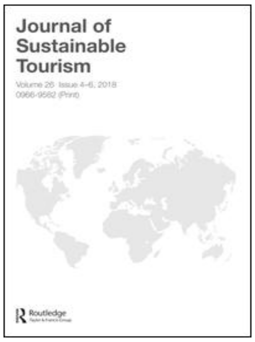

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How use of knowledge sources influences eco-innovation in the tourism sector through product innovation and/or process innovation

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ABSTRACT
Although studies that analyze eco-innovation without differentiating among industries are proliferating, research has not yet identified the factors that lead to eco-innovation in tourism sector firms. Since innovation in general is nourished by access to knowledge sources and the intensity with which they are used, this study analyzes the effect of intensive use of knowledge sources on eco-innovation in the tourism sector. It also analyzes the possible mediating role of traditional orientation of the firm in product innovation and/or process innovation.
We use two data sources: panel data from Spain's National Statistics Institute on 199 tourism firms for 2011-2015 and primary data gathered from a set of 198 tourism firms collected separately via questionnaire in 2021 during the Covid-19 pandemic. The second dataset, which was collected independently of the first, aims to corroborate the results of the first in a different economic context and different firms.
Our results indicate a significant distinction between product/service and process innovation. The findings show that that tourism firms rely on process innovation to implement eco-innovation, whereas product innovation has no influence in these firms in any of the years analyzed.

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KEYWORDS
Process innovation; product innovation; knowledge use; eco-innovation; tourism sector

Introduction

Organizations increasingly promote behavior committed to preserving the environment (Tseng et al., 2013), and the tourism sector is no exception. Eco-innovation has been gaining ground in the business world due to very diverse factors, such as greater pressure from governments, financing of projects that respect the environment, and greater customer awareness (Kuo et al., 2022). This shift indicates that a significant percentage of firms' innovations now consider their impact on the natural environment. Innovations may, for example, reduce nonrenewable energy consumption, or improve health and safety requirements. In tourism, hotels increasingly tell customers of the measures the hotel takes to be more respectful of the social demand for eco-friendly business practice. Although eco-innovations are important in making firms competitive and such innovations have been studied extensively in industrial sectors (García-Pozo et al., 2016), tourism eco-innovation has hardly been analyzed (Alonso-Almeida et al., 2016; Wang et al., 2020). Such analysis is needed because the industry-specific nature of eco-innovation

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requires analysis in each industry (Alos-Simo et al., 2020). Eco-innovation research on hospitality businesses is especially difficult, however, due to the sector's specific characteristics (García-Pozo et al., 2016). Not only must academia work to explain how firms eco-innovate in this sector, but the hospitality managers and practitioners must understand the practical implications of their eco-innovations to learn how to eco-innovate. Further, as governments frequently promote eco-innovation through subsidies and funding, specific studies of different industrial sectors could determine how to use public resources most efficiently/effectively in each sector.

This study defines eco-innovation as "any innovation that makes progress towards the goal of sustainable development by reducing impacts on the environment, increasing resilience to environmental pressures or using natural resources more efficiently and responsibly" (European Commission, 2012, p. 2, adapted from Decision No. 1639/2006/EC establishing a Competitiveness and Innovation Framework Programme). Eco-innovation thus involves either novel production and assimilation of a product/service or process, or management action that reduces environmental and other negative impacts (Kemp & Pearson, 2007), while seeking both ecological and economic gain (Carrillo-Hermosilla et al., 2010; Segarra-Ciprés et al., 2014). Eco-innovation is fundamentally similar to alternative notions such as "green innovation", "environmental innovation", and "sustainable innovation", with only "minor conceptual differences" (Schiederig et al., 2012, p.188). Despite this similarity, our study is grounded mainly in the eco-innovation literature.

Singal (2015) argues that tourism differs from other industries in having greater leverage, capital intensity, and competitive rivalry and that these characteristics explain differences in tourism firms' decision-making and outcomes. Such characteristics could influence how tourism firms adopt eco-innovation. The knowledge-based view of the firm (Kogut & Zander, 1992) argues that knowledge use is a key factor in both successful eco-innovation (Ghisetti et al., 2015) and sustainability in the tourism sector (Martínez-Martínez et al., 2023). In contrast to other sectors, however, examples from tourism show that technological knowledge management tools do not positively impact sustainability transitions in tourism (e.g. Buijtendijk et al., 2018). These different results may occur because service firms' innovation processes access knowledge less formally and homogeneously than do manufacturing firms (Christensen, 2008).

Because service innovation is also less concrete and explicit than innovation in non-service sectors (Miles, 2003; Pikkemaat et al., 2019), tourism firms do not always manage innovation properly (Hjalager, 2002, 2010). Having a climate of innovation—defined following Damanpour's (2010) classical distinction between product and/or process innovation—could thus facilitate eco-innovation. Hjalager (2010) argues that product innovation in tourism makes changes that customers perceive as new, whereas process innovation in this sector changes internal activities and produces novelties to improve efficiency and productivity. In the hospitality sector, for example, both process innovation (e.g. hotel reservations via digital technology) and product innovation (e.g. increasingly specialized sale of products that provide experiences, cultural packages, itineraries based on gastronomy, historical heritage) been in constant evolution (De la Peña et al., 2016). The dynamic effects of process and product innovation have received little analysis (Bondarev, 2012), and the most recent research on technological innovation has neglected the innovation needs of tertiary sectors (Stare & Križaj, 2018).

Based on the foregoing, we consider the possible mediation of alternatives (process and product innovation) in the relationship between intensive use of knowledge sources and the tourism firm's eco-innovation. As mediation may be due to firms' orientation to innovation and resulting commitment to sustainability as an innovative element in the organization, we seek to determine both the importance of eco-innovation (Alonso-Almeida et al., 2016) and the way eco-innovation is driven by knowledge and innovation in the tourism sector (Baggio & Cooper, 2010). Our analysis is empirical and longitudinal. This article seeks to determine, first, whether intensity of knowledge use influence eco-innovation through process and/or product innovation and, second, whether the influence of intensive knowledge use continues over time in either or both these types of innovation. To identify the factors determining these two paths of influence in tourism, we perform two studies with two different databases. The first study uses questions on innovation from the Oslo Manual (OECD, 2005) to perform two analyses, one of panel data from 199 tourism firms and their behavior over a 5-year period (2011-2015) and the other of primary data gathered in July 2021 from 198 tourism firms. The second study uses questions on tourism-specific innovation and primary data gathered from 198 firms in 2021. Significantly, data collection for this second database was performed in a context of crisis, the Covid-19 pandemic, which impacted tourism sector intensely (Jaaron et al., 2023). In investigating the effects of innovation on tourism in the complex, crisis-ridden context of the pandemic, we also test whether tourism firms remain committed to eco-innovation and whether this commitment differs in periods with or without crisis.

Influence of use of knowledge sources on eco-innovation

Knowledge is a decisive factor in organizations' value creation (Tsou et al., 2016). Although knowledge enables differentiation, survival, and thus competitive advantage (Wiklund & Shepherd, 2003), it is difficult to define due to its dynamicity and multi-faceted character (Rasmussen & Haggerty, 2008). This study defines knowledge as "information combined with experience, context, interpretation, and reflection" (Davenport et al., 1988). Knowledge sources act when individuals voluntarily access unfamiliar experiences, understandings, and opinions (Gray & Meister, 2004).

The knowledge-based view of the firm argues that the organization's essence is to create, transfer, and transform knowledge to generate competitive advantage (Kogut & Zander, 1992). An intangible resource (Amit & Schoemaker, 1993), knowledge is invisible and abstract, requiring application and materialization. Technological advances and intense changes in environments require firms to manage their knowledge (Intezari et al., 2017). While considered the most strategic resource (Grant, 1996; Roth, 2003), knowledge is unique and different for each organization. It is valuable for customers, non-substitutable, and difficult to imitate (Rugman & Verbeke, 2002), and has specific qualities that differentiate it from physical resources. It can be used simultaneously and variously (Wilcox King & Zeithaml, 2003), does not depreciate with use (Stewart, 1998), and can be expanded and extended throughout the organization. The more intensively knowledge is used, the more prior knowledge combines with other knowledge to generate new knowledge (Gratton & Ghoshal, 2003).

Knowledge must be recombined for sustainability-oriented innovation (Martínez-Ros & Kunapatarawong, 2019), as new processes or systems that reduce, anticipate, or prevent environmental damage are key to eco-innovation (Kammerer, 2009). Eco-innovation management has been hailed as a "win-win" strategy that benefits both environment and firm (Ghisetti et al., 2015) because it combines innovation processes with environmentally sustainable practices (Wu et al., 2019). As a type of innovation that introduces organizational, technical, or production novelties while reducing environmental risk (Alos-Simo et al., 2020), eco-innovation is generated in more demanding, complex contexts than traditional innovation (De Marchi, 2012).

Although eco-innovation is based primarily on resources and capabilities that emerge through knowledge (Cagliano & Behnam, 2019), access to information and knowledge does not ensure their use and application (Staats et al., 2014). In the context of eco-innovation, therefore, firms must train and educate employees in sustainable competences (Arnold & Hockerts, 2011). Tourism research shows that sustainable environmental strategies affect eco-innovation positively (Kuo et al., 2022), but research in sustainable management stresses the need to expand and deepen perspectives adopted from analyzing eco-innovation (Kemp & Pearson, 2007). If innovation in tourism poses a new idea to solve a problem (Bagiran Ozseker, 2019) and eco-innovation improves on this solution by incorporating environmental responsibility (Pacheco et al., 2017), firms that eco-innovate must intensify their knowledge use to improve their handling of the complex, uncertain aspects of the new process (Cainelli et al., 2015).

Based on these arguments, we formulate the following hypothesis:

H1: Intensity of use of knowledge sources positively and significantly influences eco-innovation in the tourism sector.

Influence of product innovation strategy on the relationship between use of knowledge sources and eco-innovation

We define product/service innovation as production or adoption of a new element that generates social or economic added value by renovating products, services, the market, and/or production methods and management systems (Crossan & Apaydin, 2010). This definition includes the classical distinction between product/service innovation and process innovation (Bondarev, 2012). Since product and service innovation introduce new elements into the firm's manufacturing or service operations to develop a product or deliver a service (Damanpour, 2010), customers' needs intertwine with technological innovation trajectories (Raymond et al., 2010).

Although creating new products and services involves the same steps to renew, create, integrate, and transform knowledge acquired (Ordanini & Parasuraman, 2011), innovation is less visible and tangible in services, making innovation in this sector more difficult to measure and conceptualize (Miles, 2003). This difference stems from the nature of knowledge in the service sector. Knowledge can be tacit (implicit) or explicit (Nonaka, 1994). Because tacit knowledge is embedded in actions, routines, values, ideals, and procedures (Nonaka & von Krogh, 2009), it is difficult to formalize and communicate (Huang et al., 2014). Explicit knowledge, in contrast, can be codified, expressed, and systematized (Nonaka & von Krogh, 2009). Service firms typically have higher proportions of tacit knowledge than do other sectors.

Service innovation is also multidimensional; it may change the concept of service, communication systems, and/or presentation of a new service (Drejer, 2004). Product or service innovation in tourism "refer[s] to changes directly observed by the customer and regarded as new; either in the sense of never seen before, or new to the particular enterprise or destination" (Hjalager, 2010, p. 2). When service firms innovate, they seek and acquire knowledge in a more complex, informal way (Christensen, 2008). Tourism innovation thus produces a distinctive tourist product or service with highly varied components (Stare & Križaj, 2018) by adding new attributes or recombining existing ones (Divisekera & Nguyen, 2018).

In the tourism sector, eco-innovation is proactive in tackling sustainable and environmental challenges, recognizing trends in the environment and seeking to reduce its impact on them (Khanna et al., 2009). Tourism firms strengthen the relationship between knowledge and eco-innovation through new product development (Eiadat et al., 2008). The sector has tackled challenges such as energy efficiency, reduction of water consumption, waste management, and protection of biodiversity (World Tourism Organization, 2022). Because eco-innovation is very sensitive to reduction of cost to the environment (Reinhardt, 1998), it emerges fundamentally from use of knowledge sources. The knowledge sources that companies access enable them to renew, create, integrate, and transform the company's accumulated knowledge to create new products and services (Kogut & Zander, 1992; Ordanini & Parasuraman, 2011), and thus drive the changes customers perceive (Martínez-Ros & Kunapatarawong, 2019). Because innovation combines generation of the idea with its implementation (Anderson et al., 2014), knowledge is needed both to generate and to implement new ideas (Reilly, 2008).

Based on these arguments, we formulate the following hypothesis:

H2: Product innovation positively mediates the relationship between use of knowledge sources and eco-innovation in the tourism sector.

Influence of process innovation strategy on the relationship between use of knowledge sources and eco-innovation

Process innovation is very important for tourism (Hjalager, 2010). The persons primarily responsible for monitoring the knowledge absorption in process innovation are the firm's employees and internal departments (Damanpour, 2010). Since new ideas arise when the organization's members interact and share knowledge (Yao & Lee, 2016), service innovation requires employee commitment and customer participation (Souto, 2015). Acquired with practice and integrated into the tourism sector's innovation processes (Fuglsang & Sundbo, 2002), shared knowledge can create changes that enrich tourists' experiences and improve benefits for the agents affected (Hjalager, 2015). Such knowledge from employees and customers in turn generates new cognitive structures and activates internal knowledge to stimulate creativity (Wang et al., 2014).

Process innovation requires improving use of tacit knowledge (Snihur & Wiklund, 2019). Process innovation in tourism "refer[s] typically to backstage initiatives which aim at escalating efficiency, productivity and flow" (Hjalager, 2010, p. 2). Seeking greater efficiency, process innovation incorporates modifications into production or service routines (Trantopoulos et al., 2017) to improve methods, services, and product delivery (Orfila-Sintes & Mattsson, 2009). According to the knowledge-based view of the firm (Grant, 1996), managers combine knowledge obtained in various ways to design process innovation strategies (Li et al., 2013) by developing new procedures, techniques, or methods (Naranjo-Valencia et al., 2010). Such knowledge creation is performed within the firm (Linder & Sperber, 2019) and requires high-level absorptive capacity and internal training. It also requires the organization's members to be flexible and creative (Lyles & Salk, 2007). These general requirements for process innovation are also essential in the tourism sector.

As argued above, some authors believe that knowledge in the tourism sector resides in practice (Gherardi & Strati, 2012), particularly because tourism firms' innovations improve customers' experiences and the service delivered (Weidenfeld et al., 2010). As the firm's members are the source of key capabilities in the knowledge-based view of the firm (Kogut & Zander, 1992), firms that wish to stimulate eco-innovation must stimulate generation of new environmental innovation capabilities among their members (Amores-Salvadó et al., 2014). Stimulation of shared learning is also a strategic factor in tourism firms (Hoarau & Kline, 2014), and shared knowledge has positive effects on green innovation (Martínez-Ros & Kunapatarawong, 2019). A green perspective on innovation is essential to making the tourism sector responsible and sustainable (World Tourism Organization, 2022). Due to its complexity, eco-innovation requires different resources (Cainelli et al., 2015), as well as different technical and economic solutions and thus different knowledge use (Bossle et al., 2016). Eco-innovation is more complex because it is more demanding and competitive than traditional innovation (De Marchi, 2012). The tourism firm's traditional orientation to process innovation, which requires more employee commitment and customer participation in services (Yao & Lee, 2016; Fuglsang & Sundbo, 2002; Wang et al., 2014), could help reduce that complexity. Based on the foregoing, we expect eco-innovation to increase in the tourism sector when the firm is strongly oriented to process innovation and when such innovation requires significant stimulation of shared knowledge.

Based on these arguments, we formulate the following hypothesis:

> *H3: Process innovation positively mediates the relationship between use of knowledge sources and eco-innovation in the tourism sector.*

Research method

Sample

We focus on Spain because tourism is key to Spain's economic activity. According to National Statistics Institute (INE, 2019), tourism contributed 147,946 million euros (12.3%) of Spain's GDP in 2018, and the sector employed 2.62 million workers, or 12.7% of Spain's total employees. Spain's tourism sector has traditionally been oriented to international markets, and the country received 82,808 million tourists in 2018.

To make the empirical analysis more robust, our analysis uses two data sources, one secondary database (data from 2011-2015) and one primary database (data collected in 2021). The secondary data source is composed of panel data sampled from the Spanish Technological Innovation Panel (PITEC) database compiled by Spain's National Statistics Institute (INE, 2020). Based on the Community Innovation Survey (CIS), the PITEC data are collected following the methods proposed in the Oslo Manual (OECD, 2005). PITEC has collected data on innovation in Spain from over 12,000 firms in all industries since 2003. We selected a sample of 199 tourism firms and analyzed the sample data available from PITEC for the five years of the study, 2011-2015. Open microdata and longitudinal data collected during multiple periods were used to follow the same firms during these years (Peiró-Signes & Segarra-Oña, 2018; Rindfleisch et al., 2008). Because longitudinal study is based on repetitive testing of some variables from the same individuals within a specific period, the information was anonymized for use by external agents such as researchers.

Due to economic problems, PITEC has no data from subsequent years. To overcome this handicap and contrast the results from our analysis of the PITEC data, we developed a new study of 2021, based on primary data. Coincidentally, we performed this analysis in 2021, the year of the COVID-19 pandemic. The pandemic's dramatic effects on tourism in general and the Spanish sector in particular enabled us to include the factor of context. The powerful impact of COVID-19 may have changed managers' priorities and pre-COVID-19 tendency to focus on the innovation process, leading them to focus on product innovation, change their use of knowledge sources, and/or even support eco-innovation. As a second round of data collection in a different economic context could help us to evaluate the robustness of the first study's results, we based the study on primary data collected from tourism firms. We extracted a population of 2400 tourism firms at random from the SABI database, which contains financial information on 2.7 million Spanish and Portuguese firms and a 25-year history of annual accounts. It was not possible to use the same sample analyzed in the first (PITEC) study because those firms names were not available (as mentioned above, they were coded to preserve anonymity). We contacted the tourism firms for the second study by phone in July 2021 and obtained 198 responses, a satisfactory response rate (9.17%) comparable to the cooperation academic research typically obtains from firms in Spain (Camelo et al., 2004).

We then performed two analyses, using two questionnaires. Study 1 applied the questions in the Oslo Manual (OECD, 2005). Study 2 applied questions on product and process innovation specific to tourism. To determine whether the time elapsed and the sector's crisis during the pandemic changed the results, Study 1 performed two analyses, one of each database. Analysis A used panel data from PITEC (2011-2015) and Analysis B the primary data gathered during the pandemic (July 2021). As we were uncertain whether a questionnaire based on the Oslo Manual (OECD, 2005) suited the tourism sector's idiosyncrasies (Hjalager, 2010), Study 2 introduced complementary questions specific to the sector, using primary data collected in 2021. Sample selection in both studies was based on the National Classification of Economic Activities in Spain (CNAE) codes for Group 55 (lodging services) and Group 56 (food and beverage services).

Measurements

To evaluate our theoretical model, we extracted the following variables from the sample:

Eco-innovation

To measure eco-innovation, we used 3 items from the questionnaire that asked about environmental impact of the firm's policies, energy reduction per unit produced, and especially legal environmental requirements for health and safety. These variables are consistent with the European Commission's (2012) concept of eco-innovation, Carrillo-Hermosilla et al. (2010), and Segarra-Ciprés et al. (2014). They treat issues that seek to reduce impact on the environment, considering the legal framework and economic efficiency. Numerous recent studies also used these items as indicators of eco-innovation (Jove-Llopis & Segarra-Blasco, 2018; Peiró-Signes & Segarra-Oña, 2018; Arranz et al., 2019; Alos-Simo et al., 2020; Guisado-Gonzalez et al., 2021). The data covered the period 2011-2015. Eco-innovation was a categorical-ordinal variable with responses of 1 = "high," 2 = "medium," 3 = "low," and 4="not applicable." This variable was used for Studies 1 and 2.

Use of knowledge source

We used 4 items that asked about knowledge sources. The items referred specifically to source of information from team suppliers, material, components, and software; customers from the public and private sectors; and competitors or other firms in the same sector. The items requested information on innovation activities within the firm or group of firms (departments, employees, etc.). Responses ranged from 1="high," 2="medium," and 3="low" to 4="not applicable." This variable was also categorical-ordinal and used data from 2011-2015. It was employed in Studies 1 and 2.

Product/service innovation

Study 1 applied the 5 items on strategic product and service innovation outcomes for 2011-2015. It also asked whether these innovations included a wider range of goods or services, substitution of products, penetration of new markets, greater market share, and higher quality of goods or services. The responses indicated the items' degree of importance, ranging from 1="high," 2="medium," and 3="low" to 4="not applicable." Our literature review found that prior studies of product innovation had not asked questions specific to the tourism sector. (The Study 1 items on process innovation were more general, and PITEC applied them indiscriminately to all industries.) Study 2 thus both used the questions from the Oslo Manuel for all sectors and performed a second analysis with questions specific to the tourism sector in an effort to determine whether the variables behaved differently (see Table 1). Following Hjalager (2010) based on a selection of references, Study 2 used 7 questions specific to tourism. Responses ranged from 1="not at all" to 7="greatly." As this alternative measurement of product innovation provided a detailed view specific to the tourism industry, it helped us understand the nature of this particular antecedent of eco-innovation.

Process innovation

For Study 1, we adopted the 5 items on orientation to process innovation, with response options 1="high," 2="medium," 3="low," and 4="not applicable." The variable asked about greater flexibility in production or service delivery, greater capability for production or delivery of services, lower labor costs per unit produced, fewer materials per production unit, and lower energy per unit produced. Prior studies have used this variable to measure orientation to processes (Peiró-Signes & Segarra-Oña, 2018). As our prior literature review advised including a specific tool to study process innovation, we thought it beneficial in Study 2 to include 3 additional questions on the tourism industry. We chose questions proposed by Hjalager (2010) and based on prior studies. The responses ranged from 1="not at all" to 7="to a great extent." As with product innovation, this measure provided a detailed view specific to the tourism industry, helping us to understand this particular antecedent of eco-innovation.

Figure 1 shows the hypotheses proposed and the relationship among the variables studied in the three models.

Table 1. Specific questions for process and product innovation in the tourism sector for Study 2.

Process innovation in the period …
1. During this period, the tourism organization made changes in structures to increase efficiency, productivity, and workflow.
2. The tourism firm invested in technology to speed up and improve the services delivered to customers.
3. The tourism organization implemented improvements in management strategy, such as human resources management and management of competences.
4. The tourism firm applied new technologies to speed up processes and provide better, faster services.
5. The tourism firm implemented new technological processes to reduce labor.
6. The tourism firm implemented new technological processes to improve remediation.
7. The tourism firm implemented new technological processes to provide faster, more flexible service.
Product/service innovation in the period …
1. Customers consider the changes made to be new, that is, they have never seen this new product/service.
2. The changes the tourism firm has made in the product or service have become decisive factors in the decision to buy.
3. These changes in products or services have been seen as reinvented or intensely remodeled products.

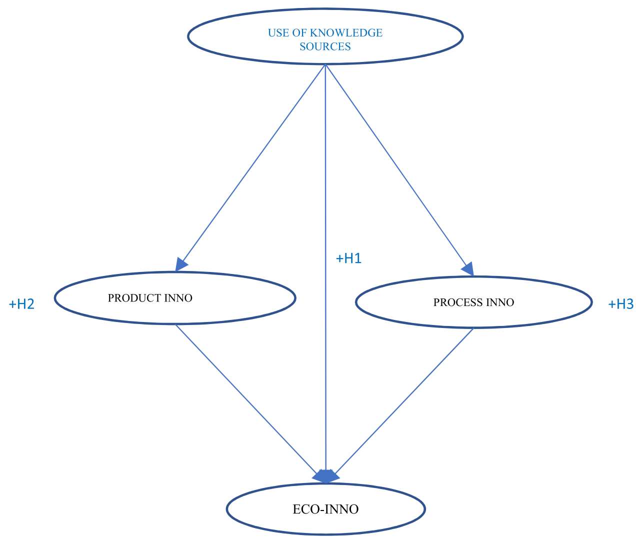

Figure 1. Theoretical model.

Analysis and results

Evaluation of the measurement model

To analyze the factors affecting the tourism sector, we used PLS-SEM and SmartPLS software (Ringle et al., 2014). PLS has been used with good results in prior studies in tourism and hospitality (e.g. Do Valle & Assaker, 2016; Henseler et al., 2018; Latan, 2018). In addition to reducing the residual variables of the dependent variables (Chin, 1998), PLS-SEM is suitable for research with secondary data for exploratory studies because it facilitates a flexible, appropriate relationship between theory and data (Benitez-Amado & Walczuch, 2012; Gefen et al., 2011; Nitzl, 2016). PLS-SEM is also appropriate for studies, like ours, that have many indicators (Hair et al., 2019).

Further, PLS-SEM uses a limited information procedure (Chin, 2010) and thus does not require specific distribution, normality of data (Chin, 2010; Hair et al., 2019), or independence of the observations (Chin, 2010). As a nonparametric sampling from resampling, PLS-SEM performs a repetitive random technique to reposition the original sample (Hair et al., 2011). In PLS-SEM, goodness of fit indices apply only to confirmatory studies (Henseler, 2018), and our study is exploratory. Because studies that use secondary data cannot redefine the measurement model to achieve fit (Hair et al., 2019), the goodness of fit indices quantify the

Table 2. Summary of results of the direct effects for Hypothesis 1.

Study 1					
Analysis A) 199 firms, years 2011–2015					
Effects on endogenous variables	Direct. eff.	(*t*-value)	*p*-value	Confidence interval	f^2
H1: us_know_sour11 -> eco-inn11	−.271	.837	.201	(−.777; .277)	.046
H1: us_know_sour12 -> eco-inn12	−.109	.540	.295	(−.386; .266)	.010
H1: us_know_sour13 -> eco-inn13	−.145	.874	.191	(−.382; .160)	.026
H1: us_know_sour14 -> eco-inn14	.015	.072	.471	(−.327; .369)	.001
H1: us_know_sour15 -> eco-inn15	.331	1.833*	.033	(.035; .627)	.160
Analysis A) 198 firms, year 2021					
Effects on endogenous variables	Direct. eff.	(*t*-value)	*p*-value	Confidence interval	f^2
H1: us_know_sour21 -> eco-inn21	.209	3.112***	.001	(.097; .320)	.049
Study 2					
Analysis B) 198 firms 2021 – specific tourism questions					
Effects on endogenous variables	Direct. eff.	(*t*-value)	*p*-value	Confidence interval	f^2
H1: us_know_sour21 -> eco-inn21	.216	2.730**	.003	(.082; .344)	.040

Note: Study 1 (Analysis A): $n = 199$; ***$p < .001$; **$p < .01$; *$p < .05$; $t < .1$. For $n = 5000$ subsamples: * $p < .05$; ** $p < .01$; ***$p < .001$ (based on distribution $t(4999)$ one-tailed Student's t); $t(0.05;\ 4999) = 1.645$; $t(0.01;\ 4999) = 2.327$; $t(0.001;\ 4999) = 3.092$.

Study 1 (Analysis B) and Study 2: $n = 198$; ***$p < .001$; **$p < .01$; *$p < .05$; $t < .1$. For $n = 5000$ subsamples: * $p < .05$; ** $p < .01$; ***$p < .001$ (based on distribution $t(4999)$ one-tailed Student's t); $t(0.05;\ 4999) = 1.645$; $t(0.01;\ 4999) = 2.327$; $t(0.001;\ 4999) = 3.092$.

divergence between the empirical correlation and the derived matrices. Finally, PLS-SEM estimates the parameters by maximizing the variance explained by the dependent variables (Chin, 1998; Hair et al., 2019).

We analyzed reliability, internal consistency, and discriminant validity (see Appendix, Tables A1 and A2). The loadings, Alpha Cronbach, and composite reliability were all higher than .70 (Nunnally & Bernstein, 1994). The confidence intervals were significant and the variance extracted higher than .50 (Fornell & Larcker, 1981). To ensure discriminant validity, we calculated the Fornell-Larcker (1981) criterion. The values obtained confirm the results and validity of the data for the constructs employed.

Evaluation of the structural model

We use the bootstrapping model with 5000 resamplings for both models. As the path coefficients took positive signs, we obtained the results of the direct effect of the relationships in the theoretical model. Our analysis of the data for R^2 confirmed that the endogenous variables explain the study variables substantially (Chin, 1998). A value of Q^2 greater than zero (available from authors) demonstrated predictive relevance. The tables also show effect size, classified following Cohen (1988) as large (f^2=.35), medium (f^2=.15), or small (f^2=.2)). Table 2 summarizes the results of the two studies for the direct effects for Hypothesis 1.

To confirm the mediation effect, we determined whether the measurement models fulfilled the quality criteria (reliability, internal consistency reliability, convergent validity, discriminant validity). After confirming the models' reliability and validity, we analyzed the structural model, which demonstrated the specific indirect effects calculated from all our bootstrap samples (Table 3). We included analyses of the confidence intervals and obtained significant results for the mediation effect, which did not include the value 0. We also determined the effect and magnitude of the mediation following Nitzl et al. (2016). Full mediations of the model showed significant indirect effects and no significant direct effect. Partial mediations were calculated using Variance Accounted For (VAF) (Hair et al., 2017) as complementary secondary criterion. We confirmed complementary partiality of these mediations, ranging from 20%-80% of the total effect (Hair et al., 2017).

Table 3. Indirect effects of the two studies for Hypotheses 2 and 3.

	Specific indirect effects	Indirect. eff.	(*t*-value)	*p*-value	Confidence interval	VAF	Type of mediation
Study 1							
Analysis A) 199 firms, years 2011–2015							
H2:	us_know_sour11 -> prod-inn11 -> eco-inn11	.373	1.107	.134	(−.150; .959)		
H2:	us_know_sour12 -> prod-inn12 -> eco-inn12	.334	1.520	.064	(−.060; .655)		
H2:	us_know_sour13 -> prod-inn13 -> eco-inn13	.435	2.563**	.005	(.162; .711)		Partial competitive med.
H2:	us_know_sour14 -> prod-inn14 -> eco-inn14	.114	.718	.236	(−.140; .368)		
H2:	us_know_sour15 -> prod-inn15 -> eco-inn15	.033	.271	.393	(−.152; .236)		
H3:	us_know_sour11 -> proc-inn11 -> eco-inn11	.776	5.849***	.000	(.513; .945)		Full mediation
H3:	us_know_sour12 -> proc-inn12 -> eco-inn12	.550	4.203***	.000	(.313; .735)		Full mediation
H3:	us_know_sour13 -> proc-inn13 -> eco-inn13	.476	3.164***	.001	(.203; .697)		Full mediation
H3:	us_know_sour14 -> proc-inn14 -> eco-inn14	.564	2.778**	.003	(.242; .904)		Full mediation
H3:	us_know_sour15 -> proc-inn15 -> eco-inn15	.358	2.761**	.003	(.164; .583)	52%	Partial competitive med.
Analysis B) 198 firms, year 2021							
	Specific indirect effects	Indirect. eff.	(*t*-value)	*p*-value	Confidence interval		
H2:	us_know_sour21 -> prod-inn21 -> eco-inn21	−.065	1.341	.090	(−.064 .016)		
H3:	us_know_sour21 -> proc-inn21 -> eco-inn21	.307	5.086***	.000	(.214; .414)	60%	Partial competitive med.
Study 2							
Specific tourism questions							
	Specific indirect effects	Indirect. eff.	(*t*-value)	*p*-value	Confidence interval		
H2:	us_know_sour21 -> prod-inn21 -> eco-inn21	.032	.597	.275	(−.054; .122)		
H3:	us_know_sour21 -> proc-inn21 -> eco-inn21	.166	2.987**	.001	(.082; .264)	43%	Partial competitive med.

Note: Study 1 (analysis A)*:* $n = 199$; ***$p<.001$; **$p<.01$; *$p<.05$; $t<.1$. For $n = 5000$ subsamples: * $p<.05$; ** $p<.01$; ***$p<.001$ (based on distribution $t(4999)$ one-tailed Student's t); $t(0.05;\ 4999)=1.645$; $t(0.01;\ 4999)=2.327$; $t(0.001;\ 4999)=3.092$. VAF = Variance Accounted For.

Study 1 (analysis B) and Study 2*:* $n = 198$; ***$p<.001$; **$p<.01$; *$p<.05$; $t<.1$. For $n = 5000$ subsamples: * $p<.05$; ** $p<.01$; ***$p<.001$ (based on distribution $t(4999)$ one-tailed Student's t); $t(0.05;\ 4999)=1.645$; $t(0.01;\ 4999)=2.327$; $t(0.001;\ 4999)=3.092$. VAF = Variance Accounted For.

Examination of H1, on the direct effect of knowledge sources on eco-innovation, shows that the results are only significant for one year of Study 1 (2015) and for Study 2 (2021). Thus, knowledge use only influences eco-innovation for 2 of the 6 years analyzed. The relationship between knowledge sources and eco-innovation is not significant for the other study years. For H2, on mediation of product and service innovation strategies in the relationship between intensive knowledge use and eco-innovation, the results show partial competitive—or inconsistent—mediation (Hair et al., 2017). In this case, although mediation exists, the mediating variable acts as a suppressor, reducing the effect. This finding thus suggests that the results are not significant for Study 1 and Study 2. The data thus support the trend that product innovation does not mediate the relationship between knowledge source and eco-innovation. This trend holds for both the panel data from the secondary sources (2011-2015) and the primary data (2021), as the results are not significant for the questions specific to the tourism

Table 4. Significance of carryover effects in the panel data (2011–2015).

Carryover effects	Direct. eff.	(*t*-value)	*p*-value
eco-inn11 -> eco-inn12	.060	.817	.207
eco-inn12 -> eco-inn13	.005	.072	.471
eco-inn13 -> eco-inn14	.137	2.013**	.022
eco-inn14 -> eco-inn15	.110	1.491^{t}	.068
proc-inn11 -> eco-inn11	.839	5.653***	.000
proc-inn11 -> proc-inn12	.118	1.773**	.038
proc-inn12 -> eco-inn12	.648	4.048***	.000
proc-inn12 -> proc-inn13	.192	1.898**	.029
proc-inn13 -> eco-inn13	.615	3.415***	.000
proc-inn13 -> proc-inn14	.163	2.540**	.006
proc-inn14 -> eco-inn14	.683	3.102***	.001
proc-inn14 -> proc-inn15	.314	3.128***	.001
proc-inn15 -> eco-inn15	.526	3.412***	.000
prod-inn11 -> eco-inn11	.389	1.125	.130
prod-inn11 -> prod-inn12	.093	1.329	.092
prod-inn12 -> eco-inn12	.379	1.510	.066
prod-inn12 -> prod-inn13	.076	.767	.222
prod-inn13 -> eco-inn13	.494	2.627**	.004
prod-inn13 -> prod-inn14	.268	3.420***	.000
prod-inn14 -> eco-inn14	.155	.723	.235
prod-inn14 -> prod-inn15	.246	2.646**	.004
prod-inn15 -> eco-inn15	.043	.283	.388
us_know_sour11 -> proc-inn11	.924	39.853***	.000
us_know_sour11 -> prod-inn11	.959	76.154***	.000
us_know_sour11 -> us_know_sour12	.718	10.109***	.000
us_know_sour12 -> proc-inn12	.849	13.118***	.000
us_know_sour12 -> prod-inn12	.883	16.803***	.000
us_know_sour12 -> us_know_sour13	.801	13.361***	.000
us_know_sour13 -> proc-inn13	.774	8.896***	.000
us_know_sour13 -> prod-inn13	.880	10.433***	.000
us_know_sour13 -> us_know_sour14	.730	11.381***	.000
us_know_sour14 -> proc-inn14	.826	13.697***	.000
us_know_sour14 -> prod-inn14	.739	10.222***	.000
us_know_sour14 -> us_know_sour15	.823	12.943***	.000
us_know_sour15 -> proc-inn15	.681	6.799***	.000
us_know_sour15 -> prod-inn15	.751	8.186***	.000

sector. For H3, on mediation of process innovation in the relationship between intensive use of knowledge sources and eco-innovation, all results are significant for Study 1 (Analysis A, 2001-2015; Analysis B, 2021) and for Study 2 (2021), which included questions analyzing specific characteristics of the tourism industry. We thus confirm the influence of process innovation in both studies.

Analysis of evolution of the panel data model

We analyzed evolution of the panel data model, following instructions by Roemer (2016) for analyzing panel data and using the same firms for a five-year period. First, we estimated the direct effects (Table 2) and carryover effects (Table 4).

Second, to test whether the changes in the path coefficients were significant at one point in time relative to the next point in time, we performed multigroup analysis (Roemer, 2016), creating different groups for each time period (Benitez et al., 2018; Palos-Sanchez et al., 2019). Bootstrapping of the model with 5000 subsamples confirmed the significance of the direct and carryover effects on the path coefficients and confidence interval in time. An additional analysis of whether the coefficient was inside or outside the confidence interval (Roemer, 2016) (Appendix, Table A3) showed that very few changes in the effects were significant. The data therefore support the hypotheses. Like the beta coefficients in a regression, the size of the path coefficients indicates the strength of the relationships among the latent variables. A change in the size of the path coefficients over time would thus demonstrate a change in the pattern studied. Our analysis of the evolution of the path coefficients over time indicated that this change is not significant. Testing the nonparametric confidence interval, consistent with PLS methodology, verified that the path coefficient of t_i is within 95% of the confidence interval of t_i+1. To confirm the longer evolution, we compare the 5 years analyzed.

Discussion

Academia shows increasing interest in analyzing implementation of sustainable management (Alos-Simo et al., 2020), but few studies have analyzed eco-innovation in the tourism sector (Martínez-Pérez et al., 2015), and even fewer relate implementation of eco-innovation to the tension between product and process innovation. Our study determines how intensity of knowledge use influences eco-innovation through product and process innovation, deepening knowledge of three main issues: a) the influence of knowledge sources in tourism and their significance to eco-innovation, b) the distinction between process and product innovation in tourism to determine the area on which firms should focus their resources, and c) the process tourism firms use to innovate in sustainable contexts.

Our study generates the following research contributions:

First, although prior studies have confirmed a direct relationship between knowledge use and green innovation (Martínez-Ros & Kunapatarawong, 2019) and a direct effect of knowledge on eco-innovation (Nagano & Iacono, 2019), their analyses are not specific to tourism firms. Unlike these studies, our analysis of the tourism sector does not identify a direct contribution of intensity of use of knowledge sources to eco-innovation (H1) for 2011-2015 but does identify one for 2021. Significantly, these direct effects occur only in 2021 in both studies. Although this difference may be due to the pandemic, we cannot identify a trend and thus cannot confirm H1. Because the direct relationship did not occur in the years analyzed and we lack complete information for 2011-2021, we cannot identify a trend. We propose two reasons for this difference between our findings and those of studies that do not differentiate among industries: 1) eco-innovations have specific characteristics that differentiate them from other innovations, especially additional difficulty and complexity (Cainelli et al., 2015; De Marchi, 2012); and 2) services industries have specific characteristics (Pikkemaat et al., 2019), as does the tourism sector (Singal, 2015). Our study makes an original contribution by indicating that mere use of knowledge does not guarantee eco-innovation in tourism, as firms should also be implementing traditional innovation (product and process innovation). No prior studies find that mediation of variables of an environment of innovation is a prerequisite to eco-innovation success.

Second, this study does not seek to explain the importance of innovating in tourism. Rather, it seeks to show how tourism firms can apply eco-innovation given tourism's special characteristics. The literature on innovation has studied manufacturing and patent development industries intensively (Beneito et al., 2014; Higham et al., 2021), sectors in which product innovations provide tangible innovations that are almost always visible to customers. Most product innovations in tourism are, in contrast, determined by broadening the range of options for customer experiences (De la Peña et al., 2016). Although some studies have analyzed eco-innovation implementation through internal processes of ordinary and dynamic capabilities in the tourism sector (Dias et al., 2021), they do not analyze whether or how firms prioritize product vs. process innovation processes. Our study reinforces the view, shared by managers and researchers, that tourism innovation is different from other forms of product or service innovation (Stare & Križaj, 2018). We should thus study the variables of product and process innovation separately and as mediators between knowledge use and eco-innovation. In response to calls in the literature to determine the place of process innovation in the service sector (Hjalager, 2010), our results show that tourism eco-innovation is grounded in process but not product innovation. Knowledge sources influence eco-innovation through process, not product, innovation. When use of knowledge sources creates a climate of constant innovation in a firm, climate becomes an engine driving implementation of eco-innovation. This finding is only relevant, however, when use of knowledge sources generates process and not product innovation. In other words, when a tourism firm focuses on product innovation only, it is less likely to engage in eco-innovation. In sum, the very nature of tourism makes it easier for firms involved in process innovation to transform knowledge sources in eco-innovations.

Third, much literature on services is based on qualitative and case studies (Bell & Ruhanen, 2016; Hjalager, 2010) and is thus limited by these methods' limitations for longitudinal analysis. In contrast to the tourism sector's call for qualitative studies with clearer conclusions, our study uses two samples, composed of public panel data from 199 tourism firms and a primary database of 198 firms, respectively. Our quantitative, longitudinal, and transversal results confirm the stability of the behavior analyzed. The results show that using knowledge sources influences eco-innovation in tourism through process innovation for all five years studied. To confirm this pattern of eco-innovation in tourism, we conducted a second study with data collected in 2021. Many studies reveal serious management crises and ruptures in the tourism sector following the COVID-19 crisis. Our examination of these new crisis contexts shows that the sector was indeed operating under special conditions due to the global pandemic (Higgins-Desbiolles, 2021; Jaaron et al., 2023). Although COVID-19 as an a priori unplanned event was a huge setback in our study as well as for the tourism sector, we recognized the need for a second study to confirm the results of the original panel data study.

The results of the 2021 study show the same behavior pattern, quantitatively confirming the significance of process innovation in implementing eco-innovation. This result gives our proposed model greater robustness. The pandemic's effects on the tourism sector were dramatic and could have affected product innovation as a new way of recruiting customers. The 2021 study indicated, however, that tourism firms remained oriented to process innovation. This result is very significant, as it identifies process innovation as the main point on which tourism firms focus, independently of context. Further, obtaining significant direct relationships only in 2015 and 2021 suggests that external factors (e.g. the pandemic) may cause the direct effects of eco-innovation as the need to translate use of knowledge sources into eco-innovations intensifies. An additional external factor may also contribute—tourism sector customers' growing awareness of all topics related to eco-innovation. Still, further in-depth studies are needed to reach conclusive results on this question.

As to limitations that can become future lines of research, one limitation derives from the types of innovation included in the Oslo Manual (organizational and marketing innovation). Our study focused on more technical aspects of innovation, such as process and product innovation, which directly impact both the service the customer receives and the environment. Both types may also be sensitive to knowledge use and have implications for eco-innovation. Although organizational and marketing innovations may impact environments and customers significantly, their effect is less direct. We therefore suggest that subsequent studies analyze issues related to perceived value generated by marketing actions or changes in the organization. A final limitation of this study is the absence of panel data after 2015. Although we solved this problem with the 2021 study, a better view of the trajectory of firms throughout the full range of pre-pandemic and pandemic years (2020 and 2021) would have enriched the results.

Conclusion

Our findings suggest that process innovation is much more prominent in eco-innovation implementation contexts in tourism than in other sectors, where product innovation is more significant. Our goal was to detect the different levels of these two forms of innovation so that governments and organizations can propose new action strategies. Such strategies are essential to modifying and transforming eco-innovation, not only through process innovation but also by transforming actions to achieve product innovation. This study fills an important research gap in use of quantitative data for several years, providing essential quantitative evidence of the tourism sector's uniqueness to enable measurement and data analysis. Such quantitative analyses facilitate research with large numbers of participants and more generalizable results. They also facilitate business and government decision-making. In addition to advancing knowledge, quantitative analyses contribute to detailed monitoring of tourism development and the impact of actions in the sector, enabling clearer action at the level of business and government management.

This study also has indirect implications for tourism and sustainability policies at government level. The tourism industry must work harder to contribute to sustainable development goals, which seek to reduce the environmental impact of tourism (Cotterell et al., 2019). Achieving this goal would strengthen the value of both environment and market to achieve more responsible tourism (Mihalic, 2016). Our study offers some conclusions which, although not derived directly from our study, can orient public administrations' policy to fostering eco-innovation in the tourism sector. Governments must develop new proposals to stimulate tourism firms to implement process innovations. Based on two data sources, our results show that process innovation plays a consistently and stably more important role than product innovation in stimulating eco-innovation indirectly. Public administration can thus help the tourism sector by designing programs to stimulate eco-innovation and support these stimuli with programs to foster process innovation. Although local, regional, and national governments have been promoting tourism firms' application of knowledge by opening access to knowledge and company networks (e.g. university-company, business innovation institutes), our results suggest reconfiguring this impulse to foster relationships and improvement.

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Appendix

Table A1. Measurement reliability of panel data analysis (2011–2015).

		Loadings	*p*-value	Confidence interval	Weights	*p*-value	Confidence interval	Alpha Cronbach	Composite reliability	Average variance extracted (AVE)
eco-inn11	eco-inn1111	.982	.000	(.967; .995)	.336	.000	(.333; .340)	.987	.992	.976
	eco-inn1211	.996	.000	(.993; .999)	.339	.000	(.334; .345)			
	eco-inn1311	.985	.000	(.966; .998)	.338	.000	(.334; .343)			
eco-inn12	eco-inn1112	.980	.000	(.965; .994)	.340	.000	(.334; .347)	.985	.990	.970
	eco-inn1212	.988	.000	(.977; .997)	.341	.000	(.334; .348)			
	eco-inn1312	.988	.000	(.974; .997)	.334	.000	(.330; .338)			
eco-inn13	eco-inn1113	.996	.000	(.994; .999)	.335	.000	(.333; .339)	.997	.998	.994
	eco-inn1213	.997	.000	(.994; .999)	.334	.000	(.332; .336)			
	eco-inn1313	.996	.000	(.998; .999)	.333	.000	(.332; .335)			
eco-inn14	eco-inn1114	.963	.000	(.933; .990)	.333	.000	(.328; .338)	.978	.986	.958
	eco-inn1214	.988	.000	(.982; .995)	.343	.000	(.336; .351)			
	eco-inn1314	.985	.000	(.975; .995)	.345	.000	(.338; .353)			
eco-inn15	eco-inn1115	.965	.000	(.937; .993)	.334	.000	(.328; .339)	.972	.982	.947
	eco-inn1215	.981	.000	(.973; .991)	.346	.000	(.337; .356)			
	eco-inn1315	.973	.000	(.959; .990)	.347	.000	(.338; .356)			
us_know_sour11	us_know_sour111	.937	.000	(.905; .965)	.265	.000	(.255; .275)	.965	.974	.905
	us_know_sour211	.943	.000	(.916; .968)	.252	.000	(.243; .260)			
	us_know_sour311	.964	.000	(.950; .979)	.268	.000	(.261; .274)			
	us_know_sour411	.961	.000	(.942; .979)	.266	.000	(.258; .274)			
us_know_sour12	us_know_sour112	.940	.000	(.918; .960)	.263	.000	(.255; .272)	.969	.978	.916
	us_know_sour212	.946	.000	(.916; .973)	.252	.000	(.243; .262)			
	us_know_sour312	.974	.000	(.963; .984)	.266	.000	(.257; .276)			
	us_know_sour412	.969	.000	(.952; .984)	.263	.000	(.255; .271)			
us_know_sour13	us_know_sour113	.948	.000	(.924; .970)	.262	.000	(.254; .270)	.963	.973	.900
	us_know_sour213	.935	.000	(.907; .962)	.265	.000	(.253; .277)			
	us_know_sour313	.958	.000	(.940; .974)	.261	.000	(.255; .267)			
	us_know_sour413	.954	.000	(.931; .976)	.267	.000	(.258; .275)			
us_know_sour14	us_know_sour114	.949	.000	(.928; .969)	.262	.000	(.253; .270)	.969	.977	.915
	us_know_sour214	.953	.000	(.934; .971)	.262	.000	(.254; .269)			
	us_know_sour314	.970	.000	(.960; .981)	.261	.000	(.255; .267)			
	us_know_sour414	.955	.000	(.936; .974)	.260	.000	(.254; .267)			
us_know_sour15	us_know_sour115	.919	.000	(.891; .947)	.255	.000	(.246; .266)	.967	.976	.910
	us_know_sour215	.969	.000	(.957; .980)	.263	.000	(.256; .270)			
	us_know_sour315	.968	.000	(.953; .982)	.264	.000	(.258; .271)			
	us_know_sour415	.958	.000	(.934; .981)	.266	.000	(.259; .272)			
proc-inn11	proc-inn1011	.946	.000	(.927; .965)	.215	.000	(.207; .223)	.973	.979	.901
	proc-inn611	.957	.000	(.934; .977)	.215	.000	(.208; .221)			
	proc-inn711	.955	.000	(.933; .973)	.209	.000	(.203; .215)			
	proc-inn811	.948	.000	(.924; .970)	.208	.000	(.199; .215)			
	proc-inn911	.940	.000	(.908; .967)	.207	.000	(.198; .216)			

proc-inn12	proc-inn1012	.959	.000	(.944; .974)	.211	.000	(.203; .220)	.973	.979	.901
	proc-inn612	.940	.000	(.915; .964)	.211	.000	(.204; .219)			
	proc-inn712	.937	.000	(.911; .963)	.205	.000	(.199; .213)			
	proc-inn812	.965	.000	(.945; .980)	.214	.000	(.209; .220)			
	proc-inn912	.947	.000	(.914; .975)	.211	.000	(.206; .217)			
proc-inn13	proc-inn1013	.969	.000	(.953; .985)	.213	.000	(.206; .222)	.978	.983	.920
	proc-inn613	.959	.000	(.944; .972)	.213	.000	(.206; .221)			
	proc-inn713	.957	.000	(.938; .975)	.208	.000	(.201; .216)			
	proc-inn813	.961	.000	(.940; .979)	.207	.000	(.201; .214)			
	proc-inn913	.951	.000	(.917; .978)	.200	.000	(.195; .206)			
proc-inn14	proc-inn1014	.959	.000	(.934; .980)	.207	.000	(.203; .212)	.982	.986	.934
	proc-inn614	.966	.000	(.954; .979)	.211	.000	(.206; .216)			
	proc-inn714	.978	.000	(.967; .988)	.210	.000	(.206; .214)			
	proc-inn814	.964	.000	(.940; .986)	.205	.000	(.201; .210)			
	proc-inn914	.964	.000	(.942; .983)	.202	.000	(.197; .207)			
proc-inn15	proc-inn1015	.942	.000	(.907; .973)	.211	.000	(.204; .218)	.977	.982	.914
	proc-inn615	.952	.000	(.928; .973)	.210	.000	(.203; .216)			
	proc-inn715	.965	.000	(.951; .980)	.210	.000	(.204; .215)			
	proc-inn815	.954	.000	(.925; .981)	.208	.000	(.202; .214)			
	proc-inn915	.968	.000	(.956; .981)	.208	.000	(.202; .215)			
prod-inn11	prod-inn111	.949	.000	(.920; .974)	.203	.000	(.199; .209)	.976	.981	.913
	prod-inn211	.959	.000	(.934; .981)	.209	.000	(.204; .215)			
	prod-inn311	.958	.000	(.932; .979)	.207	.000	(.203; .212)			
	prod-inn411	.969	.000	(.950; .986)	.209	.000	(.205; .214)			
	prod-inn511	.941	.000	(.904; .973)	.218	.000	(.208; .230)			
prod-inn12	prod-inn112	.949	.000	(.917; .976)	.209	.000	(.204; .216)	.980	.984	.925
	prod-inn212	.923	.000	(.879; .961)	.201	.000	(.194; .207)			
	prod-inn312	.980	.000	(.965; .992)	.212	.000	(.206; .219)			
	prod-inn412	.987	.000	(.978; .993)	.209	.000	(.205; .214)			
	prod-inn512	.970	.000	(.949; .987)	.208	.000	(.203; .214)			
prod-inn13	prod-inn113	.963	.000	(.938; .983)	.205	.000	(.201; .209)	.981	.985	.931
	prod-inn213	.948	.000	(.919; .972)	.206	.000	(.202; .211)			
	prod-inn313	.976	.000	(.963; .986)	.207	.000	(.202; .211)			
	prod-inn413	.973	.000	(.953; .988)	.206	.000	(.202; .211)			
	prod-inn513	.964	.000	(.942; .982)	.213	.000	(.207; .219)			
prod-inn14	prod-inn114	.961	.000	(.941; .978)	.204	.000	(.199; .209)	.981	.985	.930
	prod-inn214	.932	.000	(.894; .964)	.207	.000	(.198; .214)			
	prod-inn314	.971	.000	(.955; .986)	.205	.000	(.201; .210)			
	prod-inn414	.981	.000	(.971; .989)	.209	.000	(.205; .215)			
	prod-inn514	.976	.000	(.965; .986)	.212	.000	(.206; .218)			
prod-inn15	prod-inn115	.926	.000	(.885; .960)	.203	.000	(.195; .211)	.973	.979	.904
	prod-inn215	.911	.000	(.869; .949)	.210	.000	(.198; .220)			
	prod-inn315	.967	.000	(.949; .983)	.213	.000	(.206; .222)			
	prod-inn415	.977	.000	(.966; .987)	.213	.000	(.207; .220)			
	prod-inn515	.970	.000	(.956; .982)	.213	.000	(.207; .220)			

Note: $n = 199$; CR: composite reliability; AVE: average variance extracted; Cronbach: Alpha Cronbach; ***$p<.001$.

Table A2. Measurement reliability of primary data analysis (2021).

		Loadings	*p*-value	Confidence interval	Weights	*p*-value	Confidence interval	Alpha Cronbach	Composite reliability	Average variance extracted (AVE)
us_know_sour21	us_know_sour121	.722	.000	(.633; .792)	.332	.000	(.275; .391)	.764	.850	.586
	us_know_sour221	.783	.000	(.707; .842)	.309	.000	(.254; .363)			
	us_know_sour321	.803	.000	(.733; .855)	.319	.000	(.263; .373)			
	us_know_sour421	.753	.000	(.680; .812)	.348	.000	(.291; .412)			
proc-inn21	proc-inn121	.687	.000	(.586; .767)	.285	.000	(.227; .343)	.718	.814	.500
	proc-inn221	.691	.000	(.581; .774)	.307	.000	(.249; .362)			
	proc-inn321	.616	.000	(.497; .711)	.209	.000	(.145; .265)			
	proc-inn421	.720	.000	(.639; .783)	.296	.000	(.242; .348)			
	proc-inn521	.701	.000	(.618; .768)	.358	.000	(.298; .419)			
eco-inn21	eco_inn121	.815	.000	(.763; .857)	.503	.000	(.433; .581)	.701	.850	.619
	eco_inn221	.804	.000	(.747; .854)	.459	.000	(.400; .530)			
	eco_inn321	.739	.000	(.619; .824)	.299	.000	(.210; .369)			
prod-inn21	prod-inn121	.708	.000	(.588; .793)	.219	.000	(.143; .279)	.764	.840	.513
	prod-inn221	.655	.000	(.567; .728)	.289	.000	(.225; .359)			
	prod-inn321	.699	.000	(.604; .777)	.255	.000	(.189; .321)			
	prod-inn421	.783	.000	(.716; .837)	.330	.000	(.272; .397)			
	prod-inn521	.729	.000	(.626; .799)	.300	.000	(.237; .359)			

Note: $n = 198$; CR: composite reliability; AVE: average variance extracted; Cronbach: Alpha Cronbach; ***$p<.001$.

Table A3. Significance test of changes in coefficients.

Time	Effect	Beta coef.$_t$	Beta coef.$_{t+1}$	Size of the change	Bias corrected CI$_t$	Bias corrected CI$_{t+1}$	Comparison of beta coef.$_{t+1}$ with CI$_t$	Beta coef. $_{t+1}$ inside CI$_t$	Comparison of beta coef.$_t$ with CI$_{t+1}$	Beta coef.$_t$ inside CI$_{t+1}$	Significant change?
t1_t2	us_know_sour -> eco-inn	−.268	−.130	.138	[−.778, −.436]	[−.436, .210]	−.778<-.130	No	−.436<-.268<.210	Yes	No
t1_t3	us_know_sour -> eco-inn	−.268	−.141	.127	[−.770, −.346]	[−.346, .134]	−.770<-.141	No	−.346<-.268<.134	Yes	No
t1_t4	us_know_sour -> eco-inn	−.268	−.043	.225	[−.783, −.409]	[−.409, .329]	−.783<-.043	No	−.409<-.268<.329	Yes	No
t1_t5	us_know_sour -> eco-inn	−.268	.308	.576	[−.771, .020]	[.020, .641]	−.771<.308	No	−.268<.641	No	Yes
t2_t3	us_know_sour -> eco-inn	−.130	−.141	−.011	[−.476, −.348]	[−.348, .128]	−.476<-.141	No	−.348<-.130<.128	Yes	No
t2_t4	us_know_sour -> eco-inn	−.130	−.043	.087	[−.464, −.398]	[−.398, .316]	−.464<-.043<-.398	Yes	−.398<-.130<.316	Yes	No
t2_t5	us_know_sour -> eco-inn	−.130	.308	.438	[−.458, .020]	[.020, .632]	−.458<.308	No	−.130<.632	No	Yes
t3_t4	us_know_sour -> eco-inn	−.141	−.043	.098	[−.362, −.427]	[−.427, .308]	−.362<-.043	No	−.427<-.141<.308	Yes	No
t4_t5	us_know_sour -> eco-inn	−.043	.308	.351	[−.398, .014]	[.014, .638]	−.398<.308	No	−.043<.638	No	Yes
t5_t4	us_know_sour -> eco-inn	−.141	.308	.449	[−.353, .022]	[.022, .647]	−.353<.308	No	−.141<.647	No	Yes
t1_t2	us_know_sour -> proc-inn	.924	.921	−.003	[.878, .869]	[.869, .960]	.878<.921	No	.869<.924<.960	Yes	No
t1_t3	us_know_sour -> proc-inn	.924	.919	−.005	[.878, .882]	[.882, .945]	.878<.919	No	.882<.924<.945	Yes	No
t1_t4	us_know_sour -> proc-inn	.924	.934	.01	[.877, .899]	[.899, .959]	.877<.934	No	.899<.924<.959	Yes	No
t1_t5	us_know_sour -> proc-inn	.924	.917	−.007	[.876, .871]	[.871, .947]	.876<.917	No	.871<.924<.947	Yes	No
t2_t3	us_know_sour -> proc-inn	.921	.919	−.002	[.866, .883]	[.883, .946]	.866<.919	No	.883<.921<.946	Yes	No
t2_t4	us_know_sour -> proc-inn	.921	.934	.013	[.867, .900]	[.900, .959]	.867<.934	No	.900<.921<.959	Yes	No
t2_t5	us_know_sour -> proc-inn	.921	.917	−.004	[.868, .868]	[.868, .946]	.868<.917	No	.868<.921<.946	Yes	No
t3_t4	us_know_sour -> proc-inn	.919	.934	.015	[.882, .900]	[.900, .959]	.882<.934	No	.900<.919<.959	Yes	No
t4_t5	us_know_sour -> proc-inn	.934	.917	−.017	[.901, .869]	[.869, .947]	.901<.917	No	.869<.934<.947	Yes	No
t5_t4	us_know_sour -> proc-inn	.919	.917	−.002	[.882, .873]	[.873, .947]	.882<.917	No	.873<.919<.947	Yes	No
t1_t2	us_know_sour -> prod-inn	.959	.949	−.01	[.933, .916]	[.916, .969]	.933<.949	No	.916<.959<.969	Yes	No
t1_t3	us_know_sour -> prod-inn	.959	.939	−.02	[.932, .907]	[.907, .960]	.932<.939	No	.907<.959<.960	Yes	No
t1_t4	us_know_sour -> prod-inn	.959	.938	−.021	[.933, .906]	[.906, .960]	.933<.938	No	.906<.959<.960	Yes	No
t1_t5	us_know_sour -> prod-inn	.959	.935	−.024	[.932, .896]	[.896, .961]	.932<.935	No	.896<.959<.961	Yes	No
t2_t3	us_know_sour -> prod-inn	.949	.939	−.01	[.917, .908]	[.908, .959]	.917<.939	No	.908<.949<.959	Yes	No
t2_t4	us_know_sour -> prod-inn	.949	.938	−.011	[.916, .904]	[.904, .960]	.916<.938	No	.904<.949<.960	Yes	No
t2_t5	us_know_sour -> prod-inn	.949	.935	−.014	[.916, .896]	[.896, .962]	.916<.935	No	.896<.949<.962	Yes	No
t3_t4	us_know_sour -> prod-inn	.939	.938	−.001	[.909, .905]	[.905, .960]	.909<.938	No	.905<.939<.960	Yes	No
t4_t5	us_know_sour -> prod-inn	.938	.935	−.003	[.907, .896]	[.896, .962]	.907<.935	No	.896<.938<.962	Yes	No
t5_t4	us_know_sour -> prod-inn	.939	.935	−.004	[.909, .895]	[.895, .961]	.909<.935	No	.895<.939<.961	Yes	No
t1_t2	proc-inn -> eco-inn	.839	.671	−.168	[.621, .358]	[.358, .881]	.621<.671	No	.358<.839<.881	Yes	No
t1_t3	proc-inn -> eco-inn	.839	.616	−.223	[.612, .283]	[.283, .865]	.612<.616	No	.283<.839<.865	Yes	No
t1_t4	proc-inn -> eco-inn	.839	.748	−.091	[.610, .349]	[.349,1.084]	.610<.748	No	.349<.839 < 1.084	Yes	No
t1_t5	proc-inn -> eco-inn	.839	.617	−.222	[.621, .392]	[.392, .845]	.621<.617	No	.392<.839<.845	Yes	No
t2_t3	proc-inn -> eco-inn	.671	.616	−.055	[.344, .293]	[.293, .867]	.344<.616	No	.293<.671<.867	Yes	No
t2_t4	proc-inn -> eco-inn	.671	.748	.077	[.348, .320]	[.320,1.065]	.348<.748	No	.320<.671 < 1065	Yes	No
t2_t5	proc-inn -> eco-inn	.671	.617	−.054	[.363, .391]	[.391, .840]	.363<.617	No	.391<.671<.840	Yes	No
t3_t4	proc-inn -> eco-inn	.616	.748	.132	[.271, .331]	[.331,1.085]	.271<.748	No	.331<.616 < 1.085	Yes	No

(*Continued*)

Table A3. Continued.

Time	Effect	Beta coef. $_t$	Beta coef. $_{t+1}$	Size of the change	Bias corrected CI_t	Bias corrected CI_{t+1}	Comparison of beta coef.$_{t+1}$ with CI_t	Beta coef.$_{t+1}$ inside CI_t	Comparison of beta coef.$_t$ with CI_{t+1}	Beta coef.$_t$ inside CI $_{t+1}$	Significant change?
t4_t5	proc-inn -> eco-inn	.748	.617	−.131	[.355, .399]	[.399, .841]	.355<.617	No	.399<.748<.841	Yes	No
t5_t4	proc-inn -> eco-inn	.616	.617	.001	[.281, .384]	[.384, .841]	.281<.617	No	.384<.616<.841	Yes	No
t1_t2	prod-inn -> eco-inn	.386	.415	.029	[−.147, −.038]	[−.038, .781]	−.147<.415	No	−.038<.386<.781	Yes	No
t1_t3	prod-inn -> eco-inn	.386	.493	.107	[−.180, .188]	[.188, .770]	−.180<.493	No	.188<.386<.770	Yes	No
t1_t4	prod-inn -> eco-inn	.386	.248	−.138	[−.134, −.134]	[−.134, .576]	−.134<.248	No	−.134<.386<.576	Yes	No
t1_t5	prod-inn -> eco-inn	.386	.060	−.326	[−.158, −.188]	[−.188, .333]	−.158<.060	No	−.188<.386	No	Yes
t2_t3	prod-inn -> eco-inn	.415	.493	.078	[−.022, .190]	[.190, .783]	−.022<.493	No	.190<.415<.783	Yes	No
t2_t4	prod-inn -> eco-inn	.415	.248	−.167	[−.029, −.131]	[−.131, .573]	−.029<.248	No	−.131<.415<.573	Yes	No
t2_t5	prod-inn -> eco-inn	.415	.060	−.355	[−.025, −.177]	[−.177, .338]	−.025<.060	No	−.177<.415	No	Yes
t3_t4	prod-inn -> eco-inn	.493	.248	−.245	[.189, −.138]	[−.138, .571]	.189<.248	No	−.138<.493<.571	Yes	No
t4_t5	prod-inn -> eco-inn	.248	.060	−.188	[−.109, −.185]	[−.185, .339]	−.109<.060	No	−.185<.248<.339	Yes	No
t5_t4	prod-inn -> eco-inn	.493	.060	−.433	[.205, −.207]	[−.207, .324]	.205<.060	No	−.207<.493	No	Yes

Note: CI = confidence interval.