International Journal of Scientific Research and Engineering Development-– Volume 6 Issue 4, July- Aug 2023

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

EFFECT OF PRODUCT DESIGN ON OPERATIONAL PERFORMANCE OF SUGAR FIRMS IN KENYA

Kunyoria Ogora Joseph[1], Albert Washington Ochung Tambo[2] and Victor Lusala Aliata[3]

1. Ph. D Student (Doctor of Philosophy in Operations Management),
Department of Management science,
School of Business and Economics,
Maseno University, Kenya
Email: kunyoriaj@gmail.com

2. Lecturer, Maseno University
Department of Management science,
School of Business and Economics,
Maseno University, Kenya
Email: vickylusala@gmail.com

3. Lecturer, Tom Mboya University
Faculty of Business & Economics,
Email: ochungalbert@gmail.com

----------**********----------

Abstract:

Product design is a key indicator of a successful operational performance realization and is gaining robust momentum among Sugar Firms as a survival and growth strategy. The Sugar Firms in Kenya contribute approximately 26% directly to the Gross Domestic Product (GDP) and an additional 25% indirectly through agro-based and associated industries linkages. However, they have experienced a significant decline of milled sugar production from about 635,700 tonnes in 2015 to 491,100 tonnes in 2018 according to Kenya National Bureau of Statistics in 2019. This decline was mainly attributed to the high cost of production stemming from inefficiencies across the value chain from inadequate research and extension leading to the design of production systems that are inefficient. Despite the vast contribution of the Sugar Firms to the economy, this problem of inefficient production system has not been solved and thus the Sugar Firms performance continues to spiral downward leading to the dissolution of some firms, downscaling of operations etc. Reviewed the studies also, established a weak relationship between product design and operational performance and warrants investigation. It is in this regard that this study purposes to establish the effect of product design on operational performance of Sugar Firms in Kenya. The research was guided by the resource-based view theory and transaction cost theory. A census survey was conducted targeting all 164 managers and assistant managers of Sugar Firms in Kenya. A pilot study was conducted of 14 participants constituting of managers and assistant managers of seven departments in Transmara Sugar Company to test for reliability using Cronbach's alpha, with a threshold of 0.70, indicating satisfactory instrument reliability. The Cronbach's Alpha reliability coefficient obtained in this study was 0.849. Primary data was collected using questionnaires. A multiple linear regression model was applied to establish the association among explanatory variables in this study. The results established that product design significantly affects operational performance (β =0.742, p=.000), hence, adoption of a one-standard deviation increase in product design yields a significant 0.742 unit increase in operational performance for Sugar Firms. Indicating a positive and significant association between the two variables. Hence, the study offers a products design model that can assist in enhancing operational performance.

Key words: Product Design and Operational Performance

----------**********----------

1. INTRODUCTION

The key aim of product design is to ensure that customer interests are addressed in the production transformation process at lower production costs (Sabir, 2020). For this to be achieved operations managers adopt concurrent engineering for robust transformation from the design stage to the actual production while addressing production time and cost with enhanced quality in mind. Indicators such as e-manufacturing, supply chain management, and quality function deployment proposed by Heizer *et al*., (2017); and digital technologies proposed by Sayar & Er, (2019), can be adopted by manufacturing companies for effective implementation of product design. And their adoption in the production line may result in lower production costs, enhanced quality, and reduced production time. Therefore globally most production lines have been decentralized resulting in manufacturing firms experiencing production breakdowns. It is eminent for manufacturing firms to review their production lines with the advent of the global markets focusing on their product designs. According to United Nations Industrial Development, (2020),theglobal manufacturing growth rate declined in two consequent years declining to a marginal rate of 2% in 2019. Decline in production can be due to high cost of production resulting to reduced revenues, throughput inefficiency, delays in delivery, lost market share and insufficient institutional capacity.

The term "product design" and the frameworks associated with it are not mutually understood (Homburg *et al*., 2015). This is because product design is customized from one product line guided by consumer perceptions and production dimensions (Bloch, 2011). Product design is a set of unified elements of consumer perceptions, organized as a multifaceted union entailing 3 aspects; functionality, symbolism and aesthetics (Bloch, 2011; Homburg *et al*., 2015; Luchs & Swan, 2011). According to Edwards, (2014) product design is the incorporation of technical and industrial designs with the intent of producing products. Reid & Sanders (2013) further provided a feasible definition of product designas the process of establishing the appearance, materials, dimensions, tolerances, and performance standards of a company. Bleda *et al*., (2021) and Roper, (2016) on the other hand defined product design as an interface between product development and innovation. Based on the robust definitions of product design, it can be defined as a link among the marketing (consumer ideas), finance (for facilitation), and research & innovation (for review) with an overhauled interface of operations management (for development and adoption) to develop or review a production system guided by its characteristic and dimensions. Jindal *et al*., (2016) classified product design into three dimensions: form, function, and ergonomics. The following indicators were adopted in this study to measure product design: e-manufacturing, supply chain management, and quality function deployment proposed by Heizer *et al*., (2017); and digital technologies proposed by (Sayar & Er, 2019).

Firms' production lines are vulnerable to lack of customer knowledge, poor communication between production teams, and wastes, resulting in inefficiency in production hence the need for the adoption of product design. Product design is the lead segment in the assessment of the product's life cycle because its implementation directly affects materials, quality, cost, processes, associated packaging and logistics, and ultimately the product supply chain (Heizer *et al*., 2017). Product design also defines product specifications, raw materials, and bought-out parts, and moderates the contracts with the customers (Chary, 2012). Besides, that product design is the cornerstone for the development of any business strategy(Schroeder *et al*., 2016). This research adopted the subsequent indicators in measuring product design: e-manufacturing proposed by Reid & Sanders, (2013) supply chain management and quality function deployment proposed by Heizer *et al*., (2017); and digital technologies proposed by Sayar & Er, (2019).

Previous similar studies endeavored to define the influence of product design in relation to a company's operational performance. Rincon-Guevara *et al*., (2020) while writing on product design and manufacturing system operations an

integrated approach for product customization in the USA focused on product upgradability and flexibility. Fernandes & Canciglieri, (2014) focused on sustainable product design by developing a conceptual model for method-integrated product development in Brazil geared toward feasibility. Ahmad *et al*., (2018) empirically explored the relationship among product design and process design on new product performance in the manufacturing industry in Malaysia, however, they focused on design of new products and processes. Bagshaw, (2017) while looking at the process and product design: production efficiency of manufacturing firms in Rivers State, Nigeria observed that both designs for process and design are significant and positively influence production efficiency. Roble & Wanjira, (2021) while looking at the effects of product design on performance of commercial banks in Garissa County, Kenya rated on a scale focused on unique products, reliability, and integration. As indicated all the previous studies did not consider e-manufacturing, quality function deployment, supply chain management, and digital technologies as measuring indicators of product design studies.

Previous studies adopted metrics that were limited and could not, therefore, yield valid results onthe regarding the impact of product design on operational performance. Similarly, an attempt by previous scholars to establish a metric of operational performance so us to determine the influence of product design applied weak measures of operational performance with a focus on the input and output wastes rather than the whole manufacturing system which is key in any manufacturing organization's transformation process. With the view of addressing this most studies (Everaert & Swenson, 2014; Kropivšek *et al*., 2021; Tornberg *et al*., 2002; Wedowati *et al*., 2020) adopted activity-based costing, however, it is criticized by Balakrishnan *et al*., (2015) who disputed that it is resource intensive and time-consuming making them unable to address the issue of short time delivery and limited utilization of resources in the product line guided by the product design. Despite the voluminous scholarly writings to evaluate the connection between product design and operational performance, justification of e-manufacturing proposed by Reid & Sanders, (2013) supply chain management and quality function deployment proposed by Heizer *et al*., (2017); and digital technologies proposed by Sayar & Er, (2019) which forms product design metrics are applied in establishing the influence of product design on operational, is however missing.

Operational performance has become the most current production term both by practitioners and academicians. Since there is no comprehensive definition of operational performance, most academics and practitioners are restricted to their affiliated disciplines. Operational performance is the strategic scope a company opts to adopt to gain a competitive edge (Chavez *et al*., 2015). Measurement of the manufacturing systems operation performance elevates manufacturing companies economically and sustainably. Hence the study adopted five standalone metrics: speed, quality, flexibility, product dependability, and cost to measure operational performance proposed by (Slack & Brandon-Jones, 2018).

The sugar sub-sector contributes about 26% to the GDP and an additional 25% to the agro-based and related industries according to the Sugar Sub-Sector Strategic Plan 2021-2025 established by (Kenya Association of Manufacturers, 2021). Agricultural production is the major economic subsector in Kenya with Sugar production being the key industry (KIPPRA, 2018). Kenya Association of Manufacturers, (2020)also established that sugar sub-sector in Kenya is key in the both country's agricultural sector and economy with the potential to contribute to regional development, employment creation, food security, and improved livelihoods for more than eight million Kenyans. However, Kenya National Bureau of Statistics, (2019) survey demonstrates that Kenya has experienced a significant decline in milled sugar production from about 635,700 tonnes in 2015 to 491,100 tonnes in 2018. Similar findings were registered in the sugar sub-sector report by Kenya Association of Manufacturers, (2020) production of sugar in Kenya has gradually declined, from 523,652 metric tones in 2010 to 440,935 metric tones in 2019. Kenya Association of Manufacturers,

(2020)Strategic Plan 2021-2025,this is due to many challenges facing the sugar sub-sector including: high cost of production, inefficiencies across the value chain, obsolete technology, inadequate research and extension, and policy limitations. As a result, sugar importation has been increasing rapidly for the periods under review (2014,2015,2016,2017and 2018) 192.1, 227.4, 334.1, 989.6, 284.2 tones respectively (Kenya National Bureau of Statistics, 2019). This is due to the increased cost of production as established by the (Kenya National Assembly Eleventh Parliament, 2015). Also, Miwani Sugar, Muhoroni and Mumias companies have been put under receivership with Ramisi and Soin closing their operations (Kenya Association of Manufacturers, 2020)

The sugar sub-sector contributes about 26% to the GDP and an additional 25% to the agro-based and related industries according to the Sugar Sub-Sector Strategic Plan 2021-2025 established by (Kenya Association of Manufacturers, 2021). Agricultural production is the major economic subsector in Kenya with Sugar production being the key industry (KIPPRA, 2018). Kenya Association of Manufacturers, (2020)also established that sugar sub-sector in Kenya is key in the both country's agricultural sector and economy with the potential to contribute to regional development, employment creation, food security, and improved livelihoods for more than eight million Kenyans. However, Kenya National Bureau of Statistics, (2019) survey demonstrates that Kenya has experienced a significant decline in milled sugar production from about 635,700 tonnes in 2015 to 491,100 tonnes in 2018. Similar findings were registered in the sugar sub-sector report by Kenya Association of Manufacturers, (2020) production of sugar in Kenya has gradually declined, from 523,652 metric tones in 2010 to 440,935 metric tones in 2019. Kenya Association of Manufacturers, (2020)Strategic Plan 2021-2025,this is due to many challenges facing the sugar sub-sector including: high cost of production, inefficiencies across the value chain, obsolete technology, inadequate research and extension, and policy limitations. As a result, sugar importation has been increasing rapidly for the periods under review (2014,2015,2016,2017and 2018) 192.1, 227.4, 334.1, 989.6, 284.2 tones respectively (Kenya National Bureau of Statistics, 2019). This is due to the increased cost of production as established by the (Kenya National Assembly Eleventh Parliament, 2015). Also, Miwani Sugar, Muhoroni and Mumias companies have been put under receivership with Ramisi and Soin closing their operations (Kenya Association of Manufacturers, 2020)

1.1 Research Objective

The following research objective was constituted in the study:

i. To investigatethe effect of product design on operational performance of Sugar Firms in Kenya.

1.2 Research Hypotheses

H_{o1}. Product design has no significant effect relationship with operational performance of Sugar Firms in Kenya.

2. LITERATURE REVIEW

2.1 Effect of Product Design on Operational Performance

In pursuit of the studies objective, ''to establish the effect of product design on operational performance of Kenyan sugar companies'', several previous research studies on product design were reviewed to facilitate the establishment of the research.

Roble & Wanjira, (2021) carried out a study on the effects of product design on the performance of commercial banks in Garissa County, Kenya. This research embraced census to collect data from 82 employees of 4 Commercial Banks in Garissa. The study adopted unique products, reliability, and integration as indicators to measure product design. The researchers revealed a definite substantial correlation between product design and operational performance signified by an adjusted R^2 value of 0.772(77.2%) expounded by the three independent indicators of product design that were under study. This study did not use any moderating variable to measure the extent to which product design can impact operational performance.The study was

based on the commercial banks in Garissa County and did not factor in other regions with more stabilized commercial in contrast to the growing county. Also, the study was focused on unique product, reliability, and integration as indicators to measure product design and did not address e-manufacturing, quality function deployment, supply chain management, and digital technologies which are key indicators that measure product design. The study focused on a confined geographical area which might limit the applicability of the study's findings to a broader context.

Kariuki, (2016) conducted a study on the production system design and operational performance of steel manufacturers in Kenya. The research was centered on 20 steel manufacturing firms in Kenya. The study population entailed departmental managers of maintenance, production, and plant/operations departments yielding a combined total of 60 respondents. The study acknowledged a substantial influence of production system design on the operational performance of an organization, evidenced by a correlation coefficient of 0.784.However, this study did not use any moderating variable to measure the extent to which product design can impact a firm's operational performance.

Bagshaw, (2017) while looking at the process and product design: production efficiency of manufacturing firms in Rivers State, Nigeria observed that product design and process design are considerable and positively affect the efficiency of production with a correlation coefficient of 0.824. The research was based on a sample of 28 production managers of manufacturing companies based Nigeria. The researcher focused on a confined geographical area which might limit the applicability of the study's findings to a broader context. The study did not define the appropriate survey design to adopt during data collection given that the researcher was studying the entire and small target population.

Ahmad *et al*., (2018)carried out a study on the impact of product design and process design on new product performance in manufacturing industry in Malaysia. The findings established a notable and positive correlation between product design and product process design in relation to new product performance. The study further revealedan outstanding relationship between product design and organizational performance ($r(80) = 0.570$, $p < 0.05$). The research adopted a questionnaire-basedmethod to gather views from 400 respondents and out of which only 80 responded representing 20% of the target population. This is a small response rate (20%) meaning that the study suffered 80% nonresponse biasness of hence commemorating to biased conclusions.

Kwaku & Fan, (2020) conducted a study on the effect of good product design and packaging on market value and the performance of agricultural products in the Ghanaian market. 250 agricultural product marketers, processors, and consumers from 25 countries were sampled using a survey. The study participants were selected using simple random sampling and purposive sampling techniques.The research recognized thatagricultural products' performance in the Ghanaian market was positively impacted by product design, with a correlation coefficient of 0.736. However, the study did not apply e-manufacturing, quality function deployment, supply chain management, and digital technologies which are key indicators that measure product design. The possibility of bias in sample selection exists when the purposive sampling technique is used.

Putri & Rofiq, (2020) conducted a study to establish the effect between product design and iconic product in attractiveness on cultural identity with buying decision (study on Batik Consumer Malang) in Egypt. With a target population of 166 consumers of Malangn bkit the research adopted an explanatory research design. The study established that the quality of batik with design product has a significant effect on consumer decision to buy it with a coefficient correlation of .882. Conversely, the research did not take into account e-manufacturing, quality function deployment, supply chain management, and digital technologies which are important metrics for evaluating product design.

A study was carried out by Coudounaris, (2018) on the Mediation of product design and moderating effects of reference groups in the context of country of origin effect of a luxury brand in Tartu, Estonia.

The study adopted product design as a moderator and antecedent factors as the independent variables with luxury brand as the dependent variable. The study conducted an online survey from a sample of 3848 respondents and recorded 275 responses out of the online survey. The findings revealed that antecedent factors and product experience are partially mediated by product design on the demand for luxury brand with *b*=0.72, t=16.29, p=0.0000, and adjusted R^2=00.521. However, the study adopted an online survey which is prone to non-response bias, as survey fraud is eminent when conducting online surveys. The respondent margin was very small compared to the sample population, hence may prevent the findings from being extrapolated.

The reviewed studies did not adopt a moderating variable to measure the extent to which product design can impact operational performance. Besides that, they were based on a small case study hence they may make the findings of the study not generalizable. Also, the review studies did not address e-manufacturing, quality function deployment, supply chain management, and digital technologies which are key indicators that measure product design. Finally, the reviewed studies did not take Sugar Subsector as a case study hence forming a basis for this study.

The outcomes of this research are aligned with the results of a prior investigation carried out by(Kariuki, 2016; Roble & Wanjira, 2021; Ahmad *et al.*, 2018; Bagshaw, 2017; Bagshaw, 2017)confirmed the existence of a positive correlation between product design and operational performance. However, the findings of previous studies had their own weakness which do not align with the findings of the current study. (Kariuki, 2016) the study demonstrated a week association of R square=0.767, p=0.002 as compared to the present research which demonstrated a more positive and significant connection between variables. (Ahmad *et al.*, 2018) the research adopted a questionnaire method to gather data from 400 respondents and out of which only 80 responded representing 20% of the target population.This is a small response rate (20%) meaning that the study suffered 80% nonresponse biasness of hence commemorating to biased conclusions, further, the study registered a weaker association (r(80) = 0.570, p < 0.05).Bagshaw, (2017) the research was based on a sample of 28 production managers of manufacturing firms in Nigeria. The research focused on a confined geographical area which might limit the applicability of the study's findings to a broader context. Further, Bagshaw, (2017) established a week association of (PV=0.000<0.05, t-cal=5.559>t-tab (0.05, 27)=2.05)as compared with the current study's result (β=0.742, p=0.000) which demonstrated a demonstrates a more significant and interpretable relationship between variables, supported by a strong effect size and a highly significant p-value.

3. RESEARCH METHODOLOGY

This study was guided by a correlational research design. Creswell, (2015) postulated that correlational research design as the use of statistical tests to establish the pattern or tendency between two (or more) variables or sets of data to vary consistently. The positivism research philosophy served as the study's guiding philosophy. This is because the positivism research philosophy is of the understanding that factual knowledge is attained via observation (the senses), as well as measurement is trustworthy (Saunders *et al.*, 2009). Verhaegh, (2020) the positivist model proclaims that real phenomena can be pragmatic empirically and substantiated by logical analysis. Positivism research philosophy expresses that reality is stable. Positivism applies hypothetico-deductive method to determine priori hypotheses quantitatively and functional associations may be consequential among causal and explanatory factors (independent variables) and outcomes (dependent variables) (Jacobs & Chase, 2008).

The research was conducted within the context of Sugar Milling Companies in Kenya, encompassing: Muhoroni Sugar Company, Chemelil Sugar Company, Mumias Sugar Company, Nzoia Sugar Company, Sony Sugar Company, Miwani Sugar Company, Ramisi Sugar, West Kenya Sugar Company, Soin Sugar Company, Kibos Sugar & Allied Industries Limited, Butali Sugar Mill limited, Transmara Sugar Company, Sukari Sugar Company,

Kwale International Sugar Company, Ole Pito Sugar Company, and Busia Sugar Company. The study was based on western Kenya Sugar Companies. Western Kenya Sugar Firms was selected because according to Kenya Association of Manufacturers, (2020) it has 75% of Sugar Firms.

The sample population was 164 respondents which constituted all 84 departmental managers and 84 assistant managers of the Sugar Firms in Kenya. The choice for managers and assistant managers was based on their direct engagement with systems and active participation in implementing functional practices make them well-suited sources for capturing accurate and comprehensive data, aligning with the study's objective of exploring the association between manufacturing activities and operational performance. The study used a census survey as a guide for data collection from 164 sugar firms' employees in Kenya. A census survey was suitable for this study because it is applied when all the units of observation in a study are considered and they are of a small sample size (Kothari, 2004).

Primary data was collected using questionnaires from employees of Sugar firms in Western Kenya (departmental managers and assistant managers).

The rates of response returns of employees from various Sugar Firms in Kenya are established in Table 1. Among the companies surveyed, Chemelil Sugar Company had a response return rate of 80.0%, Nzoia Sugar Company attained 81.8% response return rate, Sony Sugar Company had 77.8% response return rate, Butali Sugar Mills Limited had 83.3% response return rate, with Sukari Sugar Companyhaving a response return rate of 94.4%, Kibos Sugar & Allied Industries Limitedhaving a response return rate of 83.3%, West Kenya Sugar Companyhaving a response return rate of 87.5%, Ole Pito Sugar Companyhaving a response return rate of 81.3% and Busia Sugar Company exhibited a rate of response return of 77.8%. The grand total rate of response was recorded at 82.9%. which conforms to(Ary *et al.*, 1996; Fowler Jr, 1993)who postulated that a minimum response return of 75% is significant.

Table 1: Response Return Rate

Sugar Firm	Proposed Sample	Response return rate (%)
Chemelil Sugar Company	20	16(80.0)
Nzoia Sugar Company	22	18(81.8)
Sony Sugar Company	18	14(77.8)
Butali Sugar Mills Limited	18	15(83.3)
Sukari Sugar Company	18	17(94.4)
Kibos Sugar & Allied Industries Limited	18	15(83.3)
West Kenya Sugar Company	16	14(87.5)
Ole Pito Sugar Company	16	13(81.3)
Busia Sugar Company	18	14(77.8)
Grand total	**164**	136(82.9)

Source: Survey data, (2023)

3.1 Model Specification

This study modified and adopted a multiple linear regression model reviewed by Fairchild & MacKinnon, (2009) to establish the simultaneous effect of product design on operational performance of sugar firms in Kenya as illustrated below:

$Y_{ij}= \beta 0+\beta_1 X_{ij} +\varepsilon_i$…….…… (3.1)

Y_j represents operational performance, measured using a 5-point Likert scale.

X_j represents product design

j ranges from 1 to 136

$Y_{ij}=\beta 0+\beta_1(EM)_{ij}+\beta 2(QFD)_{ij}+\beta 3(SCM)_{ij}+\beta 4(DT)_{ij}+\varepsilon_i$……..(3.2)

Where i =1 or 2 (Y1= operational performance and Y2 is mean scores) and E-manufacturing (EM), Quality function deployment (QFD), Supply chain management (SCM), Digital Technologies (DT)

$Y_{ij}= \beta_0+\beta_1 X_{ij}+\varepsilon_o$…… (3.3)

i=1, 2, 3, 4, 5 and Y_1= Speed of production, Y_2 is Product quality, Y_3 is Production flexibility, Y_4 is Product dependability, Y_5 is Production cost

β_0=Represents the y-intercept within the equation.

β_1 = Magnitude of the causal impact of X, indicated by the coefficient of product design.

εi= Represents the error term.

X_i is the product design sub-indicators E-manufacturing (EM), Quality function deployment (QFD), Supply chain management (SCM), Digital Technologies (DT)

j=1,2,3,…136

4. RESULTS AND DISCUSSION

4.1 Effect of product design on operational performance

To accomplish the first objective of the study, which aimed to investigatethe effect of product design on operational performance of Sugar Firms in Kenya. First, an analysis involving the Pearson product-moment correlation coefficient was performed to evaluate the potential association between product design and operational performance.The decision to begin the research by conducting a Pearson correlation analysis was strategically chosen to establish an initial understanding of the relationships between variables, thereby providing a foundational framework for the subsequent ANOVA analysis (Zikmund & Babin, 2015). This approach allows for the exploration of potential associations among key factors, facilitating a more comprehensive and informed interpretation of the ANOVA results and contributing to a more robust overall analysis of the specific objective under investigationMeyers *et al*., (2016).

The approach used to address the first objective involved formulating a null, positing that "Product design has no significant effect relationship with operational performance of Sugar Firms in Kenya."This hypothesis was examined acrossfour distinct sub-indicators of product design; e-manufacturing, quality function deployment, supply chain management, and digital technologies. The four sub-indicators of product design were individually correlated with operational performance, and bi-variate correlations were attained.The tested hypothesis was then concluded by calculating an overall mean and correlating it with operational performance. At a predefined value of 0.05, all correlations were declared to be significant. Table 2 presents the conclusions.Table 2 provides an illustration of the outcomes.

Table 1: Relationship between product design and operational performance of Sugar Firms in Kenya.

		Operational Performance
E-manufacturing	Pearson Correlation	.545**
	Sig. (2-tailed)	.000
	N	136
Quality Function Deployment	Pearson Correlation	.607**
	Sig. (2-tailed)	.000
	N	136
Supply Chain Management	Pearson Correlation	.636**
	Sig. (2-tailed)	.000
	N	136
Digital Technologies	Pearson Correlation	.315**
	Sig. (2-tailed)	.000
	N	136
Product Design	Pearson Correlation	.742**
	Sig. (2-tailed)	.000
	N	136

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Survey Data 2023

E-manufacturing exhibited a somewhat positive association with operational performance (r=0.545, p=.000), suggesting that e-manufacturing sub-indicator of product design is linked to high levels of operational performance. The correlation between quality function deployment and operational performance demonstrated a statistically significant and moderately positive correlation (r=0.607, p=.000).The correlation between supply chain management and operational performance was found to be moderate and positive (r=0.636, p<0.001).The strength of the correlation between digital technologies and operational performance was found to be weak. Hence, the Pearson product-moment correlation between digital technologies and operational performance was found to (r=0.315, p<0.001). This indicates that although the extent of digital technology implementation was somewhat modest, there existed a marginally elevated degree of operational performance, leading to a subtle connection between these factors. The final results indicated an overallnoteworthy and positive connection between product design and operational performance (r=0.742, p<0.001), suggesting that the application of product design by Sugar Firms in Kenya can be linked to high levels of operational performance. As a result, the null hypothesis was rejected in favor of the alternative hypothesis, which suggests a positive and noteworthy connection between product design and operational performance. Therefore, the adoption of product design in the production line of Kenya Sugar Firms in is associated with improved operational performance.

Further, in pursuit of the first objective, the following sub-indicators were used to measure product designe-manufacturing, quality function deployment, supply chain management, and digital

technologies. Table 3 presents frequency counts, percentages, averages, and standard deviation based on a 5-point Likert scale, where 1 signifies the strongest disagreement and 5 indicates the being the strongest agreement.

Table 2: Product Design

Statement	SD f (%)	D f (%)	N f (%)	A f (%)	SA f (%)	MEAN	SD
E-manufacturing has enabled my company to benefit from digital transformation			22(16.2)	76(55.9)	37(27.2)	4.10	.676
The adoption of e-manufacturing has improved productivity and efficiency in my firm.			27(19.9)	61(44.9)	48(35.3)	4.15	.729
Quality function deployment has helped my company to define customer satisfaction and translate those customer desires into the target design			28(20.6)	54(39.7)	52(38.2)	4.15	.794
Quality function deployment has improved customer satisfaction			23(16.9)	62(45.6)	50(36.8)	4.18	.732
Supply chain management has reduced operating expenses arising throughout the supply chain in my firm			22(16.2)	65(47.8)	49(36.0)	4.20	.697
My firm practices integrated supply chain links that allow collaboration and simultaneous product design between suppliers and manufacturers			26(19.1)	53(39.0)	57(41.9)	4.23	.750
Digitalization has resulted in increased efficiency in			13(9.6)	71(52.2)	52(38.2)	4.29	.631

Statement	SD f (%)	D f (%)	N f (%)	A f (%)	SA f (%)	MEAN	SD
production in my firm							
Digital technology has improved and optimized manufacturing systems in my firm			19(14.0)	64(47.1)	53(39.0)	4.25	.686

Source: Survey data, (2023)

The outcomes presented in Table 3 suggests that adoption of e-manufacturing enabled sugar firms to benefit from digital transformation. 55.9% of respondents expressing agreement with this statement andthe mean score stands at 4.10, validating the findings. Also, the standard deviation (SD = 0. 676) suggests some variations in the responses from the participants. In the second statement, adoption of e-manufacturing improved productivity and efficiency of sugar firms. 44.9% of respondents expressed agreement with this statement and the results were confirmed by a mean score of 4.15. Also, the standard deviation (SD = 0. 729) suggests some variations in the responses from the participants.Based on the perspectives of the respondents, it was observed that quality function deployment helped sugar firms to define customer satisfaction and translate the customer desires into the targeted design with 39.7% of respondents expressed agreement with this statement and the mean score stands at 4.15, validating the findings. Also, the standard deviation (SD = 0. 794) suggests some variations in the responses from the participants.This finding was closely aligned with quality function deployment improved customer satisfaction with 45.6% of respondents expressed agreement with this statement and the mean score stands at 4.18, validating the findings. Also, the standard deviation (SD = 0. 732) suggests some variations in the responses from the participants.Besides that, respondents approved that the adoption of supply chain management resulted in reduced operating expenses throughout the supply chain, as evidenced by the largest proportion of participants, (47.8%) who agreed and the mean score stands at 4.20, validating the findings. Also, the standard deviation (SD = 0. 697) suggests some variations in the responses from the participants. In addition, integration of supply chain links enabled collaborative efforts and simultaneous product design between suppliers and manufacturers, majority of respondents expressed a positive rating for the statement 41.9% (strongly agree) with a mean score of 4.23, justifying that respondents' responses strongly affirm the results.Also, the standard deviation (SD = 0. 750) suggests some variations in the responses from the participants.Subsequently, the results also unveiled that digitalization resulted in increased efficiency of production in sugar firms with 52.2% of respondents expressed agreement with this statement and the mean score stands at 4.29, validating the findings. Also, the standard deviation (SD = 0. 631) suggests some variations in the responses from the participants.Further, the results also unveiled that digitalization improved and optimized manufacturing systems in the Sugar firms with 47.1% of respondents expressed agreement with this statement and the mean score stands at 4.25, validating the findings. Also, the standard deviation (SD = 0. 686) suggests some variations in the responses from the participants. Table 4 provides the model's results.

Table 3: Model significance for the relationship between lean manufacturing practices and operational performance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.577	1	3.577	164.101	.000[b]
	Residual	2.921	134	.022		
	Total	6.498	135			

a. Dependent Variable: Operational Performance

b. Predictors: (Constant), Product Design

Source: Survey data, (2023)

The outcomes presented in Table 4 indicate that the model is statistically noteworthy at the 0.05 alpha level, with an F-statistic of 164.101. This implies that the null hypothesis of the model is rejected to uphold the alternative hypothesis, indicating a meaningful connection between the independent variable (product design) and operational performance within the studied population. Hence, the chosen model is considered suitable for investigating the research hypothesis. Subsequently, a summary of the research hypothesis model results was presented to assess how product design may potentially influence operational performance. This is presentation is depicted in Table 5.

Table 4: Summary Model for the Percentage Change in Operational Performance Explained by Product Design

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.742[a]	.550	.547	.14764	.550	164.101	1	134	.000

a. Predictors: (Constant), Product Design

b. Dependent Variable: OperationalPerformance

Source: Survey data, (2023)

The findings presented in Table 5 reveal that product design accounted for 55.0% of the variance in operational performance [R square=0.550, F=164.101, p=0.000]. This implies that product design explain 55.0% of the observed variability in operational performance of Kenya Sugar Firms.In the context of this study, the F-Statistic (F) holds a value of 164.101. The F-statistic is an essential tool

for evaluating the comprehensive significance of the regression model(Lipson, 2020). This observation suggests that when the F-value is larger, as evidenced by the substantial F-Statistic value, the predictor variable (product design) plays a considerable role in elucidating the variations observed in the dependent variable (operational performance). In essence, the prominence of the F-value underscores the increasing likelihood that the link between product design and operational performance carries substantial positive statistical significance.Further, table 6 portrays results concerning the effect of product design on operational performance.

Table 5: Estimated Regression Coefficients for the Effect of Product Design on Operational Performance

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.017	.248		4.106	.000
	Product Design	.747	.058	.742	12.810	.000

a Dependent Variable: Operational Performance:

Source: Survey data, (2023)

The coefficient outcomes in Table 6 demonstrated that product design is statistically significant and positively connected with operational performance (β=0.742, p=0.000). Hence, according to the findings, a one-standard deviation increase in product design would result in a positive 0.742 unit change in operational performance in the absence of any other variable.This implies that the null hypothesis was rejected to uphold the alternative hypothesis, indicating a meaningful connection between the independent variable (product design) and operational performance. Therefore, the adoption of product design in the production system of Kenya Sugar Firms is associated with improved operational performance. Additionally,the study aimed to assess whether the model could elucidate a noteworthy alteration in operational performance when incorporating lean manufacturing as a variable.

The outcomes of this scholarly enquiry are alignedalongside the findingsof a prior investigation conducted by(Kariuki, 2016; Roble &Wanjira, 2021; Ahmad *et al*., 2018a; Bagshaw, 2017; Bagshaw, 2017)confirmed the presence of a positive correlation between product design and operational performance.However, it is worth noting that the prior research approaches have been criticized.(Kariuki, 2016) the study demonstrated a weak association of R square=0.767, p=0.002 as compared to the present research which demonstrated a more positive and significant connection between variables. (Ahmad *et al*., 2018b) the research adopted a questionnaire method to gather data from 400 respondents and out of which only 80 responded representing 20% of the target population.This is a small response rate (20%) meaning that the study suffered 80% nonresponse biasness of hence commemorating to biased conclusions, further, the study registered a weaker association ($r(80) = 0.570$, $p < 0.05$).Bagshaw, (2017) the research was drawn from a sample size of 28 production managers of manufacturing firms in Nigeria. The research focused on a confined geographical area which might limit the applicability of the study's findings to a broader context. Further, Bagshaw, (2017) established a week association of (PV=0.000<0.05, t-cal=5.559>t-tab (0.05, 27)=2.05)as compared with

the current study's result (β=0.742, p=0.000) which demonstrated a demonstrates a more significant and interpretable relationship between variables, supported by a strong effect size and a highly significant p-value.Indeed it is worth noting that the current study employed unique metrics: e-manufacturing, quality function deployment, supply chain management, and digital technologies, to measure product design. These unique measures allowed for a more comprehensive assessment of how product design affects operational performance, providing valuable insights into specific aspects that contribute to favorable outcomes. By incorporating these unique metrics, this research enriches contribute the existing knowledge hub by providing a more nuanced view of the relationship between product design and operational success in the dimension of Sugar Firms in Kenya by including these distinctive indicators. The research outcomes enhance the current body of knowledge,thereby, offering potential contributions to the refinement of both the resource based view theory and transaction cost theory that guided the study, which served as the guiding frameworks for this research. By establishing a notable and positive correlation between product design and operational performance, the study underscores the importance of strategic resource allocation and efficient transaction management within the context of sugar firms in Kenya.

The integration of new metrics, such as e-manufacturing, quality function deployment, supply chain management, and digital technologies, into the evaluation of product design further enriches the understanding of how firms can optimize their resources and minimize transaction costs to improve operational performance. This newfound insight challenges traditional assumptions and encourages scholars and practitioners to consider a more holistic approach to analyzing and enhancing firm performance.

By contributing empirical evidence to support and strengthen these theoretical frameworks, the study not only advances academic understanding but also offers practical implications for industry stakeholders. The insights gained from this research can be leveraged by sugar firms in Kenya and beyond to devise more effective strategies, optimize their production processes, and ultimately achieve better operational performance. As a result, the study's findings are instrumental in shaping the theoretical underpinnings and practical applications of the resource-based view theory and transaction cost theory, bringing about meaningful advancements in the field of organizational management and strategy.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The research objective aimed toinvestigate the effect of product design on operational performance of Sugar Firms in Kenya. This investigation involved four sub-indicators of product design, namely e-manufacturing, quality function deployment, supply chain management, and digital technologies. To determine the relationships between these sub-indicators and operational performance, Pearson product-moment correlation was utilized.The results revealed that supply chain management exhibited the strongest and most significant association with operational performance, followed by quality function deployment and operational performance. Additionally, there was a noteworthy relationship between e-manufacturing and operational performance, and a similar association was also observed between digital technologies and operational performance. These findings indicate that all four sub-indicators of product design are positively associated with the operational performance of Sugar Firms in Kenya.

5.2 Conclusions

For objective one, which focused on investigating the effect of product design on operational performance of Sugar Firms in Kenya, it was concluded that supply chain management played a more prominent role in determining product design compared to digital technologies which had the lowest prevalence in that regard. However, the study highlighted the importance of improving the dimension of digital technologies in product design to ensure a more robust and comprehensive approach to product design. This finding

emphasizes the need for Sugar Firms to pay attention to enhancing their digital technologies capabilities to enhance their overall product design process. The study findings indicated a significant and positive relationship between all four sub-indicators of product design and operational performance among Sugar Firms in Kenya. This result suggests that a well-developed and comprehensive product design approach results to a noteworthy positive and statistically significant influences the operational performance of these firms.

5.3 Recommendations of the Study

In reference to the study's objective, which aimed to investigate the effect of product design on the operational performance of Sugar Firms in Kenya, the research implies the possibility of improving the comprehension of the construct of product design sub-indicators. To address this, it is recommended that Sugar Firms' Management focus on both operational performance and product design in their manufacturing systems. Paying special attention to supply chain management is essential for achieving high levels of product design. Therefore, it is advised that the management of Sugar Firms should prioritize and consistently work towards improving the aspects related to supply chain management. However, the study also revealed a weak relationship between digital technologies and operational performance. Therefore, it is crucial for Sugar Firms to place greater emphasis on the adoption of digital technologies in their manufacturing systems to effectively leverage a robust product design and ultimately enhance their operational performance. By doing so, the Sugar Firms can capitalize on the potential benefits that digital technologies offer and further optimize their operational performance.

5.4 Suggestions for Further Studies

For future studies,the following recommendation is put forth to further enhance the understanding of the topics explored in this research:

1. Future researcher may conduct longitudinal studies over an extended period would enable researchers to observe the long-term effects of product design and lean manufacturing practices on operational performance.

Future studies can delve into a more comprehensive range of product design sub-indicators, considering various sub-indicators such as eco-friendliness, production iterations, design ethics, and privacy considerations.

REFERENCES

1) Ahmad, M. F., Hoong, K. C., Hamid, N. A., Sarpin, N., Zainal, R., Ahmad, A. N. A., & Hassan, M. F. (2018a). *The impact of product design and process design on new product performance in manufacturing industry*. 020016. https://doi.org/10.1063/1.5055418
2) Ary, D., Jacobs, L., & Razavieh, A. (1996). *Introduction to research in education.. Ft. Worth*. Holt, Rinehart, and Winston, Inc.
3) Bagshaw, K. B. (2017). Process and Product Design: Production Efficiency of Manufacturing Firms in Rivers State, Nigeria. *Engineering Management Research*, *6*(1), 49. https://doi.org/10.5539/emr.v6n1p49
4) Balakrishnan, K., Goico, B., & Arjmand, E. M. (2015). Applying Cost Accounting to Operating Room Staffing in Otolaryngology: Time-Driven Activity-Based Costing and Outpatient Adenotonsillectomy. *Otolaryngology–Head and Neck Surgery*, *152*(4), 684–690. https://doi.org/10.1177/0194599814568273
5) Bleda, M., Querbes, A., & Healey, M. (2021). The influence of motivational factors on ongoing product design decisions. *Journal of Business Research*, *129*, 562–569. https://doi.org/10.1016/j.jbusres.2020.02.018
6) Bloch, P. H. (2011). Product Design and Marketing: Reflections After Fifteen Years: Product Design and Marketing: Reflections After Fifteen Years. *Journal of Product Innovation Management*, *28*(3), 378–380. https://doi.org/10.1111/j.1540-5885.2011.00805.x
7) Chary, S. N. (2012). *Production and operations management*. Tata McGraw-Hill.
8) Chavez, R., Yu, W., Gimenez, C., Fynes, B., & Wiengarten, F. (2015). Customer integration and operational performance: The mediating role of information quality. *Decision Support Systems*, *80*, 83–95. https://doi.org/10.1016/j.dss.2015.10.001
9) Coudounaris, D. N. (2018). Mediation of product design and moderating effects of reference groups in the context of country-of-origin effect of a luxury Brand. *Review of International Business and Strategy*, *28*(2), 169–205. https://doi.org/10.1108/RIBS-05-2017-0044
10) Creswell, J. W. (2015). *A concise introduction to mixed methods research*. SAGE publications.
11) Edwards, K. (2014). Interaction between Functional and Human-Centered Attributes in Materials Selection. *Materials Experience*, 13.
12) Everaert, P., & Swenson, D. W. (2014). Truck redesign case: Simulating the target costing process in a product design environment. *Issues in Accounting Education*, *29*(1), 61–85.
13) Fairchild, A. J., & MacKinnon, D. P. (2009). A General Model for Testing Mediation and Moderation Effects. *Prevention Science*, *10*(2), 87–99. https://doi.org/10.1007/s11121-008-0109-6
14) Fernandes, P. T., & Canciglieri, O. (2014). Sustainable Product Design: The Development of a Conceptual Model. *Applied Mechanics and Materials*, *518*, 335–342. https://doi.org/10.4028/www.scientific.net/AMM.518.335
15) Fowler Jr, F. J. (1993). Applied social research methods series. *Survey Research Methods*, *1*.
16) Heizer, J., Render, B., & Munson, C. (2017). *Operations management: Sustainability and supply chain management* (Twelfth edition). Pearson.
17) Homburg, C., Schwemmle, M., & Kuehnl, C. (2015). New Product Design: Concept, Measurement, and Consequences. *Journal of Marketing*, *79*(3), 41–56. https://doi.org/10.1509/jm.14.0199
18) Ivanov, D., Tsipoulanidis, A., & Schönberger, J. (2017). *Global Supply*

Chain and Operations Management. Springer International Publishing. https://doi.org/10.1007/978-3-319-24217-0

19) Jacobs, F. R., & Chase, R. B. (2008). *Operations and supply management: The core* (Internat. student ed). McGraw Hill/Irwin.
20) Jindal, R. P., Sarangee, K. R., Echambadi, R., & Lee, S. (2016). Designed to Succeed: Dimensions of Product Design and Their Impact on Market Share. *Journal of Marketing*, *80*(4), 72–89. https://doi.org/10.1509/jm.15.0036
21) Kariuki, A. M. (2016). *Production system design and operational performance of steel manufacturers in Kenya*. 59.
22) Kenya Association of Manufacturers. (2020). *Sugar subsector profile*. 28.
23) Kenya Association of Manufacturers. (2021). *Sugar Sub-Sector Strategic Plan*.
24) Kenya National Assembly Eleventh Parliament. (2015). *The Third Session of the Kenya National Assembly Eleventh Parliament: Departmental Committee on Agriculture, Livestock and Cooperatives on the Crisis facing Sugar Companies in Kenya.*
25) Kenya National Bureau of Statistics. (2019). *Economic Survey 2019*. c
26) KIPPRA. (2018). *Kenya Economic Report 2018*.
27) Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Age International.
28) Kropivšek, J., Jošt, M., Grošelj, P., Kitek Kuzman, M., Kariž, M., Merela, M., & Gornik Bučar, D. (2021). Innovative Model of the Cost Price Calculation of Products from Invasive Non-Native Wood Species Based on the FTDABC Method. *Forests*, *12*(11), Article 11. https://doi.org/10.3390/f12111519
29) Kwaku, A. R., & Fan, Q. (2020). Effect of good product design and packaging on market value and the performance of agricultural products in the Ghanaian market. *Open Access Library Journal*, *7*(9), 1–14.
30) Lipson, M. (2020). Interpreting f-statistics and admixture graphs: Theory and examples. *Preprints*, *1*, 18.
31) Luchs, M., & Swan, K. S. (2011). Perspective: The Emergence of Product Design as a Field of Marketing Inquiry*: Product Design and Marketing. *Journal of Product Innovation Management*, *28*(3), 327–345. https://doi.org/10.1111/j.1540-5885.2011.00801.x
32) Meyers, L. S., Gamst, G., & Guarino, A. J. (2016). *Applied multivariate research: Design and interpretation*. Sage publications.
33) Putri, E. D. S., & Rofiq, A. (2020). THE EFFECT BETWEEN PRODUCT DESIGN AND ICONIC PRODUCT IN ATTRACTIVENESS ON CULTURAL IDENTITY WITH BUYING DECISION (STUDY ON BATIK CONSUMER MALANG). *PalArch's Journal of Archaeology of Egypt/Egyptology*, *17*(4), 3223–3240.
34) Reid, R. D., & Sanders, N. R. (2013). *Operations management*. John Wiley & Sons. http://proquest.safaribooksonline.com/9781118122679
35) Rincon-Guevara, O., Samayoa, J., & Deshmukh, A. (2020). Product design and manufacturing system operations: An integrated approach for product customization. *Procedia Manufacturing*, *48*, 54–63. https://doi.org/10.1016/j.promfg.2020.05.020
36) Roble, A. M., & Wanjira, D. J. (2021). *Effects of Product Design on Performance of Commercial Banks in Garissa County, Kenya*. 6.
37) Roper, S. (2016). The roles and effectiveness of design in new product development: A study of Irish manufacturers. *Research Policy*, 11.

38) Sabir, S. S. (2020). Does product design stimulate customer satisfaction? Mediating role of affect. *Asia Pacific Journal of Marketing and Logistics*, *32*(6), 1255–1268. https://doi.org/10.1108/APJML-03-2019-0216
39) Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods forbusiness students. *Essex: Prentice Hall: Financial Times*.
40) Sayar, D., & Er, Ö. (2019). The transformative effects of digital technologies on the product design practices of servitizing manufacturers. *The Design Journal*, *22*(sup1), 2007–2017. https://doi.org/10.1080/14606925.2019.1594924
41) Schroeder, R. G., Goldstein, S. M., & Rungtusanatham, M. J. (2016). *Operations management in the supply chain: Decisions and cases* (Seventh edition). McGraw-Hill Education.
42) Slack, N., & Brandon-Jones, A. (2018). *Operations and process management principles and practice for strategic impact* (Fifth edition). Pearson Education Limited.
43) Tornberg, K., Jämsen, M., & Paranko, J. (2002). Activity-based costing and process modeling for cost-conscious product design: A case study in a manufacturing company. *International Journal of Production Economics*, *79*(1), 75–82.
44) United Nations Industrial Development. (2020). *International Yearbook of Industrial Statistics*. United Nations Industrial Development Organization.
45) Verhaegh, S. (2020). The American Reception of Logical Positivism: First Encounters, 1929–1932. *HOPOS: The Journal of the International Society for the History of Philosophy of Science*, *10*(1), 106–142.
46) Wedowati, E. R., Laksono Singgih, M., & Gunarta, I. K. (2020). Product value analysis on customized product based on pleasurable design and time-driven activity-based costing in food industry. *Cogent Business & Management*, *7*(1), 1823581.
47) Zikmund, W. G., & Babin, B. J. (2015). *Essentials of marketing research*. Cengage Learning.

