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An Ergonomic and Economic Analysis of the Implementation of a Multifunctional Folding Chair at CV. Fixed Interior

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Abstract

This study aims to analyze the ergonomic and economic aspects of implementing a multifunctional folding chair at CV. Fixed Interior, Semarang. The research addresses the high risk of non-ergonomic working postures and low time efficiency due to insufficient supporting facilities in the production environment. A comparison of working time before and after chair implementation was conducted, along with an economic feasibility analysis. Ergonomic assessments utilized the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), while the economic evaluation employed Net Present Value (NPV), Internal Rate of Return (IRR), Break-Even Point (BEP), and Benefit-Cost Ratio (BCR). Results show a reduction in standard time from 678.31 minutes to 441.51 minutes, indicating a 35% efficiency increase. RULA and REBA scores reflected a lower posture risk level. Economically, the project is feasible, with an NPV of IDR 8,156,523, IRR exceeding the discount rate, BEP at five units sold, and a BCR of 14.15. Therefore, the folding chair is effective and commercially viable.

1. INTRODUCTION

The manufacturing industry plays a strategic role in supporting Indonesia's economy, with the industrial sector being one of the country's primary sources of revenue, including the furniture industry. Indonesia holds significant potential to further develop its furniture sector in line with the rapid economic growth. This condition encourages furniture companies to continuously innovate in product design and expand marketing strategies to meet the growing market demands (Ministry of Industry of the Republic of Indonesia, 2021).

Indonesia's abundant natural resources, particularly its vast forests, are vital in providing raw materials for the furniture industry. However, major challenges include the limited supply of wood and rising costs caused by deforestation and inefficiencies in supply chain management. According to a report by the Central Statistics Agency (2021), the forest products industry has experienced an average decline of approximately 3% over recent years. This decline not only affects the industrial sector but also poses serious threats to environmental sustainability. (Bahar, 2016)

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One of the major furniture production centers in Indonesia is located in Semarang City. The furniture industry in this city significantly contributes to the local economy and is a key driver in increasing regional revenue (Pendapatan Asli Daerah/PAD). With production capacity covering various types of furniture for both household and office needs, the industry is capable of reaching a broad market. Furthermore, competition among producers in Semarang helps maintain competitive pricing, making furniture more affordable for consumers. (Dahlan & Al Hakim, 2018)

CV. Fixed Interior is one of the manufacturing companies located at Puspowarno XI Street No. 16, Semarang City, specializing in the production of furniture such as chairs, tables, cabinets, and other household and office items. The research was conducted at CV. Fixed Interior, which faces several challenges that impact its production efficiency and competitiveness. A key issue is the lack of product innovation, resulting in furniture designs that may appear less appealing compared to competitors with more creative approaches.

In addition, suboptimal production management can lead to raw material waste, inaccurate market demand forecasts, and increased operational costs. The company also struggles with unstable raw material prices and uncertain availability, which can disrupt production flow and reduce profitability. Moreover, employee welfare and motivation are critical factors, as an unsupportive work environment can lower morale and productivity. To remain competitive and grow, the company must address these challenges by implementing innovative and efficient strategies across its operations. (Dzikrillah & Yuliani, 2017)

The multifunctional folding chair product we have designed to address the challenges faced by CV. Fixed Interior holds promising prospects within the wood-processing industry, given its high demand and wide applicability across various sectors. In its production, ergonomic and economic aspects will be further examined in this study to help address the company's key operational issues. (Rahmah & Herbawani, 2021)

The furniture production process takes quite a long time, namely 7.5 hours for wardrobes, 7 hours for tables, and 8.5 hours for chests of drawers. The length of this production time is largely due to the long breaks taken by workers during the production process. These breaks are needed to relieve muscle pain and cramps caused by poor and uncomfortable working postures.

To address this issue, the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) methods are applied to evaluate the effectiveness of the multifunctional folding chair in reducing physical workload and improving labor efficiency (Tarwaka, 2011).

In addition to ergonomics, economic factors play a crucial role in the production process. Each product manufactured by a company represents an investment. Therefore, an economic analysis is essential to assess the balance between investment costs and their impact on production processes and company revenue. The Net Present Value (NPV), Internal Rate of Return (IRR), Break-Even Point (BEP), and Benefit-Cost Ratio (BCR) methods are used to evaluate the financial feasibility of the multifunctional folding chair to determine whether it is suitable for further production and capable of delivering economic benefits (Rahmah & Herbawani, 2021)

By considering both ergonomic and economic aspects, this study aims to develop a multifunctional folding chair that is cost-effective, ergonomically sound, and tailored to the needs of industry and end-users. This dual-approach provides a solid foundation for research, offering practical benefits to the company while also contributing to product quality improvement and worker well being.

2. METHODS

This study was conducted at CV. Fixed Interior, a furniture manufacturing company located in Semarang, Indonesia. The subject of the research is the company itself, while the object of the study is the multifunctional folding chair developed and produced within the company. The primary goal of this research is to analyze the ergonomic and economic aspects of the product to ensure that it provides both physical comfort and financial feasibility.

The data used in this study consist of both primary and secondary sources. Primary data were collected through direct observations of production activities and interviews with employees to assess their working conditions and obtain input on product usage. Secondary data were obtained from literature sources such as books, academic journals, and company reports that relate to ergonomics, product design, and investment analysis.

Several tools were utilized in the research process. Writing instruments were used for recording observations and interviews. SolidWorks software was employed to create accurate two-dimensional (2D) and

three-dimensional (3D) design models of the folding chair. Microsoft Excel was used to process and analyze the data, particularly for ergonomic scoring and economic calculations.

The research followed a structured sequence of steps. It began with a preliminary study to identify existing problems in the workplace, followed by the formulation of research objectives. Data collection was conducted through field observations and literature reviews. After collecting the data, processing was carried out in two main streams: ergonomic and economic analysis.

For the ergonomic aspect, the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) methods were used. These tools evaluate the posture of workers when using the chair and provide scores indicating the level of musculoskeletal risk. The results from RULA and REBA were then interpreted to determine the urgency of ergonomic intervention.

From the economic perspective, investment feasibility was analyzed using four key financial metrics: Break Even Point (BEP), Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR). These calculations aimed to determine whether the production of the multifunctional folding chair would be financially viable over time. The results of the ergonomic and economic analyses were then used to draw conclusions and make recommendations for product improvement.

The research was carried out over a six-month period, beginning with problem identification in February and concluding with the final thesis defense in August. Each activity ranging from proposal writing and data collection to analysis and reporting was conducted systematically to ensure that the study produced valid and reliable results that could contribute to both academic knowledge and practical application in the furniture industry..

3. RESULT AND DISCUSSION

Multifunctional Folding Chair

The results of the multifunctional folding chair design project, including product design and technical specifications. The design was developed based on user ergonomic needs, with the aim of creating a functional, comfortable, and economically viable product.

2D and 3D Designs of the Multifunctional Folding Chair

The following is the 3D design of the multifunctional chair resulting from the assembly of all components:

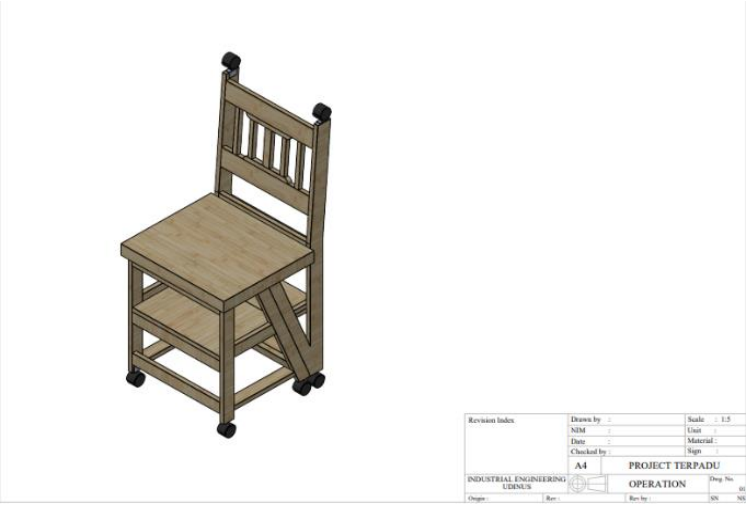

Fig. 1 3D Design of Multifunctional Folding Chair

The following is a 2D design of a multifunctional chair based on the previous 3D design. The 2D design consists of a left view, front view, and right view.

Fig. 2 2D Design of Multifunctional Folding Chair

Product Results of the Multifunctional Folding Chair

Below is an image of the multifunctional folding chair product that has been successfully designed and manufactured. This product is designed to support comfort, flexibility, and workspace efficiency.

Fig. 3 Multifunctional Folding Chair Product

After the design and implementation of the multifunctional folding chair at CV. Fixed Interior, a reassessment was conducted on the production cycle time for three types of products: wardrobe, table, and drawer table. The cycle times for each product were recorded at 345 minutes for the wardrobe, 325 minutes for the table, and 418 minutes for the drawer table. The average cycle time after the use of the multifunctional chair was calculated to be 362.67 minutes. Furthermore, an adjustment factor assessment was conducted using the Westinghouse method. Based on observations, adjustments were made in four aspects: skill (excellent), effort (very good), working conditions (good), and work consistency (very good). The total adjustment factor obtained was 0.10, resulting in a rating factor of 0.90 used in further analysis.

Based on these calculations, the normal time was obtained by multiplying the cycle time by the rating factor, resulting in 362.67 × 0.90 = 326.40 minutes. Subsequently, an evaluation of the work allowance after using the multifunctional chair was carried out. Compared to the conditions before the chair was introduced, the allowance decreased significantly from 41% to 27%. This indicates a considerable improvement in working conditions, particularly in terms of working posture and operator fatigue.

This result demonstrates that the use of the multifunctional folding chair successfully reduced the standard time significantly, from 678.31 minutes to 447.67 minutes. This reduction serves as an indicator that ergonomic improvements achieved through the chair design directly contributed to increased work efficiency and labor productivity at CV. Fixed Interior.

Multifunctional folding chairs are made from materials like wood, metal, and plastic, which affect their durability, comfort, and aesthetic appeal. Their designs range from minimalist to complex, with added features such as storage space or transformation into tables. These chairs are space-saving, flexible, cost-effective, and

portable ideal for small rooms, various occasions, and outdoor use. However, challenges include potential discomfort during prolonged use, reduced durability depending on materials, and compromised stability in lightweight designs.

Ergonomics is the study of human interaction with systems and environments, aiming to enhance safety, comfort, and efficiency. It includes physical ergonomics (focused on posture, tool design, and environmental factors), cognitive ergonomics (dealing with perception, memory, and decision-making), and organizational ergonomics (concerning structure, communication, and workplace culture). Applying these concepts helps minimize risks of injury and optimize user well-being and performance.

Key ergonomic principles include designing for user variability, reducing discomfort, preventing injuries, maximizing productivity, and ensuring system adaptability. Benefits include better health, increased productivity, cost savings, and improved employee satisfaction. Ergonomics is applied across sectors—industrial (tool/workstation design), office (adjustable desks and chairs), transportation (vehicle layout), and healthcare (equipment design and space organization).

MSDs involve injuries or pain in muscles, joints, and connective tissues, with common types such as arthritis, tendonitis, bursitis, fractures, carpal tunnel syndrome, and fibromyalgia. Causes range from physical strain and poor posture to psychosocial stressors. Symptoms include pain, stiffness, and limited motion. Preventive strategies involve ergonomic workplace design, physical activity, and proper lifting techniques. Treatment may include physical therapy, medication, or surgery in severe cases.

Anthropometry is the science of measuring human body dimensions for application in ergonomic design. It considers factors like age, gender, and ethnicity to inform the creation of comfortable and safe products and workspaces. There are two types: static (measuring body in fixed postures) and dynamic (measuring body in motion). Data is typically analyzed using percentiles (5th, 50th, 95th) to accommodate a wide range of users, ensuring inclusivity in design practices, especially in furniture, workplaces, and transportation systems.

Standard Time Calculation Before Using the Chair

Standard time calculations are used to determine the actual duration required by workers to complete production activities before the implementation of the multifunctional folding chair.

Standard Time Calculation Before Using the Chair

This section discusses the standard time required to complete furniture production processes before the implementation of the multifunctional folding chair at CV. Fixed Interior. The purpose of this calculation is to determine the actual duration taken by workers to perform various tasks under existing working conditions without ergonomic support.

The cycle time for producing a wardrobe without using the folding chair was recorded as follows: 1 hour for cutting wood, 30 minutes for polishing and smoothing, 3 hours for assembling parts, 1 hour for coating and painting, and 1.5 hours for inspection. This resulted in a total cycle time of 7.5 hours. Similarly, the production of a standard table took a total of 7 hours, while the production of a drawer table required 8.5 hours. These tasks involved intensive manual labor and non-ergonomic postures such as prolonged standing and repetitive bending.

From these three product categories, the average cycle time was calculated to be approximately 460 minutes. The adjustment factor for the normal time calculation was determined using the Westinghouse method. Based on the evaluation of four factors skill (Excellent, 0.08), effort (Good, 0.05), working condition (Average, 0), and consistency (Average, 0), a total adjustment of 0.13 was obtained. Hence, the rating factor (Rf) was calculated as 0.87.

The normal time (Wn) was derived by multiplying the average cycle time (Ws) with the rating factor, resulting in:

$$Wn = 460 \times 0.87 = 400.2 \text{ minutes}$$

To calculate the standard time (Wb), an allowance factor of 41% was applied, considering fatigue due to physical exertion, awkward posture, repetitive motions, visual strain, and environmental factors. These allowances were determined based on common workplace conditions, such as the need to frequently bend or stand, perform difficult motions, and work in a suboptimal environment.

The resulting standard time was:

$$Wb = 400.2 / (1 - 0.41) \approx 678.3 \text{ minutes}$$

This duration reflects a considerable time expenditure attributed to non-ergonomic working conditions. It suggests that the lack of supportive seating and inefficient postures not only cause increased physical fatigue but also elevate the risk of musculoskeletal disorders (MSDs), thereby reducing work efficiency and productivity.

Ergonomic Analysis

This subsection presents an ergonomic assessment to evaluate the impact of using a multifunctional folding chair on worker comfort and health, particularly in reducing the risk of musculoskeletal disorders (MSDs). Two ergonomic evaluation tools—Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) were employed to systematically analyze the postural risks associated with furniture production activities at CV. Fixed Interior.

Rapid Upper Limb Assessment (RULA)

The RULA method was applied through direct observation of workers during the production process. Before using the folding chair, workers typically maintained awkward and physically taxing postures such as continuous standing and bending while assembling, painting, or inspecting furniture. This resulted in a high degree of physical strain, especially in the upper limbs, back, and neck areas.

Photographic documentation captured before and after the chair's implementation revealed a noticeable improvement in posture. The folding chair allowed workers to perform tasks at middle and lower levels of the furniture without excessive bending, thereby minimizing physical fatigue and postural stress. The chair offered support during repetitive tasks such as painting and finishing, contributing to enhanced comfort and reduced ergonomic risk.

The RULA assessment was then carried out to measure the postural risk associated with using the chair. The evaluation involved two groups: Group A (upper limbs) and Group B (neck, trunk, and legs). In Group A, the upper arm posture was scored +3 due to a 70-degree flexion, forearm +2 for a 40-degree angle, and wrist +1 for slight twist accumulating a total of 4 when including repetitive motion adjustments. Group B included neck (+2 for 12-degree flexion), trunk (+2 for slight bending), and legs (+1 for stable and balanced position), summing to 3 after adjustments.

Based on the combined scores of Group A and Group B, the final RULA score was calculated as 3, which falls into the "Medium Risk" category. According to the RULA risk scale, this indicates that further investigation is required, and posture improvements may be necessary to prevent long-term injuries. The use of the folding chair was therefore found to be beneficial, although additional ergonomic refinements—such as adjusting chair height—could further reduce the risk of MSDs.

Rapid Entire Body Assessment (REBA)

The REBA method is used to evaluate workers' postures in a comprehensive ergonomic analysis. It helps identify posture-related risks and recommends corrective actions. In this study, posture scores were assessed for both Group A (trunk, neck, legs) and Group B (arms, forearms, wrists). The combined score yielded a REBA value of 3, indicating a low risk that may require corrective measures. This result supports ergonomic improvements, particularly in designing the multifunctional folding chair.

Standard Time Calculation After Using the Chair

After implementing the multifunctional folding chair at CV. Fixed Interior, production cycle times for three furniture items were measured:

- Wardrobe: 5 hours 45 minutes
- Table: 5 hours 25 minutes
- Drawer Table: 6 hours 58 minutes

An average cycle time was calculated, and a performance rating of 0.84 (using Westinghouse method) was applied, resulting in a normal time of 304.64 minutes. With an allowance factor of 31%, the final standard time becomes 441.51 minutes. This reduction in time and allowance percentage reflects improved productivity due to more ergonomic working postures.

Economic Analysis

The economic feasibility of implementing the multifunctional folding chair was evaluated using NPV, IRR, BEP, and BCR methods. Total production cost was Rp. 620,034, consisting of Rp. 420,034 for raw materials and Rp. 200,000 for labor. These values represent the complete manufacturing cost, supporting a detailed financial analysis of the chair's implementation in production processes.

Table 1. Break Even Point (BEP)

Selling Price / Unit	Rp 3.000.000
Investment Cost (Fixed Cost)	Rp 620.034
Production Cost / Unit (Variable Cost)	Rp 2.850.000
Contribution Margin / Unit	Rp 150.000
BEP in Unit	5 unit
BEP in Rupiah	Rp 15.000.000

Table 2. Net Present Value (NPV)

Selling Price / Unit	Rp 3.000.000
Production Cost / Unit	Rp 2.850.000
Contribution Margin / Unit	Rp 150.000
Monthly Net Profit	Rp 267.000
Monthly Discount Rate	0,5%
NPV for 36 months	Rp 8.159.296
ROI for 36 months	1.550,23%

Table 3. Internal Rate of Return (IRR)

Initial Investment	Rp 620.034
Monthly Cash Flow	Rp 267.000
Duration	36 bulan
Monthly IRR	43,34%
Discount Rate	0,5%

Table 4. Scenario of Cash Flow Reduction

Cash Flow Reduction	New Cash Flow	New BCR	Status
0%	Rp. 267,000	14.15	Highly Feasible
25%	Rp. 200,250	10.61	Highly Feasible
50%	Rp. 133,500	7.07	Highly Feasible
75%	Rp. 66,750	3.54	Feasible
90%	Rp. 26,700	1.42	Feasible
93%	Rp. 18,690	0.99	Not Feasible

Break-even Point: The project remains feasible up to a cash flow reduction of 92.9%.

This investment project is considered highly financially feasible based on the Benefit-Cost Ratio (BCR) analysis. With an initial investment of Rp. 620,034 and monthly cash flow of Rp. 267,000 for 36 months, the project yields a BCR of 14.15, meaning that every Rp 1 invested will return benefits worth Rp. 14.15. The Present Value of Benefits reaches Rp. 8,776,557, with a positive Net Present Value (NPV) of Rp. 8,156,523, indicating substantial profit potential.

Furthermore, sensitivity analysis results show that the project remains feasible even with a cash flow reduction of up to 92.9%, providing a high safety margin for investors. With a very high return rate and relatively low risk, this project is strongly recommended for implementation due to its potential to deliver significant added value.

4. CONCLUSION

Based on the research findings on the impact of multifunctional folding chairs on work time efficiency, economic aspects, and ergonomic factors at CV. Fixed Interior, the following conclusions can be drawn: The use of multifunctional folding chairs has been proven to improve work time efficiency at CV. Fixed Interior. This is

evidenced by a reduction in standard working time from 678.31 minutes to 441.51 minutes after the use of the chair, representing a 35% improvement. This reduction indicates that the chair helps decrease fatigue, accelerate work processes, and enhance overall labor productivity. From an ergonomic perspective, using the REBA and RULA methods, the posture risk scores dropped from high to medium and low risk categories after the chair's implementation. The chair assists workers in avoiding previously dominant bent or squatting postures during production processes. Economically, the multifunctional folding chair is considered a feasible investment. The Break-Even Point (BEP) is reached with the sale of five units or a revenue of Rp. 15,000,000, with a contribution margin of Rp. 150,000 per unit. The Net Present Value (NPV) of Rp. 8,156,523 indicates a positive net gain, while the Internal Rate of Return (IRR), which exceeds the discount rate, reflects a high investment return. Additionally, the Benefit-Cost Ratio (BCR) of 14.15 shows that the economic benefits far outweigh the costs, making this a profitable and low-risk investment. Based on the research conducted, several recommendations are proposed: CV. Fixed Interior is advised to implement the multifunctional folding chair across its operations due to its proven ability to enhance efficiency and work comfort. The chair design should be further refined using workers' anthropometric data to achieve better ergonomic fit. Furthermore, this chair holds strong potential for commercial product development, given its demonstrated economic feasibility.

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