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Toward a Sustainable Society: The Role of Environmental Knowledge, Knowledge Capability, Sustainable Innovation, and Innovation Orientation in Product Innovation

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Abstract

Contemporary stakeholders persist in pressuring firms toward environmental stewardship, while dynamic organizations demonstrate high-level capability and strategically respond to market evolution and align operations toward sustainability. This study aimed at investigating the connection between environmental knowledge and awareness and product/service innovation, as well as the mediating roles of knowledge process capability-application dimensions and sustainable innovation, and the moderating effects of innovation orientation. Through a questionnaire, empirical data were collected from 354 bank employees operating in western Nigeria, whose bank ranked on the list as being the most sustainable bank in Nigeria in the 2024 sustainability ranking. SPSS and SmartPLS were used for data analysis and the testing of hypotheses. The findings showed a significant positive association between environmental knowledge and awareness and product/service innovation, and additionally, knowledge process capability-application and sustainable innovation significantly mediate the relationship between environmental knowledge and awareness and product/service innovation. Meanwhile, innovation orientation negatively moderates the relationship between environmental knowledge and awareness and knowledge process capability-application. However, innovation orientation did not moderate the relationship between sustainable innovation and product/service innovation. This study underscores the importance of knowledge management strategy and firm innovation orientation toward sustainability stewardship in service organizations and provides valuable theoretical insights for management scholars. An integrated dynamic capability, as well as absorptive capacity theories, underpinned this study.

Keywords: dynamic capability theory; absorptive capacity theory; sustainability; environmental stewardship; stakeholders; knowledge management

Check for updates

Academic Editor: Alina Badulescu

Received: 21 May 2026
Revised: 11 June 2026
Accepted: 16 June 2026
Published: 29 June 2026

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1. Introduction

The pursuit of sustainable competitive advantage has compelled organizations to strategically respond to market dynamics and stakeholders' expectations across the value chain [1–5]. Research in the marketing literature asserts that, to gain stakeholders' trust, firms must learn to simultaneously configure their market offerings to align with current market demands, i.e., the market-driven-cum-customer-dominant approach [6,7]. The dynamic nature of the market is a consequence of the shifting interplay of time, events, and value proposition [8]. Market dynamism has been reflected in strategic management

literature, beckoning business approaches to shift from the firm's production and managerial views to stakeholder management [9]. The emergence of the stakeholder management approach is due to the inadequacies of the production and managerial approach that failed in addressing the emerging demands of contemporary, more aware stakeholders who are clamoring for sustainable business practices [10–12]. Stakeholders' business perspectives thus advocate for a more inclusive business operation of economic, social, and environmental performance to realize sustainability initiatives [10,13].

The research stream of environmental protection and natural resource management has prompted a new way of thinking by advocating for the sustainable management of the Earth's resources [14,15]. This view corresponds with the proponents of stakeholder management theory, whose central view hinges on "those with a stake or are affected by the firm operation". Following this line of thinking, it stands to reason that the environment is a stakeholder and is affected by the actions of humans; for example, the loss of biodiversity, the ozone layer, climate change, drought, and the depletion of critical natural resources. This indicates that the environment is a different type of unclassified stakeholder, affected by the activities of humans; as such, new approaches to business are being advocated under a broader concept that is known as sustainability. As the pursuit toward a more sustainable society continues, organizations are caught in a web of complexity on how to accommodate social and environmental issues, such as "knowledge", in business processes that benefit sustainable, innovative outcomes [16–19]. Additionally, another major challenge is in understanding how *knowledge is processed and applied* and how sustainable innovation practices and innovation orientation (IO) translate environmental knowledge and awareness (EKA) into sustainable product and service development that meets sustainability goals and has potential for sustainable competitive advantage [20–24]. Previous literature has often bypassed the role of these constructs, especially regarding the mediation of the knowledge process capability-application dimension (KPC-A), sustainable innovation (SI) practices, and the moderating effect of innovation orientation (IO) on product/service innovation (PSI). This call for further examination of how environmental knowledge and awareness, complemented by knowledge process capability, sustainable innovation (SI) practices, and a strong innovation orientation (IO), can be mobilized to facilitate the development of sustainable products and services that have implications for meeting stakeholder demands through the delivery of valuable, rare, inimitable, and organized market-ready offerings, such an approach is critical for achieving sustainable competitive advantages and, consequently, fostering a sustainable society [25–27].

Proactive organizations adopt processes that enable them to respond to market and environmental dynamics, also known as the dynamic capability perspective [28–30]. Extant research linked process capability to the deployment of a knowledge management strategy, whose outcome leads to enhancing organizational performance and meeting the ever-changing needs of the market [31–35]. This is sensemaking because knowledge management capability empowers organizations to create, access, apply, and distribute strategic knowledge to organizational actors [34,36,37]. The knowledge-based view of the firm strongly contends that knowledge is the most valuable resource of the firm, which benefits sustainable competitive advantage [38,39]. In alignment, [40] proposed a knowledge management cycle model, demonstrating how knowledge is transformed from intangible resources to tangible market-ready products and services. Thus, this study draws on extant scholarship from strategic knowledge management and sustainability as a point of departure and proposes a knowledge-based sustainability (KBS) model.

Knowledge management has become a compelling force in the hand of decision makers, as well as a hot research area for strategic management scholars and business professionals, as seen by the surge in the number of studies available on knowledge man-

agement. However, it is interesting to see that most of these studies investigated the direct relationship of an organization's knowledge management capability with firm performance [20,31,33,34,41,42] and that most of these studies are not within the context of sustainability. Therefore, this study fills this gap and contributes to existing empirical literature on knowledge management and sustainability by bridging the gap between knowledge management and sustainability and their simultaneous effects on product/service innovation (PSI). Secondly, most of these studies examined the direct relationships of these constructs with product/service innovation (PSI) and overlooked the mediating roles of knowledge process application and sustainable innovation (SI) processes in product/service innovation (PSI); for instance, sustainable innovation (SI) regarding the development of product and service innovation was initially examined by [43], the KM dimension of acquisition, dissemination, and responsiveness in green innovation by [44], KM in innovation by [45], and the relationship of innovation and sustainable performance by [46]. Thus, this paper addresses this gap. Third, current scholarship has overlooked the moderating role of innovation orientation of firms in developing sustainable innovative outcomes, and the paper also fills this research gap. Finally, most of the sustainability literature focuses on the advanced economy of western firms, with very few studies on sustainability focused on developing countries, and this study also fills this gap with empirical study of the financial sector of Nigeria and contributes to existing knowledge on the sustainability footprint of the Nigerian banking sector [47].

Therefore, the central focus of the study was to investigate how environmental knowledge and awareness (EKA) contribute to developing sustainable product and service innovation (PSI) within the Nigerian banking sector. Precisely, the paper examined the mechanisms through which EKA translate to sustainable innovation outcomes by investigating the mediating roles of knowledge process capability-application (KPC-A) and sustainable innovation (SI), as well as the moderating role of innovation orientation (IO). To address this overarching objective, the study pursues the following specific objectives: To examine the direct effect of environmental knowledge and awareness on knowledge process capability-application. To investigate the direct effect of environmental knowledge and awareness on sustainable innovation. To assess the direct effect of environmental knowledge and awareness on product and service innovation. To determine whether knowledge process capability-application mediates the relationship between environmental knowledge and awareness and product and service innovation. To examine whether knowledge process capability-application mediates the relationship between environmental knowledge and awareness and sustainable innovation. To investigate whether sustainable innovation mediates the relationship between environmental knowledge and awareness and product and service innovation. To assess the sequential mediating effects of knowledge process capability-application and sustainable innovation in the relationship between environmental knowledge and awareness and product and service innovation. To investigate the moderating impact of innovation orientation on the relationships among environmental knowledge and awareness, knowledge process capability, sustainable innovation, and product and service innovation. By addressing these objectives, the study aims to provide a comprehensive understanding of how environmental knowledge resources can be transformed into sustainable innovation capabilities and enhanced product and service innovation outcomes in commercial banks.

Consequently, the study present the following questions. How does environmental knowledge and awareness (EKA) influence the development of product/service innovation (PSI)? Does environmental knowledge and awareness (EKA) benefit knowledge process application in the development of an innovative sustainable product and services? Does environmental knowledge and awareness (EKA) lead to sustainable innovative practices

capable of producing sustainable products and services? To what extent does knowledge process application and sustainable innovation (SI) mediate the relationship between environmental knowledge and awareness (EKA) and product and service innovation? To what extent does innovation orientation moderate the relationship between environmental knowledge and awareness (EKA), knowledge process application and sustainable innovation (SI) in developing sustainable products and services?

2. Theoretical Review, Hypotheses Development and Conceptual Framework

Extant theories provide the basis for sound scientific reasoning that eventually lends itself to making specific scientific statements that are further subjected to scientific testing. Claims are built upon relational concepts uncovered during rigorous review of related scholarly works. The study reviewed a collection of relevant theories and, based on the objectives of this research, the study located the dynamic capability and absorptive capacity theories for justification of claims. The conceptual framework cum hypotheses are developed based on the central premises of these theories.

2.1. Theoretical Review

An integrated framework of dynamic capabilities theory (DCT) and absorptive capacity theory (ACT) underpinned the research, and these theories provide a comprehensive illumination of the interdisciplinary nature of the concepts of knowledge management, sustainability and innovation of products and services. An integrated theoretical approach offers holistic evaluation of the variables under investigation and provides a treasure trove of unique insights to the study [48].

2.1.1. Dynamic Capabilities Theory

DCT is a derivative of a combination of three extant theories in strategic management discipline, e.g., Porter competitive forces [49], the strategic conflict of game theory approach [50], and the resource efficiency paradigm [51]. DCT was put forward in an effort to shed more light on why firms build and sustained competitive advantage in regimes of environmental and technological turbulence [28]. In other words, dynamic capabilities theory emphasizes opportunity sensing, adaptation, integration, and the reconfiguration of internal and external capabilities in order to respond to environmental changes. It argues that a firm's superior performance is a function of continuous learning, resource deployment, and lean innovation capabilities. The term dynamic according to [28] refers to rapid environmental changes induced by technology and market forces, while capabilities are seen as resting on the firm's processes, resources, competencies and position. Thus, dynamic capabilities are a firm's ability to leverage its resources both internally and externally to rapidly respond to emerging market demand through the introduction of new business models. The important components of DCT are *identification of opportunity*—this involves opportunity sensing through unmatched analytical capabilities, R&D activities and strong entrepreneurial foresight to identify emerging market trends, competitive stances and new technology to inform long-term business strategy capable of producing idiosyncratic results [39,52,53]; *opportunity capitalization*—this involves resource allocation and galvanization to capitalize on emerging market opportunities orchestrated by environmental dynamism and the reconfiguration and realignment of capabilities to maintain and sustain a competitive stance.

2.1.2. Absorptive Capacity Theory (ACT)

ACT highlights the importance of an organizational knowledge processing capability to inform innovation especially in regimes of environmental turbulence. Proposed by [54],

it is theorized that an organization's innovation level is a function of its capability to absorb and process external knowledge. ACT benchmark external knowledge as an important component of organizational resources critical for strategic innovation. Scholars in strategic management and organizational learning have applied ACT to study innovation in organizations [55]. The main components of ACT include "*knowledge acquisition*" which emphasizes identifying and acquiring external knowledge through R&D activities and synergistic strategies; "*assimilation*" which entails the organization's capabilities to interpret, internalize, and integrate imported knowledge into organizational routines to compliment existing knowledge. Here, the internal processing capability of the organization is amplified; "*transformation*" which involves the combination of different forms of organizational knowledge to create new insights that align with prevailing market condition; "*exploitation*" which focuses on the application of acquired and transformed knowledge to produce strategic gains, which lead to the development of new products and services critical for achieving competitive advantage [54].

Although both theories emphasize organizational adaptation and knowledge utilization, they operate at distinct levels of complementary analysis. ACT represents the abilities of the firm to absorb environmental knowledge and awareness which constitute important external knowledge assets that the enterprise must consciously convert to create valuable resources. Subsequently, through absorptive capacity of the firm (the knowledge management capacity), sustainability-oriented knowledge is converted into critical organizational knowledge assets. DCT appears when critical organizational knowledge resources, "the absorbed knowledge", are redesigned into sustainable innovative packages and enhance product/service innovation performance. Thus, sustainable innovation is a consequence of a firm's dynamic capability deployed to reconfigure knowledge resources which in turn enhance operational processes and produce differentiated environmentally conscious products and services. Coherently, both theories demonstrate that environmental knowledge and awareness benefit knowledge process capability (absorptive capacity) and act as input to the firm's dynamic capability to further use the knowledge to design sustainable innovation approaches and enhance the innovation of products and services. Innovation orientation supplements this process by encouraging firms to aggressively exploit acquired knowledge and seek innovative opportunities.

2.2. Environmental Knowledge and Awareness (EKA)

Environmental knowledge and awareness (EKA) are a by-product of knowledge management activities. For instance, knowledge dissemination indirectly impacts green innovation through environmental awareness [44], household knowledge management pertaining to energy saving [56], and environmental awareness through education [57]. The knowledge economy has opened up opportunities for organizations to access plenty of information using different mechanisms, such as digital tools and social media platforms to acquire environmental information [58]. Sustainability themes have become central to international conferences and there is a strong expression toward humans and the environment, for example, environmental psychology which emerged in the 1960s in the US examined the complexity of interaction between humans and the environment [59]. Environmental knowledge and the antecedent awareness are critical concepts in comprehending an individual's attitude and behavior toward the material world and how such an individual or groups approach sustainability issues, e.g., studies have linked environmental knowledge and awareness (EKA) to green behavior [59–61] and green awareness of customers through environmental knowledge [62]. By extension, recent scholarship also investigated and found a strong correlation between environmental knowledge and green products [63]. The environmental management literature also highlighted the moderating

roles of environmental knowledge on green innovation [64,65]. EKA are an important enabler in driving green behavior [66] and influencing public and organizational policies and the subsequent sustainable development [67]. As the name implies, environmental knowledge and awareness (EKA) are an individual's understanding about environmental issues, concepts and the associated consequences of human impact on the environment. Awareness, on the other hand, is acknowledging environmental issues and the need for actions, often tied to a sense of responsibility [59,68]. Advancing this reasonning to the organizational context or the managerial perspective, this implies an organization's understanding about environmental problems and the need for collective action. Camacho et al. assert in recent publications that environmental knowledge is vital in shaping employee and organizational behavior [2,69]. According to [59] environmental knowledge is grouped into "*factual knowledge*" which is knowing the state of the environment and "*procedural knowledge*" which is understanding how to remediate environmental problems. Additionally, there are arguments about the forms of specific environmental knowledge that predict ecological behavior [70]. The research stream on responsible environmental behavior has benchmarked environmental knowledge as an influencing predictive factor for responsible environmental behavior. Individuals or groups possessing a superior level of environmental knowledge have a predictive tendency to act in ways that are less harmful to the environment. Moreover, environmental awareness is a precursor that compliments environmental knowledge with action [42,68,70,71]. However, knowledge alone does not culminate in action, therefore, it is critical according to [59] to address the knowledge–action gap by engaging this knowledge in accordance with social norms, which implies the integration of environmental knowledge and awareness into organization knowledge management strategy to scale up performance that aligns with sustainable development templates. This notion leads to the formulation of the following hypotheses which are in alignment with the DCT and ACT perspectives. For instance,

> (. . .) According to Absorptive Capacity Theory, firms can generate value from their absorptive ability to acquire, assimilate, transform, and apply external knowledge. Environmental knowledge and awareness constitute an important source of organizational knowledge resources that drive firms toward recognizing emerging environmental issues, and market opportunities—here (stakeholder expectations, environmental laws and ecological issues are captured). Additionally, DCT theorized that firms that effectively sense environmental changes and redesign organizational knowledge resources are highly likely to develop lean capabilities and enhance innovation outcomes. Furthermore, from ACT perspective, the possession of environmental knowledge does not automatically translate to value unless those knowledge are transform and integrated into organizational routine, such integration enable firm to create environmentally friendly products. Dynamic Capability Theory asserts that organizations capable of exploiting environmental knowledge can reconfigure knowledge resources to create innovative market offerings. hence, organizations possessing higher environmental knowledge resources are expected to achieve greater levels of product and service innovation that has potential in creating competitive advantage.

H1. *Environmental knowledge and awareness (EKA) determine to a great extent knowledge process application (KPC-A) (action stage 1).*

H2. *Environmental knowledge and awareness (EKA) determine to a great extent sustainable innovation (SI) practices (action stage 2).*

H3. *Environmental knowledge and awareness (EKA) directly impact product/service innovation (PSI) (direct outcome stage).*

2.3. Knowledge Process Capability-Application (KPC-A)

The research landscape of knowledge management has consistently confirmed the linked between KM, firm innovativeness and performance [45,72–76]. To reap KM benefits organizations need to transition from the knowledge and awareness sphere to integrating knowledge from various sources into knowledge management strategy [59] and that is where knowledge management matters the most. Accordingly, the knowledge-based view (KBV) of the firm posits that an organization's knowledge process capability-application (KPC-A) is critical in leveraging the knowledge asset of the firm for the realization of strategic business benefits [38]. The literature has highlighted three major components of KPC-A, *knowledge acquisition*, *sharing and knowledge application*, and the KM application dimension mobilizes acquired and shared knowledge to create value, improve processes and trigger innovation [34,45,77]. The knowledge process capability-application, dimension which is the focus of the study, emphasizes the organizational ability to manage and integrate knowledge resources from different sources to scale up performance [78]. For instance, knowledge integration and team performance were earlier investigated by [79], encapsulating individual competencies, organizational processes, culture and structure that compliment the effective use of knowledge assets, according to [37]. Knowledge application has implications for addressing organizational challenges, exploiting opportunities and producing actionable outcomes. KPC-A amplifies *knowledge integration*, which involves bringing together knowledge from diverse sources to confront organizational processes, while *knowledge utilization* focuses on knowledge usage to solve problems, improve processes and initiate innovation. Furthermore, *knowledge renewal* focuses on updating, refining and integrating new knowledge to align with environmental changes [80], which will in turn enhance organizational processes, benefit the development of innovative products and services and proactively respond to market dynamism with potential for superior performance. This is critical especially for knowledge-intensive sectors such as the financial industry. Knowledge application allows for quicker decision making, boosting innovation along the value chain and enhancing competitive profile of the organization [41]. The degree of organizational efficiency, innovation and strategic agility is a function of knowledge integration of both tacit internally oriented and explicit externally oriented knowledge [38,81]. In a knowledge-driven economy, application of organizational knowledge is critical in driving innovation; it is transitionining from knowing to doing. In other words, it is based on applied knowledge and propels organizations toward the achievement of sustainable competitive advantage. Therefore, the following hypotheses are formulated based on the synthesis of previous literature.

H4. *Environmental knowledge and awareness (EKA) impact product/service innovation (PSI) through the positive influence of knowledge process capability-application dimension (KPC-A).*

H5. *Environmental knowledge and awareness (EKA) impact sustainable innovation (SI) through the positive influence of knowledge process capability-application dimension (KPC-A).*

2.4. Innovation

Innovation has become a common language among individuals and business people, which is attributed to its unique relevance to business success. For this reason, there is a lack of consensus on the definition, leading to misunderstanding [82,83]. Kenneth B. Kahn acknowledged this misconception ascribed to the meaning of innovation and theorized that, for organizations to benefit from innovation, there is need to recognize that innovation has

three stages and each of these stages functions synchronously for the optimum realization of the benefits of innovation. He went on to identified these stages as, "*Innovation as a process, Innovation as a Mindset and Innovation as an outcome*" [82]. More specifically:

> (. . .) Innovation as an outcome (Product/service innovation (PSI)) emphasizes what output is sought, including product innovation, process innovation, marketing innovation, business model innovation, supply chain innovation, and organizational innovation. Innovation as a process (Sustainable innovation (SI)), attends to the ways in which innovation should be organized so that outcomes can come to fruition; this includes an overall innovation process and a new product development process. Innovation as a mindset (Innovation orientation (IO)), addresses the internalization of innovation by individual members of the organization where innovation is instilled and ingrained along with the creation of a supportive organizational culture that allows innovation to flourish. Such an understanding and definning necessary elements, considerations, and vernacular surrounding the term so that better decisions can be made, thereby enabling innovation and having a greater propensity to succeed. ([82] in Understanding Innovation.)

These insights serve as guidance for the framing of the current study and encapsulate the full essence and meaning of innovation which are represented accordingly, for instance, sustainable innovation (SI) as a process, innovation orientation (IO) as a mindset and product/service innovation (PSI) as an outcome.

2.4.1. Sustainable Innovation (SI) (Innovation as Process)

The environmental science literature has persisted in raising the issues of environmental problems of natural resource depletion [84–89]. Following these issues, economists and natural resource management researchers have associated the problems of natural resource depletion to overpopulation, economic growth and the industrial revolution [84,90,91]. To control the continous depletion of these critical economic natural resources, scholars and stakeholders are advocating for the adoption of sustainable business practices that balance economic, social and environmental aspect of business performance [92–95]. Subsequently, the concept of sustainable innovation (SI) emerged within the themes of sustainability [96–98] which implies, according to the literature, "*the introduction and execution of new production processes that integrate the economic, social and environmental dimension into value proposition*" [43,93–95,97,99].

Considering the increasing demand for environmental stewardship and sustainable development, adopting sustainable business model perspectives has implications in addressing sustainability challenges, innovating processes that produce differentiated market offerings and driving firms toward realization of competitive market position [98,100–103]. Consequently, sustainable innovation (SI) according to extant literature involves a combination of several organizational strategies from *eco-innovation* which aims at developing processes and outcomes that mitigate environmental impact [104–107] to the adoption of sustainable business frameworks that integrate sustainability with profitability such as the circular economy business model of waste management and product regeneration [101,108], the green innovation model of product, process and service innovation that reduces environmental impact and encourages sustainability [109,110], transitioning to stakeholder management theory to allow collaboration of stakeholders in the cocreation of market offerings [9], and a system thinking perspective that allows for a holistic evaluation of the economic, social and environmental business performance [111]. Sustainable innovation (SI) as a process is pivotal for the successful realization of sustainable product/service innovation (PSI), thus, it cannot be overlooked [82]. Evidently, the previous literature and

theoretical lanscape of sustainable innovation (SI) practices lead to the formulation of the following hypotheses.

H6. *Sustainable innovation (SI) practices positively mediate the relationship between environmental knowledge and awareness (EKA) and product and service innovation.*

H7. *Environmental knowledge and awareness (EKA) sequentially influence product/service innovation through the positive influence of knowledge process capability-application (KPC-A) and sustainable innovation (SI).*

2.4.2. Innovation Orientation (IO) (Innovation as a Mindset or Culture)

Innovation orientation (IO) as a cultural construct appeared in the early work of [112] in his competing value model under the quadrant adhocracy culture, drawing from the work of Robert E Quinn. IO, from a cultural perspective, emphasizes sourcing new information in the external environment, and it is premised on fostering creativity and change management prior to organizational advancement [82,112,113]. As a multidisciplinary field, IO is an organizational strategic belief and learning philosopy that drives wide-ranging innovation in organizations, recognizing opportunities and mobilizing and allocating resources capable of producing new products, services and process improvement critical for the achievement of sustainable competitive outcomes. It provides guidance and directs all organizational strategy, philosophy and operation [114–116]. A survey of the literature on innovation reveals an interesting differentiating aspect between *innovation and innovation orientation*, while the later formal emphasized product–process innovation [117,118] is an organizational wide-ranging philosophical application geared toward continous learning, opportunity sensing, and intra-organizational collaboration spanning the entire organization to align innovation strategy with market dynamism with a focus on producing idiosyncratic outcomes. This approach is supported by the knowledge-based view of the firm [38]. Adopting such a holistic business philosophy has the capability of synchronizing contemporary market forces prevalent in today's sustainability era. For instance, four aspects of IO have being identified from a synthesis of the research stream of innovation orientation (IO), which are *"market orientation"—which is incorporating stakeholders' insights, e.g., customers, competitors and sustainability advocates, into the firm's strategic planning and value preposition* [119,120]; *"the learning orientation"—emphasizing the deployment of knowledge management to acquire competencies crucial for lean innovation* [114,121]; *"technology orientation"—the investments made in R&D activities and the acquisition of critical technologies that are required for innovation capability* [122]; *and lastly, the "enterpreneural orientation dimension"—the proactiveness and risk management approaches deployed toward venturing into perceived innovative opportunities* [123–125]. Collectively, the business cases for innovation-oriented firms have also been directly investigated. Innovation-oriented firms are directly associated with idiosyncratic outcomes and enhance corporate performance critical for market differentiation [117,126]. IO is also associated directly with superior performance [127] and able to integrate social and environmental issues into the firm's innovation strategy which are crucial in delivering sustainable innovative solutions [95]. Therefore, given the wide-ranging moderating philosophical roles of the construct, the paper positions IO as a key moderator in the conceptual framework with the ensuing hypotheses.

H8. *Innovation orientation (IO) moderates the relationship between environmental knowledge and awareness (EKA) and product/service innovation (PSI).*

H9. *Innovation orientation (IO) moderates the relationship between knowledge process application (KPC-A) and product/service innovation (PSI).*

H10. *Innovation orientation (IO) moderates the relationship between sustainable innovation (SI) and product/service innovation (PSI).*

2.4.3. Product/Service Innovation (PSI) (Innovation as Outcome)

Product and service innovation that result from sustainable practices differ from those of other innovations. For instance, the emergence of energy-saving devices and alternative energy like solar energy are classic examples of such innovations. Natural resource management and environmentally conscious processes are the central focus of organizations whose aim is to deliver sustainable products and services, whose outcomes meet the need of today's market and contemplate the needs of future society [43,82,128,129]. To this end, organizations and individuals alike have adopted several environmentally conscious strategies to inform their actions. For example, the literature has identified cleaner production, environmental management practices and circularity cum waste management as enablers of sustainable product innovation [101,130,131].

Prevailing research in the context of sustainability defines product innovation as the creation of new products and the improvement of goods and services that are capable of mitigating environmental problems, while service innovations are sustainable business models that are capable of delivering sustainable market values or new services [82,131]. Such business models include the triple bottom line that measures economic, social and environmental dimensions of corporate performance. Sustainable organizational outcomes from this perspective imply balancing all aspects of people, planet and profit [132]. The circular economy business model of resource reuse and waste management supports sustainability through innovative practices such as the product-as-a-service (PaaS) business model and the closed-loop supply chain [133–137].

Obviously, it has been recognized by prior research that the systematic synchronization of both sustainable innovation (SI), in other words, innovation as a process, and innovation orientation (IO), that is, innovation as a mindset or culture, is the antecedent of product/service innovation (PSI) [43,82,138]. Coherently, sustainability-oriented processes are capable of delivering innovative products and services whose outcomes are cost-effective and resource-efficient, reduce environmental impact and extend product and service life cycles [82,107]. Therefore, the hypotheses and conceptual framework (Figure 1) are developed based on the integration of DCT and ACT and prevailing literature.

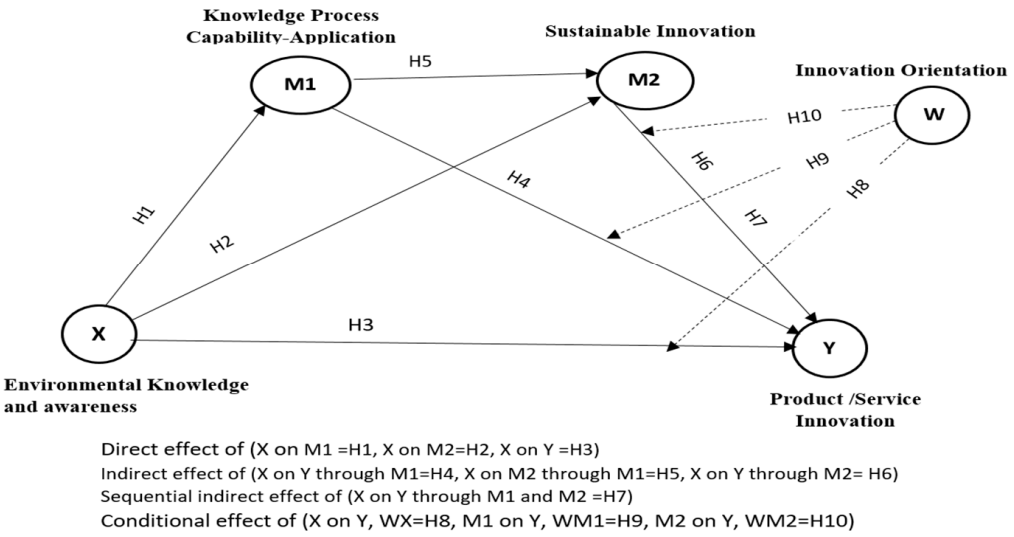


Figure 1. Authors' research model.

3. Methodology

3.1. Research Approach

This study utilized a quantitative research design which is suitable for the collection of standardized data from a large number of participants and useful in investigating relationships among constructs [139]. This approach supports generalization of research results and normalization to measure employees' perceptions of sustainability practices of some sampled banks operating in western Nigeria and their impact on organizational outcomes. An adopted structured survey instrument with a 5-point Likert scale was utilized to assess the variables of environmental knowledge and awareness (EKA), knowledge process capability-application dimension (KPC-A), sustainable innovation (SI), innovation orientation (IO) and product/service innovation (PSI). The numerical data provide validation of patterns and sustainability footprints of participating banks, and previous studies have demonstrated the numerous advantages of numerical data which aid in uncovering trends [140,141]. The integrated theories used in conceptualizing the research model further established the research questions and hypotheses [28,54].

3.2. Population and Sampling Techniques

To enhance the rigor of the sampling procedure and ensure participants possessed sufficient knowledge and experience relevant to the objectives of the investigation, specific exclusion and inclusion criteria were established at both the organizational and individual levels. These criteria were introduced to ensure participating banks demonstrated adequate commitment to sustainability practices and that individual participants were familiar with their organization sustainability programs, operational processes and innovation outcomes.

At the organizational level, only commercial banks listed among the top ten most sustainable banks in Nigeria in the 2024 sustainability ranking were included in the study, and these banks were selected because they are recognized as pioneers in sustainability practices and have successfully implemented sustainability programs relating to environmental, social and governance (ESG) practices [47]. Additionally, the level of service innovation among the listed banks is competitively higher than that of rivals, and these banks also dominate the list of the most profitable banks in Nigeria in the 2024 fiscal year [142]. This performance indicator confirmed the positive association between sustainability and financial performance [143]. Therefore, these outcomes benchmark these commercial banks as a focal point of study. The second criterion is, at the individual level, that eligible participants were bank executives and employees who had completed a minimum of two years of continuous service within their respective financial institutions. This threshold is based on previous findings that longer work tenure contributes significantly to accumulated knowledge and enables familiarity with organizational culture and processes, enabling employees to provide informed and reliable information [144] Furthermore, clearly defining the population has implications for replicability, reliability and generalizability of findings [145,146]. Coherently, these criteria support the aim of the current paper and allow for examining the relationship between the variables under investigation. The study applied a combination of non-probability convenience and snowball sampling techniques because they increase participation. The authors of [147] acknowledged that convenience sampling allows the researcher to easily access participants and strengthen representation and generalization of research findings. Similarly, snowball techniques enhance participation through a networking and referral strategy, where the initial contacts further distribute the survey to potential participants who meet the survey criteria [148].

3.3. Data Collection and Procedure

A structured questionaire adopted from previous studies was utilized in data collection, which was distributed using a combination of face to face and electronic sharing methods to participants working in the selected banks. Additionally, to ensure ethical compliance, the questionnaire was carried out under the protection of the General Data Protection Law and with the approval of the Research Ethics Committee as per substantiated opinion number "EKK25-26/10/03". The measuring instrument was based on a 5-point Likert scale of 1 = Strongly agree to 5 = Strongly disagree. The Likert scale is a popular tool among researchers and instrumental in measuring participants' perceptions about a particular subject [149]. In this context, the survey measures environmental knowledge and awareness (EKA), sourced from [60], knowledge process capability-application (KPC-A) adopted from [76], and sustainable innovation (SI) and product/service innovation (PSI) sourced from [43], while innovation orientation (IO) was adopted from [113].

The procedure of data collection involved two different stages: The first phase involved the distribution of surveys to five participants from each of the 10 selected banks, resulting in an initial sample of 50 respondents. The initial seed of 50 was then used to pilot test the questionnaire to examine the reliablility and content validity of the instrument [139]. The second stage engaged snowball sampling techniques where the questionnaire was further distributed by the first cohort of respondents to participants who meet the inclusion criteria [145]. The data collection period spanned approximately 59 days from 15 January to 15 March 2026. At the end of the survey, a total number of 354 respondents spanning different departments were included (i.e., 6 participants completed the survey per day), and because the total number of distributed surveys is unknown due to snowball technique application, the traditional calculation of response rate was not feasible. Rather, a participation standard was applied in accordance with the American Association for Public Opinion Research (AAPOR) [150]. In addition, since the total population of bank employees in western Nigeria is not publicly available or known, Cochran's sample formula was adopted to determine the adequacy of the realized sample size, because it is appropriate when the total population is unknown [151,152]. The formula below is Cochran's sample formula for assessing the adequacy of a sample size.

$$n_0 = \frac{Z^2 P(1-P)}{e^2} \tag{1}$$

Cochran's sample formula is based on the following assumptions:
N = Sample size;
Z = 1.96 (95% confidence level);
P = 0.5 (calculated proportion of the population, 0.5 is used if estimated proportion of the population is unknown);
e = Margin of error.

Therefore, this formula can be rearranged to compute for the margin of error, since we have our sample size of 354 participants.

$$e = \sqrt{\frac{Z^2 P(1-P)}{n_0}} \tag{2}$$

$$e = \sqrt{\frac{(1.96)^2 (0.5)(1-0.5)}{354}} = 0.0521 \approx 5.21\% \tag{3}$$

Using a 95% confidence level and a *p*-value of 0.5, the sample size of 354 results in a margin of error of ±5.2%, suggesting that the sample size is adequate and acceptable for statistical precision [151].

4. Data Analysis

The collected data was screened and coded for analysis with Statistical Package for the Social Sciences (SPSS) version 26 and SmartPLS software version 4.1.1.4 [153]. General and demographic information was portrayed with descriptive statistics, while the hypotheses were tested using regression analysis. Additionally, the mediation and moderation analyses were performed with process macro version 4.2 by Andrew F. Hayes which is appropriate for the analysis of mediation and moderation.

Table 1 presents the demographic profile of participants according to specific categories, and descriptive statistics such as frequencies and percentages was used to describe the characteristics of respondents which further helps in the interpretation of results. The results of the analysis indicate that the majority of the participants are male with 187 (52%) of the total respondents, while female respondents comprised 167 (47.2%). Concerning the age of participants they were grouped into age brackets to provide valuable insights on participants, and the most predominant age brackets of respondents are between 21 and 30 years old, amounting to 132 participants (37.3%), and 31 to 40 years old, amounting to 107 participants (30.2%), and the next largest age bracket of respondents is 41 years and above which accounted for 115 respondents (32.5%). Furthermore, regarding information about the marital status of participants, the output result shows that 182 (51.4%) of participants are single, while respondents who are married accounted for 135 (38.1%), 23 (6.5%) are divorced, and 14 participants (about 4.0%) are separated. Regarding educational level of participants, the majority of the sample hold a bachelor degree (258 participants (72.9%)), while those with master degree amounted to 82 respondents (23.2%), and only 14 participants (4.0%) hold a Ph.D. degree. Regarding banking experience of participants, employees with 2 to 6 years' experience amounted to 231 participants (65.3%), being the majority, followed by those with 7 to 11 years' experience (74 respondents 20.9%), individuals with 12 to 17 years of experience accounted for 45 (12.7%) participants and, finally, those with 18 years of experience and above included four participants (1.1%). Concerning job titles, 21 account clerks (5.9%), 15 banking associates (4.2%), 16 bookkeepers (4.5%), 49 branch managers (13.8%), 83 customer care agents (23.4%), 7 executive directors (2.0%), 29 general managers (8.2%), 74 investment analysts and loan officers (21%), 9 managing directors (2.5%) and, finally, 51 teller officers (14.4%) took part in the study. These descriptive figures offer clarification of the demographic distribution of participants, which essentially constitute bank employees working in western Nigeria and since the study aimed at measuring employees' perceptions of sustainability programs of their respective banks.

Table 1. Demographic profile of participants.

	Variables	Frequency	%
Gender	Male	187	52.8
	Female	167	47.2
Age group (Years)	21–30	132	37.3
	31–40	107	30.2
	41 and above	115	32.5

Table 1. *Cont.*

	Variables	Frequency	%
Marital status	Single	182	51.4
	Married	135	38.1
	Divorced	23	6.5
	Separated	14	4.0
Education	Bachelor	258	72.9
	Master	82	23.2
	Ph.D.	14	4.0
Years of Exp	2–6 Early career	231	65.3
	7–11 Mid-career	74	20.9
	12–17 Late career	45	12.7
	18 and above Highly exp	4	1.1
Job title	Account Clerk	21	5.9
	Banking Associate	15	4.2
	Bookkeeper	16	4.5
	Branch manager	49	13.8
	Customer Care Agent	83	23.4
	Executive Director	7	2.0
	General Manager	29	8.2
	Investment analyst	37	10.5
	Loan officer	37	10.5
	Managing Director	9	2.5
	Teller	51	14.4
	Total	354	100.0

4.1. Descriptive Analysis of the Study Variables

Decriptive statistics is employed to describe the five variables under investigation, using the values of aggregate mean and standard deviation because these statistical components provide valuable information about the central tendency of the variables and their variability. For instance, the survey was based on a reversed five-point likert scale of 1 = Strongly agree to 5 = Strongly disagree, thus, a lower aggregate mean score indicates a strong agreement with the measured construct among participants, while the standard deviation suggests the extent of distribution of responses relative to the mean value [154]. Therefore, the values of the aggregate mean and standard deviation for environmental knowledge and awareness (M = 5.94, SD = 2.38) present a relatively high aggregate mean, which demonstrates respondents' high level of environmental awareness and antecedent issues, while the standard deviation is relatively balanced, indicating variability in participants' responses although with little disparity, reflecting a high level of awareness among participants with differing understanding of environmental knowledge. The aggregate mean score for knowledge process capability-application dimension (M = 4.39, SD = 1.82) is comparatively lower than the aggregate mean values of other constructs, meaning that application of knowledge resources in their respective organizations is relatively high. Similarly, the lower standard deviation reflects consistency in participants' responses around the aggregate mean score, implying a greater application of knowledge process capability (KPC-A). The analysis shows that sustainable innovation (SI) recorded aggregate mean values (M = 11.02, SD = 4.68) suggesting that participants perceived their organizations as actively engaging in sustainability practice, while the high standard deviation shows differences in the perceptions of participants, which implies that some organizations are probably more advanced in implementing sustainable innovation (SI) practices than their counterparts. Regarding innovation orientation, the aggregate mean score (M = 9.25) is com-

paratively higher than that of environmental knowledge and awareness (EKA), however, it is lower than that of sustainable innovation (SI). The implication for this is that innovation orientation (IO) has a strong association with innovation and, as for the high score for standard deviation (SD = 4.07), this suggests variability and differing views in strategic alignment of innovation across participants and their respective organizations. Lastly, the aggregate mean score for product/service innovation (PSI) (M = 5.97) is similar to the mean value of environmental knowledge and awareness (EKA), meaning there is a strategic fit on product/service innovation (PSI). Furthermore, the balanced standard deviation score (SD = 2.59) show diverse responses, implying differences in the level of strategic innovation and adoption among participating firms. In essence, sustainable innovation (SI) appears to be the most significant variable because of its high aggregate mean values, highlighting its centrality in the present scholarship on corporate sustainability. Innovation orientation (IO) is the second most important construct, also due to its large aggregate mean score, demonstrating its relevance to organizational innovation cum sustainable competitive outcomes. Moreover, knowledge process capability-application seems to be less mobilized, pointing to a critical gap to fully exploit knowledge effectively. Additionally, environmental knowledge and awareness (EKA) and product/service innovation (PSI) occupied balanced positions, underscoring their importance. This results are in line with the notion of organizations integrating sustainability to drive innovations, however, knowledge application is often neglected [95,155]. Table 2 presents the aggregate mean scores and standard deviations of the variables.

Table 2. Means and Standard deviations of variables.

Variables	Aggregate Mean	SD
Environmental knowledge and awareness (EKA)	5.9435	2.38080
Knowledge process capability-application (KPC-A)	4.3898	1.82383
Sustainable innovation (SI)	11.0169	4.67768
Innovation orientation (IO)	9.2514	4.07321
Product/service innovation (PSI)	5.9689	2.58929

4.2. Scale Reliability and Validity

Scale reliability analysis evaluates the internal consistency and dependability of measuring items in a scale to ensure the intended constructs are being measured, while a validity test is performed to ensure the right construct is being measured [156]. Frequently used tools for assessing the accuracy and quality of measuring instruments in empirically based social science research are Cronbach's alpha and composite reliability [157]. Cronbach's alpha examines items' interrelationship and assumes equal contributions of items to concepts. On the one hand, composite reliability offers in-depth analysis as it accounts for factor loading and the overall contributions of each indicator to the same latent construct and is very relevant in structural equation modeling [158–160]. The acceptable threshold for composite reliability coefficient values is generally 0.70, while Cronbach's alpha values within the range of 0.67–0.87 are considered reasonable and acceptable [161,162]. Additionally, the average variance extracted (AVE) is utilized to examine the convergent validity of indicators of a construct, in other words, how well assortments of items converge to measure the same construct, and the computed values convey the interrelationship and the accuracy of indicators of same construct. AVE values exceeding 0.50 confirmed convergent validity of items in the measurement scale [163]. In Table 3, the SmartPLS output shows the reliability and validity of the items used in the study. Furthermore, results from the factor loading exceed the minimum acceptable threshold of 0.60, demonstrating items' suitability for the study [159]. Although the Cronbach's alpha value for KPC-A was 0.577, which falls

below the acceptable threshold of 0.70, it exceeded the minimum benchmark acceptable for developing and exploratory research [164]. Furthermore, KPC-A achieved a satisfactory composite reliability value of 0.780 and the average variance extracted was 0.545, both of which exceeded the recommended benchmarks of 0.70 and 0.50 respectively [160], thus, KPC-A was considered reliable and valid for further analysis. Figure 2 presents the structural model generated using SmartPLS illustrating the hypothesized direct, mediating and moderating relationships among environmental knowledge and awareness (EKA), knowledge process capability-application (KPC-A), sustainable innovation (SI), innovation orientation (IO), and product/service innovation (PSI).

Table 3. Reliability and validity result.

Variables	Outer Loading > 0.06	Cronbach's Alpha > 0.6	CR > 0.7	AVE > 0.5
Environmental knowledge and awareness (EKA)				
EKA1	0.682			
EKA2	0.677	0.67	0.801	0.502
EKA3	0.771			
EKA4	0.702			
Innovation orientation (IO)				
IO1	0.651			
IO2	0.658			
IO3	0.798	0.819	0.87	0.529
IO4	0.681			
IO5	0.728			
IO6	0.828			
Product/service innovation (PSI)				
PIS1	0.692			
PIS2	0.715	0.718	0.826	0.543
PIS3	0.743			
PIS4	0.793			
Knowledge process capability-application (KPC-A)				
KPC-A1	0.766			
KPC-A2	0.708	0.577	0.78	0.542
KPC-A3	0.733			

4.3. Discriminant Validity—Cross-Loading

Discriminant validity analysis examines how collections of items measure a particular construct and not another concept in the model. According to [165], discriminant validity ensures that constructs are different from other constructs in the model and its associated items accurately measure the intended construct [166]. Review of collections of articles uncovered several techniques for assessing discriminant validity, and a few of such techniques include the heterotrait monotrait ratio (HTMT), the Fornell–Larcker criterion and cross-loading. The HTMT technique measures average correlation of constructs in the model and the relative average correlation within the same construct. Different authors published different thresholds for HTMT [167], with recommended HTMT values of <0.90 for conceptually similar concepts. To access discriminant validity of constructs the authors inspected the HTMT table from SmartPLS output and found some values slightly exceeded

the recommended threshold > 0.90. This points to a possible overlap, however, this scenario is not problematic when the investigated constructs have high theoretical similarities, e.g., sustainable innovation, product/service innovation, innovation orientation, environmental knowledge and knowledge process capability have high theoretical proximity and collectively contribute to organizational sustainability and innovation outcomes. Prior studies have encountered such cases where HTMT exceeded the recommended values [168] and, for this reason, SmartPLS cross-loading was scrutinized to examine indicators' loading on constructs, since it is one of the oldest approaches used to discriminate between variables. Cross-loading shows the average correlation between items, built on the assumption that, for discriminant validity to exist, indicators should load more strongly or highly on the theoretical latent construct it is intended to measure than every other construct in the model [160,169]. Aditionally, all variance inflation factor (VIF) values for all indicators range between 1.159 and 2.179, below the recommended benchmark of 5, suggesting there is no multicollinearity problem in the outer model. Furthermore, collinearity for predictors (environmetal knowledge and awareness, knowledge process capability-application, and sustainable innovation) was assessed, and the VIF values range between 1.000 and 2.153, which also fall below the acceptable threshold of 5. Similarly, common method bias (CMB) is not a major concern in the study since the VIF values fall below the conventional threshold value of 3.3 recommended by [170]. Therefore, using multiple assessment from construct reliability, validity and cross-loading analysis, the investigated constructs show distinctiveness, providing additional support for discriminant validity. The statistical output result from SmartPLS in Table 4 shows that all items in the measurement scale met this requirement, demonstrating items' adequacy, distinctiveness of constructs and the absence of multicollinearity.

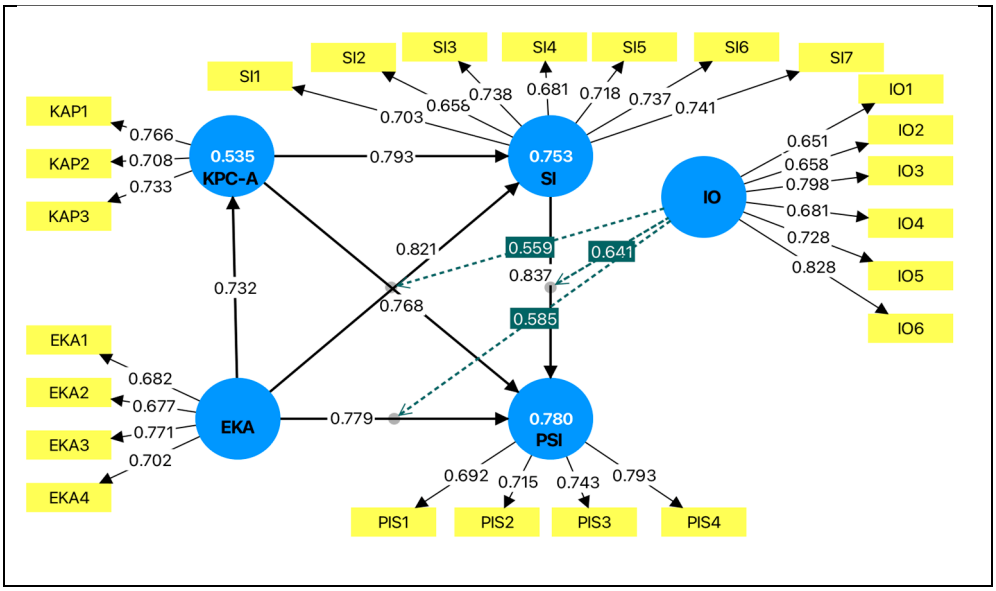


Figure 2. Structural model.

4.4. Inter-Construct Correlation

Correlation measures the direction and the linear strength of the relationship between variables under investigation. Researchers frequently use the Pearson product moment correlation coefficient to examine the direction and the strength of relationships between constructs, and the correlation coefficient (r) ranges between −1 and +1, with −1 indicating a significantly negative relationship, while +1 is considered a significantly positive relationship [171]. Similarly, according to [172], a correlation value of 0.1 signifies a weak relationship, 0.3 a moderate association, while values of 0.5 and above demonstrate a strong

correlation among variables. In this study, the Pearson product moment correlation analysis output result (Table 5) shows that all constructs in the model are highly connected (i.e., all (r) values are above the 0.5 threshold).

Table 4. SmartPLS Cross-Loading matrix table.

Items	EKA	IO	KPC-A	PSI	SI	VIF
EKA1	**0.682**	0.522	0.461	0.510	0.558	1.242
EKA2	**0.677**	0.505	0.443	0.497	0.531	1.250
EKA3	**0.771**	0.651	0.598	0.655	0.607	1.345
EKA4	**0.702**	0.587	0.555	0.533	0.626	1.229
IO1	0.449	**0.651**	0.448	0.530	0.527	1.469
IO2	0.529	**0.658**	0.563	0.583	0.606	1.385
IO3	0.624	**0.798**	0.645	0.648	0.690	1.970
IO4	0.624	**0.681**	0.606	0.616	0.617	1.418
IO5	0.613	**0.728**	0.591	0.618	0.649	1.547
IO6	0.645	**0.828**	0.661	0.701	0.647	2.179
KPC-A1	0.521	0.618	**0.766**	0.595	0.595	1.228
KPC-A2	0.541	0.564	**0.708**	0.529	0.544	1.159
KPC-A3	0.554	0.607	**0.733**	0.570	0.609	1.161
PIS1	0.507	0.574	0.549	**0.692**	0.544	1.304
PIS2	0.514	0.638	0.545	**0.715**	0.581	1.311
PIS3	0.673	0.628	0.594	**0.743**	0.667	1.339
PIS4	0.590	0.664	0.573	**0.793**	0.662	1.519
SI1	0.553	0.550	0.480	0.543	**0.703**	1.579
SI2	0.454	0.493	0.456	0.486	**0.658**	1.456
SI3	0.576	0.666	0.628	0.569	**0.738**	1.740
SI4	0.604	0.608	0.569	0.652	**0.681**	1.430
SI5	0.619	0.668	0.609	0.628	**0.718**	1.630
SI6	0.626	0.639	0.606	0.658	**0.737**	1.631
SI7	0.626	0.624	0.569	0.602	**0.741**	1.649

Table 5. Inter-construct correlation matrix table.

Constructs	1	2	3	4	5
Environmental knowledge and awareness (EKA)	1				
Knowledge process capability-application	0.732 **	1			
Sustainable innovation (SI)	0.817 **	0.793 **	1		
Innovation orientation	0.807 **	0.814 **	0.861 **	1	
Product/service innovation	0.780 **	0.766 **	0.835 **	0.852 **	1

n = 354, ** $p < 0.05$. ** Correlation is significant at the 0.01 level (2-tailed).

4.5. Hypotheses Testing

This section is dedicated to examining the structural relationship among investigated constructs; it details important statistical descriptions drawn from testing the study hypotheses. Table 6 presents the direct and total direct effects and the antecedent findings, Table 7 explores the mediation analysis, and finally Table 8 shows the moderation analysis. These analyses are demarcated for the purpose of clarity.

Table 6. Direct and total direct effects.

Hyp.	Paths	R^2	β	SE	*t*-Value	*p*-Value	Decision
H1	EKA→ KPC-A	0.54	0.73	0.028	20.14	0.000	Supported
H2	EKA→ SI	0.67	0.82	0.060	26.55	0.000	Supported
H3	EKA→ PSI	0.61	0.85	0.036	23.39	0.000	supported

n = 354, EKA = Environmental knowledge and awareness, KPC-A = Knowledge process capability-application, SI = Sustainable innovation, PSI = Product/service innovation.

Table 7. Mediation analysis (Indirect effect).

Hyp	Structural Paths	R^2	*p*	β	BSE	95% CI BLL-BUL	Result
H4	EKA → KPC-A → PSI	0.69	0.00	0.33	0.05	0.21–0.41	Supported
H5	EKA → KPC-A → SI	0.75	0.00	0.31	0.04	0.23–0.39	Supported
H6	EKA → SI → PSI	0.72	0.00	0.49	0.05	0.38–0.60	Supported
H7	EKA → KPC-A → SI → PSI	0.74	0.00	0.14	0.032	0.087–0.21	Supported

n = 354, bootstrapped = 5000, EKA = Environmental knowledge and awareness, KPC-A= Knowledge process capability-application, SI = Sustainable innovation, PSI = Product/service innovation.

Table 8. Moderation analysis.

Hyp	Structural Path	R^2	β	t	*p*-Values	95% CI BLL-BUL	Decision
H8	IO×EKA → PSI	0.75	−0.017	−2.15	0.03	−0.0327–0.0015	Supported
H9	IO×KPC-A → PSI	0.74	−0.025	−2.54	0.01	−0.0439–0.0056	Supported
H10	IO ×SI → PSI	0.76	0.000	0.098	0.922	−0.008–0.009	Not supported

n = 354, EKA = Environmental knowledge and awareness, KPC-A = Knowledge process capability-application, SI = Sustainable innovation, PSI = Product/service innovation, IO = Innovation orientation.

4.5.1. Direct Effect

Direct effect examines the direct prediction of an independent variable X on dependent variable Y, in other words, it is not mediated by a third or intermediate variable in the model [173].

As shown in Table 6, all the examined variables are positively and significantly significant, for instance, in H1, environmental knowledge and awareness (EKA) has a positive statistically significant effect on knowledge process capability-application (KPC-A), (β = 0.73, t = 20.14, $p < 0.001$), implying that the more modern organizations become knowledgeable and aware about operating environments, the more likely they apply that knowledge in their value chain especially in the context of sustainability. Additionally, EKA explains 54% of the variance in KPC-A ($R^2 = 0.54$), indicating substantial explanatory power, therefore H1 is sustained. H2 tests the impact of EKA on SI, and the result shows that environmental knowledge and awareness (EKA) have a statistically positive influence on sustainable innovation (SI) (β = 0.82, t = 26.55, $p < 0.001$), meaning that organizations exposed to current environmental issues are more likely to engage in sustainable innovative practices. Furthermore, 67% of the variance in SI ($R^2 = 0.67$) is explained by the influence of EKA, suggesting strong predictive capability. Thus, H2 is supported.

Furthermore, H3 regarding EKA on PSI has a positive and statistically significant result (β = 0.85, t = 23.39, $p < 0.001$). The positive influence of EKA on PSI suggests that environmental knowledge resources enhance a firm's capability to introduce innovative products and services that are stakeholder-conscious and meet evolving market demands. Additionally, EKA account for 61% ($R^2 = 0.61$) of a variability in PSI, demonstrating that PSI is a functionality of organizational awareness of its various stakeholders and market needs.

4.5.2. Mediation Analysis

Mediation analysis investigates the different pathways and mechanisms (mediators) by which an independent variable (predictor) affects the dependent variable (outcome). It has a time-dimensional process, in other words, time 1 (t_1), when the independent variable starts operating, through time 2 (t_2), the mediating variable, and time 3 (t_3), the dependent variable [156]. Logically, according to [174], the coefficient of any individual indirect effect, that is, the value of the travel effect of the independent variable from (t_1) through (t_2) to (t_3), should typically be smaller than any examined total direct effect (i.e., the absence of t_2). The coefficient values (β) in the mediation output result in Table 7 met this condition.

To assess the significance of the mediation of constructs the bootstrapped lower and upper level confidence intervals (CIs) were used. According to [174], if the values of the bootstrapped CI is above zero, this supports the claim that the indirect effect is statistically positive. As seen in Table 7, all the mediation analyses supported the various claims, for instance, the conclusion that EKA significantly impacting PSI through the mediative effect of KPC-A (H4) has a statistically positive effect due to the absence of zero values in the 95% CI (BoothLL0.21-BoothUL0.41) with coefficient value β = 0.31, p = 0.00. This effect is visible under the R^2 value, e.g., the combined forces of both EKA and KPC-A result in 69% variation in PSI, which implies that organizations with a higher level of stakeholder knowledge and awareness can process and leverage that knowledge to produce idiosyncratic sustainability-integrated products and services. Furthermore, the mediation mechanism between EKA and SI through KPC-A was also statistically significant (H5), e.g., β = 0.31, p = 0.00, 95% CI (boothLL0.21-boothUL0.41), and the R^2 also explained the variance in SI (R^2 = 75%).

Also, regarding H6, the positive influence of EKA on PSI through SI was statistically significant as the standardized 95% CI (boothLL0.38-boothUL 0.60) values are above zero with coefficient value of β = 0.49, $p < 0.01$, indicating that firms with sound environmental knowledge are capable of engaging in sustainable practices that result in producing sustainable innovative products and services. This variability in PSI is manifested under the R^2 of 72% induced by the combined presence of EKA and SI.

The authors are also interested in testing the sequential mediation that integrates mediations 1 and 2 as illustrated in Figure 1 (authors' research model). Regarding H7, where KPC-A and SI sequentially mediate the relationship between EKA and PSI, the sequential mediation analysis results suggest that KPC-A and SI sequentially mediate the effect between EKA and PSI, thereby producing a statistically significant outcome as the standardized CI value exceeds zero (boothLL0.087-boothUL0.21) with coefficient value β = 14, demonstrating a complete sequential mediation. Additionally, it is important to note that the combined interactions of EKA, KPC-A and SI account for 74% of the variation in PSI (R^2 = 0. 74) and, simultaneously, organizations with a higher level of environmental knowledge and awareness (EKA) with efficient knowledge process architecture are capable of infusing that knowledge to inform sustainability footprints that translate to producing sustainable differentiated market offerings.

4.5.3. Moderation

Moderation analysis seeks to understand the conditions under which the relationship between the independent and the dependent variables is impacted, instead of finding different pathways as in the case of mediation. A moderator predicts or modifies the size or effect of the independent variable on the dependent variable [156,174].

Table 8 presents the moderation analysis carried out in the study, utilizing PROCESS v4.2 by Andrew F. Hayes. The first moderation hypothesized the moderation effect of IO on the relationship between EKA and PSI (H8), and the output result shows that 75% (R^2)

of the variation in PSI was explained by the combined effect of IO and EKA, demonstrating a strong impact on PSI. Also, the 95% CI above zero (BoothLL-0.0327-boothUL-0.0015) means that the combined interaction of IO and EKA on PSI is negatively and statistically significant ($\beta = -0.17$, $p < 0.05$), in other words, as IO increases, the positive effect of EKA on PSI diminishes. Furthermore, IO significantly moderates the relationship between KPC-A and PSI (H9) and the analysis shows that 74% (R^2) of the variance in PSI is accounted for by IO and KPC-A, although negatively significant ($\beta = -0.02\ 5$, $p < 0.01$) with the absence of zero values in the 95% CI (boothLL-0.0439-boothUL-0.0056). This implies that, as IO moves incrementally, the positive impact of KPC-A on PSI declines. H10 proposes that IO moderates the effect of SI on PSI, and the analysis revealed that the overall model is statistically significant, meaning that 76% of the variation in PSI is explained by IO and SI, however, the coefficient result shows that the interaction model (IO × SI) is not statistically significant ($\beta = 0.00$, $p = 0.922$). Moreover, the 95% CI has a zero value (boothLL-0.008-boothUL 0.009) meaning that IO has no moderating effect on the relationship between SI and PSI.

These findings have foundational theoretical implications when considering the diverse configuration of organizational resources. For instance, the resource-based view (RBV) of the firm asserts that organizations depend largely on critical resources such as environmental knowledge to obtain competitive advantage. Conversely, according to dynamic capabilities theory (DCT), the presence of strong innovation orientation (IO) empowers firms to independently innovate without needing environmental knowledge [28]. For this reason, the marginal benefits of environmental knowledge on innovation decline, resulting in a negative outcome.

5. Results and Discussion

Sustainability-embedded innovation is central to modern stakeholders and, as such, firms scramble to integrate and align processes that produce sustainable innovative outcomes. The study investigated the contributions of environmental knowledge and awareness (EKA) of some selected Nigerian commercial banks in rolling out products and services that are stakeholder-conscious. Furthermore, it examined the mediating roles of knowledge process capability-application dimension (KPC-A) and sustainable innovation (SI), while paying particular attention to the moderating effect of innovation orientation (IO) of firms. Insights from the findings offer critical theoretical implications to dynamic capabilities and absorptive capacity theories.

The supported hypotheses suggest firms that are sensitive to environmental issues are able to refine and process ready-to-use knowledge, thereby positioning environmental knowledge and awareness (EKA) as foundational catalysts for innovation. Additionally, sustainable innovative processes and product and service innovation are a direct functionality of environmental knowledge possession. The dynamic capabilities theory emphasizes the need for firms' environmental scanning, opportunity exploitation and transformation of resources in alignment with market shifts, and the strategic management literature recommends such tools like SWOT and other similar analytical tools for acquiring environmental knowledge [28,175] Similarly, absorptive capacity theory [54] benchmarks environmental knowledge and awareness (EKA) as important organizational resources that allow firms to exploit and translate new knowledge into new product and service development, thereby underscoring the critical roles of knowledge in innovation cycles.

The positive impact of environmental knowledge and awareness (EKA) on product and service innovation through the interaction of knowledge process capability-application dimension (KPC-A) signifies that organizations need to strategically synergize and apply acquired knowledge to benefit innovation outcomes. Environmental knowledge and

awareness as a first order in innovation cycles provide the foundational information, however, innovation only occurs when dynamic and capable organizations consciously coordinate and transform possessed knowledge into tangible innovative products and services. Knowledge process capability-application constitutes an important organizational capability that enables firms to share and apply external environmental knowledge to confront pressing organizational problems, and this view aligns with the proposition of dynamic capabilities and absorptive capacity theories that a firm's ability to exploit, reconfigure and capitalize on knowledge resources is the most differentiating dynamic and absorptive ability that enables the firm to deliver lean innovation [55,176]. The notion that mediation benchmarks knowledge process capability-application as a central mechanism whereby environmental knowledge and awareness (EKA) transition from knowledge state to action state through conversion cum application that results in superior innovation fills the knowledge–action gap highlighted by [59].

As expected, knowledge process capability-application plays a significant role in environmental knowledge and sustainable innovation (SI) by empowering enterprises to convert environmental information into eco-efficient processes that eventually lend themselves to environmentally conscious solutions such as low carbon emissions, waste management solutions and so on. This finding sheds light on how organizations interpret, incorporate and apply environmental knowledge and awareness (EKA) to render sustainability-concentrated innovations and, according to [93], such innovation represents business–society dialogue. Dynamic capabilities theory proposes that firms recognize their capabilities and knowledge resources and align them to ecological requirements [52]. Knowledge process capability-application represents such a dynamic capability where environmental knowledge is operationalized into sustainability-oriented processes, and this supports the argument that sustainability is capability-based processes and not a passive response to stakeholders' demands. Similarly, absorptive capacity theory asserts that the ability to exploit and transform new external knowledge assets into innovative solutions is directly related to a firm's innovative capabilities [54].

The positive impact of environmental knowledge and awareness on product and service innovation through the mediating influence of sustainable innovation (SI) demonstrates that organizations with strong knowledge of operating environments possessed a higher tendency of introducing environmentally friendly strategies like waste management and paperless solutions critical for improvement of commercial ends. This finding positioned sustainable innovation (SI) practices as a dynamic capability that allows enterprises to seamlessly adapt to environmental changes and compete favorably. The absorptive capacity theory contends strongly that a firm's ability to assimilate and apply extant environmental knowledge might also incorporate sustainable innovative practices into organizational operations which in turn result in innovative outcomes.

Innovation orientation (IO) is of particular interest to the authors as, prior to this research, IO as a higher-order construct [115] was perceived to be playing an important moderating role in shaping how firms sense and seize economic opportunities, however, the analysis suggests that innovation orientation (IO) negatively moderates the relationship between environmental knowledge and awareness (EKA) and product/service innovation (PSI). The negative interaction indicates that, as IO is amplified across organizational processes, the positive effect of environmental knowledge and awareness (EKA) on product/service innovation (PSI) decreases. Similarly, IO negatively moderates the relationship between knowledge process capability-application (KPC-A) and product/service innovation (PSI), suggesting that, at a higher level of IO, the positive impact of knowledge process capability on product/service innovation also diminishes. These findings demonstrate that firms with a stronger level of innovation philosophies continuously engage in

research and development (R&D) activities to generate new market insights which in turn inform novel processes and product and service development driven by market forces, thus positioning environmental knowledge and knowledge process capability-application as already embedded organizational capabilities. This is consistent with the work of [115] conceptualizing innovation orientation (IO) as a multidimensional concept. In accordance with dynamic capability theory, innovation orientation (IO) is a higher-order dynamic capability intrinsically compelling firms to recognize and exploit opportunities and, as an enabler, IO provides a conducive climate for environmental knowledge and knowledge process capability-application to impact product and services. Consequently, the overall impact of IO on the two moderating models (i.e., IO and EKA and IO and KPC-A on product/service innovation (PSI)).

The unsupported moderation analysis of IO on the relationship between sustainable innovation (SI) and product/service innovation (PSI) may suggest that sustainability-oriented practices largely depend on external influences such as regulations and stakeholders' pressure, rather than strategic orientation, because sustainability innovation relies more on regulatory compliance and incremental innovation. This discovery also resonates with the notion of green dynamic capability theory and institutional theory, that not all innovation outcomes reflect internal organizational capabilities, and some environmentally and socially oriented innovations are driven by institutional requirements and long-term sustainability goals [177,178].

5.1. Theoretical Implications

This paper provide important theoretical inputs to dynamic capabilities theory by identifying environmental knowledge and awareness (EKA) as a critical organizational capability deployed for scanning the economic environments of firms and for identification of relevant stakeholders, emerging environmental shifts and economic opportunities. Research in mainstream knowledge management recognized environmental knowledge and awareness (EKA) as belonging to the knowledge acquisition sphere [34]. Thus, the foundation of organizational change and the consequent knowledge process application and the integration of environmental and social aspects that eventually impact processes and product/service innovation (PSI) are rooted in environmental knowledge and awareness (EKA) capability of business entities. Similarly, the study contributes to absorptive capacity theory by demonstrating how environmental knowledge is assimilated, coordinated and transformed through knowledge application and sustainable practices to create environmentally oriented economic values, benchmarking knowledge process application and sustainable innovation (SI) practices as crucial components of a firm's absorptive capacity—"*A firm ability to consolidate on extant knowledge assets to confront processes, product and services innovation*" [54]. Additionally, the paper contributes to ongoing debates on sustainability-cum-innovation literature by empirically testing the role of environmental knowledge and awareness in the development of sustainability-oriented products and services and the mediation of knowledge process application and sustainable innovation practices. This capability mechanism explains the foundation of sustainable product and service development in service organizations.

5.2. Managerial Implications

The study presents decision makers and organizational strategists in the financial and service-oriented sectors important insights for collecting, combining and coordinating varied knowledge resources to confront processes and create economic values that are stakeholder-conscious. The contemporary financial industry operates in a regime of high market changes spurred by sustainability themes and technological introductions and, to

remain competitively relevant, management needs to synchronize stakeholders' interest with economic objectives. Consequently, management practitioners should recognize environmental knowledge and awareness (EKA)—"*a collation of knowledge resources encompassing regulations, ecological impacts, customers reviews, business networks and competitors*"—as the foundation for the identification of market gaps. Managerial dynamic capability appears when assortments of knowledge assets are orchestrated and synchronized in alignment with sustainability requirements that result in producing a portfolio of idiosyncratic market values that are difficult to imitate by rivals [25]. The path mechanism of the model, if carefully followed, has managerial contributions that could help scale up processes critical for meeting emerging environmental pressures that characterize today's business environment. Innovation orientation (IO) of firms is pivotal in shaping how managers engage in knowledge acquisition activities, collaborate and reconfigure knowledge resources to generate novel innovations.

6. Conclusions

Translating abstract theories into real-time practices is the key objective of the pragmatic school of thought. Based on empirical evidence, the study draws on dynamic capabilities and absorptive capacity theories to explain how financial institutions operating in western Nigeria employ environmental knowledge and awareness (EKA) as a dynamic organizational capability to shape and reconfigure market propositions. Environmental knowledge is seen as a critical organizational resource used by firms to respond to varied interests of stakeholders and, as such, economic values of competing firms are a functionality of inputs from different environmental sources. Additionally, doing business sustainably requires that captured knowledge is processed and appropriately applied for effective decision making in the value creation chain, thus, knowledge process capability-application dimension and sustainable innovation represent absorptive capacities of firms where the allocation of processed knowledge occurs to confront processes and determine sustainability ventures that render products and services capable of filling prevailing market gaps. Business objectives are anchored on stakeholders' analysis to determine specific market values, while innovation orientation (IO) serves as a philosophical trajectory that guides the overall direction and business objectives of firms.

Research Agenda

This study provides strong theoretical and empirical insights and contributes to the growing body of literature on knowledge management, sustainability and innovation by emphasizing the pivotal roles of environmental knowledge and awareness in advancing knowledge process capability, sustainable innovation, and product–service innovation within financial institutions. The discovery further uncovered the implicit importance of innovation orientation in shaping the effectiveness of these constructs.

It has several shortcomings that highlight future research directions. Similar to extant literature, the use of a quantitative research approach in the current study limits its depth and context and does not reflect how the investigated variables developed into strategic organizational capabilities over time, therefore, a longitudinal research approach should be adopted to unpack how these capabilities evolved and developed. Additionally, the quantitative questionnaire approach is subject to common method bias and the social desirability effect, where respondents may wrongly represent or overstate their company's sustainability footprints, thereby distorting reality. Therefore, future research should focus on incorporating sustainability certifications and reporting for an extended period of time to measure sustainability-based innovation performance. Furthermore, future investigations may examine the proposed framework across different industries, such as telecommuni-

cations, public institutions, healthcare, and manufacturing, to determine the applicability of the observed relationships. Cross-sectoral analysis would offer a more comprehensive understanding of how environmental knowledge and awareness contribute to sustainable innovation outcomes under varying organizational climates. Also, alternative mediators such as green intellectual capital, knowledge-sharing behavior, organizational learning, employee green behavior and creativity should also be investigated. Such studies would provide more theoretical insights regarding how environmental knowledge and awareness translate into tangible innovation outcomes. Moreover, comparative studies of different institutional, national, developing and developed economies would enhance generalizability and provide meaningful insights on how environmental regulations and cultural factors impact the relationship between environmental knowledge and innovation outcomes.

Finally, the unsupported moderation of innovation orientation on the relationship between sustainable innovation and product/service innovation open a research window to explore alternative moderators such as stakeholders' pressure, regulation, organizational structure, or technological turbulence.

Author Contributions: Conceptualization, G.O.O.; Methodology, G.O.O.; Validation, T.A.; Investigation, G.O.O.; Data curation, G.O.O.; Writing—original draft, G.O.O.; Supervision, T.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by Scientific Research and Publication Ethics Committee of Cyprus International University with decision number EKK25-26/10/03 on 21 January 2026.

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: During the preparation of this study, the authors used Cyprus International University institutional subscription package of SmartPLS version 4.1.1.4 and Statistical Package for the Social Sciences (SPSS) for the purposes of data analysis.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EKA	Environmental Knowledge and Awareness
KPC-A	Knowledge Process Capability-Application
SI	Sustainable Innovation
IO	Innovation Orientation
PSI	Product/Service Innovation

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