University sustainability rankings and sustainability performance: assessing the relationship

Sustainability Accounting, Management and Policy Journal

163

Received 29 April 2025
Revised 19 September 2025
24 April 2026
Accepted 12 July 2026

Chiara Alberti, Michele Meoli and Stefano Paleari
Department of Management, Information and Production Engineering, University of Bergamo, Bergamo, Italy

Abstract

Purpose – This study aims to investigate the relationship between sustainability performance and sustainability rankings in higher education institutions. It explores the existence of a bidirectional relationship, assessing how sustainability performance influences ranking outcomes and how rankings, in turn, affect institutional behavior and performance.

Design/methodology/approach – The authors collected external sustainability data from Italian universities and applied the Granger causality test to examine whether a bidirectional relationship exists with the UI GreenMetric ranking. Subsequently, the authors used dynamic panel models to investigate the determinants of this relationship.

Findings – The findings reveal a bidirectional relationship between sustainability rankings and sustainability performance: rankings not only reflect institutional outcomes but also actively shape them. On the one hand, rankings effectively capture certain dimensions of performance; on the other, they are associated with improvements in the metrics they measure, while other sustainability dimensions may decline or receive less attention.

Practical implications – University managers should critically assess how rankings influence strategic decisions to avoid prioritizing short-term ranking gains over long-term sustainability goals.

Social implications – University rankings are widely used by policymakers as proxies for performance in funding allocation and policy design. However, uncritical reliance on these tools may lead to suboptimal decisions and incentivize strategic manipulation, highlighting the need for greater public oversight, more transparent methodologies, and the development of shared and reliable sustainability metrics.

Originality/value – Sustainability rankings have emerged alongside traditional rankings to assess institutional quality in this area. Originally created to measure university quality, rankings can also influence institutional priorities. However, while traditional rankings and their effects have been widely studied, sustainability rankings remain relatively unexplored.

Keywords Sustainability performance, Sustainability ranking, Higher education, Granger test, Sustainability accounting, Sustainable university

Paper type Research paper

1. Introduction

The ongoing debate on rankings in the higher education sector (Marginson and Van Der Wende, 2007) has recently been affected by the introduction of sustainability rankings

Funding: This study was supported by European Union - NextGenerationEU - GRINS project No. GRINS PE00000018 – CUP F83C22001720001.

Sustainability Accounting, Management and Policy Journal
Vol. 17 No. 7, 2026
pp. 163-197
Emerald Publishing Limited
2040-8021
DOI 10.1108/SAMPJ-04-2025-0598

(Kaiser *et al.*, 2022). Sustainable development represents one of the greatest challenges currently facing society, and education has been recognized as a crucial element in addressing this issue (Lozano *et al.*, 2015; Rau *et al.*, 2018). Over the past years, rankings have become widely used tools for assessing and comparing university quality (Hazelkorn, 2014; Urdari *et al.*, 2017). However, their impact and credibility remain subjects of extensive discussion (Kauppi, 2018).

Given the societal push towards sustainability and the expected contribution of Higher Education Institutions (HEIs), new rankings have emerged to measure their commitment to sustainable development (Gutiérrez-Mijares *et al.*, 2023; Suwartha and Sari, 2013). The most prominent are the UI GreenMetric (Henceforth GM ranking), the Times Higher Education Impact ranking (THE-IR) and the QS Sustainability ranking (QS-SR). Like traditional rankings, sustainability rankings face criticism regarding their impact and reliability in measuring the quality of higher education (Lauder *et al.*, 2015; Saisana *et al.*, 2011). Moreover, the multifaceted nature of sustainability complicates its assessment (Adams *et al.*, 2014; Böhringer and Jochem, 2007).

Despite criticism and new proposals for evaluating universities, rankings remain pervasive in the higher education sector, highlighting the need to examine both their validity and impact (Olcay and Bulu, 2017). While extensive literature exists on rankings (e.g. Marginson and Van Der Wende (2007)), sustainability rankings remain scarcely studied. Some researchers have addressed the assessment issue through a qualitative analysis of indicators (Bautista-Puig *et al.*, 2022; Galleli *et al.*, 2022; Suwartha and Sari, 2013), but studies specifically examining the effects of these rankings are limited (Atici *et al.*, 2021; De La Poza *et al.*, 2021; Sierra-García *et al.*, 2024).

This study addresses this gap by investigating the relationship between sustainability performance and sustainability rankings. First, while prior literature has examined rankings' validity (Kaiser *et al.*, 2022) and their organizational effects (Rindova *et al.*, 2018) as separate issues, we argue that these two dimensions are inherently correlated. Accordingly, we conceptualize the relationship between rankings and performance as a complex bidirectional process. Second, as rankings can be interpreted as evaluative tools that signal institutional quality, we posit that improvements in sustainability performance should be associated with corresponding changes in ranking outcomes, provided that such signals are not distortive (Espeland and Stevens, 1998; Spence, 1973). Third, rankings as external evaluative tools can shape organizational responses and incentivize universities to adapt their strategies (Oliver, 1991; Rindova *et al.*, 2018). Drawing on organizational and institutional theories (DiMaggio and Powell, 1983), we argue that rankings create incentives to prioritize performance dimensions that are rewarded, even at the expense of other aspects of sustainability.

To investigate these mechanisms, we collected data on 75 Italian HEIs from 2010 to 2023 and analyzed the relationship using the GM ranking. We consider data regarding three main university missions (teaching, research and third mission). All data were obtained from publicly available sources, ensuring transparency and reproducibility. Unlike most existing studies that rely on ranking-collected data (Atici *et al.*, 2021), we measure performance externally. This allows us to directly assess ranking validity while including both ranked and nonranked institutions. Finally, Italy is selected as an appropriate empirical setting for the study due to the early adoption of this ranking and the recent governmental emphasis on sustainability. To test our hypotheses, we used the Granger causality test and dynamic panel models.

The findings suggest that the GM ranking and sustainability performance stand in a bidirectional relationship. The GM ranking responds positively to improvements in performance, particularly those related to teaching and research, thereby supporting its validity. At the same time, our results indicate that rankings can significantly shape sustainability performance, encouraging improvements in dimensions that enhance the score while potentially neglecting others.

Empirical insights into the relationship between sustainability ranking and performance can greatly benefit key stakeholders, such as university managers and policymakers. Managers can leverage this knowledge to optimize their strategic planning and operational management (Rindova *et al.*, 2018). Similarly, policymakers frequently use university rankings as a proxy for institutional performance due to the lack of information (Dill and Soo, 2005). A more detailed understanding of the rankings can facilitate the formulation of more informed and targeted policies.

The remainder of the paper is organized as follows. Section 2 presents a review of the literature on the integration of sustainability in HEIs and provides an overview of sustainability ranking systems. Section 3 outlines the theoretical framework and develops the corresponding hypotheses. Section 4 describes the research design, including data and methodology. Section 5 presents and discusses the results. Section 6 provides a detailed examination of the implications. Finally, Section 7 concludes the study and discusses its limitations.

2. Literature review

2.1 Sustainability in higher education institutions

Sustainability is a broad concept, and since its introduction, many definitions have emerged. The most cited definition from Brundtland (1987) describes sustainable development as meeting present needs without compromising the ability of future generations to meet their own. However, given the widespread integration of sustainability concepts across various research fields and the resulting proliferation of interpretations, establishing a single universally accepted definition remains challenging. What remains consistent across these definitions is the emphasis on the interconnection among the economy, environment and society, with the idea that these elements should support or reinforce one another in a reciprocal relationship (Elkington, 1998).

In the context of transitioning to a sustainable society, higher education has been recognized as a key driver of sustainability transformation (Gutiérrez-Mijares *et al.*, 2023; Miller *et al.*, 2021). Velazquez *et al.* (2006) defined a sustainable university as an institution that integrates sustainability into its teaching, research, outreach and operations to minimize its negative environmental, economic and social impacts.

This has led universities to change their operations, redefine their missions and shift organizational cultures to accommodate sustainability-related concerns (Prior *et al.*, 2024). Given the lack of consensus on the definition of sustainability, initiatives within the higher education sector are diverse (Gutiérrez-Mijares *et al.*, 2023). A sustainable university can be defined in many ways, depending on the perspective taken (Lozano *et al.*, 2015). The current literature highlights several key areas, including education, research, community engagement or outreach, campus operations and assessment or reporting practices (Fischer *et al.*, 2015; Lozano, 2006).

2.2 Sustainability performance in higher education institutions

With the growing focus on sustainability, universities and policymakers have started considering metrics to assess institutions based on their sustainability performance (Gutiérrez-Mijares *et al.*, 2023). Nevertheless, sustainability measurement adds another layer of complexity to the already challenging task of evaluating HEIs (Lauder *et al.*, 2015).

Performance measurement serves various purposes, such as evaluation, communication, planning future actions and making comparisons (Findler *et al.*, 2019). Accordingly, various assessment tools and measures have been developed to evaluate sustainability alongside traditional indicators of excellence (Adams *et al.*, 2014; Otto *et al.*, 2021).

In general, universities pursue three main missions: teaching, research and outreach – also known as third mission – all of which play a crucial role in the transition to sustainability (Stephens *et al.*, 2008). First, HEIs have a social responsibility in societal development through the education of future generations. According to Emanuel and Adams (2011), the knowledge of sustainability is essential for the transition and universities can integrate this concept into the curriculum using three distinct methods: incorporating it into existing courses, offering specialized courses and establishing entire sustainable programs (Lukman and Glavič, 2007). In any case, university programs can substantially affect the perception and attitudes of students (Kagawa, 2007).

In addition to their educational mission, university research plays a key role in knowledge creation (Confraria *et al.*, 2024) and is pivotal for sustainable development (Waas *et al.*, 2010). Various bibliometric measures are used in research evaluation; among them, two simple yet informative indicators are the number of publications and the number of citations (Ellegaard and Wallin, 2015). The former can be considered a proxy for research production, while the latter is commonly used as an indicator of research impact (Moed, 2005; Waltman *et al.*, 2011). Although highly debated, evidence suggests that citation counts are positively associated with research quality (Aksnes *et al.*, 2019). Furthermore, despite the complexity and controversy surrounding bibliometric indicators, these measures become less susceptible to criticism the more they are aggregated (Aksnes *et al.*, 2019).

Next, the area commonly defined as the third mission, or outreach, must be considered (Jongbloed *et al.*, 2008). This mission encompasses activities aimed at transferring knowledge to society, including various forms of communication and social engagement (Di Berardino and Corsi, 2018). The connection with stakeholders outside academia is crucial for the sustainability transition and includes creating spinoffs and startups, generating intellectual property and participating in collaborative research, all of which support social and sustainability objectives (Trencher *et al.*, 2014).

In addition, the campus environment plays a crucial role in sustainability transition due to the various complex activities taking place within it (Alshuwaikhat and Abubakar, 2008). A sustainable university campus should promote energy and resource conservation, waste reduction, efficient environmental management and equity and social justice (Lozano *et al.*, 2015).

2.3 Sustainability rankings

Given the advocacy for sustainable development, HEIs face growing pressure to adopt and demonstrate sustainable practices. Showcasing this commitment has become essential, driven by stakeholder demand (Olcay and Bulu, 2017) and government calls for accountability and transparency (Bleiklie, 1998). HEIs can achieve this either through direct communication of their activities (Dienes *et al.*, 2016) or by relying on third-party assessments (Prior *et al.*, 2024).

In this context, third-party assessments have gained momentum, largely due to their perceived legitimacy (Devinney *et al.*, 2008). Among external indicators of university performance, rankings are increasingly valued for translating qualitative attributes into standardized, comparable metrics (Calderon, 2023; Lozano, 2006). As excellence in sustainability is viewed as a natural extension of universities' excellence, there is a growing demand for global rankings that assess universities using sustainability criteria (Johnes, 2018), providing an alternative perspective for evaluating institutions (Calderon, 2023).

Within this context, sustainability rankings provide opportunities and a framework for building a green university (Suwartha and Sari, 2013). However, these rankings also present criticalities, including methodological limitations (Lauder *et al.*, 2015), challenges in data collection (Ragazzi and Ghidini, 2017), the presence of biases and a lack of real commitment (Alberti *et al.*, 2025), as well as difficulties in ensuring comparability (Calderon, 2023). Nonetheless, several scholars argue that, even with imperfections, sustainability rankings can be desirable tools to incentivize environmental progress (Atici *et al.*, 2021; Galleli *et al.*, 2022; Smolennikov *et al.*, 2024).

The first global ranking focused on sustainability is the GM ranking, conducted by the University of Indonesia and published annually since 2010 (Galleli *et al.*, 2022). GM includes six categories of indicators: Settings and Infrastructure; Energy and Climate Change; Waste; Water; Transportation; and Education and Research. GM ranking has successfully disseminated the topic of sustainability and gained substantial popularity in recent years (Boiocchi *et al.*, 2024), as reflected in the increasing number of participating institutions. However, like any ranking, it has drawbacks, including concerns about the validity and reliability of the data, because the ranking is based on a self-administered questionnaire with data provided by the universities themselves (Dill and Soo, 2005).

The success of GM and the growing importance of sustainability have also contributed to the development of other rankings, such as the Times Higher Education Impact ranking (THE-IR) and the QS Sustainability ranking (QS-SR). The THE-IR, published annually since 2019, measures universities' contributions to the SDGs using research, institutional and policy indicators. The QS-SR, first issued in 2022, highlights how universities address key environmental, social and governance (ESG) challenges.

3. Theoretical framework and hypotheses development

Rankings were originally developed as information products aimed at measuring and signaling university performance (Rindova *et al.*, 2018; Spence, 1973). Within this framework, rankings represent quality assurance tools, helping to reduce information asymmetry between universities and their stakeholders (Chatterji and Toffel, 2010). This signaling function is particularly important in areas such as higher education, where quality assessment can be complex or subjective (Rindova *et al.*, 2018). This transparency enables more informed decision-making by students, families, funding bodies and policymakers (Nassa and Arora, 2021).

However, rankings are not merely passive reflections of performance. A growing body of literature suggests that they also shape organizational behavior, influencing outcomes such as research quality, student demand, technology transfer and financial resources (Bastedo and Bowman, 2011; Horstschräer, 2012; Sine *et al.*, 2003). This dual role implies that rankings may act both as evaluative mechanisms and as drivers of change (Siler and Larivière, 2022). Building on this, we argue that the relationship between rankings and sustainability performance is inherently bidirectional: rankings are expected to reflect underlying performance, while at the same time influencing it. Accordingly, we introduce the following hypotheses:

H1a. There is a causal relationship from sustainability performance to sustainability rankings.

H1b. There is a causal relationship from sustainability ranking to sustainability performance.

A key assumption underlying the use of rankings is that they provide a credible signal of organizational quality. Drawing on signaling theory (Spence, 1973), a signal is informative only if it accurately reflects the underlying attributes it intends to convey (Connelly *et al.*, 2011). In this sense, university rankings should mirror actual improvements in institutional performance.

Nevertheless, this assumption has been widely debated. Rankings have faced substantial criticism (Marginson and Van Der Wende, 2007). Scholars have questioned the validity and reliability of the indicators, aggregation models and data sources used (Dill and Soo, 2005; Hamann and Ringel, 2023). Concerns have also been raised about manipulation strategies, including performance enhancement through self-reported data or the strategic inflation of participation and input measures (Hazelkorn, 2014). Finally, De Witte and Hudrlikova (2013) and Barron (2017) argue that rankings frequently reflect reputation and visibility rather than genuine institutional quality, favoring well-established universities.

However, despite these criticisms, rankings remain widely used within organizations and by external audiences. Internally, they provide performance benchmarks that can support strategic decision-making and resource allocation (Nõmm and Randma-Liiv, 2012). Externally, they respond to the growing demand for accountability by informing stakeholders about institutional activities (Costa and Pesci, 2016).

Given their widespread adoption and intended signaling function, we argue that improvements in sustainability performance should be reflected in ranking positions. Accordingly, rankings can be interpreted as informative signals of underlying performance, even though part of the underlying information is based on self-reported data provided by universities. Importantly, our study does not seek to test signaling theory *per se*, which already provides the conceptual foundation for interpreting rankings as signals. Rather, we build on this framework to empirically examine whether these signals are aligned with independently measured performance:

H2. Improvements in sustainability performance are positively associated with improvements in a university's ranking position.

Beyond reflecting performance, rankings can actively influence organizational behavior. Their growing prominence has increased the pressure on universities to improve their positions, thereby shaping strategic decisions (Kaidesoja, 2022; Shore and Wright, 2015).

From an institutional perspective, rankings act as external pressures that organizations are incentivized to respond to. Drawing on the theory of institutional isomorphism (DiMaggio and Powell, 1983), organizations tend to become more similar when exposed to such pressures through three mechanisms: *coercive*, *mimetic* and *normative*. University rankings operate through all three of these mechanisms: *coercive* mechanisms arise when rankings are linked to funding allocation or regulatory frameworks (Marginson, 2007); *mimetic* mechanisms occur when institutions imitate higher-ranked universities perceived as successful models (Grewal *et al.*, 2008); and *normative* mechanisms reflect professional and academic expectations within the higher education community (Hazelkorn, 2008).

A key mechanism underlying this response is reactivity, defined as behavioral change in response to being measured and evaluated (Espeland and Sauder, 2007). Because ranking positions are highly visible, universities are incentivized to improve them, often by adapting their internal processes and resource allocation (Fowles *et al.*, 2016; Tóth *et al.*, 2024). As part of this reactive process, universities tend to prioritize activities that are explicitly captured by ranking methodologies. This often translates into increased investments in areas known to improve ranking scores (Hazelkorn, 2014). As a consequence, rankings do not merely evaluate performance but actively shape it, influencing how organizations define and pursue success (Devinney *et al.*, 2008).

This behavior is further reinforced by external stakeholders, who rely on rankings to evaluate institutions (Martins, 2005), as well as by competitive dynamics, where top-ranked universities set benchmarks that others seek to emulate (Jones, 2017). In addition, from a resource-based perspective, higher-ranked universities may gain access to additional resources, further strengthening incentives to invest in ranking-relevant dimensions (Rindova *et al.*, 2018; Waddock, 2008).

However, the prioritization of ranking-related dimensions may come at a cost. Given resource constraints, increased investment in measured areas may lead to the neglect of nonmeasured activities. This dynamic is consistent with the idea that performance metrics can induce selective optimization, encouraging organizations to focus on what is measured rather than on overall performance (Heinrich, 2002; Rindova *et al.*, 2018). In this context, universities may improve indicators included in rankings while overlooking broader or less visible aspects.

Finally, it should be acknowledged that such reactive behavior is not universal. Universities may resist rankings, selectively engage with them or attempt to influence evaluation criteria (Clementino and Perkins, 2021; Greenwood *et al.*, 2011; Pollock *et al.*, 2018). Moreover, rankings can also foster genuine improvements by enhancing accountability and transparency, encouraging the development of monitoring and reporting systems that support broader performance gains (Clementino and Perkins, 2021; Hamed *et al.*, 2025).

Nevertheless, even in the presence of these positive effects, we argue that the combination of external pressure, resource constraints and measurement focus suggests that ranking-induced improvements are likely to be unevenly distributed across performance dimensions. This reasoning leads to the formulation of the following hypothesis:

H3a. Improvements in a university's ranking position are associated with a subsequent increase in its sustainability performance in dimensions included in the ranking methodology (i.e. dimensions explicitly captured by ranking indicators).

H3b. Improvements in a university's ranking position are associated with a subsequent decrease in its sustainability performance in dimensions not included in the ranking methodology (i.e. dimensions not directly captured by ranking indicators).

Figure 1 summarizes the relationships under investigation with the hypotheses formulated and their expected directions and signs.

4. Research design

4.1 Sample selection

This research focuses on the Italian higher education system. Italian universities provide a relevant case for several reasons. First, they are involved in sustainable development, as evidenced by their participation in the Network for Sustainable Development (RUS). This network was established in 2015 and now includes almost all universities. Second, recently, the National Recovery and Resilience Plan (PNRR) has provided funding to promote sustainable development in universities, making this case interesting for policymakers (Sacchi *et al.*, 2023). Finally, since the first edition of the GM ranking, several Italian universities have participated, and this number continues to grow, showcasing their commitment to sustainability.

Italian universities are distributed across the national territory and, regardless of the issuing institution, university degrees have the same legal value throughout the country (Cattaneo *et al.*, 2017). In line with the objectives of the study, we exclude special universities and distance-learning

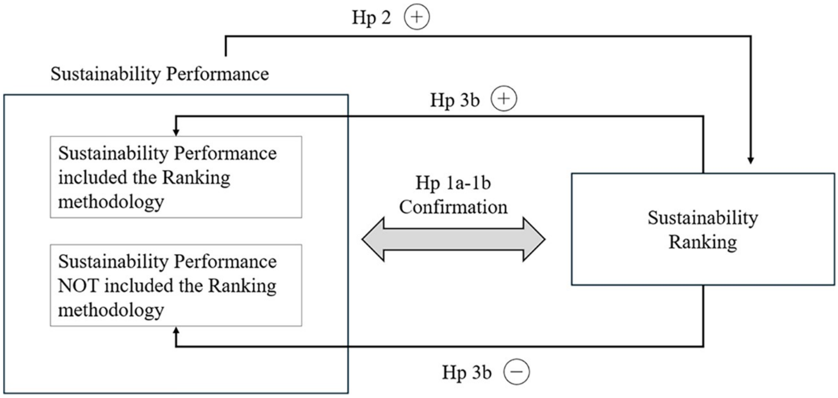

Figure 1. Theoretical framework and hypotheses presentation

institutions due to differences in their student populations and institutional mission [1] (see e.g. Beine *et al.*, 2020; Cattaneo *et al.*, 2017; Triventi and Trivellato, 2012). These institutions do not offer traditional degree programs, often have only PhD-level student populations, and in several cases do not engage in teaching or research activities in a structured way. In addition, three private institutions were excluded from the analysis due to the unavailability of the requisite data [2].

The final sample comprises 75 public and private universities observed between 2010 and 2023. Despite the exclusion of some institutions, the sample remains highly representative [3], encompassing the largest student population within the system.

4.2 Description of variables

4.2.1 Sustainability ranking. We selected the GreenMetric ranking for our analysis because it was the first established sustainability ranking and has had a long-term impact on universities, ensuring a representative data set, while also covering all university missions. The GM data was sourced from its dedicated website [4]. The variable *Ranking* is included in all regressions as a continuous variable, measured as the inverse of the ranking position. This transformation allows for a more intuitive interpretation of the estimated coefficients, as higher values of the variable correspond to better ranking positions. In addition, the measure is rescaled by multiplying by 100 to avoid excessively small coefficients.

4.2.2 Sustainability performance. To evaluate sustainability performance, we acknowledged its multifaceted nature and the multiple missions of universities. For each institution, we collected data on sustainability-related academic programs, research activities and third mission initiatives. These variables reflect the three core missions of universities – teaching, research and outreach – as defined by Lozano *et al.* (2015). Importantly, the data were collected from external and verifiable sources, including Scopus, Orbit, university websites and spinoff registries. This approach ensures both objectivity and reproducibility, in contrast with self-reported surveys. Notably, some of these variables, such as the number of sustainability-related courses, publications and spinoffs, are also included in the GM ranking, but in that case, they are self-reported by universities via a questionnaire. Our approach provides an independent validation of these components, while also incorporating additional variables that are not captured in the GreenMetric methodology. Table 1 reports the variables, along with their measures, data sources and summary information.

4.2.3 Control variables. In our analysis, we included several control variables. Specifically, we controlled for the number of students to account for size, the proportion of

Table 1. Sustainability performance variables

Measure	Definition	Included in GM	Source	Coverage year	University mission
Sustainability courses	Number of courses of the year under consideration that are related to sustainability. It includes all courses that have a title specifically related to the topic of sustainable development	Yes	Ministry of university database	2010–2023	Teaching
Sustainability publications	Number of publications of the year under consideration containing at least One of the following terms in the title, abstract or keywords: “SDGs,” “sustainable development,” “sustainability” (Raman *et al.*, 2024) retrieved through Scopus (Markard *et al.*, 2012)	Yes	Scopus	2010–2023	Research
Citations	Number of citations of sustainability publications in the year under consideration	No	Scopus	2010–2023	Research
Sustainability spinoffs	Number of university spinoffs established in the year under consideration that belong to the “energy and environmental” sector	Yes	Spinoff italia website	2010–2019	Third mission
Green patents	Number of green patent applications according to the CPC classification (Y02, Y04)	No	Orbit database	2010–2023	Third mission

STEM faculty as a proxy for scientific orientation, and tuition fees to reflect the market model of universities. We also controlled for inclusion in the THE ranking to capture the excellence or reputation of a university (Jacqmin, 2021). In addition, we accounted for the impact of policies affecting the higher education system by including controls for two events: the establishment of RUS in 2015 and the PNRR in 2021, which provides funding for sustainable initiatives. Definitions of control variables are provided in Table 2.

4.3 Empirical strategy

We estimated our models using a balanced panel data set of 1,050 observations over 14 years. First, we use Granger causality tests to explore the temporal direction of the relationship between sustainability performance and university ranking. This test allows us to test *H1a* and *H1b*. Second, we estimate dynamic panel models to account for both persistence over time and potential endogeneity and to estimate the magnitude of these effects. These models enable us to test *H2*, *H3a* and *H3b*.

In the empirical specification, sustainability performance is denoted by Y, while ranking is denoted by X. However, the two sets of variables are used interchangeably as dependent and independent variables in different model specifications. In detail, to test *H1a* and *H2*, we use ranking as the dependent variable and sustainability performance as the independent variable, whereas for *H1b*, *H3a* and *H3b*, we reverse the specification. In all regressions, we included the control variables described in Table 2 (denoted as C), lagged by one period.

4.3.1 Granger causality test. We tested the causal relationship between GM ranking and universities' sustainability performance using the Granger causality test (Granger, 1969). This approach involves creating a regression model that incorporates previous values of one variable to determine if they can help predict the value of another variable. To apply the Granger test, we first tested the stationarity of our variables using the Levin-Lin-Chu test (Levin *et al.*, 2002). If the level variable is nonstationary, the series is differenced and year dummies are included to capture trend variations. Equation (1) presents the general regression model. However, two different specifications are used depending on the nature of the dependent variable: a Tobit panel model when ranking is the dependent variable, given its left-truncated nature and an OLS fixed-effects panel model when sustainability performance is the dependent variable [5]. The existence of bidirectional relationships is assessed based on the statistical significance of the lagged explanatory variables in the respective specifications.

In these tests, we included the variables lagged by three periods. We selected a three-year lag structure based on improved model fit (AIC and BIC) and the rule of thumb for dynamic

Table 2. Control variables definition and sources

Control variables	Definition	Source
Size	Total number of students enrolled at university, rescaled in thousands	Ministry of university database
STEM faculty ratio	Proportion of faculty members specializing in science, technology, engineering and mathematics (STEM)	
Tuition	Average tuition fees paid by students, rescaled in thousands	
The dummy	Dummy equals to 1 if the university is ranked in THE ranking for the year under consideration, 0 otherwise	THE website
RUS	Dummy equals to 1 for year from year 2015 onwards	RUS website
PNRR	Dummy equals to 1 for year from year 2021 onwards	Ministry of university database

panels (Time ≥ 5 + 3*lags, Thornton and Batten, 1985), balancing empirical performance with sample size constraints:

$$Effect_{i,t} = \alpha_0 + \sum_{j=1}^{3} \alpha_1^j Effect_{i,t-j} \sum_{j=1}^{3} \alpha_2^j Cause_{i,t-j} + \alpha_3 C_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

4.3.2 Dynamic panel models. To analyze the relationship between ranking and sustainability performance, we use dynamic model specifications. This allows us to assess the direction and magnitude of the effect of each variable on the other by examining the estimated coefficients in both specifications. We apply the GMM technique, which is appropriate for data sets with many cross-sections and short time series (Arellano and Bover, 1995). This method uses the lags of the variables as instrumental variables and removes cross-sectional fixed effects. In this research, two-step system GMM was applied, which is asymptotically more effective. Equation (2) presents the dynamic panel regression model, while equation (3) presents the GMM difference model, which also captures all unobservable fixed effects:

$$y_{i,t} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 x_{i,t-1} + \beta_3 C_{i,t-1} + \omega_i + \varepsilon_{i,t} \quad (2)$$

$$\Delta y_{i,t} = \beta_1 \Delta y_{i,t-1} + \beta_2 \Delta x_{i,t-1} + \beta_3 \Delta C_{i,t-1} + \Delta\varepsilon_{i,t} \quad (3)$$

5. Results and discussion

5.1 Descriptive statistics and preliminary tests

Table 3 reports the descriptive statistics for the sustainability performance metrics analyzed. The variables associated with courses, publications, citations, patents and ranking are available from 2010 to 2023, resulting in 1,050 observations. Conversely, information regarding spinoff activities extends only up to 2019. Each variable exhibits a distinct range and set of values, reflecting the different aspects and metrics of sustainability performance analyzed.

Table 4 presents the outcomes of the panel unit root tests, which aim to reject the null hypothesis that a unit root exists. The results indicate that most variables in levels are nonstationary. Nevertheless, using first differences addresses this problem for all variables, except for ranking. Given the significance of this variable in our analysis, we opted to include year dummies to capture the trend.

5.2 Causality analysis

Table 5 shows the results of the Granger test conducted to examine the causal effect of sustainability performance on ranking position. The results suggest that the number of

Table 3. Descriptive statistics

Variable	*N*	Mean	SD	Min.	Max.
Ranking	1,050	0.2	0.9	0.0	10.0
Sustainability courses	1,050	2.3	2.6	0.0	19.0
Sustainability publications	1,050	31.4	43.9	0.0	347.0
Citations	1,050	702.6	1,018.9	0.0	8,684.0
Sustainability spinoffs	750 [8]	0.3	0.6	0.0	3.0
Green patents	1,050	0.3	1.0	0.0	12.0

Table 4. Results of the stationarity tests

Variable	Absolute value	First-difference
Ranking	8.4	−0.1
Sustainability courses	8.0	−3.8***
Sustainability publications	16.1	−5.9***
Citations	−4.6***	−12.8***
Sustainability spinoffs	−0.1	−6.2***
Green patents	−4.0***	−6.0***
Size	−9.5***	−5.8***
STEM-faculty ratio	0.3	−13.7***
Tuition	−5.3***	−9.4***

Note(s): This table reports the results of the Levin–Lin–Chu test for stationarity, which is conducted only on continuous variables. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

sustainability courses (Model 1), sustainability publications (Model 2), citations (Model 3) and green patents (Model 5) have a positive causal effect on ranking position, while no evidence was found for sustainability spinoffs (Model 4). These results support *H1a*, indicating that an enhancement in sustainability performance is associated with a causal improvement in ranking position. The lack of empirical evidence regarding spinoffs can be attributed to the inherent challenges in measuring sustainable spinoffs – which, unlike green patents, lack a specific identification code – and to the limited observation period.

Table 6 presents the results of the Granger test, which examines the causality direction of ranking on performance. In this regression, we also include the variables related to policies (RUS and PNRR). The results show that ranking exerts a causal effect on the number of sustainability publications (Model 2), citations (Model 3) and green patents (Model 5), while no evidence of an effect is found for sustainability courses (Model 1) and spinoffs (Model 4). The causal effect of ranking on sustainability performance allows us to partially accept *H1b*.

Overall, these results confirm a bidirectional causal relationship between sustainability ranking and sustainability performance, whereby each influences the other. Results are also confirmed by the robustness checks [see Appendix – Tables A1 and A2 for the causal direction from performance to ranking (*H1a*), and Tables A3 and A4 for the opposite causal direction (*H1b*)]. Furthermore, despite being based on the GM ranking, our results can be generalized. Every ranking, even if based on different measures, follows a similar underlying mechanism (Galleli *et al.*, 2022). Moreover, because Italian universities exhibit similar positions across rankings, their behavior in GM is likely to be reflected in other rankings as well.

5.3 Determinant analysis

Table 7 presents the results of the dynamic panel model with ranking as the dependent variable. These models account for endogeneity, allowing interpretation of the coefficients. Model 1 considers the number of sustainability courses as a metric of sustainable performance, whose impact on the ranking is positive and statistically significant (0.045, *p*-value < 5%). Models 2 and 3, focusing respectively on sustainability publications and citations, show a positive impact on the ranking (0.979, *p*-value < 5% and 0.015, *p-value* < 5%, respectively). Models 4 (sustainability spinoffs) and 5 (green patents) report no significant effect on the ranking.

These results provide partial support for *H2*, which posits that improvements in sustainability performance are associated with higher ranking positions. The findings

Table 5. Results of the granger causality test

Variables	(1) Ranking	(2) Ranking	(3) Ranking	(4) Ranking	(5) Ranking
Y_{t-1}	0.477*** (0.103)	0.505*** (0.100)	0.442*** (0.0995)	0.153 (0.175)	0.130 (0.0916)
Y_{t-2}	0.526*** (0.107)	0.432*** (0.102)	0.545*** (0.104)	0.157 (0.145)	0.258*** (0.0935)
Y_{t-3}	0.196* (0.114)	0.167 (0.111)	0.205* (0.114)	–	0.0622 (0.0985)
Sustainability performance	Sustainability courses	Sustainability publications	Citations	Sustainability spinoffs	Green patents
Sustainability performance$_{t-1}$	0.0688* (0.0369)	7.645** (3.074)	0.0523 (0.0457)	−0.0721 (0.0714)	0.0637** (0.0308)
Sustainability performance$_{t-2}$	0.0377 (0.0450)	−2.344 (3.303)	0.114** (0.0539)	−0.0750 (0.0686)	0.0868** (0.0362)
Sustainability performance$_{t-3}$	−0.0402 (0.0522)	10.86***	0.00915 (0.0534)	–	0.0446 (0.0363)
Size$_{t-1}$	0.128*** (0.0495)	0.120*** (0.0463)	0.137*** (0.0491)	0.0875 (0.0740)	0.00695 (0.0531)
THE-dummy$_{t-1}$	0.214 (0.148)	0.180 (0.140)	0.207 (0.144)	0.0279 (0.181)	0.219 (0.139)
STEM-faculty ratio$_{t-1}$	0.571 (3.765)	0.267 (3.681)	0.302 (3.680)	2.208 (7.192)	1.564 (4.198)
Tuition$_{t-1}$	−0.0483 (0.196)	−0.0829 (0.189)	−0.0950 (0.193)	−0.177 (0.450)	0.0692 (0.207)
Constant	−0.746*** (0.143)	−0.813*** (0.0790)	−0.747*** (0.142)	−1.255*** (0.234)	−0.956*** (0.171)
Year dummy	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.65	0.65	0.66	0.68	0.58

Note(s): This table reports the causal impact of sustainability performance on sustainability ranking using a Tobit panel model, as the ranking variable is left-censored. This analysis is used to test the *H1a*. Both the dependent and independent variables are expressed in first differences, which also absorb individual fixed effects. They follow a three-year lag structure while the control variables are lagged by One year. In Model 4, only Two lags are used due to data limitations. Standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 6. Results of the granger causality test

Variables	(1) Sustainability courses	(2) Sustainability publications	(3) Citations	(4) Sustainability spinoffs	(5) Green patents
Y_{t-1}	−0.392*** (0.0415)	−0.428*** (0.0431)	−0.618*** (0.0395)	−0.795*** (0.0470)	−0.795*** (0.0470)
Y_{t-2}	−0.252*** (0.0492)	−0.0106 (0.0497)	−0.467*** (0.0475)	−0.523*** (0.0518)	−0.523*** (0.0518)
Y_{t-3}	−0.230*** (0.0573)	0.0552 (0.0518)	−0.356*** (0.0485)	–	−0.249*** (0.0445)
$Ranking_{t-1}$	0.175 (0.151)	1.811 (1.450)	129.9 (108.8)	0.0835 (0.144)	−0.182 (0.118)
$Ranking_{t-2}$	−0.233 (0.151)	−2.731* (1.432)	−55.64 (108.7)	−0.0370 (0.172)	−0.400*** (0.118)
$Ranking_{t-3}$	0.235 (0.150)	6.518*** (1.456)	−258.3** (109.5)	–	−0.613*** (0.119)
$Size_{t-1}$	0.0567 (0.0630)	2.245*** (0.611)	−102.7** (46.07)	−0.0351 (0.0528)	−0.0391 (0.0495)
THE-$dummy_{t-1}$	−0.224 (0.163)	−1.668 (1.571)	7.079 (119.7)	−0.0561 (0.120)	−0.0593 (0.128)
STEM-faculty $ratio_{t-1}$	−2.785 (3.647)	−33.44 (34.96)	4,135 (2,667)	3.894 (3.588)	0.311 (2.859)
$Tuition_{t-1}$	0.0215 (0.175)	−1.931 (1.678)	30.67 (128.1)	−0.381* (0.220)	0.0756 (0.137)
RUS	−0.731*** (0.180)	7.395*** (1.721)	472.5*** (130.1)	−0.153 (0.0991)	0.246* (0.140)
PNRR	1.627*** (0.126)	0.991 (1.209)	−1,267*** (90.83)	–	−0.266* (0.0982)
Constant	−0.00761 (0.127)	5.618*** (1.243)	128.8 (92.15)	0.0325 (0.0733)	−0.135 (0.0988)
Year-Dummy	Yes	Yes	Yes	Yes	Yes
R-squared	0.310	0.281	0.375	0.459	0.256

Note(s): This table reports the causal impact of sustainability rankings on sustainability performance using a first-differences panel OLS model that also accounts for fixed effects. This analysis is used to test *H1b*. The dependent variable and key explanatory variables are included with a three-year lag structure, while the control variables are lagged by One year. In Model 4, only Two lags are used due to data limitations. Standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 7. Results of the GMM model

Variables	(1) Ranking	(2) Ranking	(3) Ranking	(4) Ranking	(5) Ranking
Ranking_{t-1}	0.795*** (0.082)	0.355 (0.230)	0.947*** (0.129)	1.118*** (0.237)	0.798*** (0.181)
Sustainability performance:	Sustainability courses	Sustainability publications	Citations	Sustainability spinoffs	Green patents
$\text{Sustainability performance}_{t-1}$	0.045** (0.020)	0.979** (0.005)	0.015** (0.0001)	−0.069 (0.071)	0.043 (0.053)
Size_{t-1}	−0.015 (0.014)	0.003 (0.010)	0.020 (0.016)	0.009 (0.010)	0.044* (0.026)
THE dummy_{t-1}	0.023 (0.028)	0.026 (0.037)	0.008 (0.056)	−0.059 (0.063)	0.017 (0.060)
$\text{STEM-faculty ratio}_{t-1}$	−0.027 (0.499)	−0.024 (0.487)	−1.299 (0.972)	0.253 (1.002)	0.912 (1.613)
Tuition_{t-1}	0.013 (0.022)	0.050 (0.044)	0.105 (0.074)	−0.004 (0.063)	0.025 (0.040)
Year dummy	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test AR(1)	−1.75*	−1.76*	−2.3**	−2.5***	−2.5**
Arellano-Bond test AR(2)	0.74	0.73	0.7	−1.4	0.7
Hansen-test	22.4	15.3	23.9	11.3	29.1

Note(s): This table presents the analysis of the impact of sustainability performance on sustainability ranking using a GMM model. This table is used to test the *H2*. We acknowledge that ranking is a truncated variable; however, the same specification is used. This proxy is acceptable as it is not used for forecasting, and robustness checks (Table AII) show similar results when using an OLS regression instead of a Tobit model. Independent and control variables are lagged by one year ($t-1$). Lagged values of the dependent variable and ranking are used as GMM instruments, while the remaining variables are used as IV instruments. Arellano-Bond and Hansen tests confirm the validity of the model. Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

indicate that advancements in education and research are reflected in ranking scores; in particular, sustainability-related publications significantly influence rankings, consistent with patterns observed in traditional ranking systems (Vernon *et al.*, 2018). Moreover, the number of citations received by sustainability papers is also impacted, despite not being explicitly included in the data set. By relying on externally collected data, we are able to assess whether rankings capture underlying improvements in sustainability performance, thereby providing evidence of their external validity.

Table 8 presents the results of the dynamic panel model with sustainability performance as dependent variables. Model 1 shows that ranking positively affects sustainability courses (0.311, p-value < 10%). Similarly, in Model 2, GM has a positive effect on sustainability publications (12.49, p-value < 10%), while Model 4 finds no significant determinants for sustainability spinoffs. While the results for sustainability spinoffs are not statistically significant, this may partly reflect the restricted timeframe available for this variable. The remaining models, however, provide support for *H3a*. By contrast, Model 3 shows a strong negative effect on citations (−847.6, p-value < 5%) and Model 5 reveals a negative effect of ranking on green patents (−0.443, p-value < 10%). These findings corroborate *H3b* [6].

Interestingly, when considering the impact of sustainability-related policies, the RUS variable shows a positive effect on sustainability courses, publications and citations. This may reflect the fact that the network primarily focuses on the educational and research missions of universities, which are more institutionalized and easier to coordinate across institutions, while paying comparatively less attention to third mission activities, which encompass a broader and more heterogeneous range of initiatives. The PNRR is positively associated with sustainability courses, suggesting that it may have incentivized the creation of new academic programs. Given the recent introduction of PNRR funding, teaching-related outcomes may be the most immediately responsive dimension. It is also worth noting that these policy variables are closely correlated with time trends and may therefore absorb part of broader temporal effects, capturing changes that occurred over the same period beyond the specific policy intervention itself.

Overall, these results suggest that rankings can prompt organizations to adopt reactive conformance measures aimed at improving performance in the areas explicitly included in the ranking, especially when such measures are relatively straightforward (Espeland and Sauder, 2007; Fowles *et al.*, 2016). Concurrently, a higher ranking position is associated with a reduction in sustainability performance in dimensions not captured by the ranking itself. While we are not able to disentangle the relative contribution of the different underlying drivers, it is nonetheless useful to discuss some plausible mechanisms that may help interpret these findings.

One possible explanation relates to the so-called gaming effect (Johnes, 2018): the pressure to improve ranking positions may push researchers to focus on "mainstream" publications that increase productivity, but are less likely to have a real impact and attract citations (Ter Bogt and Scapens, 2012). Similarly, patents are resource-intensive and universities may prefer to reallocate scarce resources to activities with more immediate visibility in the rankings. However, other dynamics may also be at play. Participation in rankings can enhance organizational accountability, making universities aware of their performance (Hamed *et al.*, 2025). In response, institutions may find it easier to prioritize improvements in measured indicators, while progress in other areas may require longer time horizons. Differences across disciplines may further shape these strategic responses, and the effects on sustainability outcomes may take time to materialize. Overall, these findings highlight the need to critically reflect on which indicators are included in rankings (Dill and Soo, 2005), and more broadly on how to assess the impact of universities on sustainability.

Table 8. Results of the GMM model

Variables	(1) Sustainability courses	(2) Sustainability publications	(3) Citations	(4) Spinoff Sustainability	(5) Green patents
Y_{t-1}	−0.095 (0.074)	0.545*** (0.159)	0.055 (0.087)	0.092 (0.068)	0.420*** (0.077)
$Ranking_{t-1}$	0.311* (0.163)	12.49* (7.258)	−847.6** (349.2)	−0.275 (0.260)	−0.443*** (0.144)
$Size_{t-1}$	0.054 (0.058)	2.554 (1.846)	−50.51 (47.01)	0.004 (0.023)	−0.051** (0.025)
THE $dummy_{t-1}$	−0.190 (0.173)	4.027 (12.93)	142.6 (128.1)	−0.019 (0.107)	−0.173 (0.205)
STEM-faculty $ratio_{t-1}$	−0.839 (2.212)	378.0 (919.8)	−530.6 (1,493)	−0.190 (1.507)	1.322 (1.242)
$Tuition_{t-1}$	−0.230* (0.129)	−60.84*** (21.54)	73.00 (60.50)	−0.065 (0.121)	0.047 (0.061)
RUS	0.605*** (0.225)	48.64*** (12.72)	231.5* (125.1)	0.042 (0.096)	0.230 (0.166)
PNRR	0.395** (0.155)	5.031 (5.239)	25.86 (113.0)		−0.093 (0.157)
Year dummy	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test AR(1)	−1.95***	−2.77***	−2.70***	−4.20***	−2.87***
Arellano-Bond test AR(2)	−0.70	2.08	−0.08	0.23	1.35
Hansen-test	39.8	15.2	37.1	12.9	65.8

Note(s): This table reports our analysis of the impact of sustainability ranking on sustainability performance. We use a GMM model. This table is used to test the *H3a* and *H3b*. Independent and control variables are lagged by one year (t − 1). Lagged values of the dependent variable and ranking are used as GMM instruments, while the remaining variables are used as IV instruments. Arellano-Bond and Hansen tests confirm the model's validity. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

5.4 Ad hoc performance analysis

To explore the broader implications of sustainability beyond the variables used to test our hypotheses, we conduct a performance analysis to examine whether rankings exert a wider influence on sustainability measures. This section provides supplementary evidence related to *H3b*; however, it considers only ranked institutions. Our goal is to assess the impact of the ranking not only on sustainability measures related to the three core missions of universities but also on broader aspects of sustainability, including infrastructure, energy, waste production and recycling, water usage and transportation. To achieve this, we relied only on data provided by GM, which collects sustainability-related information from universities. We collected the scores assigned by the GM organization to the following areas: Setting and Infrastructure, Energy and Climate Change, Waste, Water and Transportation over the 2014–2023 period. Table 9 provides the definitions and sources of these variables.

To test the impact of the ranking on these performance measures, we first address potential sample selection issues: because we consider only universities included in the ranking, as the measures are retrieved from it, we implement a two-stage estimation procedure following Heckman (1979). In the first stage, we estimate a probit model that captures the probability of a university being included in the GM ranking by considering the whole sample. This step allows us to model the selection process and to obtain an inverse Mills ratio used to correct for potential selection bias in the second stage. Identification is ensured through an exclusion restriction, whereby at least one variable is included in the selection equation but excluded from the outcome equation. In the second stage, we estimate an OLS regression on the subsample of universities included in the ranking, where the dependent variable is the GreenMetric score in the different areas outlined in Table 9. This specification includes the full set of control variables (excluding the exclusion restriction) and incorporates fixed effects. The inverse Mills ratio derived from the first stage is added as an additional regressor to control for potential selection bias.

Table 10 presents the regression results obtained using the Heckman correction model. In the first stage, we calculate the probability of being ranked in GM, introducing a variable called “imitative behavior.” This variable represents the proportion of universities ranked within the same NUTS 2 region as the university considered in the same year [7]. This variable serves as our exclusion variable and has a significant positive impact on the probability of being included in the ranking, confirming its validity. This stage allows us to calculate the IMR, which is included in the second stage to correct for potential bias.

In the second stage, we evaluate the impact of ranking position on sustainability variables at large. The results show a positive impact of GM ranking on these sustainability scores and thus performance. The inclusion of year fixed effects, along with their growing coefficients and impact, confirms that Italian universities entering the ranking are more likely to improve their performance and, consequently, their ranking position.

Control variables suggest that larger universities are better equipped to implement efficiency mechanisms, positively impacting energy, climate change and water consumption. In addition, universities that are also ranked in the THE ranking perform better in these areas, indicating that experienced universities or those with dedicated ranking offices are more effective at collecting relevant data.

Overall, these results show that rankings impact sustainability and can be interpreted in different ways. First, universities that are ranked tend to improve their sustainability performance, thereby confirming isomorphism theory (DiMaggio and Powell, 1983). Second, universities may become more accountable by improving their ability to collect and communicate data, as well as by becoming more aware of their performance (Dal Molin *et al.*, 2017). Finally, ranked universities are more likely to focus on improving the performance metrics included in the

Table 9. Dependent variable description for the second stage of the Heckman estimation model

Ranking scores	Definition	Mean	Min.	Max.	Source	Year of collection
SI – Setting and infrastructure	Score relative to university policy towards green environment	246.2	0	1,350	GreenMetric website	2014–2023
EC – Energy and climate change	Score to university attention to the use of energy and energy efficiency and related climate change issues	375.8	0	1,975		
WS – Waste	Score relative to waste treatment and recycling programs	448.8	0	1,800		
WR – Water	Score relative to water usage and conservation programs	168.3	0	1,000		
TR – Transportation	Score relative to university policies to reduce transportation carbon footprint	357.3	0	1,800		

Table 10. Regression with Heckman two stage estimation model

	First stage	Second stage				
		(1)	(2)	(3)	(4)	(5)
Dependent variable	GreenMetric dummy	SI – Setting and infrastructure	EC – Energy and climate change	WS – Waste	WR – Water	TR – Transport
GreenMetric ranking$_{t-1}$		130.4*** (17.18)	157.0*** (23.06)	129.5*** (26.58)	90.90*** (11.07)	185.5*** (22.00)
Imitative behaviour	4.290*** (0.722)					
IMR		−102.5*** (26.14)	−101.9*** (35.08)	−172.3*** (40.44)	−55.19*** (16.84)	−108.4*** (33.48)
Size$_{t-1}$	0.0351** (0.0139)	−4.738 (6.748)	2.357 (9.058)	0.987 (10.44)	−6.463 (4.347)	3.780 (8.644)
STEM-faculty ratio$_{t-1}$	4.319*** (1.466)	−236.6 (673.2)	−572.2 (903.7)	−151.2 (1,042)	−102.1 (433.7)	−220.5 (862.4)
Tuition$_{t-1}$	0.000919 (0.129)	−18.04 (34.51)	7.504 (46.33)	4.122 (53.41)	10.50 (22.23)	−0.716 (44.22)
THE dummy$_{t-1}$	0.587** (0.298)	49.01 (37.97)	108.0** (50.97)	135.9** (58.75)	22.71 (24.46)	109.7** (48.64)
Constant	−5.327*** (0.922)	564.5* (306.2)	532.5 (411.1)	722.1 (473.9)	367.9* (197.3)	376.3 (392.3)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.264	0.267	0.211	0.298	0.291	0.264

Note(s): This table reports the analysis of the impact of sustainability ranking on the sustainability score as additional analysis. In the first stage, a probit model is used to estimate the probability of being ranked, using a binary dependent variable indicating ranking inclusion. In the second stage, an OLS panel regression with university-level fixed effects is estimated. The regressions include 675 observations over the period 2014–2023. Independent and control variables are lagged by one period. Standard errors are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

rankings, reflecting a reactive response (Espeland and Sauder, 2007). Although not directly linked to a specific hypothesis, these results serve as supplementary evidence that corroborates the impact of rankings in enhancing performance included in the ranking measures.

6. Implications

As outlined in the Introduction, this study offers practical implications for university managers, policy implications for policymakers and external stakeholders, and theoretical implications for future research in this field.

6.1 Practical implications

Organizations perceive a favorable ranking position as an indication of a legitimate and credible third-party assessment that can influence stakeholder perceptions (Devinney *et al.*, 2008). In this sense, university managers may view rankings as a form of feedback or an external source of pressure (Andrades *et al.*, 2024; Rindova *et al.*, 2018).

Rankings can also impact an institution's accountability by driving the collection of more performance data, influencing both the organizational structure and institutional priorities (Hazelkorn, 2008). As a result of the proliferation of rankings, many universities have established formal internal mechanisms to review institutional rankings and their own institution's position (Hazelkorn, 2008). Because top-ranked universities are externally rewarded by stakeholders, this legitimizes their sustainability activities and influences the strategies of all universities (DiMaggio and Powell, 1983; Jones, 2017).

Recognizing the causal link between sustainability performance and ranking can support strategy development, especially given the public sector's recent emphasis on performance measurement (Adams *et al.*, 2014; Söderlind and Geschwind, 2019). However, managerial decisions may be driven more by the desire to improve ranking positions (Locke, 2014) rather than by the objective of achieving strategic goals (O'Connell and Saunders, 2013). Finally, our research also highlights potential ranking biases, which may lead some universities to opt out of participation (Clementino and Perkins, 2021).

6.2 Policy implications

Beyond university managers, policymakers frequently use university rankings as a proxy for performance to address a lack of information (Dill and Soo, 2005). Because governments are key stakeholders for HEIs, these rankings can significantly influence funding allocation and grant distribution (Hazelkorn, 2014). In addition, governments could use rankings as an alternative to direct regulation to encourage universities to enhance efficiency and performance (Dill and Soo, 2005). This research can illuminate the true sensitivity of rankings to actual performance.

Our findings empirically confirm that if stakeholders and policymakers use rankings as a basis for their choices, it may result in suboptimal decisions (Saisana *et al.*, 2011). Furthermore, if policymakers use university rankings to determine grants, they may inadvertently incentivize universities to manipulate rankings rather than pursue genuine sustainability (Dill and Soo, 2005).

These considerations also open up a reflection regarding the possibility of a public intervention in the development and distribution of rankings (Dill and Soo, 2005). One possible approach is to introduce an independent audit system to certify the data submitted for ranking, which enhances reliability, credibility and comparability across institutions. However, several challenges must be considered. First, the cost of implementing such audits may be too high, particularly for smaller institutions. Second, given the global distribution of participating universities, the feasibility of a centralized international audit system is a major concern.

A more viable alternative would be to involve national quality assurance agencies. For instance, in Italy, ANVUR (the National Agency for the Evaluation of Universities and Research Institutes) is responsible for assessing the quality of universities and research activities through panels of internal and external experts. In this context, ANVUR has already undertaken evaluation activities that incorporate sustainability-related dimensions in selected case studies. However, these sustainability dimensions remain broad in scope and do not always include direct or standardized measures. Therefore, this experience could be further extended and systematized into a more formalized and consistent audit framework for sustainability data. In the first phase, ANVUR could involve selected sustainability experts to define and establish indicators, minimum disclosure requirements and auditing standards. Subsequently, a pilot phase could be implemented on a limited sample of universities to test the feasibility of data collection and the effectiveness of the proposed indicators. Pilot cases could also help contain initial implementation costs. Following the pilot phase, the system could be gradually scaled up. ANVUR could conduct periodic audits (e.g. every two–three years), combining document-based verification with random on-site inspections. This approach would support the establishment of dedicated personnel responsible for sustainability-related data collection and reporting within universities. In addition, to address the global nature of rankings, coordination among national agencies could be promoted through the establishment of international networks, enabling mutual recognition of audit standards and the alignment of measurement approaches. This could enhance both universities' efforts to comply with ANVUR indicators and the reliability of the data reported to international rankings. As a third step, once the maturity and effectiveness of the indicators have been confirmed, a funding-linked incentive mechanism could be introduced, whereby a portion of public funding is allocated based on performance. This could help promote a virtuous cycle, encouraging universities to further invest in sustainability.

While theoretically appealing, this mechanism could also present some challenges. First, sustainability is a broad concept, and universities may define their own approaches (Böhringer and Jochem, 2007). Second, while this could incentivize positive institutional change, it also introduces the risk of unintended consequences (Andrades *et al.*, 2024). For example, institutions might engage in "greenwashing" practices, focusing on what can be measured while disregarding other equally important sustainability efforts (Alberti *et al.*, 2025; Espeland and Sauder, 2007). To mitigate these effects, it would be advisable to avoid aggregating all sustainability performance into a single composite ranking, because disaggregated indicators would allow more detailed evaluations (Daraio and Bonaccorsi, 2017; Moggi, 2023). Nevertheless, simplification pressures from media and public stakeholders often increase the demand for overall rankings. In addition, high-ranking institutions are interested in preserving these hierarchies. In light of this, we strongly recommend that policymakers exercise caution when using rankings as decision-making tools (Saisana *et al.*, 2011; Soh, 2012). At the same time, we suggest that governments and policymakers promote the systematic collection of reliable, audited sustainability data to inform evidence-based policies and institutional strategies.

Beyond policymakers, this research can also benefit other stakeholders. Despite the value placed on rankings for their ability to synthesize information, this study demonstrates that the data presented in such rankings do not necessarily reflect reality. Conversely, institutions that appear to be more sustainable may merely be engaging in ranking-driven competition.

6.3 Theoretical implications

Our findings contribute to the extant literature by representing the first empirical observation of the causal relationships between sustainability ranking and sustainability performance within universities. To the best of our knowledge, only Atici *et al.* (2021) and De La Poza *et al.* (2021) have studied the impact of sustainability rankings on academic performance, while Sierra-García *et al.* (2024) identified the contribution of university quality to sustainability rankings. Our research adds to the body of knowledge regarding rankings and their impact on HEIs, recommending that future studies examine and potentially include this dual relationship. In addition, we aim to contribute to the ongoing debate about sustainability performance and its assessment.

7. Conclusions and limitations

This paper tested three sets of hypotheses regarding the relationship between sustainability ranking and sustainability performance. First, the results show a bidirectional relationship between sustainability ranking and sustainability performance. Second, the results confirm the validity of GM Ranking in reflecting actual performance, especially for sustainability courses and publications. Third, GM ranking impacts the sustainability performance of universities. It positively affects the variables included in the ranking measure, while negatively affecting the others.

These results support the idea that rankings both reflect and influence performance. However, their influence is different among performance: they react to ranking by increasing measures that can boost the score while neglecting the others (Heinrich, 2002). This may be an example of reactive behavior in response to isomorphism pressure whereby universities seek to align themselves with top-ranked institutions (DiMaggio and Powell, 1983; Espeland and Sauder, 2007; Rindova *et al.*, 2018). However, it may also suggest that universities become accountable in those dimensions, and other sustainability impacts take longer to be effective. Future research could further disentangle the underlying mechanisms by investigating how different allocation strategies and organizational responses affect the relationship between rankings and the multidimensional nature of sustainability performance. However, despite its limitations, this study represents an important first step in uncovering these dynamics.

Although this study can make a valuable contribution to the field, some limitations and future directions should be acknowledged. From a performance perspective, while online-retrieved data are verifiable, they may omit some important features and characteristics of universities. The advent of official or internationally shared metrics will facilitate comparability. In terms of evaluation, we opted to use indicator-based measures, despite the existence of alternative approaches, such as account and narrative assessments; further research could explore this avenue. GM ranking is used, although different indicators may demonstrate varying degrees of effectiveness. Once sufficient data has been collected on other sustainability rankings, it will be possible to examine this relationship, assess the robustness of our findings and explore potential differences in institutional behavior. Finally, our study focuses on a single country, and future research may expand this perspective.

Notes

[1.] Of these, 6 are dedicated to doctoral students, 3 to foreign students and 11 are distance-learning universities.

[2.] Recent institutions established after 2010: Humanitas University, LinkCampus University and UniCamillus.

[3.] We also estimate a Heckman selection model as a robustness check using the full sample of universities, with results remaining stable.

[4.] https://greenmetric.ui.ac.id/

[5.] To test robustness, we estimated Tobit and OLS models including and excluding first-differences and fixed effects (see Appendix).

[6.] In the Appendix (Table A5), the sensitivity analyses further confirm our results.

[7.] Regions (NUTS2) with only one university have been merged with neighbouring regions. Specifically, we merged Molise with Abruzzo, Basilicata with Calabria, Liguria and Valle d'Aosta with Piemonte and Umbria with Marche.

[8.] Observations from 2010 to 2019.

References

Adams, C., Muir, S. and Hoque, Z. (2014), "Measurement of sustainability performance in the public sector. Sustainability accounting", *Management and Policy Journal*, Vol. 5, pp. 46-67, doi: 10.1108/SAMPJ-04-2012-0018.

Aksnes, D.W., Langfeldt, L. and Wouters, P. (2019), "Citations, citation indicators, and research quality: an overview of basic concepts and theories", *Sage Open*, Vol. 9 No. 1, p. 215824401982957, doi: 10.1177/2158244019829575.

Alberti, C., Civera, A., Lehmann, E.E., Meoli, M., Otto, J. and Paleari, S. (2025), "University sustainability rankings: a critical literature review on the UI GreenMetric ranking system", *The Journal of Technology Transfer*, Vol. 50 No. 6, doi: 10.1007/s10961-025-10223-9.

Alshuwaikhat, H.M. and Abubakar, I. (2008), "An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices", *Journal of Cleaner Production*, Vol. 16 No. 16, pp. 1777-1785, doi: 10.1016/j.jclepro.2007.12.002.

Andrades, J., Martinez-Martinez, D. and Larrán, M. (2024), "Sustainability reporting, institutional pressures and universities: evidence from the Spanish setting", *Sustainability Accounting, Management and Policy Journal*, doi: 10.1108/SAMPJ-07-2023-0455.

Arellano, M. and Bover, O. (1995), "Another look at the instrumental variable estimation of error-components models", *Journal of Econometrics*, Vol. 68 No. 1, pp. 29-51, doi: 10.1016/0304-4076(94)01642-D.

Atici, K.B., Yasayacak, G., Yildiz, Y. and Ulucan, A. (2021), "Green university and academic performance: an empirical study on UI GreenMetric and world university rankings", *Journal of Cleaner Production*, Vol. 291, p. 125289, doi: 10.1016/j.jclepro.2020.125289.

Barron, G.R.S. (2017), "The Berlin principles on ranking higher education institutions: limitations, legitimacy, and value conflict", *Higher Education*, Vol. 73 No. 2, pp. 317-333, doi: 10.1007/s10734-016-0022-z.

Bastedo, M.N. and Bowman, N.A. (2011), "College rankings as an interorganizational dependency: establishing the foundation for strategic and institutional accounts", *Research in Higher Education*, Vol. 52 No. 1, pp. 3-23, doi: 10.1007/s11162-010-9185-0.

Bautista-Puig, N., Orduña-Malea, E. and Perez-Esparrells, C. (2022), "Enhancing sustainable development goals or promoting universities? An analysis of the times higher education impact rankings", *International Journal of Sustainability in Higher Education*, Vol. 23 No. 8, pp. 211-231, doi: 10.1108/IJSHE-07-2021-0309.

Beine, M., Delogu, M. and Ragot, L. (2020), "The role of fees in foreign education: evidence from Italy", *Journal of Economic Geography*, Vol. 20, pp. 571-600, doi: 10.1093/jeg/lby044.

Bleiklie, I. (1998), "Justifying the evaluative state: new public management ideals in higher education", *Journal of Public Affairs Education*, Vol. 4 No. 2, pp. 87-100, doi: 10.1080/15236803.1998.12022016.

Böhringer, C. and Jochem, P.E.P. (2007), "Measuring the immeasurable — a survey of sustainability indices", *Ecological Economics*, Vol. 63 No. 1, pp. 1-8, doi: 10.1016/j.ecolecon.2007.03.008.

Boiocchi, R., Adami, L., Rada, E.C. and Schiavon, M. (2024), "Towards context-independent indicators for an unbiased assessment of environmental sustainability in higher education: an application to Italian universities", *Journal of Environmental Management*, Vol. 366, p. 121658, doi: 10.1016/j.jenvman.2024.121658.

Brundtland, G.H. (1987), "Our common future—call for action", *Environmental Conservation*, Vol. 14 No. 4, pp. 291-294, doi: 10.1017/S0376892900016805.

Calderon, A. (2023), "Sustainability rankings: what they are about and how to make them meaningful", *Journal of Studies in International Education*, Vol. 27 No. 4, pp. 674-692, doi: 10.1177/10283153231172022.

Cattaneo, M., Malighetti, P., Meoli, M. and Paleari, S. (2017), "University spatial competition for students: the Italian case", *Regional Studies*, Vol. 51 No. 5, pp. 750-764, doi: 10.1080/00343404.2015.1135240.

Chatterji, A.K. and Toffel, M.W. (2010), "How firms respond to being rated", *Strategic Management Journal*, Vol. 31 No. 9, pp. 917-945, doi: 10.1002/smj.840.

Clementino, E. and Perkins, R. (2021), "How do companies respond to environmental, social and governance (ESG) ratings? Evidence from Italy", *Journal of Business Ethics*, Vol. 171 No. 2, pp. 379-397, doi: 10.1007/s10551-020-04441-4.

Confraria, H., Ciarli, T. and Noyons, E. (2024), "Countries' research priorities in relation to the sustainable development goals", *Research Policy*, Vol. 53 No. 3, p. 104950, doi: 10.1016/j.respol.2023.104950.

Connelly, B.L., Certo, S.T., Ireland, R.D. and Reutzel, C.R. (2011), "Signaling theory: a review and assessment", *Journal of Management*, Vol. 37 No. 1, pp. 39-67, doi: 10.1177/0149206310388419.

Costa, E. and Pesci, C. (2016), "Social impact measurement: why do stakeholders matter? Sustainability accounting", *Sustainability Accounting, Management and Policy Journal*, Vol. 7 No. 1, pp. 99-124, doi: 10.1108/SAMPJ-12-2014-0092.

Dal Molin, M., Turri, M. and Agasisti, T. (2017), "New public management reforms in the Italian universities: managerial tools, accountability mechanisms or simply compliance?", *International Journal of Public Administration*, Vol. 40 No. 3, pp. 256-269, doi: 10.1080/01900692.2015.1107737.

Daraio, C. and Bonaccorsi, A. (2017), "Beyond university rankings? Generating new indicators on universities by linking data in open platforms", *Journal of the Association for Information Science and Technology*, Vol. 68 No. 2, pp. 508-529, doi: 10.1002/asi.23679.

De La Poza, E., Merello, P., Barberá, A. and Celani, A. (2021), "Universities' reporting on SDGs: using the impact rankings to model and measure their contribution to sustainability", *Sustainability*, Vol. 13 No. 4, p. 2038, doi: 10.3390/su13042038.

De Witte, K. and Hudrlikova, L. (2013), "What about excellence in teaching? A benevolent ranking of universities", *Scientometrics*, Vol. 96 No. 1, pp. 337-364, doi: 10.1007/s11192-013-0971-2.

Devinney, T., Dowling, G.R. and Perm-Ajchariyawong, N. (2008), "The financial times business schools ranking: what quality is this signal of quality?", *European Management Review*, Vol. 5 No. 4, pp. 195-208, doi: 10.1057/emr.2008.14.

Di Berardino, D. and Corsi, C. (2018), "A quality evaluation approach to disclosing third mission activities and intellectual capital in italian universities", *Journal of Intellectual Capital*, Vol. 19 No. 1, pp. 178-201, doi: 10.1108/JIC-02-2017-0042.

Dienes, D., Sassen, R. and Fischer, J. (2016), "What are the drivers of sustainability reporting? A systematic review", *Sustainability Accounting, Management and Policy Journal*, Vol. 7 No. 2, pp. 154-189, doi: 10.1108/SAMPJ-08-2014-0050.

Dill, D.D. and Soo, M. (2005), "Academic quality, league tables, and public policy: a cross-national analysis of university ranking systems", *Higher Education*, Vol. 49 No. 4, pp. 495-533, doi: 10.1007/s10734-004-1746-8.

DiMaggio, P.J. and Powell, W.W. (1983), "The iron cage revisited: institutional isomorphism and collective rationality in organizational fields", *American Sociological Review*, Vol. 48 No. 2, p. 147, doi: 10.2307/2095101.

Elkington, J. (1998), *Cannibals with Forks: The Triple Bottom Line of 21st Century Business, Conscientious Commerce*, New Society Publishers, Gabriola Island, BC ; Stony Creek, CT.

Ellegaard, O. and Wallin, J.A. (2015), "The bibliometric analysis of scholarly production: how great is the impact?", *Scientometrics*, Vol. 105 No. 3, pp. 1809-1831, doi: 10.1007/s11192-015-1645-z.

Emanuel, R. and Adams, J.N. (2011), "College students' perceptions of campus sustainability", *International Journal of Sustainability in Higher Education*, Vol. 12 No. 1, pp. 79-92, doi: 10.1108/14676371111098320.

Espeland, W.N. and Sauder, M. (2007), "Rankings and reactivity: how public measures recreate social worlds", *American Journal of Sociology*, Vol. 113 No. 1, pp. 1-40, doi: 10.1086/517897.

Espeland, W.N. and Stevens, M.L. (1998), "Commensuration as a social process", *Annual Review of Sociology*, Vol. 24 No. 1, pp. 313-343.

Findler, F., Schönherr, N., Lozano, R., Reider, D. and Martinuzzi, A. (2019), "The impacts of higher education institutions on sustainable development: a review and conceptualization", *International Journal of Sustainability in Higher Education*, Vol. 20 No. 1, pp. 23-38, doi: 10.1108/IJSHE-07-2017-0114.

Fischer, D., Jenssen, S. and Tappeser, V. (2015), "Getting an empirical hold of the sustainable university: a comparative analysis of evaluation frameworks across 12 contemporary sustainability assessment tools", *Assessment and Evaluation in Higher Education*, Vol. 40 No. 6, pp. 785-800, doi: 10.1080/02602938.2015.1043234.

Fowles, J., Frederickson, H.G. and Koppell, J.G.S. (2016), "University rankings: evidence and a conceptual framework", *Public Administration Review*, Vol. 76 No. 5, pp. 790-803, doi: 10.1111/puar.12610.

Galleli, B., Teles, N.E.B., Santos, J.A.R.D., Freitas-Martins, M.S. and Hourneaux Junior, F. (2022), "Sustainability university rankings: a comparative analysis of UI green metric and the times higher education world university rankings", *International Journal of Sustainability in Higher Education*, Vol. 23 No. 2, pp. 404-425, doi: 10.1108/IJSHE-12-2020-0475.

Granger, C.W.J. (1969), "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, Vol. 37 No. 3, p. 424, doi: 10.2307/1912791.

Greenwood, R., Raynard, M., Kodeih, F., Micelotta, E.R. and Lounsbury, M. (2011), "Institutional complexity and organizational responses", *Academy of Management Annals*, Vol. 5 No. 1, pp. 317-371, doi: 10.5465/19416520.2011.590299.

Grewal, R., Dearden, J.A. and Lilien, G.L. (2008), "The university rankings game: modeling the competition among universities for ranking", *The American Statistician*, Vol. 62 No. 3, pp. 232-237.

Gutiérrez-Mijares, M.E., Josa, I., Casanovas-Rubio, M. D M. and Aguado, A. (2023), "Methods for assessing sustainability performance at higher education institutions: a review", *Studies in Higher Education*, Vol. 48 No. 8, pp. 1-22, doi: 10.1080/03075079.2023.2185774.

Hamann, J. and Ringel, L. (2023), "The discursive resilience of university rankings", *Higher Education*, Vol. 86 No. 4, pp. 845-863, doi: 10.1007/s10734-022-00990-x.

Hamed, R., Smolarski, J., Al-Shattarat, W. and Al-Shattarat, B. (2025), "CSR reporting and corporate performance: the role of strategic emphasis", *Sustainability Accounting, Management and Policy Journal*, Vol. 16 No. 3, pp. 845-873, doi: 10.1108/SAMPJ-04-2024-0348.

Hazelkorn, E. (2014), "Reflections on a decade of global rankings: what we've learned and outstanding issues", *European Journal of Education*, Vol. 49 No. 1, pp. 12-28, doi: 10.1111/ejed.12059.

Hazelkorn, E. (2008), "Learning to live with league tables and ranking: the experience of institutional leaders", *Higher Education Policy*, Vol. 21 No. 2, pp. 193-215, doi: 10.1057/hep.2008.1.

Heckman, J.J. (1979), "Sample selection bias as a specification error", *Econometrica*, Vol. 47 No. 1, pp. 153-161, doi: 10.2307/1912352.

Heinrich, C.J. (2002), "Outcomes–based performance management in the public sector: implications for government accountability and effectiveness", *Public Administration Review*, Vol. 62 No. 6, pp. 712-725, doi: 10.1111/1540-6210.00253.

Horstschräer, J. (2012), "University rankings in action? The importance of rankings and an excellence competition for university choice of high-ability students", *Economics of Education Review*, Vol. 31 No. 6, pp. 1162-1176, doi: 10.1016/j.econedurev.2012.07.018.

Jacqmin, J. (2021), "Do ads influence rankings? Evidence from the higher education sector", *Education Economics*, Vol. 29 No. 5, pp. 509-526, doi: 10.1080/09645292.2021.1918642.

Johnes, J. (2018), "University rankings: what do they really show?", *Scientometrics*, Vol. 115 No. 1, pp. 585-606, doi: 10.1007/s11192-018-2666-1.

Jones, D.R. (2017), "Opening up the Pandora's box of sustainability league tables of universities: a Kafkaesque perspective", *Studies in Higher Education*, Vol. 42 No. 3, pp. 480-503, doi: 10.1080/03075079.2015.1052737.

Jongbloed, B., Enders, J. and Salerno, C. (2008), "Higher education and its communities: interconnections, interdependencies and a research agenda", *Higher Education*, Vol. 56 No. 3, pp. 303-324, doi: 10.1007/s10734-008-9128-2.

Kagawa, F. (2007), "Dissonance in students' perceptions of sustainable development and sustainability: implications for curriculum change", *International Journal of Sustainability in Higher Education*, Vol. 8, pp. 317-338, doi: 10.1108/14676370710817174.

Kaidesoja, T. (2022), "A theoretical framework for explaining the paradox of university rankings", *Social Science Information*, Vol. 61 No. 1, pp. 128-153, doi: 10.1177/05390184221079470.

Kaiser, F., Melo, A.I. and Hou, A.Y.C. (2022), "Are quality assurance and rankings useful tools to measure 'new' policy issues in higher education? The practices in Europe and asia", *European Journal of Higher Education*, Vol. 12 No. sup1, pp. 391-415, doi: 10.1080/21568235.2022.2094816.

Kauppi, N. (2018), "The global ranking game: narrowing academic excellence through numerical objectification", *Studies in Higher Education*, Vol. 43 No. 10, pp. 1750-1762, doi: 10.1080/03075079.2018.1520416.

Lauder, A., Sari, R.F., Suwartha, N. and Tjahjono, G. (2015), "Critical review of a global campus sustainability ranking: GreenMetric", *Journal of Cleaner Production*, Vol. 108, pp. 852-863, doi: 10.1016/j.jclepro.2015.02.080.

Levin, A., Lin, C.-F. and James Chu, C.-S. (2002), "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, Vol. 108 No. 1, pp. 1-24, doi: 10.1016/S0304-4076(01)00098-7.

Locke, W. (2014), "The intensification of rankings logic in an increasingly marketised higher education environment", *European Journal of Education*, Vol. 49 No. 1, pp. 77-90, doi: 10.1111/ejed.12060.

Lozano, R. (2006), "A tool for a graphical assessment of sustainability in universities (GASU)", *Journal of Cleaner Production*, Vol. 14 Nos 9-11, pp. 963-972, doi: 10.1016/j.jclepro.2005.11.041.

Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F.J., Waas, T., Lambrechts, W., Lukman, R. and Hugé, J. (2015), "A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey", *Journal of Cleaner Production*, Vol. 108, pp. 1-18, doi: 10.1016/j.jclepro.2014.09.048.

Lukman, R. and Glavič, P. (2007), "What are the key elements of a sustainable university?", *Clean Technologies and Environmental Policy*, Vol. 9 No. 2, pp. 103-114, doi: 10.1007/s10098-006-0070-7.

Marginson, S. (2007), “Global university rankings: implications in general and for Australia”, *Journal of Higher Education Policy and Management*, Vol. 29 No. 2, pp. 131-142, doi: 10.1080/13600800701351660.

Markard, J., Raven, R. and Truffer, B. (2012), “Sustainability transitions: an emerging field of research and its prospects”, *Research Policy*, Vol. 41 No. 6, pp. 955-967, doi: 10.1016/j.respol.2012.02.013.

Marginson, S. and Van Der Wende, M. (2007), “To rank or to Be ranked: the impact of global rankings in higher education”, *Journal of Studies in International Education*, Vol. 11 Nos 3-4, pp. 306-329, doi: 10.1177/1028315307303544.

Martins, L.L. (2005), “A model of the effects of reputational rankings on organizational change”, *Organization Science*, Vol. 16 No. 6, pp. 701-720, doi: 10.1287/orsc.1050.0144.

Miller, K., Cunningham, J. and Lehmann, E. (2021), “Extending the university mission and business model: influences and implications”, *Studies in Higher Education*, Vol. 46 No. 5, pp. 915-925, doi: 10.1080/03075079.2021.1896799.

Moed, H.F. (2005), *Citation Analysis in Research Evaluation*, *Information Science and Knowledge Management*, Springer, Dordrecht [Great Britain].

Moggi, S. (2023), “Sustainability reporting, universities and global reporting initiative applicability: a still open issue”, *Sustainability Accounting, Management and Policy Journal*, Vol. 14 No. 4, pp. 699-742, doi: 10.1108/sampj-05-2022-0257.

Nassa, A.K. and Arora, J. (2021), “Revisiting ranking of academic institutions”, *DESIDOC Journal of Library and Information Technology*, Vol. 41 No. 1, pp. 5-19, doi: 10.14429/djlit.41.1.16673.

Nõmm, K. and Randma-Liiv, T. (2012), “Performance measurement and performance information in new democracies: a study of the Estonian Central government”, *Public Management Review*, Vol. 14 No. 7, pp. 859-879, doi: 10.1080/14719037.2012.657835.

O’Connell, C. and Saunders, M. (2013), “Mediating the use of global university rankings: perspectives from education facilitators in an international context”, *Journal of Studies in International Education*, Vol. 17 No. 4, pp. 354-376, doi: 10.1177/1028315312453743.

Olcay, G.A. and Bulu, M. (2017), “Is measuring the knowledge creation of universities possible? A review of university rankings”, *Technological Forecasting and Social Change*, Vol. 123, pp. 153-160, doi: 10.1016/j.techfore.2016.03.029.

Oliver, C. (1991), “Strategic responses to institutional processes”, *The Academy of Management Review*, Vol. 16 No. 1, p. 145, doi: 10.2307/258610.

Otto, J.M., Zarrin, M., Wilhelm, D. and Brunner, J.O. (2021), “Analyzing the relative efficiency of internationalization in the university business model: the case of Germany”, *Studies in Higher Education*, Vol. 46 No. 5, pp. 938-950, doi: 10.1080/03075079.2021.1896801.

Pollock, N., D’Adderio, L., Williams, R. and Leforestier, L. (2018), “Conforming or transforming? How organizations respond to multiple rankings”, *Accounting, Organizations and Society*, Vol. 64, pp. 55-68, doi: 10.1016/j.aos.2017.11.003.

Prior, D.D., Mysore Seshadrinath, S., Zhang, M. and McCormack, M. (2024), “Measuring sustainable development goals (SDGs) in higher education through semantic matching”, *Studies in Higher Education*, Vol. 50 No. 7, pp. 1-14, doi: 10.1080/03075079.2024.2386625.

Ragazzi, M. and Ghidini, F. (2017), “Environmental sustainability of universities: critical analysis of a green ranking”, *Energy Procedia*, Vol. 119, pp. 111-120, doi: 10.1016/j.egypro.2017.07.054.

Raman, R., Lathabhai, H., Pattnaik, D., Kumar, C. and Nedungadi, P. (2024), “Research contribution of bibliometric studies related to sustainable development goals and sustainability”, *Discover Sustainability*, Vol. 5 No. 1, p. 7, doi: 10.1007/s43621-024-00182-w.

Rau, H., Goggins, G. and Fahy, F. (2018), "From invisibility to impact: recognising the scientific and societal relevance of interdisciplinary sustainability research", *Research Policy*, Vol. 47 No. 1, pp. 266-276, doi: 10.1016/j.respol.2017.11.005.

Rindova, V.P., Martins, L.L., Srinivas, S.B. and Chandler, D. (2018), "The good, the bad, and the ugly of organizational rankings: a multidisciplinary review of the literature and directions for future research", *Journal of Management*, Vol. 44 No. 6, pp. 2175-2208, doi: 10.1177/0149206317741962.

Sacchi, A., Molino, M., Dansero, E., Rossi, A.A. and Ghislieri, C. (2023), "How sustainable is the governance for sustainability in higher education? Insights from an Italian case study", *International Journal of Sustainability in Higher Education*, Vol. 24 No. 8, pp. 1970-1990, doi: 10.1108/IJSHE-08-2022-0254.

Saisana, M., d'Hombres, B. and Saltelli, A. (2011), "Rickety numbers: volatility of university rankings and policy implications", *Research Policy*, Vol. 40 No. 1, pp. 165-177, doi: 10.1016/j.respol.2010.09.003.

Shore, C. and Wright, S. (2015), "Audit culture revisited: rankings, ratings, and the reassembling of society", *Current Anthropology*, Vol. 56 No. 3, pp. 421-444, doi: 10.1086/681534.

Sierra-García, L., Gambetta, N., Azcarate Llanes, F. and García Benau, M.A. (2024), "The academic quality of universities and its contribution to the sustainable development goals", *International Journal of Sustainability in Higher Education*, Vol. 25 No. 8, pp. 1854-1869, doi: 10.1108/IJSHE-07-2023-0290.

Siler, K. and Larivière, V. (2022), "Who games metrics and rankings? Institutional niches and journal impact factor inflation", *Research Policy*, Vol. 51 No. 10, p. 104608, doi: 10.1016/j.respol.2022.104608.

Sine, W.D., Shane, S. and Gregorio, D.D. (2003), "The halo effect and technology licensing: the influence of institutional prestige on the licensing of university inventions", *Management Science*, Vol. 49 No. 4, pp. 478-496, doi: 10.1287/mnsc.49.4.478.14416.

Smolennikov, D., Makarenko, I., Bacho, R., Makarovych, V., Oleksich, Z., Gorodysky, M. and Polishchuk, I. (2024), "Do higher education institutions contribute to countries' SDG progress: evidence from university rankings", *Knowledge and Performance Management*, Vol. 8 No. 1, pp. 133-148, doi: 10.21511/kpm.08(1).2024.10.

Söderlind, J. and Geschwind, L. (2019), "Making sense of academic work: the influence of performance measurement in Swedish universities", *Policy Reviews in Higher Education*, Vol. 3 No. 1, pp. 75-93, doi: 10.1080/23322969.2018.1564354.

Soh, K.C. (2012), "Simpson's paradox and confounding factors in university rankings: a demonstration using QS 2011–12 data", *European Journal of Higher Education*, Vol. 2 No. 4, pp. 389-402, doi: 10.1080/21568235.2012.743223.

Spence, M. (1973), "Job market signaling", *The Quarterly Journal of Economics*, Vol. 87 No. 3, p. 355, doi: 10.2307/1882010.

Stephens, J.C., Hernandez, M.E., Román, M., Graham, A.C. and Scholz, R.W. (2008), "Higher education as a change agent for sustainability in different cultures and contexts", *International Journal of Sustainability in Higher Education*, Vol. 9 No. 3, pp. 317-338, doi: 10.1108/14676370810885916.

Suwartha, N. and Sari, R.F. (2013), "Evaluating UI GreenMetric as a tool to support green universities development: assessment of the year 2011 ranking", *Journal of Cleaner Production*, Vol. 61, pp. 46-53, doi: 10.1016/j.jclepro.2013.02.034.

Ter Bogt, H.J. and Scapens, R.W. (2012), "Performance management in universities: effects of the transition to more quantitative measurement systems", *European Accounting Review*, pp. 1-47, doi: 10.1080/09638180.2012.668323.

Thornton, D.L. and Batten, D.S. (1985), "Lag-Length selection and tests of granger causality between money and income", *Journal of Money, Credit and Banking*, Vol. 17 No. 2, p. 164, doi: 10.2307/1992331.

Tóth, B., Motahari-Nezhad, H., Horseman, N., Berek, L., Kovács, L., Hölgyesi, Á., Péntek, M., Mirjalili, S., Gulácsi, L. and Zrubka, Z. (2024), "Ranking resilience: assessing the impact of scientific performance and the expansion of the times higher education word university rankings on the position of Czech, Hungarian, polish, and Slovak universities", *Scientometrics*, Vol. 129 No. 3, pp. 1739-1770, doi: 10.1007/s11192-023-04920-1.

Trencher, G., Yarime, M., McCormick, K.B., Doll, C.N.H. and Kraines, S.B. (2014), "Beyond the third mission: exploring the emerging university function of co-creation for sustainability", *Science and Public Policy*, Vol. 41 No. 2, pp. 151-179, doi: 10.1093/scipol/sct044.

Triventi, M. and Trivellato, P. (2012), "Does graduating from a private university make a difference? Evidence from Italy", *European Journal of Education*, Vol. 47 No. 2, pp. 260-276, doi: 10.1111/j.1465-3435.2012.01522.x.

Urdari, C., Farcas, T.V. and Tiron-Tudor, A. (2017), "Assessing the legitimacy of HEIs' contributions to society: the perspective of international rankings", *Sustainability Accounting, Management and Policy Journal*, Vol. 8 No. 2, pp. 191-215, doi: 10.1108/SAMPJ-12-2015-0108.

Velazquez, L., Munguia, N., Platt, A. and Taddei, J. (2006), "Sustainable university: what can be the matter?", *Journal of Cleaner Production*, Vol. 14 Nos 9-11, pp. 810-819, doi: 10.1016/j.jclepro.2005.12.008.

Vernon, M.M., Balas, E.A. and Momani, S. (2018), "Are university rankings useful to improve research? A systematic review", *PLOS ONE*, Vol. 13 No. 3, p. e0193762, doi: 10.1371/journal.pone.0193762.

Waas, T., Verbruggen, A. and Wright, T. (2010), "University research for sustainable development: definition and characteristics explored", *Journal of Cleaner Production*, Vol. 18 No. 7, pp. 629-636, doi: 10.1016/j.jclepro.2009.09.017.

Waddock, S. (2008), "Building a new institutional infrastructure for corporate responsibility", *Academy of Management Perspectives*, Vol. 22 No. 3, pp. 87-108, doi: 10.5465/amp.2008.34587997.

Waltman, L., Van Eck, N.J., Van Leeuwen, T.N., Visser, M.S. and Van Raan, A.F.J. (2011), "Towards a new crown indicator: some theoretical considerations", *Journal of Informetrics*, Vol. 5 No. 1, pp. 37-47, doi: 10.1016/j.joi.2010.08.001.

Appendix

Tables A1 and A2 report the results on the causal impact of sustainability performance on ranking using two alternative specifications. Table A1 presents estimates based on an OLS model instead of a Tobit model, while Table A2 excludes first differences and includes university fixed effects. The findings confirm that sustainability performance has a causal impact on ranking.

Tables A3 and A4 also test the causal impact of ranking on sustainability performance using two alternative specifications. Table A3 removes first differences and includes university fixed effects, whereas Table A4 examines this relationship while excluding the policy variables (RUS and PNRR). These findings corroborate the causal impact of ranking on sustainability performance and, together with the previous tables, support the existence of a bidirectional relationship between ranking and performance.

Table A5 shows a test for the citations and sustainability patents due to make a sensitivity analysis around the negative result. Column (1) and column (2) test different lag of the ranking on the number of citations obtained by sustainability papers. The results remain robust even if considering the ranking variables lagged respectively of two and three periods. Column (3) shows a falsification test for patents by considering as dependent variables nonsustainable patents. The fact that ranking in this case is not significant confirms the validity of our results.

Table A1. Robustness check: causal impact of sustainability performance on sustainability ranking

Variables	(1) Ranking	(2) Ranking	(3) Ranking	(4) Ranking	(5) Ranking
$Ranking_{t-1}$	0.160*** (0.0372)	0.180*** (0.0364)	0.152*** (0.0367)	0.345*** (0.0572)	0.118*** (0.0366)
$Ranking_{t-2}$	0.290*** (0.0379)	0.270*** (0.0365)	0.295*** (0.0370)	0.240*** (0.0518)	0.313*** (0.0365)
$Ranking_{t-3}$	0.0162 (0.0386)	0.0224 (0.0382)	0.0207 (0.0382)		0.0570 (0.0380)
Sustainability performance	Sustainability courses	Sustainability publications	Citations	Sustainability spinoffs	GreenPatents
Sustainability $performance_{t-1}$	0.0270** (0.0109)	0.258 (0.976)	0.0130 (0.0144)	−0.0295 (0.0184)	0.0563*** (0.0126)
Sustainability $performance_{t-2}$	0.0124 (0.0129)	−4.353*** (0.993)	0.0380** (0.0169)	−0.0240 (0.0183)	0.0809*** (0.0144)
Sustainability $performance_{t-3}$	−0.00823 0.0151	4.610*** 0.0137	−0.00973 0.0165	0.0212 0.0222	0.0341** 0.0136
$Size_{t-1}$	(0.0136) 0.0547	(0.0128) 0.0378	(0.0136) 0.0519	(0.0139) 0.0152	(0.0134) 0.0559
THE-$dummy_{t-1}$	(0.0434) 0.415	(0.0417) 0.348	(0.0433) 0.220	(0.0485) 0.595	(0.0426) 0.256
STEM-faculty $ratio_{t-1}$	(0.936) 0.0406	(0.908) 0.0192	(0.934) 0.0253	(1.393) 0.0138	(0.916) 0.0297
$Tuition_{t-1}$	(0.0441) 0.0151	(0.0429) 0.0137	(0.0439) 0.0165	(0.0803) 0.0222	(0.0430) 0.0136
Constant	0.0407 (0.0339)	0.0221 (0.0137)	0.0380 (0.0336)	0.0244 (0.0343)	0.0399 (0.0330)
Year dummy	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.158	0.169	0.161	0.159	0.190

Note(s): This table reports the first robustness check of the causal impact of sustainability performance on sustainability ranking using an OLS model in first differences, which also accounts for fixed effects, instead of a Tobit model. Variables are lagged by three periods, except in Model 4, which uses only Two lags due to the shorter period (2010–2019). Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table A2. Robustness check: causal impact of sustainability performance on sustainability ranking

Variables	(1) Ranking	(2) Ranking	(3) Ranking	(4) Ranking	(5) Ranking
$Ranking_{t-1}$	0.970*** (0.0350)	1.149*** (0.0340)	1.139*** (0.0349)	1.262*** (0.0438)	1.111*** (0.0349)
$Ranking_{t-2}$	0.131*** (0.0489)	0.0628 (0.0509)	0.0746 (0.0521)	−0.00335 (0.0538)	0.104** (0.0514)
$Ranking_{t-3}$	−0.230*** (0.0379)	−0.204*** (0.0393)	−0.216*** (0.0399)		−0.214*** (0.0393)
Sustainability performance	Sustainability courses	Sustainability publications	Citations	Sustainability spinoffs	GreenPatents
Sustainability $performance_{t-1}$	0.0287*** (0.0103)	−1.999* (1.080)	0.0238* (0.0144)	−0.0378** (0.0179)	0.0562*** (0.0123)
Sustainability $performance_{t-2}$	−0.0119 (0.0123)	−5.617*** (1.236)	0.0309** (0.0148)	−0.00960 (0.0176)	0.0260** (0.0132)
Sustainability $performance_{t-3}$	−0.0247** (0.0124)	9.145*** (1.330)	−0.0298** (0.0142)	0.00622 (0.0402)	−0.0429*** (0.0127)
$Size_{t-1}$	0.00774 (0.00518)	0.00214*** (0.000631)	0.00102 (0.000756)	0.00227*** (0.000584)	0.00130** (0.000587)
THE-$dummy_{t-1}$	0.0103 (0.0319)	−0.0178 (0.0233)	−0.0238 (0.0253)	−0.0664** (0.0258)	−0.0234 (0.0248)
STEM-faculty $ratio_{t-1}$	0.528 (0.623)	0.0681 (0.0511)	0.0433 (0.0510)	0.0519 (0.0500)	−0.00244 (0.0515)
$Tuition_{t-1}$	0.0871*** (0.0312)	0.0105** (0.00467)	0.0110** (0.00472)	0.00584 (0.00490)	0.00887* (0.00468)
Constant	0.0287*** (0.0103)	0.0287*** (0.0103)	0.0287*** (0.0103)	0.0287*** (0.0103)	0.0287*** (0.0103)
Year dummy	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.99	0.92	0.92	0.99	0.93

Note(s): This table reports the second robustness check of the causal impact of sustainability performance on sustainability ranking using a Tobit model with university fixed effects instead of differenced variables. Variables are lagged by three periods, except in Model 4, which uses only Two lags due to the shorter period (2010–2019). Standard errors are in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table A3. Robustness check: causal impact of sustainability ranking on sustainability performance

Variables	(1) Sustainability courses	(2) Sustainability publications	(3) Citations	(4) Sustainability spinoffs	(5) Sustainability patents
Sustainability performance$_{t-1}$	0.498*** (0.0407)	0.488*** (0.0389)	0.119*** (0.0371)	−0.0749* (0.0440)	0.235*** (0.0366)
Sustainability performance$_{t-2}$	0.0296 (0.0486)	0.463*** (0.0437)	−0.0247 (0.0369)	−0.0919** (0.0452)	−0.0531 (0.0377)
Sustainability performance$_{t-3}$	−0.105** (0.0488)	0.292*** (0.0476)	−0.0808** (0.0359)	−0.0613 (0.0446)	−0.187*** (0.0365)
Ranking$_{t-1}$	0.246* (0.138)	2.252* (1.277)	184.3** (89.44)	0.0654 (0.120)	0.108 (0.102)
Ranking$_{t-2}$	−0.294 (0.193)	−5.838*** (1.768)	−58.72 (122.9)	−0.199 (0.197)	−0.0301 (0.135)
Ranking$_{t-3}$	0.271* (0.150)	6.853*** (1.389)	−248.7** (96.59)	0.110 (0.154)	−0.405*** (0.109)
Size$_{t-1}$	−0.0154 (0.0204)	0.236 (0.192)	−23.47* (13.42)	−0.0149 (0.0170)	0.0263* (0.0149)
THE-dummy$_{t-1}$	−0.252** (0.126)	−0.478 (1.175)	130.4 (81.97)	−0.238*** (0.0902)	0.0715 (0.0899)
STEM-faculty ratio$_{t-1}$	0.710 (2.460)	32.05 (23.15)	2,332 (1,613)	2.920 (2.753)	−0.492 (1.768)
Tuition$_{t-1}$	−0.260** (0.123)	0.178 (1.174)	−22.72 (81.43)	−0.0257 (0.139)	0.0155 (0.0883)
RUS	−0.394** (0.178)	4.388** (1.774)	1,095*** (122.3)	−0.170 (0.111)	0.171 (0.127)
PNRR	1.811*** (0.178)	−5.044*** (1.680)	−1,205*** (113.0)		−0.281** (0.121)
Constant	3.370* (1.750)	−18.55 (16.35)	2,165* (1,142)	0.882 (1.520)	−1.170 (1.255)
Year-Dummy	Yes	Yes	Yes	Yes	Yes
R-squared	0.888	0.967	0.699	0.322	0.621

Note(s): This table reports the robustness check of the causal impact of sustainability ranking on sustainability performance using an OLS regression with variables in first differences without considering the impact of policies. Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table A4. Robustness check: causal impact of sustainability ranking on sustainability performance

Variables	(1) Sustainability courses	(2) Sustainability publications	(3) Citations	(4) Sustainability spinoffs	(5) Sustainability patents
Sustainability performance$_{t-1}$	−0.307*** (0.0399)	−0.110*** (0.0389)	−0.594*** (0.0372)	−0.697*** (0.0437)	−0.447*** (0.0358)
Sustainability performance$_{t-2}$	−0.173*** (0.0474)	0.417*** (0.0406)	−0.425*** (0.0436)	−0.432*** (0.0485)	−0.296*** (0.0410)
Sustainability performance$_{t-3}$	−0.185*** (0.0555)	0.412*** (0.0470)	−0.306*** (0.0438)	−0.194*** (0.0422)	−0.307*** (0.0385)
Ranking$_{t-1}$	0.203 (0.137)	4.348*** (1.417)	153.0 (94.89)	0.0761 (0.122)	−0.0193 (0.104)
Ranking$_{t-2}$	−0.228 (0.139)	−3.536** (1.433)	−18.59 (95.67)	−0.0390 (0.158)	−0.224** (0.104)
Ranking$_{t-3}$	0.257* (0.142)	5.715*** (1.488)	−220.5** (98.74)	−0.177 (0.147)	−0.476*** (0.108)
Size$_{t-1}$	0.0199 (0.0501)	0.775 (0.522)	−78.82** (35.13)	−0.0394 (0.0335)	0.00344 (0.0380)
THE-dummy$_{t-1}$	−0.220 (0.160)	−0.285 (1.655)	13.76 (112.1)	−0.0993 (0.112)	−0.0594 (0.121)
STEM-faculty ratio$_{t-1}$	−1.722 (3.444)	−11.14 (35.68)	3,862 (2,414)	2.768 (3.307)	0.160 (2.605)
Tuition$_{t-1}$	−0.0593 (0.162)	−2.074 (1.683)	−2.123 (113.5)	−0.225 (0.187)	0.0674 (0.122)
Constant	−0.00373 (0.125)	2.103 (1.297)	139.0 (86.87)	0.0235 (0.0680)	−0.113 (0.0938)
Year-Dummy	Yes	Yes	Yes	Yes	Yes
R-squared	0.266	0.299	0.363	0.385	0.234

Note(s): This table reports the robustness check of the causal impact of sustainability ranking on sustainability performance using an OLS regression with university fixed effect without differences. Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table A5. Robustness test for citations and patents

Variables	(1) Citations	(2) Citations	(3) Patents
$Citations_{t-1}$	0.126 (0.100)	0.224 (0.243)	
$Patents_{t-1}$			0.255** (0.122)
$Ranking_{t-1}$			0.961 (1.053)
$Ranking_{t-2}$	−759.1** (311.8)		
$Ranking_{t-3}$		−643.3** (309.4)	
$Size_{t-1}$	−0.0330 (0.0420)	−0.0116 (0.0627)	0.000638 (0.000429)
STEM-faculty $ratio_{t-1}$	−1,343 (2,443)	−849.4 (2,207)	−96.38 (66.17)
$Tuition_{t-1}$	0.104 (0.0753)	0.0372 (0.0921)	−0.0189 (0.0185)
THE-$dummy_{t-1}$	108.8 (182.8)	246.1 (203.0)	0.775 (0.788)
Year dummy	Yes	Yes	Yes
Arellano-Bond test AR(1)	−3.07***	−1.95**	−2.31**
Arellano-Bond test AR(2)	0.17	0.43	1.42
Hansen test	30.8	41.8	24.3

Note(s): This table reports the robustness check for citations and patents using GMM system model. Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Corresponding author
Chiara Alberti can be contacted at: chiara.alberti@unibg.it