THE WORLD OF INNOVATION

https://doi.org/10.15407/scine21.03.110

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THE IMPACT OF INNOVATION ON ADVANCING SUSTAINABLE PRACTICES IN THE INDUSTRIAL SECTOR

Introduction. *Sustainable development within the industrial sector has garnered attention due to environmental, social, and economic concerns arising from the irresponsible use of resources. Manufacturing companies have faced the challenge of reducing or optimizing resource use in production processes.*

Problem Statement. *The paradox in Colombian manufacturing companies has been their declaration of concern for environmental, economic, and social responsibilities while simultaneously demonstrating policies that increase resource use and environmental degradation.*

Purpose. *This study has aimed to understand how disruptive and incremental innovation in products, production methods, and organizational methods influence the efficient use of resources and waste management in the Colombian industrial sector.*

Materials and Methods. *Data from two surveys covering 8,264 manufacturing companies across 56 subsectors have been analyzed using advanced statistical techniques. Innovation capabilities have been assessed in terms of product, process, and organizational methods, alongside their environmental impact.*

Results. *Findings have revealed that innovation in production methods significantly enhances the efficient use of raw materials, while both incremental and disruptive innovations have positively affected waste management practices. However, a need for more investment in research and sustainable practices has been identified, especially in complex sectors like pharmaceuticals and plastics.*

Conclusions. *The Colombian manufacturing industry has made commendable efforts in innovation and capability building, leading to better environmental performance and reduced raw material usage. The study concludes that despite waste management and resource utilization challenges, a commitment to a circular economy and greener processes presents a viable path forward for the industry.*

Keywords: sustainability, innovation, raw material, waste, industry.

Citation: Velez Osorio, Iris Maria. (2025). The Impact of Innovation on Advancing Sustainable Practices in the Industrial Sector. *Sci. innov.*, 21(3), 110—124. https://doi.org/10.15407/scine21.03.110

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Sustainable development has become one of the biggest concerns in the business environment, not only because of customer complaints regarding environmental, social, and sustainability policies but also because of the economic implications of the irresponsible use of resources. Due to their high transformation component, manufacturing companies continuously require large-scale inputs; reducing or at least being more efficient with these resources in each process becomes a constant challenge.

The present study seeks to understand how the forms of disruptive and incremental innovation in products, innovation in production methods, and organizational methods affect the efficient use of resources in the production system and the use of waste; few studies have reviewed the capability of innovation in these three areas, product, process and organizational method, and its influence on environmental practices, such as the efficient use of resources and reuse of waste. While the sectors seek to be innovative, the environmental cost can be high, especially when the innovation is carried out in the production systems. From this paradoxical reality of the Colombian manufacturing companies, it is especially striking that the industries promulgate an essential concern for the three spheres of responsible practices: environment, economy, and society, but the growing effects of industries demonstrate a contradiction in their policies, for example, the use of more resources and environmental degradation, inadequate waste management, and natural disasters caused by industrial practices. Consequently, this study seeks to understand the relationship between the capability for incremental and disruptive innovation and responsible practices, especially those related to using raw materials and waste.

Manufacturing companies worldwide are striving to reduce resource use in their production processes. This is particularly crucial in countries like Colombia and Ukraine, where the impact of climate change, water scarcity, and limited fertile lands has made sustainability a top priority for both entrepreneurs and governments.

Ukraine, similar to Colombia, has a strong industrial sector that is facing sustainability challenges. Important sectors in Ukraine, such as metallurgy, chemicals, and agro-industry, play a vital role in the economy. Meanwhile, in Colombia, the agro-industry, as a traditional sector, heavily depends on natural resources and generates significant waste. Developing sustainable practices presents an opportunity to improve practices in both countries and establish commercial partnerships while learning to effectively combine innovation and ecological practices.

In Colombia, innovation has already improved raw material use and waste management. Ukrainian companies are pursuing similar strategies to achieve sustainability goals. Therefore, understanding the Colombian case can benefit Ukrainian readers, providing insights into the challenges, wise choices, and opportunities that manufacturing companies pursuing innovation and sustainability face.

CONCEPTUAL FRAMEWORK

Waste Management

Based on the theories of natural resources and sustainable development, organizations have recognized the growing impact of their work on the environment; with the advent of corporate social responsibility, the creation of value, and the millennium goals, the Organizations have been implementing best practices to reduce their ecological impact on the external environment, one of the most common practices is the use of waste from the production process to reduce costs and the effect on the environment, as well as the impact on the use of new resources.

Generally, as the industrial sector develops better products and advances in its processes, it develops skills to innovate incrementally and sometimes radically, which can favor the use of waste [1] as a source for the generation of these innovations or a consequence of disruptive and incremental innovation, which allows finding a way to take advantage of the vast residues of the industrial process.

According to some authors [2, 3], the manufacturing sector manages to recover materials that are lost in the production process from the use of production residues, which allows an impact on sustainability and generate better ways of production. In other cases, alternative sources can be used [4], creating incremental innovations to improve production processes by taking advantage of existing raw materials.

Therefore, for the manufacturing sector, developing processes that use waste is essential for its sustainability policies [5]; however, it must go hand in hand with innovation. The development of new innovative products, both at an incremental and radical level, makes it possible to strengthen the waste recovery system, mainly because innovations generate new ways of working in the production area. Therefore, it can be established that: H1 The capability for disruptive and incremental innovation positively affects the use of waste.

Organizations in the industrial sector have already developed better forms of production in the Colombian context. Now, using waste in their production processes can become a valuable tool for building new sustainability policies within the firm; the innovations that emblematic companies of the country have promoted can have the necessary positive effect for the effective use of waste from production processes.

Incremental Innovation and Disruptive Innovation

The theory of natural resources has been studied less than the theory of resources and capacities; from the theory of dynamic capabilities, it can be explained how industrial organizations tend to develop specific skills that allow them to ensure better performance in the management of their raw materials, and waste, however, dynamic capacities require a context to develop not only the capability but also the organizational routine behind the use of resources. Several previous studies [6—15], have explained the impact of innovation capability on different sustainability practices (see Table 1).

However, the directional impact of disruptive and incremental product innovation capability and innovation in production towards the use of waste and raw materials has not been studied, particularly in the Colombian context; the impact of disruptive and incremental innovation on the organizational methods has not been analyzed, which would make it possible to identify appropriate practices and patterns for Colombian companies seeking to improve their levels of innovation and environmental impact; converting the sector in general into more environmentally committed industries.

Like previous studies [16], the reference framework that is included corresponds to the theory of resources and capabilities, complementing the natural resources approach, both theories are very useful to establish the different capacities that required by industrial sectors in the Colombian context, both to innovate and to develop responsible practices, the most crucial relationship when establishing both theories as a starting point for the study, corresponds to the wealth of natural resources and the scarcity of resources for innovation in In this context, which turns out to be very particular, while companies enjoy a great diversity of sources of natural resources such as water, land and energy sources [7], human, financial, technological and intangible resources seem be less abundant for the industry, mainly due to the low investment in research and development that is typical in the country and some barriers to the use of public resources by companies to generate research and development for the same sector. Consequently, disruptive and incremental innovation for the Colombian industry is a great first step in the development of better skills within the organization and, at the same time, in improvements in production methods; this impact on innovation in production methods results of interest because companies that develop innovations in production processes tend to use less amount of raw material, which turns the industry into a group of environmentally responsible organizations. Therefore, the following hypotheses are established:

ISSN 2409-9066. Sci. innov. 2025. 21(3)

Table 1. **Description of Studies on Sustainability Practices**

Innovation Capability	Sustainability Practice	Result	Reference
Green product innovation	Sustainability-oriented dynamic capability	The integration of external resources directly affects the capability for innovation in green products.	Dangelico, R. M., Pujari, D., Pontrandolfo, P. (2017). Green product innovation in manufacturing firms: A sustainability-oriented dynamic capability perspective. *Business Strategy and the Environment*, 26(4), 490—506. https://doi.org/ 10.1002/bse.1932 Marino, A., Pariso, P. (2022). Africa's view of the circular economy: Bottlenecks and opportunities. *The International Journal of Environmental Sustainability*, 19(2), 1. *The International Journal of Environmental Sustainability*, 19(2), 1—16. https://doi.org/10.18848/2325-1077/CGP/v19i02/1-16
Strategic orientation to innovation and performance	Environmental Innovation Capability	Customer and technology orientation positively impact environmental innovation capability, while environmental innovation capability mediates the relationship between strategic orientation to innovation and sustainable environmental performance.	Tseng, C. H., Chang, K. H., Chen, H. W. (2019). Strategic Orientation, Environmental Innovation Capability, and Environmental Sustainability Performance: The Case of Taiwanese Suppliers. *Sustainability*, 11(4), 1127. https://doi.org/10.3390/su11041127
Eco-innovation innovation capability in service	Organizational performance in sustainability and environmental innovation	Eco-innovations improve sustainability performance, and service innovation capability is a barrier to competitors' entry.	Fernando, Y., Jabbour, C. J. C., Wah, W. X. (2019). Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: Does service capability matter? *Resources, Conservation, and Recycling*, 141, 8—20. https://doi.org/10.1016/j.resconrec.2018.09.031 Jochamowitz Yriberry, M., Jochamowitz Yriberry, S., Larios Francia, R. P. (2023). The Role of Ecodesign in Circular Economy to Improve the Performance of Enterprises in the Fashion Industry: A Systematic Review of Literature. *The International Journal of Environmental Sustainability*, 19(1), 43—74. https://doi.org/10.18848/2325-1077/CGP/v19i01/43-74
Detection, Capture, and Reconfiguration Capability	Innovation for sustainability	Dynamic detection, capture, and reconfiguration capabilities directly and positively affect innovation for sustainability.	Mousavi, S., Bossink, B., van Vliet, M. (2018). Dynamic capabilities and organizational routines for managing innovation towards sustainability. *Journal of cleaner production*, 203, 224—239. https://doi.org/10.1016/j.jclepro.2018.08.215
Disruptive and incremental innovation and performance	Environmental and social sustainability	Innovation and sustainability are related to each other and have a positive impact.	Behnam, S., Cagliano, R. (2017). Be sustainable to be innovative: An analysis of their mutual reinforcement. *Sustainability*, 9(1), 17. https://doi.org/10.3390/su9010017
Innovation performance of the firm	Environmental sustainable development	Sustainability practices contribute positively to business innovation and social and ecological performance.	Masocha, R. (2018). Sustainable marketing practices and sustainable consumer behaviour of tertiary students in South Africa. *Journal of Economics and Behavioral Studies*, 10(3), 248—257. https://doi.org/10.22610/jebs.v10i3.2331

Source: prepared by the author.

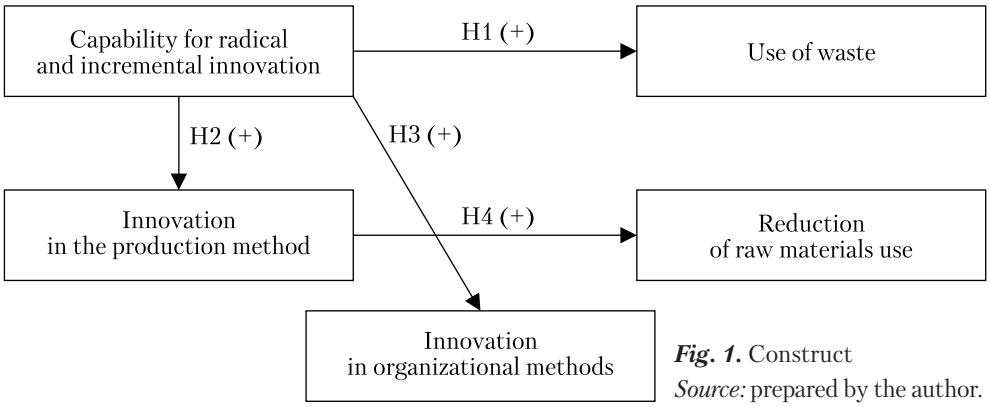

Fig. 1. Construct
Source: prepared by the author.

- H2 The capability for disruptive and incremental innovation positively affects innovation in the production method.
- H3 The capability for disruptive and incremental innovation positively affects innovation in organizational methods.

Decrease in the Use of Raw Material

In the manufacturing sector, the main component is the raw material, essential for the entire production process; as the industry evolves, the reduction of raw material is possible with the optimization of processes, the use of new materials, the efficiency in the use of packaging, and the evaluation of the life cycle of the products [17] however, the production processes can be demanding when the requirements of the clients [18] are too specific; likewise, the use of materials that are scarce turn out to be the main components in various sectors.

Some industries present new scopes with the use of better materials that include recycling inputs, which is currently known as circular economy or bioeconomy [9, 19]; the sectors with the most significant environmental impact, constantly seek not only to reduce said impact but also to seek alternative sources of raw material, the cost associated with privileged raw material in the Colombian context can make companies lose competitiveness and reduce ecological performance [22]. Therefore, industries are trying to permanently reduce the use of 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 [21], which allows establishing the best way for the productive process of the good to offer. The dynamics of the industry have changed with the new technological advances; they help it to be more efficient in using raw materials, which in the long term generates better sustainability practices [24] for the industry. Therefore, the following hypothesis is proposed: H4 Innovation in production methods positively affects the reduction of raw material use.

For this analysis, two surveys have been taken: the EDIT Technological Development and Innovation Survey with data from 2014—2015 and the Annual Manufacturing Survey 2014—2015 created by the National Administrative Department of Statistics (DANE), which collects 56 industries (see Table 2) for a total of 8264 organizations surveyed. The survey is characterized by cataloging the subsectors of the industrial sector by ISIC Revision 4 classification, which corresponds to international codes.

The variables selected from the questionnaires show the capacity for innovation in three main aspects: level of innovation (incremental and dis-

ISSN 2409-9066. Sci. innov. 2025. 21(3)

ruptive), innovation in the production method, and innovation in the organizational method. The measurement of incremental and disruptive innovation by Tseng, Chang, and Chen (2019) [12] was used, and the innovation in production method was measured as in previous studies on innovation [23, 24]. For the number of organizational methods, measurements made by other authors were applied, such as Damanpour and Aravind, 2012 [25], Camisón and Villar, 2014 [26], Mas-Verdu et al., 2016 [27]; Azar and Ciabuschi 2017 [28]; Cho et al., 2019 [29]. For the sustainability variables, the use of waste is measured by the number of instances rather than the amount of waste, following methodologies from previous studies [30—32]. This approach ensures a more effective assessment of waste utilization across industries and subsectors. Similarly, the reduction in raw material usage is quantified by the number of instances in which tangible material reduction was implemented. While the measurement of this variable varies in the literature, a common factor across studies is the extent to which each industry optimizes raw material usage. Based on prior research [33—36], this shared criterion was adopted for measuring the variable. The sample selection criteria included the availability of complete industry data, ensuring no missing information. The variables considered were the type of innovation — incremental or disruptive — the number of innovations implemented in each industry, and innovation in production and organizational methods, which were measured by the number of innovations of each type. Additionally, the use of waste and the reduction in raw material usage were quantified based on the number of instances in which waste utilization or material reduction was successfully achieved.

The list of industries in Table 2 consists of 56 manufacturing sectors, where innovation types require similar investment, technologies, and capabilities to be developed. Each industry represents innovative industries over the years, which are economic representatives for the whole sector.

Table 2. **Types of Industry**

Industries by ISIC Code Revision 4
Processing and preservation of meat, fish, crustaceans, and mollusks.
Processing and preservation of fruits, legumes, vegetables, and tubers.
Manufacture of oils and fats of vegetable and animal origin.
Manufacture of dairy products.
Manufacture of milling products, starches, and products derived from starch.
Elaboration of coffee products.
Elaboration of sugar and panela.
Manufacture of other food products.
Manufacture of prepared animal feed beverage manufacturing.
Preparation, spinning, weaving, and finishing of textile products.
Manufacture of other textile products.
Tanning and retaining of leather; manufacture of travel articles, handbags, and similar articles; and manufacture of saddlery and saddlery dressing and dyeing of furs shoe manufacturing.
Manufacture of parts and pieces of wood, carpentry, and joinery for construction.
Manufacture of paper, cardboard, and paper and cardboard products.
Printing activities and printing-related service activities.
Manufacture of rubber products.
Manufacture of plastic products.
Manufacture of glass and glass products.
Manufacture of non-metallic mineral products n.c.p.
Primary industries of precious metals and non-ferrous metals.
Manufacture of metallic products for structural use, tanks, deposits, and steam generators.
Manufacture of other fabricated metal products and service activities related to metalworking.
Manufacture of machinery and equipment for special use.
Manufacture of motor vehicles and their engines.
Manufacture of bodies for motor vehicles.
Manufacture of parts, pieces (auto parts), and accessories. (luxuries) for motor vehicles.
Furniture manufacturing.
Manufacture of mattresses and bed bases.
Manufacture of games, toys, and puzzles.
Manufacture of medical and dental instruments, apparatus, and materials (including furniture).
Other manufacturing industries n.e.c.

Source: prepared by the author.

These industries are characterized by internal consumption but also exports for commercial allies; the contribution of this sector to the economy is pivotal for competitiveness and improvement of manufacturing capabilities. Some of these representative products are coffee, sugar cane, and panela, derived from sugar cane, which are traditional and have cultural significance for communities. Conventional methods and modern techniques are combined for metallic, leather, furniture, and similar manufacturing products to offer products with internal consumption, exports, and potential new markets.

In Table 3, the descriptive statistics and correlations are presented. All the variables have a high compound reliability, and the variables measured represent the construct and are well measured. The correlation between incremental innovation and disruptive innovation suggests that companies work with both incremental and disruptive innovation in their industry. The Cronbach Alpha presents a strong internal consistency for each variable.

Agree with the relationships established to analyze the PLS model where obtained a regression analysis for each one as follows:

- Incremental innovation to Use of Waste;
- Disruptive innovation to Use of Waste;
- Incremental Innovation to Innovation in the Production Method;
- Disruptive innovation to Innovation in the Production Method;
- Incremental Innovation to Innovation in Organizational Methods;
- Disruptive innovation to Innovation in Organizational Methods;
- Innovation in the Production Method to Reduction of Raw Materials.

The result of this analysis is exposed in Table 4.

These results explain the statistical significance of the relations between innovation variables, the use of waste and reduction of raw material, and the relationship between innovation types. Incremental innovation has a positive and significant relationship with innovation in production and organizational methods. In contrast, disruptive innovation shows a positive relation with both but with less impact than incremental innovation.

After the regression analysis, a model that proposes a positive relationship between innovation and some practices of environmental responsibility was analyzed, finding the following paths and results (Fig. 2).

It was possible to verify that innovation in production can reduce the use of raw materials, demonstrating that innovation in production has the potential to help companies in the industrial sector obtain greater efficiency in their processes through the reduction of raw materials.

Table 3. **Descriptive Statistics**

Variables	Mean	Standard Deviation	Compound Reliability	Extracted Variance	1	2	3	4	5
1. Incremental innovation	19.691	22.514	0.965	0.932	(0.927)				
2. Disruptive innovation	25.400	36.143	0.965	0.932	0.864	(0.927)			
3. Innovation in the production method	31.491	35.493	1.000	1.000	0.533	0.466	(1.000)		
4. Innovation in organizational methods	0.818	0.606	1.000	1.000	0.638	0.610	0.712	(1.000)	
5. Use of waste	7.945	7.971	1.000	1.000	0.229	0.255	−0.009	−0.101	(1.000)
6. Reduction of raw materials use	0.673	0.574	1.000	1.000	0.554	0.463	0.594	0.666	0.013
The correlation is significant at the 0.05 level (bilateral) Cronbach's alpha is shown on the diagonal in parentheses									

Source: prepared by the author.

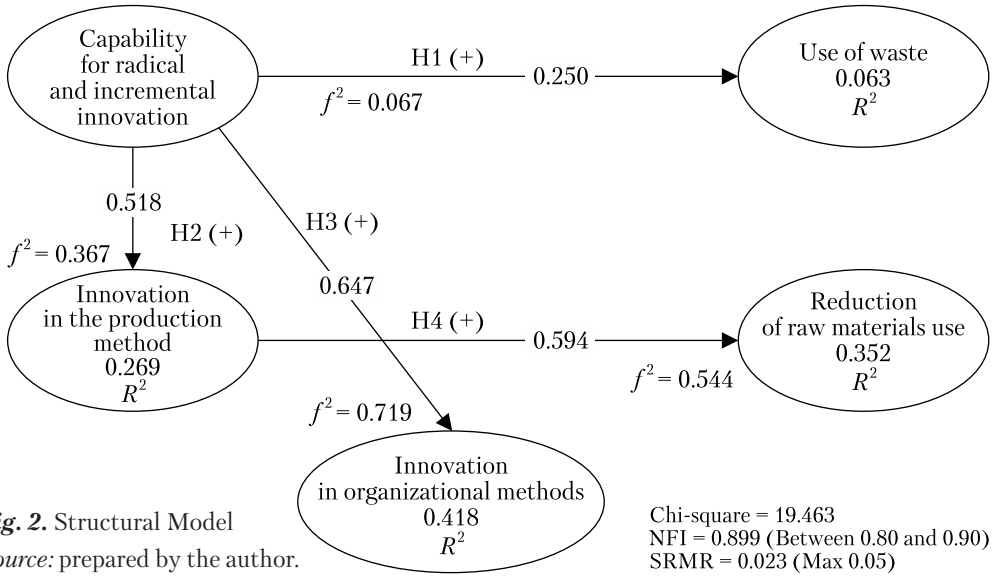

Fig. 2. Structural Model
Source: prepared by the author.

The degree of disruptive and incremental innovation can impact a more significant number of innovations in organizational methods, which suggests that industrial organizations that aim to improve their environmental performance can obtain benefits by implementing both incremental and disruptive innovation approaches, which allows making gradual and total changes; as well as the existence of an effect, although less interesting for future studies, is the ability to use production waste, which represents an advance in the relationship between innovation and environmental sustainability, since innovation allows the creation of opportunities from waste for new uses or new resources within the organization. The model presents an alpha or chi-square of 19.463, a Standar-

Table 4. **Regression Table**

Dependent Variable	Independent Variable	Coefficient	Standard Error	P Value	Interval Coefficient 95%
Use of waste	Incremental innovation	0.000357	0.000201	0.0819	(–0.00004675, 0.0007613)
Use of waste	Disruptive innovation	0.000247	0.000125	0.0524	(–0.00000261, 0.0004972)
Innovation in the production method	Incremental innovation	0.8399	0.1833	0.000028	(0.4723, 1.2075)
Innovation in the production method	Disruptive innovation	0.4574	0.1194	0.000338	(0.2180, 0.6968)
Innovation in organizational methods	Incremental innovation	0.01602	0.002214	0.000000186	(0.01158, 0.02046)
Innovation in organizational methods	Disruptive innovation	0.008917	0.001510	0.000000256	(0.005889, 0.01195)
Reduction of raw materials use	Innovation in the production method	0.01001	0.001312	0.0000000004378	(0.007380, 0.01264)

Source: prepared by the author.

dized Root Mean Square Residual (SRMR) of 0.023, and the Normed Fit Index (NFI) of 0.899, representing an excellent statistical adjustment of the proposed model.

β coefficients are the regression standardized coefficients. They explain the magnitude and address of the relationship between the independent and dependent variables. The value of 0.518 explains an increase in the standard deviation of the independent variable, the degree of innovation, associated with the dependent variable: innovation in the production method.

R^2 values appear inside the circles of the dependent variables (e.g., $R^2 = 0.269$ for innovation in the production method); an R^2 of 0.269 suggests that the degree of innovation can explain 26.9% of the variability in innovation in the production method.

The effect size f^2 is a measure that quantifies an independent variable's contribution to a dependent variable's explanatory power. The results for this effect size are:

$f^2 = 0.367$ for Degree of Innovation to Innovation in Production Method indicates a more than moderate effect of Degree of Innovation on Innovation in Production.

$f^2 = 0.544$ for Innovation in Production Method to Reduction in Materials Use indicates a large effect of Innovation in Production on Reduction in Materials Use.

$f^2 = 0.719$ for Degree of Innovation to Innovation in Organizational Method suggests that Degree of Innovation greatly affects Innovation in Organizational Method.

$f^2 = 0.067$ for Degree of Innovation to Capacity to Utilize Production Waste indicates a small effect of Degree of Innovation on Capacity to Utilize Production Waste.

The structural equations for this model are:

Innovation in the Production Method as a dependent variable:

Innovation in the Production Method = β1 × × Capability for disruptive and incremental innovation + e1,

where β1 is the regression coefficient that represents the influence of capability for disruptive and incremental innovation on innovation in the production method; e1 is the error associated with this equation.

Innovation in Organizational Methods as dependent variable:

Innovation in Organizational Methods = β2 × × Capability for disruptive and incremental innovation + e2,

where β2 is the regression coefficient that represents the influence of capability for disruptive and incremental innovation on innovation in organizational methods; e2 is the error associated with this equation.

Use of Waste as a dependent variable:

Use of waste = β3 × capability for disruptive and incremental innovation + e3,

where β3 is the regression coefficient that represents the influence of capability for disruptive and incremental innovation on innovation in the production method; e3 is the error associated with this equation.

Reduction of Raw Materials:

Reduction of raw materials = β4 × capability for disruptive and incremental innovation + β5 × × innovation in the production method + e4,

where β4 and β5 are the regression coefficients representing the influence of capability for disruptive and incremental innovation and innovation in the production method on reducing the raw materials; e4 is the error associated with this equation.

Based on the proposed model, it was possible to establish that the capability for innovation can help the industrial sector to carry out better practices in the use of resources and the use of waste from the theory of resources and capabilities (see Fig. 2), the resources invested in the Colombian context to develop sustainability policies are scarce, the capabilities that manage to develop from small investments and trial and error in manufacturing, are those that in the long term can generate a guideline for the development of a sector with solid capacities for the sustainable development.

However, industries with different subsectors must adjust their waste utilization systems. A disruptive or incremental innovation does not have

ISSN 2409-9066. Sci. innov. 2025. 21(3)

a high impact on how waste from the production process is used; therefore, the performance of the sector concerning the relationship between innovation capability and responsible practices in raw materials and waste occurs as follows (see Table 5).

The industrial sector is especially recognized for working on innovation at all levels; therefore, they carry out incremental and disruptive innovation; this degree of innovation allows recognizing in the manufacturing sector an important intention when it comes to innovating, in the first hypotheses 1a and 1b was expected a positive relationship between the degree of innovation and the ability to take advantage of production waste; however, a positive but weak relationship is found, which may indicate that although disruptive and incremental innovation is carried out, the manufacturing industry in its test and experimental error, generate more waste but do not necessarily have a process to take advantage of all the waste generated, a broader commitment would be needed regarding the use of waste, as is the case of the mills in Valle del Cauca region than in their production processes recycle the water that they have used in their production process.

Nevertheless, the degree of innovation does affect innovation in production methods, confirming hypotheses H2a and H2b. The degree of innovation controls the number of new production methods that are developed; for the Colombian industry, it is very important to recognize that not only does disruptive innovation count in their production systems, but improvements within the production process can have an indirect positive effect on the efficient use of raw materials.

Innovations in production methods affected by the degree of innovation can cause a better use of raw materials, confirming hypothesis 4; the reduction in the use of raw materials can be explained by improvements in processes that lead to a decrease in costs, including the use of unnecessary materials. This turns each manufacturing sector into a more efficient industry, which in the long term can positively affect the environment.

It is essential to highlight that innovation in organizational methods, although they are not related to the use of waste and the reduction in the use of raw materials, is affected by the degree of innovation; having disruptive and incremental innovations allows the industrial sector to improve their internal processes not related to the production process, confirming hypotheses 3a and 3b, which is very interesting for organizations in the industrial sector that consider carrying out innovation to overcome their levels of organizational effectiveness, to improve their internal indicators such as quality, inventories, response times, resource location, supply chain, customer service among many others.

Studying disruptive and incremental innovation, organizational and production innovation, combined with raw materials reduction and waste use, this paper aims to shed light on how industrial organizations can improve their envi-

Table 5. **Hypothesis and Results**

Incremental innovation → Use of waste	Hypothesis 1a	Confirmed but weak relationship
Disruptive innovation → Use of waste	Hypothesis 1b	Confirmed but weak relationship
Incremental innovation → Innovation in the production method	Hypothesis 2a	Confirmed
Disruptive Innovation → Innovation in the production method	Hypothesis 2b	Confirmed
Incremental innovation → Innovation in organizational methods	Hypothesis 3a	Confirmed
Disruptive innovation → Innovation in organizational methods	Hypothesis 3b	Confirmed
Innovation in the production method → Reduction of raw materials	Hypothesis 4	Confirmed

Source: prepared by the author.

ronmental performance through different types of innovation.

First, the relationship between innovation and waste use opens up opportunities to create better policies within the organization to repurpose production waste, adjusting the current waste utilization system to maximize the benefits of disruptive and incremental innovation; this advancement in the relationship between sustainability and innovation types implies the potential for industrial companies to adopt circular economy principles, with a resource-efficient approach.

Second, it is important to highlight that innovation in production processes can be followed by a reduction of raw materials; this can indicate that innovation types can help industrial companies achieve higher efficiency levels, minimizing their dependence on scarce resources.

This analysis also examines the impact of different innovation types, in this case, disruptive and incremental, with the potential to influence an extensive number of innovations in organizational methods; a combination of innovations can lead to gradual changes to reach better environmental practices in industrial companies.

This research also found that innovative production methods can reduce raw material usage and that both incremental and disruptive innovation can drive organizational method innovations; it is possible to affirm that innovation can benefit both the environment and the industrial sector. In the Colombian context, these characteristics are relevant to emphasize the importance of developing capabilities for sustainable development despite scarce resources. With this analysis, it is possible to recommend that industrial companies find ways to optimize waste use and balance different types of innovation to go further and reach the ecological process.

Although the results are satisfactory, the sacrifice of certain responsibility factors for cost reduction is worrisome for manufacturing organizations; most sectors work with well-established policies in environmental management, where the capacity for innovation has a significant influence, the reduction of raw material seems to be evident due to the immediate effect it has on industry budgets, being a practice that considerably reduces the costs associated with production. While the use of waste from the production process requires more research and development to fine-tune those wastes that can be included again in manufacturing, the cost associated with designing the production process that allows reusing some waste can result in extended systems, complex and with large investments, which Colombian manufacturing organizations are not willing to assume if they do not find short-term benefits; therefore, it is interesting that the effect of disruptive and incremental innovation is stronger to reduce the use of raw materials, in innovation in the production method and the organizational method than in the case of waste utilization in the industry.

With the present study, it can be affirmed that the Colombian manufacturing industry stands out for making essential efforts in terms of innovation, the capacity that they have built in recent years through higher investment in tangible and intangible resources that allow them to build unique capabilities, become a relevant factor in developing in the long term best practices of responsibility, especially in the environmental sphere, the raw material that responds to one of the fundamental needs of the sector can be reduced, that is, that the production processes can be transformed to make them less polluting and in the future possibly deploy advanced manufacturing systems that respect the environment but also help to improve it.

These results also suggest critical practical implications; industrial companies can design specialized innovation strategies that promote environmental sustainability, making major changes in their production processes and organizational methods, which will also help to increase their environmental impact.

The great challenge for the Colombian industry will be waste management; the industry generates millions of tons daily. However, reusing this waste in a circular economy, or eco-manufacturing, will be complex. Manufacturing systems in Colombia

have yet to develop the capacity to take advantage of their waste; in some sectors, especially agro-industrial sectors such as sugar, coffee, and fruit, there are practices in this regard, but other more complex sectors such as pharmaceuticals, plastics, and metals, further research is required to develop these practices and turn them into capabilities.

On the other hand, gaining operational efficiency while looking for environmental solutions using fewer materials or transforming waste into resources is a second challenge for the industrial sector, which can also be converted into forms of innovation, developing a circular process of constant innovation and greener practices for sustainability.

This study recognizes the Colombian manufacturing industry's worthy efforts in adopting innovation and building unique capabilities. These efforts have positioned the industry as a significant driver in the long-term development of responsible practices. The industry's commitment to minimizing its environmental impact is evident in the reduction of raw materials achieved through innovative production processes. It is possible to argue that these efforts have the potential to lead the way for the future implementation of advanced manufacturing systems that not only respect but also contribute to improving the ecosystem.

However, waste management remains a significant challenge for the Colombian industry. Despite generating millions of tons of waste daily, the industry has yet to fully develop the capacity to control this waste within a circular economy. This research shows that while specific agro-industrial sectors have exhibited some practices in this regard, more complex sectors require further research and investment to effectively develop better waste management capabilities.

The practical implications of this research are essential for companies seeking to enhance their environmental sustainability while innovating; companies can effectively integrate responsible practices into their production processes and organizational methods, promoting positive environmental impacts and furthering a competitive advantage in the industry.

Moreover, the industry can embrace a circular approach through constant innovation and sustainable practices by seeking operational efficiency while working for better processes and systems to create ecological products. This process of innovation, aimed at greener and more sustainable practices within organizations, not only benefits the environment but also ensures the industry's continued growth and resilience to face environmental changes such as high temperatures, contamination, water scarcity, energy alternatives, and food security, among others.

In conclusion, this study highlights the Colombian manufacturing industry's innovation and the development of unique capabilities, which serve as a foundation for sustainable practices. The industry's ability to reduce raw material use and adopt innovative types is worthy and must inspire other sectors globally to better practices. Although challenges remain for industrial companies, particularly in waste management and resource utilization, commitment to investment, environment comprehension, and a circular approach to innovate with greener processes can convert these challenges into opportunities.

Limitations and Future Research

The present study allows us to understand the relationship between innovation and sustainability from some critical variables for the manufacturing industry; however, it is not enough to show the dynamics of each sector, both in the use of waste and in the reduction of raw materials, it would be important to compare the sectors and see its evolution from a longitudinal study. A significant limitation also responds to the waste recovery system and its different practices, its analysis in terms of impact for multiple sectors, and the detailed description of the levels or degrees of innovation in this sector. These limitations open the path to future studies focused on a comprehensive analysis of these practices and reviewing other variables, such as technological intensity and its relationship with environmental impact and innovation

measures against ecological performance, moderated by this technological intensity.

As the relationship between both incremental and disruptive innovation with waste use is confirmed but weak, it is important to take a multifaceted approach to waste management and environmental sustainability in the industrial sector; this analysis gave some hints about the different challenges that can make it difficult a successful waste management as toxic waste, low training to employees, technology, suppliers agreements, customer's needs, high costs and must be included in future studies. Also, relying only on one type of innovation may not yield the desired outcomes for sustainability practices; this is an essential limitation of this study; instead, organizations should consider integrating both types of innovation or several innovation forms in a complementary manner to analyze ecological practices.

To gain valuable insights, industrial organizations that have successfully integrated both incremental and disruptive innovations into their waste management practices could be studied through case studies and comparative analyses between sectors and countries; also, recognizing human resources abilities within sustainable practices can help to understand the complementarities between innovation and ecological performance.

Future studies can also explore the specific barriers that hamper the integration of innovation and waste management in the industrial sector; recognizing these challenges can guide the development of strategies, investments, and best practices to improve waste use and integrate innovation into an environmental perspective.

CONFLICT OF INTEREST STATEMENT

The author declares that no known competing financial interests or professional or personal relationships could have influenced the work reported in this paper.

REFERENCES

1. Lozano, F. J., Lozano, R. (2018). Assessing the potential sustainability benefits of agricultural residues: Biomass conversion to syngas for energy generation or to chemicals production. *Journal of cleaner production*, 172, 4162—4169. https://doi.org/10.1016/j.jclepro.2017.01.037
2. Ajemigbitse, M. A., Cannon, F. S., Klima, M. S., Furness, J. C., Wunz, C., Warner, N. R. (2019). Raw material recovery from hydraulic fracturing residual solid waste with implications for sustainability and radioactive waste disposal. *Environmental Science: Processes & Impacts*, 21(2), 308—323. https://doi.org/10.1039/C8EM00248G
3. Qi, X., Fu, Y., Wang, R. Y., Ng, C. N., Dang, H., He, Y. (2018). Improving the sustainability of agricultural land use: An integrated framework for the conflict between food security and environmental deterioration. *Applied Geography*, 90, 214—223. https://doi.org/10.1016/j.apgeog.2017.12.009
4. Munda, S., Shivakumar, B. G., Rana, D. S., Gangaiah, B., Manjaiah, K. M., Dass, A., ..., Lakshman, K. (2018). Inorganic phosphorus along with biofertilizers improves profitability and sustainability in soybean (*Glycine max*) — potato (*Solanum tuberosum*) cropping system. *Journal of the Saudi Society of Agricultural Sciences*, 17(2), 107—113. https://doi.org/10.1016/j.jssas.2016.01.008
5. Gupta, N., Poddar, K., Sarkar, D., Kumari, N., Padhan, B., Sarkar, A. (2019). Fruit waste management by pigment production and utilization of residual as bioadsorbent. *Journal of environmental management*, 244, 138—143. https://doi.org/10.1016/j.jenvman.2019.05.055
6. Manual, O. (2005). The measurement of scientific and technological activities. *Proposed Guidelines for Collecting an Interpreting Technological Innovation Data*, 30(162), 385—395. https://doi.org/10.1787/9789264013100-en
7. Jochamowitz Yriberry, M., Jochamowitz Yriberry, S., Larios Francia, R. P. (2023). The Role of Ecodesign in Circular Economy to Improve the Performance of Enterprises in the Fashion Industry: A Systematic Review of Literature. *The International Journal of Environmental Sustainability*, 19(2), 43—74. https://doi.org/10.18848/2325-1077/CGP/v19i02/43-74
8. Asadi, S., Pourhashemi, S. O., Nilashi, M., Abdullah, R., Samad, S., Yadegaridehkordi, E., ..., Razali, N. S. (2020). Investigating influence of green innovation on sustainability performance: A case on Malaysian hotel industry. *Journal of cleaner production*, 258, 120860. https://doi.org/10.1016/j.jclepro.2020.120860

9. Marino, A., Pariso, P. (2022). Africa's view of the circular economy: Bottlenecks and opportunities. *The International Journal of Environmental Sustainability*, 19(2), 1. *The International Journal of Environmental Sustainability,* 19(2), 1—16. https://doi.org/10.18848/2325-1077/CGP/v19i02/1-16
10. Mousavi, S., Bossink, B., van Vliet, M. (2018). Dynamic capabilities and organizational routines for managing innovation towards sustainability. *Journal of cleaner production*, 203, 224—239. https://doi.org/10.1016/j.jclepro.2018.08.215
11. Masocha, R. (2018). Sustainable marketing practices and sustainable consumer behaviour of tertiary students in South Africa. *Journal of Economics and Behavioral Studies*, 10(3), 248—257. https://doi.org/10.22610/jebs.v10i3.2331
12. Tseng, C. H., Chang, K. H., Chen, H. W. (2019). Strategic Orientation, Environmental Innovation Capability, and Environmental Sustainability Performance: The Case of Taiwanese Suppliers. *Sustainability*, 11(4), 1127. https://doi.org/10.3390/su11041127
13. Fernando, Y., Jabbour, C. J. C., Wah, W. X. (2019). Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: Does service capability matter? *Resources, Conservation, and Recycling*, 141, 8—20. https://doi.org/10.1016/j.resconrec.2018.09.031
14. Behnam, S., Cagliano, R. (2017). Be sustainable to be innovative: An analysis of their mutual reinforcement. *Sustainability*, 9(1), 17. https://doi.org/10.3390/su9010017
15. Dangelico, R. M., Pujari, D., Pontrandolfo, P. (2017). Green product innovation in manufacturing firms: A sustainability-oriented dynamic capability perspective. *Business Strategy and the Environment*, 26(4), 490—506. https://doi.org/10.1002/bse.1932
16. Mengova, E., Green, D. (2023). The Role of Innovation and Technology in Renewable Energy. *The International Journal of Environmental Sustainability*, 19(2), 17. https://doi.org/10.18848/2325-1077/CGP/v19i02/17-41
17. Sameer, H., Bringezu, S. (2019). Life cycle input indicators of material resource use for enhancing sustainability assessment schemes of buildings. *Journal of Building Engineering*, 21, 230—242. https://doi.org/10.1016/j.jobe.2018.10.010
18. Franco, J. C., Hussain, D., McColl, R. (2019). Luxury fashion and sustainability: looking good together. *Journal of Business Strategy*, 41, 55—61. https://doi.org/10.1108/JBS-05-2019-0089
19. D'Amato, D., Veijonaho, S., Toppinen, A. (2018). Towards sustainability? Forest-based circular bioeconomy business models in Finnish SMEs. *Forest Policy and Economics*, 101848. https://doi.org/10.1016/j.forpol.2018.12.004
20. Vikas, I., Sdrali, D., Abeliotis, K., Apostolopoulos, C. (2022). Environmental Performance Influencing Factors in Industrial Clusters. *The International Journal of Environmental Sustainability*, 18(1), 59. https://doi.org/10.18848/2325-1077/CGP/v18i01/59-68
21. Lenzo, P., Traverso, M., Mondello, G., Salomone, R., Ioppolo, G. (2018). Sustainability performance of an Italian textile product. *Economies*, 6(1), 17. https://doi.org/10.3390/economies6010017
22. Sicoli, G., Bronzetti, G., Baldini, M. (2019). The Importance of Sustainability in the Fashion Sector: ADIDAS Case Study. *International Business Research*, 12(6), 41—51. https://doi.org/10.5539/ibr.v12n6p41
23. Salerno, M. S., de Vasconcelos Gomes, L. A., Da Silva, D. O., Bagno, R. B., Freitas, S. L. T. U. (2015). Innovation processes: Which process for which project? *Technovation*, 35, 59—70. https://doi.org/10.1016/j.technovation.2014.07.012
24. Matt, D. T., Rauch, E., Dallasega, P. (2015). Trends towards distributed manufacturing systems and modern forms for their design. *Procedia cirp*, 33, 185—190. https://doi.org/10.1016/j.procir.2015.06.034
25. Damanpour, F., Aravind, D. (2012). Managerial innovation: Conceptions, processes and antecedents. *Management and organization review*, 8(2), 423—454. https://doi.org/10.1111/j.1740-8784.2011.00233.x
26. Camisón, C., Villar-López, A. (2014). Organizational innovation as an enabler of technological innovation capabilities and firm performance. *Journal of business research*, 67(1), 2891—2902. https://doi.org/10.1016/j.jbusres.2012.06.004
27. Mas-Verdu, F., Ortiz-Miranda, D., García-Álvarez-Coque, J. M. (2016). Examining organizational innovations in different regional settings. *Journal of Business Research*, 69(11), 5324—5329. https://doi.org/10.1016/j.jbusres.2016.04.132
28. Azar, G., Ciabuschi, F. (2017). Organizational innovation, technological innovation, and export performance: The effects of innovation radicalness and extensiveness. *International business review*, 26(2), 324—336. https://doi.org/10.1016/j.ibusrev.2016.09.002
29. Cho, H., Lee, P., Shin, C. H. (2019). Becoming a sustainable organization: focusing on process, administrative innovation and human resource practices. *Sustainability*, 11(13), 3554. https://doi.org/10.3390/su11133554
30. Katinas, V., Marčiukaitis, M., Perednis, E., Dzenajavičienė, E. F. (2019). Analysis of biodegradable waste use for energy generation in Lithuania. *Renewable and Sustainable Energy Reviews*, 101, 559—567. https://doi.org/10.1016/j.rser.2018.11.022
31. Sirohi, R., Singh, A., Malik, S. (2018). Production, Characterization and Industrial Applications of Cellulase Derived from Agro-waste. *Current Journal of Applied Science and Technology*, 1—9. https://doi.org/10.9734/CJAST/2018/41302
32. Posmyk, M., Wzorek, M. (2018). Assessing the possible use of selected types of rural waste in biogas production. *Intercathedra*, 36(3), 283—289. http://dx.doi.org/10.17306/J.INTERCATHEDRA.2018.00034

33. Sayadi-Gmada, S., Rodríguez-Pleguezuelo, C. R., Rojas-Serrano, F., Parra-López, C., Parra-Gómez, S., García-García, M. D. C., García-Collado, R, Lorbach-Kelle, M. B., Manrique-Gordillo, T. (2019). Inorganic Waste Management in Greenhouse Agriculture in Almeria (SE Spain): Towards a Circular System in Intensive Horticultural Production. *Sustainability*, 11(14), 3782. https://doi.org/10.3390/su11143782
34. Cai, W., Lai, K. H., Liu, C., Wei, F., Ma, M., Jia, S., ..., Lv, L. (2019). Promoting sustainability of manufacturing industry through the lean energy-saving and emission-reduction strategy. *Science of The Total Environment*, 665, 23—32. https://doi.org/10.1016/j.scitotenv.2019.02.069
35. de Vargas Mores, G., Finocchio, C. P. S., Barichello, R., Pedrozo, E. A. (2018). Sustainability and innovation in the Brazilian supply chain of green plastic. *Journal of cleaner production*, 177, 12—18. https://doi.org/10.1016/j.jclepro.2017.12.138
36. Kairytė, A., Vaitkus, S., Vėjelis, S., Pundienė, I. (2018). A Study of Rapeseed Oil-Based Polyol Substitution with Bio-based Products to Obtain Dimensionally and Structurally Stable Rigid Polyurethane Foam. *Journal of Polymers and the Environment*, 26(9), 3834—3847. https://doi.org/10.1007/s10924-018-1266-8

Received 21.04.2024
Revised 07.09.2024
Accepted 13.09.2024

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РОЛЬ ІННОВАЦІЙ У ПРОСУВАННІ СТІЙКИХ ПРАКТИК У ПРОМИСЛОВОМУ СЕКТОРІ

Вступ. Сталий розвиток у промисловому секторі привернув увагу через екологічні, соціальні та економічні проблеми, що виникають через невідповідальне використання ресурсів. Виробничим компаніям доводиться зіштовхуватися з викликом зменшення або оптимізації використання ресурсів у виробничих процесах.

Проблематика. Парадокс колумбійських виробничих компаній полягає у їхніх заявах про екологічну, економічну та соціальну відповідальність, тоді як водночас демонструють політику, що збільшує використання ресурсів та погіршення стану довкілля.

Мета. Показати як радикальні та інкрементальні інновації у продуктах, методах виробництва та організаційних методах впливають на ефективне використання ресурсів й управління відходами у колумбійському промисловому секторі.

Матеріали й методи. Дані з двох опитувань, які охоплювали 8264 виробничих компаній у 56 підсекторах, були проаналізовані за допомогою передових статистичних технік. Здатність до інновацій було оцінено в термінах продукту, процесу та організаційних методів на рівні з їхнім екологічним впливом.

Результати. Інновації в методах виробництва значно підвищують ефективне використання сировини, тоді як інкрементальні та радикальні інновації позитивно впливають на практики управління відходами. Визначено потребу в більших інвестиціях у дослідження та стійкі практики, особливо у складних секторах, таких як фармацевтика і виробництво пластмаси.

Висновки. Колумбійська виробнича промисловість зробила похвальні зусилля в інноваціях та розвитку унікальних заходів, що призвели до більш екологічного виробництва і зменшення використання сировини. Незважаючи на виклики в управлінні відходами та використанні ресурсів, орієнтування на циркуляційну економіку й більш «зелені» процеси відкриває можливості для розвитку індустрії.

Ключові слова: стійкість, інновації, сировина, відходи, промисловість.