







# Driving sustainability-oriented innovation: a study of Portuguese industrial companies' business models

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## Abstract

In response to society's growing demand for sustainable practices, innovation across products, services, processes, and business models is now expected to minimize the adverse impacts of industrial processes. This study investigated the influence of innovation management on sustainability within the business models of Portuguese industrial companies. A quantitative approach was employed through a survey conducted among Portuguese industrial companies, with data analysis performed using the partial least squares technique. The findings revealed a positive relationship between sustainability-oriented innovation practices and sustainable business models. Furthermore, the adoption of such systems had a positive influence on the level of innovation. This research contributes to the existing literature by exploring the association of innovation management with sustainability within business models. The insights gained can provide valuable guidance to managers and decision-makers in promoting innovation and facilitating the transition to a more sustainable future.

**Keywords:** Business Model; Innovation; Portuguese Companies; Sustainability; Sustainability Strategy.

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## Introduction

Sustainability has increasingly become the agenda in multiple economic and social contexts, and its insertion into business strategy represents a competitive challenge for organizations. Society has been demanding that innovation in products, services, processes, and business models be accompanied by sustainable practices to minimize the adverse impacts of industrial processes. Dyck and Silvestre (2018) highlighted that society has become increasingly aware of the need to find solutions to oppose socio-environmental crises by adopting more sustainable lifestyles. According to the authors, innovations promoting sustainable development are fundamental to this confrontation.

Research has shown that sustainable performance can only be achieved with innovation because it requires adaptation and change in processes, products, management approaches, and policy orientations. Sustainable innovations that are frequently adopted improve specific organizations and the entire supply chain trajectory, achieving superior sustainability performance (Silvestre, 2015; Silvestre & Țircă, 2019). Adams et al. (2016) reported that sustainability-oriented innovation is related to changing an organization's philosophy and values, as well as its products, processes, and practices, to create social and environmental benefits beyond economic returns.

Therefore, sustainable innovation requires changes in the corporate environment and is related to a business model that strategically contemplates economic prosperity, social well-being, and environmental preservation. Some authors have established sustainability-oriented

innovation as a business model challenge (Rohrbeck et al., 2013; Adams et al., 2016). According to Boons and Lüdeke-Freund (2013), searching for business models for sustainable innovation is equivalent to seeking a business model that challenges the neoclassic economic view. Nevertheless, a systemic perspective of the business model may contribute to a sustainable innovation agenda by providing new approaches to overcome internal and external organizational barriers (Boons & Lüdeke-Freund, 2013).

The management of sustainable innovation in industrial companies may reflect on their business model. Yang et al. (2017) believed that business model innovation is an emerging research area and is essential to sustainability and the diffusion of sustainable business practices. This study provides important empirical validation and expands the academic discussion by investigating the association between sustainability-oriented innovation management and the business model of industrial companies.

Given the above, the fundamental question of this study is: "How does adopting innovation management for sustainability influence the business model of Portuguese industrial companies?" The general objective is to analyze the association of innovation management with sustainability in the business model of such companies. This study offers important theoretical contributions, providing empirical validation of the proposed model, which is based on the archetypes suggested by Bocken et al. (2014) and Ritala et al. (2018), as well as on the concepts of the sustainable business model proposed by Boons and Lüdeke-Freund (2013), Kiron et al. (2013), and Taran et al. (2015).

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## Theoretical framework

The theoretical framework deals with aspects of sustainability-oriented innovation and business modeling to support the theoretical construct of the study.

### Sustainability-oriented innovation

The conscious use of natural resources to adequately meet social demands has led to a growing debate on sustainability and its relation to economic, social, and environmental objectives in the last decade (Cillo et al., 2019). Sustainability requires immediate action and change by business, government, and society (Silvestre & Țîrcă, 2019); thus, incorporating social and environmental goals in existing regulations results in greater corporate sustainability (Forcadell et al., 2019).

The business environment competitiveness is associated with the global concern of properly using natural resources, requiring companies to implement sustainability strategies (Maier et al., 2020). Innovation is critical for long-term business success and comprises modifying products, processes, and managerial activities involved in delivering a product or service (Maier et al., 2020; Chege & Wang, 2020). From this perspective, the connection between innovation and sustainability in the literature has introduced new concepts, including green innovation, sustainable innovation, eco-innovation, and clean technologies (Ghassim, 2018). Klewitz and Hansen (2014) provided three categories of sustainability-oriented innovations, comprising product, process, and organization, making intentional changes to an organization's philosophy and values, products, procedures, and practices to create and deliver social and environmental value along with economic returns (Adams et al., 2016). Indeed, innovating for sustainability aims to improve the ecological, social, and financial performance of the solution presented (Juntunen et al., 2019).

Sustainable innovations continuously improve organizations and the entire supply chain's trajectory, enabling superior performance (Silvestre & Țîrcă, 2019). These authors propose a typology of innovation for sustainability: traditional innovation, green innovation, social innovation, and sustainable innovation. Therefore, innovation strategies for sustainability from an environmental perspective are imperative in the contemporary crisis arising from industrial activity and demand for new business models to deal with sustainability challenges (Chege & Wang, 2020; Adams et al., 2016).

### Business models

The concept of business model gained emphasis in the 1990s (Boons et al., 2013; Taran et al., 2015), and the debate on business model innovation was broadened in the 2000s (Vils et al., 2017). According to Amit and Zott (2001), the business model describes the content, structure, and governance to create value through exploiting business opportunities. Business model innovation is a way to address sustainability challenges (Shakeel et al., 2020); business model innovation for circularity or sustainability is becoming critical to sustaining competitive advantage and an emerging research field (Pieroni et al., 2019; Lüdeke-Freund & Dembek, 2017).

The decision-making sense of a sustainability-oriented business model is not only focused on making profits but also on recognizing society and the environment as essential and influential (Preghenella & Battistella, 2021). The sustainable business model includes sustainability, circular economy, value chain, information technology, core values, value creation, organizational values, performance management, and stakeholder engagement, which must be integrated into a holistic business model (Goni et al., 2021).

The definitions for business models are still conflicting in the literature (Pieroni et al., 2019). Shakeel et al. (2020) affirmed that a sustainable business model either (1) incorporates goals, conceptions, and principles of sustainability or (2) aggregates sustainability aspects into value propositions, creation, delivery, and capture. Hence, business models reveal activities to advance sustainability transitions (Hernández-Chea et al., 2021).

Some studies have covered definitions of sustainable business model archetypes (Bocken et al., 2014; Ritala et al., 2018), including the taxonomy of 45 patterns to support sustainability-oriented business model innovation (Lüdeke-Freund et al., 2018), the Three Layer Business Model Canvas (Joyce & Paquin, 2016), the circular business model (Lüdeke-Freund et al., 2019), and the anatomy of sustainable business model innovation (Shakeel et al., 2020). Kiron et al. (2013) developed a framework to analyze business models regarding sustainability and found that 50% of respondents who changed three to four elements of their business model profited from integrating sustainability.

Boons and Lüdeke-Freund (2013) highlighted that the company must integrate various elements into the business model, suggesting a generic structure composed of four components: (1) value proposition (the value embedded in the products/services offered by the company), (2) supply chain (relationship with suppliers), (3) customer interface (relationship with customers), and (4) financial model (costs, benefits, and their distribution among stakeholders).

Bocken et al. (2014) identified eight sustainable business model archetypes: (1) maximize material and energy efficiency, (2) close resource loops, (3) replace with renewables and natural processes, (4) deliver functionality rather than ownership, (5) adopt a stewardship role, (6) encourage sufficiency, (7) repurpose for society and the environment, and (8) develop sustainable scale-up solutions. The company may use the archetypes alone or with others to develop new sustainable business model ideas, increasing innovations by guiding new opportunities (Bocken et al., 2014). Ritala et al. (2018) included archetype (9), inclusive value creation, as it reflects the rise of peer-to-peer and sharing models and value creation for a customer base. The archetypes were grouped according to environmental, social, and economic dimensions (Ritala et al., 2018).

The outcomes of incorporating sustainability rely on the ambition of decision-makers and the strategies adopted (Pieroni et al., 2019). Thus, the literature highlights the critical role of sustainable business models in achieving development goals by adopting sustainable practices (Hernández-Chea et al., 2021). The following section presents the theoretical model of this study.

### Theoretical model hypotheses

The sustainable business model archetypes identified by Bocken et al. (2014) and Ritala et al. (2018) are listed in Table 1.

**Table 1:** Sustainable business model archetypes

Innovation	Archetype	Definition
Environmental	Maximize energy and material efficiency	Doing more with fewer resources, generating less waste, emission, and pollution.
	Close resource loops	Reusing materials and products, transforming waste into raw materials for other products and processes.
	Replace with renewables and natural processes	Using non-finite materials and energy sources.
Social	Deliver functionality, not ownership	Providing services that satisfy users' needs without owning physical products.
	Adopt a stewardship role	Proactively engaging with stakeholders to ensure long-term health and well-being.
	Encourage sufficiency	Seeking solutions that actively reduce end-user consumption.
Economic	Repurpose for society and the environment	Creating positive value for all stakeholders, especially society and the environment.
	Inclusive value creation	Sharing resources, knowledge, ownership, wealth creation, and value creation.
	Develop sustainable scale-up solutions	Providing large-scale sustainable solutions to maximize benefits to society and the environment

Source: Bocken et al. (2014) and Ritala et al. (2018).

Regarding the business model, we adopted the studies of Boons and Lüdeke-Freund (2013), Kiron et al. (2013), and Taran et al. (2015) to verify the variables in Table 2.

**Table 2:** Business model

Business model	
Variables	Indicators
The value proposition of the company	- The company's value proposition regarding economic, social, and environmental criteria.
Supply chain	- Suppliers actively involved in sustainable supply chain management to develop new products and processes that integrate sustainability.
Customer relationship	- Mechanisms to motivate customers to take responsibility for their consumption. - Customer relationships based on sustainability challenges.
Financial model	- A financial model that reflects an appropriate distribution of economic costs and benefits among stakeholders responsible for the ecological and social impacts of the company.
Degree of innovation of the business models	- Changing the business model through sustainability activities and decisions. - The impact of sustainability investments on the degree of business model innovation.

Source: Boons and Lüdeke-Freund (2013); Kiron et al. (2013) and Taran et al. (2015).

Sustainable development practices enable innovation commitment by revising policies and procedures based on the principles and values they convey (Chege & Wang, 2020). The ambition level of business model innovations should focus on maximizing social and environmental benefits, rather than just economic gain (Bocken et al., 2014). Large, capitalized companies primarily adopt environmentally oriented archetypes, and to a lesser extent, social and organizational ones (Ritala et al., 2018).

Sustainable business models facilitate sustainable transitions by delivering functionality rather than ownership, reducing waste through buyback schemes, and using renewable or recycled materials in products and processes (Hernández-Chea et al., 2021). Hence, archetypes are mechanisms and solutions contributing to business model innovation for sustainability (Bocken et al., 2014).

The sustainable business model will be constantly refined by integrating sustainability (Stubbs & Cocklin, 2008). Companies develop sustainability-oriented innovation practices while challenging fundamental parts of their business models, such as how they sell products and value propositions (Hernández-Chea et al., 2021). Archetypes contribute to building the business model for sustainability (Bocken et al., 2014), and applying such a model infers innovation and adaptation to new aspects of sustainability (Goni et al., 2021). Therefore, the hypotheses of this study are presented:

H1: Adopting sustainability-oriented innovation practices is positively related to sustainable business models.

H2: Adopting sustainability-oriented innovation practices positively influences the innovation degree of sustainable business models.

### Method of the study

A quantitative and descriptive approach was employed to collect data and for analysis. Portuguese industrial companies integrating the Iberian Balance Sheet Analysis System (SABI) database were selected. This database was chosen because it comprises numerous Portuguese industrial companies of various segments and sizes.

Two theoretical dimensions were analyzed for data collection: a) the sustainable business model archetypes identified by Bocken et al. (2014) and Ritala et al. (2018); b) the business models of Boons and Lüdeke-Freund (2013), Kiron et al. (2013), and Taran et al. (2015). A structured questionnaire with a 5-point interval scale (ranging from 1 [strongly disagree] to 5 [strongly agree]) was sent by e-mail to the sample universe using an online platform.

A minimum sample was calculated by analyzing the statistical power of the sample size (80% [0.80] with a significance level of 5% (0.05) and mean effect ( $f^2$ ) of 0.15 for two predictors) using the G\* Power 3.1.9.2 software (Faul et al., 2007). The minimum sample size calculated for the study should be at least 55 cases; about 500 questionnaires were sent, and 55 returned, representing 11% of the surveyed sample. Thus, we assumed that the evidence could not be extrapolated to the research universe; nevertheless, it reached the statistical power needed to analyze the method.

The partial least squares (PLS) technique, a variance-based structural equation modeling (SEM) method, was used to test the hypotheses. The main features of PLS-SEM were decisive in choosing the analysis method, including the ability to handle small samples, the possibility of testing complex models, and the fact that it does not assume the normality of the data (Hair et al., 2014). Moreover, the PLS allows one to simultaneously assess the reliability and validity of the measures of theoretical constructs (measurement model) and estimate the relations between these constructs (structural model). This study used the SmartPLS software for the PLS-SEM analysis (Ringle et al., 2015).

### Presentation and discussion of the results

First, we present the measurement model and SEM structural analysis results and discuss them theoretically.

### Measurement and structural model analysis

The factorial loads of each indicator were observed to analyze the measurement model, followed by an analysis of the composite reliability (CR), average variance extracted (AVE), Cronbach's alpha ( $\alpha$ ) of first-order latent variables (LV), and the LVs of the structural model (related to the hypotheses) (Hair et al., 2014). Table 3 lists the values achieved for the convergent validity and reliability of the measurement model.

**Table 3:** Convergent validity and reliability of the measurement model

First-order latent variables	Indicator	Question	Factorial load
Environmental innovation practices [Env_Inov_Prac] AVE = 0.679 CR = 0.927	ENV1	Practices to improve energy efficiency.	0.888
	ENV2	Practices to improve water efficiency.	0.786
	ENV3	Practices to reduce supply chain emissions.	0.831
	ENV4	Products and services that use fewer resources to reduce waste, emissions, and pollution.	0.812
	ENV5	Processes for reusing materials and products or transforming waste into raw materials for other products/processes.	0.826
	ENV6	Innovation in products and production processes to introduce renewable resources and energies and develop new solutions by imitating natural systems.	0.796
Social innovation practices [Soc_Inov_Prac] AVE = 0.710 CR = 0.880	SOC1	Alternatives for replacing products for services (i.e., product-service system) based on the idea that consumers do not purchase the product, but the utility provided.	0.753
	SOC2	Sustainable practices to ensure stakeholders' well-being (employees, customers, suppliers, and shareholders).	0.892
	SOC3	Actions that encourage sustainable consumption or more sustainable lifestyles by final consumers.	0.876
Economic innovation practices [Eco_Inov_Prac] AVE = 0.668 CR = 0.908	ECO1	Integration with local communities and other stakeholders to create social and environmental benefits.	0.884
	ECO2	Mechanisms for interacting with stakeholders.	0.926
	ECO3	Mechanisms for sharing resources, knowledge, and property (collaborative platforms/sharing/peer-to-peer).	0.741
	ECO4	Mechanisms to maximize sustainability benefits (sustainability incubators and collaboration or crowdsourcing platforms).	0.678
	ECO5	Sustainable solutions that bring benefits to society and the environment.	0.830

First-order latent variables	Indicator	Question	Factorial load
Sustainable business models [Sust_BM] AVE = 0.776 CR = 0.954	SBM1	The company's value proposition is related to economic, social, and environmental criteria.	0.845
	SBM2	Suppliers actively involved in sustainable supply chain management to develop new products and processes that integrate sustainability.	0.909
	SBM3	Mechanisms to motivate customers to take responsibility for their consumption.	0.878
	SBM4	Customer relationships based on sustainability challenges.	0.924
	SBM5	A financial model that reflects an appropriate distribution of economic costs and benefits among stakeholders.	0.857
	SBM6	A financial model is responsible for the ecological and social impacts of the company.	0.869
Degree of innovation of the business model [Deg_Inov_Sust_BM] AVE = 0.798 CR = 0.888	DISBM1	A high degree of change in business model from sustainability activities and decisions.	0.906
	DISBM2	Rate the overall impact of sustainability investments on the degree of innovation of the company's business model: 1 low (incremental) and 5 high (radical)	0.881

Source: Prepared by the authors.

All factor loadings and data reliability (Cronbach's alpha) reached satisfactory levels. In addition, the LVs achieved convergent validity

because their AVE measures were over 0.50 (Fornell & Larcker, 1981). Table 4 shows the discriminant validity of the LVs.

**Table 4:** Discriminant validity of the measurement model

First-order LVs	1	2	3	4	5
1 Env_Inov_Prac	<b>0.824</b>				
2 Soc_Inov_Prac	0.784	<b>0.843</b>			
3 Eco_Inov_Prac	0.748	0.801	<b>0.817</b>		
4 Sust_BM	0.761	0.831	0.737	<b>0.881</b>	
5 Deg_Inov_Sust_BM	0.653	0.759	0.663	0.840	<b>0.893</b>
<b>LV structural model</b>	<b>1</b>	<b>2</b>	<b>3</b>		
1 Inov_Sust_Prac	<b>0.760</b>				
2 Sust_BM	0.737	<b>0.881</b>			
3 Deg_Inov_Sust_BM	0.740	0.840	<b>0.893</b>		

Note 1: The correlation matrix between the LV and the square root of the AVE is in bold.

Note 2: Endogenous LV Sust\_Inov\_Prac was evaluated by repeating indicators from the predictor LVs (Env\_Inov\_Prac, Soc\_Inov\_Prac, and Eco\_Inov\_Prac).

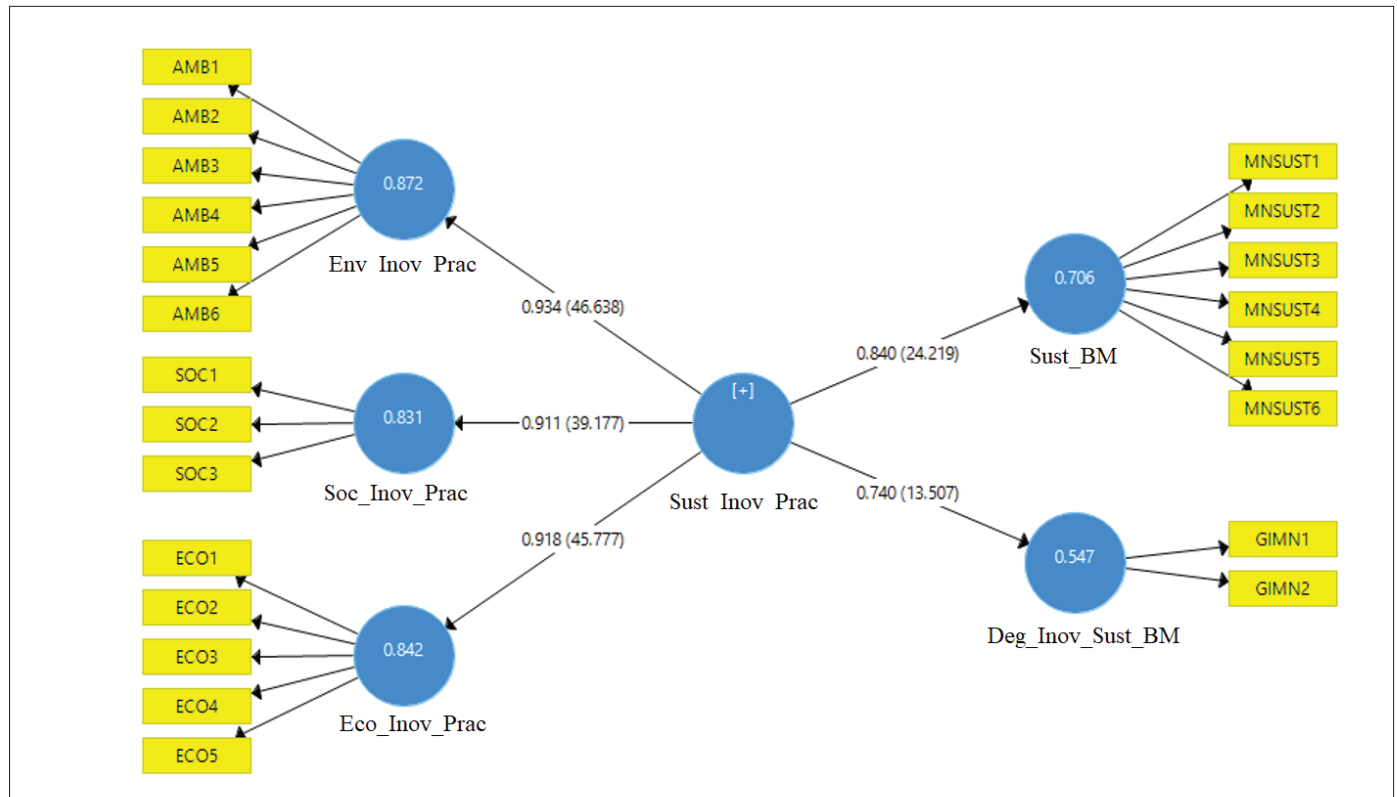
Note 3: All correlations are significant at 1%.

Source: Prepared by the authors.

No correlation was higher than the AVE root value, confirming the discriminant validity of the data (Hair et al., 2014); the bootstrapping (5000 resamplings) and blindfolding (omission distance of 7)

techniques were utilized for structural model analysis and hypothesis testing (Hair et al., 2014).

Figure 1: Structural model analysis (PLS-SEM)



Source: Prepared by the authors.

Predictive relevance and effect size results confirm that the structural model has satisfactory predictive relevance. It obtained  $Q^2$  value  $> 0$  for all LVs and  $f^2$  values with medium and large effects, demonstrating that the model has accuracy and the constructs are essential for the

overall fit. The  $R^2$  values that explain the variance of the endogenous variables by the structural model have a significant effect (Sust\_BM = 0.706; Deg\_Inov\_Sust\_BM = 0.547) (Cohen, 1997). Table 5 presents the results of the hypotheses analyses.

Table 5: Significance of structural relations

Hypotheses	Structural relationships	$\beta$	Standard error	t-Student	Result
H1	Sust_Inov_Prac $\rightarrow$ Sust_BM	0.840	0.034	24.219	Confirmed
H2	Sust_Inov_Prac $\rightarrow$ Deg_Inov_Sust_BM	0.740	0.056	13.507	Confirmed

\* = 1% significance level ( $p < 0.001$ ).

Source: Prepared by the authors.

Hypothesis 1 confirmed that adopting sustainability-oriented innovation practices positively relates to sustainable business models ( $\beta = 0.840$ ;  $p < 0.001$ ). Hypothesis 2 confirmed that adopting sustainability-oriented innovation practices positively influences the innovation degree of sustainable business models ( $\beta = 0.740$ ;  $p < 0.001$ ).

**Discussion**

This section discusses the study’s hypotheses: (H1) Adopting sustainability-oriented innovation practices is positively related to sustainable business models, and (H2) Adopting sustainability-oriented innovation practices positively influences the innovation degree of sustainable business models. Both were confirmed by the statistical model.

Sustainable business models combine innovation and sustainability, and business model innovation is a process of exploration, adjustment, improvement, redesign, revision, creation, development, adoption, and transformation (Geissdoerfer et al., 2018). Hence, it is necessary to integrate economic, social, and environmental objectives for sustainable business model development and keep sustainability essential (Schaltegger et al., 2012; Abdelkafi & Tauscher, 2016).

Regarding the positive relationship between sustainability-oriented innovation practices and the sustainable business model, Ouvrard et al. (2020) surveyed the wine industry and found that sustainable practices shape the business model. Inserting sustainability changes is how companies generate value, understand, and do business

(Pieroni et al., 2019). Since environmental and social issues have gained relevance in company strategies, broad changes for sustainability have been made (Sinthupundaja et al., 2020).

Organizations must incorporate aspects of sustainability into their products and processes to meet stakeholders' needs based on the principles of continuous improvement (Maletič et al., 2014). As operations become more efficient and sustainable, they challenge fundamental parts of the business models (Hernández-Chea et al., 2021). In the economic dimension, innovation practices create social value, such as integrating with local communities and other stakeholders; similarly, collaborative approaches contribute to a sustainable business model (Sinthupundaja et al., 2020).

Cross-sector collaborations extend the environmental and economic dimensions of the circular business model and create economic and social benefits for organizations and individuals outside the collaboration network (Cantele et al., 2020). Management commitment to sustainability and incorporating the Triple Bottom Line into strategic decision-making are influential practices for sustainable supply chain management, emphasizing multi-stakeholder collaboration (Mathivathanan et al., 2018).

Regarding the degree of innovation, according to the objectives and motivations that drive the innovation process, sustainable business models can have different manifestations and environmental, economic, and social outcomes (Sinkovics et al., 2021). According to these authors, other business models of various degrees combine the three dimensions of sustainability. Business models reveal the activities that include ecological, social, and financial changes and collaboration with stakeholders to implement sustainable activities (Hernández-Chea et al., 2021). Social and economic aspects are important elements in the sustainability equation and essential to companies' business models (Thorisdottir & Johannsdottir, 2019).

Business models are critical for companies to define their sustainability goals (Comin et al., 2020). Operationalization challenges companies to act and implement feasible and measurable practices (Comin et al., 2020), and evidence has confirmed that innovation practices in the three dimensions of sustainability (environmental, social, and economic) positively influence sustainable business models through archetypes and their innovation degree (Bocken et al., 2014; Ritala et al., 2018).

Lastly, the engagement of all countries, regardless of differences in economic models, contributes to the replication of sustainable practices and adherence to sustainable industrial policies (Terzi et al., 2023). Implementing business models related to the circular economy is a complex and dynamic process, necessary in international markets (Chabowski et al., 2025). Therefore, transcending the local context is essential; European countries can contribute to Latin America, especially given the demands of international markets and the adoption of the 2030 Agenda, highlighting the role of industry in this process.

## Conclusions

This study analyzed the influence of innovation management on sustainability in the business models of Portuguese industrial companies, making contributions to the adoption of sustainable innovation practices for business models. Our findings confirmed the hypotheses, establishing that (H1) adopting sustainability-oriented innovation practices is positively related to sustainable business models, and (H2) adopting sustainability-oriented innovation practices positively influences the innovation degree of sustainable business models.

Environmental, social, and economic innovations comprise a set of practices that contribute to sustainability by modifying business models. This study confirmed that the archetypes proposed by Bocken et al. (2014) and Ritala et al. (2018) are positively related and influence the sustainable business model. Thus, the influence of the sustainable business model on the degree of innovation highlights the need to improve sustainability-oriented practices, considering the three dimensions.

Future research can analyze specific business sectors that employ sustainability-oriented innovation practices and their relevance in adopting a sustainable business model. Case studies in industries allow in-depth analysis of innovation management for sustainability, and comparisons between emerging and developed countries are also possible. The low response rate (11%) is a limitation of the study, as it may introduce non-response bias, compromise the representativeness of the sample, and limit the generalizability of the results. Nevertheless, the inferences contribute to discussions on the topic of sustainable business models, bringing theoretical and managerial implications, as explained below.

## Theoretical and managerial implications

There is a gap in the literature regarding the implementation of sustainability in business models (Nosratabadi et al., 2019); therefore, this study contributes to the topics of sustainable innovation and business models. It presents managerial implications by examining how innovation management for sustainability impacts the business models of Portuguese industries, and provides a scientific approach by discussing the influence of innovation management for sustainability on these business models. Moreover, the results are helpful for companies to reassess their role in implementing the Sustainable Development Goals.

Furthermore, the findings of this research can inform public policymakers in Europe and Latin America, including the development of new regulatory frameworks ("green" legislation), innovation incentives for micro, small, and medium-sized enterprises, as well as financial and tax support to encourage the adoption of sustainable business models. Therefore, the archetypes for sustainable business models proposed herein can serve as a basis for proposing government incentives for sustainable innovation in the industrial sector.

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