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Causal Relationship Analysis between Sustainable Management Control Systems and Ambidextrous Green Innovation Using the DEMATEL Approach

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1. Introduction

Industrial growth has greatly improved societal well-being but has (Patel & Patel, 2021; Ma & Zhu, 2024) also caused significant environmental challenges, such as pollution, increased greenhouse gas emissions, and resource depletion (Farida & Setiawan, 2024). Green innovation has emerged as a vital strategy for achieving environmental sustainability (Chen, 2008; Dangelico & Pujari, 2010), gaining attention across management, marketing, and business ethics fields (Bendell, 2017; Song et al., 2019). This approach not only enhances a company's reputation among customers (Chen, 2008) but also provides a sustainable competitive advantage (Chang, 2011). However, its adoption varies across firms due to barriers like high costs and inefficiencies in traditional management control systems (Bansal & Roth, 2000). Based on ambidexterity theory, green innovation includes exploitative and exploratory dimensions (O'Reilly & Tushman, 1996). Exploitative innovation improves existing green products and processes, while exploratory innovation focuses on developing new green solutions. These dimensions allow firms to leverage current knowledge and explore new opportunities, helping them meet social responsibilities and prevent competitor imitation (Chang, 2011). Meanwhile,

sustainable management control systems (MCSs) are essential for promoting innovation and sustainability by guiding organizational behavior (Bedford, 2015). Simons' (1995) levers of control framework, which includes belief, boundary, diagnostic, and interactive systems, is a widely used model for studying sustainable MCSs (Johnstone, 2019). These levers support innovation by fostering a sustainability culture, monitoring performance, and promoting organizational learning (Gond et al., 2012). Iran, ranked 113 out of 180 in the Environmental Performance Index (EPI) (Mosaferi et al., 2024), is confronted with severe challenges such as air pollution, high greenhouse gas emissions, waste of water and energy resources, and deforestation (Haghighi et al., 2021). The country's greenhouse gas emission intensity was approximately 0.54 kg of CO2 per $1000 of Gross Domestic Product (GDP) in 2023, which underscores the urgent need for adopting sustainable solutions (EDGAR, 2024). To combat these issues, the Iranian government has supported green projects and allocated $5.5 billion from the National Development Fund toward the development of renewable energy sources (Iran Watch, 2025). Furthermore, training programs have been implemented in companies to promote environmentally friendly products (Afshar Jahanshahi31 et al., 2020). Nevertheless, barriers such as the high cost of green initiatives, which are often considered uneconomical by senior executives, have limited the adoption of these activities (Mohammadi et al., 2016).

Kavir Tire, a prominent Iranian company, demonstrates success by combining exploitative innovation (improving green tires) with exploratory efforts (using nanotechnology to enhance tire performance) (Donya-e-Eghtesad Special Issue). Although previous studies in Iran have explored green innovation and MCSs (Asiaei et al., 2022b), the causal relationships between sustainable MCSs and ambidextrous green innovation remain understudied. This research addresses this gap using the DEMATEL approach.

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2. Research Questions

This study aims to answer the following questions:

1. What are the causal relationships between Simons' levers of control (belief, boundary, diagnostic, and interactive) and the dimensions of ambidextrous green innovation (exploitative and exploratory)?
2. Which levers and dimensions act as causes or effects, and how strong are their interactions?

3.Methods

This study uses a quantitative, descriptive-correlational design and applies the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique to explore relationships between Simons' (1995) levers of control and ambidextrous green innovation dimensions, as defined by Wijethilake (2017) and Wang et al. (2020). The framework consists of four levers (belief, boundary, diagnostic, and interactive) and two green innovation dimensions (exploitative and exploratory). Data were collected using a DEMATEL-based questionnaire with a 5-point Likert scale (0 = no influence to 4 = very high influence). The questionnaire was distributed electronically over two months, from February to March 2025.

The target population included experts in sustainability and MCSs, selected based on their expertise, a minimum master's degree, and published research. Out of 50 distributed questionnaires, 12 responses were received, which meets the requirements for DEMATEL analysis (Asgharpour, 2009). Five experts confirmed the questionnaire's face validity, and its reliability was verified with a Cronbach's alpha of 0.876. Data analysis involved constructing a direct-relation matrix, normalizing it, and calculating the total-relation matrix (T) in Microsoft Excel. A threshold 1.623 was used to identify significant relationships. Metrics such as (D) (influence), (R) (affected), (D + R) (interaction), and (D - R) (causal or effect role) were

calculated. Ethical standards, including informed consent and data confidentiality, were fully observed.

4. Results

The results show that the belief system, with (D = 10.576) and (D - R = 1.311), is the most influential criterion and a primary causal factor. It has significant relationships with all other criteria: boundary (T= 1.765), diagnostic (T= 1.777), interactive (T= 1.765), exploitative (T= 1.844), and exploratory (T= 1.879). Its strongest link is with exploratory innovation, emphasizing the importance of a sustainability culture in driving new green solutions. The diagnostic (D = 9.911) and interactive (D = 9.751) levers also play causal roles, supporting green innovation through performance monitoring and feedback. In contrast, the boundary (D - R = -0.417), exploitative (D - R = -0.684), and exploratory (D - R = -0.659) dimensions are effect criteria. Exploratory innovation, with (R = 10.201), is the most affected, indicating its dependence on well-coordinated control levers. A bidirectional relationship between exploitative and exploratory innovation (T= 1.663), (T= 1.673) highlights their interdependence, which is critical for ambidextrous green innovation. The causal diagram positions the belief system as a central node, showing its influence on all criteria.

5. Discussion and Conclusion

This study investigates the causal relationships between Simons' levers of control and ambidextrous green innovation using the DEMATEL approach. The belief system's strong influence aligns with Nani and Safitri (2021), who emphasize the role of formal control systems in enhancing innovation. The high dependence of exploratory innovation on other dimensions matches findings by Gong et al. (2021) and Shahzad et al. (2022), who highlight ambidextrous innovation's role in organizational performance. These results also align with studies in Iran (Tayaran et al., 2020), which stress the importance of an innovation-driven culture for environmental outcomes. However, barriers in Iran, such as high costs and managerial resistance, hinder green innovation adoption. Managers should focus on strengthening belief and interactive systems through training and feedback mechanisms. Policymakers can support adoption by offering financial incentives and enforcing stricter environmental regulations. Future research could explore mediating factors like organizational learning or compare these dynamics across industries. The study's limitations include a small sample size (12 experts), the subjective nature of DEMATEL

judgments, and cross-sectional data, which limit generalizability. Despite these limitations, this research provides valuable insights into sustainable management practices in Iran, contributing to environmental sustainability efforts in developing economies.

Keywords: Sustainable Management Control System, Ambidextrous Green Innovation, Sustainability, DEMATEL.