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Sustainability management practices in the furniture sector: an analytical study

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ABSTRACT: This study presents an analysis to evaluate the sustainability performance of a company operating in the furniture sector and to shape its future strategies. Initially, critical data such as production volume, energy consumption, waste volume and business customer satisfaction were examined. A correlation and regression analysis was then carried out to determine the relationships between these data. The results of the analysis indicated that the company should focus on energy efficiency, waste management and customer satisfaction. In particular, the high correlation between energy consumption and production volume emphasizes the need for the company to review its energy efficiency measures. In addition, the negative relationship between waste volume and customer satisfaction suggests the development of waste management and recycling programs. This study highlights the importance of green innovation in determining the company's sustainability strategies. It can be said that green innovation can play a significant role in reducing environmental impacts and supporting sustainability goals.

Keywords: Sustainability Management, Furniture Sector Analysis, Green Production

Mobilya sektöründe sürdürülebilirlik yönetimi uygulamaları: analitik bir çalışma

ÖZ: Bu çalışma, mobilya sektöründe faaliyet gösteren bir şirketin sürdürülebilirlik performansını satış sonrası müşteri memnuniyeti ölçütüyle değerlendirmek ve gelecekteki stratejilerini şekillendirmek amacıyla bir analiz sunmaktadır. İlk olarak, işletmenin üretim miktarı, enerji tüketimi, atık miktarı ve müşteri memnuniyeti gibi temel veriler toplanarak, bu veriler incelenmiştir. Ardından bu veriler arasındaki ilişkileri belirlemek için korelasyon ve regresyon gibi ilişkisel analizler yapılmıştır. Analiz sonuçları, işletmenin enerji verimliliği, atık yönetimi ve müşteri memnuniyeti alanlarına odaklanması gerektiğini göstermektedir. Özellikle, enerji tüketimi ile üretim miktarı arasındaki yüksek korelasyon, işletmenin enerji verimliliği önlemlerini gözden geçirmesi gerektiğini vurgulamaktadır. Ayrıca atık miktarı ile müşteri memnuniyeti arasındaki negatif ilişki, atık yönetimi ve geri dönüşüm programlarının geliştirilmesi gerektiğini işaret etmektedir. Bu veriler çerçevesinde bu çalışma, işletmenin sürdürülebilirlik stratejilerini belirlerken yeşil inovasyonun da göz önünde bulundurulması gerektiğini vurgulamaktadır. Yeşil inovasyonun, çevresel etkilerin azaltılmasında ve sürdürülebilirlik hedeflerinin desteklenmesinde önemli bir rol oynayabileceği söylemek mümkündür.

Anahtar kelimeler: Sürdürülebilirlik Yönetimi, Mobilya Sektör Analizi, Yeşil Üretim.

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1 Introduction

Today, businesses are increasingly prioritizing the adoption and implementation of sustainability principles. Sustainability is the effort of businesses to balance their environmental, social, and economic impacts to ensure long-term success and growth (Epstein, 2018). In this context, businesses operate with a focus on profit and consider their impacts on society and the environment (Barbosa et al., 2020).

Furthermore, the increasing awareness among consumers and their growing demands for environmental consciousness are directing businesses to focus more on sustainability principles (Kautish & Sharma, 2020). Today's consumers not only care about the quality and price of products but also consider the environmental and social impacts of the production process when making purchasing decisions, thus they form a more conscientious consumer base (Rustam et al., 2020). Therefore, businesses can respond to these changing consumer expectations and gain a competitive advantage by embracing sustainability principles (Boz et al., 2020). In this context, developing and implementing sustainability-focused strategies by businesses operating in the furniture sector can lead to environmentally and economically significant outcomes (Schiano et al., 2020).

The furniture sector holds significant threat in sustainability issues such as using natural resources, waste management, and energy consumption (Xiong, 2020). This sector can cause environmental impacts across various processes from raw material sourcing to the distribution of final products. Additionally, furniture products are generally expected to have a long lifespan, making the sustainability of production and consumption processes even more critical (Hartini et al., 2020).

This study in this context aims to evaluate the sustainability performance of a furniture manufacturer that produces chairs and shapes its future strategies. This company is a prominent player in the sector and prioritizes customer satisfaction. However, it has potential for improvement in certain areas to advance sustainability.

This study presents a series of analyses to understand a company operating in the furniture sector's sustainability performance and determine its future strategies. The analysis aims to identify areas where the company can improve, particularly in critical areas such as energy consumption, waste management, and customer satisfaction. In this way, it aims to contribute to achieving sustainability goals.

2 Conceptional Dimension

Sustainability in production entails a range of strategies aimed at mitigating businesses' environmental footprint and optimizing resource utilization (Appolloni et al., 2022). At its core lies green production which embraces eco-friendly practices and offers long-term competitive advantages to businesses. In this context, green manufacturing strategies encompass holistic approaches businesses adopt to achieve sustainability objectives (Madah, 2023). These strategies focus on implementing eco-conscious practices, enhancing energy efficiency, minimizing waste generation, and mitigating environmental impacts (D'Angelo et al., 2023). Their implementation on a global scale contributes to maintaining economic and ecological balance.

2.1 Energy Efficiency

Energy efficiency is a critical component of sustainable production practices driven by the need to reduce greenhouse gas emissions and mitigate climate change (Dell'Anna, 2021; Lu et al., 2020; Tennison et al., 2021). Sustainable production models focus on minimizing energy consumption while maximizing the output (Zhao et al., 2022). Key strategies include

deploying intelligent sensors and monitoring systems to track and optimize energy use in real time (Ma et al., 2020; Chinnathai & Alkan, 2023) and integrating energy-saving technologies such as upgrading equipment and adopting intelligent energy management systems (Akhtar et al., 2020; Rodriguez & Fumo, 2021).

In addition, businesses are increasingly adopting renewable energy sources including solar, wind, and hydroelectric power to reduce reliance on fossil fuels (Holechek et al., 2022; Li et al., 2021). The implementation of on-site solar panels has been demonstrated to result in a reduction in energy costs and carbon emissions, thereby contributing to the achievement of sustainability objectives (Brown et al., 2021). These measures not only reduce energy consumption and environmental impact but also enhance operational resilience, competitiveness, and resource conservation (Belkhir & Elmeligi, 2019; Ekinci et al., 2022).).

2.2 Waste Management

The close relationship between energy efficiency and waste management demonstrates that optimizing energy use in production processes can also reduce waste generation. The alignment of production processes with energy efficiency goals serves to minimize waste at its source, and thus it ensures the sustainability of industrial operations (Vertakova & Plotnikov, 2019). Effective waste management entails the efficient utilization of resources, the reduction of pollution, and the minimization of ecosystem degradation (Dada et al., 2022).

The key strategies for the reduction of waste include the optimization of resource utilization, the prioritization of recyclable and reusable materials, and the integration of circular economy principles in product design (Nižetić et al., 2019; Das et al., 2019). The recycling and reuse of materials serve to enhance resource efficiency with businesses focusing on the collection, processing, and reintegration of materials into production (D'Adamo et al., 2022). Advanced technologies, such as intelligent sensors, offer new opportunities to monitor and reduce waste generation in production processes (RameshKumar et al., 2020; Kumar et al., 2020).

2.3 International Cooperation

International cooperation and standards are essential in sustainable production and green industrial transformation (Sachs et al., 2019). In this context, collaborating at international platforms and developing common standards have the potential to reduce environmental impact and ensure more efficient use of resources (Denters et al., 2023).

Additionally, international standards serve as a guide to achieving sustainability goals. Common standards make it easier for businesses to measure, report, and compare their environmental performance (Ikram et al., 2021). These standards promote sustainability in international trade and cooperation by ensuring reliability and transparency between businesses (Bryndin, 2023).

International cooperation and standards also support policy formulation and implementation for sustainability. Policymakers at national and local levels are guided by setting common goals on international platforms, and the development of more effective policies on sustainability is encouraged (Zarei & Mosavi Madani, 2020).

2.4 Literature Review

Today, sustainability has become an increasingly prioritized issue among the strategic goals of businesses. Especially, the furniture sector has an important role in minimizing environmental impacts such as the use of natural resources, energy consumption and waste management. Sustainability in furniture design processes is based on a holistic approach that

requires consideration of not only environmental factors but also economic and social dimensions. There are various studies in the literature that address the environmental benefits of sustainable production and design as well as its effects on customer satisfaction and operational efficiency. However, no standardized framework has yet been presented on how sustainability attributes should be applied in furniture design processes and how these should be integrated with these attributes into design decisions. In this context, addressing the existing gaps in the sustainability literature is critical for the development of sustainability practices in the furniture industry.

2.4.1 Literature review of previous studies

Suandi et al. (2022) reviewed 137 articles and identified 10 environmental, 17 economic, and 16 social sustainability characteristics in furniture design within the triple bottom-line framework. While environmental attributes were less implemented, social and economic aspects were more common highlighting the need for standardization in sustainability criteria. Ratnasingam and Ioras (2003) emphasized the role of industry liberalization and skilled labor in addressing stagnating productivity in the Asian wooden furniture sector. Similarly, Johann et al. (2022) found that operational and social sustainability practices positively impacted performance and competitiveness in Brazilian furniture companies while environmental practices showed limited effects.

Borowiecki et al. (2022) analyzed the competitive position of Polish small enterprises and developed a sustainable competitiveness model focusing on quality and quantitative measures. Feil et al. (2017, 2022) introduced systems for measuring sustainability in micro and small furniture enterprises identifying deficiencies in environmental aspects such as recycling, energy, and waste management. Hartini et al. (2020) proposed a sustainability index (MSI) using lean manufacturing and sustainability concepts while Michelsen and Fet (2010) presented a three-step method for SMEs to improve environmental performance in their supply chains.

Sustainability studies in the furniture sector require clearer frameworks despite the growing body of research. A bibliometric analysis can identify trends, gaps, and future research directions offering a structured approach to understanding the application of sustainability criteria within the triple bottom line framework.

2.4.2 Bibliometric Analysis

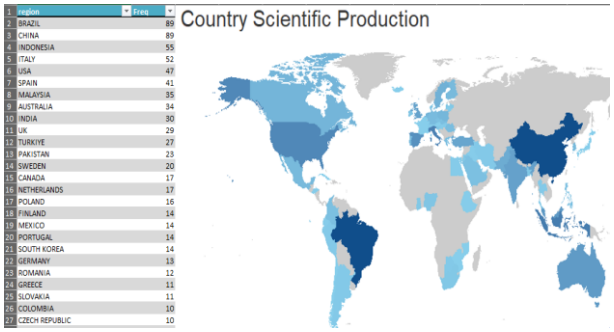
The literature search was conducted in the Scopus database using "Sustainability" and "Furniture" as keywords within titles, abstracts, and keywords. Relevant studies were selected and citation data was analyzed using Bibliometrix software to identify research trends, gaps, and the study's context. This review establishes the knowledge base and framework for the analyses and findings.

Table 1. Main Information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2014:2024
Sources (Journals, Books, etc)	158
Documents	245
Annual Growth Rate %	2.92
Document Average Age	4.14
Average citations per doc	12.89

This bibliometric analysis provides valuable insights into research conducted in the field of sustainability and the furniture industry. A total of 245 documents were examined with the contributions of 3 authors between 2014 and 2024. Most of these documents were authored by multiple individuals indicating a collaborative approach in research. The average number of co-authors per document is approximately 2.97 indicates underscoring the prevalence of collaboration. Additionally, the high average citation count per document (12.89) suggests that research in this area is deemed impactful and valuable. The annual growth rate of 2.92% indicates a steady increase in research activity reflecting sustained interest in sustainability and the furniture industry. However, the absence of specific author's keywords and international co-authorship may be considered notable weaknesses suggesting the need for a more comprehensive approach in future research endeavors.

Table 2. Country Scientific Production



	region	Freq
1	BRAZIL	89
2	CHINA	89
3	INDONESIA	55
4	ITALY	52
5	USA	47
6	SPAIN	41
7	MALAYSIA	35
8	AUSTRALIA	34
9	INDIA	30
10	UK	29
11	TURKIYE	27
12	PAKISTAN	23
13	SWEDEN	20
14	CANADA	17
15	NETHERLANDS	17
16	POLAND	16
17	FINLAND	14
18	MEXICO	14
19	PORTUGAL	14
20	SOUTH KOREA	14
21	GERMANY	13
22	ROMANIA	12
23	GREECE	11
24	SLOVAKIA	11
25	COLOMBIA	10
26	CZECH REPUBLIC	10

Brazil and China are the leading countries in terms of sustainability research output in the furniture industry with 89 and 55 publications, respectively. Indonesia (55), Italy (52), and the USA (47) follow in this regard. Turkiye with 27 publications evinces a growing commitment to this field and the potential to make further contributions through research and innovation.

Despite the valuable insights provided by existing studies, many of them lack structured frameworks and standardized criteria, particularly about the integration of sustainability features into furniture design processes (Feil et al., 2020). This study addresses these gaps by presenting a comprehensive roadmap for the application of sustainability criteria within a triple bottom line framework. By focusing on detailed integration strategies, it offers a novel perspective on sustainability practices in furniture design.

3 Material and Methods

The objective of this study is to evaluate the operational performance of a furniture company. For this purpose, operational data and customer feedback collected in June 2024 were analyzed. The key performance indicators including production quantity, energy consumption and waste output were collected through automated tracking systems ensuring accuracy and real-time capture. Customer satisfaction was evaluated through structured post-purchase surveys targeting customers who had completed transactions within the previous six months.

The analysis identified strengths and weaknesses in areas such as energy efficiency, waste management, and customer satisfaction. Feedback mechanisms including surveys and follow-ups provided actionable insights into product and service quality. The findings will inform strategic improvements and support the company in creating a sustainable growth roadmap.

3.1 Company Information

The implementing company (X) is an enterprise operating in the furniture sector and is mainly known for producing chairs. The company has an annual production capacity of 2000

products with 120 employees and a factory area of 1500 square meters. However, it has been observed that approximately 1500 products are produced per year according to the analysis conducted in the last five years. This shows that the company needs to demonstrate an increasing operational efficiency performance to achieve its targets. Company X continuously strives to increase its operational efficiency and ensure customer satisfaction by adopting a sustainability and quality-oriented approach. These efforts contribute to the company maintaining its strong position in the sector and improving its competitive production capability.

3.2 Data

Table 3 shows the amount of product production, energy consumption, waste, and customer satisfaction rates over the last five periods of the business. This data will be evaluated to analyze the operational performance of the business and determine future strategies.

Table 3. Operational Information

Years	2019	2020	2021	2022	2023
Production Quantity (piece)	1450	1300	1600	1750	1850
Energy Cons. (kWh)	75000	68000	80000	85000	82000
Amount of Waste (tons)	20	15	17	19	20
Customer Sat. %	85	90	88	86	88

The data presented in Table 3 offers insights into the operational performance of the business over the past five years. While these figures provide a valuable foundation for understanding trends in production, energy consumption, waste generation, and customer satisfaction, it is important to recognize the inherent limitations in the data collection process. These limitations may influence the scope and accuracy of the analysis as well as the interpretation of the results. The following section outlines these methodological constraints to provide a clearer understanding of the study's framework and the potential impacts on the findings.

3.3 Methodological limitations

Certain limitations of this study’s data collection and analysis methods may affect the scope of the research and the interpretation of its findings. These limitations are outlined below:

3.3.1 Data collection limitations

- Energy Consumption and Waste Amount: The energy consumption and waste data were collected through automated monitoring systems installed in the production facilities. While these systems provide high data collection accuracy, they only measure specific time intervals which means they may not capture short-term fluctuations or changes outside of the system's monitoring periods. Additionally, waste categorization relies on waste management software which carries the risk of misclassification.
- Customer Satisfaction: Customer satisfaction data were collected via post-purchase surveys. Since participation in these surveys is voluntary, this data collection method may be subject to participant bias. Dissatisfied customers may be less likely to participate, which can cause data to skew toward more positive feedback. Furthermore, the surveys only capture customer perceptions at a specific point in time and may not reflect longer-term satisfaction trends.

3.3.2 Correlation analysis limitations

The study employs correlation analysis to investigate the interrelationships between variables. However, it is essential to recognize that correlation does not imply causation (Smith, 2020; Willett, 2023). The identified correlations elucidate the associations between factors such as production quantity, energy consumption, and customer satisfaction; nevertheless, they do not establish the underlying cause-and-effect relationships. The general formula for calculating the correlation coefficient:

$$r = \Sigma (X_i - X)(Y_i - \hat{Y}) / \sqrt{\Sigma (X_i - X)^2 \Sigma (Y_i - \hat{Y})^2}$$

Therefore, caution should be exercised when interpreting these results and further research, potentially involving experimental or longitudinal studies, would be needed to establish causality.

3.3.3 Regression Analysis Limitations

While regression analysis is a valuable tool for understanding relationships between variables, it has certain limitations that should be considered within the formula:

$$Y = \beta^0 + \beta^1 X + \varepsilon$$

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta\square X\square + \varepsilon$$

- Model Assumptions: The fundamental assumption of regression analysis is that the relationship between the dependent and independent variables is linear (Shi & Conrad, 2009). If the relationship between the variables is non-linear, the regression model may prove an inadequate representation of the data (Bates, 1988). In this study, a linear regression model was employed but the potential for non-linear relationships was not investigated.
- Multicollinearity: A further potential limitation of regression analysis is multicollinearity which occurs when the independent variables are highly correlated with each other (Daoud, 2017). The presence of multicollinearity can give rise to difficulties in estimating the regression coefficients which may ultimately result in the generation of unreliable results. Despite efforts to minimize multicollinearity, the possibility remains that it may have influenced the results.
- Data Quality and Outliers**:** The accuracy of the regression model can be affected by the presence of outliers or extreme data points (Li et al, 2024). Despite efforts to clean the data, outliers may still influence the regression results and affect the overall model's robustness. Identifying and handling outliers more effectively could enhance the model's accuracy.

By acknowledging these limitations, the study provides a more transparent and nuanced understanding of its findings guiding future research and practical applications in the field of sustainability management.

4 Evaluation of data

The data collection process was carefully planned and conducted through specialized systems.

- Energy Consumption: Real-time data were gathered using automatic monitoring systems in production facilities, tracking energy usage on a machine basis and identifying inefficiencies through monthly trend analysis.

- Waste Amount: Waste data were categorized by type (e.g., metal, plastic, wood) using waste management software and digital weighing systems ensuring accurate daily, weekly, and monthly reports.
- Customer Satisfaction: Feedback was collected via post-purchase surveys using a 5-point Likert scale to evaluate product quality, delivery time, and customer service. Responses were analyzed using an automated platform for consistency and reliability.

Data collection began in 2019 in line with the company's sustainability and digital sales strategies, and a comprehensive trend analysis was provided. Production generally increased from 2019 to 2023 except for a decline in 2020 due to the COVID-19 pandemic. In 2023, energy consumption decreased due to the adoption of energy-efficient lighting. Regression analysis (Table 4.) was employed to quantify relationships between variables and forecast trends providing valuable insights for strategic decision-making (Mooi et al., 2018).

Table 4. Regression Results

Dep. Variable:	energy consump.			R-squared:	0.937	
Model:	OLS			Adj. R-squared:	0.912	
Method:	Least Squares			F-statistic:	37.21	
Date:	Mon, 25 Apr 2024			Prob (F-statistic):	0.00946	
Time:	00:00:00			Log-Likelihood:	-37.586	
No. Observations:	5			AIC:	79.17	
Df Residuals:	3			BIC:	78.05	
Df Model:	1			Covariance Type:	nonrobust	
	coef	std err	t	P>|t|	[0.025	0.975]
const	5.037e+04	1.17e+04	4.304	0.021	1.34e+04	8.74e+04
production	22.4156	3.673	6.102	0.009	11.528	33.303
Omnibus:	nan			Durbin-Watson:	1.852	
Prob(Omnibus):	nan			Jarque-Bera (JB):	0.609	
Skew:	0.000			Prob(JB):	0.739	
Kurtosis:	1.500			Cond. No.:	1.42e+04	

The regression results indicate the R-squared value is 0.937 indicating that the amount of production explains a large part of the variability in energy consumption. Moreover, the coefficient for the Quantity of Production is statistically significant ($p < 0.05$) indicating the quantity of production significantly impacts energy consumption. An increase in production quantity leads to an increase in energy consumption. This shows that the enterprise's energy needs also increase with the increase in production, and energy efficiency measures should be reviewed. According to the results of the regression analysis, it was necessary to look at the relationships between the amount of production and other variables and between the other variables themselves. For this, the correlation matrix was used.

Correlation analysis is essential for understanding the relationship between two or more variables (Cohen et al., 2013). It helps to determine whether and how strongly variables are related to each other. We can identify patterns, dependencies, and associations between different factors by examining correlations. Businesses can make strategic decisions by determining the relationships between variables through correlation analysis (Nicholas & Hilary, 2016). According to these results,

Table 5. Correlation Matrix

	Years	Quantity	Energy C.	Waste	Customer S.
Years	1.000000	0.890588	0.734770	0.291730	0.162221
Quantity	0.890588	1.000000	0.928794	0.654724	-0.277387
Energy C.	0.734770	0.928794	1.000000	0.639606	-0.480627
Waste	0.291730	0.654724	0.639606	1.000000	-0.792691
Customer Sat.	0.162221	-0.277387	-0.480627	-0.792691	1.000000

Correlations between Production Quantity and Other Variables

Production Quantity and Energy Consumption (r=0.93): The strong positive correlation (0.93) between production and energy consumption indicates that higher production leads to significant energy use, increasing costs and environmental impact. Adopting energy-efficient production methods such as optimizing machinery, using renewable energy, and implementing smart energy management systems can reduce energy consumption while maintaining production levels.

Production Quantity and Waste Quantity (r=0.65): A moderate positive correlation (0.65) suggests that increased production generates more waste. Strategies like lean manufacturing, recycling, and reusing by-products can minimize waste lowering costs and environmental impact while enhancing operational efficiency.

Production Quantity and Customer Satisfaction (r=-0.28): The weak negative correlation (-0.28) suggests that higher production may slightly decrease customer satisfaction due to quality or service issues. To address this, the company should maintain product quality and customer service standards through better quality control and streamlined processes.

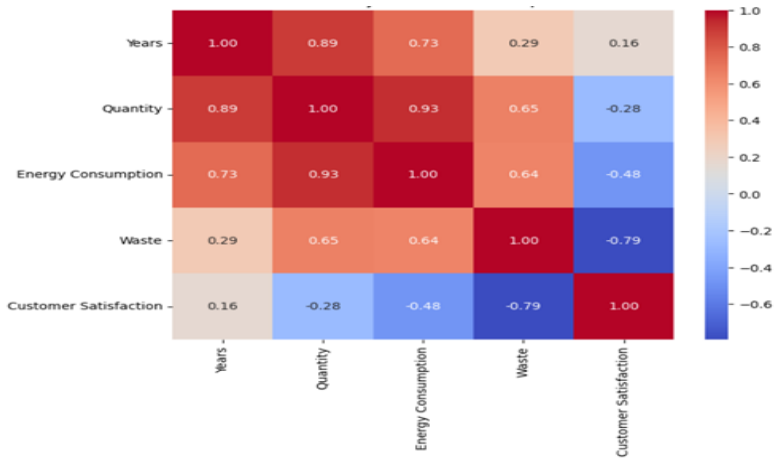
These findings highlight the interconnectedness of production, energy consumption, waste generation, and customer satisfaction. Strategic management of these factors can optimize processes, reduce environmental impact, and improve customer satisfaction.

Correlations between Other Variables

Energy Consumption and Waste Amount (r=0.64): The moderately positive correlation (0.64) suggests that higher energy consumption leads to increased waste generation highlighting inefficiencies in the production process. Adopting energy-efficient technologies and waste-reducing strategies can address this issue improving sustainability performance.

Energy Consumption and Customer Satisfaction (r=-0.48): The moderate negative correlation (-0.48) indicates that high energy consumption may reduce customer satisfaction possibly due to higher costs or environmental concerns. Implementing energy-saving measures and renewable energy sources can enhance the company's environmental image and appeal to eco-conscious customers.

Waste Amount and Customer Satisfaction (r=-0.79): The strong negative correlation (-0.79) reveals that waste generation significantly reduces customer satisfaction as modern consumers expect environmentally responsible practices. Strategies like recycling, using recyclable materials, and minimizing waste in production can improve brand reputation, reduce costs, and increase customer loyalty. These findings emphasize the need for integrated strategies to optimize energy use, reduce waste, and enhance customer satisfaction.



Graph.1. Correlation Matrix Heatmap

The correlation heatmap indicates a robust positive correlation between production and energy consumption (r = 0.93) and a moderate correlation with waste generation (r = 0.65). A strong negative correlation is observed between waste generation and customer satisfaction (r = -0.79) while a moderate negative correlation is evident between energy consumption and customer satisfaction (r = -0.48). These findings underscore the necessity of adopting sustainable production practices particularly about energy usage and waste management.

4.1 Discussion of results

The correlation analysis offers valuable insights into the company's production, energy consumption, waste generation, and customer satisfaction guiding strategic improvements for enhanced operational performance and sustainability.

The strong positive correlation between production and energy consumption (0.93) indicates that higher production levels are associated with increased energy use which is in accordance with the findings of Dell'Anna (2021) and Song et al. (2023). These studies emphasize the significance of energy efficiency in sustainable production. To address this issue, it would be prudent for the company to adopt energy-efficient methods such as optimizing machinery and utilizing renewable energy sources with a view to reducing costs and mitigating environmental impact.

Similarly, the moderate positive correlation between production and waste generation (0.65) indicates that increased production is associated with an increase in waste. This highlights the necessity for waste minimization strategies such as lean manufacturing and recycling in line with the findings of Luthra et al. (2022) and Simon et al. (2021) who stress the significance of effective waste management for sustainability.

The weak negative correlation between production and customer satisfaction (-0.28) indicates that higher production levels may have a detrimental impact on the quality of goods or services provided. Schiano et al. (2020) and Rustam et al. (2020) posit that sustainable production practices are pivotal for the maintenance of customer satisfaction and loyalty. Therefore, it is recommended that the company should focus on maintaining quality and streamlining production to ensure customer satisfaction as production scales.

Furthermore, the moderate negative correlation between energy consumption and customer satisfaction (-0.48) indicates that elevated energy utilization results in increased operational expenses which may have a detrimental impact on customer perceptions. The implementation of energy-saving measures can facilitate the enhancement of the company's environmental image and customer satisfaction as proposed by Singh et al. (2020).

The robust negative correlation between waste and customer satisfaction (-0.79) underscores the significance of efficacious waste management. Consumers are becoming increasingly aware of the environmental impact of products as observed by Schiano et al. (2020). Therefore, it is recommended that the company should give priority to recycling, the use of recyclable materials and the minimization of waste to align its activities with customer expectations and enhance its brand reputation.

These findings identify key areas for enhancing the company's sustainability efforts and operational performance. The company can maintain a competitive advantage and strengthen both its operational and sustainability performance as recommended in the literature by prioritizing energy efficiency, waste reduction, and customer satisfaction, (Dell'Anna, 2021; Luthra et al., 2022).

5 Conclusion and Recommendations

This study evaluated the relationships between production, energy consumption, waste generation, and customer satisfaction in a furniture manufacturing context, identifying key areas for improving sustainability and operational performance. The findings underscore the following:

Energy consumption and production: A strong positive correlation highlights the need for energy-efficient production methods to reduce costs and environmental impact.

Waste management: Increased production is moderately correlated with waste generation, highlighting the importance of waste minimization strategies such as recycling and lean manufacturing.

Customer satisfaction: The study found that higher energy consumption and waste generation negatively affect customer satisfaction, highlighting the importance of aligning operational practices with customer expectations.

Based on these findings, the following strategies are recommended to improve the company's sustainability and competitiveness:

- Stakeholder engagement: Actively engage stakeholders through consultations and feedback systems to align business practices with sustainability goals (Silva et al., 2019; Özözen, 2024).
- Regulatory compliance: Developing internal mechanisms to ensure compliance with global and local sustainability standards (Vigneau et al., 2015).
- Circular economic principles: Implement closed-loop production systems that focus on waste reduction, recycling, and sustainable design (Burke et al., 2023; Şenkal, 2023).
- Green innovation: Establish a green innovation fund to support sustainable materials and energy efficient technologies (Singh et al., 2020).

By systematically addressing these priorities, companies can achieve both environmental and economic sustainability while maintaining a competitive edge in the furniture industry.

Author Contribution

M. Paşa Gültaş: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

There is no conflict of interest between the authors.

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