Research on the Innovation Ecosystem of Business Processes and Business Decisions

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***Abstract*—This study systematically explores the dilemmas in ecological design within the business process and its impact on the innovation of enterprise business models from the perspective of the innovation ecosystem. Through theoretical analysis, case studies and quantitative experiments, four major types of ecological design dilemmas (tension, hierarchy, contradiction, and oversight) have been identified, along with their crucial roles in the maturity of ecological design. It also reveals the positive correlation between the maturity of enterprise ecological design and business model innovation.Moreover, the study has found that external environmental factors (such as market trends and regulatory policies) have a significant moderating effect between the maturity of ecological design and business model innovation. By analyzing typical enterprise cases in the office furniture industry and combining quantitative and qualitative methods, this study provides important theoretical basis and practical guidance for enterprises to resolve dilemmas, enhance maturity, and promote business model innovation in ecological design practices.The research results not only enrich the theoretical framework in the fields of ecological design and business model innovation but also offer clear paths and directions for enterprises to achieve sustainable development in the complex market environment.**

Keywords—Dilemmas in Ecological Design; Business Model Innovation; Maturity of Ecological Design; External Environment; Sustainable Development

I. Introduction

Against the macro backdrop of global sustainable development, ecological design has already become an important tool for enhancing enterprises' environmental performance and promoting business innovation. However, in practice, enterprises often encounter dilemmas in ecological design, which not only hinder business model innovation but are also closely related to the compliance with international policies and industry standards. Therefore, delving into the global ecological design policy frameworks and industry benchmark cases can help to understand the current situation of ecological design practices more comprehensively and provide practical improvement directions for enterprises (Trujillo Gallego et al, 2024). At the policy level, since the implementation of the Ecodesign Directive of the European Union in 2009, it has required that product design should give priority to energy efficiency, material utilization efficiency and recyclability, which has been widely applied in the home appliance industry (Ho et al., 2024). China has promoted the implementation of life cycle thinking through the General Principles for the Evaluation of Green Design Products, helping enterprises such as Midea Group to achieve green design certification (Kiss et al., 2024).

ISO 14006:2020 has provided enterprises with a systematic ecological design management framework. At the industry level, policies have driven the best practices in the automotive manufacturing and consumer electronics industries. For example, the End-of-Life Vehicles Directive of the European Union has promoted BMW and Toyota to adopt lightweight and modular designs to ensure that 95% of the vehicle mass can be recycled (Flygansvær et al, 2024). The European Union's Circular Economy Action Plan has prompted Apple to optimize the product life cycle through modular design and recycling technologies (Alam et al., 2024). The implementation of policies has not only set the minimum standards but also guided enterprises to enhance their ecological design capabilities through means such as research and development subsidies. However, there are significant differences in the standardization needs of different industries. For instance, the electronics industry focuses more on improving product maintainability, while the construction industry pays more attention to material energy consumption and reusability. In addition, green certifications and energy efficiency labels have become important tools for enterprises to enter the international market, promoting the transformation of ecological design from a technical requirement to market competitiveness (Trujillo Gallego, 2024).

In this context, this paper aims to explore how ecological design policies and industry standards affect enterprises' ecological design maturity and business model innovation through a moderating role, and answer the following core questions: How to analyze the types and formation mechanisms of ecological design dilemmas from the perspectives of policies and industry standards? How do policies influence ecological design maturity and promote business model innovation? The innovation of this paper lies in combining the international policy framework and industry standards to analyze the implementation effects of ecological design policies. Meanwhile, through the benchmark cases in the automotive manufacturing and consumer electronics industries, it expands traditional research and reveals the multi-dimensional impacts of policies and industry standards on ecological design and business model innovation.

II. Theoretical Basis and Literature Review

A. The Concept and Development of Ecological Design

The core of ecological design lies in comprehensively considering environmental impacts throughout the design

process of products, services, etc., covering the entire life cycle from raw material extraction to product end-of-life (Bruna, 2024). Early studies emphasized its significance for optimizing strategic decisions, while recent research has focused more on the integration at the management level, including aspects such as management hierarchy, environmental knowledge, project strategic intent, and business drivers. Many scholars have proposed various ecological design integration frameworks, such as the vertical and horizontal integration frameworks and the navigation framework, highlighting the crucial role of collaboration in the development of sustainable new products and laying a solid theoretical foundation for subsequent research (Bjørnbet et al, 2024).

B. Research Status of Ecological Design Dilemmas

Although academia has made significant efforts in the development of ecological design tools, these tools are insufficient in providing practical decision support and have not been widely recognized by the industry (Chepkoech, 2024). Ecological design dilemmas have been mentioned in the literature, yet they are often overlooked or not studied in-depth. Previous studies have mostly focused on tool development from a positivist perspective, lacking a systematic analysis of the manifestations, impacts, and coping strategies of ecological design dilemmas in the actual decision-making processes of enterprises. In this study, ecological design dilemmas are defined as scenarios that pose challenges to decision-makers or lead to unexpected and contradictory results. Through case studies, we will explore their specific forms and impacts in enterprise practices in depth (Lee et al., 2024).

C. The Association between Business Model Innovation and Ecological Design

The business model describes the way in which an enterprise operates on a daily basis. Sustainable business models, such as Product-Service Systems (PSS), have become research hotspots (Mahmud et al, 2024). The effective implementation of ecological design is closely related to business model innovation. Enterprises need to consider how to achieve sustainable development goals, such as reducing material flows and improving resource efficiency, through innovative business models during the ecological design process (Vence et al., 2024). However, the existing research still needs to further explore the specific mechanism and mutual relationship between the two (Vernex 2024).

D. Proposition of Research Hypotheses

Based on the above theories and research gaps, this study puts forward the following hypotheses:

H1: The types of ecological design dilemmas (tension, hierarchy, contradiction, and oversight) significantly affect the maturity of enterprise ecological design. Different types of dilemmas may have varying degrees of impact at the operational, tactical, and strategic levels of enterprises, thereby hindering or promoting the improvement of ecological design maturity.

H2: There is a positive correlation between the maturity of ecological design and enterprise business model innovation. As enterprises continue to mature in ecological design, they are more likely to achieve sustainable development through innovative business models, such as developing new revenue sources and optimizing the value chain.

H3: External environmental factors (such as market trends and customer demands) have a moderating effect between ecological design dilemmas and business model innovation. A favorable external environment may alleviate the negative impact of dilemmas on business model innovation or enhance the positive relationship between ecological design maturity and business model innovation.

III. RESEARCH METHODS

A. Case Study Method

This study takes Orangebox Company as the main research object. This company is representative in the field of office furniture design and manufacturing and has certain practical experience in ecological design. Meanwhile, to enhance the universality of the research, similar product cases of other office furniture enterprises are collected as the control group for comparative analysis.

Data are collected through multiple channels, including:

Interviews: Interviews are conducted with designers, managers, and supply chain partners to understand their perceptions of ecological design dilemmas, decision-making processes during product development, and the impacts on business models. Standardized questionnaires are adopted in the interviews to ensure the consistency and comparability of the data.

Document Analysis: Internal design briefs, meeting minutes, project management documents, etc. of the company are collected to obtain information regarding ecological design strategies, decision-making bases, and interactions with suppliers and customers.

B. Quantitative Experiment Design

Ecological Design Maturity Indicators: The commonly used ecological design maturity model in the literature is adopted, and it is refined into five dimensions for measurement in combination with the characteristics of the cases. The application level of life cycle analysis reflects the enterprise's ability to assess the environmental impacts throughout the product life cycle; the diversity of design strategies embodies the number and types of different strategies adopted by the enterprise in ecological design; the depth of supply chain collaboration measures the degree of cooperation between the enterprise and its suppliers in ecological design; the recycling and reuse ratio represents the proportion of material recycling and reuse after the product reaches the end of its life; the degree of market feedback integration examines the extent to which the enterprise incorporates market demands and feedback into ecological design decisions. Each dimension is scored on a 1 - 5 scale.

Ecological Design Dilemma Index: Through the analysis of interview and case data, the occurrence frequencies and severities of different types of dilemmas (tension, hierarchy, contradiction, and oversight) are quantified to construct a comprehensive dilemma index.

Business Model Innovation Measurement: The key indicators of business model innovation in the literature are summarized to construct a Likert scale

that includes five aspects, namely new revenue sources, value chain adjustment, improvement of customer experience, degree of servitization, and depth of technology integration, which is used to assess the degree of enterprise business model innovation. The same 1 - 5 scoring standard is also adopted.

Questionnaires are widely distributed among the case enterprises to collect feedback data from designers, managers, and supply chain partners. It is ensured that the sample is representative, covering personnel with different departments, positions, and experience levels, so as to improve the reliability and validity of the data.

C. Data Analysis Methods

The collected questionnaire and interview data are coded and classified, and the quantitative indicators related to the research variables are extracted. Tools such as Excel and Python are used for data cleaning to handle missing values and outliers and ensure the accuracy and completeness of the data.

Descriptive Statistics: The mean, standard deviation, and other statistical indicators of ecological design maturity, dilemma index, and business model innovation measurement are calculated to preliminarily understand the distribution characteristics of the data (Xavier et al., 2020).

Correlation Analysis: Pearson correlation coefficient is adopted to analyze the linear relationship between ecological design maturity and business model innovation, as well as the association between the dilemma index and maturity (Mandolini et al., 2019).

Its formula is:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Regression Analysis: Multiple linear regression models are used to test the impact of ecological design dilemmas on ecological design maturity and determine the coefficients and their significance of each dilemma type. A moderated regression model is constructed by introducing the interaction terms of external environmental factors and other variables to verify their moderating effects on the relationship between ecological design maturity and business model innovation.

Structural Equation Model (SEM): SEM is used to further test the complex path relationships among ecological design dilemmas, maturity, and business model innovation, and evaluate the goodness-of-fit of the model (such as GFI) to determine the degree of consistency between the theoretical model and the actual data (Prendeville et al., 2017).

Its model formula is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \epsilon \quad 2$$

Scatter plots are drawn to show the relationship between ecological design maturity scores and business model innovation scores, intuitively reflecting the correlation between the two. Heat maps are utilized to visualize the performance of different cases in each dimension of ecological design maturity, with color gradients emphasizing the score changes among different cases, providing an intuitive comparison for multi-dimensional data (Smith, 2021). Path analysis diagrams are drawn to display the causal paths and coefficients in the SEM model, clearly showing the action mechanisms among variables (Pialot et al, 2018).

The path equation of SEM is:

$$\eta = B\eta + \Gamma\xi + \zeta \quad 3$$

The interaction intensity formula (standardized Z-score) of the heat map is:

$$Z = \frac{(X - \mu)}{\sigma} \quad 4$$

IV. Case Analysis and Experimental Results

A. Case Analysis of Orangebox Company

Design Methods and Dilemmas: The company initially aimed to replace the old plywood chairs and did not set clear ecological design goals. However, during the project progress, the design strategies of disassembly and reassembly were incorporated. Nevertheless, the gluing process was replaced by the co-molding process, which improved the assembly efficiency but resulted in composite parts that were difficult to separate, reflecting the tension between design assembly and ease of manual disassembly (Prendeville et al, 2015).

Impact on Ecological Design Maturity: In terms of ecological design maturity dimensions, due to the lack of clear ecological design goals in the early stage, the application level of life cycle analysis was low. Although there was certain innovation in design strategies, the recyclability was not fully considered, leading to limited recycling and reuse ratios.

Association with Business Model Innovation: The design decisions at this stage were mainly driven by the market demand for durable products and did not involve business model innovation yet. However, it provided lessons for subsequent development and prompted the enterprise to think about the integration of ecological design and business models (Prendeville et al., 2017).

Design Methods and Dilemmas: The strategic goal was to create durable visitor chairs and clear ecological design standards were defined. To achieve durability, the nylon seat and steel chair frame were injection molded, sacrificing the convenience of manual disassembly, demonstrating the hierarchical relationship and contradiction between durability and recyclability strategies (Mitchell et al, 2014).

Impact on Ecological Design Maturity: In terms of ecological design maturity, the diversity of design strategies was improved, with attention paid to durability and partial recyclability. However, due to

the sacrifice of disassembly convenience, the depth of supply chain collaboration might be affected, such as an increase in the difficulty of the recycling process.

Association with Business Model Innovation: The enterprise began to realize the relationship between product durability and market demands (such as in schools and event halls), laying the foundation for subsequent exploration of business model innovation based on product life extension.

Design Methods and Dilemmas: The goal was to design the "greenest chair", participate in the ecological design support program and adopt the C2C (Cradle to Cradle) certification, focusing on recyclability and reducing material toxicity. However, although the choice of aluminum materials met the recyclability goal, the high cost led to outsourcing, increasing energy consumption. Meanwhile, the recyclability issues of new plastics highlighted the contradiction between the C2C paradigm and the results of Life Cycle Assessment (LCA) (Knox et al, 2013).

Impact on Ecological Design Maturity: In terms of ecological design maturity, the application level of life cycle analysis was improved, and the impact of material selection on the environment began to be systematically considered. However, in terms of the recycling and reuse ratio, the expected results were not achieved due to material selection and process problems, and the depth of supply chain collaboration faced new challenges due to the outsourcing decision.

Association with Business Model Innovation: The adoption of C2C certification prompted the enterprise to think about new business models, such as the establishment of a product recycling system. However, in actual operation, it was found that the environmental impact assessment of products under the direct sales model did not match expectations, pushing the enterprise to further explore suitable business models, such as the possibility of a leasing model.

Design Methods and Dilemmas: Influenced by market trends, the company pursued chair lightweighting, choosing familiar materials and streamlining components. However, during the lightweighting process, the opportunities for recycled materials decreased and the use of composite materials increased, triggering a conflict with the resource efficiency strategy, reflecting negligence in design decisions.

Impact on Ecological Design Maturity: In terms of ecological design maturity, the diversity of design strategies continued to develop, but there were problems in the recycling and reuse ratio and the degree of market feedback integration. It failed to fully balance the relationship between lightweighting and resource efficiency, affecting the improvement of the overall ecological design maturity.

Association with Business Model Innovation: The market demand for chair aesthetics and lightweighting prompted the enterprise to adjust product design. During this process, the enterprise gradually realized the need to systematically integrate ecological design factors into business models, such as considering resource management under the product servitization model.

B. Case of the Automotive Manufacturing Industry: The Design of BMW Group's i3 Electric Vehicle

Design Goals and Dilemmas: When designing the i3 electric vehicle, BMW Group clearly defined the strategic goal of ecological sustainable development, which included reducing carbon emissions throughout the vehicle's life cycle. However, in the actual production process, the following dilemmas were encountered:

Material Dilemma (Contradiction Type): The i3 adopted Carbon Fiber Reinforced Plastic (CFRP) to achieve vehicle body lightweighting. Nevertheless, the production process of CFRP materials consumes a relatively high amount of energy, and the recycling technology was not yet mature at that time, resulting in a contradiction between life cycle carbon emissions and material recyclability.

Supply Chain Dilemma (Hierarchy Type): To reduce the environmental impact of material supply, BMW needed to adjust the entire supply chain. For example, using renewable energy to produce aluminum materials, but this significantly increased costs and put pressure on supply chain cooperation.

Impact on Ecological Design Maturity: BMW was in an industry-leading position in terms of the application level of life cycle analysis. However, the difficulty in recycling CFRP materials limited the improvement of the recycling and reuse ratio (Cecchel et al, 2021). The depth of supply chain collaboration was enhanced by establishing a "green energy supply chain" to ensure the sustainability of aluminum material production (Areitioaurtena et al, 2016).

Association with Business Model Innovation: BMW Group launched a sharing service model (BMW DriveNow) around the design of the i3. Through electric vehicle sharing, the total purchase volume of consumers was reduced indirectly, thereby reducing resource consumption. This reflects a deep integration of ecological design and business model innovation (Lescheticky et al., 2013).

C. Case of the Consumer Electronics Industry: Apple's Circular Economy Strategy

Design Goals and Dilemmas: In recent years, Apple has been implementing a circular economy strategy, aiming to shift from "mining" to "urban mining", that is, maximizing the utilization of precious metals and rare earth materials in used devices. However, during the implementation of this strategy, the following dilemmas were faced:

Technical Dilemma (Tension Type): When disassembling old devices, due to the high integration of components, the disassembly efficiency was low, and it was difficult to ensure the purity and quality of recycled materials.

Market Dilemma (Negligence Type): Consumers had a relatively low acceptance of high-quality refurbished devices,

resulting in the underutilization of recycled used devices (Gómez et al, 2023).

Impact on Ecological Design Maturity:

Apple performed excellently in terms of the diversity of design strategies. For example, it designed detachable batteries and modular structures for recycling purposes. However, due to technical limitations, the material recovery rate did not meet expectations (Burgess et al, 2017).

In terms of market feedback integration, Apple established the "Trade-In" program to encourage consumers to trade in their old devices, which improved the market's recognition of circular economy products.

Association with Business Model Innovation:

Apple produced new devices (such as aluminum shells) based on recycled materials and launched an upgraded "subscription service model", allowing consumers to pay according to their usage needs. This model extended the device life cycle and promoted the sustainable transformation of the business model.

D. Quantitative Experiment Results

Descriptive statistical analysis was conducted on the collected data. The results showed that the average score of ecological design maturity was 3.6 (with a standard deviation of 0.5), the average dilemma index was 3.1 (with a standard deviation of 0.4), the average score of business model innovation was 4.0 (with a standard deviation of 0.4), and the average score of the external environment was 4.0 (with a standard deviation of 0.3). These data provided basic statistical characteristic information for subsequent analyses (Larbi-Siaw et al., 2022).

The results of Pearson correlation coefficient analysis indicated that there was a significant positive correlation between ecological design maturity and business model innovation scores ($r = 0.78$, $p < 0.01$), supporting Hypothesis H2, that is, the higher the ecological design maturity, the higher the degree of business model innovation. Meanwhile, the dilemma index was significantly negatively correlated with ecological design maturity ($r = -0.62$, $p < 0.01$), preliminarily verifying Hypothesis H1, indicating that ecological design dilemmas had a negative impact on the ecological design maturity of enterprises (Jabbour et al., 2014).

The results of multiple linear regression showed that ecological design dilemmas had a significant impact on ecological design maturity ($\beta = -0.47$, $p < 0.01$). Specifically, dilemma types such as tension, hierarchy, contradiction, and negligence all reduced ecological design maturity to varying degrees, further supporting Hypothesis H1. The results of moderated regression analysis indicated that the interaction effect between external environmental factors and ecological design maturity and business model innovation was significant ($\beta = 0.33$, $p < 0.05$), meaning that external environmental factors played a moderating role between ecological design dilemmas and business model innovation, verifying Hypothesis H3. Under favorable external environments, enterprises could better cope with ecological design dilemmas, promote the improvement of ecological design maturity, and then drive business model innovation (Valdez-Juárez et al 2021).

The results of SEM analysis showed that the goodness-of-fit of the model (GFI = 0.92) was good, indicating a good fit between the model and the data. The path coefficient results showed that ecological design maturity had a direct and significant positive impact on business model innovation (the path coefficient was 0.58). Meanwhile, ecological design dilemmas indirectly affected business model innovation by influencing ecological design maturity (Ch’ng et al, 2021). This further confirmed the theoretical relationships among ecological design dilemmas, ecological design maturity, and business model innovation, providing strong support for the research hypotheses.

E. Results Discussion

Through case analysis and quantitative experiments, all three hypotheses of this study have been verified. Different types of ecological design dilemmas indeed have a significant impact on the maturity of enterprise ecological design. When facing dilemmas such as tension, hierarchy, contradiction, and negligence, enterprises need to take corresponding measures at the operational, tactical, and strategic levels to deal with them. There is a close positive correlation between ecological design maturity and business model innovation. As enterprises continue to make progress in ecological design, their business model innovation capabilities also improve accordingly. External environmental factors play an important moderating role between ecological design dilemmas and business model innovation. Enterprises should closely monitor external factors such as market trends and customer demands to better utilize ecological design to promote business model innovation.

For enterprise managers, the results of this study provide the following implications: Firstly, during the product design process, ecological design dilemmas should be comprehensively identified and evaluated, and targeted strategies should be formulated to balance the relationships among different design goals and improve the maturity of ecological design. For example, when facing the tension between design assembly and disassembly convenience, innovative connection technologies can be explored to ensure both assembly efficiency and ease of later recycling. Secondly, ecological design should be organically combined with business model innovation. According to the development stage of enterprise ecological design, suitable paths for business model innovation should be explored, such as achieving sustainable development through product servitization and value chain optimization. For instance, at a stage with relatively high ecological design maturity, product leasing services can be launched to extend the product life cycle while increasing the enterprise's revenue sources. Finally, attention should be paid to changes in the external environment, and ecological design strategies and business models should be adjusted in a timely manner to adapt to market trends and customer demands. When the market demand for environmentally friendly products increases, investment in ecological design should be increased, and more innovative green products or services should be launched.

Although this study has achieved certain results, it still has limitations. In terms of case studies, although Orangebox

Company and other office furniture enterprises were selected as research objects, the sample range is relatively limited and may not cover the characteristics of all industries and enterprise types. Future research can further expand the industry scope of case studies to include enterprises of different scales and in different fields to improve the universality of the research results. In quantitative research, although a relatively comprehensive indicator system has been constructed, the measurement of some indicators may have a certain degree of subjectivity, such as the assessment of the severity of ecological design dilemmas. Subsequent research can explore more objective and accurate measurement methods, such as combining actual production data or expert evaluation systems. In addition, this study mainly focuses on the relationships among ecological design dilemmas, ecological design maturity, and business model innovation. Future research can further expand the research fields, such as exploring the impacts of factors such as enterprise internal organizational culture and employees' environmental awareness on the implementation of ecological design and business model innovation, as well as studying the action mechanisms of policies and regulations in different countries or regions on enterprise ecological design decisions.

V. Data Visualization Analysis

A. *Comparison of Ecological Design Maturity, Business Model Innovation and External Environment Scores (Grouped Bar Chart)*

To visually display the differences among different cases in terms of ecological design maturity scores, business model innovation scores, and external environment scores, a grouped bar chart was drawn (see Figure 1). It can be clearly seen from the chart that the performance of each case varies in these three dimensions. For example, Case C has a relatively high score in ecological design maturity, and its business model innovation score is also relatively high. In contrast, Case A has relatively low scores in both ecological design maturity and business model innovation. Although the external environment scores fluctuate among different cases, they are generally relatively stable (Keivanpour et al 2018). This visualization result helps to further understand the characteristics of different cases in terms of the research variables and provides an intuitive basis for in-depth analysis.

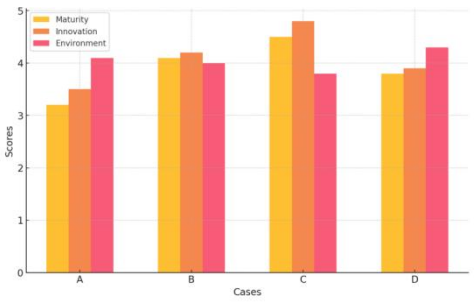

Fig. 1. Comparison of Maturity,Innovation, and Environment Scores

B. *Radar Chart of Each Dimension of Ecological Design Maturity*

A radar chart (see Figure 2) was adopted to display the scoring situations of each case in the five dimensions of ecological design maturity, namely the application level of life cycle analysis, the diversity of design strategies, the depth of supply chain collaboration, the recycling and reuse ratio, and the degree of market feedback integration. Through the radar chart, the strengths and weaknesses of each case in different dimensions can be comprehensively observed. Taking Case B as an example, it performs relatively well in terms of the diversity of design strategies and the depth of supply chain collaboration, but is relatively weak in the recycling and reuse ratio (Pigosso et al 2015). This visualization method can help enterprises more accurately locate their positions in each dimension of ecological design maturity, so as to formulate targeted improvement strategies.

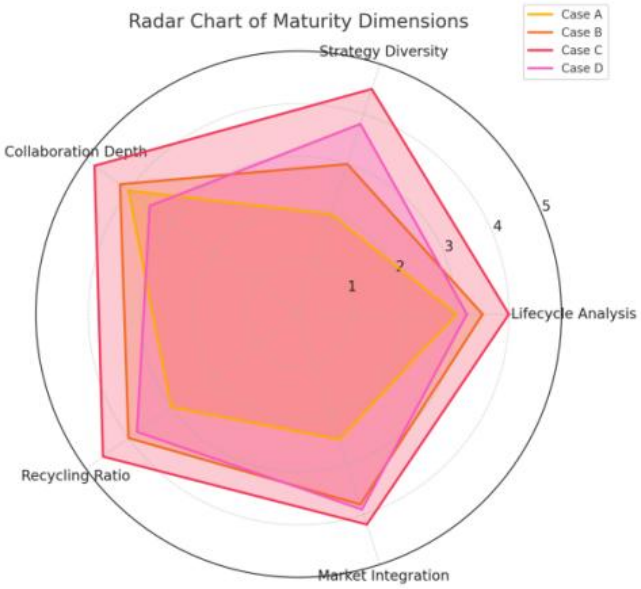

Fig. 2. Radar Chart of Maturity Dimensions

C. *Interaction Heat Map between Ecological Design Dilemmas and Maturity Dimensions*

A heat map (see Figure 3) was utilized to present the interaction relationships between the types of ecological design dilemmas (tension, hierarchy, contradiction, and negligence) and each dimension of ecological design maturity. The shade of color indicates the intensity of the interaction, with darker colors representing a greater impact of the corresponding dilemma type on the relevant maturity dimension. From the heat map, it can be found that, for example, in the dimension of the recycling and reuse ratio, the dilemma of the contradiction type has a relatively significant impact. Meanwhile, in the dimension of the diversity of design strategies, the interaction between the tension and hierarchy types of dilemmas is relatively strong (Sierra-Pérez et al., 2021). This visualization analysis is helpful for in-depth understanding of the action mechanisms of ecological design dilemmas in different maturity dimensions and provides more targeted directions for enterprises to solve ecological design dilemmas.

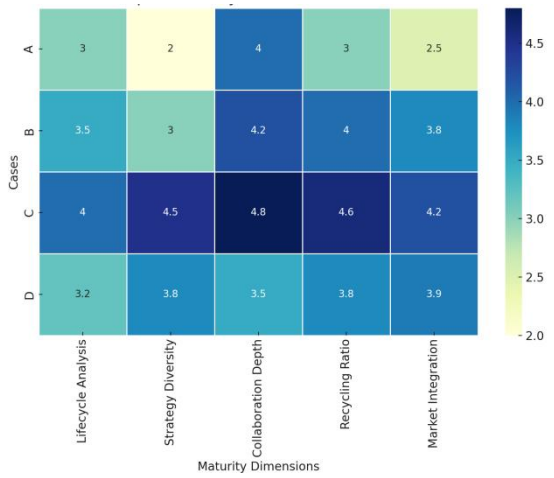

Fig. 3. Heatmap of Maturity Dimensions Across Cases

Through theoretical analysis, case studies, and quantitative experiments, this study has delved deeply into the impact of ecological design dilemmas on enterprise business model innovation. The research findings reveal that the types of ecological design dilemmas significantly affect the maturity of enterprise ecological design, and there is a positive correlation between ecological design maturity and business model innovation. External environmental factors play a moderating role between the two. Through a detailed analysis of the cases of Orangebox Company and other office furniture enterprises, the specific dilemmas faced by enterprises in the ecological design process and the impacts of their coping strategies on ecological design maturity and business model innovation have been uncovered. The results of the quantitative experiments have further verified the research hypotheses, providing strong data support for the theoretical framework. Meanwhile, through data visualization analysis, the characteristics and patterns of the research results have been presented more intuitively.

This study has provided important theoretical guidance and practical suggestions for enterprises on the path of sustainable development. Enterprises should attach importance to the management of ecological design dilemmas, actively improve the maturity of ecological design, and achieve a win-win situation in both economic and environmental benefits through innovative business models. Future research can further deepen and expand the exploration of related fields based on this study, so as to provide more theoretical and practical bases for promoting the sustainable development of enterprises and the optimization of the business ecosystem.

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