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Implementing sustainable innovation in state universities: Process and tools

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ABSTRACT

Universities have the vision, the knowledge and the power to lead the change towards a more sustainable world. However, there is a lack of studies investigating how universities can systematically reorient themselves to help society become more sustainable. In general, a research gap exists in the implementation of the business model innovation process, in the tools that should be used to pass from the design stage to implementation and in the identification of the main challenges that may hinder this process. This paper adopts the concept of a sustainable business model for interpreting the core logic through which universities create value for themselves, society and the environment. In the first stage of research, a theoretical framework was proposed for diagnosis of the integration of sustainability in the business models of universities. This framework was applied in the context of Italian state universities to identify business models with different degrees of strategic orientation towards sustainability. Now the research aim is to examine the processes and tools used and challenges faced by Italian state universities when implementing sustainable innovation. A multiple-case study is carried out on four Italian state universities showing a high level of integration of sustainability in all elements of the business model. The combination of both quantitative and qualitative data, and the patterns observed across cases, led to the presentation of five theoretical propositions, which were summarized in a preliminary model of the processes, tools and challenges involved when implementing sustainable innovation in higher education. The main theoretical contributions of this study are the advancement of knowledge regarding the dynamics (process) and the elements (tools) for the implementation of sustainability strategies in state universities, and the provision of a new causal map of the relationships among the variables that affect sustainable innovation in higher education.

1. Introduction

The ongoing COVID-19 pandemic is just an example of disruptive events revealing that short-term mindsets and policies, traditional industrial activities, and firm strategies must be reset to cope with major global challenges. In this regard, organizations are reorganizing themselves to contribute to building a more sustainable future and gain legitimacy or a competitive advantage in the marketplace. In essence, this is the content of business model innovation (BMI), a topic that has gained enormous momentum in management research in recent years, dealing with "the design process for giving birth to a fairly new BM [business model] on the market, which is accompanied by an adjustment of the value proposition and/or the value constellation and aims at generating and securing a sustainable competitive advantage" (Wirtz et al., 2016). Recent studies have pointed out that sustainability represents the first and most promising trend in the BMI literature (Foss and Saebi, 2017; Filser et al., 2021), calling for an urgent expansion of research to fill the gap about the intersection between sustainability and innovation.

The process of innovation – in terms of phases, drivers, methods and tools – has been identified as a key aspect to be investigated, as it can determine the outcomes of BMI (Foss and Saebi, 2017; Wirtz et al., 2022; Shakeel et al., 2020; Schneckenberg et al., 2022) and, particularly, sustainability transition (Preghenella and Battistella, 2021; Hernández-Chea et al., 2021). In the meantime, a more empirical and contextualized approach in BMI research has been advocated (Filser et al., 2021; Zhang et al., 2021).

Given the key role that higher education (HE) has in spreading the principles of sustainable development (SD) in society, numerous studies have started investigating how universities can implement sustainability innovations in a systemic and effective way. However, the lack of a holistic framework and empirical studies are key reasons why many sustainability initiatives in universities, as occurs in other settings (Tukker, 2015; Baldassarre et al., 2020), have a high rate of failure. It is

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clear that in HE as well, there is a 'design-implementation gap' in terms of dynamics and tools supporting organizations' ability to embrace sustainability (Geissdoerfer et al., 2018).

This paper attempts to fill this gap by analyzing how Italian state universities integrate sustainability, that is, the process and tools they use to implement sustainable innovations. The main research questions addressed by this study can be summarized as follows: how do state universities in Italy advance sustainability-related practices within their institutions? What organizational resources are assigned to this aim? How do they move towards more sustainable business models in practice? What pathways do Italian state universities follow, and what tools do they use for this purpose? The lens of sustainable BMI provides a comprehensive framework for analysis.

From a methodological point of view, this paper represents the second stage of a research project based on a mixed methods approach. In the first stage, a theoretical framework was proposed for diagnosing the integration of sustainability in the BMs of universities. In particular, the concept of an SBM, describing how firms create value for a broader range of stakeholders by integrating social, environmental and business activities (Schaltegger et al., 2012), was adopted as a holistic framework for interpreting sustainable innovations (Bocken et al., 2014). This was firstly contextualized to HE and then used to explore how Italian state universities incorporate sustainability into different activity areas (Giovanelli et al., 2021). Building on these findings, the focus of this study, which represents the second stage of the project, is on those Italian state universities showing stronger strategic orientation towards sustainability to shed light on the processes, tools and challenges associated with implementing sustainable innovations.

The first contribution of this study is the extension of existing knowledge about the dynamics (process) and the elements (tools) for a holistic implementation of BMI. To date, very few studies have tried to address the 'design-implementation' gap. Second, the study addresses the call for a more empirical and contextual investigation of how organizations should implement sustainable innovations. In fact, most studies are conceptual and do not clarify the context in which sustainable BMI occurs in terms of environmental conditions, industry features and transformation process. To the best of our knowledge, this is the first study to apply the concept of an SBM and investigate how sustainability innovations should be implemented in HE, and particularly in state universities.

Finally, the findings of the study provide a new interpretation of the relationships among variables affecting sustainable innovation. In particular, an original view of the relationships between drivers and outcomes of innovation, in terms of strategies and degree of innovation, is provided.

2. Literature review

2.1. HE and sustainable innovation

The Declaration of the United Nations at the end of the Stockholm Conference in 1972 placed the environment at the forefront of international attention and marked the start of a dialogue on the links between natural resource preservation, social well-being and economic growth. HE has been assigned a special role in building a sustainable future. First, universities have the moral responsibility to lead the change in mindset necessary for achieving the vision of a healthier, more equitable and sustainable world. Second, they have the resources and knowledge to develop ideas and technical solutions to implement this vision (Ramísio et al., 2019). Third, universities are generators and platforms for the economic growth of society (Etzkowitz, 2008). This is why the literature has paid increasing attention to the inclusion of SD in HE. For instance, numerous special issues have been focused on this topic in the Journal of Cleaner Production (Lozano García et al., 2006; Zilahy et al., 2009; Wang et al., 2013; Adomβent et al., 2014; Holm et al., 2016). However, despite the increasing number of initiatives taken by individual universities (Boks and Diehl, 2006), most of them have integrated sustainability by focusing on specific areas of their activities (Velazquez et al., 2006), without embedding it in the system's strategies and activities as a whole (Bautista-Puig and Sanz-Casado, 2021). Parvez and Agrawal (2019) analysed the Indian HE context and showed that the implementation of SD strategies by technical universities was neither comprehensive nor systematic, and this was also due to a lack of monitoring and reporting mechanisms. The role of the sustainability reports in promoting holistic and strategic changes in universities (relating to sustainable development) was also examined by Yáñez et al. (2019). However, there is a lack of studies investigating how universities can systematically reorient themselves to help society become more sustainable (Lozano et al., 2013; Ramísio et al., 2019; Figueiró et al., 2022). A gap also exists between the theoretical and practical research into sustainable innovation in HE, which prevents university management from systematically rethinking their traditional models.

Lozano (2006) first analysed the causes of why SD has not been implemented throughout most universities of the world, then addressed ways to overcome the resistance and barriers. He argued that SD is a radical innovation within universities; therefore, it is necessary to incorporate it incrementally in the face of resistance. Velazquez et al. (2005) identified a set of barriers obstructing the implementation of sustainability initiatives in HE, including, among others, the awareness, interest and involvement of the university community, functional integration of the organizational structure, funding, support from university administrators, time devoted to promoting sustainability, accessible data about sustainability practices, training and communication. Blanco-Portela et al. (2017) reviewed the main drivers for integrating sustainability and the barriers to change to help universities identify good practices and prevent obstacles to becoming more sustainable. Their findings revealed that the largest number of barriers was associated with the academic community, followed by obstacles related to the internal structure and the institutional framework. Aleixo et al. (2018) explored the challenges and barriers faced by Portuguese HE institutions to promote sustainability, finding that the lack of financial resources and falling numbers of students were perceived as the main barriers. Rigid organizational structures and resistance to change by university stakeholders were found to have an impact as well. Velazquez et al. (2006) presented a comprehensive managerial model for developing and implementing sustainability within universities. The strategic management process consists of incremental steps aimed at continually improving environmental, social and economic performance, and is articulated in four phases: developing a sustainability vision, including sustainability into the mission, creating policies, targets and objectives for sustainability and incorporating sustainability in all aspects of the university (sustainability strategies).

Lozano et al. (2013) found that resistance to change was due to a lack of SD awareness, insecurity and a threat to academic credibility from teachers, over-crowded curricula, a lack of support, SD being considered non-relevant to the course or discipline, the uncertainty of the efforts required to incorporate SD, and discipline-restricted organizational structures. They proposed that university leaders and staff should be empowered to implement new paradigms and ensure that SD was the 'Golden Thread' throughout the university system. They also identified a set of elements that should complement the recognised university system, including collaborating with other universities, fostering trans-disciplinarity, making SD an integral part of the institutional framework, creating on-campus life experiences and developing 'Educating-the-Educators' programmes.

Some recent studies have focused on innovations in pedagogic approaches and assessment tools, especially in business schools, for fostering greater sustainability integration. Hoveskog et al. (2018) described the use of a service-learning pedagogic approach and a tool for collaborative visual business modelling for developing Swedish farm-based biogas production, whereas Stough et al. (2018) observed a gap in the research of issues arising from measurement, therefore carried

out a case study to understand the potential of utilizing a supplementary course file during curricular assessments. They found that a complementary course file can be a useful tool for both gaining a more holistic picture of how courses are contributing to HE for SD and sensitizing instructors to conceptualize sustainability more holistically, although some limitations remain. Kapitulčinová et al. (2018) focused on the tools, methods, frameworks or models available for change agents, who are viewed as critical elements in sustainability integration at HE institutions. They introduced an integrated change agentry approach encompassing a change management process and a supporting toolset, which they found, through an international survey, to be suitable for promoting sustainability integration in all dimensions of HE practice. León-Fernández et al. (2018) stressed the importance of involving university community members to enhance environmental management in universities and illustrated the methodology for a participatory process using the case of the Spanish University of Córdoba. In general, engaging stakeholders within and outside the institution is an important mechanism for systemic change in HE, as reported by Dlouhá and Pospíšilová (2018) in regard to networking, viewed as platforms for discussing progress, exchanging experience and formulating joint policies for sustainability implementation.

Leal Filho et al. (2019a) focused on the role played by sustainability offices in an HE context, revealing that setting up such offices is an effective tool for supporting the implementation of sustainability initiatives on campuses and fostering both students' and staff's awareness of matters related to SD. Leal Filho et al. (2019b) then shed light on how the interaction between universities and local communities happens and demonstrated the potential of universities as local players. In particular, Nave and Franco (2019) revealed that the university-firm cooperation relationship is a mechanism to promote and implement a firm's sustainability. Leal Filho et al. (2019c) also identified deficiencies in planning as being one of the main barriers hindering the implementation and attainment of SD objectives in universities, and the lack of funding, support and interest at the administration level as the main issues affecting planning. These issues can be addressed by effective teamwork, collaboration with the outside community and more effective communication. Bien and Sassen (2020) conducted a qualitative analysis of a large German university and argued that the outcomes of sustainability transition (i.e., defining and integrating sustainability) are associated with the ability of academics to create meaning or 'make sense' of the conception of sustainability through discourse strategies. Klein et al. (2022) investigated the influence of lean management practices on sustainability practices in HE institutions and found aspects such as leadership support, systemic view and long-term thinking within the organization to be particularly relevant for success in promoting sustainability practices and thinking.

In general, a strategic approach has rarely been adopted to examine the integration of sustainability into the policies and practices of HE institutions. Vaughter et al. (2013) highlighted a deficit of multi-site studies explaining how universities incorporate sustainability goals into the logic and strategies used to create and capture value and revealed a research gap in the dimensions of governance and community engagement. Ramísio et al. (2019), focusing on the case of the University of Minho, analysed the holistic implementation of sustainability, identifying seven principles to be followed to ensure success, with an emphasis on the importance of a mixed bottom-up and top-down approach as well as collaborative networks to successfully change the organizational culture. Fissi et al. (2021) explored the path towards sustainability in the case of the University of Florence, finding that setting out clear strategies and support from top management are essential for the success of sustainability integration and that there is a lack of systematic coordination between sustainable initiatives. Singh and Segatto (2020) highlighted the importance that partnerships have, as facilitating elements, helping to overcome the challenges associated with the implementation of sustainability in HE institutions, and they proposed a conceptual framework following a relational capabilities perspective. Figueiró et al. (2022) examined the most relevant elements necessary to integrate sustainability into HE institutions and developed a conceptual framework based on four dimensions: contextual, organizational, curricular and pedagogical. Based on a literature review, they found that organizational challenges were the most frequent ones, particularly factors such as resistance to change, lack of interdisciplinarity and departmentalization of universities, and lack of leadership and training. Based on this literature review, it is possible to classify the elements that may facilitate (drivers) or hinder (barriers) the integration of sustainability within HE institutions following the categories that compose a BM.

In this paper, we use the concept of a BM as composed of three elements (Rotondo et al., 2019): the structure, which explains what assets and processes are used to obtain and sell a value proposition, the value proposition, which depicts what a company offers to its customers and the value network involved in the creation of such a proposal, and the market, which includes those customer segments whose needs are addressed by a company's value proposition. Table 1 shows the classification of drivers and barriers in structure, value proposition and market categories.

2.2. SBM and innovation

A BM represents a firm's underlying core logic and strategic choices for creating and capturing value within a value network. It is based on high consistency between internal and external elements that explain how a company operates and gains a competitive advantage (Shafer et al., 2005). In particular, some scholars have defined as 'sustainable' those BMs that are developed by companies seeking to create a competitive advantage by delivering superior customer value while also contributing to the SD of the company and society as a whole (Lüdeke-Freund, 2010).

In the context of HE, a conceptual framework for the diagnosis of the integration of sustainability into the BMs of universities has been

Table 1
A classification of drivers and barriers based on the BM's elements.

STRUCTURE	VALUE PROPOSITION	MARKET
• Functional integration of the organizational structure • Financial resources • Institutional framework (mission, systemic view and long-term thinking) • Awareness, interest and involvement of the university community • Top-management leadership • Interest and support from the administrative level • Resistance to change by university stakeholders • Methods and models available for change agents • Planning and measurement tools • Sustainability offices • Training for educators and staff • Internal information and communication systems	• Interdisciplinarity and transdisciplinarity • Departmentalization of universities (discipline-restricted organizational structures) • Over-crowded curricula • Relevance of SD to the courses or disciplines • Security and academic credibility from teachers • Service-learning pedagogic approach • Instructors' sensitivity to conceptualize sustainability more holistically • Curricular assessment tools • Collaborations with other universities • Networking for discussing, exchanging experience and formulating joint policies for sustainability implementation	• Service approach to students and communities • Students' awareness of matters related to SD • Trend in student enrollment • Engaging stakeholders outside the institution • Accessible data about sustainability practices • Existence of on-campus life experiences • Interaction between universities and local communities • University-firm cooperation relationship • External information and communication systems • Time devoted to promoting sustainability

proposed by Giovanelli et al. (2021). This framework, which is based on the strategic management literature and university sustainability literature, comprises three elements and four question blocks, which explain the core logic of value creation in universities (Fig. 1). In turn, these elements and question blocks include the multiple areas in which sustainability can be implemented in HE: curricula, governance, research community engagement and operations (Vaughter et al., 2013), and assessment and reporting (Lozano, 2006). Giovanelli et al. (2021) then used this framework to identify the degree of strategic orientation towards sustainability in Italian state universities.

In general, an increasing amount of studies, and a number of special issues in the Journal of Cleaner Production (Dentchev et al., 2018; Pociovăliş;teanu et al., 2018; Bocken et al., 2021), have paid attention to the topic of BMI, which is associated with a process of change (from incremental changes to radical changes) in the configuration of the elements of an existing BM to gain or maintain a competitive advantage (Amit and Zott, 2012).

Recently, several reviews of the literature have been conducted to provide new insights into the BMI phenomenon and identify research gaps in BMI research and future directions for organizations, managers and researchers. For instance, Foss and Saebi (2017) observed severe problems with respect to construct clarity and that current research separates into four distinct streams. They also highlighted the need to increase the attention paid to the innovation process since a crucial issue for both theory and practice is the identification of the drivers, facilitators and hindrances of BMI. Antecedents and outcomes of BMI were also at the centre of the meta-analytic review by Zhang et al. (2021). Their findings reveal that antecedents and effects of BMI vary by type of organization and industry. Filser et al. (2021) suggested that there are four main literature streams within the field of BMI, the first one focusing on value creation through BMI, in turn, shared into three sub-streams closely related to the process: organizational learning and experimentation, BM design elements and future directions for academics and practitioners. They pointed out that the first and most significant trend in BMI literature is sustainability and advocate for more research in this field as well as more empirical and context-specific studies. Wirtz et al. (2022) performed a meta-literature analysis deriving 12 key areas that can be grouped into four headings. The third heading, 'BMI configurations and processes', deals with phases, drivers (opportunities), planning and control tools to make innovation effective. In the end, a research agenda was proposed, which included qualitative exploratory research to investigate the process of BM conversion or creation in practice, the identification of phases, the conceptualization of the relationship between internal characteristics of a firm and the external environment, the investigation of the activities and practices that increase BMI success, the empirical observation of the development and use of BMI methods and tools. Andreini et al. (2021) carried out a systematic literature review on the concept of a BMI process, finding that the studies of sustainable BMI prioritise value creation and, in general, a substantial lack of a mixed-methods approach. Schneckenberg et al. (2022) developed an organizing framework to provide orientation for future BMI studies.

An expanding stream of research has focused on the key role of BMI in delivering greater social and environmental sustainability. Schaltegger et al. (2012), for instance, proposed a framework for BMI as a means to strategically create business cases for sustainability on a regular basis. They argued that voluntary social and environmental activities must be systematically developed and managed to address a set of drivers and contribute to corporate success. Furthermore, they identified three strategies for interpreting sustainable innovation: defensive strategies,

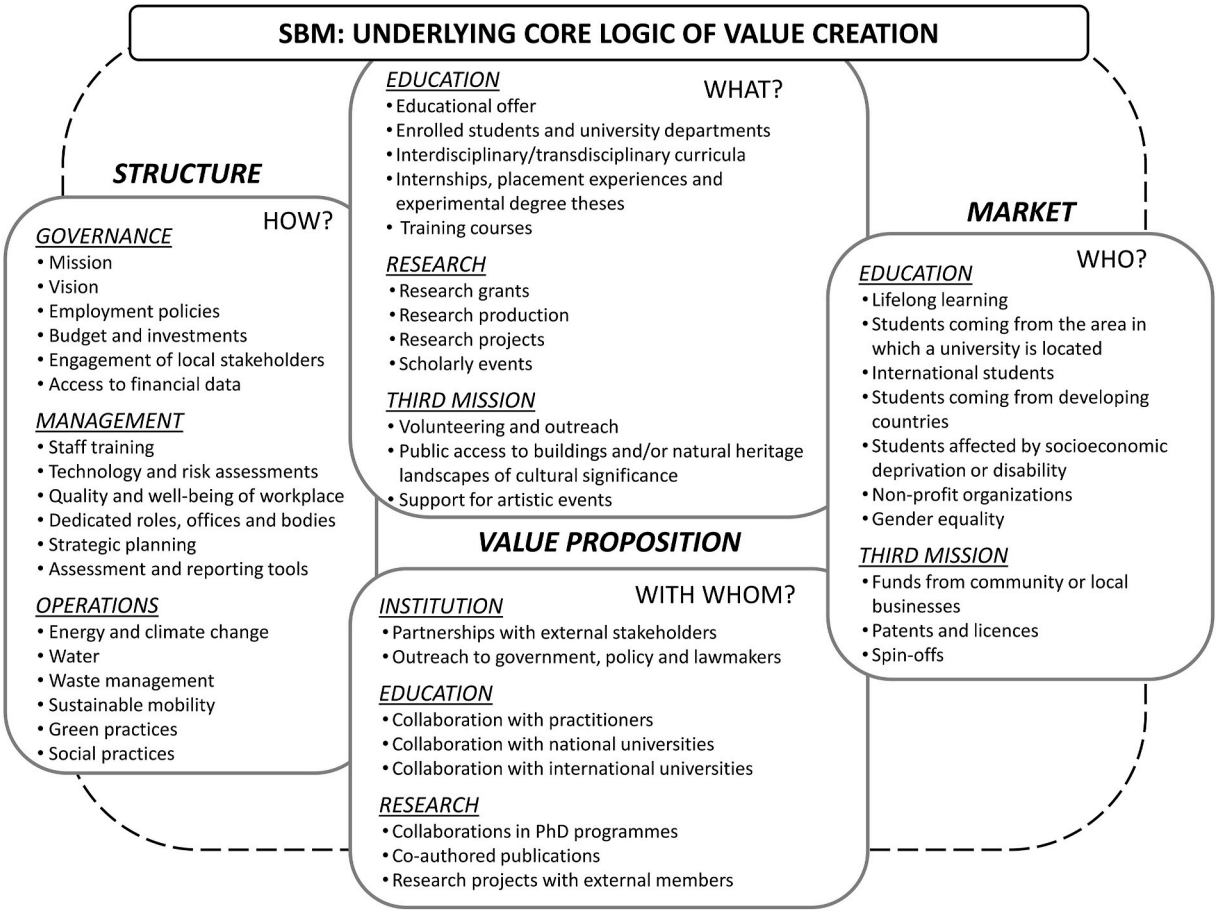

Fig. 1. The integration of sustainability into the BM of universities: a conceptual framework.

which are often a reaction to cost constraints and aim to protect the existing business, accommodative strategies, which imply the cautious modification of internal processes to consider environmental or social objectives, and pro-active strategies, which integrate environmental and social objectives as core business goals and view sustainability performance as a key element in achieving business leadership. Finally, they presented an integrated framework to associate sustainability strategies with different degrees of BMI: BM adjustment, in which few elements change, BM adoption, in which changes are made for matching competitors' strategy, BM improvement, in which a major number of elements are simultaneously changed, and BM redesign, in which the underlying business logic is revised.

Boons and Lü;deke-Freund (2013) proposed a set of basic normative requirements for successful marketing of sustainable innovations and formulated several guiding questions for a future research agenda, including whether firms consider these normative requirements in their innovation practices, whether such innovations are process-, product-, or system-oriented, and whether firms connect the four elements of a BM to their innovation attempts. However, although sustainability innovations can take many forms (such as process, product or managerial), recent literature reviews, such as that by Hermundsdottir and Aspelund (2021), who focused on the relationship between sustainability innovations and competitiveness, have demonstrated that most studies do not differentiate between the different forms. Observing studies mainly using quantitative methods, Hermundsdottir and Aspelund (2021) have also proposed that future research into sustainability innovations should be conducted using more case studies. Others have identified various drivers for the adoption of sustainability innovations, calling for more investigation of how different conditions, such as internal and external factors, affect the outcome of sustainability innovations, usually measured in terms of profitability (García-Sanchez et al., 2019).

Few studies have empirically assessed the effect of different drivers on the propensity to engage in BMI. The same can be said about the effects of BMI, which have mainly been considered in terms of competitive advantage and profitability (Foss and Saebi, 2017). Rantala et al. (2018) observed that the more organizations value economic sustainability and institutional sustainability, the more they are willing to adopt BM innovations. Zhang et al. (2021) addressed the call for an identification of the factors motivating firms' BMI and their consequences by developing an integrative framework regarding the antecedents and the specific impact of BMI on firm performance. Although the literature remained confused about the distinction between internal and external drivers, the authors included among the external factors market opportunity, situational factors, value network and technology innovation, whereas among the internal factors managerial cognition, internal resources and capabilities and organization characteristics. They demonstrated significant positive effects of both the antecedents on financial and operating performance, finding a gap in studies on the effects of BMI on other aspects of organizational performance. Fellnhofer (2017) used Stevenson's multilevel entrepreneurial approach to identify drivers of innovation success in sustainable businesses. She found, in particular, that opportunity-based strategic orientation and opportunity-based growth orientation facilitate sustainable-oriented firms' innovation success, which means that exploiting new opportunities and achieving growth are viewed as a starting point for value creation through innovation. Long et al. (2018), by adopting an organizational change management approach, identified critical success factors for the transition to BMs for sustainability as collaboration, a clear narrative and vision, continual innovation, a sustainable foundation, and serendipitous external events, among which increased competition and the existence of a visible crisis. Barriers hindering this transition included external events, principle-agent issues and a lack of support from wider actors and systems. Van Bommel (2018) examined tensions deriving from BMI for sustainability, for instance, the existence of belonging or identity tensions due to competing demands of personal versus organizational interests, and proposed paradoxical or integrative strategies as possible solutions. Olofsson et al. (2018) examined BMI as an organizational change process as well and reported that the trajectory was characterized by small, incremental changes and the gradual development of management tools. Wirtz et al. (2022) identified 'BMI determinants' as the first heading in the literature. In this regard, they derived the future research needs to understand the role of capabilities as internal drivers considering the firm and market characteristics, and to identify network and stakeholder characteristics that promote or hinder BMI within the firm. Consistently, a recent literature review by Shakeel et al. (2020) aimed at shedding light on the philosophy of sustainable BMI has pointed out that two areas require to be addressed for further development in the theoretical-implementation gap, namely, the interdependence among the BM components during sustainable innovation and the role of the external environment.

Bocken et al. (2014) analysed a wide range of examples of mechanisms and solutions for identifying the patterns and attributes of the sustainable innovation of BMs, whereas Bocken et al. (2015) pointed out that the development of such a BM must be preceded by a systemic approach seeking to integrate the three dimensions of sustainability in a manner that generates shared value creation. López-Nicolás et al. (2021) used the triple-layered canvas as a theoretical framework and studied the case of a small Spanish company in the wine sector. They found that the chronological steps of the firm's journey to sustainability were, first, the economic innovations, then the social innovations and, finally, the ecological innovations. Moreover, they highlighted the importance of a formal, deliberate and planned process based on a clear vision, transformational leadership, proper change management and regular reflection. Yang et al. (2017) suggested focusing on value uncaptured to help firms understand the negative aspects of their BMs. Evans et al. (2017) argued that the lack of theoretical grounding about the successful adoption of SBMs was also reflected by the scarce number of case studies and empirical analyses. Geissdoerfer et al. (2018) carried out a comprehensive review of the literature and found that the main problem that firms face when trying to incorporate sustainability into their business is the 'design-implementation gap'. Therefore, they identified a research gap in the following three areas of SBM innovation: the implementation of the BMI process, the tools that firms must develop to make this process effective, and the challenges faced by innovators. Finally, they set out a central question for future research: understanding how firms move from a BM to an SBM in practice.

Actually, only three studies have been aimed at bridging this critical gap so far. Baldassarre et al. (2020) used a design science research methodology, combining theoretical insights from SBM innovation, business experimentation and strategic design literatures, to develop a tool for setting up small-scale pilots of SBMs. They tested this tool on nine startups and one multinational company. Zapata Riveros et al. (2021) combined two established methods, i.e., BMI and system dynamics, to propose a framework for exploring innovative business models under deep uncertainty, that is, in a context of sociotechnical transition such as the energy sector. Ferlito and Faraci (2022) explained what pathways a firm can take when implementing an SBM innovation process in line with Sustainable Development Goals (SDGs) by conducting a literature review and then proposing a framework.

Based on a literature review comparing the state of the art in sustainability-oriented and circular economy-oriented BMI approaches, Pieroni et al. (2019) observed that although successful cases of BM for sustainability appear in literature and practice, systematized support with methods and tools helping the dissemination of more successful implementations is still lacking. In particular, they organized research approaches according to three stages of BMI, i.e., sensing (understanding opportunities), seizing (translating opportunities in BM concepts) and transforming (building new competences and implementing organizational renewal), and found a lack of studies referring to the third stage, that is, focusing on methods and tools for experimenting, testing, and implementing the BM concepts.

Bocken et al. (2019) presented a framework to enable a systemic

form of sustainable business model experimentation, considering three key issues: construct clarity, boundary setting and uncertainty about outcomes. They also proposed a new approach for stimulating more profound forms of SBM innovation, which includes the identification of stakeholders, the assessment of their needs and potential contributions, and the identification of the interactions that need to be created to support the innovation of BMs towards sustainability. To help innovations succeed by applying network and ecosystem perspectives to traditional BM concepts, Madsen (2020) proposed a conceptual framework through which to understand how critical success factors such as knowledge, creativity and innovation relate to internal as well as external components of BMI. In this regard, some recent studies have focused on the boundary-spanning nature of SBM innovation. For instance, Berkowitz (2018) proposed a meta-organization approach to sustainable innovation governance based on the principle that collective action and learning among organizations are required to encourage and control the development of the organizational capabilities that are necessary for the diffusion of sustainable innovations. Brehmer et al. (2018) took a boundary-spanning perspective on the BM to understand how value is created and transferred between the focal organization and the external network of BM actors. By adopting the same perspective, Oskam et al. (2018) demonstrated that networking facilitates changing the value proposition but may also change the revenue model through a more appropriate distribution of costs and benefits.

Velter et al. (2020) studied multi-stakeholder engagement and alignment in order to identify steps and phases of the process and implications for organizational boundaries. In their analysis of the role of stakeholder interaction in developing and innovating SBMs, Fobbe and Hilletofth (2021), among others, found that although this approach is essential when both a new SBM is developed or an existing BM is innovated towards sustainability, the specific role and potential contribution of stakeholder interaction differs.

Hernández-Chea et al. (2021) examined how firms create BMI for system-level transformation towards sustainability following a deductive approach: a systematic literature review and two illustrative cases were used to propose a conceptual model. Among others, their findings demonstrate the importance of a shared vision and dialogue with firms from other industries to leverage business opportunities for sustainability (strategic level), the creation of networks and collaborations with stakeholders (tactical level), adopting sustainable practices and tools, conducting awareness campaigns and experimenting with partnerships to deliver values based on sustainable practices (operational level).

Preghenella and Battistella (2021) explored BM for sustainability through a literature review that identified six research streams. The fourth stream, namely, the transition process, focuses on key success factors and barriers to the transition. Due to the low number of studies, it represents a potential future research direction. They also found that the literature is mainly related to theory building, while empirical studies are sparse. Furthermore, the analysis of the context – in terms of environmental conditions and transformation process steps – in which SBMs are developed is usually disregarded. A scant investigation is also observed about the organizational capabilities needed to implement an SBM.

Bocken and Short (2021) investigated the dominant unsustainable BM types and potential sustainable BM solutions per key sector, concluding that the success of the business transformation depends on the holistic integration of sustainability principles into the way the business operates and that the focus for SBM innovation should be, to some extent, sector-specific.

Ultimately, as argued by He and Jaime Ortiz (2021), although the innovation of BMs aimed at sustainability has become a hot topic, their development is still affected by a high failure rate due to a lack of reliable and efficient methods. For this purpose, they presented a design framework consisting of portrayal, exploration, prototype, and evaluation, demonstrating the need for the application of design thinking to SBM innovation. In cases of publicly funded organizations, Hall et al. (2018) point out that the 'Eroom effect', which occurs when improved price performance due to technological advances is outweighed by increasing costs of regulatory approval and other commercialization costs, may constitute a drawback of sustainable innovation to be tackled with additional funds.

Sanchez-Carrillo et al. (2021) conducted a systematic review of the literature to identify advances in the implementation of sustainability in HE, setting out five strategies to lessen the problems and enable institutions to embrace sustainability more fully.

In order to address the 'design-implementation gap', we built on the findings of Giovanelli et al. (2021) to examine the process and tools used by Italian state universities to implement sustainability strategies.

In fact, the conceptual framework developed in the first stage of research was used to assess how these universities create shared value through systemic integration of sustainability in the different elements of their BM, while now the aim is to analyse how Italian state universities develop and implement SBMs. In this regard, we used organizational and management perspectives to analyse the SBM innovation process (Long et al., 2018; Olofsson et al., 2018).

In light of the above-mentioned studies, many reasons make Italian state universities a particularly suitable field for this analysis. First, Italian state universities have never benefitted from institutional and economic support or incentives, which are viewed as key drivers for implementing sustainable innovation (Long et al., 2018; Rantala et al., 2018). Second, they lag behind private universities in terms of openness towards the external environment, ability to gain resources from their socio-economic contexts and innovative practices since they have usually been funded on the basis of historical expenditure, whereas competitive mechanisms have only been introduced in recent times (Fadda et al., 2021). Third, whereas funds for the whole Italian HE system are traditionally lower than the average of OECD countries (OECD, 2010), public funds for state universities, which should rely on higher funds than private ones (Hall et al., 2018), have followed an up and down trend since the decrease in 2008. In addition, the number of students, which has represented the main driver of public funds from the introduction of a competitive mechanism with Law No. 240/2010, and one of the criteria used for recruitment, has recently started to fall, determining a potential additional barrier to SD in HE (Aleixo et al., 2018). However, it is worth noting that a gradual development of sustainability incentives has started (Ministerial Decree No. 581/2022). A reward share of about 30% of public funds is currently allocated on the basis of research quality (80%) and a performance contracting mechanism through which the Ministry and each state university agree upon a set of objectives (20%). In the last round of the research quality assessment, results obtained in the 'third mission activities', which explain the impact of each university on society, have been included (although they are about just 0.9% of total funds). As regards the performance contracting mechanism, in the last round of negotiations, the Ministry proposed that state universities also be evaluated on some objectives related to sustainability issues. Considering that each university has to select four objectives from those proposed by the Ministry (not all related to sustainability), sustainability performance weighs on total funds far less than 6%.

3. Methodology

3.1. The first stage

During the first stage of the research, a quantitative analysis was carried out to identify the SBMs adopted by Italian state universities. For this purpose, a conceptual framework for investigating the ways and level to which sustainability had been integrated into the different elements of a university's BM was developed (see Fig. 1). This framework was then tested in the context of the Italian HE system to identify BMs with different degrees of strategic orientation towards sustainability. In particular, a cluster analysis of all 61 Italian state universities was

conducted, using eight indicators to measure the four categories that compose the three elements of a university's SBM (Table 2). For more details, see Giovanelli et al. (2021).

The cluster analysis produced six SBMs, revealing the presence of different approaches to sustainability in the domain of Italian state universities (Table 3).

However, only the so-called 'widespread sustainability model' was close to a true SBM, since it shows a high integration of sustainability in all three elements and four BM categories. This cluster includes four universities: the Polytechnic of Milan (PoliMI), the University for foreigners of Perugia (UnistraPG), the University for foreigners of Siena (UnistraSI), and the University of Trento (UniTN) (Table 4).

3.2. The second stage

In order to extend the findings of the first stage, a qualitative approach is now used to examine the process, tools and challenges in implementing sustainable innovation in Italian state universities. In particular, a multiple-case study is carried out for the four universities using the widespread sustainability model. This method is helpful for understanding a current phenomenon in a specific context and formulating a theory based on this observation (Eisenhardt, 1989).

Case studies were developed based on interviews with key stakeholders (rectors and their delegates) involved in university strategic management and sustainability management. In January 2021, they were invited to be interviewed by email. A semi-structured questionnaire, which was prepared during the period December 2020–January 2021 and posted online in February 2021, was used for the interviews. The questionnaire included three main areas: the process, tools and challenges relevant to the implementation of sustainable innovation. The questionnaire was then supplemented by a telephone call, to allow interviewees to speak freely and elaborate on their responses. All the phone calls were conducted by two researchers, recorded and transcribed.

To triangulate data and build a chain of evidence, a document analysis of universities' official websites, strategic plans and performance reports, mandatory disclosure documents and national datasets was used as an additional source of information.

Questionnaires were collected and phone calls completed during March 2021, and the data were analysed during April 2021. Data analysis was divided into three stages. Open coding, which was performed separately by each investigator through the examination of the questionnaires, recordings and key documents of all cases, was aimed at identifying and comparing concepts and relationships for each case. Axial coding was undertaken by all investigators to re-analyse data relating to each case and to confirm concepts and relationships. The researchers decided to focus on the sub-categories of the processes, tools and challenges shown in Table 5. Finally, a cross-case search for explanations and patterns was conducted by all investigators in collaboration. This led to the definition of causal relationships among variables and, ultimately, a set of research propositions.

Table 2
Indicators of the university SBM framework.

Element	Name	Formula
STRUCTURE		
How?	*Sustainability integration in a university's strategy*	Sustainability in a university's mission + Sustainability objectives in the Strategic Plan/Total objectives
	Sustainability reporting	Presence of specific sustainability reporting tools + Presence of sustainability results in mandatory disclosure
VALUE PROPOSITION		
What?	*Sustainability integration in curricula*	Degree courses on sustainability/ Degree courses
	Sustainability integration in research	Publications on sustainability/ Publications
With Whom?	*Partnerships in education*	Double-degree courses/Total degree courses
	Partnerships in research	PhD courses in partnership with firms/Total PhD courses + PhD courses in partnership with foreign universities/Total PhD courses
MARKET		
Who?	*Students affected by socioeconomic deprivation or disability*	Students with disabilities/Enrolled students + Students in poverty/Enrolled students
	Funds gathered from the community and local businesses	Tuition Fees/Total revenue + External revenue/Total revenue

4. Results

The following subsections present the cases separately, with the main findings articulated in line with the research aims. Table 5 illustrates in a thematic matrix display the issues associated with sustainable BMI innovation in the selected universities.

4.1. The Polytechnic of Milan: increasing the economic value of its technical knowledge

4.1.1. The BM practice

Established in 1863, PoliMI is a scientific-technological university focused on engineering, architecture and design. It is the biggest polytechnic in the country and ranks as the ninth largest Italian state university for students enrolled.

PoliMI integrates sustainability in all elements of its BM. As regards the structure, sustainability orientation informs governance, management and operations. The attention paid to SD is declared in the value statement (PoliMI pursues 'the social, economic and environmental sustainability of its activities'), and a relevant share of strategic objectives set out in the planning documents deals with sustainability (13 out of 71, i.e., 18.31% in 2018). Furthermore, several rector's delegates (10 out 21, i.e., 48%) have been appointed, and a dedicated office has been established to support sustainability.

PoliMI's extensive integration of sustainability is also demonstrated in its value proposition: the educational offer includes 36 out of 66° that incorporate sustainability (54.54%, the highest share amid the Italian state universities), and SD also represents a central topic in research (between 2017 and 2019, its scholars have published 273 articles on sustainability). In addition, PoliMi's scholars are conducting several research projects on sustainability. Regarding the value network, the university has forged several relationships to increase the quality of both education (e.g., double degrees) and research (e.g., international research networks, PhD programmes in collaboration with international universities or firms). Several collaborations have then been developed with non-profit organizations for spreading awareness on SD and increasing stakeholder engagement.

Regarding the market, PoliMi acts as a platform for the socioeconomic development of its area, as demonstrated by the high percentage of funds raised from the community and local businesses, the number of patents and the creation of more than 60 spin-offs.

4.1.2. The process

The current SBM results from an incremental innovation started in 2010, which was motivated by both financial and ethical purposes and gradually led to encompassing a broader concept of sustainability. The

Table 3
Cluster composition.

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
The 'unsustainable model'	*The 'community service model'*	*The 'collaborative model'*	*The 'formal sustainability model'*	*The 'model of the sustainable value proposition'*	*The 'widespread sustainability model'*
(10)	(11)	(9)	(23)	(4)	(4)
Piedmont Orientale	Turin	Milan Bicocca	Basilicata	Tuscia	Siena (Foreigners)
Pavia	Genoa	Teramo	Sassari	Reggio Calabria	Perugia (Foreigners)
Ferrara	Turin Polytechnic	Verona	Calabria	Naples Parthenope	Trento
Salento	Cassino	Perugia	Messina	Venice IUAV	Milan Polytechnic
Palermo	Vanvitelli	Parma	Rome Tre		
Sannio	Bergamo	Modena and R. Emilia	Catania		
Molise	Macerata	Bologna	Trieste		
Catanzaro	Bari Polytechnic	Venice Cà Foscari	Siena		
Naples L'Orientale	Insubria	Camerino	Rome Foro Italico		
Naples Federico II	Urbino		Chieti Pescara		
	Milan		Cagliari		
			Foggia		
			Udine		
			Pisa		
			Padua		
			Brescia		
			Marche		
			Florence		
			Rome La Sapienza		
			Salerno		
			Bari		
			L'Aquila		
			Rome Tor Vergata		

Table 4
The universities using the widespread sustainability model.

	PoliMI	UnistraPG	UnistraSI	UniTN
Enrolled[a]	45,432	1094	2170	16,783
First-time enrolled[a]	7699	147	496	3100
Teaching staff[a]	1430	56	52	669
Administrative staff[a]	1219	141	94	712
Graduates[a]	12,288	262	416	3701
Degree courses[b]	66	7	4	58

[a] Academic year 2019–2020.
[b] Academic year 2018–2019.

transition from environmental sustainability to 360-degree sustainability was fostered by the adhesion to international and national networks. This new awareness had a major impact on the organization, its educational offer and its third mission activities. Two projects were significant for promoting SD within and outside the university: the 'Sustainable Campus' started in 2011 and carried out with the University of Milan to improve the quality of the university district, and the 'ViviPoliMI' started in 2017 to 'increase the quality of life in the neighbourhood that has hosted us for over 100 years'. Furthermore, PoliMI offers courses developed with the Italian Universities Network for SD and the Italian Alliance for Sustainable Development to 'increase the literacy about sustainability and sustainable development of the university community of stakeholders'.

The main motivation for sustainable innovation was improving financial performance: steady increases in research and external funds can be observed from 2014 to 2019 (+24.7%). This result has been achieved by the university by better exploiting its high technological skills and competences better, which led, for instance, to increased numbers of patents. Its specialized research and teaching represented a key driver of change. Finally, the development of a 'sustainable image' was used to improve the university's reputation. In this regard, the engagement of internal and external stakeholders was used as a lever to support sustainable innovation.

4.1.3. The tools

Regarding sustainability management, a different choice has been made for the planning and control phases. Whereas planning mainly relies on the existing mandatory documents, which have been integrated with a set of sustainable objectives and indicators, sustainable performance is reported through ad hoc documents and the institutional website.

Finally, the main barriers to change have been identified, first, in the clash between sustainability innovation and the university mission, which required a long process to rethink the university's role and embrace a system-level perspective; second, in the presence of inadequate management tools and staff who were not sufficiently prepared in managing sustainability, which required investments in advanced information systems and long-term training courses for all levels of the organization.

4.2. The university for foreigners of Perugia: polishing the university's image

4.2.1. The BM practice

UnistraPG is a specialized university whose mission is to 'contribute to the promotion of Italian language and culture worldwide and to knowledge about diversity'. It is the smallest Italian state university in terms of students enrolled, resulting from a decade of decreasing numbers since the death of the UK student Meredith Kercher (students enrolled dropped about 52% over the period 2007–2016).

The university underwent two reforming waves (2010–2014, and 2019 to now) interspersed with an interlocutory one. Its current BM embraces a broad concept of sustainability that integrates social, environmental, and economic aspects and considers sustainability a core business goal rather than a supplementary one as it did before 2010. In terms of the structure, although sustainability does not explicitly appear in the mission statement, it is considered in seven out of 85 strategic objectives (8.24%) in 2018. However, SD is the cornerstone of the Water Resources Research and Documentation Centre (Warredoc), whose mission is 'strictly integrated into the UnistraPG's strategy' and influences teaching, research, and the third mission other than operations.

Table 5
Sustainable BMI: the process, tools and challenges.

	POLIMI	UNISTRAPG	UNISTRASI	UNITN
THE PROCESS				
Start date	2010 (from environmental sustainability to 360-degree sustainability)	2010, two phases (structure; value proposition)	2008, three phases (internal environment; sociality; 360-degree sustainability)	2015, two phases (environment; 360-degree sustainability)
Type	Incremental through gradual improvements	Glitchy incremental	Incremental through gradual improvements	Incremental through gradual improvements
Core competences	High technological skills and competences	International orientation and sociocultural capabilities	International orientation and sociocultural capabilities	Community-university relationship
Partnerships	National and international universities and networks	National government, non-profit organizations, local government	Local government, students, national universities	National and international universities and students
Drivers	Specialized research and teaching; support from external environment; interest and involvement of the university community	Competitive pressure; government incentives; sustainability champions	Small size; interest and involvement of the university community; support from external environment	Interdisciplinarity; support from external environment; reputation
Aims	Financial and ethical	Competitive	Competitive	Ethical
THE TOOLS				
Financial resources	Constant and conspicuous investments	No dedicated budget	Medium (growing)	Growing investments
Governance structure	Chief sustainability officer, several delegates and dedicated office	Chief sustainability officer but no specific delegates or a dedicated office	Chief sustainability officer, several delegates but not a dedicated office	Chief sustainability officer, several delegates and dedicated office
Advanced management systems	Information systems, performance measurement systems, staff training	Disclosure of sustainability performance	Informative systems, performance management systems, staff training	Performance measurement systems
Relationship between sustainability and mandatory planning and control	Integrated planning and separated reporting	Sustainability integrated into the mandatory documents	Sustainability was first only integrated into the mandatory documents, then the additional documents	Separated planning and integrated reporting
Website	Dedicated space	Dedicated space	No dedicated space	Dedicated space
THE CHALLENGES	Organizational issues: Renewing the mission; Advanced management system development; Top-management leadership	Organizational issues: Resistance to change from the administrative staff; Top-management leadership; Unclear definition of sustainability	Organizational issues: Lack of personnel; Red tape; Implementation of sustainable initiatives	Organizational issues: Lack of personnel

The research centre is focused on water treatment but also contributes to 'supporting cultural diversity, gender equality and […] developing countries'. UnistraPG's value proposition is strongly oriented towards sustainability, as highlighted by several research projects on SD and an educational offer that includes three degrees out of seven (42.86%) and many training activities on this topic (e.g., advanced training for cultural mediators).

Furthermore, in line with its specialized mission and international orientation, UnistraPG has developed relationships with international universities to support teaching activities and has joined global cooperation networks to attract international students (e.g., the Marco Polo programme for Chinese students). From a market perspective, UnistraPG shows a low ability to attract students affected by socioeconomic deprivation or disability, but this can be explained by the highly specialized teaching activities. However, the university shows a high ability to collect resources from external stakeholders.

4.2.2. The process

The strategic innovation towards sustainability was motivated by two reasons that determined a competitive issue: the decline in enrolments following the university's damaged reputation caused by 'the murder of Meredith', and the competitive pressure from southern universities. Therefore, using the leadership of some champions of sustainability (which included the rector), the strong interdisciplinarity within the institution and the incentives from national and local governments as its main drivers, a general rethink of the educational offer, research, services to students and third mission was carried out. Sustainable innovation has been fragmented more than systemic and mainly aimed to adjust one or few BM elements from time to time.

Whereas the first phase of reform has mainly addressed structural issues (e.g, the university's mission and statute) and the renewal of teaching staff, the second phase has mainly involved the value proposition. In particular, the educational offer has been renewed to become more attractive for students. However, the process has suffered many slowdowns and gaps, as in the current situation due to the resignations of those in the highest positions of the university.

4.2.3. The tools

It is worth noting that a clear definition of sustainability has never been provided. Fragmentation of sustainable innovation has been worsened by the delay in developing specific tools to coordinate and manage the different initiatives. For instance, a delegate for sustainability has not been appointed and a specific office for sustainability has not been created. Furthermore, sustainability initiatives have never been provided with a specific budget. At the moment, sustainability goals and results are planned and reported within the mandatory documents. However, great attention is paid to the disclosure of sustainability performance.

The sustainable innovation process has been challenged by several internal constraints, such as a low interest and resistance to change from the administrative staff and the difficulty in making them aware of the importance of sustainability for the university's future. These problems have been enhanced by the lack of management skills and capabilities among academics, mainly those involved in university governance bodies. These barriers have been tackled by developing several training courses dedicated to administrative staff while the renewal of the governance bodies is seen as the best way to overcome them.

4.3. The university for foreigners of Siena: outperforming competitors in a niche market

4.3.1. The BM practice

UnistraSI is a specialized institution established in 1921 to promote the Italian language and culture through teaching and research. It has

the lowest number of academics and administrative staff amid the Italian state universities, while the number of students enrolled has increased by 263% from 2007 to 2019.

UnistraSI shows a gradual integration of sustainability into the 'structure' category of the BM. Although sustainability is not integrated into the mission statement, two sustainability objectives out of 10 have been added in the strategic plan for 2019–2021 (none before). In addition, sustainability integration has been supported by the appointment of six delegates on sustainability topics out of 21 (28.58%), even though a dedicated office does not exist. Furthermore, staff have been supported through dedicated training initiatives to promote 'the responsible use of resources'. SD has also been implemented through different actions to pursue energy and water saving and green practices. Sustainability is strongly incorporated in the educational offer: two out of four degree courses integrate sustainability and are carried out in cooperation with international universities. On the contrary, research seems to be less oriented to sustainability: in 2017–2019, its scholars did not publish any papers related to sustainability, and nor does the only PhD course involve external partners. However, UnistraSI has developed a broad set of institutional relationships at the national (e.g., Tuscany University Network) and international level (e.g., the Chinese government) to attract students. Similar to UnistraPG, UnistraSI shows a limited ability to attract students affected by socioeconomic deprivation or disability, and this is due to the focus on a niche market.

4.3.2. The process

UnistraSI's BM is the result of a long-lasting sustainable innovation process started in 2008 and articulated in three main phases. The strategy change, mainly driven by ethical and competitive purposes, took place in an organizational environment where SD was *de facto* ignored. The opportunity to conquer a higher position in a niche market due to the difficulties of the main competitor represented a strong motivation. The first phase was characterized by an internal orientation: a new headquarters with the highest standard of sustainability was inaugurated, and this positively influenced the organizational climate towards SD. Paying more attention to the external side was the aim of the second phase (begun in 2011), during which UnistraSI reinforced its socially responsible approach by supporting external stakeholders on specific topics (e.g., migration policies and management). During the third phase (started in 2015 and currently ongoing), a broader concept of sustainability was implemented. This more conscious approach was evidenced by the appointment of the rector's delegate responsible for sustainability policies, reinforcement of the institutional network (e.g., by joining the Italian Universities Network for SD) and promotion of green practices among internal stakeholders.

The sustainable innovation benefitted from the university's small size, the increasing effort provided by all the internal stakeholders, and the positive influence exerted by an external environment traditionally oriented towards sustainability. The most relevant effort has been devoted to developing and reinforcing relationships with students, who are at the centre of the sustainable strategy: they are both key actors in implementing sustainability initiatives and the primary beneficiaries of UnistraSI's sustainable value proposition.

4.3.3. The tools

The sustainable innovation followed an incremental path during which one or a few BM elements were modified a little at a time. Sustainability integration first resulted in focused actions taken on internal and external aspects of the business, and then in the introduction of managerial practices and tools and the investment of a growing share of resources to foster SD culture and practices. In the first phase, sustainability was integrated into the existing planning and reporting documents; then sustainability management was improved by developing informative systems, dedicated tools and documents for collecting, assessing and reporting sustainability performance.

Several challenges have hindered the path to integrating sustainability into UnistraSI's BM. First, the university could not rely on enough staff to manage sustainability initiatives properly. This barrier was increased by the bureaucratic burden that slowed the innovation process and reduced the ability to turn sustainable strategies into operations. Promoting awareness of sustainability importance among teaching and administrative staff through a set of symbolic initiatives (e.g., installing water fountains to reduce the use of bottled water) and increased resources dedicated to sustainability were used to tackle these challenges.

4.4. The University of Trento: increasing the university's role in society

4.4.1. The BM practice

UniTN is a medium-sized university founded in 1962 as a private institution that became a state university in 1982. It is located in the Autonomous Province of Trento. The close relationship with the local government makes UniTN a *unicum* within the Italian HE system (UniTN has been financed only by the province since 2009).

UniTn's BM demonstrates the effort to integrate sustainability into the university's strategies and operations at all levels and areas of the organization. The structure is characterized by a strong integration of sustainability into the university mission and the planning and control system, as evidenced by the inclusion of nine sustainability objectives out of 60 (15%) into the mandatory planning documents in 2018. UniTN has adopted a conscious approach to sustainability, revealed by the strategic project 'UniTrento Sostenibile' intended 'to collect and put in place sustainability actions' involving 'many University sectors and activities: energy sources, water, mobility, greenhouse gas emissions, waste management'. The full integration of sustainability emerges in the strategic plan for 2017–2021, in which five of the 11 strategic lines deal with sustainability issues, and one of them explicitly aims at sustainable change.

Additional plans focused on single sustainability topics have been adopted, such as the 'Environmental sustainability plan' shared by UniTn and local stakeholders 'to become an example of a virtuous, innovative, responsible and sustainable community'. Sustainability is also integrated into *what* is offered to the customers. UniTN provides 18° courses out of 58 (31%) that integrate sustainability issues, and it puts relevant effort into sustainability research (8% of papers and several research projects in the period 2017–2019). In addition, UniTN ranks first among state universities for the percentage of double degrees offered (34 out of 58, i.e., 58.62%). This is due to a strategic commitment to internationalization, which is confirmed by its joining of eight international networks to cooperate in education, research and relations with industry. Regarding the market, UniTN shows a low ability to attract students living in poverty, but this can be partially explained by the prosperous environment in which the university operates compared to other Italian regions (per capita income is about 9000 euro higher than the Italian average in 2019). Otherwise, UniTN shows a relevant ability to collect additional financial resources through scientific and technological transfer.

4.4.2. The process

UniTN's sustainable innovation started in 2015 when ethical purposes and a set of favourable circumstances convinced the university management to replace the formal approach to sustainability with a more conscious approach to make it the pillar of the university strategy. In the first phase, UniTN has focused on the environmental side of sustainability. In contrast, in the second phase, a more comprehensive concept of sustainability has been adopted, and sustainability has gradually become a core business goal of the university strategy. Sustainability has been used to differentiate the value proposition in the eyes of students and the community to increase the university's attractiveness. In particular, the quality of teaching and research has been improved by strengthening the relationships with national and international universities (more than 450 universities worldwide). Students

and other universities are the key partners in building a more sustainable university and, consequently, a more sustainable society. The main driver of innovation has been the strong interdisciplinarity among the structures, degree courses and research fields. From a broader perspective, the social capital built with the community has acted as a facilitating driver towards sustainable transition. In this regard, UniTN benefitted from the positive historical attitude of the external environment, that is, a local government and a population well aware of the crucial importance of SD.

4.4.3. The tools

Sustainable innovation had an extensive impact on UniTN's organization and governance. In 2015, a rector's delegate for sustainability was appointed for the first time, and now eight delegates out of 33 (24.24%) oversee specific sustainability issues. Furthermore, a dedicated body has been established and funded with an increasing budget. A strong effort has also been made to develop advanced managerial tools and, in particular, performance measurement systems. However, specific training activities to support staff have not been implemented to date. The lack of sufficient staff is seen as the most significant challenge in implementing sustainability. Therefore, the integration of new personnel and reinforcement of existing ones in the following years represent the key to achieving a higher sustainability integration level.

5. Discussion

The research questions behind this study were answered within the context of a cross-case analysis, which allowed us to draw inferences regarding the process and tools used and the challenges faced by Italian state universities when implementing sustainable innovation. These inferences were then used to set out five theoretical propositions, presented below and summarized in the model shown in Fig. 2.

The findings reveal that universities with BMs strongly oriented towards sustainability in their innovation attempts connect the elements of the BM differently, depending on the core competences, the drivers and the aims of the sustainable transition and the strategies and tools used to implement it. The findings confirm that, in Italian state universities, successful sustainable innovations follow incremental steps to improve environmental, social and economic performance (Velazquez et al., 2006). In a context of a lack of institutional and financial incentives (Rantala et al., 2018), several phases are necessary to gradually empower stakeholders to reduce resistance to change and, in the meantime, develop tools and practices needed to manage sustainability and institutionalize it as a daily routine (Lozano, 2006; Olofsson et al., 2018).

The first step is mainly focused on addressing environmental sustainability issues (PoliMI, UniTN and UnistraSI), and strengthening the BM's structure in terms of mission and governance (UnistraPG), strategies (UniTN), internal environment (UnistraSI) and personnel skills (PoliMI). The next step is devoted to enhancing the value proposition's attractiveness and paying more attention to social issues to deliver better services to both students (UnistraPG) and society (PoliMI, UniTN and UnistraSI). The order through which the three aspects of sustainability were integrated differs from that observed by López-Nicolás et al. (2021) in the wine sector but is in line with the chronological steps found by Sanchez-Carrillo et al. (2021) in the HE context. This suggests that organizations, in their sustainability journey, tend to primarily reinforce the aspects of sustainability that are less considered in their usual routines.

Each university carries out sustainable innovation using its core competences. For PoliMI, these include advanced technological knowledge and skills, for UniTN a privileged relationship with the community, and for UnistraPG and UnistraSI a strong international orientation and sociocultural capabilities. This does not mean that resources represent a starting point for sustainable innovation, which would reveal an 'administrative focus' (Fellnhofer, 2017). On the contrary, opportunity-based strategic orientation is assumed to promote sustainable-oriented firms' innovation, but effective implementation and its outcomes are facilitated by opportunities overlapping with existing resources.

Furthermore, in line with their own peculiarities, universities strengthen relationships with the stakeholders who can help them

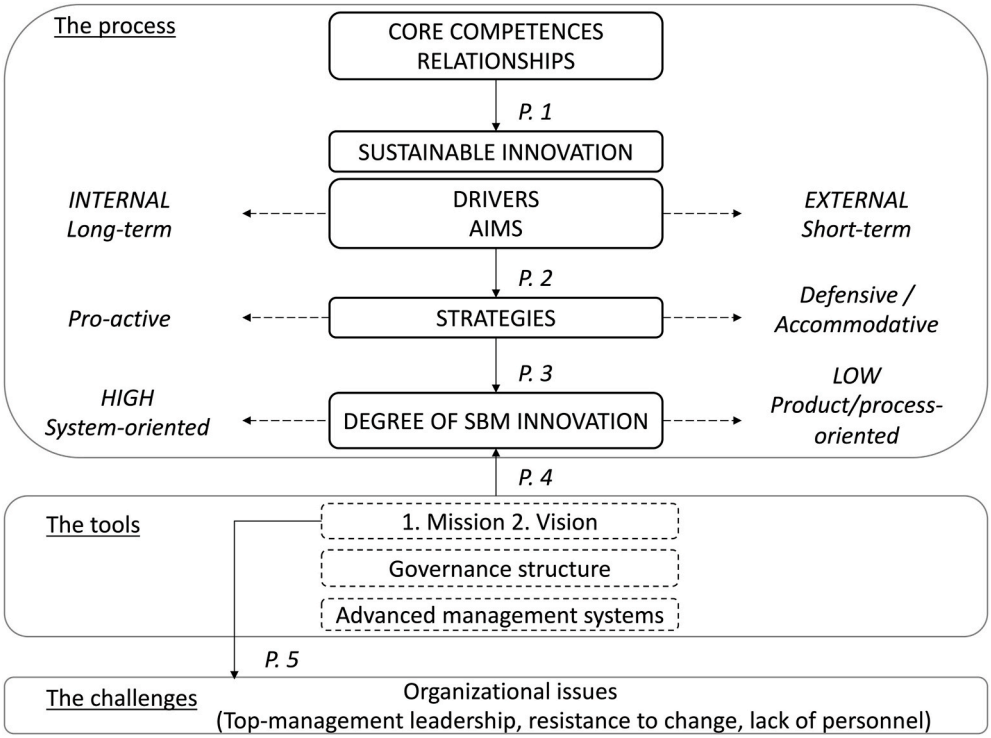

Fig. 2. A model of the processes, tools and challenges involved in implementing sustainable innovation in HE.

exploit their core competences for sustainability purposes, as pointed out by Ramísio et al. (2019). This confirms that boundary-spanning is crucial to complement resources and capabilities (Berkowitz, 2018), exchanging experience and formulating joint policies for sustainability implementation (Brehmer et al., 2018; Dlouhá and Pospíšilová, 2018), enabling firms to operationalize BMI (Schneckenberg et al., 2022). In the case of Italian state universities, networking serves not just the purpose of facilitating a change in the value proposition, as observed by Oskam et al. (2018) (e.g., PoliMI and UniTN fostered relationships with national and international networks to improve the quality of education ad research), but also for enhancing attractiveness (e.g., UnistraSI fostered relationships with foreign governments and local networks and UnistraPG with global cooperation networks to attract international students). In general, this finding is in line with those studies asserting that promoting partnerships with stakeholders, both local communities (Leal Filho et al., 2019b) and firms (Nave and Franco, 2019), can support the innovation of the BM towards sustainability (Bocken et al., 2019; Singh and Segatto, 2020; Velter et al., 2020) and, in particular, provides more evidence of the role of stakeholder interaction when organizations try to innovate an existing BM towards sustainability. In this case, in fact, assessment, alignment and creation of new partnerships are basically used to enable and strengthen the innovation process (Fobbe and Hilletofth, 2021). It is worth noting that in their investigation of how Spanish universities integrate sustainability into their institutions, Bautista-Puig and Sanz-Casado (2021) have already revealed a correlation between sustainability practices such as the presence of sustainability plans, working collaboratively in networks and having green offices.

Proposition 1. *Sustainable innovation in Italian state universities is an incremental process based on core competences and increased relationships with key stakeholders.*

The drivers triggering sustainable innovation and, consequently, the aims of the change vary among state universities, leading to different outcomes. In fact, in line with Zhang et al. (2021), drivers may be internal', which can be defined as those related to a university's organization and peculiarities, or 'external', when competitive pressure and external incentives or support prompt universities to innovate their BMs. Similarly, the main aim of change may be 'internal' or 'external' depending on whether the main motivation is either better exploiting core competences or outperforming competitors. In this regard, the drivers and aims of sustainable innovation in PoliMI and UniTN can be viewed as internal, and associated with economic benefits and growth (Long et al., 2018).

In fact, specialized research and teaching and university community engagement drove the sustainable transition in PoliMI, which was aimed at increasing the economic value of its technical knowledge. The high technological knowledge not fully exploited by PoliMI also confirms the role of 'value uncaptured' as a trigger of BM sustainable innovation (Yang et al., 2017). UniTN built on its strong interdisciplinarity, reputation and support from the external environment to further increase its central role in society. Conversely, the drivers and aims of sustainable innovation in UnistraPG and UnistraSI were basically external: the first used sustainability to tackle the tremendous damage to its image that had led to a major drop in student enrolments, while the second one exploited the strategic opportunity of gaining a competitive advantage over the main competitor within its niche market. This is in line with the studies asserting the crucial influence the existence of a visible crisis and increased competition have on the transition to BMs for sustainability and also on how sustainability is implemented in an organization (Long et al., 2018). For Italian state universities, a drop in student enrollment has a direct impact on financial resources (an increasing part of the basic share of total funds is related to the number of regular students), leading them to find new ways to attract students and grasp market shares from competitors.

Sustainable innovation stemming from internal factors and aiming to enhance a university's core competences reveals a more conscious and long-term approach to sustainability. In this case, universities are likely to develop pro-active strategies that, as argued by Schaltegger et al. (2012), consist of a number of concomitant and voluntary initiatives through which environmental and social objectives are integrated as core business goals (PoliMI and UniTN). When drivers and aims are external, a contingent and short-term orientation characterizes sustainable innovation, which results, at most, in defensive strategies aimed to protect the existing business (UnistraPG), or accommodative strategies, which imply a cautious modification of internal processes so as to consider environmental or social objectives (UnistraSI).

Proposition 2. *Sustainable innovation in Italian state universities leads to different outcomes depending on the main drivers and aims of change: 'internal' drivers and aims are conducive to developing pro-active strategies, while 'external' drivers and aims are conducive to developing defensive or, at most, accommodative strategies.*

The findings broaden the understanding of factors motivating firms' BMI and consequent performance (Zhang et al., 2021), offering a new causal map of the relationships among the elements that affect sustainable innovation. Adopting an organizational and management perspective (Long et al., 2018; Olofsson et al., 2018), drivers are associated with a new kind of outcomes (Foss and Saebi, 2017; Wirtz et al., 2022), that is, sustainability strategies and the degree of BM innovation (Schaltegger et al., 2012). In this regard, the degree of innovation is seen as a key characteristic and result of the innovation process (Boons and Lüdeke-Freund, 2013) since it attests to what extent sustainability is holistically implemented into a university strategy, while previous research has investigated how and what internal or external conditions affect firm profitability and competitiveness (García-Sanchez et al., 2019; Hermundsdottir and Aspelund, 2021). From the analysis, it emerges that the state universities adopting pro-active strategies are likely to revise the logic of their business around the concept of sustainability, which leads to a high degree of innovation of their BM. For instance, UniTN, using its solid technological foundation, has gradually redesigned its BM by developing a completely new value proposition. PoliMI has simultaneously changed a major number of elements, starting from its governance structure and focusing on institutional and community relationships, making its path an example of 'BM improvement'. The degree of BMI was low for state universities adopting defensive or accommodative strategies, but while UnistraPG focused on the value proposition and services to students in order to recover competitive positions, therefore representing a case of 'BM adoption', UnistraSI can be viewed as an example of 'BM adjustment', which involved few elements. With regard to the drivers for the adoption of sustainability innovations, this finding supports the argument presented by García-Sanchez et al. (2019), who see innovation oriented towards sustainability of the value proposition as a way of exploiting opportunities associated with a growing number of customers, which may result in product differentiation, an increased customer base and improved brand positioning. However, this may reveal a short-term focus which, as argued by Hermundsdottir and Aspelund (2021), contrasts with the necessary patience and risk associated with sustainability. Ultimately, it can be argued that pro-active strategies are conducive to system-oriented innovation, whereas defensive and accommodative strategies are conducive to process- or product-oriented innovation (Boons and Lüdeke-Freund, 2013).

Proposition 3. *In Italian state universities, pro-active strategies are associated with a high degree of BMI, while defensive and accommodative strategies are associated with a low degree of BMI.*

Due to the recent introduction of financial incentives related to sustainability performance for Italian state universities, although in a low percentage of total funds, a general delay in the use of management tools for sustainable innovation has characterized the Italian HE system. In this regard, the cases under investigation stand out for anticipating

the times by developing tools for planning, monitoring and reporting sustainable performance. However, each of them did it following different motivations and approaches. Tools for SBM innovation can be analysed together with the phases required to implement it to shed light on the transformation process and the organizational capabilities needed to implement an SBM (Preghenella and Battistella, 2021). In line with Velazquez et al. (2006), it seems that a systemic move towards sustainability begins when someone within the university envisions the possibility that sustainability plays a key role in the university's future, as was the case for PoliMI and UniTN. The clear definition of a vision promotes 'sustainable business thinking' across the university community, which is the antecedent of system-level innovation for sustainability (Bocken et al., 2015). In general, this is in line with Madsen (2020), who argued that a clear and common vision and leadership are the two main conditions for BMI, and who demonstrated, through a case study, that this vision provides the foundation and direction for working on a new company strategy, incorporating knowledge, creativity and innovation to achieve SD. Hernández-Chea et al. (2021) claim that, at the strategic level, the development of a viable vision and purpose is the starting point for adopting an SBM, whereas, at an operational level, firms have to establish their sustainable vision by implementing sustainable-related practices to create value together. With regard to HE institutions, Klein et al. (2022) also demonstrated that leadership and a systemic vision are relevant elements of promotion of sustainability practices and thinking. As a consequence, increasing resources are invested in spreading the SD philosophy within the organization and creating the structural conditions to make this vision real. Therefore, in the next phase, the first action is restructuring university governance to give responsibility to dedicated figures and bodies. Other than a chief sustainability officer, both PoliMI and UniTN have specific delegates and an office for managing sustainability. In general, this confirms that these structures may assist efforts within universities to work in the field of SD (Leal Filho et al., 2019a). The second action is developing management systems and tools to facilitate the implementation of sustainability initiatives, including additional information systems and performance measurement systems. The last phase is devoted to implementing pro-active strategies in the different areas of the organization. In contrast, the sustainable innovation of UnistraPG and UnistraSI is carried out through uncorrelated actions to accomplish a short-term competitive goal. A global vision to guide behaviours is not defined, nor are significant resources invested in restructuring university governance. In the first phase, these universities focus on the appointment of a chief sustainability officer and the development of management tools to plan and control single initiatives, mainly involving improvements or adjustments in processes and products. This confirms that planning (Leal Filho et al., 2019c) and reporting (Ramísio et al., 2019; Parvez and Agrawal, 2019) are important for the implementation of SD in HE, and suggests that the achievement of SD outcomes is possible when the starting point is a vision of how things might be changed for the better, bringing stakeholders together, extending knowledge about sustainability across the organization and serving to build commitment from the beginning of the journey (López-Nicolás et al., 2021). The case of UnistraPG also reveals that when the definition of sustainability is neither clear nor widespread across the university community, the role of key individuals, such as the rector (Fissi et al., 2021) or some sustainability champions (Lozano, 2006), becomes prominent in driving the transition towards sustainability. In general, we argue that, in Italian state universities, the improvement in governance structures and management tools is a starting point for higher involvement of the university community, which can be fostered, for instance, through the implementation of dedicated training programmes, as in the cases of PoliMI and UnistraSI.

These findings confirm the role of 'design thinking' in promoting SBM innovation, since most of its key elements, such as a human-centred approach, a gradual and iterative process and multidisciplinarity, also appear to be relevant in the HE setting. However, they extend the design framework proposed by He and Jaime Ortiz (2021) as they also suggest inclusion of drivers and outcomes of change when considering the phases of the process. In fact, when drivers are internal, customer understanding (portrayal) and value proposition innovation (exploration) are preceded by structural interventions on mission, governance and personnel, which are conducive to system-level innovation, while external drivers are usually associated with value proposition transformation leading to product-oriented innovation.

Proposition 4. *In Italian state universities, the development of a vision and the investment in the governance structure and advanced management systems are conducive to system-oriented innovation, while the development of advanced management systems only is associated with process- or product-oriented innovation.*

The main challenges Italian state universities face during sustainable innovation, as observed in the literature (Lozano, 2006), are basically internal and related to organizational issues, such as the lack of leadership, resistance to change, red tape, the difficulty of implementing sustainability strategy and the lack of personnel. This is in line with the findings of Blanco-Portela et al. (2017), who revealed that in addition to stakeholder involvement, the internal structure and the institutional framework were relevant barriers to sustainability integration in universities, and the findings of Sanchez-Carrillo et al. (2021), who pointed out that the internal structures of universities are a significant obstacle to implementing sustainable practices. Similarly, Figueiró et al. (2022) found that organizational challenges, particularly a lack of interdisciplinarity, education and support, are the most relevant ones for sustainability integration in HE institutions. These findings can also be interpreted in light of the barriers affecting Portuguese HE institutions, i.e., lack of financial resources, falling numbers of students and resistance to change, as reported by Aleixo et al. (2018). In Italian State universities, the lack of personnel is strictly connected with the cut of public funds that has been enforced for more than a decade. Since then, the possibility of recruiting new personnel is also associated with the number and level of student tuition fees. This raises serious concerns for the future since enrolment rates are decreasing.

However, the number and incidence of these barriers decrease when sustainability is already integrated into the mission of a university, laying a foundation for the future actions and philosophies that underlie those actions, as is the case with UniTN and was the case with the University of Minho (Ramísio et al., 2019). In fact, in contrast to the order proposed by Velazquez et al. (2006), when the mission already incorporates sustainability, it is easier to build a vision, to communicate it to the academic community and finally to turn it into daily routines. This finding can be interpreted in the light of the sensemaking perspective used by Bien and Sassen (2020) to analyse the sustainability transition of universities. In fact, when sustainability is rooted in the organization, the change process can rely on a mutual understanding of the concept, which means that no, or at least fewer, discourse strategies are required to remove the cultural barriers that may prevent an organization from embracing a shared vision. If sustainability is already a core business goal, personal and organizational interests around sustainability are aligned, reducing the identity tensions that usually arise from the BMI for sustainability (van Bommel, 2018).

It is no coincidence that UniTN reports, as the only serious challenge, the lack of a sufficient number of staff but no problems with behaviours, skills or practice in dealing with sustainability. Rather, PoliMI, which still developed pro-active strategies leading to system-oriented innovation, reports as the main barrier hindering the process, the difficulty of rethinking its mission, which did not include sustainability. The amendment of the mission constituted the last phase of a long process, which also required the investment of huge resources to empower top management, train the staff and develop management tools, as recommended by Sanchez-Carrillo et al. (2021). This extends the finding by Yáñez et al. (2019) as it shows that dedicated management tools can contribute to the holistic and strategic vision of the institution by

fostering internalization of the mission through increased communication with stakeholders and participation in decision-making. Obviously, the lack of a mission considering sustainability issues adds to the inability to develop a vision, as is the case for UnistraPG and UnistraSI, making the removal of organizational challenges very difficult. Long-term investments are required to cope with this issue while advanced management systems can at most facilitate the achievement of a short-term competitive advantage. This integrates the findings of Leal Filho et al. (2019c), since it confirms the significance of problems such as lack of resources and support for planning and implementing SD in universities, but it suggests that the main problem is cultural and can be interpreted in the context of the university mission and consequently addressed by developing purpose through a complete rethinking of mission and vision before strategy execution.

Proposition 5. *The challenges Italian state universities face in carrying out sustainable innovation are lower when the integration of sustainability in the mission predates the development of a vision.*

6. Conclusion

In the context of the Italian HE system, in which institutional and financial support for sustainable innovation was poor, this paper aimed to investigate in depth the BMs of state universities strongly oriented towards sustainability and, consequently, examine the process, tools and challenges affecting the implementation of sustainable innovation. Our analysis reveals that sustainable innovation is an incremental process made up of continuous improvements over different phases. Usually, the first phase focuses on environmental issues and aims to improve the university structure, while the following phases are used to reinforce the value proposition, develop management tools and embrace a broader concept of sustainability. Although each university bases its sustainable innovation on its core competences and strengthens relationships accordingly, the drivers and aims behind this transition determine the outcomes, in terms of strategies and degree of innovation. In fact, 'internal' drivers and aims are conducive to developing pro-active strategies and system-oriented innovation, while 'external' drivers and aims are conducive to defensive or accommodative strategies and process- or product-oriented innovation. Different tools are used across different phases to make sustainable innovation system-oriented: building and spreading within the organization a vision in which sustainability is a cornerstone of the university's future, and then investing in the structural conditions, mainly in terms of governance and management systems, to turn this idea into reality. The findings show that the main challenges to sustainable innovation are internal and mainly related to organizational issues, but these barriers have less impact on universities whose mission already incorporates sustainability. The patterns observed across the cases confirm a relationship between the process, tools and challenges involved in implementing sustainable innovation in HE. Consequently, we developed a set of propositions to present these relationships and summarized them in a preliminary model.

This paper is one of the few contributions aimed at filling the 'design-implementation' gap in the literature on sustainable innovation and the first in the context of HE. In particular, it advances knowledge regarding the dynamics (process) and the elements (tools) for the holistic implementation of sustainability strategies in HE when incentives are scant, as in the case of Italian state universities. It also makes an important theoretical contribution by providing a new causal map of the relationships among variables affecting sustainable innovation. In fact, it offers a new interpretation of the relationships between innovation drivers and performance, which is evaluated, adopting an organizational and management perspective, not only in terms of profitability and competitiveness but also in terms of strategies and degree of innovation. In the context under investigation, it also demonstrates the preeminence of structural conditions, which build a mutual understanding of the SD concept within the organization, in guiding the sustainability transition in universities. This study, which to our knowledge is the first to apply the concept of an SBM to HE, also answers the call for a more empirical approach in research into how organizations should implement sustainability innovations, considering that this process varies depending on national and industry factors. The use of organizational and management perspectives to shed light on how Italian state universities incorporate sustainability in their BMs provides directions for future research related to the outcomes of SBM transformation. In fact, it suggests the need for further investigation of the relationship between value creation and value capture, in order to understand whether greater sustainability orientation and particular processes and tools are conducive to increased competitive and financial performance.

This study also has important implications for practitioners. By focusing on the context in which sustainable innovation takes place and examining relevant cases of Italian state universities whose BMs are strongly oriented towards sustainability, it provides an understanding of how SBMs can be developed in practice, helping university management to identify transformation process steps, organizational capabilities and tools needed to implement an SBM in relation to the university's type, mission, history, financial schemes, external environment and core competences. Then, the findings support policymakers seeking to build a more sustainable HE system as they highlight areas and activities, such as governance bodies, personnel education and management systems, to be addressed by specific regulations, guidelines, and incentives aimed at fostering sustainability in state universities.

This study has several limitations, which pave the way for future research. First, the current analysis is context-specific, so the preliminary model that has been proposed needs to be tested in other countries, whose HE systems may be based on different financial, recruitment and organizational structures and mechanisms. Since we used organizational and management perspectives to analyse sustainable BMI, our findings cannot even be applied to Italian private universities, which have different funding, recruitment and accountability systems from state universities. Therefore, a future research direction is the adaption of our conceptual framework to the context of private universities, selecting a set of different indicators to evaluate the integration of sustainability. In addition, although the current impact of sustainability performance on total funds is shallow for Italian state universities, the increasing attention paid to the topic and the gradual introduction of financial incentives by the State suggest replicating the analysis in the future to understand whether and how other universities are joining the four pioneering universities in implementing sustainable innovation. In future research, it will be worth investigating how external trends, such as the decrease in student number, funds and personnel, and priorities related to sustainability, such as digital innovation and distance learning, internationalization and course diversification, contribute to sustainable BMI in state universities and the impact these factors have on private universities. Then, further investigation of the relationship between sustainable innovation and outcomes, in terms of competitive and financial performance, is needed. Finally, although challenges faced in the process of sustainable innovation were considered, they were not the main focus of the study and need to be investigated further.

CRediT authorship contribution statement

Federico Rotondo: Conceptualization, Methodology, Formal analysis, Project administration, Investigation, Writing – original draft, Writing – review & editing. **Lucia Giovanelli:** Conceptualization, Writing – original draft, Investigation, Supervision. **Alberto Ezza:** Formal analysis, Methodology, Investigation, Data curation, Writing – original draft, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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