Economic Impact Analysis Versus Investment Analysis: Cast-Bike Frame Manufacturing from Recycled Aluminum Alloy

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Abstract

This paper discusses the economic impact and investment of cast bicycle production on human resources, the estimated annual production of the product, the use of materials, and the production process. Human resources will be reviewed in the labor sector and labor productivity trends. The amount of investment that must be passed to achieve the Break-Even Point (BEP) for cast-bike products is also explained. On the other hand, the material used to produce this cast-bike is also discussed, which is sourced from recycled metal and the production process is carried out through simple metal casting techniques. Bicycle frame innovation from recycled aluminum alloy is interesting to study. There are two advantages, such as a simple production process and the use of recycled materials. As a result, the selling value of bicycle products is cheaper than other bicycles. The cast-bike from the aluminum recycled production process is also discussed in detail, starting from the design, simulation of stresses caused by loading conditions, material availability, and the production process. The result is a trend of labor productivity of around 24.27 thousand USD/worker and labor productivity of 2.96 percent/year. The total BEP of the cast-bike reached 400 units. The materials used and the production process can reduce the selling price of the product so that it has a significant impact on the economic development of the domestic community.

Keywords: Economic impact analysis, Cast-bike, Metal recycling, Metal casting techniques.

1. Introduction

Bicycles are an environmentally friendly means of transportation. The use of bicycles today is immensely evolved along with reducing air pollution and reducing fossil fuel uses. The development of bicycle frames is currently increasing, especially in the field of materials used. Some research on the materials used to make bicycle products lighter, on the other hand, the development of bicycle designs that are comfortable for the rider. Today's bicycle frames are made of pipe-shaped aluminum alloy. Aluminum pipe is made using the extrusion method [1]. The line was cut into pieces then assembled to form a bicycle frame using the welding method [2].

The problem is that the primary failure of the bicycle frame generally occurs in the main material (pipe) or the weld area because that area receives the most significant load. Furthermore, the welding filler material used is usually different from the base metal of the bicycle frame, so the failure is usually not in the position of the weld area, but the failure occurs in the primary pipe material around the weld area [3]. The loss happens because the heat generated during welding changes the properties of the base metal to be lower than before welding, resulting in changes in the grain structure of the metal. Welding technology, especially aluminum, is generally only used in large industries or large-scale bicycle assembly industries and does not develop in small enterprises. In addition, equipment for welding aluminum is quite expensive. On the other hand, market saturation for pipe frames is also affected. Therefore, it required research and development of new designs for bicycle frames without welding, and it presents them through cast bicycle innovation with production methods through metal casting technology.

The advantages of this innovation include that aluminum metal is quickly melted by small industries (home industries) because the melting point of aluminum is lower than other metal materials. The bicycle frame, made using metal casting techniques, integrates without any joints between the parts. The material used is recycled aluminum, where the raw material can be in any form; it doesn't have to be pipe metal. The new innovative design of this bicycle frame product has a "T" and "I" cross-section so that it can be produced through metal casting techniques. As with metal casting technology, bicycle frame products are easy to manufacture in large quantities, repeatedly with the exact dimensions and shapes.

The purpose of this paper is to analyze the economic impact and investment of cast-bike production on the labor sector, trends in labor productivity, the value of investment to achieve BEP, the number of workers employed, the number of cast-

bike produced per year, the use of recycled materials, and the production process by simple metal casting.

2. Methodology

The methodology used in this economic impact analysis is from a literature review. To specify the research scopes, the literature review focuses on labor productivity, investment analysis of cast bicycles from recycled metal, analysis of economic impacts, use of materials, and production processes so that products in low prices. Therefore, the economic analysis discussed in this paper is the analysis of investment/cost-benefit assessment and analysis of the economic impact of production/economic impact analysis [4].

The literature reviewed in this paper includes case studies, best practices, journal articles, government documents, and other website articles that are also the reading sources to ensure gray areas and comprehensive data considerations.

3. ASEAN Labor Productivity

The metal casting industry is one of the businesses that have a strategic role in the structure of the national economy, especially in supporting transportation products, the metalworking industry, and other industries. Metal casting products are included in the increasing demand for production in small enterprises. Most of these products are transportation components, one of which is made of non-ferrous metals such as aluminum. This condition is undoubtedly encouraging because it will increase income for small industries [5].

However, the increasing level of competition in the automotive component market, especially from imported products, follows the agreement of the economic ASEAN community/MEA and the ASEAN-China free trade/ACFTA. So that many component products from the ASEAN region and China invaded Indonesia at lower prices, both officially and illegally [6]. Based on the Indonesian statistics agency/BPS, the three largest imported non-oil and gas goods suppliers during January-December 2019. China occupied the first rank with a value of USD 44.58 billion (29.95 percent), Japan occupied the second at USD 15.59 billion (10 .47 percent), and lastly, Thailand USD 9.41 billion (6.32 percent). Non-oil and gas imports from ASEAN were USD 29,291.9 (19.68 percent), while from the European Union were USD 12,344.5 (8.29 percent) [7]. As a result, it hurts the domestic automotive industry, especially for the local metal casting industry.

If you look at the trend of labor productivity of ASEAN countries, especially productivity per worker in 2018, the total is 24.27 (thousands of USD). The data show that there is a considerable variation between countries. According to the Asian Productivity Organization (APO), labor productivity is 2.96 percent (average) per year for each country in ASEAN. Thailand recorded the highest average annual growth rate of 3.44 percent per year. The data was recorded in the period 1971 to 2018 [6].

3.1. Investment Aspect Analysis

The analysis of the financial aspects for bicycle production consists of calculating the overall cost of the bicycle frame production project. In addition, the calculation is estimating the working capital needed, determining funding sources, profit and loss projections, and cash flow projections/predictions. Therefore, several indicators apply, such as Break-Even Point (BEP), Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit-Cost Ratio (Net B/C), Pay Back Period (PBP), and sensitivity analysis.

The break-even point is a way to determine the level of bicycle production where sales of bicycle products are the same as other costs. If the sale proceeds must be above the return point/BEP, the BEP value can be calculated by Equation 1, which can obtain the profits. [8]. The essence of this BEP study is to present the fact that the production value or sales level, if it cannot exceed this point, the project in question will not make a profit. Based on the calculation results of Eq. 1, the company must produce 400 units of recycled bicycles to achieve BEP.

$$Q(BEP) = \frac{Fixed\ cost}{price/units - variable\ cost/units}$$
$$BEP\ Sales = \frac{Fixed\ cost}{1-(Variable\ cost/Sales\ cost)} \quad (1)$$
$$Percentage = \frac{BEP\ Sales}{Total\ sales\ income}\ x\ 100\%$$

The net present value is the difference between current and current expenditure prices at a specific interest rate; the NPV is obtained through Eq. 2 [9].

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \quad (2)$$

B_t is the gross benefit of the recycled frame production project in year *t*, C_t is the gross cost of the project in year *t*, *n* is the project's economic life, and *i* is the social opportunity cost of capital (discount rate). If NPV > 0, then the project is declared running; if NPV = 0, then the project returns the social opportunity cost of capital (discount rate), whereas if the NPV < 0, producers will reject the project.

The porpuses' internal rate is to find the interest rate that equates to the present value of the expected cash flows in the future, provided that the profits earned per unit time are reinvested (calculated by Eq. 3). Thus, IRR is the interest rate that produces an NPV equal to zero [10].

$$IRR = i_1 + \frac{NPV_1}{NPV_1 + NPV_2} \; x \; (i_2 - i_1) \quad (3)$$

NPV_1 is negative *NPV* at interest rate i_1, and NPV_2 is positive *NPV* at interest rate i_2. Therefore, if the IRR is greater than the prevailing interest rate (*IRR* > *i*), then the recycled bicycle frame production project is declared continued. At the same time, if *IRR* < *i*, then the recycled bicycle frame production project is announced discontinued.

The net benefit-cost ratio compares the total present value of the net profit to the current value of net costs [11]. Thus, if Net *B/C* > *1*, then the project is declared feasible; net *B/C* = *1* means that the recycled bicycle frame production project reaches the break-even point. And if net *B/C* < *1*, then the recycled bicycle frame production project is declared unfeasible (net *B/C* can be calculated through Eq. 4).

$$Net\ B/C = \frac{\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} (for\ B_t - C_t > 0)}{\sum_{t=0}^{n} \frac{C_t - B_t}{(1+i)^t} (for\ B_t - C_t > 0)} \quad (4)$$

The payback period is the time required to be able to return the investment capital. The choice is usually for a recycled bicycle frame production project with the shortest payback period, calculated through Eq. 5 [12].

$$PBP = \frac{Initial\ investment}{Periodic\ income} \; x\ 1\ year \quad (5)$$

Sensitivity analysis aims to determine the effect of certain factors on financial analysis. This sensitivity analysis can determine how far the recycled bicycle frame production project is still feasible if there are changes to specific parameters. For example, an increase in the cost of raw and auxiliary materials will decrease the selling price of products, etc.

3.2. Economic Impact Analysis

The methodology is an essential part of assessing the economic impact of a technology product. First, investigate strengths and weaknesses in economic impact to develop best practice guidelines to identify priority benefits and reduce side effects. For example, the activities of the bicycle industry can be expected to impact various fields of development, including the economic sector. The indicators used are the number of workers, companies, income, and production [13].

This innovation aims to grow a small-scale metal casting industry (home industry) in making bicycle frame products, improving the community's economy. EIA is a method developed to estimate how a project will impact economic growth at the local, regional and national scale. The basis for developing this method is based on Keynesian income determination theory and Leontief's input-output (*I-O*) multiplication [14].

The basis of reference for developing the I-O model is the interconnection of various sectors in an economy. This interconnection can be analyzed by forecasting economic output, employment, labor income, and tax revenue derived from a project. The result is then classified based on the effect, such as direct effects, indirect effects, and induced effects. The immediate impact is the project's production value, while the indirect impact is the purchase of equipment and supplies needed for the project. Finally, the induced effect is the purchase made by the project employee on the consumer of the product. The economic impact analysis indicators assessed in this paper are presented in Table 1.

Table 1. Economic impact analysis indicators.

No.	Indicator	Number	Ref.
1	Number of domestic bicycle companies	Five companies	[15]
2	Number of human resources	Estimated 1,500 people	-
3	Production quantity	3-3,5 (IRD million units/year)	[16]

Table 2. The number of employees and total production of five bicycle companies.

No.	Companies	Number of employees	Total production
1	PT Insera Sena, **Polygon**	370 [17]	1 million units/year [18]
2	PT Terang Dunia Internusa, **United**	-	600 million units/year [19]
3	PT Wijaya Indonesia Makmur Bicycles Industries, **Wimcycle**	297 [19]	800 thousand units/year [20]
4	PT Roda Pasifik Mandiri, **Pacific**	-	750 thousand units/year [21]
5	PT Roda Maju Bahagia, **Element**	-	400 thousand units/year [21]

Five domestic bicycle manufacturers are PT Insera Sena, which produces Polygon bicycles; PT Terang Dunia Internusa, which has United bicycles; PT Wijaya Indonesia Makmur Bicycles Industries, which makes Wimcycle bicycles, PT Roda Pasifik Mandiri, which produces Pacific bikes, and PT Roda Maju Bahagia which has Element bicycles [15]. The demand for bicycles in the Indonesian domestic

market reaches approximately 8 million units. According to the Indonesian bicycle industry association/AIPI, this need can be met by domestically produced bicycles of around 3 - 3.5 million units per year [16]. Figure 1 and Table 2 show the number of employees working and the number of bicycles produced per year from several bike companies.

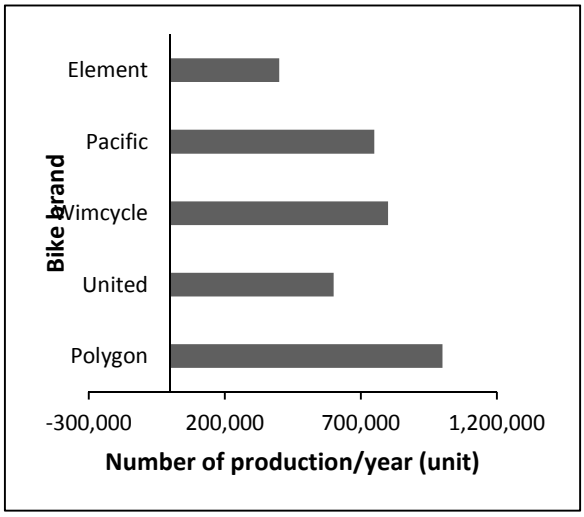


Figure 1. The number of bicycles produced by several companies.

4. Cast-Bike Materials and Fabrication Process

4.1. Material Bike Frame

The bicycle frame is the main component that dramatically affects the price of a bicycle. Several materials are often used as materials for producing bicycle frames. For example, Hi-Ten steel is a material made of steel [22]. The advantages: the price is low, reasonable, and sturdy, the value of elasticity is high so that the frame will bend first before breaking, easy to repair—the disadvantage: heavier, easy to corrosion, so it needs to be coated with paint.

The bicycle frame is called Chromoly; this frame is made of steel that uses an alloy with chromium and molybdenum materials [23]. Better quality than Hi-Ten steel frame. The advantages: more robust and lighter than Hi-Ten steel frames and more corrosion resistant. The disadvantage: slightly heavier than aluminum alloy.

Aluminum bicycle frames have become one of the most popular in the community now, both from beginners to professionals. The most common aluminum alloy frames are of two types, such as 6061 and 7005 series aluminum [24]. The difference between the two aluminum is the mixture of materials used, such as alloying with magnesium, silicon, and zinc. The advantages: lighter than a steel bicycle frame, the material is readily available at a low price, easy to shape to make it more aerodynamic, welded joints can be made smooth, invisible, strong, and anti-corrosion. The disadvantage: more brittle so that if it is impacted, it will be broken shortly; the aluminum frame has a lifetime from 5 to 10 years. The quality and durability will decrease over time.

Carbon-fiber bicycle frames are the lightest weight compared to other types of frames [25]. Carbon-fiber bicycle frames are suitable for bicycles that require acceleration and speed, such as racing bicycles. The manufacturing process is quite complicated and requires high accuracy, but it can be shaped according to the preferences depending on the manufacturer's creativity. Carbon bicycle frames have good durability and resistance, so they are light enough and strong and easily damaged and broken. The advantages: light, easy to shape for aerodynamic and futuristic shaped, no welded joints because it is made with carbon fiber molds. Disadvantages: the manufacturing process is complicated and requires high accuracy, easy to crack or break if dropped/impact by hard materials.

Titanium bicycle frames are relatively more expensive than other structures but are as strong as steel and lighter than aluminum alloys [26]. In addition, the titanium frame is anti-corrosion, so the frame is generally unpainted. The disadvantage is that the raw material availability in the market is challenging to obtain, so the price is relatively higher. In addition, the structure usually is not coated with paint, so the colors seem more straightforward and monotonous.

4.2. Production Process

Figure 2. Recycled aluminum alloy: (a) used cans, (b) used profiles, (c) used engine pistons, and (d) used pans [27].

Garbage in all regions and even worldwide is currently a significant problem; many programs are made to reduce waste disposal. One of them is the waste recycling program that is promote carried out. Waste is divided into two main categories: organic waste and inorganic waste. Meanwhile, metal waste is one of the inorganic wastes because it is difficult to decompose. Used aluminum alloy: soft drink cans,

used pans, used pistons, and aluminum profiles can be recycled into some products, as shown in Figure 2.

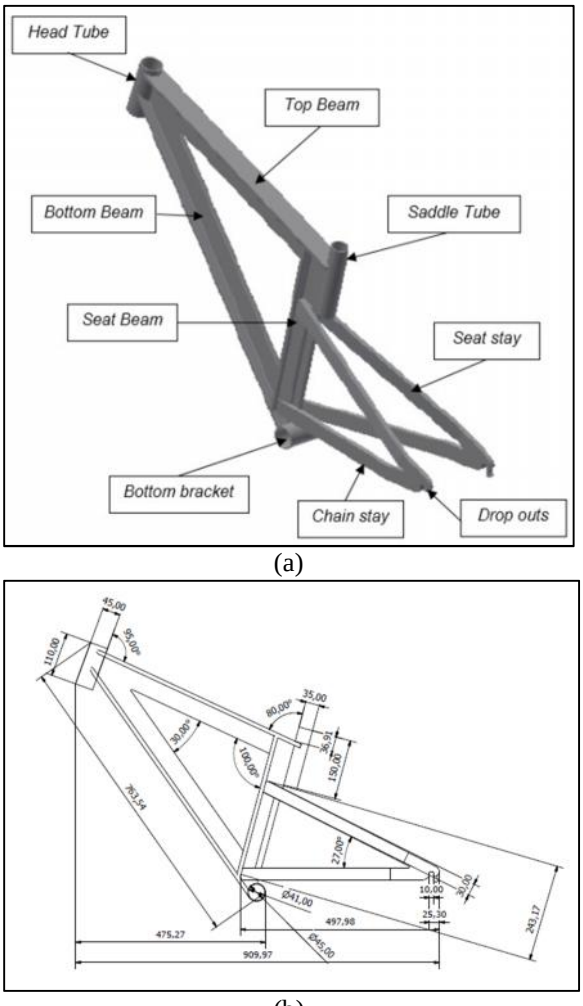
(a) (b) (c)

Figure 3. Simple metal melting furnace with fuel: (a) charcoal, (b) waste oil/diesel fuel, (c) LPG gas [27-29].

The active development of science and technology today can support the development of the latest research. For example, recycling aluminum waste alloy can be done through simple smelting and metal casting techniques. Three main tools are used to make a cast metal product: the metal smelting furnace, the materials used, and the mold. The mold is used as a molten metal molding container where the cast cavity corresponds to the desired final shape of the product. Simple metal melting furnaces can also be built quickly and cheaply. They are melting furnaces using charcoal, melting furnaces using waste oil/diesel fuel, and melting furnaces using liquefied petroleum gas (LPG) as fuel, it is shown in Figure 3.

4.3. Cast-bike Frame Produce by a Recycled Aluminum

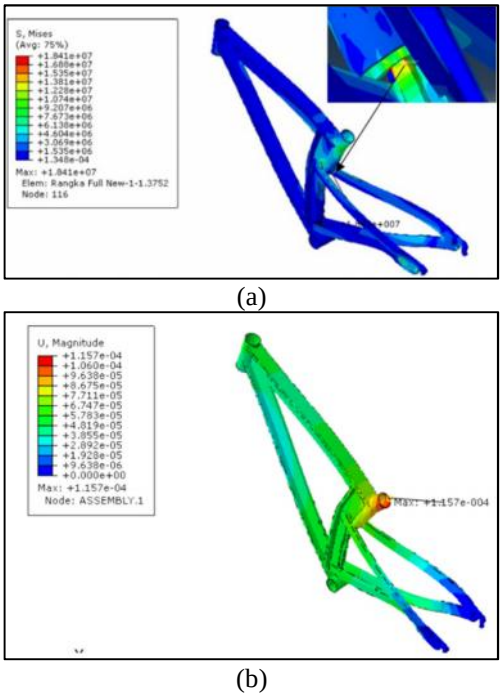
The aluminum waste alloy can be used as the base material for producing machinery components or other products, one of which is bicycle frames. Bicycle frames are currently made from metal alloys in the form of pipes. Investigations on the chemical composition and strength, hardness, toughness of used aluminum metal cans, waste plate rack rods, used pistons, and used pans have been carried out through metal casting [30]. As a result, the bicycle frame design with a cross-section of the "T" and "I" profiles has been successfully developed to produce a bicycle frame through casting technology, as shown in Figure 4 [31].



(a)

(b)

Figure 4. 3D design of an aluminum bicycle frame produced by metal casting: (a) naming the parts of the bicycle frame, (b) detailed dimensions [31].



(a)

(b)

Figure 5. Simulation results of cast-bike frame stress under static start-up loading conditions: (a) von-mises stress, (b) displacement [31].

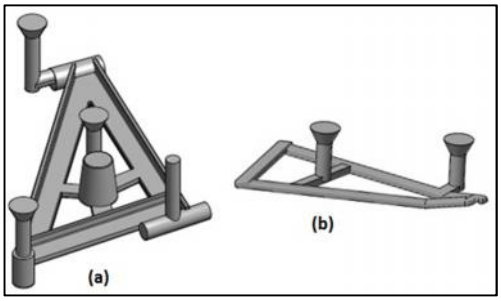


Figure 6. Design pattern for riser and gating system: (a) T profile, (b) I profile [32].

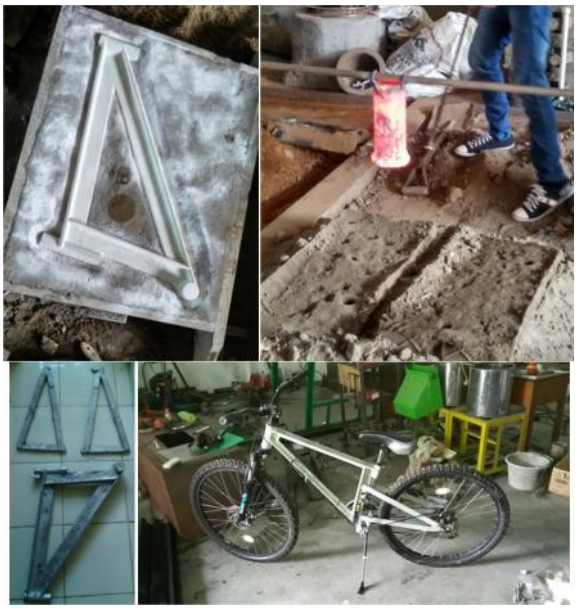


Figure 7. Bicycle frame casting process [31].

The production of bicycle frames using metal casting techniques begins with a 3D design, then simulations of strength: strain and displacement (Figure 5). The next stage of production on the manufacture of a bicycle frame is molded using metal casting techniques. This stage begins with designing the material pouring system and the position and shape of the riser so that the cast product can be reduced from casting defects (Figure 6). The next stage is the stage of melting and casting. The softening used aluminum alloy by using the melting furnace, then pouring it into a sand mold (Figure 7). The final stage is the finishing stage: cleaning, tidying, painting. Lastly, the final touch is to assembly with other components such as tires, handlebars, saddles, forks, paddles, chains, brakes, and other features.

5. Conclusion

The economic impact analysis compared to the investment analysis in the case of bicycle frame fabrication from recycled aluminum alloy materials was discussed, it can be concluded are:

1. The labor sector is the most important part to analyze the economic impact and investment of a product. Labor productivity trend data for ASEAN countries is 24.27 (in thousands of USD per worker). Labor productivity data in ASEAN is 2.96 percent (average per year). Thus, based on the labor productivity data, it can significantly affect the economic impact and investment of a product, in this case for analysis on the cast-bike frame.
2. The investment value only reaches BEP after the total cast-bike production exceeds 400 units.
3. Based on data on the number of workers absorbed, and the number of bicycle production per year from five domestic bicycle companies, if it is assumed that only half of it can be covered by the industry from cast-bike products, it can improve the economy of the domestic community. The bicycle industry from recycled aluminum alloys has a positive economic impact.
4. Materials from recycled metal and the production process with simple metal casting techniques can reduce the selling price of the product. The decline in the selling price per unit of bicycles had a significant impact on the economic development of the domestic community.

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