THE FACTORS INFLUENCING THE ADOPTION OF ADDITIVE MANUFACTURING IN MANUFACTURING INDUSTRY

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This thesis is submitted in partial fulfilment of the requirement for the award of Bachelor of Technology Management (Technology Innovation) with Honors

Faculty of Technology Management and Technopreneurship

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MAY 2019

DECLARATION

I/We hereby declared that I/We had read through this thesis and in my/our opinion that this thesis is adequate in terms of scope and quality which fulfill the requirements for the award of Bachelor Degree in Technology Management (Technology Innovation).

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"I declared that this report is the result by my own work, except certain explanation and passage where every part of it is cited with sources clearly stated in Reference"

SIGNATURE : ______________________________

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FiGURES

LIST OF ABBREVIATIONS

AM -	Additive Manufacturing
AMT -	Additive Manufacturing Technology
SM -	Subtractive Manufacturing
TAM -	Technology Adoption Model
IDT -	Innovation Diffusion Theory
% -	Percentage
SPSS -	Statistical Package for Social Science
MRA -	Multiple Linear Regression

DEDICATION

Special thanks to:

My beloved parent

Siblings

Friends

My supervisor: Dr Nusaibah Binti Mansor

For all the spirituals and moral support that had been given to me all the time.

ACKNOWLEDGEMENT

First of all, I would like to express my grateful to Allah S.W.T the Most Gracious and Most Merciful for His Blessing and be Upon His messenger Muhammad S.A.W. because giving me the strength and capabilities to complete and finished my project and gained an experience during the process to complete this project. I might want to express my most profound acknowledge to my family particularly my cherished guardians for their endless help and boldness as far as money related and feeling too. Without their assistance this undertaking it cannot be totally effectively.

Aside from that, I might want to offer my thanks to my supervisor, Dr Nusaibah Binti Mansor who has been giving me direction persistently to ensure I am dependably at the correct way. Other than that, I might want to express my appreciative to Dr Siti Norbaya Binti Yahaya who brought up the mix-up I made during the introduction. Without her, my mixed up would not be acknowledged and most likely will cause to genuine results.

Next, I would also like to thank to my housemates, course mates and friends for the cooperation and rendered their help during research going. They do not hesitate in sharing their knowledge in developing the project. Last but not least, this appreciation goes to every person that I know who always ready to help me whenever I faced difficulties in doing the project and willing to share the information to me direct or

indirectly. Hopefully, this report will be a reference to the others in the future.

ABSTRACT

In spite of the colossal development in the earlier decade, added substance fabricating advancements currently is known as 3D-printing yet still once in a while utilized in assembling industry. This paper find fluctuated factors that decide the choice to embrace AM innovations for the assembling business. A survey of the pertinent writing uncovered six potential components. These can be arranged into three interdisciplinary classifications: innovation related variables, firm-related-factors, and production network related components. Uncommon thought is given on the budgetary assets issues, in light of the fact that these angles affect the choice to embrace AM innovations. The point of this exploration is to recognize the impacting elements of Additive Manufacturing appropriation in Manufacturing Industry. The exploration was finished by utilizing quantitative strategy and examination technique was finished by utilizing Pearson connection to gauge the connection between free factors and ward variable. Relapse investigation was utilizing for theory testing. Subsequently, it is trusted that this examination paper will valuable to the business experts and academicians to be filled in as future reference.

Keywords: *Adoption, AM, 3D printing, Manufacturing Industry, Influencing Factor*

ABSTRAK

Walaupun pertumbuhan yang besar dalam dekad yang lalu, teknologi pengilangan tambahan kini dikenali sebagai percetakan 3D namun masih jarang digunakan dalam industri pembuatan. Maka kajian ini mengenal pasti faktor yang menentukan keputusan untuk mengadopsi teknologi AM untuk industri pembuatan. Kajian semula literatur yang berkaitan menunjukkan enam faktor yang berpotensi. Ini boleh diklasifikasikan kepada tiga kategori interdisipliner: faktor berkaitan teknologi, faktor berkaitan firma, dan faktor berkaitan rantaian bekalan. Fokus khas diletakkan pada isu sumber kewangan, kerana terdapat petunjuk bahawa aspek-aspek ini mempunyai pengaruh terhadap keputusan untuk mengadopsi teknologi AM. Matlamat penyelidikan ini adalah bagi mengenalpasti faktor-faktor yang mempengaruhi implementasi AM dalam Industri Pembuatan. Penyelidikan ini telah selesai dengan menggunakan kaedah kuantitatif dan kaedah analisis diselesaikan dengan menggunakan korelasi Pearson untuk mengukur hubungan antara pembolehubah bebas dan pembolehubah tergantung. Analisis regresi menggunakan ujian hipotesis. Oleh itu, kertas penyelidikan ini kana memberi manfaat kepada pengamal industri dan ahli akademik untuk dijadikaan rujukan masa depan.

Kata kunci*: Adopsi, AM, percetakan 3D, Industri Pembuatan, Faktor Mempengaruhi*

CHAPTER 1

INTRODUCTION

1.0 Background of study

Additive Manufactuirng (AM) is a legitimate name for depicting the advances that collect 3D questions by including layer after layer of material, regardless of whether metal, plastic or cement. AM alludes to the way toward joining materials to make objects from 3D model information, as in opposition to techniques of Subtractive Manufacturing (SM), for example, customary assembling. Contrasted and other assembling advancements, the benefits of AM incorporate their capacity to construct troublesome geometries and excessively lightweight items, cut generation costs for little amounts of customized items.

In general, AM processes have good characteristics of the environment. By using only the amount of material required for build the product, additive manufacturing technologies possible to decrease the mass of the life cycle of material and energy consumed compared to traditional subtractive technologies by completely remove scrap while eliminating the use of dangerous additional process enablers. Some AM methods also have the ability to totally eliminate supply chain activities connected with the manufacturing of fresh instruments by repairing and reproducing outdated or failed instruments (Sreenivasan, Goel, & Bourell, 2010).

Thirty years into its extension, additive manufacturing has turned into a typical assembling process. Additive Manufacturing develops components by including materials one layer at any given moment dependent on an electronic 3D strong model. The utilization of installations, cutting apparatuses, coolants and other extra assets isn't required. It permits streamlining of the structure and the generation of altered parts on interest. Its favorable circumstances over conventional creation have dazzled the open's creative mind (Huang, Liu, Mokasdar, & Hou, 2013).

The Malaysian production industry is an significant financial sector that has contributed about 22% of GDP over the last five years. To date, its growth has had the effect of stimulated jobs, attracted investments and created company opportunities in the downstream and associated services industries. The production industry is anticipated to stay resilient and is on track to attain the targeted annual GDP growth rate of 5.1% under the 11th Malaysia Plan (RMK-11) (Hasbullah & Abd Rahman, 2018).

1.1 Problem Statement

Subtractive manufacturing is a process by which 3D objects are constructed by successively cutting material away from a solid material block. Conventional subtractive manufacturing is a process where large quantities of materials must to be removed. The conventional subtractive manufacturing techniques consists of the elimination of engineered waste and inputs from damaging auxiliary processes. This is not an environmentally friendly technology.

The manufacturing of “green” products, especially those used in renewable energy systems and clean technology machinery of all types, and “greening” production will decrease pollution and waste by minimizing the use of natural resources use, recycling and reuse of what was deemed waste, and lowering emissions. Since the conventional subtractive manufacturing is producing waste, then it is not a green technology. Now, it is the time for manufacturing industry transforming into green manufacturing to take care of our environment.

In addition, Industry 4.0 depicts a future state of sector characterized by a thorough digitization of financial and manufacturing flows. It requires horizontal integration at every stage of the production procedure, in connection with machines. In Industry 4.0's globally connected world, machines also interact with each other. Additive Manufacturing is one of the nine technological pillars of Industry 4.0. With Industry 4.0, these technologies will be selected for their very elevated efficiency in the manufacturing of small lots of customized products. Decentralized systems will decrease transportation and inventory management costs.

Despite its strong present position, the state of the manufacturing industry has been of concern in recent years. Malaysia has shifted away from being an investment target for low-cost manufacturing and is challenged by low-cost rivals from emerging economies and quickly changing technologies. By embrace Industry 4.0 in the manufacturing industry, it will lead to offer opportunities for growth of manufacturing industry.

1.2 Research objective

a) To identify the current practice or adoption of additive manufacturing in Malaysia.
b) To analyze the relationship between the factors influencing and the adoption of additive manufacturing in manufacturing industry.

c) To suggest the guidelines to the manufacturing industry on the adoption of additive manufacturing.

1.3 Research questions

a) What is the current practice or adoption of additive manufacturing in Malaysia?
b) What is the adoption of additive manufacturing in manufacturing industry?
c) What is the most influencing factors for AM technology adoption ?

1.4 Scope of study

The Factors Influencing the adoption of Additive Manufacturing in Manufacturing Industry research is mainly design for manufacturing industries around industrial area at Shah Alam, Selangor. The researcher is targeted the manufacturing industry in Selangor because it has a highest concentration of manufacturing establishments in Malaysia. In this study, researcher focus on executive, manager or any those staff to carry out the email questionnaires survey or online questionnaires in order to provide a wider scope for the research.

1.5 Limitation

During doing this research, there have some limitation that been had by the researcher such as constraint of geography and honesty of respondent. This research is going to be conduct in industrial area at Shah Alam, Selangor. Due to insufficient time to complete data collection, researcher only focus to do data collection in focused area that represent manufacturing industries in Malaysia. Answer of questionnaire may be influence by the respondent's honesty. Respondents did not need to disclose and talk about the element of a subject matter that the researcher wants to analyze. The result may come out only about the respondents that only provide a very partial view of the situation that cause them into a ‘socially desirable’ role or the firms for which they working in a positively or negatively.

1.6 Summary

This chapter briefly explains about the background of study, research questions and objectives are highlighted out in this chapter. Besides, this chapter also explains the scope of the study and the researcher’s limitations in conducting the research. The following chapter describes the literature review of this research in detail. Theoretical framework will also be proposed in chapter 2.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction of Literature Review

This chapter contains a review of previous research related to this final year project. Previous research has been carried out on the adoption of AM technologies for industrial parts production. Literature review has played an important role in the early development of this research. It includes a critical analysis and the integration of information from a number of sources, as well as a consideration of any literature gaps and possibilities for future research.

2.1 Additive manufacturing (AM)

Additive manufacturing is the official industry standard term for all technological applications. It is defined as the process of joining materials to create objects from 3D model data, usually layer by layer, as opposed to subtractive manufacturing methods. Additive Manufacturing refers to a process by which digital 3D design data are used to construct a component into layers by depositing material. The term "3D printing" is increasingly being used as a synonym for Additive Manufacturing. However, the latter is more precise in that it defines a professional manufacturing method that is obviously differentiated from standard material removal techniques. Instead of milling a job from a strong block, for instance, Additive Manufacturing creates components layer by layer using materials that are available in fine powder form. A variety of distinct metals, plastics and composite materials can be used.

Thirty years into its development, additive manufacturing became a major manufacturing process. Additive manufacturing constructs parts by adding materials one layer at a time based on a computerized 3D solid model. The use of fixtures, cutting tools, coolants, and other additional resources is not required. It allows the optimization of design and the production of customized parts on demand. Its advantages over conventional manufacturing have captivated the public's imagination (Huang et al., 2013).

Years	Evolution
1984	The invention of 3D printing
1986	3D printing technologies got patented
1988	3D printing machines has been distribute to the public
1990	The first inexpensive model was on sale in this year
1996	Nearly 8 years later the term 3D printer was first used
2000	This year, the first high-definition printer was born
2006	The first self-replicating 3D printer was developed
2008	First self-replication 3D printer was on sale in the market
2014	Manufacturing of basic necessities

Table 2.1 The Timeline of AM technology (3D printing)

2.2 Manufacturing Industry

The manufacturing industry refers to those industries involved in the manufacture and processing of goods and allows for either creation of new commodities or in value addition. The manufacturing sector accounts for a significant proportion of the industrial sector in developed countries. The manufacturing sector is expected to remain resilient and is on track to achieve the targeted annual GDP growth rate of 5.1 percent under the 11th Malaysia Plan (RMK-11). At the global level, Malaysia has enjoyed a fairly strong and competitive position in both manufacturing and technology use. The Global Manufacturing Competitiveness Index 2016 (by Deloitte Touche Tohmatsu) ranked Malaysia 17th among 40 countries. The report also projected Malaysia to climb four notches to 13th by 2020. On the technology and innovation side, Malaysia ranked 37th among 127 countries worldwide and 8th in Asia in the Global Innovation Index 2017 (by Cornell University, INSEAD and WIPO).

2.3 Factors Influencing the Adoption of AM

Despite enormous growth over the last decade, additive manufacturing (AM) technologies was generally called as 3D printing which are remain infrequently used in manufacturing industry. This research examines multifaceted factors that discover the decision for the manufacturing industry to adopt AM technologies. Special emphasis is placed on the impac in supply-demand, as there have been indications that the decision to adopt AM technologies influences these aspects, as AM can provide different chances for the demand and supply side of a company's manufacturing.

2.3.1 Relative advantage

Relative advantage depends on Rogers' IDT. It demonstrates the proportion of expenses and anticipated advantages from the reception of an advancement. Various investigations in the field of development the executives recommend that a relative bit of leeway is a significant indicator of an advancement rate. The variable "perceived usefulness" to clarify user acknowledgment of data innovation. Seen value in this manner implies "how much an individual trusts that utilizing a specific framework would upgrade his or her activity execution" (Davis et al. 1989). Thusly, it is like relative bit of leeway since it suggests that the expenses and advantages of embracing a development are weighted against one another. Be that as it may, the TAM is mostly connected for looking at advancement reception at an individual dimension while IDT is utilized for contemplating both, selection by people and associations. In our specific situation, the overall preferred position of AM innovations is firmly connected to the advances' advantages contrasted with other assembling advances. (Berman 2012; Holmstro ̈m et al. 2010; Khajavi et al. 2014; Walter et al. 2004):

- Decreases of expenses, particularly when building modest measures of custom items (because of the evacuation of object-specific tools),
- Lower utilization of materials during item producing (since material is just gathered where the thing should be developed),
- Design opportunity (because of the capacity to develop convoluted geometries),
- Ability to create lightweight items (for example by making empty spaces or matrix developments in the inside of an article),
- Ability to improve items for usefulness and fuse greater usefulness into a thing (for example by lessening the measure of parts to a couple subcomponents).

2.3.2 Ease of use (complexity)

In IDT, unpredictability implies "how much a development is viewed as relatively difficult to fathom and utilize" (Rogers 2003). A few investigations found an unfavorable association among multifaceted nature and selection of development (for example Rogers 2003; Tornatzky and Klein 1982; Verhoef and Langerak 2001), despite the fact that outcomes are not constantly decisive (for example Beatty et al. 2001). The TAM (Davis et al. 1989) utilizes the variable "saw convenience" to anticipate client acknowledgment of data innovation. Seen convenience would thus be able to be considered as antonym to intricacy. The cozy connection between the two develops winds up apparent in the apparent highlights of an advancement (PCI) system (Moore and Benbasat 1991), where the parameter "usability (multifaceted nature)" is speculated as a development driver. We trust that convenience (multifaceted nature) is additionally a significant determinant for the usage of AM innovation, since firms might be reluctant to pursue AM in the event that they discover the innovation hard to appreciate and utilize.

2.3.3 Absorptive capacity

An association's absorptive limit identifies with its "capacity to abuse outer comprehension" (Cohen and Levinthal 1990). Past investigation implies that organizations, which can promptly absorb new information and industrially exploit this learning, will in general embrace new advancements all the more immediately (Cohen and Levinthal 1989, 1990). The significance of "absorptive" or "learning limit" as a determinant of (ahead of schedule and serious) innovation use has just been appeared propelled producing advancements (AMT) (Arvanitis and Hollenstein 2001). AMT represents various present day, more often than not PC based frameworks that went for improving assembling exercises (Small and Yasin, 1997). Instances of AMT incorporate

PC supported structure (CAD), PC helped fabricating (CAM), PC controlled machines (CNC), adaptable assembling frameworks (FMS) and material asset arranging (MRP) frameworks (Hofmann and Orr 2005; Small and Yasin 1997).

AM advances are likewise respected to be AMT (Arvanitis and Hollenstein 2001). The specialist accordingly contend that retention limit is likewise significant detreminant for the execution of AM advances for the assembling of modern parts. Expanding on Arvanitis and Hollenstein (2001) and Cohen and Levinthal (1990), the scientist consider three viewpoints components of absorptive limit which are the limit of the organization to utilize outer information and make inward skills, which depends fundamentally alone support in R&D, the organization's integaration into learning systems, which can be operationalized as the level of particiption in R&D co-tasks with different organizations or associations, and the limit of the organization to survey innovative potential outcomes, which can be credited for the most part to its human capital enrichment.

2.3.4 Compatibility

Compatibility, which is a part of both, IDT (Rogers, 1962) and the apparent highlights of an advancement structure (Moore and Benbasat, 1991), alludes to "how much development is seen to be perfect with current qualities, past encounters and needs of planned adopters" (Rogers, 2003). Developments can in this way be steady or conflicting with socio-social qualities and feelings, thoughts prior actualized, and the clients requires advancement (Rogers, 2003). Different investigations call attention to that the similarity of a development with its execution is positively connected (Tornatzky and Klein, 1982). The equivalent could apply to the execution of AM innovation, as organizations might be bound to embrace AM if the innovation fits well