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Potential Analysis of 3D Printing Products in Surabaya

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Abstract. The cost reduction and production time reduction are the benefits of 3D printing in the manufacturing industry, which can be developed in printing casual shoes that meet customer needs. Although 3D Printing promises many benefits, many are still doubtful about its application in Indonesia. To examine the potential use of 3D printing in Indonesia, information was extracted about the knowledge of the Indonesian people about 3D printing machines and asking to potential investors for an assessment of 3D printing in Indonesia. Data collection was done through an online survey. Respondents were selected randomly with a purposive sampling technique. Survey results show that 91% of respondents said they already knew 3D printing machines, they also knew that there were various kinds of 3D printing products and various kinds of raw materials that could be used. Prospective investors will assess 3D printing products by taking into account market convenience, product uniqueness, workshop/shop location and availability of specialized human resources.

Keyword: 3D Printing, Community Knowledge of 3D Printing, Purposive Sampling, Respondents, Potential investors

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1. Introduction

One effect of implementing technology in the current Industry 4.0 era is that companies are competing to produce, develop, and market their products at a lower cost. Various strategies have been used to reduce production costs, particularly in manufacturing companies that use machinery in their production processes. One strategy that is commonly used is related to cutting tools/molds. To produce at a lower cost, some manufacturing industries choose to produce without using cutting tools or molds, thereby shortening the production process. This is done using 3D printing machines [1]. The use of 3D printing or Additive Manufacturing (AM) is one potential way to shorten the supply chain [2]. Additive Manufacturing is a production process that prints a 3D digital image created with the help of software, without using molds or cutting tools [3]. The commonly used software for creating the digital image is Computer-Aided Design (CAD). Figure 1 illustrates the AM process, which begins with creating a 3D model using CAD, followed by exporting it to the stereolithography (STL) format. This export is necessary because Slicing Software can only read files in the STL format. After generating the layer slices and tool paths using the Slicing Software, the 3D printing machine can work to produce the desired product.

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Figure 1 The AM Process [3]

In general, companies are interested in using 3D printing machines because they have advantages compared to conventional machines. The most apparent advantage of using 3D printing machines is cost savings, the machine's capabilities include no additional tooling, molds, or punches, no requirement for additional processes like scrap, milling, and sanding, and the ability to recycle raw materials.

In addition to the cost advantages, the use of 3D printing can directly accelerate product completion time and even shorten the supply chain. Acceleration mainly occurs in the production process and product/mockup development. In product development, companies need new product designs or redesign old designs into new ones. The design or redesign phase often takes quite a long time. The output of the design process will then be realized, which also takes a long time and correlates with costs.

Printing or production in 3D printing follows the 3D image produced by the software. Therefore, if there are changes to the 3D image, 3D printing will immediately follow the changes. Based on this information, there is simplicity in making products with 3D printing machines. This means that the production process is simplified, so some production tools such as molds are no longer needed [4]. In conventional machines, different products require new molds, which directly require mold-making costs [5].The absence of molds and the loss of limitations in product modeling will open opportunities for companies to receive very specific product model requests from consumers. In addition, the industry can accept requests in small quantities, which are usually avoided by companies because they are costly and tend to harm the company. Companies can also shorten/reduce assembly lines, so the supply chain can be reduced [1].The use of 3D printing will cut the supply chain by up to 50%. Illustrations related to the comparison of using 3D printing and traditional supply chains can be seen in Figure 2.

However, despite promising various benefits, 3D printing machines have limitations, such as the limited materials used and the difficulty in obtaining materials as they are generally imported products [7]. The manufacturing industry in Indonesia has also implemented the use of 3D printing to a limited extent, but there are not many publications explaining how 3D printing implementation works in Indonesia. This study is an effort to explore information related to the plan of using 3D printing in the industry.

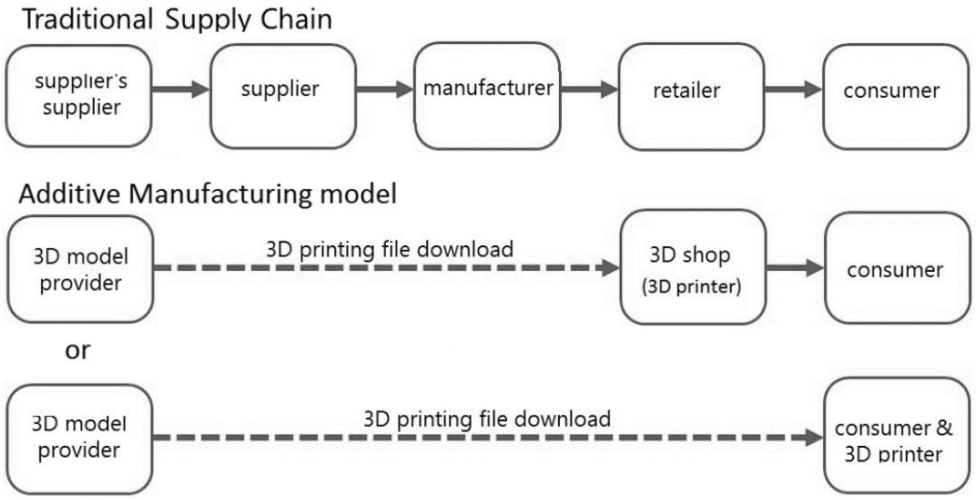

Figure 2 Supply Chain Reduction Model [6]

The use of 3D printing in Indonesia cannot yet be used for mass production. There are various factors that cause this, including the limited size of the machine to produce small-sized products, relatively slow production speed, and lack of human resources with expertise in 3D printing design [8]. These limitations are recognized by the education and industrial sectors, so what academics and practitioners are currently doing is conducting research to improve the effectiveness and efficiency of using 3D printing for various products [9].

This paper aims to: (1) identify the challenges faced in producing 3D printed products, (2) identify the extent of public knowledge in Indonesia about 3D printing machines, and (3) identify the products that potential investors are interested in to open up new business opportunities in the field of 3D printing in Surabaya.

2. Methodology

This study began with a literature analysis to determine the current scope of the use of 3D printing technology. Data collection related to knowledge and interest in products resulting from 3D printing technology was conducted through online questionnaires distributed to 100 residents of Surabaya using purposive sampling. The respondents' ages ranged from 18 to 23 years old, with a composition of 40% male and 60% female, and the results were then processed descriptively. Furthermore, a review of 3D printing products that can already be made and produced outside of Indonesian policies, such as legal, economic, and social aspects, was conducted. Products that did not have problems in these three aspects would be further examined, with the help of three potential investors. These investors would evaluate and provide values based on several aspects, including market ease, product uniqueness, workshop/shop location, and availability of specialized human resources. The research process flow can be seen in Figure 3.

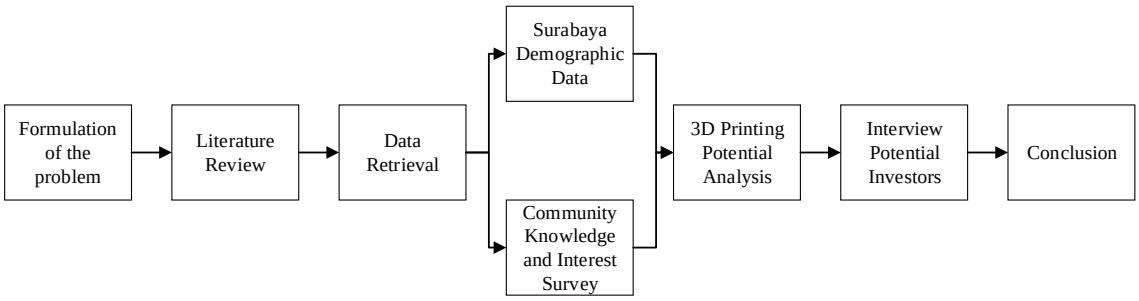

Figure 3 Research Flow

3. Literature Review

3D printing technology is one of the products of the Industrial Revolution 4.0. This technology is considered very useful for the manufacturing industry because the 3D printing system can work faster, with lower costs, less use of raw materials, products that tend to be lighter, and the process stages can be reduced, resulting in products that match the desired 3D design [10]. The use of 3D printing in product manufacturing has covered various types of industries with diverse materials. 3D printing technology has already reached various industries such as the food industry. 3D printing technology has been used to help create precise nutrition for soldiers and even astronauts [11]. 3D printing technology is also used to produce chocolates according to consumer preferences [12], and to create edible gels [13]. Besides the food industry, 3D printing technology has also been implemented in the healthcare industry, such as the production of masks, face shields, COVID-19 swab tests, and Ventilor Valves [14]. The implementation of 3D printing technology in the medical field includes the creation of bionic human tissue or organs [15].

Another application of 3D Printing Technology is in the field of weaponry and defense, such as grenade launchers, essential aircraft accessories, replacement accessories for ships, and weapon spare parts [16]. The construction industry can also use 3D Printing to build bicycle bridges, bus stops, and much more [17]. Even eating utensils like glasses can be made using 3D printing [18].

Not stopping there, 3D printing has also entered the fashion industry, one example being shoes. Several famous brands like Adidas, which partnered with Digital Light Synthesis (DLS) company, have made carbon-based shoes using 3D printing machines, and Nike also made shoes for soccer players. Brand New Balance, Reebok [19], and PEAK also made shoes for basketball players [20]. Overall, people in some countries such as Germany and the USA are familiar with shoes produced by 3D printing, but there is no data available for usage in Indonesia.

4. Data and Discussion

This research aims to explore the interest of Indonesian people, specifically in Surabaya, towards products made through 3D printing. Based on data, it is known that 3D printing machines are still rarely used in Indonesia to produce end products, although there are already limited industries that use 3D printing [21]. In this study, data was collected from 100 respondents to determine how many Indonesians are already familiar with 3D printing machines. Respondents were

randomly selected using purposive sampling technique, a non-probability technique selected according to research criteria. Then, the study will proceed to discuss what would happen if 3D printing products were produced and sold in Indonesia through several aspects such as economics, materials, law, who can produce, who can use, etc. Products that pass these three aspects will be valued by potential investors using the AHP method to determine which product is the best to produce currently.

4.1. The Society's Knowledge on 3D Printing

Of the 100 respondents, 91% said they already knew about this machine, while the rest said they did not know. Therefore, based on the data collected, it can be seen that more than 90% of respondents already know what a 3D printing machine is. Respondents learned about 3D printing machines from various media such as YouTube, Instagram social media, TikTok, exhibitions, and even from universities. Respondents knew about the use of 3D printing in various product fields such as product prototypes, food, and toys. Respondents also knew that 3D printing can use other materials, for easier reference, see Figure 4 and Figure 5.

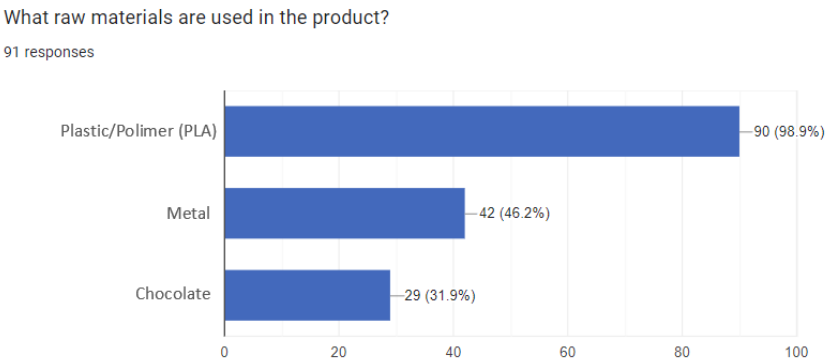

Figure 4 Diagram of Materials Used

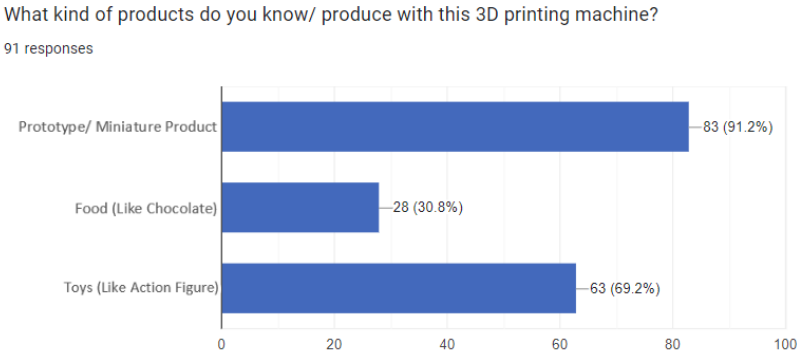

Figure 5 Diagram of Products

4.2. Sample Analysis of 3D Printing Products

As explained above, this section would discuss the examples of 3D printed products that have been previously mentioned, analyzing how they would be produced in Indonesia by considering several aspects such as legal, economic, and social aspects, who can produce them in Indonesia, and whether they can already be produced in Indonesia. Please refer to Figure 6.

No	Field	Product	Material	Legal Aspect	Economic Aspect	Social Aspect	Produce	Availability to be produced in Indonesia
1	Weapon	Weapon Components	Metal and Polymer	In Indonesia, common people are prohibited from buying or even using weapons. As a result, only PT Pindad and a few private companies that have been licensed by Indonesia can produce weapons, and they can only provide weapons to the Indonesian military.	Reducing the country's foreign exchange expenditure	Boost national pride as we can produce weaponry independently	Limited to only Pt. Pindad that is allowed to produce.	Already produced in Indonesia (Pt. Pindat has done this)
2	Food	Food according to the customer model	Chocolate	In Indonesia, to open a restaurant or sell food, one must have a Home Food Industry License or PIRT (Household Food Industry) permit. In addition, businesses that use certain staple ingredients such as milk, meat, etc. must be registered with BPOM (the National Agency of Drug and Food Control). Not only BPOM, but other certificates such as the SNI (Indonesian National Standard) and Halal certificates must also be considered if required.	Opening up new business opportunities for small shops that do not have advanced skills	Having its own unique model that is difficult to make using conventional methods.	All restaurants/ bakeries are allowed to produce	Can be produced if the 3D printing machine is available
3	Sperpart	Ring Speaker Stand	Polymer	In producing goods, the products must meet the same standards as Indonesia's SNI (National Standardization Agency), and the product type must be registered with the Ministry of Industry. Each product must also have labeling indicating the manufacturer (such as made by Pt.xxx). In Indonesia, to sell or buy goods for export or import, a permit is required. It is also important to consider patent rights for designs or other intellectual property in Indonesia.	only accept custom orders according to the size of the speaker stand	With the desired Sparepart model (Unique), it allows users to be more satisfied than with plain models.	All audio Workshop may produce	Can be produced, but nobody has used this in Indonesia, since polymer workshop distort the resulting sound
4	Fashion	Batik Clothes	Polymer	There are several types of batik that are protected by copyright such as contemporary batik motifs.	This will allow foreigners to easily and quickly purchase Indonesian products (thus increasing the Indonesian economy).	It can be better recognized by foreigners due to the ease of manufacturing.	All garment store that owns batik license	Theoretically available, but cloth materials are not supported yet (supported by existing research)
5		Shoes	Carbon	There are several copyrights, especially for sports shoes, such as the shoe cushion model submitted by Nike in 2006.		With the desired model and color by the user, it will increase the user's confidence.	All shoe factories which have reviewed copyrights	For machines made of carbon material, they are not yet officially available in Indonesia. They have to be purchased from abroad.
6	Dining Equipment	Glass	Polymer (PLA) and Orange peel	In producing goods, the products must meet the same standards as Indonesia's SNI (National Standardization Agency), and the product type must be registered with the Ministry of Industry. Each product must also have labeling indicating the manufacturer (such as made by Pt.xxx). In Indonesia, to sell or buy goods for export or import, a permit is required. It is also important to consider patent rights for designs or other intellectual property in Indonesia.	It can reduce the cost of raw materials as the orange peel is free, if combined with a juice stand.	It can attract others because it can create very unique glass models, as well as environmentally friendly glasses.	All	Theoretically possible, there is no machine capable of mixing the two materials.
7	Medical	Ear, Nose, Finger	Metal, polymer and ceramics	Selling body organs is prohibited according to Law No. 36 of 2009 concerning Health ("Health Law"). Article 192 in conjunction with Article 64 paragraph (3) of Law 36/2009 states: "Anyone who intentionally trades organs or body tissues under any pretext as referred to in Article 64 paragraph (3) shall be punished with a maximum imprisonment of 10 (ten) years and a fine of up to Rp1,000,000,000.00 (one billion rupiah)."	This can reduce the cost of imports as well as the cost of purchasing genuine organs.	The people who obtain this will increase their self-confidence in society.	Limited, only hospitals are possibly allowed to produce	Not available since the machine to produce it is not available in Indonesia
8	Health	Mask, Face shield	Polymer	In producing goods, the products must meet the same standards as Indonesia's SNI (National Standardization Agency), and the product type must be registered with the Ministry of Industry. Each product must also have labeling indicating the manufacturer (such as made by Pt.xxx). In Indonesia, to sell or buy goods for export or import, a permit is required. It is also important to consider patent rights for designs or other intellectual property in Indonesia.	Can speed up production and marketing, as currently Indonesia still implements mask-wearing protocols.	It has a unique model because it is produced using 3D printing.	Limited, companies that works in medical equipment/hospital	Can be produced in Indonesia

Figure 6 Analysis of Various Aspects of 3D Printing Product Samples

As previously discussed, producing weapons has the potential to increase a country's foreign exchange earnings. For example, the United States is the largest exporter of weapons, which has increased foreign exchange earnings from weapon sales. According to data from the Stockholm International Peace Research Institute (SIPRI) in 2020, the US sold weapons worth 36% (USD 649 billion) of the global military budget [22]. In Indonesia itself, according to the Central Statistics Agency's (Badan Pusat Statistik) August 2022 import-export data, Indonesia exported weapons worth $453,422 and imported weapons worth $34,740,349 [23]. From this data, it can be seen that if Indonesia can produce its own weapons quickly and efficiently, it will increase exports and reduce imports. In addition, there are several weapons produced by PT. Pindad that are considered world-class products and highly sought after by other countries, such as the G2 Premium Pistol, G2 Elite 9mm Pistol, and several other weapons [24].

Analysis of the use of 3D printing for the production of human organs. Imitation human organs are generally difficult to obtain and have a high price. In contrast, using 3D printing machines can easily produce organs without the need for donors to experience injury and at a lower cost than real organs [15]. Looking at the economic aspect in Indonesia, this will greatly help the Indonesian economy and society because they can sell cheaper artificial organs and people can easily obtain organs. And in the social aspect, it will greatly increase the confidence of the Indonesian people. However, this is not possible to produce freely, as the law in Indonesia prohibits trading organs, so it is possible that only those registered in the Indonesian government can produce this and only sell to certain hospitals. Another product in the health field that may be worked on is medical masks. However, in the case of mask production, there is a possibility that producing using 3D printing will not have medical standards. Therefore, producing masks using 3D printing will be used to reduce dust inhalation, as well as reduce the spread of water such as sneezing and coughing.

In the fashion industry with batik products, from a legal, economic, and social aspect, it is highly possible to produce them, but with the limitation of materials, further research using comfortable fabric materials is needed. As for shoes, from a legal aspect, it is necessary to be careful and make more effort to avoid infringing on copyright of shoes that have already been sold. Shoe products that have been sold abroad (Germany and USA) are very high, ranging from 3 to 4.5 million Rupiahs, while Indonesian people still cannot afford to spend that much to get shoes that have the same standard as conventionally made ones. A survey conducted shows that 82% of the people are willing to spend between 1 to 3 million IDR, and 18% are willing to buy in the price range of 3 to 4 million rupiah and above. More details can be seen in Figure 7.

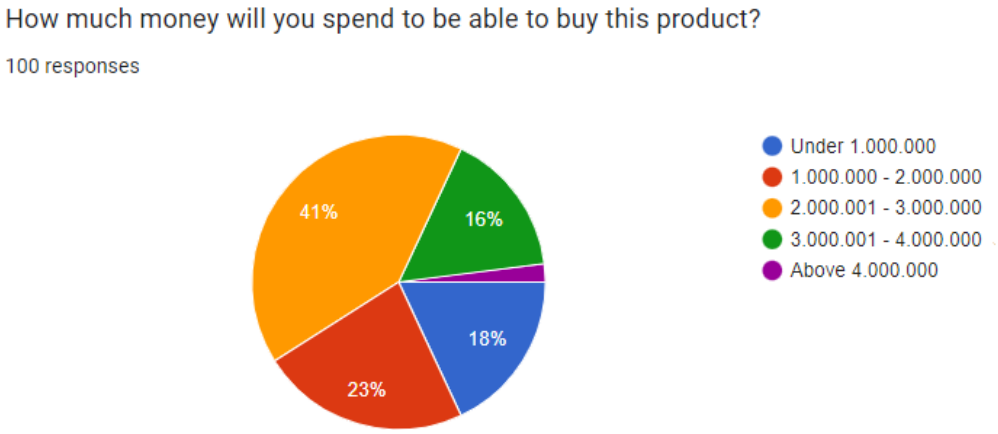

Figure 7 Possible Cost for Purchasing 3D Printed Shoes

In the field of food, spare parts, and dining equipment, it is very possible to produce them from a legal perspective. In terms of food, it can help businesses that lack the necessary skills to make food according to the customer's wishes. Spare parts are very advantageous from an economic and social perspective because they were originally made of metal using CNC/turning machines (custom), resulting in a lot of wasted material. However, now no material is wasted, and they can be easily produced without having to outsource to a factory that has a CNC/turning machine. As for glasses, if they are combined with the production of orange juice (which happens to be one of the raw materials for making glasses), it can significantly reduce the cost of raw materials, making production costs lower.

Based on this analysis, it can be concluded that food products, spare parts, and dining equipment such as glasses meet all three aspects, so these products can be easily produced in Indonesia legally. This will greatly help the economy from the perspective of the factories, society, and the country, as well as make consumers happy with the products.

4.3. Decision Alternative Selection Process

There are various ways to determine which alternative is superior, in this paper the Analytical Hierarchy Process (AHP) method is used because it is easy to use. The first use of AHP was in 1972 by Saaty [25]. For more than 40 years, this method has been used and there have been many successful studies using this method [26].

At this stage, data will be collected as needed using the AHP method to be provided and filled out by potential investors in Surabaya. As previously discussed, food products, spare parts, and dining equipment are part of the Decision Alternative with the ultimate goal of determining the best 3D printing product. Meanwhile, the criteria will be divided into 4 parts, the factors to consider in evaluating the feasibility of a 3D printing business include market ease, product uniqueness, workshop/shop location, and availability of special human resources. Market ease is determined by the number of enthusiasts/buyers and the reception from the community, indicating the demand for the products. Product uniqueness is assessed based on the quality and appeal of the 3D printed products that will be sold. Workshop/shop location evaluation takes into account visibility to consumers and the size of the land required. Lastly, the availability of special human resources focuses on identifying the necessary operators/employees, their required skills and strengths, and the number of personnel needed. Figure 8 provides a visual representation of these factors for better understanding and assessment.

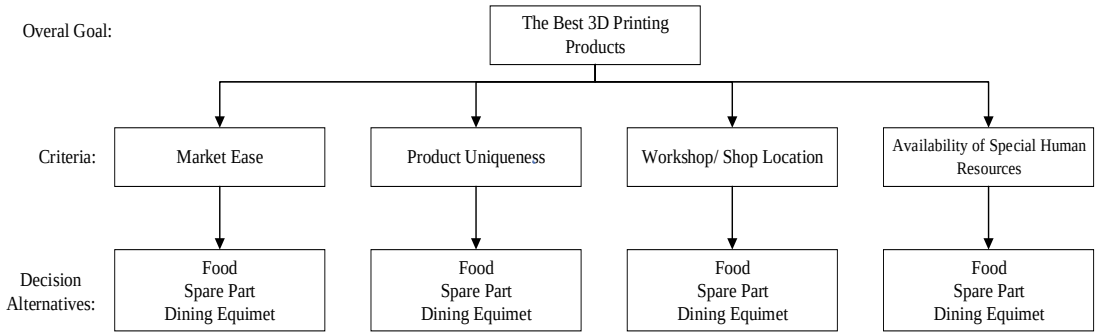

Figure 8 AHP Decision Maker

This assessment was conducted by 3 potential investors from Surabaya, and each investor filled out and evaluated it themselves. The following were the results of the evaluation from the three potential investors and the priority of the product. The value and results from potential investor 1 can be seen in Table 1 and Table 2, potential investor 2 in Table 3 and Table 4, while the value and results from potential investor 3 can be seen in Table 5 and Table 6.

Table 1 AHP Score from Potential Investors 1

Market Ease	**Food**	***Spare Part***	**Dining Equipment**
Food	1	5	1/3
Spare Part	1/5	1	1/6
Dining Equipment	3	6	1
Product Uniqueness	**Food**	***Spare Part***	**Dining Equipment**
Food	1	7	4
Spare Part	1/7	1	1/4
Dining Equipment	1/4	4	1
Workshop/Shop Location	**Food**	***Spare Part***	**Dining Equipment**
Food	1	7	6
Spare Part	1/7	1	1/3
Dining Equipment	1/6	3	1

Availability of Special Human Resources	**Food**	***Spare Part***	**Dining Equipment**
Food	1	5	6
Spare Part	1/5	1	3
Dining Equipment	1/6	1/3	1
Criteria	**Market Ease**	**Product Uniqueness**	**Workshop/Shop Location**
Market Ease	1	1/5	1/4
Product Uniqueness	5	1	2
Workshop/Shop Location	4	1/2	1
Availability of Special Human Resources	4	3	4

Table 2 Results of Priority from Potential Investor 1

Alternative	***Priority***
Food	0.677949006
Spare Part	0.141145924
Dining Equipment	0.18090507
Total	1

Table 3 AHP Score from Potential Investor 2

Market Ease	**Food**	**Spare Part**	**Dining Equipment**
Food	1	9	6
Spare Part	1/9	1	1/4
Dining Equipment	1/6	4	1
Product Uniqueness	**Food**	**Spare Part**	**Dining Equipment**
Food	1	1/6	3
Spare Part	6	1	1/8
Dining Equipment	1/3	1/8	1
Workshop/Shop Location	**Food**	***Spare Part***	**Dining Equipment**
Food	1	9	9
Spare Part	1/9	1	1/2
Dining Equipment	1/9	2	1
Availability of Special Human Resources	**Food**	***Spare Part***	**Dining Equipment**
Food	1	2	7
Spare Part	1/3	1	5
Dining Equipment	1/7	1/3	1
Criteria	**Market Ease**	**Product Uniqueness**	**Workshop/Shop Location**
Market Ease	1	6	1/5
Product Uniqueness	1/6	1	1/6
Lokasi Workshop/Shop	5	6	1
Availability of Special Human Resources	1/3	2	1/5

Table 4 Results of Priority from Potential Investor 2

Alternative	***Priority***
Food	0.736894756
Spare Part	0.136014341
Dining Equipment	0.127090903
Total	1

Table 5 AHP from Potential Investor 3

Market Ease	**Food**	***Spare Part***	**Dining Equipment**
Food	1	6	5
Spare Part	1/6	1	1
Dining Equipment	1/5	1	1
Product Uniqueness	**Food**	***Spare Part***	**Dining Equipment**
Food	1	9	3
Spare Part	1/9	1	1/6
Dining Equipment	1/3	6	1
Workshop/Shop Location	**Food**	**Spare Part**	**Dining Equipment**
Food	1	7	6
Spare Part	1/7	1	2
Dining Equipment	1/6	1/2	1
Availability of Special Human Resources	**Food**	**Spare Part**	**Dining Equipment**
Food	1	3	6
Spare Part	1/3	1	5
Dining Equipment	1/6	1/5	1
Criteria	**Market Ease**	**Product Uniqueness**	**Workshop/Shop Location**
Market Ease	1	8	4
Product Uniqueness	1/8	1	1/6
Workshop/Shop Location	1/4	6	1
Availability of Special Human Resources	1/5	4	2

Table 6 Results of Priority from Potential Investor 3

Alternative	**Priority**
Food	0.711693411
Spare Part	0.161003313
Dining Equipment	0.127303276
Total	1

From the above results, potential investor 1 determines that Food has the highest priority value with a value of 67.79%. Meanwhile, for the values of spare parts and Dining Equipment, they only have values of 14.11% and 18.09%, respectively, compared to Food. Potential investor 2 and 3 have almost the same priority values and the same order of priorities. Potential investor 2 determines that Food has a value of 73.69%, while investor 3 determines 71.17%, both of which have values above 70%. Investor 2 and 3 place spare parts in second place with values of 13.6% and 16.1%, respectively, and in third place is Dining Equipment with values of 12.71% and 12.73%, respectively.

In determining the order of priority of products with more than one respondent (which in this study is filled by 3 potential investors), there are several methods, one of which is the fuzzy AHP method that gives weight values according to experts. The result of this determination is that all three potential investors gave the same priority value to Food, which is number 1, so if given weight, it will produce the same answer. Therefore, in this study, the average method will be used.

From the above results, it can be concluded that all three potential investors have the same view, which is that Food has a higher chance of success with an average value of 70.88%, while in the area of spare parts and Dining Equipment, they only have average values of 14.6% and 14.51%, respectively. Some alternative 3D printed food products that have been implemented include making chocolate [12], making food considering nutrition for soldiers and astronauts [11], and food in the form of gel [13]. Investors consider the most popular food products among consumers, in this case, chocolate.

5. Conclusion

The 3D printing process can shorten long and time-consuming supply chains into shorter time periods. Not only that, 3D printing also makes products cheaper as it eliminates the need for molds and reduces production lines such as assembly. With layer-by-layer production, changes in consumer demand can be quickly realized without high costs.

This can be seen through various examples such as infrastructure development, production of spare parts, medical equipment, and even bionic organs which are difficult to obtain. With fast, easy, and cheaper production, factories can be established near markets. The establishment of factories near markets will reduce transportation costs and products will quickly circulate in the market. This is supported by research by Sebastian Mohr and Omera Khan [27].

In Indonesia, 91% of the population is aware of 3D printing technology and knows the various products and raw materials that can be produced and used. In Indonesia, there are several products that can now be easily and quickly produced, namely food products, spare parts, and dining equipment. These three products have positive values in terms of legal, economic, and social aspects. According to the prospective investors from Surabaya, they prefer to invest in the food sector with a value of 70.88% compared to the spare parts and dining equipment sectors.

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