2</b>	<b>211</b>	<b>9,762.767</b>	<b>12,410.760</b>	<b>26.458</b>	<b>45,000</b>	<b>72.503</b>	<b>97.723</b>	<b>1</b>	<b>375</b>
Finland	1	187	(.)	(.)	(.)	5,050	(.)	(.)	(.)	35	(.)	(.)	(.)
France	2	64.500	70.004	15	114	19,888.890	25,298.710	2,000	37,777.780	89.500	113.844	9	170
Germany	2	73.500	61.518	30	117	22,975	31,148.050	950	45,000	56.250	44.194	25	87.5
Italy	5	133	56.675	56	211	3,350	2,897.197	200	7,650	46.900	82.920	2	195
Poland	2	27	5.657	23	31	15,358.150	6,173.749	10,992.650	19,723.650	292	117.380	209	375
Spain	2	118	19.799	104	132	6,875	3,358.757	4,500	9,250	35.500	10.607	28	43
Sweden	1	7	(.)	(.)	(.)	26.458	(.)	(.)	(.)	5	(.)	(.)	(.)
Switzerland	1	77	(.)	(.)	(.)	13,122.680	(.)	(.)	(.)	82.500	(.)	(.)	(.)
United Kingdom	4	11.250	9.878	2	22	1,218.721	1,384.308	50.386	2,972	9.875	12.625	1	28
<b>Total</b>	<b>40</b>	<b>51.898</b>	<b>53.930</b>	<b>1</b>	<b>211</b>	<b>6,369.434</b>	<b>9,373.714</b>	<b>26.458</b>	<b>45,000</b>	<b>55.737</b>	<b>74.369</b>	<b>1</b>	<b>375</b>

<sup>a</sup> Companies were asked to report their annual revenues in their local currency. This amount was converted to euros based on the annual average rate reported by the Central Bank of Spain, Banco de España (2018).

(.) not available

### 3.2. *Data analysis*

The Partial Least Squares (PLS) approach to Structural Equation Modeling (SEM) was selected to test the model using ‘SmartPLS 3.’ (Ringle et al., 2015). This technique is preferable to other covariance-based methods because: i) it does not assume any distribution of the data, and ii) it is suitable for exploratory research based on small samples (Chin, 1998).

### 3.3. *Measurement of the Variables*

#### 3.3.1. *Integration of management systems*

Researchers have commonly based on the integration of certified MSs to measure IMS (Bernardo et al., 2017; Ramos et al., 2018). However, companies can implement and integrate non-certified MSs and, moreover, IMS is non-certifiable yet at the international level (Gianni et al., 2017). According to the survey of this research, holding a certified MSs is not common among candle manufacturers. Even if 72.5% of the sample applied at least one MS (out of the four studied), only 22.5% hold at most one certification (mostly a QMS). Thus, a measure of IMS was constructed based on the existing literature as follows.

The basis of IMS lays on the importance given to MSs at the top-management level, which determines IMS for the whole organization (Bernardo et al., 2017; Gianni et al., 2017; Gianni and Gotzamani, 2015; Zeng et al., 2007). Based on this argument, IMS is measured as a construct composed of two variables that depend on the importance given to MSs by the top-management: *IMS-breadth* and *IMS-depth*. These measurements were adapted from the widely used definitions proposed by Laursen and Salten (2006) in the Open Innovation literature. More specifically, *IMS-breadth* is defined as the accumulated importance of all the individual MSs for representing how broad they are applied across the organization, (i.e., how spread can their IMS be applied). So:

$$\text{IMS-breadth} = \text{QMS\_importance} + \text{EMS\_importance} + \text{OHSMS\_importance} + \text{CSR\_importance}$$

where the importance of each MS was coded as 0 ‘not relevant’, 1 ‘Low’, 2 ‘Medium’ and 3 ‘Highly important’. Therefore, companies that consider ‘Not relevant’ all of the MSs have an *IMS-breadth* equal to zero, while those considering all (four) MSs ‘Highly important’ punctuate 12.

Next, *IMS-depth* is defined as the number of MSs considered highly important, suggesting how internalized are those MSs. To measure *IMS-depth*, firstly, each of the four MSs was coded as a binary variable equal to one such MS was ‘Highly important’ to the top-management and zero otherwise, and then, they were added up. Thus, *IMS-depth* equals zero when firms do not consider

highly important any of the MSs, while it scores four if all the MSs are considered highly important (i.e., how deeply can their IMS be internalized).

### 3.3.2. *The adoption of cleaner production technologies*

CP technologies are a specific kind of process innovations (Kemp and Volpi, 2008) that occur in organizations moving towards CP (Mustapha et al., 2017; Ramos et al., 2018; Vieira and Amaral, 2016), so firms were firstly explained the ‘process innovation’ definition in accordance to the OECD (2005). Then, firms were asked if they introduced any process innovation during 2014-15, in which case they were asked to specify in which technology they innovated. Finally, they were asked to assess the importance of those innovations to: i) control pollution (cpt1), ii) have zero emissions out of their manufacturing processes (cpt2), and iii) reduce wastes such as energy and raw materials (cpt3) (CIS, 2012; Gavronski et al., 2012; Kemp and Volpi, 2008; Severo et al., 2015). Regarding firms that did not introduce any process innovation, it could be reasonably assumed that their processes did not change during 2014-15, so CPT1, CPT2 and CPT3 were classified as ‘Not relevant’.

### 3.3.3. *Sustainable product innovation*

Firms were firstly introduced to the ‘product innovation’ definition according to the OECD (2005) and asked whether they introduced any during 2014-15. Firms that answered in the affirmative way were then asked to assess the importance of such innovations related to the technical and sustainable dimensions. Firstly, the main technical aspects of a candle were assessed. According to the pre-testing, the selected variables were the introduction or improvement of: i) waxes (pi1), ii) fragrances (pi2), and iii) colors/lacquers (pi3) (Derudi et al., 2012; ECA, 2017; NCA, 2017; Orecchio, 2011). Then, the importance of environmental care (pi4) and social responsibility (pi5) in the development of new products were asked to assess the sustainable dimensions of product innovation. These dimension were chosen since several studies warn that candles could be a source of indoor pollution, which could potentially produce negative effects on health (Knight et al., 2001; Manigrasso et al., 2017).

If companies did not introduce any product innovation, it could be reasonably assumed that no improved or new products were introduced, so the abovementioned indicators were classified as ‘Not relevant’. In other words, since products remained the same during 2014-15, any improvement or introduction of new products was relevant.

### 3.3.4. *Control variables*

This sample consists of Latin-American and European firms, which could condition the results of adopting CP technologies and product innovation (Frondel et al., 2007). Thus, the continent was applied as a control variable coded as zero for Latin-American and one for European companies. As a dichotomous variable, it was immediately used as an indicator in the PLS-SEM model (Henseler et al., 2016). Finally, the revenues and age of companies were included as proxies of the structural characteristics of companies that might be related to sustainable innovations (Díaz-García et al., 2015).

#### 4. Results

In this section, firstly, the general results related to the importance of the individual MSs and of the IMS indicators are presented, followed by the types of technological process innovations adopted by candle manufacturers. Then, the PLS-SEM results are presented, consisting of the measurement model and the structural model.

##### 4.1. Results of the management systems importance and integration

Table 2 summarizes the MSs importance and IMS-*breadth* and -*depth* results across the 40 valid responses. Regarding the importance of MSs, candle manufacturers give the highest importance to QMSs, followed by OHSMSs, EMSs and finally CSR. Regarding the IMS indicators, the IMS-*breadth* mean of 8.75 (out of 12) suggests that candle manufacturers integrated their MSs broadly, which seems to corroborate the idea that companies not necessarily have to be certified to integrate MSs. Moreover, the mean of IMS-*depth* is 2.050 (the maximum punctuation is four). This outcome suggests that, on average, companies integrated in depth, or internalized, two MSs, mainly QMSs and OHSMSs. More specifically, firms deeply internalized QMSs (75.00%), followed by OHSMSs (55.00%), EMSs (37.50%) and CSR (37.50%).

Table 2. MSs importance/integration statistics and Pearson correlations (N=40)

	Variable	Mean	Median	SD	1	2	3	4	5	6
MSs importance	1. QMS	2.625	3	0.774	1					
	2. EMS	1.975	2	1.049	0.556	1				
	3. OHSMS	2.275	3	0.987	0.676	0.650	1			
	4. CSR	1.875	2	1.090	0.490	0.535	0.629	1		
IMS	5. IMS- <i>breadth</i>	8.750	9	3.248	0.788	0.833	0.886	0.816	1	
	6. IMS- <i>depth</i>	2.050	2	1.431	0.619	0.701	0.753	0.727	0.847	1

All correlations are significant at  $p < 0.01$

#### 4.2. Process innovation results

Regarding process innovations, 75% of the companies (30 out of 40) declared that they innovated in at least one process during 2014–15. As shown in Figure 2, most of the companies innovated in new packing solutions, molding (mainly in Latin-America) and filling. On average, companies that innovated in process, adopted between one and two innovations during this two-year period.

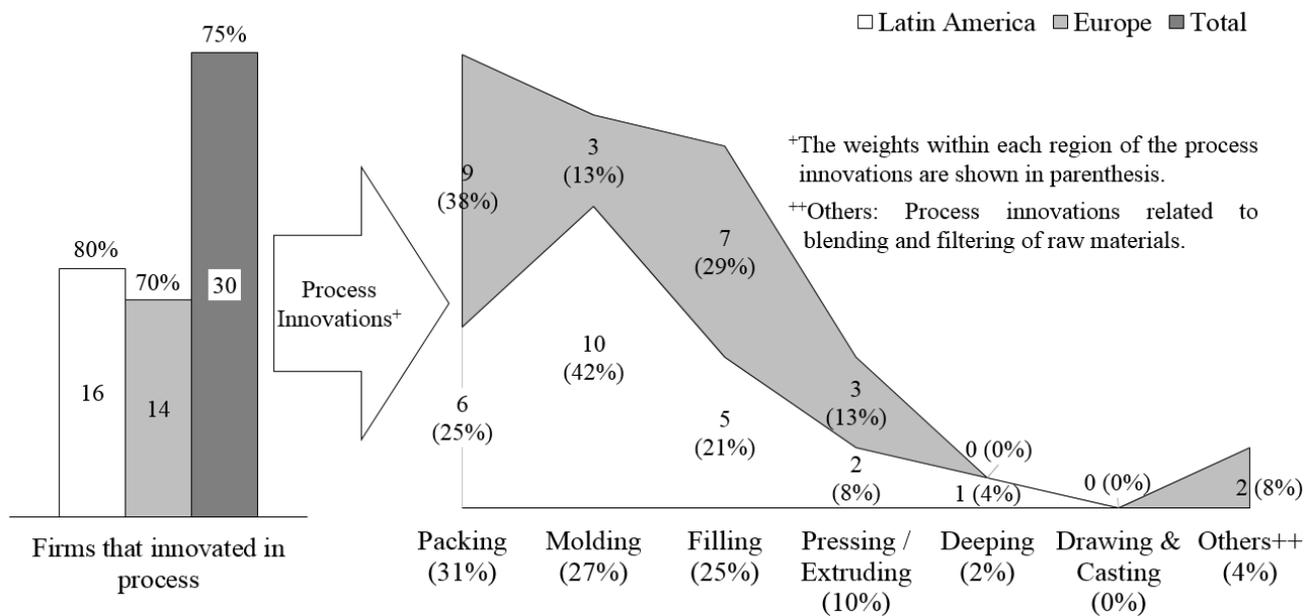


Figure 2. Process Innovations in the candle industry (N=40)

#### 4.3. PLS-SEM results

In this section, firstly the measurement model results is presented, followed by the structural model.

##### 4.3.1. Measurement model

In PLS-SEM models, the reliability and validity of the measurement model are firstly assessed (Hair et al., 2011). Table 3 shows the results for measuring construct reliability and validity. For all the constructs, the values of the Cronbach's alpha (Hair et al., 2016), coefficient Dijkstra-Henseler Rho\_A (Dijkstra and Henseler, 2015) and composite reliability (Nunnally, 1967) are above the minimum value of 0.7, so results show internal consistency reliability. Moreover, the Average Variance Extracted (AVE) is above the suggested 0.5 threshold (Hair et al., 2011), which evidences an acceptable level of convergent validity.

Table 3. Construct reliability and validity

	Cronbach's	Rho_A	Composite	AVE
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	Alpha	Reliability		
IMS	0.917	0.952	0.960	0.922
CP technologies	0.890	0.904	0.931	0.818
Sustainable product innovation	0.936	0.954	0.951	0.796

Table 4 shows the results for assessing discriminant validity. According to the Fornell-Larcker criterion that requires the square root of AVE to be larger than the inter-factor correlations (Fornell and Larcker, 1981; Hair et al., 2011), discriminant validity is established for all constructs. Moreover, the Heterotrait-monotrait (HTMT) ratio of correlations is smaller than the suggested threshold of 0.85 for all constructs (Henseler et al., 2015). Finally, the cross loading discriminant validity that requires each indicator to load the highest, and above 0.70, on its corresponding LV (Hair et al., 2011) is met.

Table 4. Discriminant validity

	1	2	3	4	5	6
<i>Fornell-Larcker criterion</i>						
1. IMS	0.960					
2. CP technologies	0.307	0.905				
3. Sustainable product innovation	0.270	0.477	0.892			
4. Continent	0.000	-0.130	-0.030	1.000		
5. Revenues	-0.028	0.237	0.044	0.303	1.000	
6. Age	-0.185	-0.128	-0.244	0.487	0.336	1.000
<i>HTMT ratio of correlations</i>						
1. IMS	-					
2. CP technologies	0.331	-				
3. Sustainable product innovation	0.279	0.484	-			
4. Continent	0.000	0.149	0.065	-		
5. Revenues	0.043	0.238	0.080	0.296	-	
6. Age	0.189	0.143	0.259	0.487	0.331	-
<i>Cross loadings</i>						
ims_breath	<b>0.951</b>	0.281	0.201	0.000	0.013	-0.141
ims_depth	<b>0.969</b>	0.306	0.307	-0.000	-0.066	-0.208
cpt1	0.337	<b>0.872</b>	0.524	0.000	0.270	-0.021
cpt2	0.244	<b>0.893</b>	0.324	-0.184	0.176	-0.136
cpt3	0.235	<b>0.947</b>	0.415	-0.197	0.163	-0.209
pi1	0.166	0.272	<b>0.853</b>	-0.074	-0.049	-0.314
pi2	0.242	0.283	<b>0.902</b>	0.036	-0.053	-0.208
pi3	0.204	0.535	<b>0.873</b>	-0.095	0.114	-0.190
pi4	0.239	0.418	<b>0.942</b>	-0.036	0.042	-0.241
pi5	0.327	0.522	<b>0.888</b>	0.038	0.088	-0.168
continent	-0.000	-0.130	-0.030	<b>1.000</b>	0.296	0.487
revenues	-0.032	0.230	0.045	0.296	<b>1.000</b>	0.331
age	-0.185	-0.128	-0.244	0.487	0.331	<b>1.000</b>

The square roots of AVE are shown in the diagonal of the Fornell-Larcker criterion

The loadings of the LV corresponding to each indicator are shown in bolds in the cross loadings.

### 4.3.2. Structural Model

The  $R^2$  of the endogenous constructs is recommended to be  $\geq 0.1$  (Falk and Miller, 1992: 80). This criterion is accomplished for both, the adoption of CP technologies ( $R^2 = 0.202$ ) and sustainable product innovation ( $R^2 = 0.288$ ). Moreover, according to Henseler et al. (2016), the only approximate model fit criterion implemented for PLS path modeling is the Standardized Root Mean Square Residual (SRMR). The SRMR is therefore a goodness of fit measure for PLS-SEM that can be used to avoid model misspecification, for which its value should be below 0.080 (Hu and Bentler, 1998). This criterion is met for both the saturated model (SRMR = 0.052) and for the estimated model (SRMR = 0.053).

Table 5 summarizes the significances and coefficients of the direct and indirect effects. According to the results, hypotheses H1 and H2 are supported, in contrast to H3 that is not supported. In the latter case, even if there is a positive relationship between IMS and sustainable product innovation (mediated by the adoption of CP technologies), this relationship is not significant at  $p < 0.05$ . Regarding control variables, results suggest that continent does not have a significant role towards the adoption of CP technologies nor to sustainable product innovation. The latter seems to be more related to younger companies, but the effect of age on sustainable product innovation is not significant. Moreover, results evidence that the adoption of CP technologies is significantly influenced by revenues, so bigger companies seem to be more prone to adopt these technologies. Finally, revenues do not have a significant role to sustainable product innovation, as well as the age of companies is not related to the adoption of cleaner production technologies according to the results.

Table 5. Results of the bootstrapping with 5,000 sub-samplings

	Coefficient	T Statistics	Conclusion
<i>Direct effects</i>			
IMS → CP tech.	0.300* (0.146)	2.050	H2 supported
IMS → Sustainable Product Innovation	0.090 (0.168)	0.536	
CP tech. → Sustainable Product Innovation	0.442* (0.178)	2.487	H1 supported
<i>Indirect effects</i>			
IMS → CP tech. → Sustainable Product Innovation	0.133 <sup>†</sup> (0.083)	1.601	H3 not supported
<i>Control variables direct and indirect effects</i>			
Continent → CP tech.	-0.182 (0.187)	0.972	
Continent → Sustainable Product Innovation	0.150 (0.185)	0.810	
Revenues → CP tech.	0.324*	2.151	

	(0.151)	
Revenues → Sustainable Product Innovation	-0.020	0.116
	(0.174)	
Age → CP tech.	-0.091	0.537
	(0.170)	
Age → Sustainable Product Innovation	-0.237 <sup>†</sup>	1.503
	(0.158)	
Continent → CP tech. → Sustainable Product Innovation	-0.080	0.841
	(0.095)	
Revenues → CP tech. → Sustainable Product Innovation	0.143 <sup>†</sup>	1.592
	(0.090)	
Age → CP tech. → Sustainable Product Innovation	-0.040	0.530
	(0.076)	

\*  $p < 0.050$ ; <sup>†</sup>  $p < 0.150$ . Standard deviations in parentheses.

Finally, Figure 3 illustrates the endogenous variables' R-squared and the path coefficients with its significance levels, which are of particular relevance to exploratory studies (Henseler, 2018).

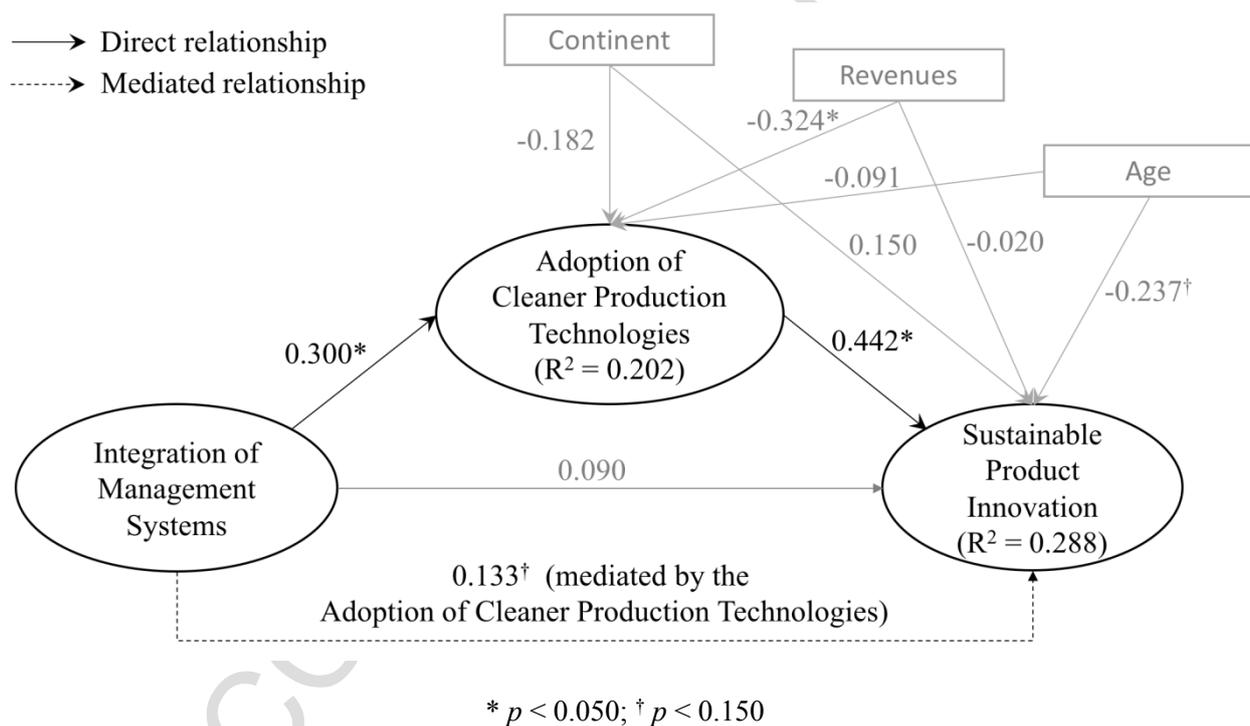


Figure 3. Results of the model relating IMS and sustainable innovation

## 5. Discussion

According to the results, adopting CP technologies is positively related to sustainable product innovation, which supports H1. This result is in line with previous research suggesting that companies should radically switch their internal operations to reduce any pollution or social effects

at source (Boons et al., 2013) to subsequently create sustainable products aiming to integrate the technical, environmental and social implications (Rebelo et al., 2016). Only then, companies would have a real focus on the objectives of cleaner production, which aims to minimize the environmental and social impacts (Kemp and Volpi, 2008; UNEP DTIE, 1996; Vieira and Amaral, 2016).

To test hypotheses H2 and H3, firstly, IMS was measured objectively. The *IMS-breadth* and *IMS-depth* indicators were introduced in this study based on the widely used definitions proposed by Laursen and Salten (2006). Both *IMS-breadth* and *IMS-depth* are overall measures of the extent at which MSs are integrated at the strategic level, based on the importance given to all MSs by the top-management (Bernardo et al., 2017; Gianni et al., 2017; Gianni and Gotzamani, 2015; Zeng et al., 2007). The higher the *IMS-breadth* and *IMS-depth*, the broader (spread) and deeper (internalized) is the IMS. This methodological contribution allows to have an IMS proxy even when MSs are not formally certified, so it complements other approaches regarding the difficulty of assessing IMS (Gianni et al., 2017).

Based on the previous measurement of IMS, a positive and significant relationship is evidenced between IMS and the adoption of CP technologies, which supports hypothesis H2. This suggests that IMS not only fosters process innovations (Bernardo, 2014; Hernandez-Vivanco et al., 2016; Simon and Petnji Yaya, 2012), but it also provides the necessary strategical support so that such innovations are sustainable (Gianni et al., 2017). Particularly, IMS fosters the elimination of pollution and social effects (including workforce) at source. This result is in good agreement with the cleaner production objectives, as concluded in Vieira and Amaral (2016) and Mustapha et al. (2017). This finding is of particular relevance given the open-ended debate of whether IMS supports sustainability-oriented practices. As reported by Ramos et al. (2018), IMS seems to be closely related to the adoption of CP-related practices. However, the authors also found that, even if this positive relationship happens in most cases, a minority of companies that adopted multiple certifications applied CP-related practices (only) to a limited extent. The authors clarify that in those cases, companies sought to satisfy the requirements of the multiple stakeholders. However, they failed to report the importance of such companies to meet those requirements. Thus, IMS measured just as the adoption of multiple certifications might not be a reliable indicator. The IMS measures proposed in this manuscript might complement others based on standardized MSs (e.g., Abad et al., 2014). In spite of such methodological differences, the positive relationship between IMS and the adoption of CP technologies is also observed, which is in good agreement with the existing literature (Mustapha et al., 2017; Ramos et al., 2018; Vieira and Amaral, 2016).

Moreover, it is evidenced that IMS does not have a significant effect on sustainable product innovation and thus, H3 is not supported. According to the results, even if the coefficient of the indirect path, mediated by the adoption of CP technologies, is positive, its *p*-value (0.109) shows very little (if any) effect on sustainable product innovation. This outcome suggests that, even if IMS might foster product innovation (Hernandez-Vivanco et al., 2016; Simon and Petnji Yaya, 2012), more efforts, beyond the adoption of CP technologies, are required to accomplish a sustainability approach in the development of new products. These results are in accordance with Ramos et al. (2018) who found that IMS might foster CP-oriented practices, but that, still, companies carried out very few structural modifications in the products seeking to reduce environmental impact. Therefore, there might be relevant differences between sustainable innovation and innovation in general that should be further explored (del Río et al., 2016). In this effort, IMS as internal factor might have significant interactions with the assimilation of external knowledge in companies that adopt open innovation strategies (Hernandez-Vivanco et al., 2016). Thus, further research might explore more complex relationships and mediators relating internal (IMS) and external (open innovation) factors. In fact, there are still major gaps in literature to understand how organizations systematically learn and embed external knowledge towards sustainable innovation (Kennedy et al., 2017). Hence, future research might deem the findings of this manuscript to include IMS as part of the organizational systematic practices involved in this debate.

Finally, the effects of control variables are discussed as follows. Regarding the effect of location, it is evidenced that both Latin-American and European companies have similar results, as opposite to other studies that have reported some differences between countries (Frondel et al., 2007). Therefore, IMS seems to promote sustainable innovation irrespective of companies' location. This fact might be attributed to the isomorphism across organizations promoted by IMS, achieved through the homogenous and high internalization of all the MSs' objectives (Bernardo et al., 2017; Gianni et al., 2017; Zeng et al., 2007). To this end, the top-management is required to be highly committed with all the MSs and with its integration (Bernardo et al., 2017). Moreover, it is observed that younger companies seem to be more inclined (but not significantly so) to developing sustainable product innovations. However, the age of companies seems not to have any significant role on the adoption of CP technologies. Furthermore, the size of companies in terms of revenues affects significantly the adoption of CP technologies since bigger companies have more resources to invest in new technologies. Nonetheless, the role of revenues towards sustainable product innovation seems to be limited and, at most, mediated by the adoption of CP technologies. These results are in line with del Río et al. (2017) who focused on studying these relationships in depth.

## 6. Conclusions

The aim of this article is to explore whether the integration of management systems acts as a driver of sustainable innovation in developed and developing countries, within the framework of cleaner production. To this end, the relationships between IMS, the adoption of CP technologies and sustainable product innovation were analyzed. Results suggest that the involvement of the top-management in the application and internalization of QMSs, EMSs, OHSMSs and CSR is critical to promote IMS. This, in turn, might foster the adoption of CP technologies, which seems to be closely related to sustainable product innovation. However, the mediated effect of IMS on sustainable product innovation is limited and requires of further research.

This study has three main implications for academia. Firstly, *IMS-breadth* and *IMS-depth* were introduced in this study as overall IMS measures to complement other approaches mainly based on certified MSs. Secondly, there seem not to be any significant differences regarding companies' location to perform sustainable innovations. In this regard, IMS might play a relevant role to promote isomorphism across organizations, achieved through the homogenous and high internalization of all the MSs' objectives. Finally, this study evidences that there might be differences in the relationship between IMS and sustainable innovation vs. IMS and innovation in general, specially regarding product innovation.

The main implication to practitioners lays on the importance given to the deep and broad IMS in companies involved in the debate of indoor pollution, regardless of their location. More specifically, IMS might provide the managerial support to adopt CP technologies not only to meet the requirements of formal regulations. This might have benefits beyond the improvement of the manufacturing process. More specifically the adoption of CP technologies seems to be closely related to the development of sustainable products. This implicates innovating with a long-term perspective by continuously improving the technical, environmental and social aspects of new products.

Regarding the contribution of this research, this is one of the first studies to relate empirically IMS, the adoption of CP technologies and product innovation in pursue of sustainability based on a cross-country sample that includes developed, middle-income and developing countries. It also contributes to literature by shedding light on the importance of IMS to promote the reduction of indoor pollution at the manufacturing process and thus, potentially benefiting consumers' health from the sustainable management perspective.

Despite its contributions, this article has some limitations. It is an exploratory study of the current status of candle manufacturers and results shall be interpreted with caution. Moreover, the

conclusions apply to candle manufacturers related to the most representative European and Latin-American candle associations, so other firms or from other industries and regions might not be represented.

Further research will focus on measuring the real effects of candles comparing the emission of potentially dangerous substances of companies that have adopted IMS vs. those that have not. Future research might also confirm the exploratory results of this paper using larger samples, more complex relationships including open innovation, more control variables and both qualitative and quantitative longitudinal studies. Other countries that are putting industry as a major priority of their political agendas should also be studied, including the United States, India, China, among others. Finally, further research might consider IMS and innovation as potential promoters of sustainable development in other industries involved in the debate of indoor and outdoor pollution.

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## Appendix

### Questionnaire

#### Notes:

- This is a questionnaire that belongs to a larger survey. Below, all the items that were used in this study are shown.
- The sources for the design of each question is indicated below the corresponding entry.
- All participants were provided with the required definitions of management systems (ISO, 2018) and innovation (OECD, 2005).
- The scales of all the questions regarding the ‘importance’ or ‘degree’ was adapted from the CIS (2012). The codification is as follows: 0 “Not relevant”, 1 “Low”, 2 “Medium” and 3 “High”.
- The codes shown in questions 4, 7 and 9 were not included in the questionnaire.

#### General information

1. To what candle's associations is your company affiliated?
2. Job title(s)
3. In what country is your company currently headquartered?

#### Management Systems

4. During the two years 2014 and 2015, how important were each of the following management systems to your company?

Code	Item	High	Medium	Low	Not relevant
QMS	Quality				
EMS	Environment				
OHSMS	Operational Health and Safety				
CSR	Corporate Social Responsibility				

*Source:* Adapted from the Spanish Innovation Panel (PITEC, 2007) in which the innovation effects on Quality and Environment are included. The importance of OHSMS and CSR were incorporated for the assessment of IMS (see e.g., Jørgensen et al., 2006; Salomone, 2008; Zeng et al., 2007).

5. Which certifications did your company hold during 2014 and 2015? (for example none, ISO 9001, ISO 14001, etc.)

#### Product Innovation

6. During the two years 2014 and 2015, did your company introduce good innovations - i.e., new or significantly improved goods (exclude the simple resale of new goods and changes of a solely aesthetic nature)? Yes/No

*Source:* Adapted from the CIS (2012).

7. Importance of PI factors for those product innovations

Code	Item	High	Medium	Low	Not relevant
pi1	Improvement of waxes formulations				
pi2	Introduction or improvement of fragrances				
pi3	Introduction or improvement of colors and lacquers				
pi4	Environmental care				
pi5	Corporate social responsibility				

*Source:* Redaction adapted from CIS (2012). The first three items represent the technical aspects and were adapted from Derudi et al. (2012), ECA (2017), NCA (2017) and Orecchio (2011). The last two items (pi4 and pi5) represent the environmental/social aspects and were adapted from Severo et al. (2015). The Spanish Innovation Panel (PITEC, 2007) also considers environmental and social aspects but as a unique question.

#### Process Innovations

8. During 2014 and 2015, did your enterprise introduce new or significantly improved methods of manufacturing or producing goods for...? (Check all that apply)

- None
- Molding
- Pressing / Extruding
- Drawing
- Other (please specify) \_\_\_\_\_
- Casting
- Deeping
- Filling
- New packing solutions

*Source:* Adapted from NCA (2017), ECA (2017) and CIS (2012).

9. To what degree did these innovations help the company to:

Code	Item	High	Medium	Low	Not relevant
cpt1	Control pollution				
cpt2	Have zero emissions out of the manufacturing processes				
cpt3	Reduce wastes such as energy and raw materials				

*Source:* Adapted from CIS (2012), Kemp & Volpi (2008), Gavronski et al. (2012) and Severo et al. (2015).

#### General results

10. Select the currency of your headquarters office

11. What was your company's total revenue for 2014 in your local currency? (Exclude all taxes)

12. What was your company's total revenue for 2015 in your local currency? (Exclude all taxes)

13. What was your company's average number of employees in 2014?

14. What was your company's average number of employees in 2015?

*Source:* Adapted from CIS (2012)

**Highlights**

- Adopting cleaner production technologies fosters sustainable product innovation
- MSs integration fosters the adoption of cleaner production technologies
- MSs integration does not influence sustainable product innovation
- No significant differences are found between Latin-American and European firms