Leveraging environmental management accounting and green ambidexterity for competitive advantage: A natural resource orchestration view

Kaveh Asiaei
Department of Accountancy, Finance and Economics
Birmingham City Business School, Birmingham City University, Birmingham,
United Kingdom
Corresponding author
Kaveh.Asiaei@bcu.ac.uk

Omid Barani
School of Accounting, College of Business and Law,
RMIT University, Melbourne, Australia
Omid.barani@rmit.edu.au

Zabihollah Rezaee
Fogelman College of Business and Economics,
University of Memphis, United States
zrezaee@memphis.edu

Nick Bontis
DeGroote School of Business, McMaster University
Hamilton, Canada
nbontis@mcmaster.ca

Khakan Najaf
Canadian University Dubai, United Arab Emirates.

najaf.khakan@cud.ac.ae

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Abstract

This study explores how organizations leverage environmental management accounting (EMA) and green ambidexterity to translate green knowledge assets into competitive advantage. Drawing on survey data from chief financial officers and analyzing the results using partial least squares structural equation modeling (PLS-SEM), we find that green human assets drive competitive advantage only through EMA, while green structural assets show no significant association with EMA. Green relational assets, however, positively influence both EMA and competitive advantage. We further demonstrate that green ambidexterity, where firms' simultaneous pursuit of exploitative and exploratory green innovation initiatives, strengthens the effect of EMA on competitive advantage. Drawing on the natural resource orchestration perspective, this study offers a novel perspective to EMA research by documenting how organizations can effectively synchronize, bundle, and structure (i.e., orchestrate) various green resources to achieve superior strategic outcomes. It offers important practical insights into how sustainability-oriented initiatives can be harnessed to build and sustain competitive advantage.

1. Introduction

Environmental factors have become central to economic development and corporate decision-making in recent years (Barani, 2025; Brooks & Schopohl, 2021; Margerison et al., 2019; van Staden et al., 2011). Global institutions increasingly warn that climate-related risks and unmanaged transitions to low-carbon systems pose significant threats to financial stability (Aggarwal et al., 2025). The Financial Stability Board, for instance, highlights the potential for abrupt asset devaluations, while World Bank projections suggest that climate-induced water scarcity could reduce GDP by as much as 6% in vulnerable regions. As environmental pressures intensify, firms are compelled to rethink resource allocation and adopt more sophisticated tools to manage ecological risks and opportunities. These challenges are particularly acute in Iran, where a rapidly industrializing economy is confronting severe air pollution, water shortages, and soil degradation conditions exacerbated by population growth, urbanization, and industrial expansion (Asiaei et al., 2023a). This context provides an ideal setting to investigate how environmental management accounting (EMA) enables organizations to convert green knowledge assets into competitive advantage by offering insights relevant to companies in emerging and developed economies.

This study is motivated by three considerations. First, although prior research examines external sustainability reporting (Setia et al., 2024), far less is known about how internal managerial systems, such as EMA, can help firms translate green knowledge assets into strategic benefits (Arjaliès & Mundy, 2013; Lisi, 2015, 2018). Second, applied theories offer mixed predictions regarding the value of green knowledge resources. The stakeholder value creation perspective argues that sustainability-related investments enhance shareholder wealth by strengthening relationships with key stakeholders (Abdel-Maksoud et al., 2021). In contrast, the agency cost view suggests that managers may overinvest in green initiatives to advance personal reputational motives or to obtain "warm-glow" satisfaction, potentially at shareholders' expense (Krüger, 2015; Asiaei et al., 2022b, 2023b; McCarthy et al., 2017). Thus, it remains an open empirical question whether green knowledge assets, on their own, can genuinely provide a competitive advantage for organizations. Third, Iran's significant environmental challenges, as reflected in its low Environmental Performance Index ranking and limited regulatory support, underscore the need for improved sustainability practices (Afshar Jahanshahi et al., 2020). Recent

governmental initiatives, including substantial green-energy funding and training programs, signal rising awareness (Eslamizadeh et al., 2020), yet empirical evidence on how Iranian firms leverage internal green resources remains scarce.

One promising way to address this critical question and underlying research tension is through the lens of resource orchestration theory (Sirmon et al., 2011), particularly the concept of natural resource orchestration (Asiaei et al., 2022a). The orchestration of green resources plays a critical role in aligning business practices with sustainability goals. Through the strategic structuring and mobilization of green assets, organizations can not only mitigate environmental risks but also gain a competitive edge (Andersén, 2023; Carton & Parigot, 2024). Within this context, the natural resource orchestration perspective offers a valuable framework for understanding how businesses can leverage green assets to drive positive outcomes and achieve lasting competitive advantage. The natural resource orchestration notion posits that the full potential of an organization's green resources is unlocked only when they are effectively structured, bundled, and managed (Asiaei et al., 2022a). We highlight that natural resource mobilization is important, emphasizing that green resources must be systematically integrated to support improved alignment, coordination, and targeted application for specific goals. However, identifying appropriate channels or mechanisms through which green assets can be mobilized remains a critical challenge and gap.

Drawing from management accounting literature, we propose that EMA is a viable pathway for managers to foster green knowledge resource mobilization. EMA represents an innovative approach that encompasses various standardized techniques and practices aimed at enhancing the effectiveness of environmental management (Gomez-Conde et al., 2019; Ferreira et al., 2010). EMA supports top management in implementing sustainability initiatives by embedding core sustainability values, measuring performance outcomes, and reducing strategic risks associated with sustainability efforts. Additionally, EMA helps to manage uncertainties in sustainability strategies and serves as a control mechanism to reduce agency costs for shareholders (Arjaliès & Mundy, 2013; Gond et al., 2012; Henri & Journeault, 2010; Knels et al., 2025). In this study, therefore, we introduce EMA as an intervening mechanism that can enable firms to mobilize their green knowledge assets more effectively, which, in turn, can yield a competitive advantage.

Additionally, we draw on the innovation ambidexterity literature to extend the notion of natural resource orchestration by introducing the concept of green ambidexterity as a critical factor that can enhance EMA's impact on competitive advantage. We argue that green ambidexterity allows firms to reconfigure green resources and strengthen management accounting capabilities, thereby supporting sustained competitive advantage. This dual capability, which involves both exploiting existing green initiatives and exploring innovative solutions, amplifies the influence of EMA on competitive advantage. In essence, green ambidexterity promotes continuous learning and knowledge development, which equips firms to innovate, manage risks, and capitalize on emerging green opportunities ahead of competitors (Coelho et al., 2024). By introducing green ambidexterity as a potential factor that can enhance EMA's effect on competitive advantage, we extend the theory's scope and highlight its applicability in fostering strategic environmental practices within organizations.

This study makes several key contributions to the sustainability accounting literature. First, by proposing a novel mediated moderation model, we extend the natural resource orchestration theory within the context of green knowledge assets, EMA, and green ambidexterity, illustrating how various green resources can be structured and mobilized to achieve sustainable competitive advantage. Second, the study advances the theoretical understanding of how resource orchestration can be applied in the sustainability accounting setting, a relatively underexplored area within this framework. Third, our findings provide empirical evidence on the role of EMA as a mediating mechanism that facilitates the effective mobilization of green knowledge assets, thereby reducing agency costs and aligning managerial actions with broader environmental goals. This insight addresses a critical gap in the literature, offering new perspectives on how environmental accounting practices can support strategic sustainability objectives. Fourth, this study contributes to the emerging literature by embedding green ambidexterity within the sustainability accounting setting, demonstrating how firms can simultaneously exploit and explore green innovative initiatives to strengthen the impact of EMA on competitive advantage. Finally, this research has practical implications for managers and policymakers in emerging markets like Iran, where environmental challenges are pressing, but regulatory support for sustainability initiatives remains limited. By highlighting the role of EMA and green ambidexterity in promoting sustainable

practices, the study provides actionable insights that can guide firms in integrating environmental considerations into their strategic management processes.

The remainder of this paper is organized as follows. Section 2 presents the theoretical framework and hypothesis development. Section 3 details the research methodology, and Section 4 reports the data analysis and results. In Section 5, we provide a comprehensive discussion of the key findings, theoretical and practical implications, limitations, and suggestions for future research.

2. Theory, literature review, and hypothesis development

Natural resource orchestration theory provides a strategic framework for structuring, bundling, and mobilizing green resources to achieve organizational goals, particularly to enhance environmental performance (Asiaei et al., 2022a). Unlike traditional approaches, which focus primarily on acquiring and accumulating resources, this approach emphasizes the dynamic green capabilities required to coordinate and deploy resources in ways that align with specific strategic objectives (Andersén, 2023; Carton & Parigot, 2024). In the context of natural resource orchestration theory, previous studies underscore the role of internal organizational practices (e.g., EMA), or dynamic green capabilities (e.g., ambidextrous green innovation) in translating green knowledge resources (e.g., green intellectual capital) into improved environmental performance (Asiaei et al., 2022a; Asiaei et al., 2023a). For example, Asiaei et al. (2022a) explored the relationship between green intellectual capital and environmental performance, mediated by EMA, while Asiaei et al. (2023a) investigated a similar association using green ambidextrous innovation as a mediator. Also, other relevant research in the green intellectual capital area, such as Asiaei et al. (2022c), examined different mediating variables (environmental performance measurement systems) and focused on different dependent variables (environmental performance and economic performance).

Building on these foundations, we argue that the core of the natural resource orchestration approach lies in natural resource mobilization, where various green resources are coordinated to enhance synchronization, alignment, and strategic focus, thereby driving competitive advantage. The present study extends this line of research in the natural resource orchestration setting, as it examines the role of green knowledge assets in driving competitive advantage through a new

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model. More specifically, as shown in Figure 1, we propose that EMA serves as a key mechanism (mediating variable) through which managers can facilitate effective green resource orchestration, thereby translating green knowledge assets into sustained competitive advantage. Further, we draw on the ambidexterity literature to extend the natural resource orchestration notion by introducing the concept of green ambidexterity as a critical factor (moderating variable) that can amplify EMA's impact on competitive advantage.

2.1. Green knowledge assets and competitive advantage

Drawing largely on the resource-based view of the firm (Barney, 1991), prior research suggests that knowledge assets are critical predictors of a firm's competitive advantage. With the rise of environmentalism, green intellectual capital has become one of the most significant areas of focus within corporate strategy (Asiaei et al., 2023a). In this context, competitive advantage increasingly stems from knowledge assets and capabilities that support environmentally and socially sustainable economic activities (Hart, 1995). Building on the work of Chen (2008) and Chang and Chen (2012), we conceptualize these environmentally oriented knowledge assets as green knowledge assets, defined as "the total stock of all kinds of intangible assets, knowledge, capabilities, and relationships, etc., about environmental protection or green innovation at both the individual and organizational levels within a company" (Chang & Chen, 2012, p. 77). According to this definition, green knowledge assets comprise three components: green human assets, which include physical and human green capabilities, innovation, and investment; green structural assets, encompassing organizational capabilities, commitments, policies, and procedures; and green relational assets, referring to interactive relationships with customers, suppliers, and employees that promote environmental management and innovation (Chen, 2008).

Research has shown that active engagement in environmental management and green innovation not only reduces production waste and enhances product development but also strengthens organizational image, enables premium pricing for green products or services, supports environmental know-how and services, and opens new markets, ultimately driving competitive advantage (Chen, 2008). Internally, green knowledge assets help reduce environmental costs, build technical expertise, and promote awareness of green practices and energy-saving technologies (Naseem et al., 2024). This internal engagement also aids companies in interpreting and adhering

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to environmental standards and regulations set by the government. According to prior research (Chuang & Huang, 2018), active investment in green knowledge resources can serve as a crucial advantage for achieving competitive success. Based on this discussion, we propose the following hypothesis:

H1: Green knowledge assets (H1a: green human assets, H1b: green structural assets, and H1c: green relational assets) are positively associated with competitive advantage.

2.2. Green knowledge assets and EMA

The type and extent of knowledge-related resources can influence the usage and design of management accounting and control systems (Asiaei & Jusoh, 2017). Organizations possessing more green knowledge assets, comprising green human assets, green structural assets, and green relational assets, are more inclined to adopt EMA practices due to the alignment between these resources and the demands of effective environmental management (Asiaei et al., 2022a). Green human assets, which include employees' knowledge, skills, and commitment toward environmental initiatives, foster an organizational culture that values sustainability (Chen, 2008). This cultural foundation creates a need for structured systems, like EMA, to track and manage environmental impacts accurately, aligning employee expertise with practical tools for environmental accountability. Green structural assets, including organizational policies, procedures, and eco-friendly technologies, form the backbone of sustainable practices within an organization, offering the structural support required to integrate environmental considerations into everyday operations (Chang & Chen, 2012; Chen, 2008). EMA serves as a natural extension of these structural assets by enabling organizations to systematically measure and report environmental performance, ensuring that established policies and practices yield tangible environmental benefits (Asiaei et al., 2022a; Gomez-Conde et al., 2019). Lastly, green relational assets, relationships with environmentally conscious stakeholders such as customers, suppliers, and regulatory bodies, heighten the organization's accountability to external stakeholders who increasingly expect transparent environmental reporting (Chen, 2008). EMA facilitates this transparency, allowing the organization to communicate its environmental performance credibly and meet stakeholder expectations (Ferreira et al., 2010). Thus, organizations with well-developed

green knowledge assets are more likely to adopt EMA practices, as these assets provide both the internal motivation and structure needed to support comprehensive environmental accounting and reporting.

H2: Green knowledge assets (H2a: green human assets, H2b: green structural assets, and H2c: green relational assets) are positively associated with the extent to which organizations adopt EMA practices.

2.3. EMA and competitive advantage

According to Burritt et al. (2023), EMA supports organizations in gaining prospective environmental advantages and realizing their responsibilities. This subsequently paves the way for companies to synthesize environmental management initiatives and financial control strategies with EMA systems. As Ferreira et al. (2010) point out, EMA is instrumental in measuring, controlling, and disclosing the company's environmental performance. Prior research demonstrates that environmentally friendly activities are positively associated with positive organizational outcomes (Henri & Journeault, 2010; Lisi, 2015; Barani et al., 2025; Gerged et al., 2024; Knels et al., 2025). According to Solovida and Latan (2017), adopting a well-aligned and robust management accounting mechanism, such as EMA, promotes the decision-making and control process, thereby resulting in a sustained competitive advantage. Prior research shows that EMA adoption is positively associated with environmental performance, as EMA is instrumental in dealing with the challenges related to environmental management systems, thereby resulting in more effective decisions about the environmental matters that affect competitive advantage (Wang et al., 2019; Knels et al., 2025). In addition, the majority of the previous studies focusing on EMA and its implications have concentrated mainly on developed country settings (Gerged et al., 2024). This implies that environmental accounting in developing countries, particularly in Iran, is still in its infancy, and it has received scant attention in the research literature. With all the foregoing discussions in mind, the third hypothesis is put forward as follows:

H3: The extent to which organizations adopt EMA practices is positively associated with competitive advantage.

2.4. The mediating role of EMA

EMA serves as a robust system that supports companies in measuring, analyzing, and reporting on their environmental practices (Gerged et al., 2024), thereby fostering the strategic use of green knowledge assets. For example, green human assets, which embrace employee competencies, know-how, and commitment to sustainability, contribute meaningfully to a company's environmental initiatives (Ni et al., 2023). Nevertheless, without a formal mechanism like EMA to capture and evaluate the impact of these contributions, much of this knowledge remains underutilized (Asiaei et al., 2022a). EMA supports managers to systematically track the environmental outcomes driven by employees' green efforts, translating this knowledge into data that supports strategic decision-making (Bresciani et al., 2023) and, ultimately, competitive advantage. In the same vein, green structural assets, which consist of an organization's policies, procedures, and eco-friendly technologies (Amores-Salvadó et al., 2021), are similarly strengthened through EMA. These assets provide the structural foundation for sustainable practices, but EMA ensures that these practices are not only implemented but also assessed for effectiveness. By aligning green structural assets with EMA processes, organizations gain insights into the efficiency and impact of their environmental practices. This alignment allows companies to refine their processes, ensuring that resources are used optimally to support competitive advantage.

Finally, green relational assets, which represent the relationships an organization maintains with external stakeholders such as customers, suppliers, and regulators (Martínez-Falcó et al., 2024), benefit from EMA by promoting transparency and accountability. Stakeholders increasingly expect businesses to report on their environmental performance (Juo & Wang, 2022), and EMA provides the framework needed to do this credibly. EMA translates the value of green relational assets into measurable outcomes, which enhances stakeholder trust and can open up new market opportunities, thereby strengthening competitive advantage (Asiaei et al., 2022a). In effect, EMA facilitates the transformation of green knowledge assets into measurable, strategic insights that drive sustainable performance. By systematically capturing and evaluating the impact of these assets, EMA serves as a critical pathway through which organizations can leverage their green resources to achieve and sustain competitive advantage. Given all the above deliberations, we suggest the fourth hypothesis as follows:

H4: The extent of EMA adoption mediates the association between green knowledge asset components (H4a: green human assets, H4b: green structural assets, and H4c: green relational assets) and competitive advantage.

2.5. The moderating role of green ambidexterity

To sustain long-term competitiveness, organizations must balance the exploration of new opportunities with the optimization of their existing capabilities in their innovation efforts. (Wabnegg, 2024). To support the fifth hypothesis, we draw on prior literature that embeds ambidexterity in the management accounting setting (Gschwantner & Hiebl, 2016; Mura et al., 2021; Bedford et al., 2019, 2022; Wabnegg, 2024) and propose the role of green ambidexterity as a strategic capability that enhances the effectiveness of EMA in driving competitive advantage. Green ambidexterity, which represents a company's capability to balance the exploration of new green innovations with the exploitation of existing sustainable practices, can equip organizations to adapt quickly to growing environmental demands while optimizing current resources (Baquero, 2024). When companies possess high green ambidexterity, they can more effectively leverage the data and insights provided by EMA, as they are equipped to act on this information both proactively and adaptively. This dual capability strengthens the alignment between EMA-driven environmental insights and strategic actions, enabling the firm to capitalize on green opportunities and mitigate environmental risks (Asiaei et al., 2023a). In effect, companies that enjoy the capability of green ambidexterity are able to use EMA data to identify areas for continuous improvement in current operations while simultaneously exploring innovative green technologies and practices (Knels et al., 2025), thereby achieving long-term sustainability. This dynamic perspective enables organizations to translate EMA insights into actions that reinforce their competitive advantage in today's increasingly eco-conscious marketplace. In line with these arguments, we propose the fifth hypothesis as follows:

H5: Green ambidexterity moderates the relationship between the extent of EMA adoption and competitive advantage.

3. Methodology

3.1. Research design and method justification

We draw upon the survey-based approach for data collection and use perceptual measures to measure all the variables of interest since this method is widely used in the literature in this area (Ferreira et al., 2010; Bedford & Speklé, 2018; Jusoh et al., 2023). We consider CFOs of the listed companies in the Tehran Stock Exchange (TSE) as the key informants. Choosing such top managers as the key informants is supported by ample evidence in the management accounting and intellectual capital settings (e.g., Tayles et al., 2007; Abernethy & Wallis, 2019). The questionnaires are targeted at CFOs because of their high level of proficiency in the subject matter as well as their hands-on experience with strategic issues. They are also knowledgeable about and directly involved in the administrative processes and procedures of the company by providing a variety of services to the business, such as financial planning and analysis, and helping to shape overall strategy and direction (Rezaee et al., 2021a; Jusoh et al., 2023).

3.2. Research setting and participants

Many organizations in the TSE are medium to large-sized companies that typically have greater potential for possessing strategic green resources and capabilities, such as green knowledge assets and EMA. Prior research recommends considering the multi-industry sample view since it paves the way for the analysis of the inter-industry effects, thereby broadening the generalization of the research (Asiaei & Jusoh, 2017; Bontis, 1998). As such, we choose all the TSE organizations as the target population, according to which the entire population is treated as the research sample. This implies that no sampling technique is carried out in our research. The rationale for adopting this approach is to take full advantage of a multi-industry sample with the main aim of getting more valid and reliable results (Asiaei et al., 2021).

Given the structural and cultural barriers to survey research in large Iranian firms, such as hierarchical bureaucracy, limited openness to external inquiries, and low research engagement, we implemented several strategies to improve data quality and response rates (Del Brio et al., 2013). A pilot test with five academic experts and ten senior managers helped refine the questionnaire for clarity, contextual relevance, and technical accuracy (Henri & Journeault, 2010). The final survey

was addressed to CFOs and included a cover letter emphasizing the study's purpose and the importance of CFO-specific responses. CFO contact details were obtained from credible databases such as Codal, Rahavard 365, and the TSE. To encourage participation, we highlighted confidentiality, explained the study's value to practice and research, and offered a summary of findings upon request. The survey design also included mandatory fields and automated prompts to minimize missing data.

The survey distribution process was supported by personalized communication, including prior phone or email notifications, followed by two structured reminders to encourage participation. Survey distribution was supported by personalized outreach and two structured reminders. Targeting all firms listed on the TSE, the final sample included 106 valid responses. To verify respondent eligibility, demographic information was collected on job title, educational background, age, and professional experience. Among the respondents, 87% represented manufacturing firms, reflecting strong alignment with their proportion in the TSE population. Table 1 presents detailed information on sample composition and organizational characteristics.

--- Insert Table 1 here ---

This study employed an online survey approach, which enabled efficient data collection. To assess nonresponse bias, we applied multigroup analysis (MGA) using PLS path modeling by comparing early and late respondents. The results revealed no significant differences, supporting the representativeness of the sample (Henseler et al., 2009). We also tested for common method bias using the full collinearity approach (Podsakoff et al., 2003).

3.3. Measurement of the variables of interest

All measurement items, along with their outer loadings, are detailed in Table 1 in the Appendix. Respondents evaluated each statement on a 7-point Likert scale ranging from 'totally disagree (1)' to 'totally agree (7)." We measure green knowledge assets based largely on the concept of green intellectual capital (Chen, 2008), which refers to various knowledge-based intangible assets pertaining to an organization's environmental or green practices. This construct includes 14 items

across three dimensions: green human assets (5 items), green structural assets (6 items), and green relational assets (3 items). In our adaptation, human asset items assess environmental skills, learning, commitment, and eco-innovation; structural items address green documentation, systems, standards, and governance; and relational items reflect external collaboration and stakeholder trust. This preserves the core human–structural–relational framework (Wang et al., 2020) while tailoring it to green knowledge practices.

We measure EMA based on the work of Ferreira et al. (2010) and Solovida and Latan (2017). As defined by Solovida and Latan (2017, p. 606), EMA is a "technique to improve, analyze and use both financial and non-financial information, with the aim of improving a company's environmental and economic performance and contributing to sustainable business." The items specifically address both monetary and physical aspects of EMA (Burritt et al., 2002). Respondents were asked to indicate the extent of EMA adoption in their organizations over the past three years using a seven-point Likert scale anchored at "Not at all" (1), "To a moderate extent" (4), and "To a very great extent" (7).

Competitive advantage refers to an organization's ability to formulate and implement unique strategies that are difficult for competitors to replicate (Barney, 1991). In line with Chen (2008), we define it as a privileged position where competitors cannot imitate the firm's distinctive strategies, enabling maximum strategic benefits. Using a validated 11-item scale (Chen, 2008), respondents rated their organization's competitive advantage relative to industry peers on a 7-point Likert scale from "strongly disagree" (1) to "strongly agree" (7). Green ambidexterity comprises two primary dimensions, namely green exploration and green exploitation. We adapted and developed a measurement tool based on He and Wong (2004) and Chen et al. (2014) to assess this construct. The adapted questionnaire in the current study includes 11 items across the two categories, with responses rated on the same 7-point Likert scale, from "strongly disagree" (1) to "strongly agree" (7).

4. Data analysis and results

This study employs SEM to test the conceptual model. SEM offers greater flexibility than traditional regression techniques, enabling the simultaneous analysis of multiple independent and dependent variables (Chin & Newsted, 1999; Hair et al., 2019). It accommodates both observed and latent constructs, accounts for measurement error, and allows mediation testing within a single model (Rigdon et al., 2017). Among the two main types, covariance-based and variance-based PLS path modeling, this study adopts PLS, which is appropriate due to its minimal distributional requirements and suitability for smaller samples (Smith & Langfield-Smith, 2004; Henseler et al., 2009; Rigdon et al., 2017; Hair et al., 2019).

PLS-SEM estimates both the measurement and structural models simultaneously. Recent research by Magno et al. (2024), reviewing 107 articles from high-quality journals, highlights the growing preference for PLS due to its causal-predictive capabilities. This method is particularly valuable when balancing explanation with prediction, aligning with today's research demands for both theoretical insight and actionable recommendations (Becker et al., 2023). PLS models are typically evaluated in two stages: assessing the measurement model's reliability and validity, followed by the structural model analysis (Hair et al., 2017, 2019; Hulland, 1999). This sequence ensures that constructs are measured accurately before interpreting inter-variable relationships (Hair et al., 1998; Hulland, 1999). The measurement model captures the link between indicators and latent constructs (Hall, 2008), while the structural model represents relationships among the latent variables. Additionally, PLS-SEM supports confirmatory modeling with high model complexity (Wold, 1975, 1980).

4.1. Assessing reflective measurement models

The first step in evaluating the reflective measurement model involves checking indicator loadings. Loadings above 0.708 suggest sufficient item reliability, as they explain more than half of the variance in the indicator. In this context, one EMA item with an outer loading of 0.691 was excluded from the model. The outer loadings and corresponding items are provided in the Appendix. Internal consistency was then assessed using Jöreskog's composite reliability (Jöreskog, 1973) and Cronbach's alpha, both of which exceeded the accepted threshold of 0.70. In this study, all CR and alpha values met or surpassed the minimum acceptable levels. While

Cronbach's alpha values are high, each item contributes unique information, and other indicators of validity (e.g., AVE, composite reliability) remain strong. Consistent with Raykov (2001) and Clark & Watson (1995), such high internal consistency is seen as a reflection of robust construct integrity rather than item redundancy.

The next step in assessing the reflective measurement model is evaluating convergent validity, typically measured using average variance extracted (AVE). An AVE of 0.50 or higher indicates that the construct explains at least 50% of the variance in its indicators. Table 2 in the Appendix presents AVE values for all constructs, confirming that both AVE and composite reliability exceed the accepted thresholds, supporting internal consistency and convergent validity. Discriminant validity, the final step, examines whether each construct is empirically distinct. Following Henseler et al. (2015), this study uses the heterotrait-monotrait ratio (HTMT), which outperforms the traditional Fornell-Larcker criterion. HTMT values below 1 confirm discriminant validity across all constructs. Additionally, green ambidexterity is modeled as a second-order reflective construct with two first-order dimensions (exploitation and exploration), each measured by multiple reflective items. The measurement model for green ambidexterity also showed satisfactory validity and reliability. All indicators show statistically significant values, confirming the robustness of the measurement model prior to the structural model evaluation, which follows in the next section.

4.2. Assessing structural models

The coefficient of determination (R^2) is used to assess the model's explanatory power, indicating the variance explained in endogenous constructs (Sarstedt et al., 2023). Values of 0.75, 0.50, and 0.25 represent substantial, moderate, and weak explanatory power, respectively (Henseler et al., 2009). This model achieves high explanatory power, with R^2 values of 0.67 for competitive advantage and 0.68 for EMA. Additionally, F^2 effect sizes assess the impact of removing an exogenous construct from the model. According to Cohen (1988), values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. The F^2 values for most variables are medium or small. Moreover, measuring the Q^2 value is another approach to measuring "the prediction accuracy of the PLS path model" (Geisser, 1974; Stone, 1974). All of the results are

greater than zero. The predictive relevance (Q²) of competitive advantage, EMA, exploitation, and exploration in this study is 0.691, 0.772, 0.691, and 0.775, respectively. It means that the model has strong predictive relevance for the omitted data points compared with the mean-based prediction.

4.2.1. Model's fit (SRMR)

This study uses the standardized root mean square residual (SRMR) to evaluate model fit. SRMR reflects the root mean square discrepancy between observed and model-implied correlations. As an absolute fit index, a value of 0 indicates a perfect fit (Hu & Bentler, 1998). Values below 0.10 are generally considered acceptable. In this study, SRMR values are 0.060 for the saturated model and 0.063 for the estimated model, both indicating a good fit.

4.2.2. Hypotheses testing

SEM is used to test the research hypotheses by evaluating model fit and path significance. Path coefficients and corresponding t-values determine statistical significance, with t-values above 1.96 indicating significance at the 0.05 level. Results show that green structural assets and green relational assets significantly enhance competitive advantage (H1b: β = 0.303, T = 3.084, p = 0.002; H1c: β = 0.238, T = 2.950, p = 0.003). This suggests that managing these assets effectively leads to competitive gains. However, green human assets do not show a significant direct effect (H1a: β = 0.006, T = 0.060, p = 0.952), indicating that their influence may operate through a mediating mechanism like EMA. Furthermore, the control variable used in this study, i.e., industry, shows no significant association with competitive advantage. Results are shown in Figure 1 and further detailed below.

Considering the second hypothesis, green human assets have a positive and significant effect on EMA (H2a: β = 0.675, p = 0.000), highlighting the vital role of employees' skills, knowledge, and environmental awareness in supporting EMA practices. Green relational assets also show a significant positive association with EMA (H2c: β = 0.177, p = 0.001), suggesting that strong stakeholder relationships facilitate EMA adoption and enhancement. Furthermore, green

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structural assets exhibit a weak effect on the relationship with EMA (H2b: β = 0.144, p = 0.076), indicating that organizational routines alone may be insufficient to advance EMA implementation.

Findings related to the third hypothesis indicate that EMA has a positive and significant effect on competitive advantage (β = 0.449, T = 4.790, p = 0.000), underscoring its strategic role in promoting firms' competitiveness. Mediation analysis (H4) further reveals that EMA significantly mediates the relationship between green human assets and competitive advantage (H4a: β = 0.303, T = 3.561, p = 0.000), suggesting that the influence of green human assets on competitive advantage is fully realized when organizations adopt robust EMA practices. EMA also partially mediates the link between green relational assets and competitive advantage (H4c: β = 0.079, T = 2.975, p = 0.003), reinforcing its role as a conduit for relational capabilities. Conversely, EMA exhibits only a weak mediating effect between green structural assets and competitive advantage (H4b: β = 0.065, T = 1.765, p = 0.078).

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Regarding the last hypothesis (H5), the analysis demonstrates that green ambidexterity moderates the relationship between EMA and competitive advantage. The interaction term is positive and statistically meaningful (β = 0.024, t = 2.379, p = 0.017), confirming that the effect of EMA on competitive advantage is strengthened by green ambidexterity (H5). Based on simple slope analysis (Figure 2), the conditional effects further clarify this moderation. At high levels of green ambidexterity (+1 SD), the influence of EMA on competitive advantage is stronger (β = 0.448, p = 0.000), while at low levels of green ambidexterity (-1 SD), the effect, though still significant, is weaker (β = 0.372, p = 0.000). At the mean level of green ambidexterity, EMA remains a significant predictor of competitive advantage (β = 0.410, p = 0.000). Overall, these results indicate that firms with higher levels of green ambidexterity are able to leverage EMA more effectively to build and sustain competitive advantage, highlighting green ambidexterity as an important strategic condition that strengthens the EMA-competitive advantage relationship.

--- Insert Figure 2 here ---

5. Discussion and conclusion

This paper is built upon the natural resource orchestration notion to investigate the mediating role of EMA in the association between green knowledge assets and competitive advantage. Further, we propose and test green ambidexterity as the moderating variable in the relationship between EMA and competitive advantage. Drawing upon the recently developed notion of "natural resource orchestration" (Asiaei et al., 2022a), we maintain that well-aligned management control systems, such as EMA, are crucial for companies to orchestrate their green knowledge assets, particularly green human and relational assets, which were shown in our analysis to significantly contribute to competitive advantage through EMA. Conversely, the relationship between green structural assets and EMA is not statistically significant, and consequently, the mediating pathway to competitive advantage through EMA is not supported. This suggests that not all types of green knowledge assets are effectively mobilized through EMA in our empirical context. We further propose that green ambidexterity, characterized by the ability to balance existing environmental practices with the exploration of new green innovations, enhances EMA's impact on competitive advantage. Our novel proposed research framework, incorporating both EMA as a mediating factor and green ambidexterity as a moderator, was tested using a survey of 106 CFOs in Iran, with PLS-SEM employed for data analysis.

5.1 Discussion of key findings

The results pertaining to H1a, H1b, and H1c indicate that among the components of green knowledge assets, green relational assets and green structural assets have a direct positive effect on competitive advantage, while green human assets do not. Instead, green human assets contribute to competitive advantage only indirectly, through the mediating role of EMA. This implies that companies emphasizing green structural and relational assets achieve a stronger competitive position in the industry, supporting Hart and Dowell's (2011) assertion that organization-specific initiatives, policies, or assets are instrumental in obtaining competitive advantage. One possible rationale for the distinct effect of green human assets is related to the perception and strategic focus of the CFOs of publicly listed companies in Iran. CFOs may view green human assets, such as employees' environmental skills and knowledge, as less immediately impactful on competitive advantage, as their influence may require substantial integration with environmental systems and processes to be fully realized.

Unlike green structural assets (e.g., green technology, eco-friendly infrastructure) and green relational assets (e.g., partnerships and networks focused on sustainability), which can more directly impact operational efficiency and external perceptions, green human assets might need the support of organizational systems (like EMA) to translate employees' knowledge into competitive outcomes. Additionally, in the Iranian context, organizational decision-makers may perceive structural and relational assets as more directly influential due to their visibility and role in formal environmental policies and stakeholder engagement. This interpretation aligns with previous findings (e.g., Chuang & Huang, 2018) that green human assets are not always directly associated with competitive advantage, though it contrasts with studies in other contexts (e.g., Chen, 2008; Chang & Chen, 2012; Delgado-Verde et al., 2014) where green human assets have shown a direct impact. These findings highlight how green human assets may require supportive mechanisms, like EMA, to contribute to competitive advantage effectively.

The results pertaining to the second hypothesis show that green human assets and green relational assets are positively and significantly related to EMA adoption within companies. However, the relationship between green structural assets and EMA is not statistically significant in the context of the current study. The two positive findings are in line with prior studies (e.g., Solovida & Latan, 2017; Lisi, 2015; Ferreira et al., 2010), which observe that environmental motivations and assets can determine the design and use of management control systems. Our results show that companies with greater green human assets and green relational assets are more oriented towards implementing EMA practices, and are likely to view EMA as a key channel for accomplishing strategic environmental objectives regarding the two foregoing aspects of green knowledge assets. This observation can be understood through the lens of the natural resource orchestration notion (Asiaei et al., 2022a), which suggests that simply possessing valuable, rare, and inimitable assets, such as green human assets, does not necessarily create a competitive advantage. Instead, companies must effectively synchronize and mobilize these assets with other environmental capabilities, like EMA, to achieve a competitive advantage. The relationship between green structural assets and EMA is not significant in this model. It is possible that these knowledge assets exist in a more passive or underutilized form, lacking the dynamic integration into managerial accounting routines needed to produce measurable effects.

The results of the third hypothesis demonstrate a positive relationship between EMA and competitive advantage. This outcome is in harmony with previous studies observing that environmentally friendly practices can bring about desirable organizational outcomes (Antonini & Gomez-Conde, 2024; Journeault, 2016). This implies that EMA, as a structured environmental control system, could facilitate strategic decision-making, foster resource efficiency, and eventually contribute to a company's competitive edge. Conversely, our results diverge from those of Henri and Journeault (2010), who observed that the relationship between environmental control practices and economic performance depends on certain conditions, such as higher levels of environmental disclosure, public awareness, environmental concerns, and company size. This difference may stem from the specific sample and context of our study, focusing on Iranian firms where environmental disclosure and public awareness may not exert the same level of influence as in other regions. In the Iranian context, firms listed on the Tehran Stock Exchange may be particularly motivated to implement EMA as a proactive approach to meeting internal environmental objectives and maintaining compliance with industry standards, even if external environmental pressures are lower. Generally, these findings support the view that EMA serves as a valuable organizational control mechanism that enhances both decision-making and strategic alignment, ultimately driving positive organizational outcomes (Hart & Dowell, 2011; Pondeville et al., 2013; Knels et al., 2025). This is consistent with recent literature in environmental accounting, which emphasizes that EMA helps managers make more accurate and effective sustainability decisions, reducing resource waste and improving pollution prevention (Tashakor et al., 2019). Together, these insights reinforce the role of EMA as a tool for aligning environmental goals with competitive objectives, thus positioning firms more favorably in an eco-conscious marketplace (Antonini & Gomez-Conde, 2024).

The findings of the fourth hypothesis reveal that EMA plays a significant mediating role in the relationship between specific components of green knowledge assets and competitive advantage. EMA fully mediates the relationship between green human assets and competitive advantage, suggesting that the impact of green human assets on competitive advantage is maximized when organizations adopt robust EMA practices. This result highlights the importance of EMA in capturing and translating employee knowledge, skills, and environmental awareness into strategic advantage (Gomez-Conde et al., 2019). Without EMA, the contributions of green

human assets may remain underutilized, as their impact on competitive advantage is largely indirect and depends on a structured accounting system to monitor and optimize environmental efforts.

Similarly, EMA partially mediates the relationship between green relational assets and competitive advantage, underscoring EMA's role in converting stakeholder relationships into competitive gains. Organizations with strong green relational assets, such as partnerships with environmentally conscious customers, suppliers, and regulatory bodies, can enhance their competitive positioning when EMA practices are in place (Asiaei et al., 2022a). EMA enables these firms to transparently track and report environmental initiatives, building trust with external stakeholders and reinforcing competitive advantage (Gerged et al., 2024). However, there is only a small mediation effect of EMA between green structural assets and competitive advantage, suggesting that green structural assets, including policies, procedures, and environmental infrastructure, may directly influence competitive advantage without relying heavily on EMA as an intermediary. These structural assets likely provide foundational support for sustainable practices, functioning effectively within the organization's established environmental framework.

The findings pertaining to the final hypothesis indicate that green ambidexterity moderates the relationship between EMA and competitive advantage. Specifically, the impact of EMA on competitive advantage is stronger at higher levels of green ambidexterity. This suggests that organizations with a high capacity for green ambidexterity, meaning they can both exploit existing environmental practices and explore new green innovations, are better positioned to maximize the benefits of EMA. Green ambidexterity enhances a firm's ability to adaptively respond to environmental challenges and seize sustainable opportunities (Martínez-Falcó et al., 2024), which amplifies the strategic value derived from EMA. When an organization is adept at balancing exploration and exploitation, it can use EMA insights not only to refine current practices but also to invest in innovative green solutions that anticipate future market and regulatory demands. This dual capability strengthens the alignment between EMA practices and strategic objectives, allowing organizations to leverage EMA data in a way that continuously drives competitive advantage. Conversely, firms with lower levels of green ambidexterity may find it challenging to fully capitalize on EMA's potential, as they are less flexible in adapting EMA-driven insights to

both refine current practices and innovate for the future. These findings reinforce the idea that ambidexterity serves as a critical organizational capability, enabling firms to translate management accounting elements into competitive gains more effectively and dynamically (Bedford et al., 2019, 2022; Wabnegg, 2024).

5.2 Theoretical implications

This research, in general, provides a unique framework for understanding how firms in emerging and environmentally challenged markets can leverage green knowledge assets and dynamic capabilities to achieve sustained competitive advantage. Specifically, this study offers several theoretical contributions to the sustainability accounting literature, with particular emphasis on the unique context of Iran. First, by investigating EMA as an intervening mechanism, we extend the natural resource orchestration theory into sustainability accounting contexts, revealing EMA's critical role in mobilizing and aligning green knowledge assets elements, particularly green human and relational assets, to drive competitive advantage. This integration provides a deeper understanding of how a well-aligned adoption of management control systems can play a strategic role in translating intangible green assets into measurable performance outcomes, thereby expanding the application of resource orchestration theory to sustainability accounting initiatives.

Second, this paper proposes green ambidexterity as a moderating variable, a novel addition that broadens the theoretical scope of natural resource orchestration theory. Our results show that green ambidexterity reinforces the association between EMA and competitive advantage, illustrating the value of a company's capability to balance the exploitation of existing sustainable practices with the exploration of new green innovations. This dual capability is principally relevant for companies operating in dynamic settings (Wabnegg, 2024), and the findings indicate how green ambidexterity supports Iranian firms in adapting to shifting regulatory demands and sustainability goals. Furthermore, the Iranian context further underscores the theoretical implications of this research. As a country with significant environmental challenges, such as water scarcity, pollution, and rapid industrialization (Rezaee et al., 2021b), Iran presents a compelling setting to explore the efficacy of green knowledge assets and EMA. Given Iran's limited regulatory pressures compared to other regions, our findings highlight how firms proactively leverage EMA and green ambidexterity to meet their sustainability objectives despite less external pressure. This contextual

insight extends the applicability of resource orchestration theory to emerging markets, where firms may rely more heavily on internal capabilities, such as green ambidexterity, to align environmental initiatives with strategic goals.

5.3. Practical implications

This study provides several practical insights for managers aiming to optimize their green initiatives for competitive advantage. A key implication is the importance of leveraging green human capital effectively. In contrast, green human assets, which contain important factors such as employee knowledge and environmental commitment, require the support of robust management systems like EMA to fully translate into competitive advantage. Managers should therefore invest not only in building environmental knowledge and skills within their workforce but also in implementing EMA practices that capture and channel this expertise into strategic outcomes. Creating a sustainability-focused culture and integrating EMA can help organizations synchronize their green assets with their strategic objectives, ensuring that green human assets contribute to desirable organizational outcomes. This approach enables companies to align their environmental motivations with organizational control systems, allowing for a structured consolidation, alignment, and "orchestration" of green capabilities (Asiaei et al., 2022a). By fostering employee commitment to sustainability and equipping the organization with EMA, firms can enhance compliance, improve resource efficiency, and achieve a sustainable competitive edge. Ultimately, this study underscores that effective environmental management requires both dedicated green knowledge assets and a strategic framework like EMA to realize their full value.

Iran faces several pressing environmental challenges, including severe air pollution, water scarcity, and high levels of greenhouse gas emissions, largely driven by rapid industrialization, urbanization, and inefficient resource management (Nemch, 2023). These issues are compounded by limited regulatory frameworks, placing additional responsibility on companies to take proactive measures toward environmental sustainability (Asiaei et al., 2023b). From an accounting perspective, this study contributes by demonstrating how EMA can play a critical role in helping firms manage their green knowledge assets effectively. EMA provides a structured approach for Iranian firms to track, measure, and report environmental impacts, ensuring that green initiatives are not only implemented but also aligned with organizational strategies. By adopting EMA, firms can translate environmental commitments into actionable data and performance metrics, enabling

them to contribute to broader environmental goals while achieving competitive advantage (Gunarathne et al., 2023). This study thus offers practical insights for Iranian companies striving to address environmental issues proactively through improved accounting practices, fostering a more sustainable business environment despite limited regulatory pressures (Rezaee et al., 2021).

5.4. Limitations and future research

This study has several inherent limitations. First, its cross-sectional design within Iran limits the generalizability of findings due to the country's specific institutional context. To validate this framework, further studies across both developing and developed countries are essential. Second, the reliance on associations rather than causal effects restricts the evidence for causality, as survey-based research with cross-sectional designs cannot provide robust causal inferences. Another limitation arises from the evolving nature of strategic organizational initiatives, such as sustainability controls and green knowledge assets, suggesting that longitudinal studies or qualitative case studies (Sundin & Brown, 2017) could better capture these strategies' development over time and their impact on competitive advantage. Additionally, future research could focus on small and medium-sized enterprises (SMEs), which often constitute a larger portion of business entities in developing regions, unlike the large companies examined here. Another source of potential bias stems from relying on CFOs' perceptions, which may not fully capture underlying constructs. While we used validated instruments and conducted a pre-test to address this, further research involving diverse informants could provide a broader perspective on stakeholders' views regarding environmental initiatives.

We suggest some avenues for potential future research that go beyond methodological refinement. For example, future research can explore how digital transformation and advanced analytics interact with environmental management accounting in stimulating strategic actions in response to climate change. Moreover, since new regulatory frameworks (such as IFRS S1 and S2, the EU CSRD, and country-specific environmental mandates) are gaining traction, scholars can discover how companies adapt their sustainability control systems to meet these evolving compliance and reporting demands. From the theoretical lens, further research could expand our understanding of how organizations orchestrate green knowledge assets under circumstances of environmental turbulence, institutional uncertainty, or resource scarcity, specifically in sectors dealing with pressure to decarbonize. Lastly, future work could also examine cross-sectoral collaborations and

eco-innovation ecosystems, where environmental management accounting may serve as a boundary-spanning mechanism to coordinate shared sustainability goals among partners.

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Declarations

No conflict of interest has been declared by the authors.
The data that support the findings of this study are available from the corresponding author upon request.

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Figures

Figure 1. Assessment of the structural model

Green Knowledge Assets
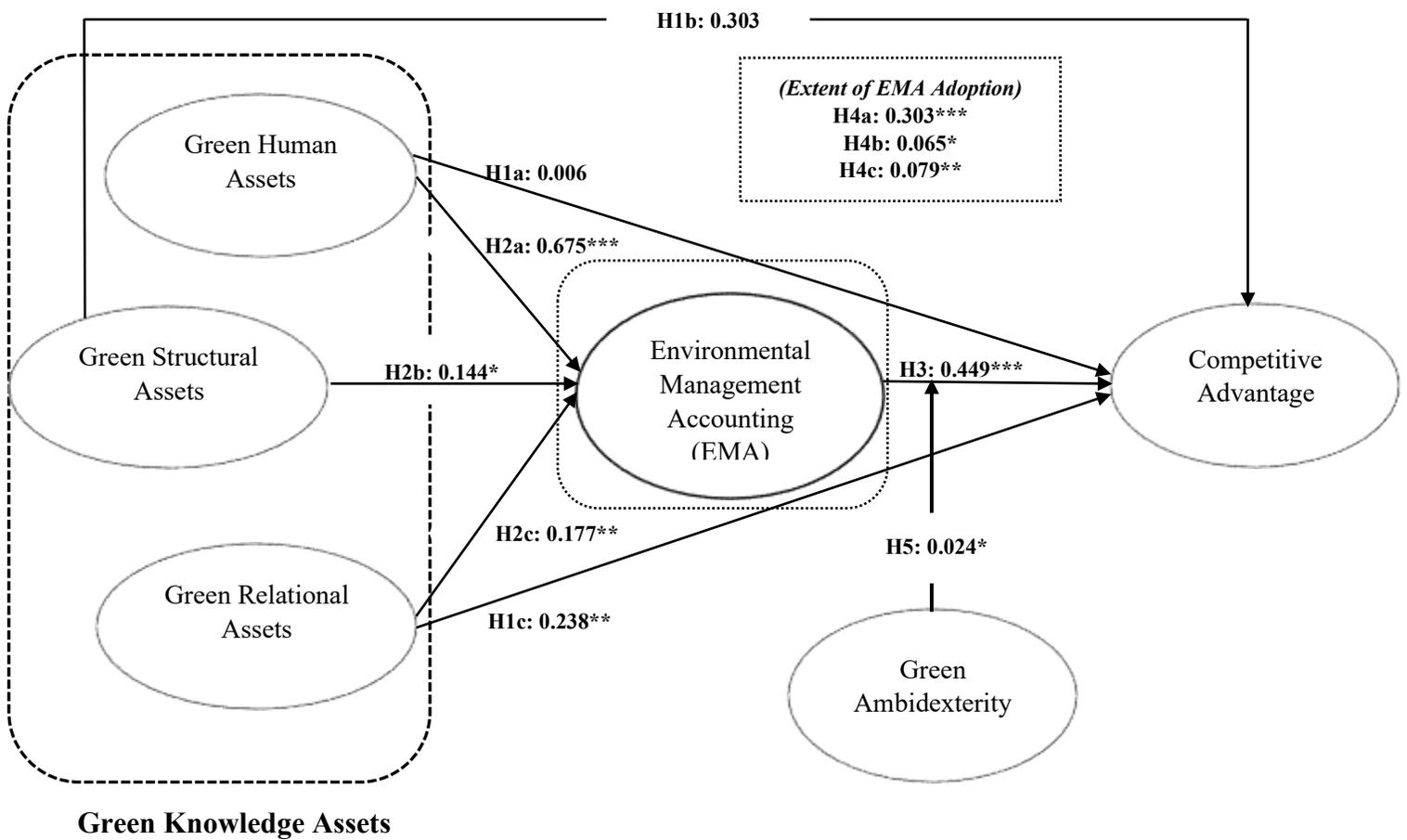
Significance level: The betas show the path, and the ***p<0.001, **p<0.010, and * p<0.100 indicate the significance.

Figure 2. Simple slope analysis
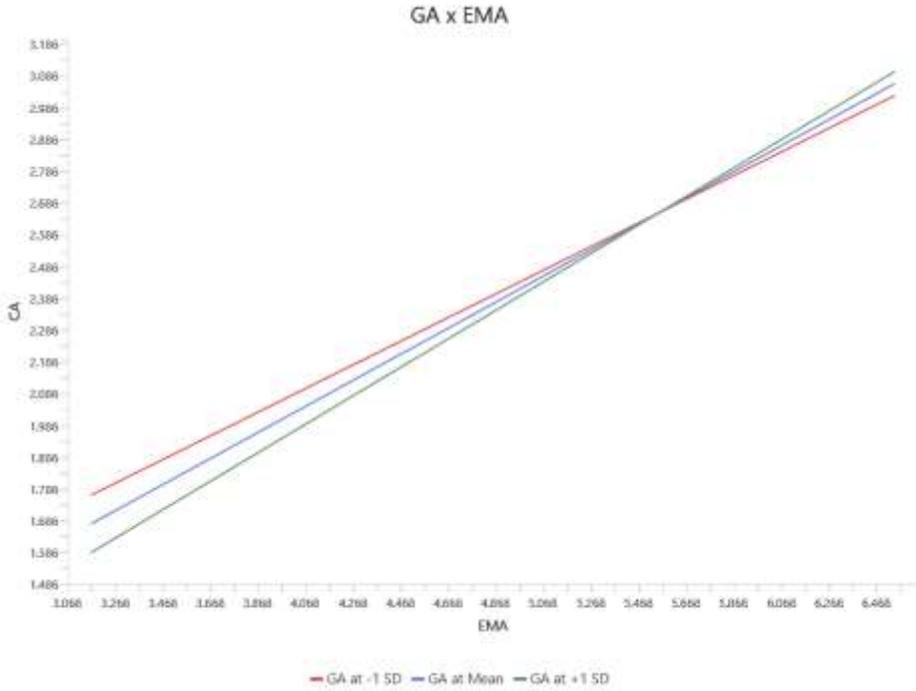
Notes. EMA: Environmental management accounting (mediating variable);
CA: Competitive advantage (dependent variable);
GA.: Green Ambidexterity (moderating variable).

Tables

Table 1
Organizational Demographics

Profile	Categories	Frequency	Percent
Type of industry	Non-Manufacturing	14	13.2%
	Manufacturing	92	86.8%
No. of employees	Less than 100	10	9.4%
	100 – 200	15	14.1%
	201 – 400	25	23.6%
	401 – 600	41	38.7%
	More than 600	15	14.2%
Sales/Turnover (in billion riyals)	Less than 500	56	52.8%
	501 – 1000	12	11.3%
	1001 – 1500	5	4.7%
	1501 – 2000	4	3.8%
	More than 2000	29	27.4%

Table 1: Items and outer loadings

Items	EMA	GHA	GRA	GSA	CA	Exor.	Exoi.
Identification of environment-related costs.	0.915						
Estimation of environment-related contingent liabilities (e.g., EPA fines)	0.898						
Classification of environment-related costs.	0.942						
Allocation of environment-related costs to production processes.	0.948						
Allocation of environment-related costs to products.	0.932						
Introduction or improvement to environment-related cost management.	0.880						
Creation and use of environment-related cost accounts.	0.934						
Development and use of environment-related key performance indicators (KPIs).	0.904						
Product life cycle cost assessments.	0.794						
Product inventory analyses (i.e., the specification of the types and quantities of materials and energy required and the amount of residues released to the environment)	0.800						
Product impact analyses (i.e., assessment of the environmental effect of competing product designs)	0.858						
Our employees possess up-to-date knowledge and skills about environmental regulations and green technologies.		0.895					
Employees are committed to the organization's environmental goals and values.		0.880					
Employees proactively generate innovative ideas and knowledge to improve the environmental performance of products and processes.		0.873					
We provide regular training that effectively builds employees' green competencies and knowledge.		0.936					
Employees feel capable and possess the knowledge to solve environmental problems in their daily work.		0.891					
Our relationships with external stakeholders (e.g., customers, communities) are grounded in shared environmental goals and transparent green practices.			0.818				
We collaborate with key suppliers and partners to co-develop or source green knowledge, materials, and solutions.			0.859				
Our external networks provide timely access to environmental standards, regulations, and technical information.			0.894				
Green standard operating procedures (SOPs) are documented, current, and easy to access.				0.887			
Our knowledge-management and IT systems enable effective storage, search, and retrieval of green know-how.				0.889			
Company-wide metrics and reporting systems track key green indicators (e.g., energy use, waste, emissions).				0.882			
Policies, organizational structures, and incentives consistently support pro-environmental behavior.				0.915			
We actively maintain and audit environmental certifications and standards (e.g., ISO 14001).				0.880			
Green intellectual property (e.g., patents, designs) is systematically managed and protected.				0.839			
The company has the competitive advantage of low cost compared to its major competitors.					0.832		
The quality of the products or services that the company offers is better than that of its major competitor's products or services.					0.869		
The company is more capable of R&D and innovation than its major competitors.					0.828		
The company has better managerial capabilities than its major competitors.					0.861		
The company's profitability is better.					0.824		
The growth of the company exceeds that of its major competitors.					0.852		
The company is the first mover in some important fields and occupies some important positions.					0.814		
The corporate image of the company is better than that of its major competitors.					0.863		
The major competitors of the company cannot imitate its products or services easily.					0.849		
The major competitors of the company cannot imitate its ideas easily.					0.853		
The major competitors of the company cannot replace its distinctive position easily.					0.876		
Our company actively adopts new green products, processes, and services.						0.841	
Our company actively explores new green products, processes, and services.						0.846	
Our company actively discovers new green markets.						0.864	

Our company actively enters new green technologies.	0.868
Our company experiments with environmentally sustainable practices that are new to the industry.	0.873
Our company invests in R&D to develop innovative green solutions for future competitiveness.	0.858
Our company actively improves current green products, processes, and services.	0.887
Our company actively adjusts current green products, processes, and services.	0.880
Our company actively strengthens the current green market.	0.870
Our company actively strengthens current green technology.	0.870
Our company expands green products and services for existing clients.	0.891

Notes. EMA: Environmental management accounting (mediating variable);

Three dimensions of green knowledge assets (independent variables), including GHA: Green human assets; GRA: Green relational assets; GSA: Green structural assets;

CA: Competitive advantage (dependent variable);

Exor.: Two dimensions of green ambidexterity (moderating variable), including green exploration and exploitation

Table 2
Construct reliability and validity

Variables	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
Competitive Advantage	0.961	0.966	0.719
Environmental Management Accounting	0.974	0.977	0.797
Exploitation	0.927	0.945	0.774
Exploration	0.929	0.944	0.737
Green Human Asset	0.938	0.953	0.802
Green Relational Asset	0.820	0.893	0.736
Green Structural Asset	0.943	0.955	0.778