INTERNATIONAL JOURNAL OF eBUSINESS AND eGOVERNMENT STUDIES
Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203
Received: 15.4.2025 | **Accepted:** 20.06.2025 | **Published Online:** 30.06.2025

-RESEARCH ARTICLE-

INTEGRATING SUSTAINABILITY INTO PRODUCT DEVELOPMENT: EVIDENCE FROM ELECTRICAL MANUFACTURING IN AN EMERGING ECONOMY

Nahda Ali Abbas Ali

Department of Business Administration, Faculty of Administration and Economics, Mustansiriyah University, Baghdad, Iraq.
ORCID: https://orcid.org/0009-0001-1604-5225
Email: nahda@uomustansiriyah.edu.iq

Yusra Rabeea Fawwaz

Department of Accounting, Faculty of Administration and Economics, Mustansiriyah University, Baghdad, Iraq.
ORCID: https://orcid.org/0009-0006-7888-3263
Email: yusraarabia@uomustansiriyah.edu.iq

Esraa Abd Al Hussein Issa

Department of Financial and Banking Sciences, Faculty of Administration and Economics, Mustansiriyah University, Baghdad, Iraq.
ORCID: https://orcid.org/0009-0009-9509-4954
Email: esraaabdalhussin@uomustansiriyah.edu.iq

—Abstract—

This study investigates the adoption of product development techniques and the integration of sustainability considerations into product design within the context of an electrical manufacturing firm in Iraq. Employing a two-phase mixed-methods design, the research first assesses the implementation levels of four core product development techniques—green manufacturing, total quality management, value engineering, and computerized production—at the General Company for Electrical Industries, Diyala, through a structured checklist administered to 57 managerial staff. Results reveal substantial implementation gaps, ranging from 20% in green manufacturing to 50% in value engineering, indicating that the firm does not apply

Citation (APA): Ali, N. A. A., Fawwaz, Y. R., Issa, E. A. A. H. (2025). Integrating Sustainability into Product Development: Evidence from Electrical Manufacturing in an Emerging Economy. *International Journal of eBusiness and eGovernment Studies*, 17(2), 45-69. doi:10.34109/ijebeg.2025170203

these techniques with uniform rigor. In the second phase, a quantitative survey of 213 respondents is analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the influence of corporate sustainability strategy and policy (CSSP), sustainable product requirements (SPR), and the sustainability integration into product development (SIPD) on sustainable product design and development (SPDD). Findings reveal that SIPD exerts a dominant and statistically significant positive influence on SPDD ($\beta = 0.806$, $p < 0.001$), while SPR contributes a significant but modest effect ($\beta = 0.091$, $p = 0.008$). Conversely, CSSP does not significantly predict SPDD ($p = 0.075$). These results advance theoretical understanding of sustainable product development in emerging economies and provide actionable managerial guidance for industrial firms seeking to align operational practices with global sustainability imperatives.

Keywords: Product Development Techniques; Green Manufacturing; Total Quality Management; Value Engineering; Computerized Production; Sustainable Product Development; PLS-SEM; Electrical Manufacturing.

INTRODUCTION

In the modern industrial world, the ability of manufacturing companies to continually develop, refine and change their product lines has become an essential factor in the determination of sustained competitive advantage. The overall concept of product development refers to the various organizational practices that are geared towards creating new or enhancing existing goods aimed at meeting the needs of consumers amidst turbulent market settings, reacting to evolving consumer decisions, and avoiding competitive obsolescence (Dąbrowski, 2023). The electrical manufacturing industry in particular works at the nexus of intense technological change, accelerating international competition, and escalating environmental regulatory pressure, making the implementation of sophisticated, evidence-based product development methodologies urgent and far-reaching.

Within operations and production management, the term 'product development techniques' is an umbrella term for a family of structured methodologies that help firms to systematically improve their manufacturing processes, their product quality, economic efficiency, and environmental performance. Among the most widely researched and implemented of these methodologies are green manufacturing, total quality management (TQM), value engineering (VE) and computer-aided production systems. All these methods are concerned with a different aspect of the product development cycle: green manufacturing aspires to environmental responsibility and resource stewardship, in all stages of the production process; TQM pursues the goal of achieving a level of quality consciousness at every organizational tier by implementing structured customer-oriented process management; VE concentrates on the achievement of functional value maximization and rationalization of costs;

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

computerized production focuses on using digital technology to achieve greater precision of design, lower errors, and a flexible responsiveness to manufacturing (Nishant et al., 2020; Vilochani et al., 2024b). Collectively, these four techniques constitute the operational toolkit manufacturers can use to achieve superior product outcomes and their balanced use is generally considered crucial to achieving competitive parity in international markets.

Simultaneously, the worldwide trend of sustainable development has fundamentally changed the expectations made of manufacturing organisations. It is well-known in the literature now that the environmental footprint of a product is mainly determined during the first design and development stages, with estimates being made that up to 80% of a product's lifetime effect on the environment is 'locked-in' during the design phase. This recognition has created significant interest among scholars and practitioners in the area of sustainable product development (SPD), a paradigm that aims to incorporate the sustainability of environmental, social, and economic considerations systematically throughout the entire product development process - from strategic goal setting and concept generation through detailed design, production planning, manufacturing and end-of-life management (Vilochani et al., 2024a). The emerging academic consensus is that for effective SPD not only well-articulated corporate sustainability strategies and policies are needed, but also more concrete operationalization of sustainability requirements at the product specification level and, crucially, the disciplined integration of sustainability principles into each stage of the product development workflow.

Despite the abundance in conceptual frameworks and normative prescriptions for SPD in the academic literature, there remain important empirical gaps in terms of actual implementation of these practises in manufacturing organisations, especially in developing economies (Borgianni et al., 2018). The electrical manufacturing industry in Iraq is a particularly interesting and uncharted empirical context. Since its establishment as one of the pillars of the national industrial strategy by the Ministry of Industry and Minerals, the Iraqi electrical manufacturers have historically operated in the environment of resource limitations, infrastructural restrictions, and regular market shocks. The General Company for Electrical Industries, located in Diyala, is one of the most important and permanent entities in this field, which has been manufacturing a variety of electrical appliances, transformers, cables, and other products since its founding in 1974 (Al-zaidi & Dunay, 2016). Notwithstanding its industrial prominence, the degree to which the company has employed contemporary product development techniques and incorporated the concept of sustainability into its product development processes has not been rigorously studied within the scholarly literature (Ismael, 2021).

This research is motivated accordingly by two interrelated empirical and theoretical objectives. The first objective is the diagnostic one: to determine, using a structured

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

checklist methodology, the current levels of implementation of four techniques for product development, namely: green manufacturing, TQM, value engineering, and computerised production, quantify the implementation gaps in each of these techniques, and establish their relative importance within the firm's operative strategy (Ismail Salaheldin, 2009). The second objective is explanatory: to use PLS-SEM to empirically test the relationships between corporate sustainability strategy and policy (CSSP), sustainable product requirements (SPR), integration of sustainability into product development (SIPD) and sustainable product design and development (SPDD) to generate statistically grounded knowledge on the drivers of sustainable product results within the company (Ceschin & Gaziulusoy, 2016).

This research area includes not only micro-level operational practices of one firm, but also includes the institutional and strategic context, in which these practices are embedded. The importance of the research is manifold. From a theoretical perspective, it enlarges on the new empirical literature on SPD in emerging economies to which quantitative contributions based on a case-study methodology are still rather weak. From a managerial perspective, it offers practical, evidence-based advice to operations managers, product development teams and senior executives who want to enhance their firms' capabilities for product development and to align them with sustainability imperatives. From a policy perspective, the results have implications for industrial policy makers in Iraq and similar developing economies who are involved in developing strategies for the modernization and greening of manufacturing industries at the national level.

Research Objectives

1. The research purpose is mainly to solve its problem, but also has other purposes that can be summarised as follows:
2. To clarify contemporary and modern technologies that companies can adopt to build their products.
3. In order to study what are the requirements of the optimal application of each of the technologies, which will contribute to determine the efficiency of the production process and its processes.
4. Understanding the current administrative reality of developing business products and its prospects in the future.

LITERATURE REVIEW

Product Development as a Strategic Imperative

The theoretical underpinnings of product development as an organizational activity are well entrenched in the literatures on operations management, strategic management, and innovation management. Researchers have long been suggesting that the ability of a company to develop new products and repeatedly enhance the old

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

ones has been one of the most effective sources of long-term competitive advantage, especially in industries where technological change and shorter product-life cycles are the norm (Dąbrowski, 2023; Morioka et al., 2017). Product development is not a discrete, time bounded organisational event; instead, it is an iterative, multi-functional process that involves marketing, finance, engineering, operations, and supply chain management in a concerted effort to turn latent customer needs into commercially viable product offerings (Borgianni et al., 2018; Ellram et al., 2007). The theoretical placement of product development in the context of strategic management has changed significantly over the last 20 years, with the resource-based view, dynamic capabilities theory, and open innovation paradigms each adding unique knowledge about why some firms are better at product development than others.

New product introduction strategies have been classified on the basis of several dimensions in the literature. The market-driven approach assumes that the development of products should be fundamentally responsive to expressed customer demands where the firm uses its marketing intelligence capabilities to identify unmet customer needs and translates this into product specification that will exceed customer expectations (Dąbrowski, 2023). By contrast, the technology-push strategy assumes that product development is technology driven, driven mainly by the technological endowments and innovation capabilities of the firm, with the market adoption of the product coming later due to the superior functionality of the product developed. More nuanced perspectives emphasise the integration model of cross-functionality, where successful product development requires persistent, structured coordination of marketing, operations, engineering, and finance teams, without giving any functional domain priority (Borgianni et al., 2018). The general consensus of evidence today is that hybrid approaches that blend insights from the market with technological innovation and collaboration across the organization's functions provide the best consistently superior product development outcomes.

Green Processing Technique.

Green manufacturing - sometimes also known as environmentally conscious manufacturing or sustainable manufacturing - is the application of environmental design principles to the entire product lifecycle, including the sourcing of raw materials, manufacturing processes, product disposal and material recovery processes. The intellectual underlying of green manufacturing is in the broader sustainability science literature and operationalized by concepts such as design for environment, life cycle assessment, industrial ecology, and cleaner production (Sangwan & Mittal, 2015). Green manufacturing is fundamentally aimed at reducing systematically, and eventually, negative environmental externality of industrial production, including energy use, greenhouse gases, water use, waste generation, and hazardous material use (Saunila et al., 2018).

Vol: 17 No: 2 Year: 2025 ISSN: 2146-0744 (Online) (pp.45-69) Doi: 10.34109/ijebeg.2025170203

Recent studies emphasize that the implementation of green manufacturing strategies does not just bring about environmental benefits and provide substantial economic value, such as cost reduction due to material and energy efficiency, increased brand equity among the environmentally conscious consumer groups, and better regulatory compliance positioning (Parmentola & Tutore, 2023). However, the empirical literature also reports significant heterogeneity in the depth and breadth of green manufacturing adoption with respect to firms and industries, and especially in the developing economies, in which institutional pressures for environmental compliance may be weaker and where the costs of green transition may be viewed by firms as prohibitive relative to the available financial and technological resources (Tseng et al., 2019). This non-uniformity in adoption highlights the need to empirically measure the level of implementation as opposed to presuming that there is a homogenous process of green manufacturing diffusion.

Total Quality Management in Product Development

Total Quality Management (TQM), as it applies to the context of product development includes the integrated use of quality planning, quality assurance and quality improvement principles during the entire product development lifecycle. Among the most rigorously theorized and practical applications of the TQM paradigm is Quality Function Deployment (QFD), a systematic methodology first developed in Japan in the late 1960s by Dr. Shigeru Mizuno and Dr. Yoji Akao that offers a disciplined format for the translation of the 'voice of the customer' into specific technical design requirements, manufacturing process parameters and production control specifications (Akao & Mazur, 1990). QFD operationalises the TQM imperative of customer centricity by ensuring that customer preferences are not merely taken note of at the outset of a product development project but are systematically embedded into every downstream design and production decision by means of a cascading series of 'Houses of Quality' matrices.

The empirical literature on TQM in manufacturing shows that firms with deeply institutionalize quality management cultures routinely outperform their peers in multiple dimensions of product development performance, such as time-to-market, product reliability, customer satisfaction, and return on product development investment (Aquilani et al., 2017). Critically, TQM scholars have also highlighted the need to recognise that quality management must be conceptualised not only as a collection of technical tools and procedures but as a cultural orientation of the organisation where quality responsibility is authentically distributed across all levels of the workforce, suppliers are conceptualised as strategic partners in quality creation, and non-negotiable continuous improvement is embedded as an organisational norm (Ismail Salaheldin, 2009).

Value Engineering Methodology

Value engineering (VE), first developed by Lawrence D. Miles at General Electric in the late 1940s, has become a mature and widely used technique for the purpose of systematically analysing the functional requirements of products and processes with the goal of providing equal or better functionality at lower cost. In modern time, VE has been applied in a wide variety of industries and application domains, including construction, infrastructure development, defence procurement, and consumer electronics, and the importance of VE for manufacturing in developing economies has become increasingly acknowledged (Emami & Emami, 2020). The basic analytic logic of VE is based on the concept of 'value', as defined as the ratio of function to cost, and the basic insight that costs can often be reduced significantly without compromising - and sometimes actually improving - product functionality through creative redesign, material substitution, process simplification and supply-base rationalisation (Venkataraman & Pinto, 2023).

VE is increasingly being recognised in the literature not only as a cost reduction tool, but as a vehicle for systematic innovation and competitive differentiation. By deploying VE within a framework of competitor benchmarking and modular product design, firms are able to simultaneously reduce production costs and improve the modularity, maintainability and customisability of their products - all of which are becoming increasingly important in markets that are based on mass customisation and rapidly changing consumer preferences (Emami & Emami, 2020). Notwithstanding its demonstrated efficacy, successful implementation of VE requires a unique blend of organizational capabilities such as access to value analysis expertise, a deep understanding of materials and production technologies, good supplier relationships, and a management culture geared toward systematic cost function rationalization, rather than incremental, function by function cost reduction. 2.5 Computerized Production and Digital Manufacturing (Cusumano, 1992). The integration of computerized technology into manufacturing (which includes Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and more recently Industry 4.0 technologies such as cyber-physical systems, the Internet of Things, and digital twins) has fundamentally changed the possibilities open to product development teams (Borangiu, 2020; Liu & Xu, 2017). CAD systems allow designers to design, edit, and evaluate complex three-dimensional models of products with a speed and precision that was completely impossible with manual drafting, dramatically shortening product development cycle times and cutting the costs of design iteration (Vilochani et al., 2024b). The CAM systems can apply these advantages into the production realm, providing the opportunity to automatically program the machining centers, robotic assembly systems, and additive manufacturing platforms and improve the accuracy of production, minimize the number of errors, and speed up the reconfigurability of production systems when changing the specifications of products. The latest empirical studies emphasize the disruptive potential of robust digitalization of manufacturing

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

capacities in developing economy settings, where the strategic implementation of computer-based production systems can help firms scale above the technological constraints of the traditional manufacturing infrastructure and reach the levels of product quality and operational efficiency that are relevant to international best practice (Kamble et al., 2020). However, the realisation of these potential benefits is dependent on the availability of adequately trained human capital, the presence of robust digital infrastructure and the true commitment of the senior management to invest in and culturally embed digital manufacturing capabilities. 2.6 Sustainable Product Development: Theory and Literature Gap Sustainable product development (SPD) has become an important research area at the convergence of product innovation, environmental management and corporate sustainability strategy (Vilochani et al., 2024b). A comprehensive systematic literature review by (Vilochani et al., 2024b) identified 61 different SPD management practises, which were brought down to 11 thematic categories, offering the most systematic and complete taxonomy of SPD practises currently available in the scholarly literature. Despite this conceptual richness, the literature on SPD in manufacturing firms in developing economies is quite empirical thin, with quantitative studies of the antecedents and mechanisms of sustainable product design and development outcomes being especially lacking (Vilochani et al., 2024a). Extant SPD research has identified corporate sustainability strategy and policy as a fundamental institutional antecedent of sustainable product outcomes arguing that sustainability commitments that are embedded in formal corporate strategy create the governance structures, resource allocations, and cultural norms required for sustainability to be operationalized at the product level (Parmentola & Tutore, 2023). Sustainable product requirements (SPR) is the process by which strategic sustainability promises are to be converted into tangible product-specification characteristics, which include environmental performance goals, material selection guidelines, recyclability goals, and social impact evaluations. The integration of sustainability in the product development process (SIPD) is the greatest and most operationally challenging dimension of SPD, involving not only embedding consideration for sustainability in a product specification, but integrating sustainability consideration into all the iteration of the development process itself. The available literature has however not subjected the relative influence of these three constructs upon sustainable product design and development outcomes, to rigorous empirical testing within an emerging economy electrical manufacture context-a gap that the present study is specifically designed to address.

RESEARCH METHODOLOGY

Research Design and Philosophical Orientation

This research work has adopted two-phase sequential mixed methods research design which is both qualitative and quantitative in nature in order to achieve a comprehensive understanding of the research problem. The approach adopted for this

Vol: 17 No: 2 Year: 2025 ISSN: 2146-0744 (Online) (pp.45-69) Doi: 10.34109/ijebeg.2025170203

study-which is mixed-methods-is epistemologically rooted in a pragmatist philosophical stance, which posits that the value of a particular research method is measured by its ability to produce knowledge that is useful, and actionable for practitioners, and that the combination of different methodological lenses offers a richer and more complex understanding of complex organisational phenomena than single methods can. The two-phase design is organized in Figure 1 in a way that the results of the first case-study-based phase will inform and contextualize the second survey-based quantitative phase in order to allow a coherent, integrated interpretation of the overall research findings.

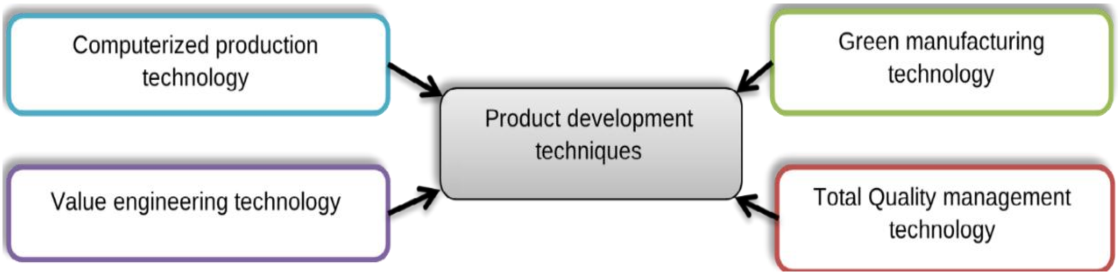

Figure 1: Product Development Techniques

Research Setting

The General Company for Electrical Industries, Diyala (GCEI-Diyala) was chosen as the research setting on the basis of some criteria, both theoretically and practically motivated, for the period between May 1, 2023 and May 1, 2024. As one of the main Iraqi industrial formations under the Iraqi Ministry of Industry and Minerals, GCEI-Diyala is institutionally representative of the national public manufacturing sector, thereby affording the findings potential generalizability to comparable state-owned industrial enterprises (within the Iraqi context). The broad and deep product portfolio of the company - electric scales, irons, spark plugs, ceiling fans, electrical transformers, argon gas, and longitudinal cables among many others, with operations extending from 1974 to the present - creates an empirically rich and methodologically tractable context for the study of multiple product development techniques. The lack of empirical research on product development practises and sustainability integration in the Iraqi industrial sector makes the company a particularly interesting object of study from the standpoint of creating knowledge.

Phase One - Case Study Methodology

The first phase of the study followed a single-case study approach which is suitable for the in-depth analysis of a complex and context-dependent phenomenon in its genuine context (Yin, 2018). Data collection during this phase was carried out using a structured checklist instrument, created by the research team based on an extensive synthesis of the theoretical and empirical literature on production development techniques and found to be content relevant and context appropriate by a panel of subject matter experts in production and operations management. The checklist was structured in four thematic sections referring to the four product development techniques investigated with each section comprising ten binary-response items evaluating the existence or not existence of particular implementation practises in the company. The instrument was administered through structured interview with the managerial staff of GCEI - Diyala.

A purposive sampling strategy was employed for the selection of research participants in the first phase, targeting managerial staff with direct operational responsibility for product development, manufacturing, and quality management functions. The final sample comprised 57 managers, including the general manager and deputies, department heads and their assistants, and branch heads and assistants. This purposive approach ensures that the data are drawn from individuals with both the positional authority and the operational knowledge required to accurately assess the implementation status of product development techniques within the firm.

Phase Two: Quantitative Survey and PLS-SEM Analysis

The second phase adopted a quantitative survey methodology with data obtained from 213 respondents that was collected through a structured self-administered questionnaire developed based on existing validated scales from the SPD literature (Vilochani et al., 2024a, 2024b). The questionnaire measured four latent constructs: Corporate Sustainability Strategy and Policy (CSSP, 5 items), Sustainable Product Requirements (SPR, 7 items), Sustainability Integration into Product Development (SIPD, 8 items) and Sustainable Product Design and Development (SPDD, 8 item). All measures were on a five-point Likert scale with response categories anchored at 'Not Applied' (1), 'Ad-hoc' (2), 'Formalised' (3), 'Measured' (4), and 'Improved' (5) to allow the evaluation of the level of implementation maturity in addition to binary adoption status. The quantitative data were processed with the help of Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS version 4 (Memon et al., 2021). PLS-SEM was chosen over covariance-based SEM (CB-SEM) based on suitability for exploratory research in situations where the theoretical model is not yet fully established, its robustness to non-normal data distributions and its ability to estimate complex structural models with relatively modest sample sizes. The analytical sequence was conducted following established best practise as it pertains to the methods of PLS-SEM, which includes initial analysis of the measurement model (examination of indicator loading, internal consistency reliability, convergent validity and discriminant validity) before assessment of the structural model (path coefficients, t-statistics and p-values) (Putra, 2022).

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

RESULTS AND DISCUSSION

Phase One: Implementation Levels and Gaps in Product Development Techniques

The results obtained from the checklist given to the 57 managerial participants in GCEI-Diyala show that there is a large heterogeneity in the level of implementation of the four product development techniques considered. As summarised in Table 1, the green manufacturing technique has the highest overall level of implementation (80%), followed by total quality management (70%), computerised production (60%) and value engineering (50%). Correspondingly, the implementation gaps, which are the proportions of the best practise criteria that are not currently being addressed by the company, are also 20%, 30%, 40%, and 50% respectively. These results have yielded very strong empirical evidence for the nullification of the study's second hypothesis that suggested that all four product development techniques receive equal organisational support; the data clearly shows that the company prioritises these product development techniques to very different extent.

Table 1: Checklists of Product Development Techniques in General Company for Electrical Industries (N=57).

Percentage of Actual Application for Green Manufacturing Technique		**80%**
Total Quality Technique		**Checkout**
11	The company cares about the desires of current and potential customers.	√
12	The company has a database of industrial and consumer customers.	√
13	The company meets the requests of its regular customers regarding changing some of the physical properties of the product.	√
14	The company adopts the principle that quality is the responsibility of everyone within the company.	×
15	The company gives production managers in its factories the authority to stop the production line in the event of a deviation from the required specifications.	×
16	The company subjects all manufacturing processes and treatments to review.	√
17	The company can modify the production path when defects are discovered in the treatments and manufacturing process.	√
18	The company views suppliers as strategic partners of the company.	×
19	The company maintains relationships with reputable and well-known suppliers in the industry in which it operates.	√
20	The company continuously evaluates its products from the time of receiving materials from suppliers until the goods are delivered to customers.	√
Percentage of Actual Application for Total Quality Technique		70%
Value Engineering Technique		Checkout
21	The company emphasizes identifying the aspects related to the value that the customer is looking for.	√
22	The company builds the added value of its products in the initial design stage.	√
23	The company is able to provide skilled operators in its production processes.	×
24	The company has unique resources that allow adding value to its products.	×
25	The company evaluates competitors' products to know the value they add to customers.	√

Vol: 17 No: 2 Year: 2025 ISSN: 2146-0744 (Online) (pp.45-69) Doi: 10.34109/ijebeg.2025170203

26	The company uses the balanced scorecard to identify critical aspects in adding value	√
27	The company emphasizes the durability of its products because it plays a major role in keeping the product in use for the longest possible period.	√
28	The company owns factories that produce its primary resources used in manufacturing.	×
29	The company is keen to have product designs that allow its parts to be replaced with other types when necessary.	×
30	The company balances between adding value and reducing production costs.	×
Percentage of Actual Application for Value Engineering Technique		50%

Table 1: Checklists of Product Development Techniques in General Company for Electrical Industries (N=57). (cont…)

Computerized Production Technique		Checkout
31	The company directs all its managers to possess computer skills.	×
32	The company has an electronic data exchange system with suppliers.	×
33	The company uses cameras installed within production processes for monitoring purposes.	√
34	The company designs its products using the latest scientific applications in the field of computers.	×
35	The company subjects all operators and production managers to training courses in the field of using computers during manufacturing.	√
36	The company is trying to obtain the advantage of zero errors by relying on robots and computers in manufacturing.	√
37	The company believes in the idea of computerization and seeks to apply it in all areas of work within production.	√
38	The company can change the specifications of its products during manufacturing by reprogramming the computers and controlling production.	√
39	The company uses computers for the purpose of controlling production costs and identifying areas of excessive and unnecessary spending.	√
40	The company relies on the computer to control inventory levels within the production process.	×
Percentage of Actual Application for Computerized Production Technique		60%

The research findings reveal that the General Company for Electrical Industries applies product development techniques at differing levels. These results allow for the identification of specific application rates, which in turn make it possible to determine the extent of application gaps experienced by the company. This analysis is Moreover, Figure (2) indicates that the General Company for Electrical Industries has not addressed the imbalance in its focus on product development techniques. Each of the four techniques has been implemented to differing extents and holds varying degrees of relative importance, as detailed in Table 2.

Table 2: Relative Importance and Sequences for Product Development Techniques in General Company for Electrical Industries.

Product Development Techniques	Actual Applications	Gaps	Relative Importance	Sequences
Green Manufacturing Technique	80%	20%	31%	1

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

Total Quality Technique	70%	30%	27%	2
Value Engineering Technique	50%	50%	19%	4
Computerized Production Technique	60%	40%	23%	3

From a lack of emphasis on the principles of sustainability to decision-making being directed at profit motives rather than environmental responsibility, ethical considerations are seemingly buried by regulatory compliance.

Techniques of Total Quality

A 30% gap is recognized in this area, corresponding to a 70% rate of application.

Computerized Production Techniques

The firm has an implementation gap of 40%, realizing an application rate of 60%. This shortfall is attributed to a lack of adequate digital competencies among the workforce as well as lingering reliance on planning processes in an analog format, coupled with traditional procurement methods. The application of computer systems for inventory control is also not comprehensive, None of the students were able to adequately describe design, and a computer-aided product design is utterly absent.

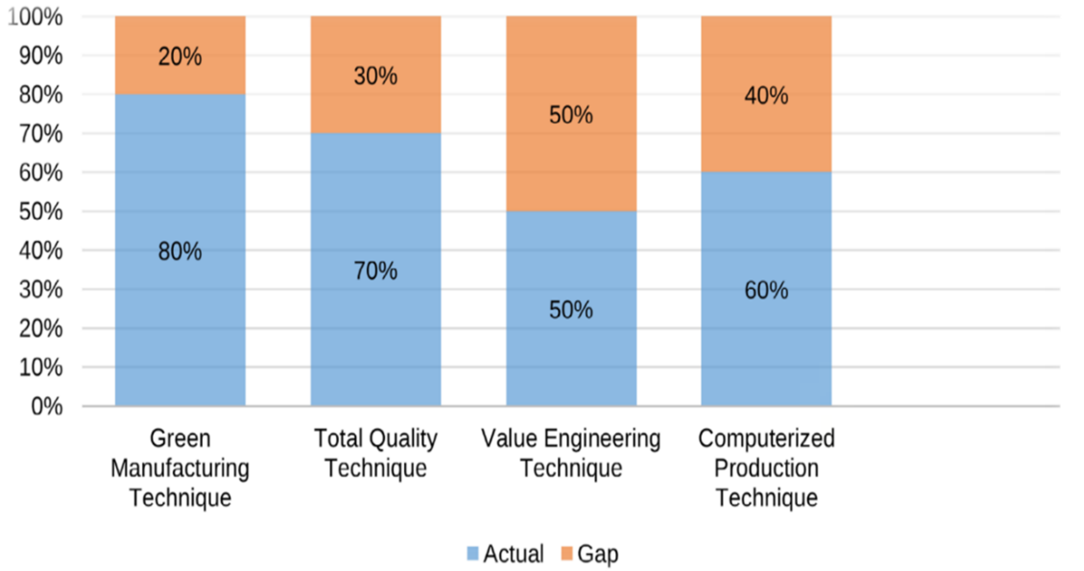

Figure 2: Actual Application and Gaps for Product Development Techniques from a Managers' View in General Company for Electrical Industries.

Value Engineering Techniques

The highest discrepancy of 50% is accompanied by an application rate of 50%, which can be fully explained through the reliance on underqualified personnel, reduced financial and technical possibilities, as well as obsolete production systems that are not flexible enough to adopt their dynamic environment as shown in Figure 2.

Development Techniques from a Managers' View in General Company for Electrical Industries. Difference in relative importance of each of product development techniques in company under study is a clear case that requires review by company's management order of importance and this is calculated in figure 3.

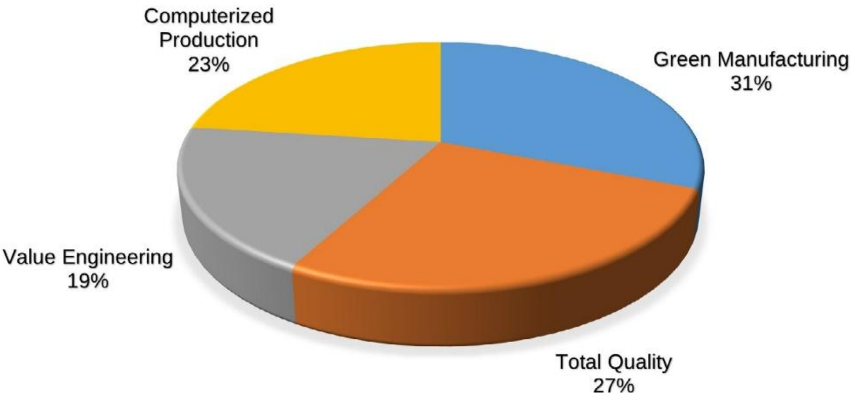

Figure 3: Development Techniques

Table 3: Implementation Levels and Gaps for Product Development Techniques at GCEI-Diyala (N = 57)

Product Development Technique	Actual Application (%)	Implementation Gap (%)	Relative Importance (%)	Priority Rank
Green Manufacturing	80%	20%	31%	1
Total Quality Management	70%	30%	27%	2
Computerized Production	60%	40%	23%	3
Value Engineering	50%	50%	19%	4

In Table 3, the diagnostic analysis of the green manufacturing technique shows that the company has made creditable progress in adopting environmentally responsible manufacturing practises, with the implementation rate of 80% placing it as the most consistently deployed technique as a company. The main advantages that have been found in the checklist are a systematic review of manufacturing processes, an opportunity to adjust the production pathways based on the detected defects, and the focus on product durability as one of the dimensions of sustainability. Despite this comparatively good performance, the 20-percent implementation gap indicates that there was still residual lack of performance in certain aspects of green manufacturing practice- most notably in the systematic updating of product specifications to reflect environmental performance requirements, formalizing customer environmental preferences into product design requirements and developing an organizational culture where environmental responsibility is truly embedded in all functions and levels of organization (Parmentola & Tutore, 2023). It seems that the present strategy of the company involved in green manufacturing is mostly compelled by the necessity to meet the regulatory demands and consider the cost-effectiveness issues, but not by the active and strategic approach to the environmental excellence. The total quality management analysis shows 70% implementation rate with a 30% implementation gap. The qualitative analysis of the checklist responses shows that the company has reasonable performance on customer-oriented dimensions of TQM (including maintaining database of customers, responding to customer requests for customization, and continuing product evaluation throughout the supply chain), but more serious weaknesses on organisational culture dimensions (including internalisation of the principle that quality is the collective responsibility of all people in the organisation and empowerment of production managers to stop production lines in the presence of specification deviations in the production line). The insufficient implementation of these latter practises is a symptom of a wider organisational problem: the institutionalisation of TQM means not only the introduction of technical means but a fundamental change in the culture where quality orientation becomes a part of every level of the organisational hierarchy (Akao & Mazur, 1990; Aquilani et al., 2017). The finding that the company does not already treat suppliers as quality partners of strategic importance, which is the basis of mature TQM practise, further indicates the disparity between current practise and best-practise benchmarks. The computerised production technique shows 60% implementation rate and its corresponding 40% implementation gap - a finding with great strategic implications because of the important role of digital manufacturing capabilities in the area of enabling precision design, flexible production and real-time quality control in the contemporary manufacturing environment (Liu & Xu, 2017). The checklist analysis shows that the company has taken measurable steps to implement production monitoring cameras, offer basic computer literacy training to production staff, develop the dream of zero-defect production through automation, and make use of computer-based cost control systems. However, substantial deficiencies are found in the areas of computer-aided product design (the company is not yet using the latest applications of science to serve as a basis for design), electronic data exchange with suppliers, computer-based inventory management, and the direction of all managerial personnel to develop adequate computer skills. These gaps suggest that the digital manufacturing transformation in the firm is still in an early, partial phase with considerable infrastructure, competency and cultural investments needed to achieve the full potential of computerised production (Bocken & Short, 2020; Kamble et al., 2020). The value engineering technique shows the greatest implementation gap, with only 50 percent of best-practise criteria currently achieved-a finding that indicates huge underutilization of one of the best tools for optimising cost value available to manufacturing management (Emami & Emami, 2020). While the company does well on the dimensions of customer value analysis, value-oriented product design, competitor benchmarking, and the use of balanced scorecard frameworks for value identification, it does significantly worse on the dimensions of access to skilled value

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

analysis practitioners, the possession of unique value-creating resources, in-house production of critical manufacturing inputs, modular product design to allow interchangeability of parts, and the systematic balancing of the value addition and cost reduction objectives.

These deficiencies are consistent with the broader challenges of VE implementation in state-owned manufacturing enterprises in developing economies, in which access to specialized VE expertise is limited, capital constraints mean that funding is limited to investment in value-enhancing production capabilities, and organizational inertia can inhibit the adoption of the creative, questioning orientation that VE requires (Luthra & Mangla, 2018; Venkataraman & Pinto, 2023).

Phase Two: Measurement Model Assessment

Prior to the testing of the structural model relationships, a strict evaluation of the measurement model was performed following established guidelines of PLS-SEM best practise (Putra, 2022). The first run of the PLS algorithm revealed that there were some measurement items with low or negative factor loading that were systematically removed from the model in order to better align latent constructs with their observed indicators. The refined measurement model retained a total of 17 items distributed across the four constructs, i.e., CSSP (4 items), SIPD (6 items), SPDD (4 items) and SPR (4 items) with all the retained items displaying factor loadings within theoretically meaningful ranges.

For the Corporate Sustainability Strategy and Policy (CSSP) construct, the refined factor loadings ranged from 0.723 to 0.846, which are acceptable to strong item-construct associations. The Sustainable Product Requirements (SPR) construct showed factor loading values between 0.659 and 0.791 indicating moderate to good indicator reliability. The Sustainability Integration into Product Development (SIPD) construct showed loadings ranging from 0.594 to 0.804, which is moderate overall level of item-construct correspondence. The Sustainable Product Design and Development (SPDD) construct showed the greatest range of the factor loading (0.771 to 0.792), which indicated a high level of consistency of the measurement of this outcome construct.

Table 4: Reliability and Convergent Validity of Measurement Model Constructs

Construct	Cronbach's Alpha	rho_A	rho_C	AVE
CSSP	0.830	0.854	0.886	0.662
SIPD	0.809	0.826	0.862	0.512
SPDD	0.807	0.811	0.873	0.632
SPR	0.742	0.777	0.831	0.553

As presented in Table 4, the four constructs all provide Cronbach's alpha values higher than the widely used threshold of 0.70 and range from 0.742 (SPR) to 0.830 (CSSP) which assures acceptable levels of internal consistency reliability across all scales (Putra, 2022). Both alternative composite reliability indices - rhoA and rhoC - show a similarly high level of reliability as all are above the 0.70 threshold with rhoA values ranging from 0.777 to 0.854 and rhoC values between 0.831 and 0.886, further supporting the reliability of all construct measurements. The average variance extracted (AVE) values for all constructs are well above the 0.50 threshold that has been recommended for establishing convergent validity, ranging from 0.512 (SIPD) to 0.662 (CSSP), suggesting that in each case the latent construct explained more variance in its indicator items than that due to measurement error (Fornell & Larcker, 1981). These results collectively confirm that the reliability and convergent validity of the measurement model is adequate.

Discriminant validity was evaluated using the Heterotrait-Monotrait (HTMT) ratio criterion, which is known to be a more sensitive test of discriminant validity than the traditional Fornell and Larcker criterion in PLS-SEM settings as shown in Figure 4. (Henseler et al., 2015).

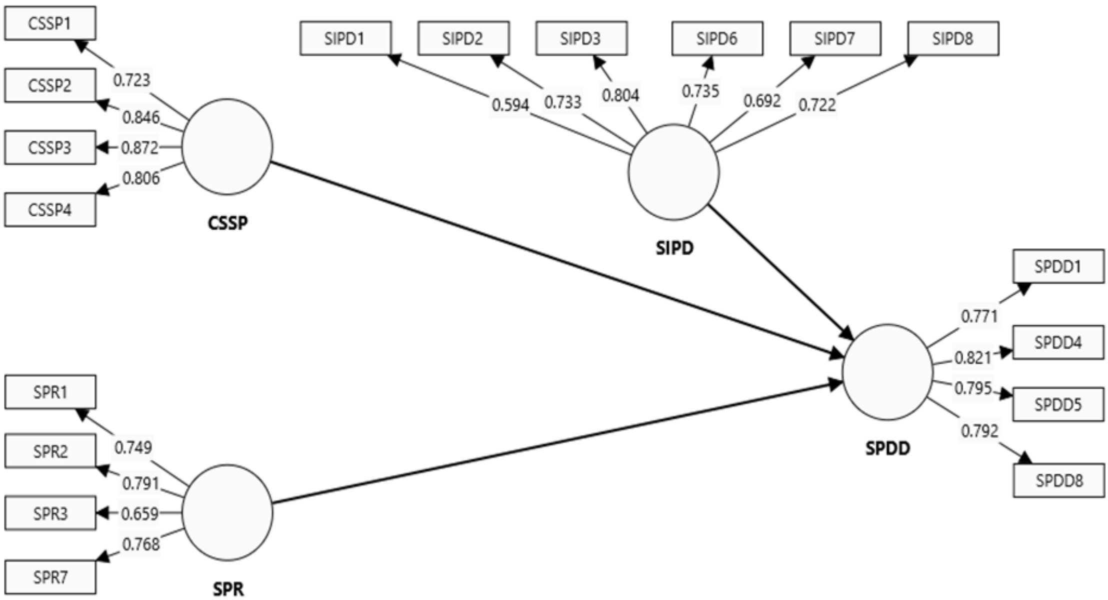

Figure 4: Measurement Model Input Diagram
Note: CSSP: Corporate Sustainability Strategy and Policy, SPR: Sustainable Product Requirements, SIPD: Sustainability Integration into Product Development, SPDD: Sustainable Product Design and Development

As presented in Table 5, all the inter-construct HTMT ratios are below the conservative threshold 0.85 and range from 0.096 (SIPD-SPDD) to 0.762 (SIPD-SPR) that shows strong evidence of adequate discriminant validity among all the four constructs. The lack of HTMT values approaching or exceeding the threshold of 0.90

supports the empirical discriminative validity of the constructs and that the inter-construct correlations reflect non-measurement redundancy.

Table 5: Discriminant Validity Assessment: HTMT Ratios

Construct	CSSP	SIPD	SPDD	SPR
CSSP	---			
SIPD	0.708	---		
SPDD	0.692	0.096	---	
SPR	0.491	0.762	0.749	**---**

Multicollinearity between items of the predictor was analyzed using Variance Inflation Factor (VIF) diagnostics, with VIF values for all items being well below the threshold 5 often used for problematic multicollinearity as illustrated in Table 6 (range: 1.268 to 2.139), which confirms that there is no problematic multicollinearity in the measurement model.

Table 6: VIF Results for the Selected Items.

Items	VIF
CSSP1	1.537
CSSP2	1.886
CSSP3	2.139
CSSP4	1.830
SIPD1	1.327
SIPD2	1.729
SIPD3	1.880
SIPD6	1.618
SIPD7	1.874
SIPD8	1.973
SPDD1	1.814
SPDD4	1.801
SPDD5	1.732
SPDD8	1.869
SPR1	1.496
SPR2	1.889
SPR3	1.624
SPR7	1.268

Structural Model Analysis and Hypothesis Testing

With the measurement model determined to be psychometrically sound, the structural model was tested to explore the hypothesised causal relationships between the four constructs. The results of the PLS-SEM structural model analysis including the path coefficients, t-statistics and p-values, are shown in Table 7. The bootstrap procedure was used (5,000 subsamples) to obtain the t-statistics and accompanying p-values for all the path coefficients, following the standard PLS-SEM analytical protocols (Memon et al., 2021).

Table 7: Structural Model Analysis: Path Coefficients and Significance Testin g

Hypothesized Path	Original Sample (β)	Sample Mean	Std. Deviation	t-Statistic	p-Value	Decision
CSSP → SPDD	-0.072	-0.074	0.040	1.782	0.075	Not Supported
SIPD → SPDD	0.806	0.802	0.038	21.274	0.000	Supported
SPR → SPDD	0.091	0.093	0.035	2.633	0.008	Supported

In Table 7, the results of the structural models indicate a very differentiated pattern of influence between the three predictor constructs. The most striking and theoretical significant finding is the dominant positive influence of Sustainability Integration into Product Development (SIPD) on Sustainable Product Design and Development (SPDD), with a path coefficient of $b = 0.806$, $t = 21.274$, $p < 0.001$. The significance and statistics of the structural model is also shown in the Figure 5.

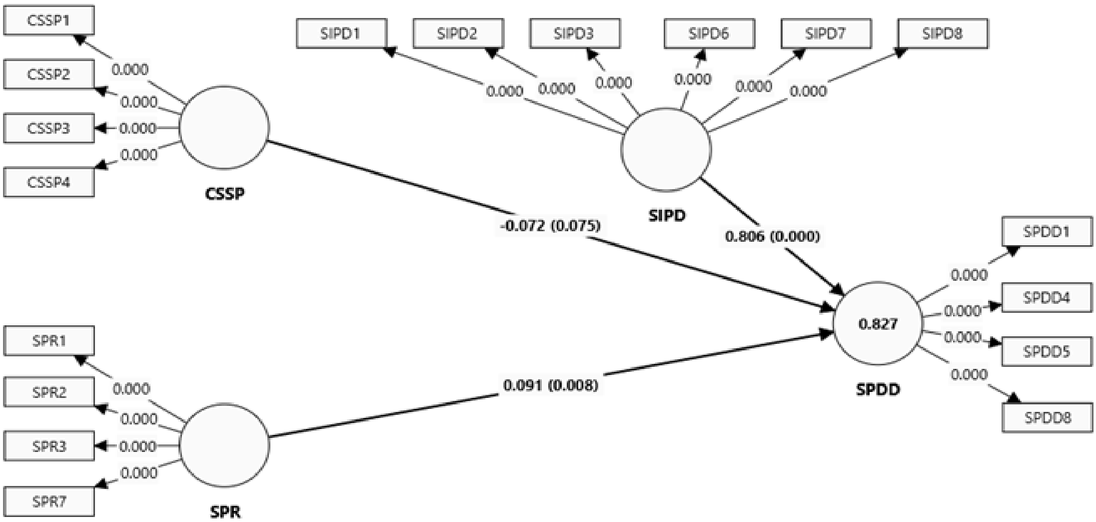

Figure 5: Significance of Structural Model

The magnitude of this effect--among the strongest reported in the SPD empirical literature--suggests that the extent to which sustainability considerations are operationally embedded within the firm's product development workflow is by far the most powerful determinant of the quality and comprehensiveness of the firm's sustainable product design and development outcomes. This finding is in line with the SPD process integration perspective, in theory, which states that sustainability shall not be considered as an end-state attribute to be checked at the product's launch but rather as a constant design principle that influences every decision made throughout the development process (Vilochani et al., 2024a, 2024b). The practical implication is equally clear: organizations that limit sustainability to strategic rhetoric without integrating it in the operational routines, decision frameworks and evaluation criteria

Vol: 17 **No:** 2 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**45-69) **Doi:** 10.34109/ijebeg.2025170203

of their product development teams will systematically underperform in comparison to organizations in which sustainability integration is a true, day-to-day operational discipline.

The Sustainable Product Requirements (SPR) construct has a statistically significant but much more modest positive impact on the SPDD ($b = 0.091$, $t = 2.633$, $p = 0.008$). While this effect meets conventional levels of statistical significance, the small size of the path coefficient indicates that the existence of clearly articulated, formalised sustainability requirements at the product specification level plays a relatively small role in the overall quality of sustainable product development outcomes, at least in the context of the present study. This finding may reflect the possibility that in organisations where the process of sustainability integration into product development is not yet mature, as appears to be the case in the present organisational setting, formalisation of sustainability requirements at the product specification level may represent a necessary but not sufficient condition for achieving superior sustainable product outcomes. Well-crafted sustainability requirements are important decision-support tools, but their contribution to SPDD outcomes depends on the overall organisational ability to integrate sustainability processes.

The relationship between Corporate Sustainability Strategy and Policy (CSSP) and SPDD produces a non-significant ($b = -0.072$, $t = 1.782$, $p = 0.075$) negative path coefficient, implying that in the current model, the formal articulation of the sustainability commitment at the corporate strategic level does not, in and of itself, translate into superior sustainable product design and development outcomes. This finding, though counterintuitive at first, is consistent with a growing stream of organisational sustainability research that makes a key distinction between symbolic and substantive sustainability commitments, arguing that many organisations engage in strategic sustainability positioning for legitimacy signalling purposes that have nothing to do with ensuring that these commitments are genuinely operationalized through concrete practises of product development (Parmentola & Tutore, 2023). In the context of Iraqi state-owned enterprises, however, the lack of consistency in the outcomes between CSSP and SPDD may also capture institutional dynamics peculiar to publicly owned industrial enterprises, where sustainability strategy formulation may be motivated in part by political imperatives and compliance with regulatory requirements rather than by a genuine commitment to incorporating sustainability throughout the product development process. Taken together, these findings suggest that for public industrial enterprises in emerging economies, the investments of operationalizing sustainability in the product development processes rather than elaboration of formal sustainability strategies documents is likely to improve the sustainable product outcomes in more substantial ways.

CONCLUSION, RECOMMENDATIONS, AND IMPLICATIONS

Conclusions

This study makes an original and substantive contribution to the existing empirical literature on product development techniques and sustainable product development in developing economy manufacturing contexts. Through a rigorously designed two-phase mixed-methods investigation, the research has established a number of important findings. First, the General Company for Electrical Industries, Diyala uses four techniques of product development (green manufacturing, TQM, value engineering and computerised production) at very different levels of maturity, with green manufacturing the most systematically applied technique (80%) and value engineering the most seriously underdeveloped (50%). These implementation gaps are substantive operational challenges that constrain firm's ability to deliver the best practice product development performance. Second, the PLS-SEM analysis shows that the sustainability integration into the product development process (SIPD) is the overwhelmingly dominant predictor of sustainable product design and development results ($b = 0.806$, $p < 0.001$), while sustainable product requirements (SPR) have a small but significant positive impact ($b = 0.091$, $p = 0.008$). Corporate sustainability strategy and policy (CSSP), by contrast, does not significantly predict SPDD results in the current model, which reveals the difference between strategic sustainability positioning and operational sustainability implementation.

Recommendations

Based on the empirical findings, the following recommendations are forwarded for management at GCEI-Diyala and similar industrial enterprises. First, the company should focus on closing the value engineering implementation gap with targeted investments in VE training, efforts to hire and/or develop dedicated value analysis expertise, and reassessing the product designs from the perspective of systematic function-cost analysis. Second, the firm should invest in deepening its digital manufacturing capabilities including computer-aided design platforms, electronic data exchange infrastructure with suppliers and computer-integrated inventory management systems to reduce the 40% computerised production implementation gap. Third, and most critically with regard to product sustainability outcomes, the company must go beyond formulation of sustainability strategies at the corporate-level and invest in the actual operationalization of sustainability integration in every stage of its product development process - embedding sustainability evaluation criteria into design reviews, product specification templates, and stage-gate decision processes. Finally, the organizational culture of total quality management should be deepened by empowering production personnel to have authority over quality and cultivating supplier relationships that are based on shared quality values rather than transactional optimization of prices.

Implications of the Theory and Practice

Theoretically, this study contributes to the empirical literature on SPD by conducting, for the first time, a quantitative analysis of the relative effects of CSSP, SPR, and SIPD on SPDD in an emerging economy electrical manufacturing context. The finding that SIPD dominates the prediction of SPDD outcomes, while CSSP exerts no significant independent influence, has important implications for theory development: it suggests the SPD literature should place greater analytical focus on the level of corporate-level sustainability strategy than on the micro-level practises through which sustainability is (or is not) embedded within product development workflows. From a practitioner standpoint, the study provides a practically applicable diagnostic framework, based on a validated checklist instrument, that industrial managers can use to systematically assess and benchmark the implementation status of important product development techniques and identify priority areas for organisational investment and capability development.

REFERENCES

Akao, Y., & Mazur, G. (1990). Quality function deployment: integrating customer requirements into product design. https://library.wur.nl/WebQuery/titel/1945283

Al-zaidi, W. A. H., & Dunay, A. (2016). The role of re-use in reducing industrial costs. A case study in the general company for electrical industries, in Diyala, Iraq. *HUNGARIAN AGRICULTURAL ENGINEERING*, (29), 36-39. DOI: 10.17676/HAE.2016.29.36

Aquilani, B., Silvestri, C., Ruggieri, A., & Gatti, C. (2017). A systematic literature review on total quality management critical success factors and the identification of new avenues of research. The TQM Journal, 29(1), 184-213. https://doi.org/10.1108/TQM-01-2016-0003

Bocken, N. M., & Short, S. W. (2020). Transforming business models: towards a sufficiency-based circular economy. In Handbook of the circular economy (pp. 250-265). Edward Elgar Publishing. https://doi.org/10.4337/9781788972727.00028

Borangiu, T., Morariu, O., Răileanu, S., Trentesaux, D., Leitão, P., & Barata, J. (2020). Digital transformation of manufacturing. Industry of the Future with Cyber-Physical Production Systems. SCIENCE AND TECHNOLOGY, 23(1), 3-37. https://romjist.ro/full-texts/paper635.pdf

Borgianni, Y., Cascini, G., & Rotini, F. (2018). Investigating the future of the fuzzy front end: towards a change of paradigm in the very early design phases? Journal of Engineering Design, 29(11), 644-664. https://doi.org/10.1080/09544828.2018.1520971

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. Design Studies, 47, 118-163. https://doi.org/10.1016/j.destud.2016.09.002

Cusumano, M. A. (1992). Shifting economies: From craft production to flexible systems and software factories. Research Policy, 21(5), 453-480. https://doi.org/10.1016/0048-7333(92)90005-O

Dąbrowski, D. (2023). New Product Development from the Perspective of Creating a Competitive Advantage. Marketing of Scientific and Research Organizations, 49(3), 141-158. https://doi.org/10.2478/minib-2023-0019

Ellram, L. M., Tate, W. L., & Carter, C. R. (2007). Product-process-supply chain: an integrative approach to three-dimensional concurrent engineering. International Journal of Physical Distribution & Logistics Management, 37(4), 305-330. https://doi.org/10.1108/09600030710752523

Emami, K., & Emami, T. (2020). Value engineering: Opportunities and challenges. Irrigation and drainage, 69(2), 307-313. https://doi.org/10.1002/ird.2410

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research. https://psycnet.apa.org/doi/10.2307/3151312

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Ismael, E. K. (2021). Analyzing indicators of the results of applying forecasting methods for production plans (A case study at the Diyala State Company for Electrical Industries). *Journal of Economics and Administrative Sciences*, *27*(127), 48-62. https://doi.org/10.33095/jeas.v27i127.2136

Ismail Salaheldin, S. (2009). Critical success factors for TQM implementation and their impact on performance of SMEs. International journal of productivity and performance management, 58(3), 215-237. https://doi.org/10.1108/17410400910938832

Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2020). Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications. International Journal of Production Economics, 219, 179-194. https://doi.org/10.1016/j.ijpe.2019.05.022

Liu, Y., & Xu, X. (2017). Industry 4.0 and cloud manufacturing: A comparative analysis. Journal of Manufacturing Science and Engineering, 139(3), 034701. https://doi.org/10.1115/1.4034667

Luthra, S., & Mangla, S. K. (2018). Evaluating challenges to Industry 4.0 initiatives for supply chain sustainability in emerging economies. Process Safety and Environmental Protection, 117, 168-179. https://doi.org/10.1016/j.psep.2018.04.018

Memon, M. A., Ramayah, T., Cheah, J. H., Ting, H., Chuah, F., & Cham, T. H. (2021). PLS-SEM statistical programs: a review. *Journal of Applied Structural Equation Modeling*, *5*(1), 1-14. DOI: 10.47263/JASEM.5(1)06

Morioka, S. N., Bolis, I., Evans, S., & Carvalho, M. M. (2017). Transforming sustainability challenges into competitive advantage: Multiple case studies kaleidoscope converging into sustainable business models. Journal of Cleaner Production, 167, 723-738. https://doi.org/10.1016/j.jclepro.2017.08.118

Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. International Journal of Information Management, 53, 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104

Parmentola, A., & Tutore, I. (2023). Environmental Sustainability and Firms' Competitive Advantage. In A. Parmentola & I. Tutore (Eds.), Industry 4.0 Technologies for Environmental Sustainability: Intended and Unintended Consequences (pp. 1-21). Springer International Publishing. https://doi.org/10.1007/978-3-031-40010-0_1

Putra, W. B. T. S. (2022). Problems, common beliefs and procedures on the use of partial least squares structural equation modeling in business research. *South Asian Journal of Social Studies and Economics*, *14*(1), 1-20. DOI: 10.9734/SAJSSE/2022/v14i130367

Sangwan, K. S., & Mittal, V. K. (2015). A bibliometric analysis of green manufacturing and similar frameworks. Management of Environmental Quality: An International Journal, 26(4), 566-587. https://doi.org/10.1108/MEQ-02-2014-0020

Saunila, M., Ukko, J., & Rantala, T. (2018). Sustainability as a driver of green innovation investment and exploitation. Journal of Cleaner Production, 179, 631-641. https://doi.org/10.1016/j.jclepro.2017.11.211

Tseng, M.-L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. Resources, Conservation and Recycling, 141, 145-162. https://doi.org/10.1016/j.resconrec.2018.10.009

Venkataraman, R. R., & Pinto, J. K. (2023). *Cost and value management in projects*. John Wiley & Sons. http://ndl.ethernet.edu.et/bitstream/123456789/23810/1/38.pdf

Vilochani, S., McAloone, T. C., & Pigosso, D. C. A. (2024a). Consolidation of management practices for Sustainable Product Development: A systematic literature review. Sustainable Production and Consumption, 45, 115-125. https://doi.org/10.1016/j.spc.2024.01.002

Vilochani, S., McAloone, T. C., & Pigosso, D. C. A. (2024b). Integration of sustainability into product development: insights from an industry survey. Proceedings of the Design Society, 4, 1517-1526. https://doi.org/10.1017/pds.2024.154

Yin, R. K. (2018). Case study research and applications (Vol. 6). Sage Thousand Oaks, CA. https://www.academia.edu/download/106905310/Artikel_Yustinus_Calvin%20Gai_Mali.pdf