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The Dual Role of Innovation in Manufacturing: Enhancing Sustainability and Employment Opportunities

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Background and Purpose: The purpose of this study is to investigate how various types of innovation impact sustainability measures within manufacturing companies; these sustainability measures include minimizing raw material usage, reducing energy consumption, and optimizing waste management. The research further evaluates the linkage between innovation types and job creation, focusing on how innovation fosters new employment opportunities and enhances sustainability in the manufacturing sector.
Methodology: The methodology involves a hierarchical regression analysis conducted on a sample of 1,570 manufacturing companies in Colombia using SPSS software. This approach aims to quantitatively assess the effectiveness of innovation, sustainability, and employment policies in these industrial organizations.
Results: The findings of the study reveal significant insights into the innovation policies of industrial companies and their management of environmental sustainability. These results underscore the practical implications of embracing innovation and sustainability for long-term benefits, despite the immediate costs.
Conclusion: This research provides a comprehensive examination of the diverse types of innovation and their consequential impacts on sustainability and employment in the manufacturing sector. Additionally, it suggests directions for future research that could further refine and enhance innovation and sustainability practices within this industry.

Keywords: *Innovation, Sustainability, Employment, Manufacturing sector*

1 Introduction

In the manufacturing sector, one of the great difficulties is establishing innovation and sustainability as two complementary elements in all its processes and achieving a constant generation of employment that remains the same as innovation is made. In this dilemma and challenge, the operational areas such as production, warehouse, purchasing, inventory, and distribution, among others, are the ones that suffer the most when it comes to hiring human resources since they need more human resources hired permanently. Then, an employee's learning can quickly vanish from one year to another or even months. This situation highlights the constant complication for innovation managers. For example, the generation of disruptive innovations must avoid displacing hired personnel and change the sector's course towards more sustainable practices.

In a much more competitive environment, with high

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levels of uncertainty and dynamism that force organizations to transform continuously (Hysa et al., 2020), innovation and human resources become the elements that make a well-defined competitive strategy possible, which helps organizations in the sector generate products with substantial improvements.

The Colombian manufacturing sector represents one of the sectors with the most remarkable economic dynamics for the country (Velez, 2023, 2021) . Understanding how the types of innovation in the manufacturing sector are related to sustainability practices and how the generation of employment can influence this relationship allows us to understand the competitive situation of the industrial sector (Føre et al., 2022, , where constant and improved development of products, processes, and methods occurred. However, it is also a social practice that allows creating environmental awareness through human resources to develop solid practices in environmental terms (Khan et al., 2024), increasingly demanded by customers from all manufacturing sectors globally. Therefore, this article aims to explain the effects of the types of innovation on sustainability practices and the moderating effect of employment.

This research is significant in this context since these types of innovation, ranging from production, product, organizational methods, and commercial improvements, need more evidence in the Colombian manufacturing sector. Few studies of this relationship have been disseminated in the Colombian context, establishing the relationship between sustainability and innovation will be the first contribution of this research. The second contribution corresponds to the difference between the types of innovation: product, commercial method, process, and organizational method (Azmat et al., 2023, OECD, 2018). The third contribution of this study will be to define how the generation of employment can influence the relationship between types of innovation and sustainability practices.

2 Literature Review

The process of innovation within organizations is multifaceted, comprising several phases. Initially, organizations engage in the search for ideas that can be transformed into business opportunities, typically derived from consumer needs (Mahr et al., 2014). This is followed by the creation of prototypes and the subsequent market placement of these innovations, which are crucial for adapting the organizational strategy. Such strategies are aimed at developing products, methods, and processes that revolutionize both the operational approach and the value offered to customers. Consumer needs vary significantly between countries and even among individuals within the same region (Stock et al., 2017).

Innovation capacity, according to Yang et al. (2018), is an intangible asset vital for organizations. It is not confined solely to research and development but is also influenced by the immediate organizational context which shapes its development and utilization as a competitive advantage. Innovation here is viewed as a dynamic capability that is essential for creating new competencies within an organization.

Moreover, the role of innovation extends beyond mere creativity (Sok & O'Cass, 2015; Valaei et al., 2017); it involves the dissemination and implementation of ideas (Wu & Chiu, 2015). For an organization that has been active in the market over a prolonged period, integrating innovation into its strategic framework is likely to yield significant long-term performance benefits (Kim et al., 2018). The Oslo Manual (OECD, 2018) defines several innovation types, including those pertinent to the manufacturing sector such as production and organizational methods, commercial, and product innovations.

The relationship between sustainability practices and innovation is also gaining attention. Brem & Ivens (2013) explored this through a propositional analysis, highlighting how reverse and frugal innovations influence sustainability. Liu et al. (2018) demonstrated how innovation systems within the wireless mobile technology sector foster sustainability. Conversely, Zhu et al. (2016) indicated that corporate social responsibility pressures firms to adopt sustainable practices (Babič et al., 2023, Afum et al., 2020), enhancing their performance (Lund-Thomsen et al., 2016) even if it sometimes comes at the expense of financial outcomes.

Additionally, energy usage, crucial for economic growth, is often studied in the context of environmental policy-driven technological innovations (Hepburn et al., 2018, Tang & Tan, 2014). In the Colombian manufacturing sector, the connection between innovation and sustainability remains under-explored, especially the impact of innovation on energy use and its implications for sustainability.

The utilization of production waste also represents a significant sustainability practice. Organizations are increasingly adopting strategies to reduce their ecological footprint through the effective use of waste from production processes (Lozano & Lozano, 2018). This not only supports sustainability but also enhances production efficiency by leveraging lost materials (Ajemigbitse et al., 2019; Qi et al., 2018) and other alternative resources (Munda et al., 2018).

Finally, the use of new materials and the optimization of processes are essential for the manufacturing sector. As the industry evolves, reducing raw material usage

[1] This paper is part of my doctoral dissertation at Universidad de Valencia. It is available at https://roderic.uv.es/items/30141ecf-f1ae-4eb0-9633-304c782b1014, but it has not previously been published in paper format.

(Mikulčić et al., 2016), enhancing material efficiency, and evaluating product life cycles (Sameer & Bringezu, 2019) become increasingly important, especially when customer requirements are stringent (Franco et al., 2019). These practices reflect the sector's ongoing commitment to innovation and sustainability, crucial for maintaining competitiveness and achieving long-term sustainability goals.

Some industries present new scopes with better materials, including recycling inputs, currently known as a circular economy or bioeconomy (D'Amato et al., 2018, Pedersen et al., 2018). The sectors with the most significant environmental impact constantly seek to reduce said impact and seek alternative raw material sources. The cost associated with privileged raw materials in the Colombian context can make companies lose competitiveness. Therefore, industries are trying to permanently reduce raw materials by optimizing or using materials from other sources.

One of the most common cycles currently used to decide on the best option in materials and processes for the elaboration of a product, from the environmental and social approach, corresponds to the social life cycle of the product (Lenzo et al., 2018), that allows establishing the best path for the production process of the good to be offered. The dynamics of the industry have changed with the new technological advances; they help it be more efficient in using raw materials, which in the long term generates better sustainability practices (Sicoli et al., 2019) for the industry. Therefore, innovation in different forms can help the organization consolidate using less raw material as a tool for long-term environmental sustainability, especially when considering a decision that cuts across manufacturing processes.

The generation of employment in manufacturing companies has multiple implications; on the one hand, the motivation of employees to feel job security, especially in a turbulent time like the current one, promises to generate better results in productivity (Callea et al., 2016; Belenzon & Schankerman, 2015) where the employee generates better results both in quality of work and in their commitment (psychological contract) with their functions (Grund & Thommes, 2017).

These implications for employment have been transferred to the relationship between employment and sustainable practices and innovation. Within sustainable practices, some authors recognize that human resources are a fundamental link to achieving sustainability practices, mainly because of the generation of employment with good working conditions (Yadav, 2019) and a strengthening in the technical capacity of the human resource (Gupta et al., 2020) better levels of commitment are obtained for the fulfillment of the objectives associated with sustainability.

The relationship between innovation and sustainability, under the effects of employment, has yet to be studied in this context, and most similar studies in other environments find complex and opposite results (Rubio & Abril, 2024, Stubbs, 2019; Mirvis & Googins, 2018). In this study, establishing how employment can moderate the relationship between types of innovation and sustainability practices is of interest for employment policy in Colombia, at a time when employment has fallen in some sectors due to the Covid-19 situation and the effects that the pandemic has in terms of the transformation of employment.

The industrial sector promises important discoveries in better, more efficient, technology-intensive forms of production, but not greener (Roy, 2015). Most of the production generated by the manufacturing sector generally makes intensive use of electrical energy, with very few movements towards new forms of energy. In Colombia, the problem is more complex; using electricity is mostly the only option available to entrepreneurs. Think of other forms of production with cleaner energy; they represent very high costs. However, some companies prefer to invest in better forms of production based on reducing water resources or using ecological materials.

It is possible to affirm that the industrial sector is at the crossroads of sustainability (Gerstlberger et al., 2016). Invest in innovating, but innovating in what is less expensive, for example, in production methods that reduce energy use from imported technology. Production methods have been widely studied; traditionally, production improvements and manufacturing innovations (Fabrizio & Tsolmon, 2014) are made from basic adaptations to significant investments, depending on the sector, the type of organization, and the dynamics of competitors. Modifications that are even suggested by the operators of the industrial machines, starting from the supervisor, are substantial improvements in changes of parts, process management, use of the machine, or broader projects with labor implications such as massive dismissals when replacing operators by technologically modified machines that allow optimal work to be carried out with less personnel.

Energy consumption for the manufacturing sector is, in addition to water, one of the most expensive and essential resources for the production process; therefore, industries have been looking for different ways to develop cleaner processes based on investment in research, technology, and patents among others, but the effect of different types of innovation on sustainability practices is not clear; consequently, it is intended to study:

H1a: Innovation in production methods positively affects sustainability practices in manufacturing companies.

New production methods are the order of the day; however, the organization's ability to integrate these tools with human resource training for this purpose (Crespi et al., 2019), trained in terms of the tool as a support and not as its replacement (Pazouki et al., 2018), are challenges for organizations (Scerbo, 2018) in the manufacturing sector. The execution of these production methods is only possible from the investment in computer equipment,

communication, and technological activities that favor the renewal of traditional forms of production and, therefore, allow the generation of more innovative processes that respond to the demands of the environment (Sabherwal et al., 2019), the requirements of customers and the pressure of competition.

These new production methods may cause the industry to need more significant hiring of human resources, which achieves a positive learning curve over time, thus determining that its capacity for innovation from production methods is solid enough to compete in environments of more significant uncertainty. Previous studies show that industrial organizations have better sustainability practices when a more conscious, collaborative, and permanent learning production process is carried out (Khurana et al., 2019). Consequently, the following hypothesis is studied:

H1b: Innovation in production methods in interaction with employment positively affects sustainability practices in manufacturing companies.

The development of novel goods has become a classic form of innovation for manufacturing companies, especially for those seeking to gain market share based on the specific characteristics of the product; generally, this type of innovation requires a great deal of learning for the firm (Ghasemzadeh et al. al., 2019). In addition to the challenges in terms of levels of innovation that the firm is willing to undertake, such as incremental and radical (Jugend et al., 2018), which help it develop better products for a more demanding customer, some authors state that the product innovation as a classic type of innovation has at least three aspects: the first associated with the possibility of building open innovation (Zhu et al., 2019) in a positive relationship with other institutions and organizations that collaborate to make innovation possible in product, second the positive effect on implicit absorption capacity in the development of new products (Gomes & Wojahn, 2017), which allows the organization to understand the information of its environment and turn it into opportunities for the company, the third element the connection with sustainability, which motivates the development of ecological products, with positive environmental impacts that have transformed the way of designing products (Buhl et al., 2019) and services.

In this last sense, organizations have been building new areas in charge of researching and developing more organic, less polluting products with less waste, which have focused on a fundamental idea: product innovation can help the company create more sustainable practices (Teixeira & Junior, 2019), from better use of resources, reduction of water use, use of renewable energies, recycling and use of waste, among many others, which is why the following hypothesis arises:

H1c: Product innovation positively affects sustainability practices in manufacturing companies.

Product innovation as it is developed in manufacturing organizations has been mobilizing towards a green economy, which has been widely studied; the development of these innovative and sustainable products should remain in the hands of a committed human resource (Alam et al., 2024, Ogbeibu et al., 2020; Grabara et al., 2020, Mousavi et al., 2018) with the idea of sustainability, care for the environment; so it would not be surprising that an organization that is innovative in product and also creates employment to complement this development of new products, should generate better sustainability practices from a well-trained human resource that is more aware of its ability to create sustainable products; therefore, the hypothesis arises:

H1d: Product innovation in interaction with employment positively affects sustainability practices in manufacturing companies.

The development of internal processes not related to production allows industrial companies to create improvements that save costs for companies, elements such as savings in time and bureaucracy in the work scheme of each department, the development of dynamic selection processes, inventory management, purchasing, and supplier management, access to information, intranet development are examples of this (Walker et al., 2015). Over the years, innovation in industrial companies was believed to be only technological. However, with the prevailing need to manage internal processes quickly, organizations realized that the key to success was not only in the technological innovation of the production process, which corresponded to organizational methods with basic technological (Fartash et al., 2018) and non-technological tools (Mun, 2018), which help improve productivity and performance.

Some preliminary analyses show interesting organizational innovation results, indicating that a leader can generate better results in the team when performing transformational leadership than transactional leadership (Jia et al., 2018). In other words, employees will feel freer to innovate and create as their leader or team leader allows them to make changes to the way they work in the organization, allowing them to propose ideas for the improvement of internal procedures, which in turn allows the company to be more successful, based on incremental and radical innovations designed for the organization from the mind of the employee (Sajjad et al., 2020). Other authors go further, explaining that innovation in the organizational method is mainly related to the organization's ability to develop high-performance teams (Edmondson & Harvey, 2018), while other authors consider that the effect of innovation in the organizational method is given by the type of contract that the employees have, that is, that employees contracted continuously in the company improve their quality of life, and therefore, can have better effects on innovation, previous studies in Spain, Germany, and France (Duhautois et al., 2018) show that the quality of work can have significant effects when it comes to innovating, companies in the industrial sector, in particular, can be favored by the positive feelings of the worker towards the com-

pany, the greater the feeling of a job that allows a good quality of life, the employee develops a greater capacity for innovation. Previous studies (Ayodele et al., 2020) affirm that organizational innovations can be an opportunity for the environment, which is not only convenient for companies but also for their employees; consequently, the following hypotheses are studied:

H1e: The number of innovations in organizational methods positively affects the sustainability practices of manufacturing companies.

H1f: The number of innovations in organizational methods in interaction with employment positively affects the sustainability practices of manufacturing companies.

Commercial innovation, also known as marketing innovation, has proven to be a type of innovation with important results for the improvement of business sustainability (Quaye & Mensah, 2019), especially because it allows the development of packaging with a positive ecological impact, placing the promotion and pricing in a novel way (Grigorescu et al., 2020). The Oslo Manual (OECD, 2018) originally included some product and process practices within commercial innovations. However, with the update of the manual in 2018, new studies show that commercial innovation practices are specially designed to develop a system of promotion, place, and price that allows the consumer to express his opinion regarding what he receives. The current client is more demanding regarding respect for the environment by companies at a global level, which has transformed commercial innovation into a very meticulous practice in terms of the use of natural resources, design of the entire chain, improvements in the use of packaging materials (Regattieri et al., 2018), to offer what the customer wants, primarily through more ecological practices.

Few studies directly relate business innovation to sustainability (Dada et al., 2024, Fiore et al., 2017). Therefore, it is important to recognize that commercial or marketing innovation requires intensive use of research and development, as well as technology (Chege & Wang, 2020), so organizations in the manufacturing sector that innovate commercially undoubtedly require personnel trained that allows them to achieve this type of innovation, which generally translates into better sustainability practices, thanks to the ability of human resources to develop, based on creativity, marketing improvements in accordance with the demands of the environment, especially of an environmental nature, such as packaging and materials. In the literature, there is no study that directly relates marketing innovation with sustainability practices and the moderation of employment, particularly in Latin American contexts such as the one in this study; it seeks to cover this gap in research with the following hypotheses:

H1g: Commercial innovation positively affects the sustainability practices of manufacturing companies.

H1h: Commercial innovation in interaction with employment positively affects the sustainability practices of manufacturing companies.

Consequently, for industrial companies in Colombia, it is necessary to understand whether the dynamics of innovation added to the hiring of personnel (Wikhamn, 2019) help organizations to have sustainable practices, which in the long term translates as a virtuous process of innovation and environmental responsibility.

The relationship between innovation and sustainability in manufacturing has been a topic of extensive research, but there are still some gaps in the literature, particularly in the Colombian manufacturing sectors. While previous studies have focused on the effects of innovation on employment and sustainability separately, the combined impact of these factors needs further exploration. This is especially relevant in Colombia, where the economic landscape is rapidly changing, and environmental concerns are growing. To complicate matters further, the specific role of different types of innovation, such as process, product, organizational, and commercial innovations, and their combined effect on sustainable practices and employment generation, has not been thoroughly investigated in developing countries.

Therefore, this study aims to address the gaps in the existing literature by examining how various forms of innovation influence sustainability and employment simultaneously in the Colombian manufacturing sectors (see table 1). The study will explore the different types of innovation, their effects on sustainable practices and employment generation, and their combined impact on the Colombian economy's growth and environmental sustainability. The study's findings could provide valuable insights for policymakers and stakeholders to promote economic growth and environmental sustainability in the region. By filling the research gaps, this study could contribute to a better understanding of the relationship between innovation, sustainability, and employment in developing countries, particularly in the Colombian manufacturing sectors.

3 Methodology

For this analysis, the EDIT Technological Development and Innovation Survey has been taken with data from 2017 - 2018 created by the National Administrative Department of Statistics (DANE). The selected sample was 1570 Colombian manufacturing companies that responded to the EDIT. The survey is characterized by cataloging the subsectors of the industrial sector by an ISIC Revision 4 classification, which corresponds to international codes. The companies in the sample have a minimum of 2 employees and a maximum of 4,181, and the sectors to which they belong are diverse, grouped into five major manufacturing categories: food and textile products, wood and paper, petroleum, pharmaceutical, chemical and rubber, metallurgy and electronics, machinery, and transportation.

Table 1: Hypotheses

Hypothesis
H1a: Innovation in production methods positively affects sustainability practices in manufacturing companies.
H1b: Innovation in production methods in interaction with employment positively affects sustainability practices in manufacturing companies.
H1c: Product innovation positively affects sustainability practices in manufacturing companies.
H1d: Product innovation in interaction with employment positively affects sustainability practices in manufacturing companies.
H1e: The number of innovations in organizational methods positively affects the sustainability practices of manufacturing companies.
H1f: The number of innovations in organizational methods in interaction with employment positively affects the sustainability practices of manufacturing companies.
H1g: Commercial innovation positively affects the sustainability practices of manufacturing companies.
H1h: Commercial innovation in interaction with employment positively affects the sustainability practices of manufacturing companies.

Table 2: Industry Types

Group Number	**Industry**
Group 1	Food and Textile Products
Group 2	Wood and Paper
Group 3	Petroleum, Pharmaceutical, Chemical, and Rubber
Group 4	Metallurgy and Electronics
Group 5	Machinery and Transportation

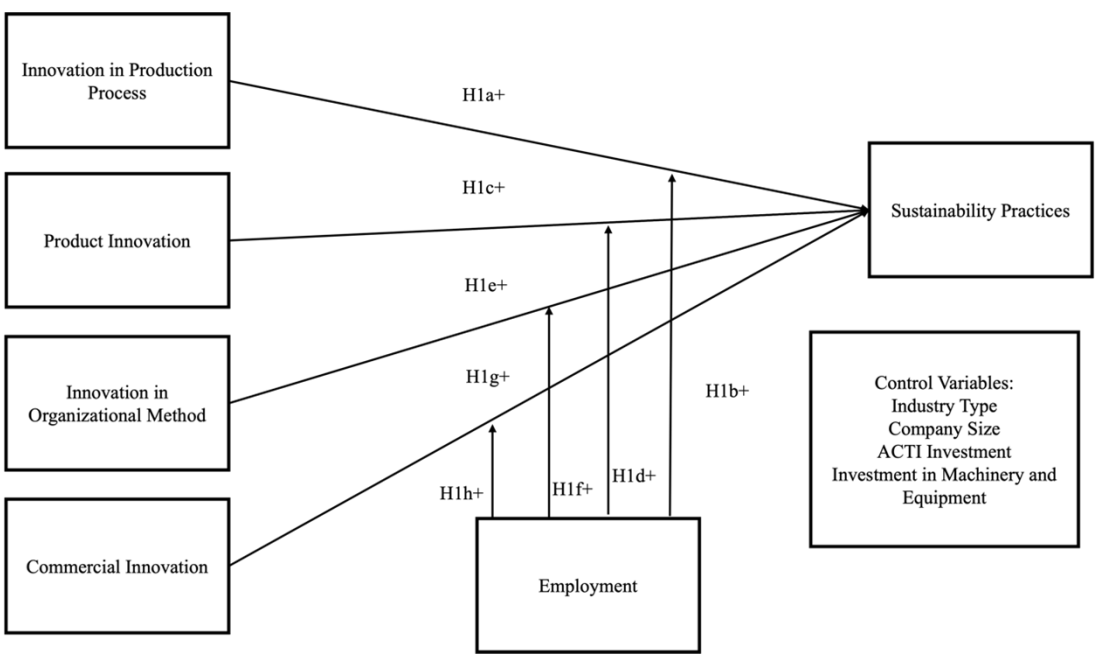

Figure 1: Construct

Within the control variables, the type of industry (Lützner et al., 2016; Betts et al., 2015; Wu & Chiu, 2015) and the size of the company (Forés & Camisón, 2016), recognizing whether the differences between companies can have an effect on sustainability practices. (See table 2).

According to the survey, the third control variable used was the investment in scientific, technological, and innovation activities in millions of pesos (Biswas et al., 2018; Saidani et al., 2017) adopted from previous studies on innovation. The fourth control variable corresponded to investment in machinery and communication equipment in millions of pesos (Wu et al., 2015; Gawer & Cusumano, 2014). A natural logarithm was applied to both variables.

The independent variables included the four types of innovation: the number of innovations in organizational methods (Damanpour & Aravind, 2012; Camisón & Villar, 2014; Mas-Verdu et al., 2016; Azar & Ciabuschi, 2017; Cho et al ., 2019; OECD, 2018), number of production method innovations according to survey data (Matt et al., 2015; OECD, 2018), number of product innovations (Gomes & Wojahn, 2017; Buhl et al., 2019; Oslo Manual, 2018) and number of commercial innovations (Quaye & Mensah, 2019; Grigorescu et al., 2020; OECD, 2018).

The dependent variable (see Figure 1) corresponds to sustainable practices (Zhu et al., 2016), which takes the arithmetic mean of three variables: reduction in energy consumption (Hepburn et al., 2018; Tang & Tan, 2014), use of waste (Gupta et al., 2019; Ajemigbitse et al., 2019; Qi et al., 2018), and decrease in the use of raw material (Lenzo et al., 2018; Sameer & Bringezu, 2019, Sicoli et al., 2019, with a measure of high, medium, and null.

As a moderating variable, the increase in employed personnel was measured by the difference in personnel hired in 2018 and 2017 (Balsmeier & Woerter, 2019; Mauno & Ruokolainen, 2017; Giuliano et al., 2017).

4 Results

The sample consisted of a total of 1570 manufacturing firms. The selection included both small and medium-sized enterprises (SMEs) and large corporations, allowing for a broad perspective on the innovation applied across different industries, which were analyzed in 5 different groups: food and textile products, wood and paper, petroleum, pharmaceutical, chemical, and rubber, metallurgy and electronics, machinery and transportation. The sample allows for identifying how these innovation practices contribute to sustainability and employment in the manufacturing sector. The results of this research reflect a significant trend toward sustainability-oriented innovation across all groups of firms.

The multiple regression analysis was conducted after taking into consideration the assumptions. The maximum inflation value of the variance factor was found to be 2.8, which is within the acceptable range. The study's findings are presented in two tables: Table 3 provides the descriptive statistics and the correlation matrix, while Table 4 presents the regressions for the dependent variable sustainable practices.

The study found that the control variables introduced in Model 1 could explain 2.9 of the variance of sustainable practices (see Table 4). It was also observed that the sector type significantly impacts sustainability practices. Specifically, the food and textile products and wood and paper sectors were found to be significant and negative, indicating that companies in these sectors have lower sustainability practices. This finding can be valuable for policymakers and industry stakeholders who can use this insight to incentivize these industries to invest in sustainability.

However, the metallurgy and electronics, machinery, and transport sectors did not show any significant results, meaning no conclusions could be drawn about greater or lesser sustainability practices in these sectors. The study also found that the company size variable was insignificant, indicating that a variation in company size does not necessarily imply that the organization has better sustainability practices.

Interestingly, the study found that while investment in scientific and innovation activities was not significant, the investment variables in machinery and equipment were significant. This result suggests that manufacturing companies in Colombia with the highest investment in machinery and equipment tend to have better sustainability practices. This finding proves that research and development alone are not enough for industrial companies to achieve sustainability goals. It requires intensive use of machinery and equipment in their production processes, which may also be necessary.

Overall, this study provides valuable insights into the factors that impact sustainability practices in different sectors and highlights the need for policymakers and industry stakeholders to incentivize sustainability efforts, especially in the food, textile, and wood and paper sectors

Model 2 consists of several independent variables, including innovation in the production process (H1a), product innovation (H1c), organizational method innovation (H1e), and commercial innovation (H1g). These variables are significant and positive, indicating that the hypotheses mentioned are confirmed, explaining that the different types of innovation positively impact sustainability practices. For H1a: Innovation in production methods positively affects sustainability practices in manufacturing companies, table 4 shows a significant positive relationship between innovation in production methods and sustainability practices ($\beta = 0.177$, $p < 0.01$). This confirms that production method innovation directly enhances sustainability practices.

Table 3: Descriptive statistics

		Minimum	Maximum	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Dependent Variable Sustainable Practice	1	3	1,70	0,57	1												
2	Variable Control Sector1 Food and Textile Products	0	1	0,37	0,48	-0,08**	1											
3	Variable Control Sector2 Wood and Paper	0	1	0,07	0,25	-0,03	-0,21**	1										
4	Variable Control Sector 3 Oil, Pharmaceutical, Chemical and Rubber	0	1	0,26	0,44	0,05	-0,45**	-0,16**	1									
5	Variable Control Sector4 Metallurgy and Electronics	0	1	0,16	0,36	0,05	-0,33**	-0,12**	-0,25**	1								
6	Variable Control Sector5 Machinery and Transport	0	1	0,15	0,36	0,01	-0,32	-0,12**	-0,25**	-0,18	1							
7	Control Variable Company Size	2	4181	251,56	421,59	0,08**	0,13**	-0,06*	-0,06*	-0,05	0,00	1						
8	Variable Control Log ACTI Investment	0,00	7,74	1,79	2,41	0,10**	-0,13**	-0,03	0,07**	0,07	0,04	0,46**	1					
9	Variable Control Log Investment in Machinery and Equipment	0,00	7,68	2,88	2,65	0,15**	-0,00	0,01	-0,02	0,02	-0,01	0,35**	0,38**	1				
10	Independent Variable Innovation in Production Process	0	1	0,61	0,49	0,16**	0,05	0,01	-0,07**	0,04	-0,02	0,07**	0,03	0,27**	1			
11	Independent Variable Commercial Innovation	0	1	0,30	0,46	0,04**	0,05**	-0,04	-0,05	-0,01	0,03	0,07**	0,04	-0,03	-0,09**	1		
12	Independent Variable Innovation in Organizational Method	0	1	0,28	0,45	0,10**	0,00	0,04	-0,01	-0,02	0,00	0,09**	0,13**	0,06*	-0,01	0,10**	1	
13	Independent Variable Product Innovation	0	1	0,35	0,48	0,11**	-0,12**	-0,07*	0,12**	0,02	0,04	0,16**	0,28**	0,14**	-0,10**	0,01	0,03	1
14	Moderator Occupied Staff Increase	0	2	1,09	0,93	-0,01	0,10**	0,03	0,01	-0,12	-0,04	-0,05	-0,06**	0,01	-0,01	0,00	-0,02	-0,04

*p < 0.05, **p<0.01

Table 4: Hierarchical Regression Analysis

Dependent Variable Sustainability Practices				
	Model 1	Model 2	Model 3	Model 4
Variable Control Food Sector and Textile Products	-0,108*** (0,037)	-0,112*** (0,037)	-0,113*** (0,037)	-0,116*** (0,037)
Variable Control Wood and Paper Sector	-0,100* (0,061)	-0,098* (0,06)	-0,099* (0,06)	-0,098* (0,061)
Variable Control Metallurgy and Electronics Sector	0,012 (0,046)	0,003 (0,045)	0,005 (0,045)	0,002 (0,045)
Variable Control Machinery and Transport Sector	-0,030 (0,046)	-0,034 (0,045)	-0,033 (0,045)	-0,037 (0,045)
Control Variable Company Size	0.000 (0.000)	0.000 (0,000)	0.000 (0,000)	0.000 (0,000)
Variable Control Log Investment ACTI	0,004 (0,007)	0,000 (0,007)	0,000 (0,007)	0.000 (0,007)
Variable Control Log Investment in Machinery and Equipment	0,029*** (0,006)	0,019*** (0,006)	0,019*** (0,006)	0,018*** (0,006)
Independent Variable Innovation in Production Process		0,177*** (0,03)	0,177*** (0,03)	0,107**(0,045)
Independent Variable Commercial Innovation		0,064** (0,031)	0,064** (0,031)	0,034 (0,047)
Independent Variable Innovation in Organizational Method		0,105*** (0,032)	0,105*** (0,032)	0,122*** (0,048)
Independent Variable Product Innovation		0,106*** (0,031)	0,106*** (0,031)	0,077* (0,046)
Moderator Occupied Staff Increase			0,006 (0,015)	0,005 (0,058)
Commercial Interaction_Increase_Personal				0,03 (0,033)
Interaction Process_Increment_Staff				0,066** (0,031)
Interaction Organizational_Increase_Personal Method				-0,014 (0,033)
Interaction Innovation_Product_Increase_Personnel				-0,027 (0,032)
Constant	1,645*** (0,003)	1,494*** (0,038)	1,487*** (0,042)	1,549*** (0,051)
R2	0,029	0,061	0,060	0,061
Change in R2	0,032***	0,034***	0,000	0,003

*p < 0.10, **p<0.05, ***p<0.01; standard deviation in parentheses

While product innovation has a positive and significant effect on sustainability ($\beta = 0.106$, $p < 0.01$) in Table 4. This indicates that product innovation contributes positively to sustainability, confirming H1c: Product innovation positively affects sustainability practices in manufacturing companies.

About H1e: The number of innovations in organizational methods positively affects sustainability practices. innovation in organizational methods had a significant positive effect on sustainability ($\beta = 0.105$, $p < 0.01$), as shown in Table 4, confirming that organizational innovations directly enhance sustainability practices.

For H1g: Commercial innovation positively affects sustainability practices in manufacturing companies. Commercial innovation had a significant positive effect ($\beta = 0.064$, $p < 0.05$), as presented in Table 4, confirming its positive impact on sustainability.

Model 3 includes all the main effects, whereas model 4 introduces the moderation effects between the four types of innovation and employment, which is measured in the increase in employed personnel. The model explains 6.1% of the variance of sustainable practices. The results show that the only significant and positive interaction is between innovation in the production process and an increase in employed personnel. As a result, hypothesis H1b is confirmed, while hypotheses H1d, H1f, and H1h are rejected.

For H1b: Innovation in production methods in interaction with job creation positively affects sustainability practices. The interaction effect between innovation in production methods and job creation was positive and significant ($\beta = 0.066$, $p < 0.05$), as shown in Table 4. This confirms that combining innovation in production methods with increased employment enhances sustainability.

In the case of H1d: Product innovation in interaction with job creation positively affects sustainability practices. The interaction between product innovation and job creation was not significant ($\beta = -0.027$), indicating that the combination does not significantly affect sustainability, leading to the rejection of this hypothesis.

About H1f: The number of innovations in organizational methods in interaction with job creation positively affects sustainability practices. The interaction between organizational innovations and job creation was not significant ($\beta = -0.014$), resulting in the rejection of this hypothesis.

Also, the interaction between commercial innovation and job creation was not significant ($\beta = 0.003$), leading to the rejection of the hypothesis H1h: Commercial innovation in interaction with job creation positively affects sustainability practices.

In summary, the confirmation and rejection of the hypotheses are based on the hierarchical regression analysis in Table 4, which provides the coefficients and significance levels necessary to evaluate the effects of various types of innovation on sustainability practices and their interaction with employment.

Table 5: Summary of hypothesis and results

Hypothesis	Result
H1a: Innovation in production methods positively affects sustainability practices in manufacturing companies.	Confirmed
H1b: Innovation in production methods in interaction with employment positively affects sustainability practices in manufacturing companies.	Confirmed
H1c: Product innovation positively affects sustainability practices in manufacturing companies.	Confirmed
H1d: Product innovation in interaction with employment positively affects sustainability practices in manufacturing companies.	Rejected
H1e: The number of innovations in organizational methods positively affects the sustainability practices of manufacturing companies.	Confirmed
H1f: The number of innovations in organizational methods in interaction with employment positively affects the sustainability practices of manufacturing companies.	Rejected
H1g: Commercial innovation positively affects the sustainability practices of manufacturing companies.	Confirmed
H1h: Commercial innovation in interaction with employment positively affects the sustainability practices of manufacturing companies.	Rejected

Therefore, manufacturing organizations that innovate in the production process and hire more personnel have better effects on sustainability practices (see table 5). Because they comply with social and environmental axes, which are a direct effect of innovation, this study fills a gap in the literature and provides a better understanding of the relationship between innovation, employment, and sustainability in industrial companies.

5 Discussion

During the last 30 years, Colombian industrial organizations have developed innovation from different perspectives, especially with a technological approach. However, in the last decade, a call has been made to care for the environment as part of the world agenda, tangentially modifying how innovation is implemented to the point that elements of environmental care have been included in the types of innovation in the Oslo Manual (OECD, 2018). Studies related to innovation and sustainability practices have shown that, depending on the context, the investment, and the types of innovation, companies can count on both practices: innovation and sustainability, developing a solid system of competitiveness based on the permanent reinvention and responsibility with the care of the environment as the axes of its planning. The results of this study confirm that various forms of innovation, including production processes, products, organizational methods, and commercial practices, positively impact sustainability practices; this finding reinforces the existing body of knowledge, emphasizing the vital link between innovation and sustainability. The study contributes to filling a research gap by providing empirical evidence to support this connection.

Also, recognizing the different forms that innovation can contribute to employment can help manufacturing organizations improve their strategies to recruit better employees and develop practices for sustainability; this research gives empirical evidence where some particular types of innovation in combination with employment are more effective to improve sustainability practices than others.

The confirmation of hypotheses H1a, H1c, H1e, and H1g indicates that innovation in production processes, products, organizational, and commercial methods directly impact sustainability practices. These results suggest that companies investing in any form of innovation will likely see improvements in their sustainability practices.

The confirmation of hypothesis H1b and the rejection of H1d, H1f, and H1h highlight the unique importance of innovation in production processes when combined with employment. This result indicates that although all forms of innovation benefit sustainability, innovation in production processes, especially when accompanied by an increase in personnel, has the most significant positive impact on sustainability practices. It explains that better capabilities developed thanks to human resources, improving efficiency, and more socially responsible production practices. However, it also creates a challenge for companies that do not transform the material into tangible products; some services companies that depend on new marketing and organizational methods to create a difference in the market should develop better strategies to connect innovation with sustainability, but also with employment, because in their case is possible that both types of innovation reduce personnel and do not allow to develop a better employment, this the traditional dichotomous experience about innovate without decreasing employees.

In the case of the manufacturing sector, the unique effectiveness of the combination of innovation in production processes and employment in improving sustainability practices suggests a model where not only technological or process innovation matters, but also how innovation affects labor structure and employment growth. This may imply that effective sustainability strategies need to consider both innovation and the social impact of that innovation, including employment.

6 Conclusion

Innovation, with its many forms, has become a fundamental tool for developing better processes and radically new products; however, innovation currently requires a significant investment in environmental components that promote sustainability, especially since the manufacturing sector requires intensive use of non-renewable materials and resources.

For organizations in the manufacturing sector, the empirical evidence of this analysis is an incentive since it allows them to recognize that carrying out innovation processes and creating jobs can help build more ecological processes, totally transforming the impact that manufacturing has on the ecological environment. In practice, Colombian industrial organizations consider innovation necessary but only sometimes profitable, especially due to the costs associated with the innovation process, while sustainability seems to be sacrificed every time investment in innovation is considered.

To a certain extent, entrepreneurs consider that they must decide between innovating or being sustainable in environmental terms, so this research can demonstrate to these companies and their managers that innovation has very positive effects on sustainability, that far from being isolated paths, they can complement each other and generate jobs. In addition, they can help in the long term to boost the economy from the new employees who can now consume, creating a positive economic, social, and environmental circle for all those involved.

From a theoretical perspective, in the resources and capacities approach, the theory can advance from understanding innovation as a capacity with different associated resources that must be obtained, shaped, and combined so that each organization can obtain the expected results. From the innovation approach, it can be established that the context affects the forms of innovation; in the present study, it is explained that the innovation in production processes and the investment in machinery and equipment predominates in the organizations of developing countries, for what studying innovation from the context and not only from the practices, would be a step forward breaking with the traditional focus of innovation studies. This relationship also underscores the significance of capital-intensive technologies in achieving sustainability goals. The outcome of this study sheds light on the crucial role of technology and equipment in promoting sustainability in manufacturing, which adds to the existing literature on the subject.

This study delves into the relationship between innovation and sustainability in the manufacturing sector and presents several novel findings. The study provides empirical evidence that different types of innovation, including process, product, organizational, and commercial innovations, can simultaneously contribute to sustainable practices and employment. This finding is particularly significant for Colombian contexts, as this linkage has not been explored enough in this region.

The analysis's results unequivocally demonstrate that innovation in production methods (H1a), products (H1c), organizational methods (H1e), and commercial innovation (H1g) significantly enhances manufacturing companies' sustainability practices. These findings underscore the pivotal role of embracing diverse forms of innovation as a strategic tool to support environmental sustainability within the manufacturing sector.

Additionally, the confirmation of hypothesis H1b emphasizes that the interaction between innovation in production methods and employment further strengthens these sustainable benefits, reinforcing the idea that production innovations accompanied by employment have a more pronounced positive effect on ecological practices.

On the other hand, the hypotheses exploring the interaction of job creation with product innovation (H1d), organizational methods (H1f), and commercial innovation (H1h) were rejected, indicating that in these cases, the combination of these innovations with employment did not significantly impact sustainability practices. This result suggests that although innovations in these areas may enhance sustainability independently, they only sometimes complement employment effects. Therefore, companies are challenged to balance innovation and employment growth within the context of their sustainability strategies.

This study's innovative approach connects the dots between different forms of innovation and their combined effects on sustainable practices, which can guide local manufacturers in their strategic planning and implementation. The study shows that a holistic approach to innovation can lead to enhanced sustainability outcomes that comply with environmental regulations and contribute to long-term economic sustainability through employment.

Nevertheless, this research has a limitation regarding the context from which the data is extracted; they are not completely generalizable results, given that the country of origin can modify the industry's behavior. It is also essential to recognize that the data is taken in a particular time range, so it would be interesting to carry out a longitudinal study to establish the evolution of these variables and their relationships. Finally, a qualitative analysis among the interest groups of these organizations could help to understand how innovation and sustainability are related from the perspective of other industry agents.

The research presents some interesting areas for future analysis. For instance, it does not delve into the type of knowledge and learning that is acquired (Brunswicker & Vanhaverbeke, 2015). It would be worthwhile to explore the human resource associated with various types of innovation and its effects on organizational learning. Additionally, it is essential to examine how the cultural and economic context can impact the types of innovation and the organizational learning curve.

In addition, future studies could include how the types of innovation can generate better organizational policies regarding human resources, especially to attract the right human talent that allows a better development of sustainable practices in all innovation processes in the industrial sector. The present study should be complemented with a cross-country analysis (Jandhyala & Phene, 2015; Crowley & Bourke, 2017), where the country effect and the cultural effect on the types of innovation and their effects on various sustainability practices are compared.

The practical implications of this study are significant for industry stakeholders. Policymakers can use these insights to support initiatives that foster diverse innovation within the manufacturing sector. Manufacturing firms can use these findings to tailor their strategic operations to ensure that innovation efforts align with economic and environmental goals. This can improve their competitive edge and operational efficiency in the global market.

For innovation policymakers, the study highlights that when companies innovate in their production process and increase the number of employed personnel, it leads to better sustainability practices; policymakers should encourage companies to innovate while creating employment opportunities. This can be done through various initiatives such as economic incentives, labor market policies, and workforce development programs. Also, policymakers can foster collaboration and knowledge-sharing among manufacturing organizations, research institutions, and government to improve sustainability performance in industrial companies.

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