

Product Design and Business Feasibility Analysis of Extendable Chair

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Abstract

The global outbreak of Covid-19 has caused countries all over the world, including Indonesia to take preventive measures, such as social and physical restrictions. Implementation of these restrictions on public facilities includes prohibiting people to sit on public chairs that are marked with a cross symbol. However, in reality, people often ignore this. In addition, existing public chairs do not have features that support health protocols. These things cause discomfort for most people, hence "Extendable Chair" is designed based on ergonomic aspects as a chair that can be extended and is equipped with several health protocols and user comfort supporting features. Authors also designed the company that will produce extendable chairs while considering and analyzing marketing aspects, technic and technological aspects, managerial and human resources aspects and financial aspects to determine the business feasibility of a company. The main target market for extendable chairs include parks, educational institutions, terminals and shopping centres in DKI Jakarta with a market share of 20%. Based on the analysis done, the company is estimated to earn total revenue of \$419,637.32 in the first year by selling 1,621 units of extendable chairs and some of the production waste. With a Minimum Attractive Rate of Return (MARR) of 15%, the company has an Net Present Value (NPV) of \$24,923.44; Internal Rate of Return (IRR) of 21%; Break Even Point (BEP) at 4,653 units; Benefit/Cost (B/C) ratio of 1.09; and the payback period is 1.997, so it can be concluded that the business is feasible.

Keywords

Covid-19, Extendable Chair, Forecasting, Systematic Layout Planning (SLP), Business Feasibility Analysis

1. Introduction

The emergence of Covid-19 which was determined as a global epidemic by the World Health Organization (WHO), has caused harmful impacts on every country all over the world. Daily activities of the community, especially interactions in public places have the potential to become a means of transmitting Covid-19 (Aprillita et. al. 2021; Joes et.al. 2021). As a response to this, various countries including Indonesia, have taken preventive measures, such as social and physical distancing, as well as regional quarantines, both on a full and limited scale. One implementation of social and physical distancing on public facilities is by prohibiting people to sit on chairs that are marked with a cross symbol. However, in reality, some people often ignore this regulation, especially people who have not been or are less educated about Covid-19 and the health protocols set by the government. This caused inconvenience to other

people in using public chairs during the pandemic. In addition, discomfort is also reinforced by the lack of space between seats and the unavailability of sterilizers. Therefore, the authors designed a product concept "Extendable Chair", which is expected to increase the level of comfort of the people in using public seating facilities.

In this research, the scope of problem mainly focus on the creation of a product design that is hoped to be able to solve existing issues regarding public seating facilities, especially during the Covid-19 pandemic. This research also analyse the sustainability prospect of a business that will focus on the production of extendable chair. A research regarding the creation of a chair design that supports both user comfort and health protocols in particular has not been done thus far, although there are several chair designs that were used as baselines during the designing process.

The objectives in this research will be written in Specific, Measurable, Attainable, Realistic and Timely (SMART) form. All of the authors of this research are involved to accomplish the research's goals to design a product concept "Extendable Chair" and the feasibility analysis of the business activities to produce the product. The designing process was done in Tarumanagara University and the business activities was planned to be executed in Tangerang, Indonesia. This research is conducted in order to solve the public seating issues in Indonesia and to increase the level of comfort of the people in using these facilities. The achievement of the goals of this research can be measured through the development of a product concept that is aesthetically acceptable and can solve existing problems (based on the questionnaire), also when the results of the feasibility analysis show that the business is feasible to run. In order to achieve the goals, the authors have enough resources and capabilities, such as analytical thinking, guidances and information from trusted sources, etc. Each and every single of the authors are committed to achieve the research objectives which are deemed to be realistic and reachable, considering the time, effort and resources dedicated for this research. The research objectives were scheduled to be accomplished by the end of June, 2022.

2. Literature Review

2.1 Market Research

Market research is a systematic design, collection, analysis, and reporting of various data or findings relevant to certain marketing situations faced by the company (Kotler 2012).

2.2 Validity and Reliability Test

Validity test is a test used to determine whether or not the results of a questionnaire are valid. The validity test aims to determine the accuracy of the data reported by the researcher with factual data (Sugiyono 2019). Reliability test is a test used to determine the level of consistency of a measuring instrument used (Sukadji 2000).

2.3 Ergonomic

Ergonomic is a study that learns and applies information about human behaviour along with the capabilities, limitations, and human character in designing an assistive device, machine, activity, work, and environment to increase the level of productivity, safety, comfort, effectiveness, and efficiency (Sanders and McCormick 1993).

2.4 Product Design and Development

Product design and development is a collection of activities, starting from analyzing consumer perceptions of market opportunities, and production processes, to selling and delivering products to consumers (Ulrich and Eppinger 2001).

2.5 Business Feasibility Analysis

Business feasibility analysis is a study to assess the feasibility of an activity plan to be implemented. Business activity is declared feasible to be implemented or developed if it is judged to be able to generate financial benefits according to a predetermined plan (Ichsan et al. 2019).

2.6 Facilities Layout Planning

Factory layout or facility layout planning is a procedure for setting up factory facilities with the aim of supporting the optimization of the production process (Arif 2017). The arrangement carried out will include regulation of the area for placing production support facilities, the best movement of materials, storage of raw materials and products, and others (Sugiyono 2018). All of this is done to minimize the overall total cost, facilitate supervision activities during the production process, and provide convenience in dealing with a future factory or facility expansion plans (Wignjosobroto 2003).

2.7 Financial Analysis

The feasibility of a business activity that is being designed needs to go through a financial aspect analysis first. Several things need to be considered in the financial aspect, including BEP, NPV, payback period, IRR, B/C ratio, and sensitivity analysis (Kasmir and Jakfar 2012).

3. Methods

In the process of planning the extendable chair product design and business activity, there are several steps to take, which are:

- a) Look for references and conduct literature studies from various trusted sources.
- b) Conduct market research by distributing questionnaires to users of public chair facilities, especially during the Covid-19 pandemic to find out complaints and needs of users.
- c) Conduct validity and reliability tests on the results of the questionnaire from the survey conducted.
- d) Determine the order of importance level of the user needs variables from questionnaire results.
- e) Create several product design concepts for an extendable chair that are under ergonomic principles and compiled based on benchmarks, preference results, and user needs to be obtained from questionnaire results.
- f) Compare each product concept with a weighted assessment of each user's needs to determine the selected product concept.
- g) Develop detailed component specifications from selected product concept and finalize the overall product design.
- h) Using QM Windows V5 to forecast the product demand from the year 2021 until the year 2025 based on the accumulation of the target market location from the year 2016 until the year 2020.
- i) Create the company layout using the SLP method.
- j) Create the cash flow to determine the feasibility of the business based on the product demand forecast from the year 2021 until the year 2025.
- k) Conduct sensitivity analysis to determine the feasibility limit of the business being carried out.

The steps described above are then arranged in the form of a flowchart as can be seen in Figure 1.

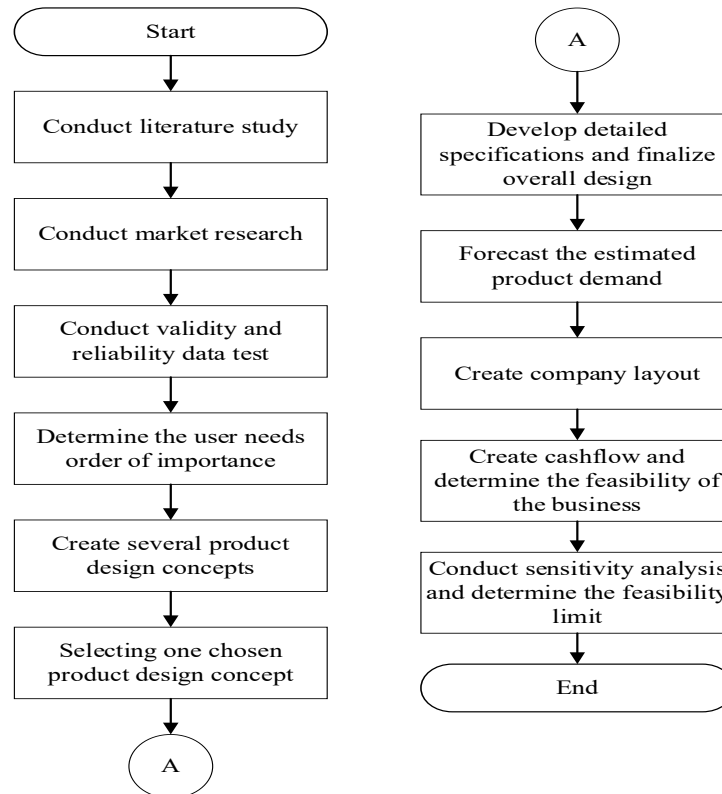


Figure 1. Method Flowchart

4. Data Collection

4.1 Customer Needs

In an attempt to identify the problems regarding public seating facilities and its solution according to the public, authors conducted the first survey in a questionnaire form. This also shows the probability of whether people will purchase the product if the design were to be realized. Results show that 90.5% (out of 137 respondents) are willing to use and purchase the product. A second survey, also in the form of a questionnaire, was then conducted to determine the importance level of the user needs variables. It was distributed to 100 respondents with the results as shown in Figure 2.

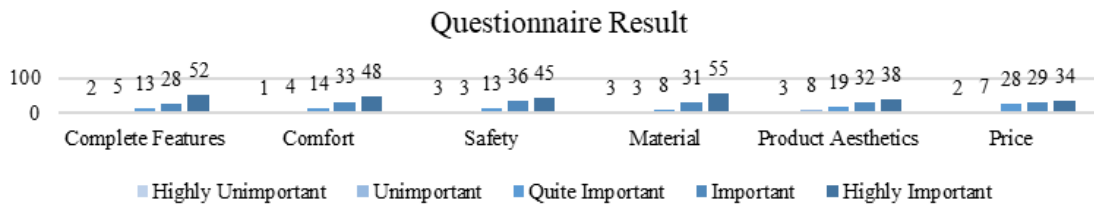


Figure 2. Questionnaire Result (Sylvia et al., 2021)

4.2 Benchmark

In product designing process, benchmarks are needed as a product reference to compare and identify the shortcomings of other similar products. Benchmarking is the continuous search and application of truly better practices, leading to superior competitive performance (Watson 1996). It is carried out to compare the work capability of several equipment with the aim of improving the quality of new products. Benchmark products are shown in Figure 3.

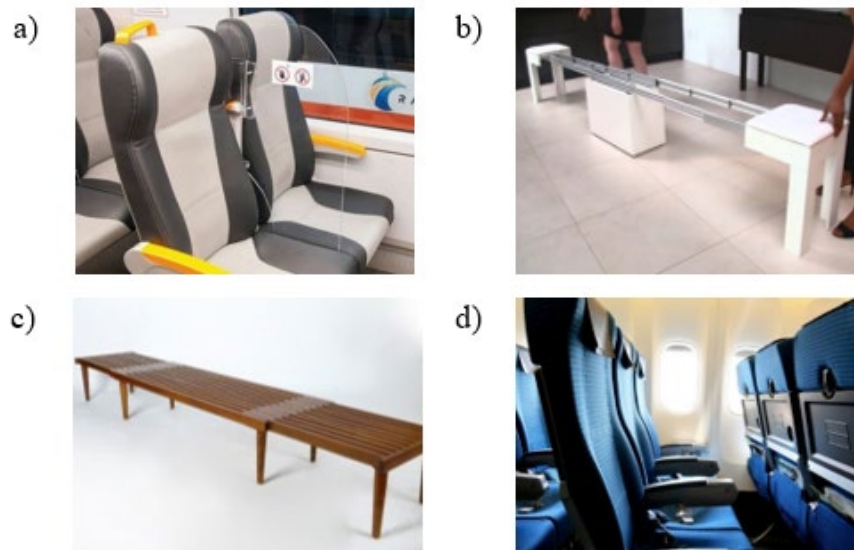


Figure 3. a) Benchmark 1, b) Benchmark 2, c) Benchmark 3, d) Benchmark 4

Based on Figure 3, it can be seen that there are existing public seats that are able to be extended and have several user comfort-supporting features but they have not implemented enough health protocols features. Therefore, extendable chair is designed by using several of the benchmarks' design as baselines to form a comfortable and safe public chair by implementing ergonomic principles and health protocols.

4.3 Forecasting Data

Based on segmentation, position, and the target market, extendable chair will be marketed in DKI Jakarta. The demand projection is based on the accumulation number of parks, educational institutions, terminals, and shopping centres in

DKI Jakarta over the past five years. Data of the parks were obtained from the Indonesian Databoks site, data of the educational institutions were obtained from the Ministry of Education and Culture website, data of the terminals were obtained from the Jakarta data site, and data of the shopping centres were obtained from the Jakarta BPS website. Results of the accumulated target market for extendable chairs can be seen in Table 1.

Table 1. Total Target Market (Sylvia et al., 2021)

Year	2016	2017	2018	2019	2020
Total (Unit)	7,838	8,055	8,760	8,450	8,382

5. Result and Discussion

5.1 Validity and Reliability Test

A validity test needs to be carried out on the results of the questionnaire to determine whether the data obtained are valid or not. The validity test was carried out using SPSS software with the Bivariate Pearson correlation testing technique. The results of the validity test can be seen in Table 2.

Table 2. Validity Test Result (Sylvia et al., 2021)

Variable	Complete Features	Comfort	Safety	Material	Product Aesthetics	Price
R Calculation	0.394	0.389	0.716	0.678	0.497	0.591
R Table	0.195	0.195	0.195	0.195	0.195	0.195
Result	Valid	Valid	Valid	Valid	Valid	Valid

Based on the results of the validity test with a sample of 100 respondents and an R table of 0.195 (significance level of 5%), it can be concluded that the data from the questionnaire for each variable is declared valid. After conducting the validity test, a reliability test was also carried out which indicated the level of reliability of the information obtained. Results of the reliability test carried out using the SPSS software can be seen in Table 3.

Table 3. Reliability Test Result (Sylvia et al., 2021)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.553	0.551	6

Based on results of the reliability test above, it is known that the value of Cronbach's Alpha is 0.553, hence the data is declared reliable.

5.2 Customer Needs Importance Level

The user needs an order of importance level was analyzed using a Likert scale. The analysis results of the user need an order of importance can be seen in Table 4.








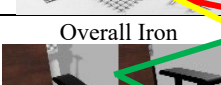

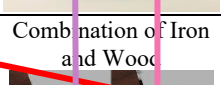









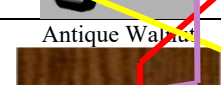


Table 4. Customer's Needs Importance Level (Sylvia et al.,2021)

Variable	Complete Features	Comfort	Safety	Material	Product Aesthetics	Price
Score	84.6%	85%	83.4%	86.4%	77.6%	76.8%
Category	Highly Important	Highly Important	Highly Important	Highly Important	Important	Important

5.3 Morphology Concept

In this section, several alternative options are presented and will be combined into a product concept, forming several product design concepts from the different combinations of available alternatives. The morphology of the extendable chair product design concept can be seen in Table 5.

Table 5. Morphology Concepts (Sylvia et al.,2021)

No.	Aspect	Component	Alternative 1	Alternative 2	Alternative 3
A.	Material	Chair Frame	Hollow Iron 	Stainless Steel 	
B.	Material	Backrest and Seat	Mahogany Wood 	Pallet Wood 	
C.	Material	Basket	Stainless Steel 	Pallet Wood 	Flexiglass Acrylic 
D.	Material	Armrest	Overall Iron 	Overall Wood 	Combination of Iron and Wood 
E.	Material	Partition Screen	Acrylic 	ABS Plastic 	
F.	Form	Backrest and Seat			
G.	Form	Armrest			
H.	Form	Chair Base			
I.	Color	Backrest and Seat	Antique Walnut 	Java 	Brown Mahogany 
			Concept 1	Concept 3	Concept 5
			Concept 6	Concept 4	Concept 2

Based on the morphology concepts, six main concepts will be taken into consideration for the product design. The six concepts will then be further selected according to a comparison of the advantages and disadvantages of each selection criteria, resulting in three selected concepts. The three selected concepts can be seen in Figure 4.



Figure 4. a) Concept 1, b) Concept 2, c) Concept 3 (Sylvia et al.,2021)

5.4 Concept Screening and Assessment

The concept screening and assessment process to select a single chosen concept is done by assigning a weighting value to each criterion for each concept option. The concepts assessment table can be seen in Table 6.

Table 6. Concepts Assessment (Sylvia et al.,2021)

Criteria	Weighted Score	Concept 1		Concept 2		Concept 3	
Complete Features	15%	5	0.75	5	0.75	5	0.75

Comfort	25.2%	3	0.756	3	0.756	5	1.26
Safety	8.8%	5	0.44	3	0.264	5	0.44
Material	43%	5	2.15	5	2.15	5	2.15
Product Aesthetics	5.1%	3	0.153	4	0.204	5	0.255
Price	2.9%	4	0.116	5	0.145	3	0.087
Total	100%		4.365		4.269		4.942
Chosen Concept			No		No		Yes

Based on the concept screening and assessment conducted, the final concept for the extendable chair is concept number three because it has the biggest total value.

5.5 Product Detail and Specification

The chosen concept of an extendable chair is designed to be able to be pulled as far as 50 centimetres from the initial position. The chair frame with two fused legs is made using a material in the form of hollow iron. This chair is equipped with a backrest and a seat connected to a shape following the human posture made using mahogany wood. The mahogany wood will be coated with a wood stain in the "Antique Walnut" colour. This chair concept is also equipped with a rectangular armrest where the handle is made of iron and the seat is made of wood, a partition screen made of acrylic, and a basket made of stainless steel. Chair armrests are divided into two types, permanent armrests and adjustable armrests. There are two adjustable armrests (one for each seat) and are located on the inner side of the seat facing down. Both of these armrests can only be used when the seat is in a retracted position by rotating it upwards so that it is in a parallel position to the permanent armrests.

Creating detailed component specifications from the selected product concept will be done to facilitate the product manufacturing process. In designing the extendable chair, the anthropometric data used as a base is the anthropometric data of Indonesian people in general obtained from the Indonesian Ergonomics Association. The size of extendable chair is determined based on a combination of 95% and 5% percentiles, so it is expected to be used comfortably by most people. The detailed specifications of the extendable chair product components can be seen in Table 7. Meanwhile, the figure of extendable chair with a specific size made through 3D modelling can be seen in Figure 5.

Table 7. Product Components' Specification Detail

No.	Component	Component Description	Dimensions (cm)	Material	Total
1.	Connecting Iron Frame	There are two types of connecting frames with different dimensions but made of the same material	50 x 5 x 5 and 0.8 thick, 100 x 3.4 x 3.4 and 0.6 thick	Hollow Iron	6 and 3
2.	Armrest	There are two types of armrests (permanent and adjustable) with the same dimensions and material	24 x 8 x 19	Hollow Iron and Mahogany Wood	4
3.	Basket	Baskets with an opening on the side and located on the back of the backseat	50 x 9 x 40	Stainless Steel	2
4.	Disinfectant Container	Located on the outer side of each basket, above the automatic hand sanitiser dispenser	10 x 12 x 18	Stainless Steel	1
5.	Partition Screen	Located between the two seats, can be mounted on the chair frame	65 x 0.5 x 67	Acrylic	1
6.	Automatic Hand Sanitizer Dispenser	Located on the outer side of each basket, under the disinfectant container	7.5 x 12 x 19	ABS	1

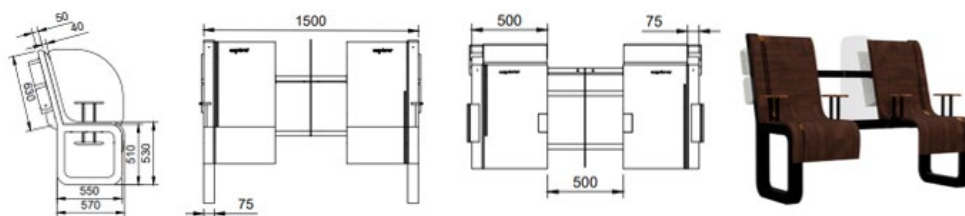


Figure 5. Extendable Chair

5.6 Forecasting

Based on the results of the forecasting error calculation that has been done, it is known that the quadratic regression method has the smallest error value overall. Therefore, the quadratic regression method is used to forecast the number of parks, educational institutions, terminals, and shopping centres in DKI Jakarta in the following years. Based on the data forecasting number of parks, educational institutions, terminals, and shopping centres, it is assumed that the market share of extendable chair is 20%. The assumption is taken into consideration that the extendable chair is a new product that has not yet been known by the general public. This assumption is also taken by considering the production capacity and initial capital of the company so that there is no case of overproduction. The results of the forecasting demand for extendable chairs and the market share can be seen in Table 8.

Table 8. Product Demand Forecast and Market Share

Year	2021	2022	2023	2024	2025
Demand Forecast (Unit)	8,107	7,620	6,951	6,101	5,070
Market Share 20% (Unit)	1,621	1,524	1,390	1,220	1,014

5.7 Organizational Structure

Organizational structure is a framework of composition and relationship between different tasks, authorities, and responsibilities in carrying out activities to achieve organizational goals. The organizational structure helps in carrying out management functions in an organization/company and supports work effectively with minimum complexity (Tewal et al. 2017). The organizational structure set by the company can be seen in Figure 5.

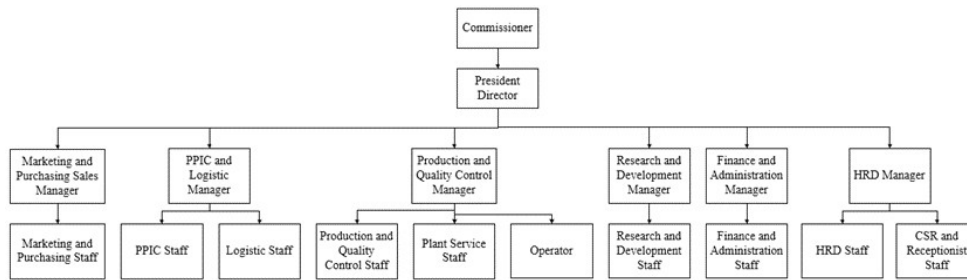


Figure 5. Organizational Structure

5.8 Systematic Layout Planning

The first step in designing the company's layout is to create a Multi-Product Process Chart (MPPC). MPPC is a chart of information about the flow of materials or components through various processes. The MPPC of the extendable chair can be seen in Table 6.

Table 6. MPPC

Component	Backrest and Seat	Adjustable Armrest	Permanent Armrest	Chair Frame and Base	Larger Connecting Iron	Smaller Connecting Iron	Basket	Disinfectant Container	Partition Screens	Assembled Extendable Chair	
Measuring Table	○	○	○	○	○	○	○	○	○		
Marking Table	○	○	○	○	○	○	○	○	○		
Chainsaw	○	○	○	○	○	○	○	○	○		
Grinder	○	○	○	○	○	○	○	○	○		
Inspection Table	○	○	○	○	○	○	○	○	○		
Adjustment Table	○	○	○	○	○	○	○	○	○		
Hand Drill	○	○	○	○	○	○	○	○	○		
Carving Tool	○	○	○	○	○	○	○	○	○		
Wood Planer	○	○	○	○	○	○	○	○	○		
Bending Machine	○	○	○	○	○	○	○	○	○		
Electric Welding Machine	○	○	○	○	○	○	○	○	○		
Sanding Machine	○	○	○	○	○	○	○	○	○		
Assembly Table	○	○	○	○	○	○	○	○	○	○	
Gluing Table	○	○	○	○	○	○	○	○	○	○	
Painting Table	○	○	○	○	○	○	○	○	○	○	
Steps	22	18	16	26	12	12	12	12	12	0	142
Least Steps	13	10	9	10	2	4	7	7	4	0	66
											47%

After constructing the MPPC, the next step is to create a From to Chart (FTC) and then continued with an Activity Relationship Chart (ARC). An ARC is a graph that is arranged to indicate the relationship of certain activities so that it can be determined which activities must be put close to one another and activities that must be put far apart in a facility layout design (Jamaludin et al. 2020). Subsequently, an Activity Relationship Diagram (ARD), which is a diagram that indicates the relationship between each activity based on the level of proximity and priority scale, was created. The company's ARC and ARD can be seen in Figure 7.

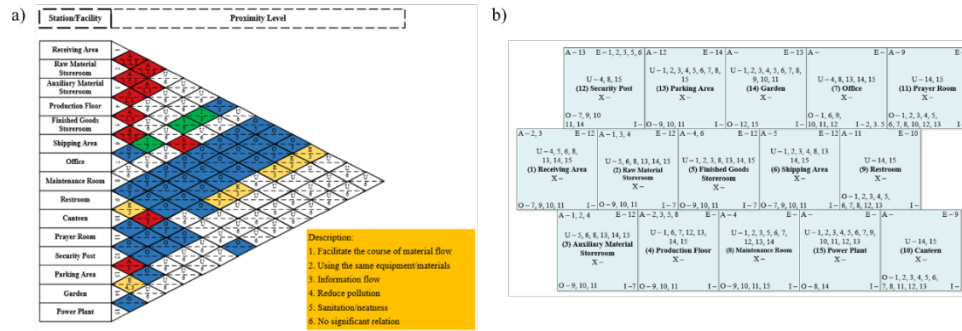


Figure 7. a) ARC, b) ARD

After constructing the company's ARC and ARD, the next step is to create an Area Allocation Diagram (AAD) which is a global layout depicting the close relationship between departments with the actual floor area size scale. The company AAD can be seen in Figure 9.

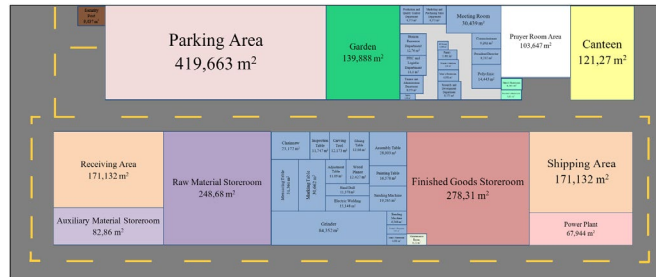


Figure 9. AAD

The last step is to arrange the company layout based on the ARC, ARD, and AAD that have been created. The company layout can be seen in Figure 10.



Figure 10. Company Layout

5.9 Business Feasibility Analysis

Business feasibility analysis needs to be conducted in order to find out whether or not a company is appropriate to be established, based on financial aspects that include every cost calculation. Business feasibility analysis is carried out using a cash flow to calculate the time to reach the BEP based on product units. BEP is a state where the company makes neither profit nor loss after calculating the profit and loss for a certain period of time (Rusdiana 2014). With a MARR value of 15%, calculations to determine the NPV, IRR, B/C ratio, and payback period values are also conducted. The company's business feasibility analysis can be seen in Table 9 to Table 11.

Table 9. Cashflow

	2020	2021	2022	2023	2024	2025
Gross Profit						
Product Sales Income		\$418,272	\$393,243	\$358,666	\$314,801	\$261,646
Other Income		\$1,366	\$1,284	\$1,171	\$1,028	\$854
Total Income		\$419,637	\$394,526	\$359,837	\$315,828	\$262,500
Fixed Cost		\$213,732	\$213,946	\$214,160	\$214,374	\$214,588
Variable Cost		\$45,262	\$42,554	\$38,812	\$34,065	\$28,313
Total Cost		\$258,994	\$256,500	\$252,972	\$248,439	\$242,902
Gross Profit		\$160,643	\$138,027	\$106,865	\$67,389	\$19,598
General Cost						
Promotion Cost		\$8,393	\$7,891	\$7,197	\$6,317	\$5,250
CSR Cost		\$4,196	\$3,945	\$3,598	\$3,158	\$2,625
Total General Cost		\$12,589	\$11,836	\$10,795	\$9,475	\$7,875
Total Profit		\$148,054	\$126,191	\$96,070	\$57,914	\$11,723
Tax						
Earning Before Tax		\$148,054	\$126,191	\$96,070	\$57,914	\$11,723
Tax		\$9,253	\$7,887	\$6,004	\$3,620	\$733
Earning After Tax		\$138,801	\$118,304	\$90,066	\$54,295	\$10,991
Cashflow Projection						
Earning After Tax		\$138,801	\$118,304	\$90,066	\$54,295	\$10,991
Salvage Value						\$3,665
Investation	-\$277,216					
Net Cashflow	-\$277,216	\$138,801	\$118,304	\$90,066	\$54,295	\$10,991
Cash Accumulation	-\$277,216	-\$138,416	-\$20,111	\$69,954	\$124,249	\$135,239

Table 10. BEP Calculation

Total Fixed Cost	Variable Cost/Unit	Price/Unit	BEP
\$1,070,800	\$28	\$258	4,653

Table 11. Financial Analysis Result

MARR	NPV	IRR	BEP	B/C Ratio	Payback Period
15%	\$24,923	21%	4,653	1.090	1.997

Based on Table 10 and Table 11, it is known that the company will reach the BEP at 4,653 units, with NPV > 0, B/C Ratio > 1, IRR > MARR and has a payback period of 2 years. Therefore, the business is concluded to be feasible to run. After conducting the business feasibility analysis, the next step is to conduct a sensitivity analysis to determine the limits of the feasibility of the business being carried out. It is used to re-analyze in order to see the effects that will occur as a result of changing circumstances, influenced by several variables including material prices, increases in costs or sales and reduced costs or revenues (Aisyah and Fachrizal 2020). The results of the company's sensitivity analysis can be seen in Table 12.

Table 12. Sensitivity Analysis

Information	MARR	NPV	IRR	B/C	Payback Period	Analysis
Material Price Increase 25%	15%	-\$787.262	15%	0.997	2.156	Business not Feasible (NPV<0, IRR<MARR B/C<1)
General Cost Increase 85%	15%	-\$248.880	15%	0.999	2.153	Business not Feasible (NPV<0, IRR<MARR B/C<1)

Total Cost Increase 4%	15%	-\$2,738.734	14%	0.990	2.147	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Profit Loss 3%	15%	-\$3,802.620	14%	0.986	2.177	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Increase 5%, Profit Loss 2.5%	15%	-\$4,157.084	14%	0.985	2.179	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Increase 10%, Profit Loss 2%	15%	-\$4,511.548	14%	0.984	2.182	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Increase 15%, Profit Loss 1%	15%	-\$78.334	14.98%	0.999	2.152	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Increase 20%, Profit Loss 0.5%	15%	-\$432.798	14.90%	0.998	2.154	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Decrease 5%, Profit Loss 3.5%	15%	-\$3,448.157	14%	0.988	2.174	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Decrease 10%, Profit Loss 4%	15%	-\$3,093.693	14%	0.989	2.172	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Decrease 15%, Profit Loss 4.5%	15%	-\$2,739.229	14%	0.990	2.170	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Decrease 20%, Profit Loss 5%	15%	-\$2,925.791	14%	0.989	2.171	Business not Feasible (NPV<0, IRR<MARR, B/C<1)
Material Price Decrease 25%, Profit Loss 5.5%	15%	-\$2,571.327	14%	0.991	2.168	Business not Feasible (NPV<0, IRR<MARR, B/C<1)

5.10 Discussion

According to Kotler (2012), market research is one of the most important things that must be done to discover current market conditions that the company will face. Therefore, in this research, market research has been carried out systematically through a survey in the form of a questionnaire. The results of the questionnaire will then be tested to prove their validity and reliability. In accordance to Sugiyono (2019) regarding the data validity requirements, the tests that have been carried out show that the questionnaire results are valid with each calculated R value > R table value (0.195). A reliability test was also carried out based on the provisions of Sukadji (2000), where the data was declared reliable when the calculated value of Cronbach's Alpha (0.553) > R table (0.195).

After discovering the market conditions and needs, authors designed the extendable chair as a solution to existing problems in accordance with the ergonomic principles presented by Sanders and McCormick (1993), namely using anthropometric data from Indonesian people with a combination of 5% and 95% percentiles. In the product design process, authors carry out a series of activities ranging from analyzing consumer perceptions of market opportunities, production processes, to selling and delivering products to consumers as described by Ulrich and Eppinger (2001).

In accordance to Arif (2017), the facility layout design process is carried out to optimize the production process during the company's activities. The design is carried out while considering various production supporting factors, as revealed by Sugiyono (2018). The layout design is done using the SLP method which consists of composing MPPC, FTC, ARC, ARD, AAD and ends with the creation of the company layout as a whole. According to Wignjosobroto (2003), all of this is done to minimize overall costs and support the company's current as well as future activities.

After designing the product and business, authors conducted a business feasibility analysis to determine the viability of the business as stated by Ichsan et al. (2019), and this is done by conducting a financial analysis as presented by Kasmir and Jakfar (2012). According to Kasmir and Jakfar (2012), a business can be said to be feasible if the NPV > 0; IRR > MARR; the B/C Ratio is positive; and the BEP is below the project age. With a MARR of 15%, NPV of \$24,923.44; IRR of 21%; BEP at 4,653 units; B/C ratio of 1.09; and payback period value of 1.997, it can be concluded that the business is feasible.

6. Conclusion

Several conclusions can be drawn based on the analysis and discussion that have been discussed previously, namely:

- a. Based on the results of the validity test with a sample of 100 respondents and an R table of 0.195 (significance level 5%), it can be concluded that the entire R calculations are greater than the R table, hence each variable is declared valid. Meanwhile, the reliability test carried out resulted in a Cronbach's Alpha value of 0.553, hence the data was declared reliable.

- b. Based on the results of the user needs an order of importance calculation using a Likert scale, it is known that the order of user needs based on the level of importance is material, comfort, completeness of features, security, product aesthetics, and price.
- c. After carrying out the morphological process and concept selection, a selected concept of an extendable chair was obtained which was designed based on ergonomic aspects and equipped with several features supporting the health protocols and user comfort.
- d. Forecasting product demand for the next 5 years is forecasted using the quadratic regression method based on the data of the main target market which includes parks, educational institutions, terminals, and shopping centres in DKI Jakarta over the past five years. Product forecasting results for the year 2021-2024 with a market share of 20% are 1,621; 1,524; 1,390; 1,220; and 1,014 units.
- e. The company has 41 employees, consisting of 16 office workers, 9 plant service workers, and 16 operator workers.
- f. The company layout is arranged using the SLP method based on the number of product demand, number of machines needed, number of operators and employees, MPPC, FTC, ARC, ARD and AAD.
- g. The company earned a total revenue of \$419,637 in the first year by selling 1,621 units of extendable chair products and waste products. With a MARR of 15%, the company has an NPV of \$24,923; IRR of 21%; BEP at 4,653 units; B/C ratio of 1.09; and a payback period of 1.997, so it can be concluded that the business is feasible to run.

References

- Aisyah, Siti and Muhammad Hanif Fachrizal, Analisis Finansial dan Sensitivitas Penggilingan Padi, *Paradigma Agribisnis*, vol. 3, no. 1, pp. 53, 2020.
- Arif, Muhammad, *Perancangan Tata Letak Pabrik*, Deepublish, Yogyakarta, 2017.
- Aprillita, M., Atmodjo, C., Kartawijaya, M., Adrian, N., Jusuf, F., Daywin, L. G., ... & Irawan, A. P. An Ergonomic Approach to Design Restaurant Dining Table During the Covid-19 Pandemic for Indonesian Society. *Eye*, 60(78.1), 95-28. (2021).
- Ichsan, Reza Nurul, Lukman Nasution and Sarman Sinaga, *Studi Kelayakan Bisnis: Business Feasibility Study*, Sentosa Deli Mandiri, Jakarta, 2019.
- Jamaludin, et al., Metode Activity Relationship Chart (ARC) untuk Analisis Perancangan Tata Letak Fasilitas pada Bengkel Nusantara Depok, *Bulletin of Applied Industrial Engineering Theory*, vol. 1, no. 2, 2020.
- Joes, S., De Candra, C., Larsen, H., Marchello, D., Daywin, F. J., Gozali, L., ... & Irawan, A. P. The design development of an ergonomic public trash bin for COVID-19 medical mask waste. In *11th Annual International Conference on Industrial Engineering and Operations Management, IEOM 2021* (pp. 2756-2769). (2021).
- Kasmir and Jakfar, *Studi Kelayakan Bisnis*, Kencana, Jakarta, 2012.
- Kotler, Philip, *Marketing Management*, Pearson Education, United States of America, 2012.
- Rusdiana, A, *Manajemen Operasi*, Pustaka Setia, Jakarta, 2014.
- Sanders, Mark S. and Ernest McCormick, *Human Factors In Engineering and Design*, McGraw Hill Education, United States of America, 1993.
- Sugiyono, Andre, *Buku Ajar Perencanaan Tata Letak Fasilitas*, Universitas Islam Sultan Agung, Semarang, 2018.
- Sugiyono, *Statistika untuk Penelitian*, CV Alfabeta, Bandung, 2019.
- Sukadji, S, *Psikologi Pendidikan dan Psikologi Sekolah*, LPSP3 Fakultas Psikologi Universitas Indonesia, Jakarta, 2000.
- Tewal, Bernhard, et al., *Perilaku Organisasi*, CV. Patra Media Grafindo, Bandung, 2017.
- Ulrich, Karl T. and Steve D. Eppinger, *Perancangan Pengembangan Produk*, Salemba Teknika, Jakarta, 2001.
- Watson, G.H., *Strategic Benchmarking: How to Rate Your Company's Performance Against The World's Best*, Gramedia Pustaka Utama, Jakarta, 1996.
- Wignosoebroto, S., *Tata Letak Pabrik dan Pemindehan Bahan*, Guna Widya, Surabaya, 2003.

Biographies

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Lina Gozali is a lecturer at the Industrial Engineering Department of Universitas Tarumanagara since 2006 and a freelance lecturer at Universitas Trisakti since 1995. She graduated with her Bachelor's degree at Trisakti University, Jakarta - Indonesia, then she got her Master's Degree at STIE IBII, Jakarta – Indonesia, and she recently got her Ph.D. at Universiti Teknologi Malaysia, Kuala Lumpur – Malaysia in 2018. Her apprentice college experience was in paper industry at Kertas Bekasi Teguh, shoes industry at PT Jaya Harapan Barutama, and automotive chain drive industry at Federal Superior Chain Manufacturing. She teaches Production System and Supply Chain Management Subjects. She did a research about Indonesian Business Incubator for her Ph.D. She has written almost 70 publications since 2008 in the Industrial Engineering research sector, such as Production Scheduling, Plant Layout, Maintenance, Line Balancing, Supply Chain Management, Production Planning, and Inventory Control. She had worked at PT. Astra Otoparts Tbk before she became a lecturer.

Wilson Kosasih was born in Medan, North Sumatra, Indonesia, Dec 2nd 1980. He is a lecturer in the Department of Industrial Engineering at Faculty of Engineering, Universitas Tarumanagara. Since 2005 conducted teaching, research and has served as Industrial Engineering Undergraduate Chairman since 2018 until now. He completed his Undergraduate Mechanical Engineering Education at Universitas Tarumanagara, obtained a Master Degree in Industrial Engineering at the Universitas Indonesia and is currently taking a Doctoral Program at the Institut Teknologi Sepuluh Nopember with a concentration in Industrial Management. Holders of professional certification in the field of supply chain and logistics, Certified Supply Chain Manager (CSCM) and Certified Professional in Logistics Management (CPLM) from ISCEA, USA, certification for Professional Engineer (IPM) from PII, and ASEAN Engineer certification from AFEO. He worked in a multinational company in the FMCG field before becoming a full-time lecturer since 2009. He has professional experience and consultant in the field of Productivity and Quality Engineering. Since becoming a lecturer, he has been active in research, scientific publications and community service by obtaining grants from within and outside Untar, such as from the Ministry of Research, Technology and Higher Education. His research field are Lean Manufacturing, Quality Engineering, and Supply Chain Management. In addition, he is also active in professional organizations, currently as a member of the Industrial Engineering Professional Engineer Competency Appraisal Council at BKTII PII.

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