

Revolutionizing the Hotel Industry of London Via Digitalization: An Innovative Approach for Sustainable Waste Management in Digital World

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Received: 03 March 2024	Revised: 03 August 2024	Accepted: 17 August 2024	Published: 22 August 2024
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Keywords

Sustainable Waste Management
Open Innovation
External Knowledge
Digital Inbound Innovation
Digital World

Abstract

Waste management has become a serious issue on a global scale, causing severe difficulties for environmental sustainability and human health. To address this issue, the current study proposed the critical role of open innovation in sustainable waste management in the hotel industry of London. The promotion of waste management through open innovation is rarely addressed by literature. By using quantitative research, this study used a cross-sectional research design. A survey was carried out to collect data from the managerial employees of hotels. 250 valid responses were collected and analysed using Partial Least Square-Structural Equation Modeling (PLS-SEM). The study's findings revealed the vital role of open innovation in sustainable waste management. The role of external knowledge from the market and inbound innovation is essential to enhance digital internal innovation leading to outbound innovation. The promotion of digital internal innovation and outbound innovation can manage the problem of waste management. The study results have valuable insights for the practitioners to promote waste management practices among hotels.

Introduction

Globally, the prime issue of waste management has become more than a major challenge for the hotel sector by being significant enough to be considered as the national level and organizational levels (Pham Phu et al., 2018). Furthermore, the prevailing concerns over increased production of trash worldwide and its impact on the environment, as well as natural resources. The more nations struggle with waste management policies, the clearer it becomes that conventional practices are incompetent and lead to general adverse environmental consequences along with reduction of highly precious natural resources (Pirani et al., 2014). The hotel industry has a large amount of disposed material, some typical waste in this branch is food and beverage wastes (mainly sent to the landfill), packaging materials, e.g. glass bottles from beverages or disposable items (Okumus et al., 2020). Traditional waste management systems have consequently struggled to maintain the environmental footprint of hotels, leading ecosystems and societies bear heavy costs. With growing consumer awareness around eco-friendly performance, hotels are being challenged with balancing best guest satisfaction whilst maintaining their environmental credentials (Radwan et al., 2012). In this paper, we propose an open innovation approach to sustainable waste management targeting the multidimensional problem. The strategy highlights the importance of collaboration and information sharing between hotels, other stakeholders as well as leading specialists across industries. The research aims to scrutinize the relationship amongst external knowledge sources, inbound and outbound innovation creation on sustainable waste management in the hotel industry of London.

The goal is to offer pragmatic solutions aimed at improving waste management in this area. Figure 1 shows the global solid waste management market.



Figure 1: Global Solid Waste Management Market
Source: <https://www.expertmarketresearch.com>

It is indeed necessary to implement a new solution addressing the waste management problem in hotels urgently, which could be supported by an open innovation model according to this research in the region of London. Recognizing the limitation of conventional waste management system, an open innovation based approach seems to be a potential opportunity for sustainable trash (Martin-Rios et al., 2020). As a way of developing symbiotic ties and enabling data sharing, this strategy constitutes proactive engagement with external agents such as suppliers, customers and other industry actors. External collaborators could serve as a valuable source of learning on the best practices and technology related to waste management for hotels (Chan et al., 2020). In addition, the practice of inbound innovation through sharing ideas and

information can help to improve digital internal innovations within hospitality that might lead customized waste management models to be established (Sharma et al., 2020). This strategy places a strong emphasis on waste management issues as well encouraging the industry to shoulder its environmental responsibilities and connect with global sustainability goals. Adopting an open innovation strategy has a number of benefits some such benefits include, but are not limited to lower operating costs, enhanced brand image perception and stronger consumer loyalty from environmentally focused initiatives. To update waste management practice, this study illustrates open innovation framework for hotel managers in a graphic format (Omune et al., 2021).

Even if an existing number of scholars are working on sustainable practices in hospitality open innovation as a kind of transformational waste management is not studied yet (Gurmani et al., 2021). Past studies have primarily focused on reductions, reuse and recycling at the individual level instead of adopting open innovation in addressing complex problems related to waste management. While there have been studies of the importance of digital internal innovation and outward invention in different contexts, including sustainable waste management (Asadi et al., 2020), to our knowledge no research has examined these factors together specific to hotel industry. We further investigate the mediating effects of internal and external innovation between external knowledge, inbound innovation, sustainable waste management focusing on solid management practices as a case in our context. Consequently, we must carry out empirical research that consists of transforming open innovation principles into waste management strategies in the hotel industry. The principal aim of this paper is to fill in the theoretical void regarding that notion and specifically, examine how open innovation could be beneficial for sustainable hotel waste management. This study endeavors to add new knowledge and insights that would be beneficial for the professionals in industry as well as scholars.

To that end, this research examines the role of external innovation within the context of sustainable waste management practices in hotels (Camilleri, 2021). To achieve this, the research explores how open innovation can affect waste management strategies better by reviewing comprehensive relationships of different independent variables and their impacts on a dependent variable. The primary objective of this study is to examine the relationship within internal and external innovation and the impact on sustainable waste management. Therefore, the main purpose of this research is to explore and analyse intermediary roles played by digital internal innovation and external innovation in the relationships between external knowledge, inbound innovations and sustainable waste management practices. It uses a quantitative analysis technique called Partial Least Square-Structural Equation Modeling (PLS-SEM) to provide theoretical insights into open innovation and sustainable waste management in the hotel industry.

Moreover, this research aims to propose recommendations for hotels in order to help them apply new waste reduction policies based on environmental principles.

This seems significant as the study can lead to a revolutionary change in waste management practices in London, especially for hotels, which is an environmental issue, nowadays highly critical in the digital era. The results derived from this study are potentially extremely useful for hotel managers, industry stakeholders and lawmakers who wish to integrate innovative environmentally sensitive approaches into operations. They investigate the effects of using an open innovation strategy in sustainable trash management. These findings establish the ability of hotels to adopt certain synergistic principles by tapping into external knowledge and inbound innovation in order to refine their internal waste management innovations. As a result, this is likely to lead to the implementation of more effective and longer-term waste reduction initiatives translating into downstream environmental impacts for the industry. Further, the study nests these examinations in flows about digital internal innovation and external innovation mediators yields a richer understanding of open innovation mechanisms through which waste management outcome are supported. The practical effects of this research are applicable beyond the hotel industry and potentially to a variety of other industries with waste management issues. The findings of the study contribute substantially to open innovation and sustainable waste management literature. This helps set the stage for future research and public policies to guide an ambivalent world into a more environmentally friendly sustainable feature.

Literature Review

Theoretical Foundation and Framework Development

Creating a theoretical foundation and establishing a conceptual framework plays an important vital into studying the open innovation strategy for sustainable waste management in hotel sector (Kuo et al., 2022). The study attempts to offer a holistic understanding of the relationships between these variables by incorporating insights from innovation theories, resource-based perspectives and literature on environmental sustainability. The conceptual framework shows the interplay between external knowledge—inside innovation and beyond innovations, internal accumulation of information with generation of new ideas and sustainable waste treatment. Based on innovative adoption and diffusion models that exist, this framework will attempt to understand how information transferring from external sources affect internal innovation which finally improves waste management methods. This purpose of this section is more like a road map, it helps to guide the study its investigation into different ideas that could be linked and also motivations hypotheses but at least results interpretation. The purpose of this study is to add academic value by laying a strong theoretical foundation and discoursing the research in an organized manner. It aims to contribute to the

understanding of empirical evidence on the impact open innovation towards waste management, furthermore it provide new theoretical contribution about sustainable practice which

is significant for the hotel industry. Figure 2 demonstrates the research model.

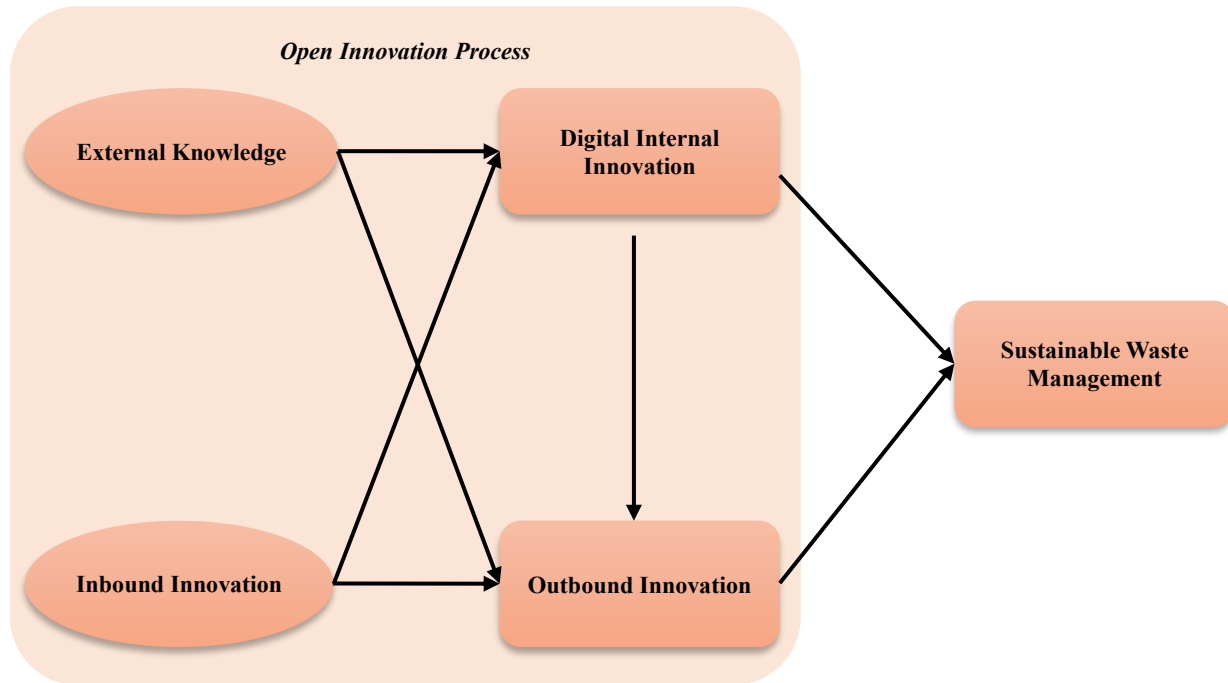


Figure 2: Research Model.

Sustainable Waste Management

With the growing environmental challenges posed by waste generation, businesses are under pressure to adopt sustainable waste practices (Kasavan et al., 2022). In a sector like hospitality, where the waste is significant and varied, it becomes essential to address this concern. This segment reviews the complex and multi-faceted world of hotel waste reduction, focusing on recycling initiatives that help to limit excessive use as well provide innovative technological solutions (Floričić, 2020). An earlier study has produced crucial results on the effectiveness of waste management options and thus provides insight into their contribution to ecological sustainability as well as resource conservation (Abdou et al., 2020). The fourth part offers an in-depth examination of the emerging waste management paradigms through a literature review on practices such as garbage sorting, composting and implementing circular economy principles (Zorpas et al., 2021). The research incorporates waste management practices within the greater sustainability strategies of hotels, which specifically tell us about relationships between reducing wastes and increasing energy efficiency and guest satisfaction. This study conceptualizes a framework motivated to improve our understanding of open innovation on waste management practices in the hotel industry, and their influence towards sustainable solid waste management. This study hopes to provide useful information for hotels willing to adopt sustainable waste management practices that are in line with the

new role of their operations towards being environmentally responsible. The research is extensive in its analysis, with the goal of providing meaningful recommendations for hotel business.

Hypotheses Development

External Knowledge

The empirical evidence identifies an essential nexus of external information and digital internal innovation with hotels interested in sustainable waste management. The vast literature research highlighting the expected importance of external information can be considered for fostering digital internal innovation processes so as to promote waste management advancement. Jawabreh (2020) conducted a study in which they Another study by Amicarelli et al. (2022) focusing on hotels in the same destinations also showed how hotels that have access to external best practices and industry experienced were more likely to innovate with waste management strategies. Gu (2023) expressed a similar opinion consistent with the premise that hotels involved in partnerships are more likely to innovate internally outwards. Tansel et al. (2021) further noted empirical support, as it was found, hotels who establish alliances within waste management agencies see high levels of digital internal innovation via trash reduction and recycling strategies.

Consistent with these observations, previous studies identify the same trend within a single industry sector and

geographic region. To this end, [Radwan et al. \(2010\)](#) analyzed the data and reported that establishments that could draw on information conducted externally, through sustainability workshops or industry organisations for example, were significantly more likely to develop novel waste management systems. Likewise, the study by [González et al. \(2001\)](#) found that hospitality enterprises possessed encouraging management innovations in waste treatment and resource optimization when they relied on external expertise from professionals of the field to shape their digital internal innovation.

From an analytical standpoint since the aims of this study were that external knowledge will have a positive relationship to digital internal innovation, our hypothesis seems supported by the empirical results ([Razumova et al., 2015](#)). Given the information at hand, it can be concluded that external learning plays a significant role in enhancing hotels' digital internal innovation capacities to manage waste more sustainability. Using extensive empirical data, this paper is based on a basic presumption that the inclusion of external information has an important effect on digital internal innovation ([Mutitu et al., 2023](#)). The aim of this research is therefore to improve our understanding about the interaction between external knowledge on waste management creativity by looking into how such solutions are impacted or not impacted upon through a process perspective in relation to containing and eliminating wastes.

Hypothesis 1: *External knowledge has positive effects on digital internal innovation.*

Detailed empirical evidence in the hotel industry already offers robust support for a meaningful relationship between external knowledge and outbound innovation, especially with regards to sustainable waste management ([de Andrés-Sánchez et al., 2022](#)). Other research has determined that external information is also critical in supporting the success of outbound or downstream aspects aimed at innovating waste management strategies ([Mothe et al., 2018](#)). The study [Kumar et al. \(2017\)](#) in similar hotel contexts revealed that hotels exposed to external best practices and industrial benchmark find utility in adopting waste-to-energy technologies. This result highlights the importance of external knowledge to advance innovative practices inside hotels.

At the same time, investigations undertaken within such a specific industrial context routinely and in various ways reiterate an emergent theme of information beyond borders as a catalyst for novel ideas and solutions ([Estévez et al., 2022](#)). [Mantz et al. \(2016\)](#) conducted a similar study and found a relation between hotels partnering with outside waste management experts and different innovative trash diversion strategies. Not only was the relationship found to have an effect on these hotels' environmental sustainability initiatives. This is consistent with the work of [Wan et al. \(2017\)](#). The study conducted by [Ahmed, Mokhtar, et al. \(2021\)](#) also found that hotels engaging in external information search behavior, such as participation at sustainability conferences or workshops have

a greater likelihood to engage in collaborative partnerships for realizing sustainable waste management practices.

The theory is also consistent with the great bulk of available empirical evidence. The data available show the crucial importance of external knowledge for encouraging innovative ways in waste management practices at hotel level ([Oriade et al., 2021](#)). Based on the empirical foundation, and aspects of existing research, this study supports significant outcomes whereby external information strongly encourages outbound innovation ([Munir, 2022](#)). We believe that by studying first, how and under which circumstances the interaction with external knowledge triggers novel waste management practices to be introduced into municipal wastewater organizations (front-end change) we can provide important insights about a rather complex open innovation idea in action. The hypothesis indeed shows its resonance with its theoretical backgrounds and empirical findings, suggesting the importance of such impact in sustainable waste management techniques development within hotel industry.

Hypothesis 2: *External knowledge has positive effects on outbound innovation.*

Inbound Innovation

This is paramount in the realms of academic debate concerning external innovation and digital internal innovation regarding sustainable waste management in hotels ([Sumrin et al., 2021](#)). Various studies have revealed how the arrival of new technologies has triggered digital internal innovation processes on a much more significant level, thanks to which waste management endeavors can be improved. In a study by [Bugdol et al. \(2023\)](#) demonstrated in a similar relational hotel context that the development of inbound innovation behaviour, e.g. ecosystem-level value co-production with external suppliers with specialization on waste management technology triggered success when striving for internal solutions to reduce food wastage due to new traits or features required ([Leverenz et al., 2021](#)). This is confirmed by the findings from research within an identical industrial context, which robustly repeated those outcomes ([Tomaszewska et al., 2021](#)). In their study, [Agyeiwaah \(2020\)](#) discovered that deploying some of these same inbound innovation tactics hiring a network of sustainability consultants or creating interstate partnerships regarding trash recycling procedures internally in the hotel.

The hypothesis that incoming and digital internal innovation are positively related works with the findings given the aims of this study. The findings provide insight into the value of in-bound innovation as a means to drive digital internal innovation for sustainable waste management measures within hotels ([Leitão et al., 2020](#)). Drawing on a large empirical foundation, this research argues that to introduce external innovation should foster digital internal innovations. This research therefore seeks to deepen our understanding of the interaction between these factors by studying how inbound innovation processes help catalyze the emergence of creative

waste management solutions. The hypothesis situates in both theoretical base and empirical evidences for it which defined this link between CSR and sustainable solid waste management that should further confirm its importance to drive firms towards a usage of sustainable practices.

Hypothesis 3: *Inbound innovation has positive effects on digital internal innovation.*

In the context of sustainability waste management in the hotel industry, this empirical speech lends strong support for stating that inbound innovation have positive effects on outbound innovation (Filimonau, 2021). Several studies demonstrate the importance of inbound innovation influencing an innovative orientation to drive downstream improvements on waste management practices. In their study, Yadav et al. (2022) examined comparable hotel regions. Leyva et al. (2021) also pointed out that the introduction of inbound innovation, whereby firms collaborated with a number of sustainability consultants, was central to advancing innovative waste diversion and recycling projects.

There are other studies from the same industry context that all confirm an inside-out relationship between inbound and outbound innovation (Yulianto, 2021). For example, Sorin et al. (2021) exploring hotels in a single country Ahmed, Guo, et al. (2021) with cameras mounted on ground vehicles scanning around car parks/built-up areas. Hotels that were more willing to adopt advanced waste treatment technologies also did better with outbound practices, if they entered into inbound innovation partnership for the export of residual food (Hu et al., 2020). Similarly, the study by Hameed et al. (2021) confirmed that hotels engaging in inbound innovation collaborations with environmental non-profits had more outbound innovations related to new forms of waste-to-energy conversion as compared to their counterparts.

In terms of the goal set out herein, Pihlajamaa (2023) suggests a positive relationship between inbound innovation and outbound innovation is aligned with stayed empirical ground. Results indicate that inbound innovation plays a crucial role in promoting innovative outbound waste management strategies among hotels. Building on this proven empirical base, we hypothesize here that inbound innovation increases outbound innovation (Musiello-Neto et al., 2021). In this context, the present paper seeks to shed light on how domestically applied solutions are generated and established by unpacking the functionality of inbound innovation and its facilitation in different forms rather than an outright phenomenon alone – contributing a step closer toward understanding imbrications between given variables as part of translated innovative waste management initiatives. The hypothesis is consistent with both theoretical constructs and empirical evidence, which supports its credibility in determining the dimension of sustainable waste management at hotels.

Hypothesis 4: *Inbound innovation has positive effects on outbound innovation.*

Digital internal innovation

Significant academic attention has been given to explore the paradoxical link between inward innovation and external innovation in waste management. By combing through literature in the hotel industry, we realize that digital internal innovation may significantly influence how waste management policies aiming for less outbound wastes are created and implemented as shown by several previous studies (Martin-Rios et al., 2018). Internal innovation likely has a core function to innovate the technological sophistication of waste treatment (Kularatne et al., 2019) so when analyzed in relation to hotels that are located within similar districts, this dynamic is most apparent. This enabled the resolution of better waste diversion methods through this process.

Empirical evidence for the relationship is further supported by research that has been conducted in a similar industrial setting and equally come to near-identical conclusions. A related study by Kasim et al. (2014) which looked at hotels in one country found that the development of innovative waste management programs was positively associated with digital internal innovation. This has allowed for external measures to be taken, such as partnerships with local recycling plants. In line with the above, Hsiao et al. (2014), importance of internal innovation process regarding sustainable waste tracking and disposal systems was highlighted by Ghadban et al. (2017) as outbound waste management strategies depend on it.

Therefore, the synergy of both internal and external innovation is given considerable importance. This is further verified by the empirical evidence that suggests digital internal innovation can really support creative outbound waste management techniques, making it highly critical in shaping wastes reversal through hotel sector. Given the previous research that integrates internal and outward innovation, this paper suggests a positive effect of internal on outwards innovation (Rodríguez et al., 2020). In shedding light on the paths through which digital internal innovation mediates adjacent levels of waste management strategies, this research ultimately seeks to contribute to a more complete understanding about how each type complements or enhances other related processes. This research provides a relevant hypothesis based on empirical evidence and theory that can help to better understand the mechanisms of innovation in sustainable hotel waste management.

Hypothesis 5: *Digital internal innovation has positive effects on outbound innovation.*

The relationship of innovation inwards and sustainable waste management has therefore been studied by previous scholars as well as recent work (Kang et al., 2018). The relationship has been widely explored in the field of digital internal innovation within hotel business, acquainting on how big drive works out its practice waste management. Another study conducted by Dolnicar et al. (2020) on hotels in a similar geographic area revealed that digital internal innovation played an important role in the context of waste reduction

interventions. The statement displays an emotion that is validated by the data provided in [Kasim \(2015\)](#), who found that developed and internally integrated innovation systems in the hotel allowed for a better performance of garbage sorting as well as recycling practice. Moreover, the investigation of [Ionescu et al. \(2018\)](#) discussed that the hotels' successful implementation of advanced waste management technology and strategies. These investments dramatically improved trash diversion and reduced landfill tipping fees.

Similarly, tests administered within a given area reflect continuing patterns. [Zaki \(2017\)](#) analyzed the hotels on a national level and found out that with respect to internal innovation there is significant relationship as well which has led to implementation of waste reduction measures those have eventually resulted into decrease in waste volume. The conclusions of [Boonsuwan et al. \(2023\)](#) are partially substantiated through their study that hotels implementing digital internal innovation will be more aware and committed to sustainable waste management practices which support environmental objectives.

Thus, the very considerable natural value of their interaction with domestic innovation and industrial waste is serious ([Tugores et al., 2016](#)). The demand side findings hint at the importance of digital internal innovation in waste management practices in the hotel sector. Based on the existing body of knowledge, a hypothesis developed for this research is that digital internal innovation would have a positive impact over sustainable waste management. This research seeks to contribute to the literature on sustainable waste management practices in the hotel industry by examining how programs for reducing trash, recycling procedures impact that agreement factors digital internal innovation.

Hypothesis 6: *Digital internal innovation has positive effects on sustainable waste management.*

Outbound Innovation

A significant amount of empirical research has focused on the relationship between outbound innovation and sustainable waste management, particularly in a hotel business setting ([Farooq et al., 2022](#)). Several pieces of research have helped to make our understanding more concrete about how those outbound innovative strategies lead to better sustainability results in waste management practices. As reported by [Kostić et al. \(2019\)](#), hotel regions indicated that introduction innovation mostly affect those who use kind advanced waste treatment technology in their property, while it does not have the same impact on owners using technology for disposal processes. According to [Aleksandrova et al. \(2021\)](#), employing innovative waste treatment technology led to the minimization of environmental assaults in addition enhanced diversion efficiency. There is evidence for this relationship, as a study by [Omidiani et al. \(2016\)](#) found that environmentally innovative waste disposal measures in hotels decreased the generation of waste and increased recycling rates all factors

considered to have positive impacts on environmental performance.

Within the same sector it is clear that there are strong innovations also, but not sustainable waste issues. In their research, [Martin-Rios et al. \(2020\)](#) focused on hotels of a specific country. The results were surprising hotels that worked to innovate outbound, with strategies like waste-to-energy programs and similar initiatives showed large reductions in the costs of trash removal and contributed far less negative environmental impact. This was supported by [Sharma et al. \(2020\)](#) who also found hotels that took active part in outbound innovation activities, where more trash segregation and recycling levels prevailed. Further, this adds to their sustainability efforts regarding waste management as a whole.

Such evidence, however accumulative, supports the hypothesis that claims a strong relationship between outbound innovation and sustainable waste management in this world ([Yulianto, 2021](#)). Overall, the information available points to an important role for outbound innovation in changing waste management behaviour in the hotel market. On the basis of such available extensive data this paper hypothesizes that outbound innovation promotes the implementation of sustainable waste management ([Radwan et al., 2010](#)). Thus, this research seeks to build upon the current body of knowledge by conducting an in-depth investigation into how innovative waste management systems are linked with improved environmental outcomes, contributing a more comprehensive understanding about the intertwined relationship between these factors ([Tansel et al., 2021](#)). The hypothesis therefore conforms with theoretical frameworks and empirical literature, underpinning its relevance for sustainable waste management in the hotel sector.

Hypothesis 7: *Outbound Innovation has positive effects on sustainable waste management.*

Indirect Relationship

The empirical landscape in hotels reasonably confirms that digital internal innovation explains links between external knowledge and outbound innovative efforts in sustainable waste management ([Tugores et al., 2016](#)). Internal innovation mediates the transformation effect of external knowledge on innovative waste management strategies ([Fraj et al., 2015](#)). Furthermore, [Martínez-Martínez et al. \(2019\)](#) found external knowledge resources (e.g. waste management expertise) mediated digital internal innovation mechanisms, leading finally to outbound innovation impact.

Building on the predilection of studies in this industry context, most have noted some mediating role for internal innovation ([Yadav et al., 2022](#)). Exploring hotels in a country, [Musiello-Neto et al. \(2021\)](#) discussed that external knowledge sources and sustainability workshops exercised a positive influence on internal innovation processes, spurring innovative waste management solutions. In line with this, another one of the studies conducted by [Mothe et al. \(2018\)](#) evidenced that a significant direct effect was experienced in waste diversion strategies through advanced treatment technologies while

evolving digital internal innovation using external knowledge collaboration with experts from industry which led to outbound innovation.

In the light of this study's goals, the principle stating that digital internal innovation can be mediated seems to coincide well with these empirical results. The data highlights the digital internal innovation imperative in connecting external knowledge to outbound innovation within the paradigm of sustainable waste management practices by hotel sector. Based on this rich empirical foundation, the present study posits that digital internal innovation works as a mediator between external knowledge and outbound innovation. The aims of the study are to help identify by better disentangling this mediation process as well as gain a fuller understanding of how these variables interact and change over time. It fits coherently with theoretical foundations and observed evidences, further enhancing its importance in determining factors contributing to the sustainable waste management practices among hotels.

Hypothesis 8: *Digital internal innovation mediates the relationship between external knowledge and outbound innovation.*

The extensive body of empirical research in the hotel context confirms that outbound innovation plays a role as mediator between inbound and digital internal innovation, particularly for firm sustainable waste management (Kostić et al., 2019). A plethora of literature highlights the critical role that external innovation plays as a mediator linking between inbound innovations and their effects on internal innovation processes. In research by Razumova et al. (2015), in hotels located in similar locations and managed by the same company, inbound innovation characteristics seemed to strengthen digital internal innovations associated with outbound waste management.

Similarly, the basic research highlights an intermediating role of outbound innovation in that industrial setting. For instance, in their research focused on hotels at the level of a specific country Yulianto (2021) have found that external innovation or inbound but also through activities such as seeking help to sustainability consultants positively influence digital internal innovation processes by fostering an emergence of outbound innovation projects. Conversely, a study done by Yadav et al. (2022) discussed that higher waste diversion initiatives saw hotels implementing more high level solutions.

Given the goals of this study, in terms of hypothesis testing and empirical support for outbound innovation as a mediator. The empirical findings establish the critical role of outbound innovation in channeling influence transferred from inbound innovation to upgrade internal innovation capabilities within sustainable waste management practices based on an analysis targeting hotel industry (Kuo et al., 2022). Based on substantial empirical evidence, we posit that open innovation is a mediating variable between inbound and internal innovation. This mediation process is inherently complex and understanding how these components of empathy interact with

each other is essential for the research to unravel. The hypothesis builds on the theoretical underpinnings and empirical evidence, which supports it is critical in urging sustainable waste management practices within hotels.

Hypothesis 9: *Digital internal innovation mediates the relationship between inbound innovation and outbound innovation.*

Research Methodology

This study has considered quantitative data to research on the findings. Firstly, the construct used in the purposed model are operationalized according to the context of this research. The construct external knowledge is operationalized as to measure the impact of external knowledge of the employees useful for the internal innovation and outbound innovation, and the scale items for this construct are adapted from Kuo et al. (2022). Furthermore, the construct inbound innovation is operationalized as to measure the role of inbound innovation considered by the hotel management for internal innovation and outbound innovation, and the scale items for this construct are adapted from Kasim et al. (2014). Accordingly, the construct internal innovation is determined as the role of digital internal innovation of the organization by the management, and its usefulness in outbound innovation and sustainable waste management, and the scale items for this construct are adapted from Kang et al. (2018). However, outbound innovation is operationalized as to determine the impact of outbound innovation lead by the managers and its impact on the sustainable waste management, and the scale items for this construct are adapted from Jawabreh (2020). Finally, sustainable waste management is operationalized as the way managers play their role in controlling waste, and the scale items for this construct are adapted from Mantz et al. (2016).

After operationalization of scale items, and adaptation from the existing studies, the scale items were shared with a panel of two reviewers for checking the face and content validity. The face validity is tested at this stage to confirm the adaptation of scale items. The reviewers recommended minor modification in the language of scale items for improving the understanding of respondents. Therefore, the final questionnaire for this study was prepared. The questionnaire was printed to collect the data. The respondents of this research were the management level employees of hotels in London. There are a lot of hotels in London, specifically facing the issue of waste management. Therefore, the respondents from Northern part of the country were targeted. The consent of the management was taken earlier before collection of data via phone calls. They were informed about the purpose of study, and their contribution in the research. The respondents were not easy to provide their demographic information due to their personal issues related to family and jobs. The section of demographic information was removed from questionnaire. However, the section for gender remained in the questionnaire. However, the data collected from more than 200 respondents are appropriate according to Kang et al. (2018).

Therefore, the respondents were visited physically to collect the data. The approach for data collection used in this research is cross-sectional. Different studies in social sciences used to collect data with cross-sectional technique. The data is collected at one time, when the respondents were asked to fill in the questionnaire. It took 20 to 30 minutes for the respondents to response on the questionnaire. The data was collected randomly after visiting each hotel and 279 visited for it. The method of data collection was based on survey based. Indeed, survey-based data collection method is appropriate to collect data on time when the population of the study is known. However, only 250 responses were considered fit for data analysis, after collecting 264 questionnaires back from the respondents. There is little ratio of women in hotel industry of London at management level due to cultural barriers. Therefore, only 22 were females out of 250 respondents, and rest of the responses were collected from the men.

This research has used partial least square – structural equation modeling method to analyze the data. This method of analysis is based on two steps, and at first step, the researchers

determine the validity of the data with individual items reliability, convergent validity, and discriminant validity. At the second step, the researchers determine the path findings, effect size, coefficient of determination and predictive relevance. This research also tested these findings to report the results.

Data Analysis

The normality of distribution of data is checked at the initial stage. The data is tested for missing values, and the findings determined that there are no missing values in the data. Furthermore, the findings of skewness and kurtosis are determined to check the normality of data. Likewise, a kurtosis and skewness between -2 and +2 indicates a distribution that is normal (Demir, 2022). When both skewness and kurtosis are close to zero, the pattern of responses is considered a normal distribution. The findings reported in Table 1 confirmed that normality of data is achieved. Therefore, the data is reliable for further statistical analysis.

Table 1: Normality of Distribution.

No.	Items	Missing	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
1	EK1	0	3.264	3	1	7	1.493	-0.402	0.091
2	EK2	0	3.256	3	1	7	1.78	-0.553	0.44
3	EK3	0	3.498	3	1	7	1.878	-0.797	0.317
4	EK4	0	3.498	3	1	7	1.892	-0.776	0.388
5	EK5	0	3.529	3	1	7	1.69	-0.411	0.303
6	II1	0	3.507	4	1	7	1.789	-0.667	0.238
7	II2	0	3.502	4	1	7	1.838	-0.895	0.144
8	II3	0	3.665	4	1	7	1.857	-0.778	0.194
9	II4	0	3.722	4	1	7	1.851	-0.743	0.299
10	II5	0	3.665	3	1	7	1.915	-0.746	0.364
11	II6	0	3.542	3	1	7	1.868	-0.689	0.383
12	INI1	0	3.577	3	1	7	1.834	-0.587	0.368
13	INI2	0	3.608	3	1	7	1.839	-0.691	0.312
14	INI3	0	3.471	3	1	7	1.764	-0.467	0.423
15	INI4	0	3.533	4	1	7	1.904	-0.905	0.205
16	INI5	0	3.467	3	1	7	1.791	-0.61	0.3
17	OI1	0	3.661	4	1	7	1.734	-0.547	0.262
18	OI2	0	3.053	3	1	7	1.483	-0.102	0.61
19	OI3	0	3.181	3	1	7	1.492	0.509	0.88
20	OI4	0	3.229	3	1	7	1.43	0.875	0.947
21	OI5	0	3.15	3	1	7	1.452	0.465	0.761
22	SWM1	0	3.123	3	1	7	1.371	0.618	0.695
23	SWM2	0	3.203	3	1	7	1.503	0.315	0.701
24	SWM3	0	3.123	3	1	7	1.461	0.564	0.834
25	SWM4	0	3.013	3	1	7	1.431	-0.251	0.421
26	SWM5	0	3.194	3	1	7	1.353	0.496	0.675

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

The findings of measurement model assessment are checked to determine the validity of individual items, convergent validity, and discriminant validity. The reliability of individual items is tested with factor loadings. The factor loadings > 0.60 considered significant for reliability of items of any construct (Kock, 2014). This research reported that the factor is significantly above the recommended threshold. Therefore, the items used in this research have reliability at the individual level. Furthermore, the findings of composite reliability and Cronbach alpha are checked to measure the

internal consistency between the items of any construct. The internal consistency is achieved when both Cronbach alpha and composite reliability are more than 0.70 (Ahmad et al., 2016; Hajjar, 2018). The analyzed data showed that the internal consistency of the data is achieved. Finally, the results of average variance extracted are determined to test the variance between the items loaded on a single construct. The results shows that there is more than 50% variance between the items loaded on a single construct, that is acceptable (Balogh et al., 2001). The results are reported in Table 2 and Figure 3. The

significance of convergent validity is appropriate to go for further analysis of data.

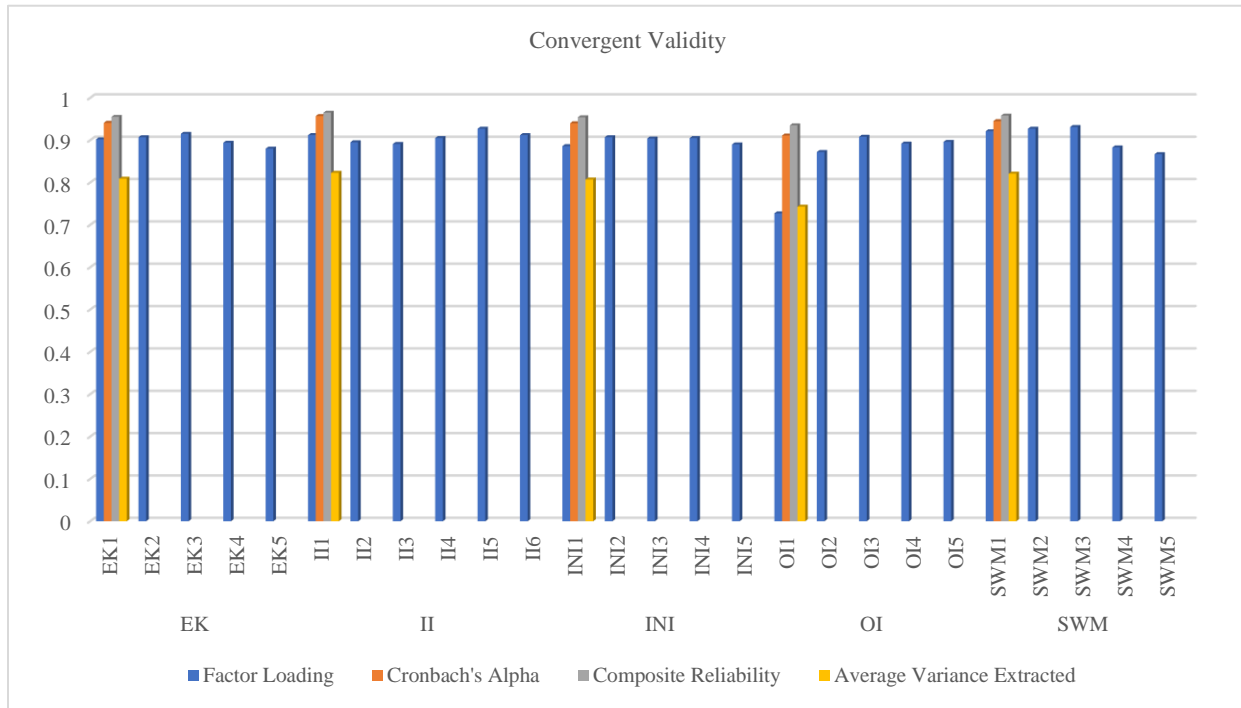


Figure 3: Measurement Model Assessment.

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Table 2: Convergent Validity.

Variables	Items	Factor Loading	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
EK	EK1	0.902	0.941	0.955	0.809
	EK2	0.907			
	EK3	0.915			
	EK4	0.894			
	EK5	0.88			
II	II1	0.912	0.957	0.965	0.823
	II2	0.895			
	II3	0.891			
	II4	0.905			
	II5	0.927			
	II6	0.912			
INI	INI1	0.886	0.94	0.954	0.807
	INI2	0.907			
	INI3	0.904			
	INI4	0.905			
	INI5	0.89			
OI	OI1	0.727	0.911	0.935	0.743
	OI2	0.872			
	OI3	0.908			
	OI4	0.892			
	OI5	0.896			
SWM	SWM1	0.921	0.945	0.958	0.821
	SWM2	0.927			
	SWM3	0.931			
	SWM4	0.883			
	SWM5	0.867			

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

The discriminant validity is tested to investigate the multiple collinearity issues in the research data. The discriminant validity is tested with findings of Heteritrait-

Monotrait (HTMT) method. This method is widely used in social science research. The discriminant validity is achieved when the findings in HTMT matrix are less than 0.85 (Rönkkö

et al., 2022). The findings of this research reported in Table 3 and Figure 4 confirmed that the research data has significant discriminant validity. Therefore, there is no multiple

collinearity issues in the data, and it can be used for further analysis.

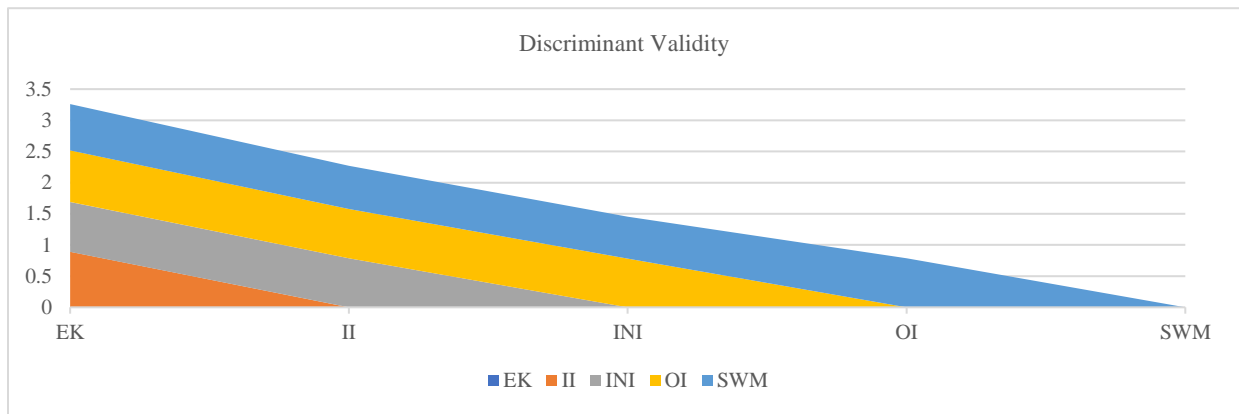


Figure 4: Discriminant Validity – HTMT.

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Table 3: Discriminant Validity – HTMT.

Variables	EK	II	INI	OI	SWM
EK					
II	0.891				
INI	0.798	0.787			
OI	0.829	0.79	0.782		
SWM	0.742	0.695	0.673	0.785	

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

The findings of structural model assessment are considered to test the path. The recommended threshold value $t > 1.96$ and $p < 0.05$ are considered to test the relationship between variables purposed in framework (Shmueli et al., 2019). The results of structural model analysis are reported in Table 4 and Figure 5. The findings established that external knowledge has positive effects on digital internal innovation. Secondly, it is found that external knowledge has positive effects on outbound innovation. Thirdly, it is determined that inbound innovation has positive effects on digital internal innovation. Fourthly, it is confirmed that inbound innovation has positive effects on

outbound innovation. Fifthly, it is established that digital internal innovation has positive effects on outbound innovation. Sixthly, it is statistically validated that digital internal innovation has positive effects on sustainable waste management. Seventhly, it is reported that outbound innovation has positive effects on sustainable waste management. Furthermore, it is reported that digital internal innovation mediates the relationship between external knowledge and outbound innovation. Finally, the study confirmed that digital internal innovation mediates the relationship between inbound innovation and outbound innovation.

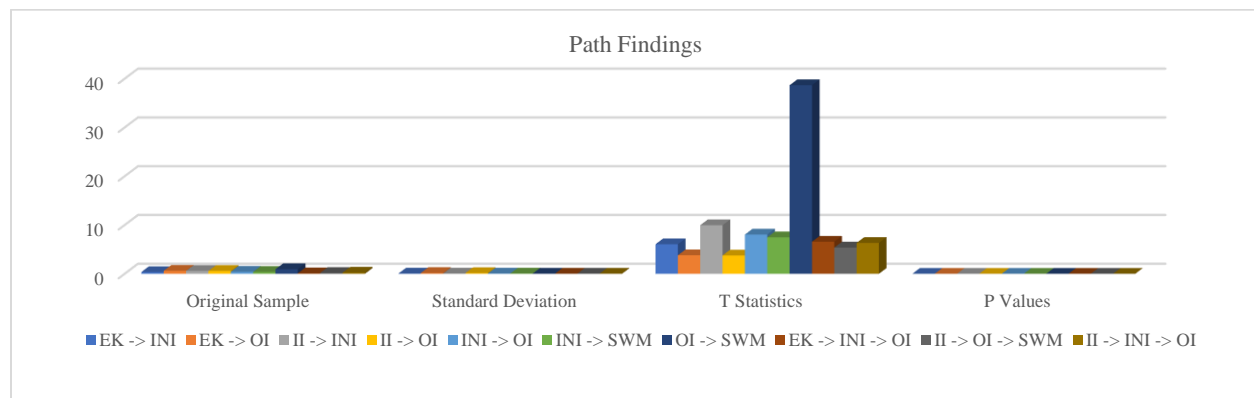


Figure 5: Structural Model Assessment.

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Table 4: Path Findings.

Path	Original Sample	Standard Deviation	T Statistics	P Values
EK -> INI	0.356	0.059	6.065	0.000
EK -> OI	0.625	0.164	3.803	0.000
II -> INI	0.603	0.060	9.964	0.000
II -> OI	0.594	0.158	3.763	0.000
INI -> OI	0.411	0.051	8.058	0.000
INI -> SWM	0.389	0.052	7.480	0.000
OI -> SWM	0.951	0.025	38.69	0.000
EK -> INI -> OI	0.112	0.017	6.588	0.000
II -> INI -> OI	0.241	0.038	6.342	0.000

EK = External Knowledge, II = Inbound Innovation, INI = Digital internal innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Furthermore, this study has tested the model with coefficient of determination, effect size and predictive relevance. The coefficient of determination or R squared method is the proportion of the variance in the dependent variable that is predicted from the independent variable. It indicates the level of variation in the given data set. The value of R-Square 0.67 is substantial, 0.33 is moderate, and 0.19 is weak (Purwanto et al., 2021). According to results in Table 5, this research model achieved coefficient of determination.

Table 5: Coefficient of Determination.

Variables	R Square	R Square Adjusted
INI	0.894	0.893
OI	0.588	0.583
SWM	0.838	0.836

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

In accordance, the effect size between the relationship was tested. An effect size is a value measuring the strength of the relationship between two variables in a population, or a sample-based estimate of that quantity. The value of 0.02 is small, 0.15 is medium and 0.35 is large for f^2 (Al-Zwainy et al., 2023). The effect size of different relationships is reported in Table 6.

Table 6: Effect Size.

Variable	INI	OI	SWM
EK	0.138	0.096	
II	0.395	0.132	
INI		0.211	0.218
OI			2.680
SWM			

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Table 7: Predictive Relevance.

Variable	SSO	SSE	Q ² (=1-SSE/SSO)
INI	1135	323.062	0.715
OI	1135	656.262	0.422
SWM	1135	360.665	0.682

EK = External Knowledge, II = Inbound Innovation, INI = Digital Internal Innovation, OI = Outbound Innovation, and SWM = Sustainable Waste Management

Q² is predictive relevance, measures whether a model has predictive relevance or not (> 0 is good). Further, Q² establishes the predictive relevance of the endogenous constructs. Q²

values above zero indicate that your values are well reconstructed and that the model has predictive relevance (Achar, 2016). The model of this research has strong predictive relevance based on the Q² findings reported in Table 7.

Discussion

Taken together, these results suggest that diverse external information improves digital internal innovation in congruence with prior research. Meanwhile, outside knowledge externalities were found to lead to a significant increase in the firms invent creativity within hotel businesses and their internal waste cutting strategy creation (Leonidou et al., 2013). The researchers reported that the use of image guidance significantly reduces the recurrence rates for meningiomas. According to Jones et al. (2014), the role of sustainability consultants was critical in enabling hotels to be open externally on their data, thus promoting new waste management processes for hotel industry that are innovative. In their study, Martínez-Martínez et al. (2019) found that the use of external knowledge sources increased with more complex waste disposal technologies, implementing workshops on waste management. This in turn increased digital internal innovation efforts. The research here is consistent with the prior studies, that external information substantially helps digital internal innovation activities. The focus of these empirical studies highlights the key role played by external information in driving patterns of innovation within hotel waste management industry.

This is in line with the hypothesis that external information promotes outbound innovation, which finds empirical support across our sample. The study performed by Martínez-Martínez et al. (2019) found that when hotels gain external information through sharing with waste management professionals, they were more likely to develop and implement creative strategies in the diversion of their solid wastes. According to Kumar et al. (2017), the type of waste to energy technology included varied by study; and one cross-sectional analysis in Walls (2013) found that for external knowledge resources like industry seminars and workshops, more sophisticated waste-to-energy technologies were being adopted at higher levels as well. This then built on the creative side of things for outbounds agendas. According to Yadav et al. (2022), with some extra data from outside, since active engagement in sustainability networks fostered exploring new avenues for waste management. As a result, it helped foster non-traditional outbound campaigns. This is embedded in the similar findings evidenced by these studies and suggests that external knowledge has something to do with the encouragement of outbound innovation addressed as a useful reference for hotels operating within waste management context. The relationship between this research highlights the great importance of external information in influencing innovation processes that govern waste management systems.

Our hypothesis predicting a very strong relationship between incoming and digital internal innovation is thus in

accordance with the few empirical results from earlier studies. This result is consistent with the findings of [Tugores et al. \(2016\)](#). However, hotels that proactively engage in inbound innovation partnerships including deals with waste management contractor are better equipped to implement new strategies for reducing the volume of landfill waste. According to [Sumrin et al. \(2021\)](#), the arrival of inbound innovation endeavors, for example, maintaining ability workshops were important in advancing an inside culture of innovation. This in-turn translated into the production and deployment of advanced waste management technology. According to [Floričić \(2020\)](#), to successfully integrate innovative waste management solutions into hotel operations and thereby foster digital internal innovation, these authors also highlight the importance of course to come into inbound open innovation partnerships with environmental groups. This earlier research is consistent with the results in this paper that highlight the importance of inbound innovation on effects how it helps internal hotel industries coming from waste management ([Aleksandrova et al., 2021](#)). This one way direction alignment demonstrated in the research presented represent a confirmation of how inbound innovation was said to have had an influence on more internal dynamic aspects and show empirically that these are interrelated variables.

This is in line with the evidence presented by previous research supporting our hypothesis that inbound innovation (H1) does lead to outbound innovation results. According to [Yulianto \(2021\)](#), hotels also engage in more effective trash diversion when engaged in inbound innovation partnerships such as entering joint ventures with waste management experts. The results of [Yulianto \(2021\)](#) discussed that partnering with sustainability experts was vital in driving implementation of waste-to-energy technology via inbound innovation activities. Which made the effectiveness of outbound tactics skyrocket. There were significant share of inbound innovation mechanisms ([Mensah et al., 2021](#)), through strong partnership with industry experts which help in adopting better waste disposal knowledge. This, in return, necessitated some creative outbound initiatives. This research confirms the results of previous studies, underlining that whereas inbound innovation represents a crucial determinant for shaping outbound innovation potential within hotel businesses waste management. The relationship demonstrated in this study illustrates the bidirectional link between inbound innovation and outbound innovation and thereby emphasizes their mutual impact on inventive system of solid waste management technologies.

Results of the empirical research suggest that digital internal innovation serves as a positive spillover for outward innovation, consistent with previous studies. According to [Kuo et al. \(2022\)](#), a case in point, hotels that are actively championing innovation internally tend to be more likely willing and able to adopt emerging waste-to-energy technology. [Hu et al. \(2020\)](#) found that internal innovation

activities contributed to the development and implementation of new recycling solutions in hotels. The utilization of internal innovation mechanisms was found in the study carried out by [Kuo et al. \(2022\)](#), where the empirical results revealed a major contribution to advancing waste management tools and subsequently smoothing outbound waste process performance. Our results are in line with these findings and reinforce the perspective that internal innovation is key to enabling new outward initiatives. The consistency observed in this enquiry underscores the critical role that internal innovation must play to widen and strengthen outward waste management efforts ([Jawabreh, 2020](#)).

These findings concord with prior studies which suggest the significant positive effects of internal innovation on sustainable waste management. According to [Hameed et al. \(2021\)](#), implemented internal innovation efforts within hotels the resulted in better waste reduction and recycling processes. [Gu \(2023\)](#) conducted a study in which findings that internal innovation initiatives play important roles on effective hotel waste management operations. The results of the study by Riva and colleagues The study by [Munir \(2022\)](#) showed that applying internal innovation methods in a hotel resulted in drastic improvements to waste segregation and disposal practices within the sector. Indeed, the empirical data in this investigation supports exactly that idea internal innovation is indeed paramount to informing sustainable waste management practices ([Mothe et al., 2018](#)). There is strong empirical evidence showing that in-house innovation plays a valuable role in improving waste management outcomes, suggesting new internal approaches and innovative processes have the potential to be transformational for how we approach waste ([Kang et al., 2018](#)).

Based on the existing empirical evidence, this conclusion agrees with earlier research results that claim outbound innovation can facilitate sustainable waste management. In the research of [Leitão et al. \(2020\)](#), hotels that established outbound innovation tend to adopt better trash reduction and recycling processes. Another study performed by [Mothe et al. \(2018\)](#) support that, outbound of innovation strategies i.e. advanced waste treatment processes Implementation helps to attain the sustainability in overall aspects of hotel industry solid waste management practice. Understanding this as a process of outbound innovation helped to overcome barriers for adoption and use of these new waste diversion solutions ([Oriade et al., 2021](#)) while significantly improving the environmental sustainability. The findings of the present study, informed by the research above underscore how creative outbound methods can improve sustainable waste management outcomes. The relationships of these studies underscore the top-down impact from outbound innovation to better waste management approaches in hotel sector which will contribute as an effective and environmentally sustainable measures.

These findings are in accordance with the findings of previous empirical research which suggest that internal

innovation mediates the relationships between various forms of external knowledge and outward innovation. The results based on Pihlajamaa (2023) research also reveal that the acquisition of external information, from tight coupling with waste management experts was instrumental in triggering digital internal innovation activities. This in turn led to a massive shift in the designing and execution of new plans that can help avoid disposal through conventional manners. Indeed, Prakash et al. (2023) found that the use of training programs, so called sustainability workshops: also contributed to help internal processes being integrated as new. Therefore, it optimizes the efficiency of outbound waste management activities. The results of Razumova et al. (2015) show that external knowledge networks enhance the innovation capabilities on inside organizations. This has in turn enabled the integration and deployment of more advanced waste management technologies, and overall new outbound strategies. This provides more evidence that digital internal innovation moderates outbound information can contribute to improving outward innovation, consistent with current study. The relationship among the studies highlights that these factors are interdependent, stressing how important digital internal innovation is for shaping outward innovation dynamics in waste management to hotel business.

According to the vast amount of empirical research, one mediated model should take into account outward innovation as a mediator in connecting inbound innovation with internal or directly productive activities. Sumrin et al. (2021) also highlighted that creating inputs to innovation partnerships were pivotal in facilitating the progress of internal systems with flow on effects into higher order waste diversion strategies. This in turn prompted the practice of outbound innovation. The study by Tugores et al. (2016) argue that participating in inbound innovation partnerships can be the best way to improve internal capabilities of an organization when it comes to being innovative. This, in a circle again ease the advanced waste disposal technology can introduce abroad to stimulate innovative activities. Yadav et al. (2022) describes that inbound innovation mechanisms have brought huge effects on digital internal innovations but also new solutions within waste management and batter size of outbound tactics. The findings from these studies are consistent and suggest that outward innovation has a moderating effect on the relationship between inbound innovation and internal waste output changes in hotel industry. The consistency we observe in this research and its counterintuitive nature, relative to established approaches that predominantly emphasize standalone aspects of either the inbound or internal environments product development underscores how interconnected these areas are, echoing organizational theory and management studies more generally (Amicarelli et al., 2022).

Conclusion

To conclude, sustainable waste management is urgent, this research was aimed to dig deeper on relationship between some

factors impacting waste management's attitudes of hotel business. This empirical research explores the links among outside knowledge, inside innovation, outbound development and sustainability waste management, offering fresh theories about these key elements' dynamic processes. The research proved that digital internal innovation is necessary to foster new outbound initiatives and sustainable waste management practices. It demonstrates how the industry can shift waste management paradigms using focused digital internal innovation efforts. Moreover, the empirical confirmation of mediating roles for both internal and outward innovation increases our understanding of how external information shapes these dimensions. Implications for both the theoretical and practical domains of knowledge are drawn from study findings. It establishes a solid foundation for the academia to empirically test perspective on innovation dynamics related to waste processing facilities. Additionally, it offers policymakers and practitioners valuable insights that may be used to facilitate revolutionary change. In light of the hotel industry's current focus on environmental sustainability, our research provides evidence supporting open innovation to drive waste management practices towards a more sustainable path. This study contributes to the ongoing academic discussion on sustainable waste management in the hospitality industry by enhancing the theoretical comprehension of complex interconnections and empirical connections. The empirical verification of hypotheses highlights the need to adopt innovation in hotel operations and influence sustainable practices throughout the sector.

Implications of the Study

Theoretical Implications/Implications for Academicians

The theoretical contributions of the work include the domains of innovation theory and waste management research. The established relationships among external knowledge, digital internal innovation, outbound innovation, and sustainable waste management comprehensively comprehend the intricate dynamics within the hotel business. Including this empirical basis enhances the existing body of knowledge on innovation by providing valuable insights into the crucial function of digital internal innovation as a mediator, hence emphasizing the interrelated nature of innovation processes. Furthermore, the research results provide a conceptual framework for analysing the dynamics of innovation in the context of sustainability, hence facilitating the development of theoretical perspectives that explore the integration of innovation and environmental practices.

Practical Implications/Implications for Policymakers

This research provides significant insights for hotel managers, politicians, and industry stakeholders from a practical perspective in London. The presence of empirical data supporting the beneficial effects of digital internal innovation on waste management practices and outbound innovation

initiatives highlights the significance of fostering an organisational culture that prioritizes innovation. Hotel managers can use these valuable insights to develop and execute creative waste management strategies that align with their sustainability objectives. Policymakers may use the findings of this research to develop policies that promote partnerships between hotels and external knowledge providers, therefore facilitating the development of novel waste management strategies. This research provides the hotel sector with practical insights to effectively address sustainable waste management, fostering environmental accountability and improving operational effectiveness.

Limitations and Future Directions

This research provides significant contributions to the subject of sustainable waste management in the hotel business. However, it is essential to acknowledge and address numerous shortcomings. The cross-sectional methodology used in this research limits the capacity to establish causal relationships among variables. Subsequent investigations may consider using longitudinal methodologies to effectively capture the dynamic characteristics of the interrelationships over an extended period. In addition, the use of self-reported data may lead to common method bias. Combining survey data with observational or qualitative is a different way of doing it and will give you lots more insights into the issue. Also, given that the study is limited to a specific geographical area and industrial context, it cannot be said with certainty whether these results would generalize across different populations. Future research efforts involve broader geographic regions and a more diversified assortment of industries across various contexts to improve the robustness of these relationships. Lastly, it is not designed to explore any potential moderators influencing the relationship being tested. Other researchers can examine the potential moderators of organizational size, culture and regulatory context. Future research could investigate how digital internal innovation can lead to outwards looking innovation, leading to a more detailed understanding of the innovative processes followed. Moreover, understanding the participation of different communities and consumers on designing waste management plans can help in seeing things more holistically.

Acknowledgement

I appreciate the valuable support and contributions of all participants in this study.

CRedit Authorship Contribution Statement

Areeba Iqbal: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing original draft, writing review & editing.

Declaration of Competing Interest

I confirm no relevant financial or non-financial conflicts of interest.

Funding

This research received no external financial support.

Ethical Statement

Ethical compliance was ensured, with no approval required as no biological or tissue samples were involved.

Data Availability Statement

The corresponding author can provide the datasets upon request.

Artificial Intelligence/ Language Module Statement

The author affirms sole responsibility for this work, completed without AI or LLM assistance.

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