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3D Printer Impacts on Small & Mid-sized Businesses (SMBs) Supply Chain

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Abstract

In this thesis, I aimed to describe the effects of the 3D Printer on small & mid-sized Businesses'(SMBs) supply chain management. Whereby, I conducted this primary research to illustrate the 3D Printer as a business idea, and then, to emphasize that usage of the 3D Printer in an organization's supply chain can be beneficial in terms of avoiding disruption in the supply chain process. While global supply chain management is eased nowadays by the progress in technology trends moreover, the 3D Printer is used in the SMB's supply chain for the aspects of qualitative results such as a good quality of the products, the less cost of production, reduction of delay, and sustainability. Therefore, my approach has been to describe the 3D Printer driving change in small & mid-sized business supply chain processes. Meanwhile, the global supply chain is constantly confronted with multiple disruptive risks, whereby, the 3D Printer implementation can impact positively SMBs supply chain management. Furthermore, the 3D Printer makes shorter the SMB's supply chain processes line beneficially, which will impact the Leadtime and increases the organization's competitiveness, meanwhile, all remains the customer's satisfaction. Therefore, to illustrate in this paper the 3D Printer as a business idea, I proceed to describe the SMBs' supply chain, and the 3D Printer machine, it then describes to the readers, the effects of the 3D Printer on SMBs' supply chain processes.

I concluded this thesis by emphasizing the feasibility of the addictive manufacturing implementation as a business idea, and as a solution that significantly reduced the cost of the organization's production by improving the SMBs' responsiveness and performance.

Keywords
Additive manufacturing, 3D printer impacts on Small & Med-sized Business's supply chain.

Table of contents

Contents

1 INTRODUCTION

Additive manufacturing known as a 3D printer is picturing itself as a major key in manufacturing, as a technology trend, and for future production of its beneficial support to the small business's supply chain management. (Nguyen et al., 2021). Whenever small & mid-sized companies are confronted with the world's supply chain issues. To maintain the business running, some small business owners increase the price and run the business with less inventory (Small Business Supply Chain Challenges, n.d.).

Even if, the agility of some small business owners, to adapt the business to the situation., the risks are still multiple for the small business supply chain, and diverse factors can provoke these exposures to the danger, such as the supplier's reliability, the delay, the longer lead-time, the data management, covid-19 pandemic, etc.
Besides the disruption risk, the less inventory, and the price inflation, the small business owners are opponents to the time, which remains, customer satisfaction. Moreover, additive manufacturing takes off from supply chain design, transportation and reduces the logistic process, and brings the products to consumers nearby the shortest distance.

3D printers use in the supply chain, will create strong mitigation strategies, and then bring the small business's supply chain risk almost to a neutral level. Production planning is more mastered by small business owners using additive manufacturing.
The 3D-printed apparel consumers have mostly described the advantages in terms of convenience, fast and good quality for consumers, and co-design. (Perry, 2018).
As a small business owner or an entrepreneur desiring to implement the 3d printer, this thesis tends to demonstrate: a facilitating and reducing aspect of delay in production time and mastering of own supply chain management due to the beneficial contribution of the use of additive manufacturing.

Thereby, this thesis is divided into four chapters as followed. Chapter 1, where is introduced the thesis topic and plans. Chapter 2 talks about the research methodology and its limitations. The 3rd chapter tells a description of the implementation of additive manufacturing including a 3D Printer overview, and a description of the SMBs supply chain, whereby, a 3D printer is presented as a value that enhances the SMB's supply chain management., chapter 4 describes 3D printer adoption in SMB's supply and chain. Finally, Chapter 5 concludes the thesis by clarifying the research question and illustrating additive manufacturing as a business idea to the readers.

2 RESEARCH INQUIRY AND LIMITATION

2.1 Thesis query

The new small-scale mobile production concepts are available due to technological development, thereby, the implementation of additive manufacturing is affordable to the individual as an entrepreneur to create a business.
Either 3D printer could import a significant impact on SMB's supply chain not just by reducing the inputs through their supply chain but also by the SMB's logistics approach.

This thesis is based on answering these questions of whether additive manufacturing can innovate and drive change in SMBs' supply chain meanwhile, regardless of using a 3D printer will be enough to have a competitive advantage in business, and in the case of a 3D Printer used in SMBs' activities processes remain the better quality of the products and thereby, and what are the costs of the 3D Production.

Furthermore, the 3D implementation will reverse the entrepreneurship processes whereby the entrepreneur can build the business idea from additive manufacturing. Whenever the entrepreneur put the idea into implementation in traditional entrepreneurship processing.

Moreover, the customization of the products empowers the customer's relationship to respond accurately to the customer's demands, which contributes to the customer's satisfaction.

Nonetheless, focusing on the-entrepreneur own motivation perspective, the risk-taking propensity to implement the 3D Printer will depend on the entrepreneur's narrow traits.

This research will describe 3D printer implementation cutting off complexities from SMBs' supply chain processes and making easier the SMBs' business activities, and to emphasize the Additive Manufacturing effects this research will also illustrate a comparison between the process length of the supply chain of traditional manufacturing procedures and the additive manufacturing implemented through the supply chain in terms of efficiency, time, and in term of cost.

2.2 Methodology and Limitations

In perspective to provide an answer on whether additive manufacturing impacts positively on SMBs' supply chain processes, this research will use a qualitative method then to concatenate the beneficial impacts of 3D printers on SBMs' supply chain overall and the significant changes in SMBs' business strategy.

In dynamic to provide a clear view to the readers of the 3D printer impacts points on the SMBs' supply chain processes, this research will perform the task to be a literature

review that joins the set of two previous qualitative and quantitative research as well as an approach.

This research will not emphasize the 3D printer machine technical maintenance or numerical data with calculations or the 3D Printer design boundary whereby, the knowledge and the mastering of the 3D Printer design application will depend on individual skills to deal with the application programming interface.

3 3D IMPLEMENTATION

3.1 A general review of the 3D Printer

Additive Manufacturing (AM) is a denomination to describe a sort of technology that creates 3D objects by adding a layer-upon layer of material. Despite variable materials, the computer is used together with 3D modelling software. (3D printing scratch, 2020). Besides, 3D printing is denominated also a Desktop fabrication, which process creates a real physical object from a 3D design blueprint. (3D Insider, 2019).

Furthermore, for a brief history of 3D printing, in the year 1984, Charles Hull created a process named stereolithography (SLA), then later he founded the company 3D Systems. Since a quick development has come in the Additive Manufacturing field, but then in the year 1990 this technology captivated more attention across the technology domain by producing fully functional organs. Using a 3D printed synthetic set wrapped with cells from the patient's body, formerly the first lab-grown organ was transplanted successfully in young patients with urinary bladder augmentation.

Withal, the Additive Manufacturing has demonstrated that the raw materials could be sourced from plastic to Metals, to Human cells meanwhile, this technology was promising no limit possibilities for the future of 3D printing. Furthermore, in the year 2008 appeared the first self-replicating printer, 3D printer has been apt to of producing itself by printing its part and components. And more, in the year 2009 Maker Bot industries marketed DYI kits which permitted people to create their desktop 3D printers.

Over years the 3D printer has evolved and has acquired a propensity to change the manufacturing and logistic processes through Small & Med-sized Business supply chain management.
However, Additive Manufacturing has been used immensely in various industries such as prototyping, construction, and biomechanical. (Ngo et al., 2018). Even so, the technological advance has allowed the news and emerging small-scale concepts that are accessible to an individual or small-sized organizations.

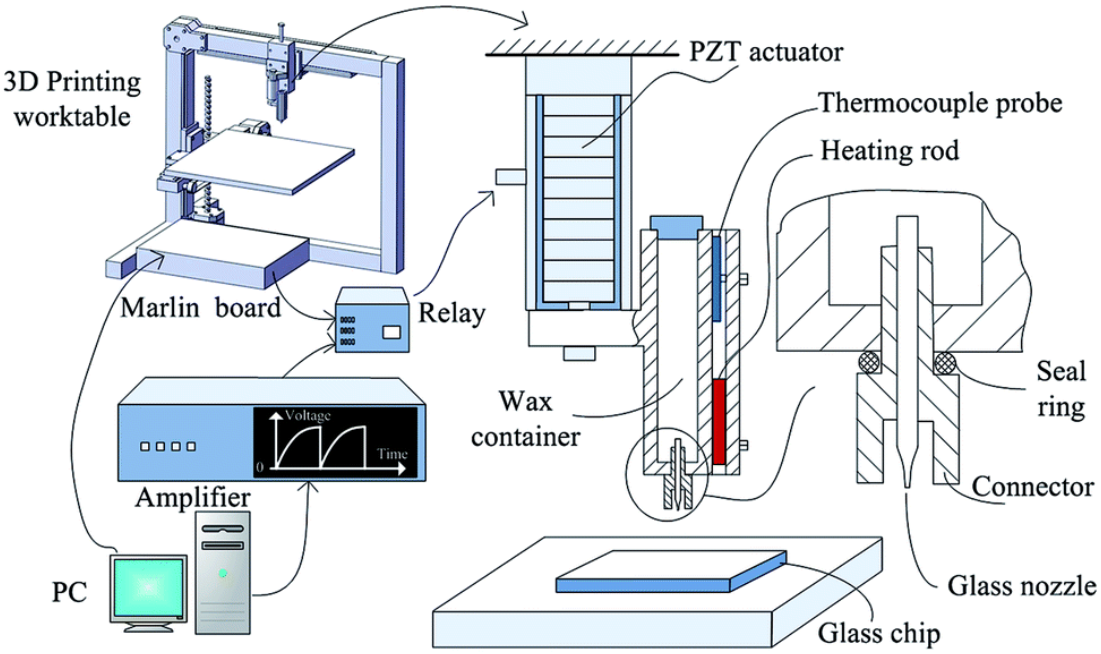

Figure 1: 3D machine. (*3D Printer*, 2017).

3.2 3D Printer perceived values and potentiality in the industry

3D implementation has demonstrated a proven conceptual benefit through some industries' supply chains, such as spare parts manufacturing. While the 3D printer was primarily used for prototyping, currently Additive Manufacturing is drafted and used growingly for industrial end-use applications. Wohlers Associates reported that, in 2012, 28.1% of all additively manufactured products were functional parts, while in 2016 the corresponding percentage was 33.8%. Due to the growth of worldwide revenue of Additive Manufacturing products and services grew from $2.25 billion in 2012 to $6.05 billion in 2016. (Chekurov et al., 2018).

Furthermore, on a global scale economy, the companies that are taking risks propensity to perform in international trade must possess a competitive advantage over other organizations in the same activity field. (Nigh, 2017). In addition, the spare parts industry has a particularity in inventory management which are different from those type of inventory e.g., the raw materials, in spare parts inventories the level is always high kept by the companies in objective to avoid the risks and the unavailability. But holding high-level inventories remain a supplementary cost to the organization. The dilemma of the companies is that the sourcing of spare parts is limited to a few suppliers, which often placed the companies under constraints with longer lead times and costs.

Whether the companies multiply suppliers for sourcing spare parts, causing risk of the variations of the quality of the materials, and the obsolescence of the machine could be a factor problem to determine the unit of spare required in inventories management, for example, antique machinery or obsolete elevators. (Chekurov et al., 2018).

Thereby, the digitalization of spare parts (DSP) manufacturing will make less severe the challenge occurring through the inventory management process. The integration of the digital spare parts could be related to the lower level of warehousing and diminishing the transportation costs meanwhile making faster lead times and delivery times. To fulfil the 3D installation the process required primarily ITC system requirements and human resources e.g., personnel qualified to manipulate the computing system.
Additionally, the DSP subgroup enhanced spare parts to better quality even than the original ones, dues to the better-elaborated design by topology optimization or decreasing the number of joints to lower the risk of failure. (Chekurov et al., 2018).

3.3 Effects of 3D Printer on the logistics line

While Additive Manufacturing operated through the supply chain of small& mid-sized businesses, this technology digitalized the supply chain and stands for to be a game-changer in organizational structure and its activities processes. 3D printers changed the supply chain design choices and the supply chain performance outputs, including the supply chain configurations, the supplier relationships, the production, and the creation of a return channel. Moreover, Additive Manufacturing influenced the main supply chain functioning by reducing costs, improving responsiveness, and preventing bottlenecks. (Verboeket & Krikke, 2019).

The distinguishing characteristics of 3D Printers related to consumers' requirements concern the likelihood to follow the product's customization and the rapid response to customer demands which reflects the Additive Manufacturing flexibility and adaptability. The 3D Printer used in manufacturing plants has demonstrated fast innovation through the organizational strategy, by decreasing the time-to-market and mitigating the risks of non-adoption meanwhile, increasing the ability to deliver the long-tail of market demands. 3D Printed prototyping and the personalization processes have included the consumer's active participation in the realization of the product designs and finished articles. Which processes impact significantly consumer satisfaction? The distribution will be decentralized dues to the digitalization of the manufacturing by providing the nearest proximity to consumers while the effectiveness increased tremendously to respond to the market needs.

3D printers have affected the length of the supply chain processes by cutting off the intermediaries, the product movements are reduced. Small & mid-sized businesses can deploy the 3D Printer through various locations, it can be print shops located on different continents, different cities, or neighbourhood levels as hubs or at local service

providers e.g., local libraries and post offices. 3D Printers in manufacturing plant requires lower-added-values production which remains fewer production costs.

Furthermore, Additive Manufacturing stands for that attribution "production closer to home", in terms of transport flow 3D Printers brought the inventories to a lower level which remains fewer costs in warehousing and reduced massively the length of distribution between the manufacturing and consumers.
The raw materials transportation input is still needed besides Additive Manufacturing used in the production, thereby they can be transported in bulk with less packaging occupying less volume and lower tonnage by km which significantly reduces the freight costs and eliminated progressively the risks of rush-delivering, which represented the propensity of employees to produce mistakes through the supply chain management. (Boon & van Wee, 2017).

Whenever products manufactured in outsourcing would be relocated and sourced in the local market which change could diminish massively the freight volumes meanwhile increasing tremendously the supply chain suppleness.
The usage of 3Dprinters increasing and changing intensively in the logistic sector and transport then from that fact, the logistic providers are dealing with the 3D network by adapting their sector for mid-future changes in supply chain processes due to the 3D printers' effects.

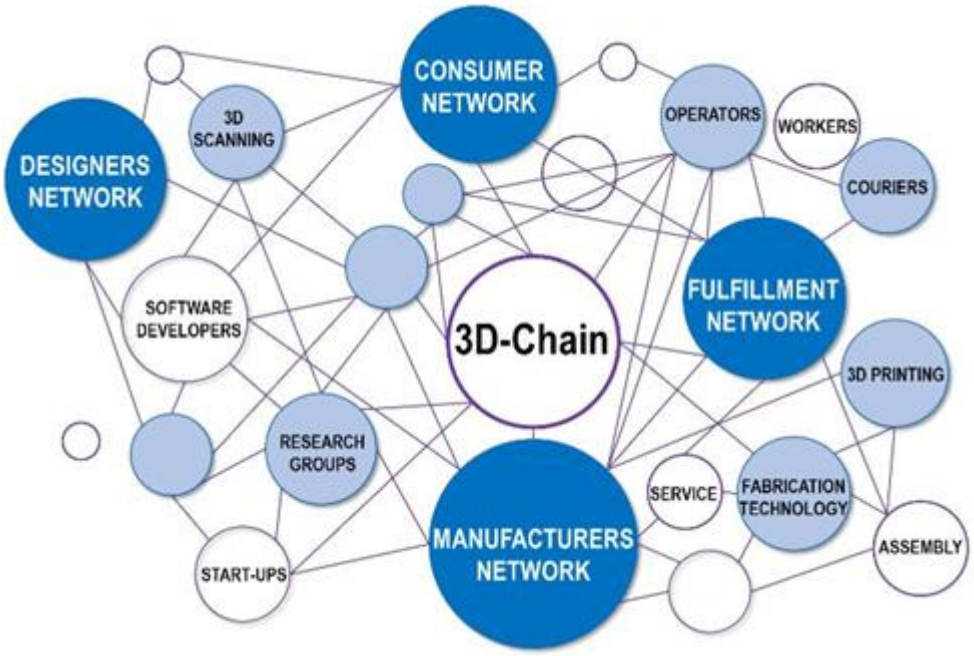

Figure 2. 3D effects and description of the supply chain**.** (*3D Effect on Supply Chain*, n.d.).

3.4 How does a 3D printer function?

Additive Manufacturing technical printing processes remain like the inkjet 2D printer which we are using every day to print out texts or designs on paper, but the 3D printer injects more layers to create a 3-dimensional object from a digital file. Whereas Additive Manufacturing is the opposite of subtractive manufacturing which is cutting out the pieces of the material. (3D Printing, 2019). The 3D technology converts the raw materials such as metals, plastics, ceramics, etc., into thin layers by heating, light laser, etc., which process is occurring with no waste of the material, because the process remains to add layers one on another until it creates the physical object from a digital design. Common 3D printing technologies are FFF, SLA, SLM, etc. FFF is the most known and the most used technology, FFF stands for Fused Filament Fabrication which is a 3D printing technology using PLA, ABS, and other thermoplastic filaments which will be heated and forced out by the squeezing head and curved layer on layer controlled by the computer to construct a shape, 3-dimensional model.

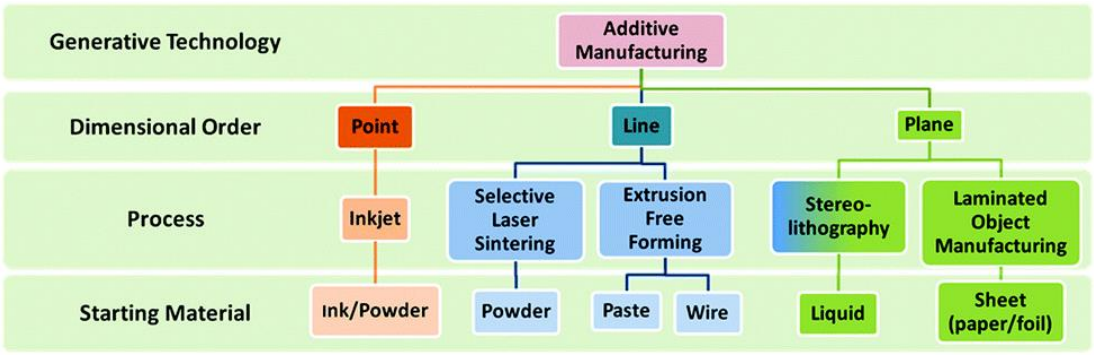

Figure 3. 3D functioning. (*3D Printer Functioning*, n.d.).

3.4.1 Modeling process

Additive Manufacturing requires only a few steps to realize your digital design, the process is easier including modelling, slicing, printing, and post-processing The 3D apparel prints from a digital design, and the modelling will convert the object into a digital model which can be printed by the apparel, whenever, 3Dmodels are created with 3D modelling software and the most common is CAD software, There are multiple software easy to use by a beginner but some of this software is suitable for professional with deep knowledge of the technical use.

Additionally, those technologies permit the creation of models for 3d printing. While from a set of basic shapes the software builds the concept of an intuitive object which you can develop the models and print out through 3D apparel. The software interface allows for storage and available a literal library capable to contain millions of files

that, users can find in forms and shapes manipulable to users' free desires, (Dehue, 2020).

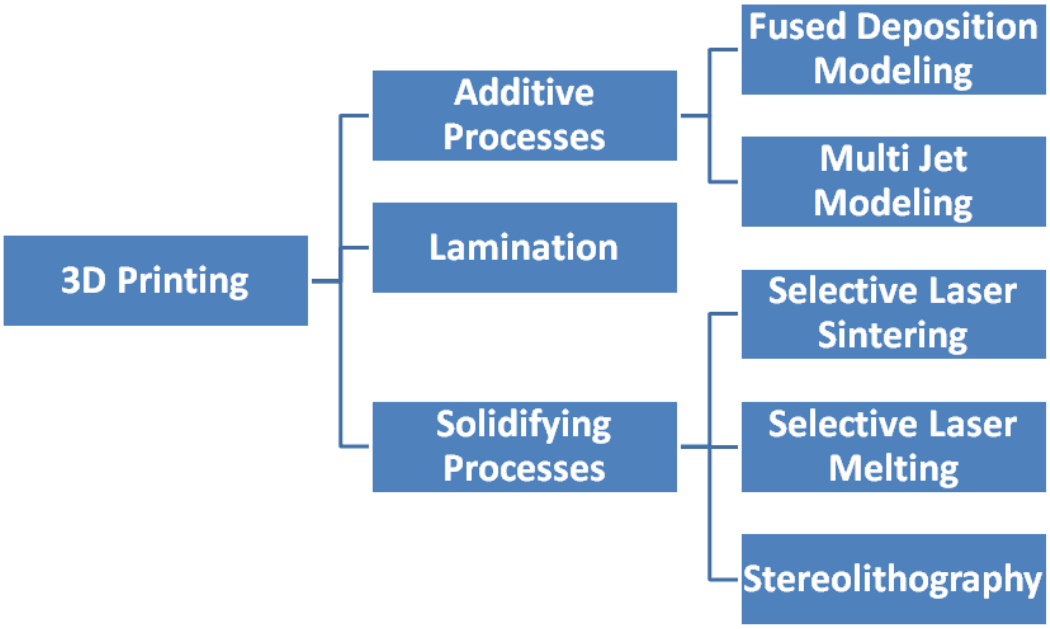

Figure 4. 3D processes and description. (*3D Printing Processes*, 2013).

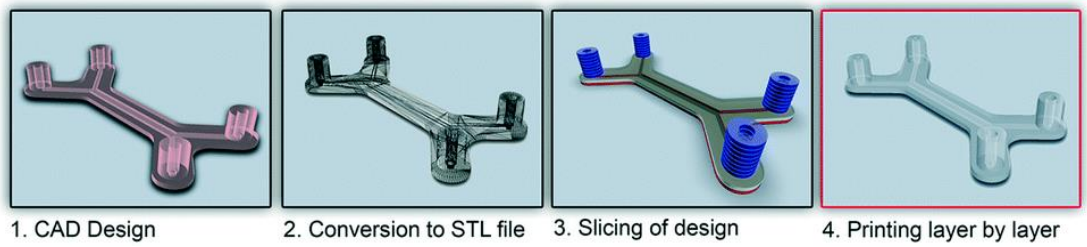

Figure 5. Printing processes. (*Printing Process*, 2016).

3.4.2 Slicing

These methods in the 3D modelling conception are easy to use also, they go from a 3D model to a printed part thereby, they take a CAD model, slice it into layers and convert the model into G-code including the 3D printer settings such as temperature, layer level, print speed to the G-Code. Then, the 3Dapparel read this G-code and produces the model layer by layer in the account of the G-code instructions. (Dehue, 2020).

In addition, the gradual real-time slicing is protected in case of the user changes the setting the slicing doesn't need to start from the grind. Because the G-code can be the only affected for the recalculation which processes is a flexible and precise program. G-code stands for an operational language for Computer Numerical Control machining. In the year 2020, the World Academy of Research in Science and Engineering. Set up all right reserved milling machines to follow the protocol process as CNC. ("Simulation In Classroom: Development Minicomputer Numerical Control (CNC) Milling Machine for G Code Movement," 2020).

Figure 6. 3D software. (*3D SLICER*, n.d.).

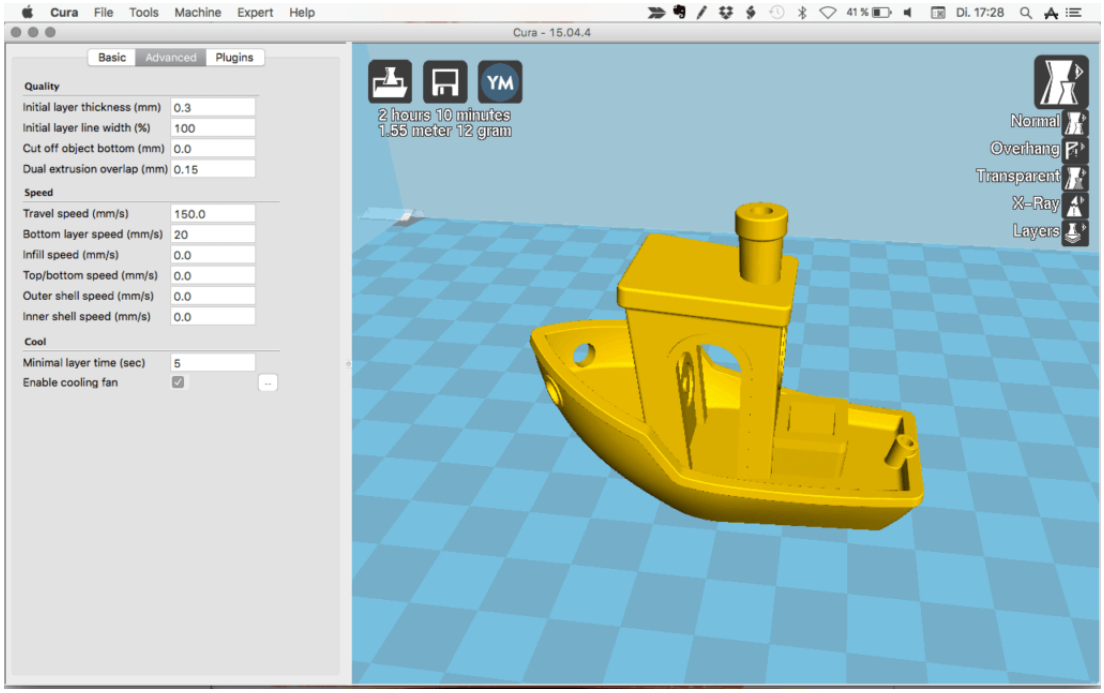

Figure 7. 3D software. (*3D Software*, 2017).

3.4.3 Printing

The printing process starts once the file is done in CAD. In contrast, the users design the 3-D model, export the file in Standard Tessellation Language (STL), and upload the file to the 3D apparel (printer) into accepted printing format, such as .obj file or. am file and can be directly applied as input to a3D apparel which process illustrates the shortened aspect of the connection between the digital design of the product and the manufacturing file. An XML-based is the Additive Manufacturing File (AMF) which allows access to standard reporting objects for 3D printing including a native reinforced for colour, material, lattices, and clusters. (Peng, 2016).

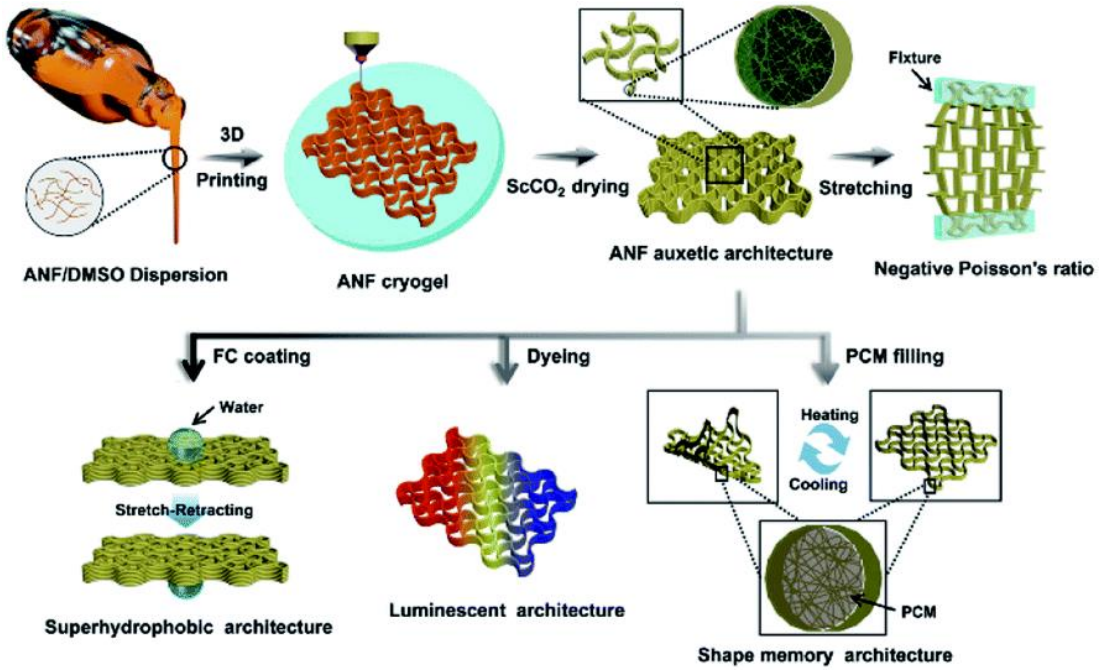

Figure 8*:* 3D printing and description. (*3D Printing*, 2020).

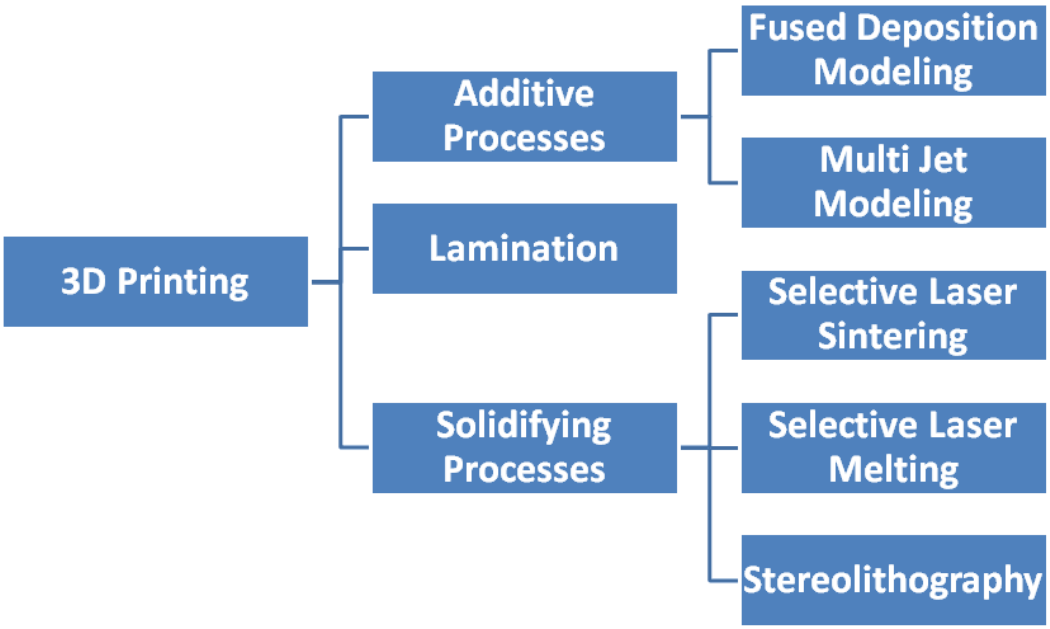

Figure 9. 3D printing. (*3D Printing*, 2013).

3.4.4 Post-Processing

Post-processing is an important step of the Additive Manufacturing process and includes any other process or task that needs to be carried out on an object printed whereas any technique or treatment utilized to enhance the object printed. while post-processing is not needed for all printed objects. Moreover, the accuracy of the shape of the 3D printed object and the product quality improved the technology efficiency. Nonetheless, diverse food additives such as xanthan gum, methylcellulose, and k-carrageenan showed conclusive influence on printing stability while their post-processing is, drying, steaming, frying, etc., meanwhile, these processes are the key challenges to retaining the original shape of the 3D printed product. (Hussain et al., 2022).

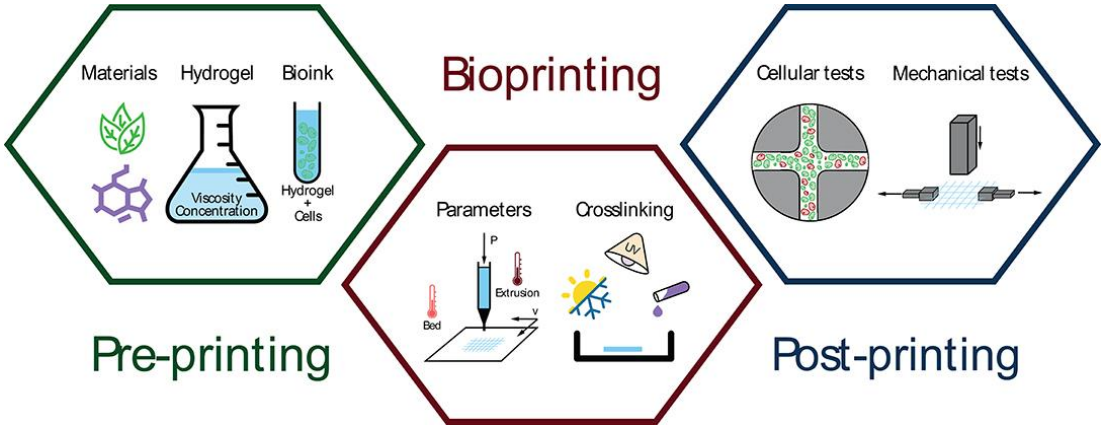

Figure 10: Bioprinting and description. (*Bioprinting*, n.d.).

The post-processing also ameliorates the 3D printed part's aesthetic while strengthening the object's properties. These processes include cleaning and prepping, and finishing. While the cleaning and the prepping process doesn't require much equipment and effort which remain to remove the support removal, Thus the support removal is insoluble supports made from the same material as the main part whereas the part and the supports will be printed from the same spool of filament. Furthermore, the finishing processing can include polishing and painting the 3D object printed. (Gregurić, 2022).

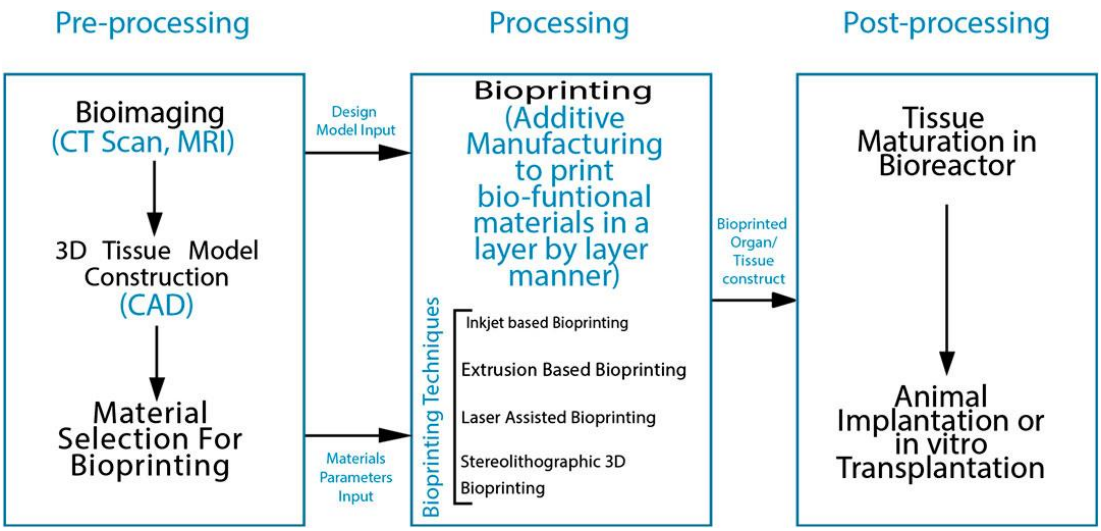

Figure 11. Bioprinting. (*3D Bioprinting*, n.d.).

3.5 The major impact of additive Manufacturing

This technology, 3D printing enables users to be involved in manufacturing processes whereas the downstream supply chain can be influenced by the customers due to the 3D implementation through the organization's supply chain. Additive Manufacturing allows the customization of the products while providing speedy and flexible responses to change. In addition, 3D printing has gained the reputation of being faster in prototyping among SMBs' activity.

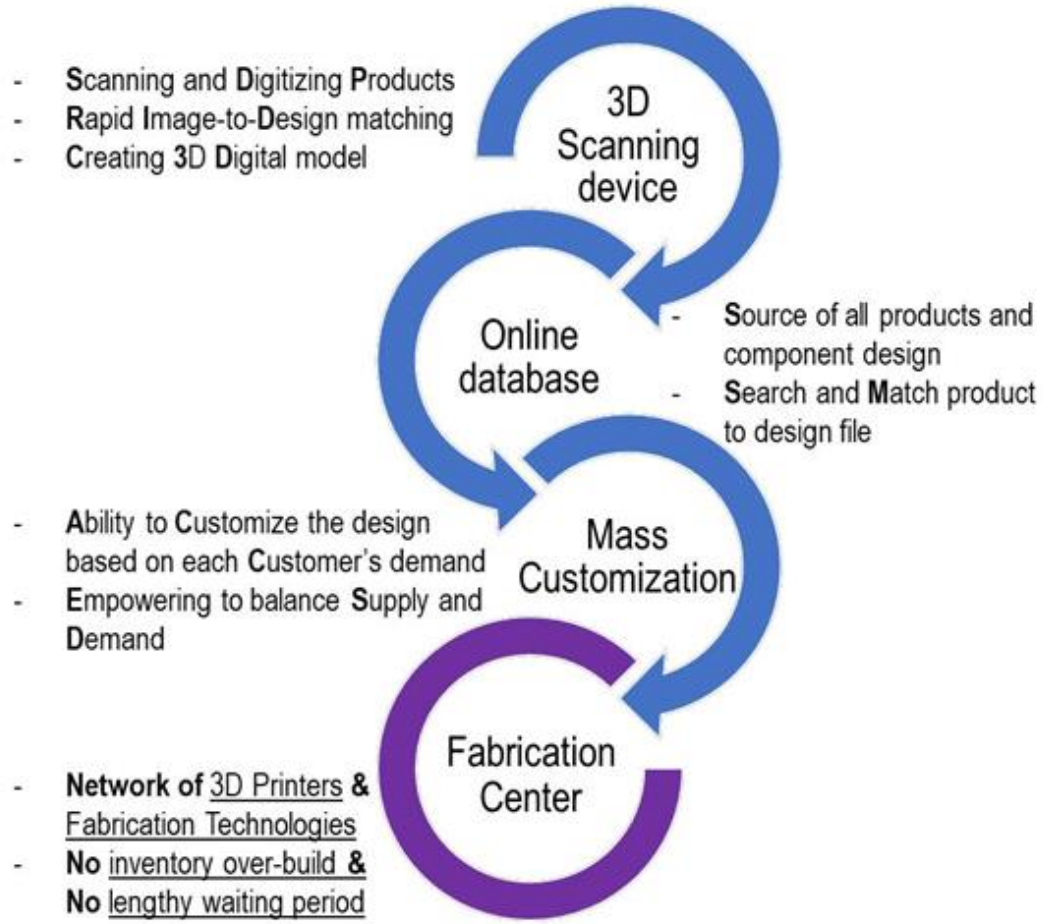

Figure 12. 3D effects on the supply chain. (*3D Effects on Supply Chain*, n.d.).

Moreover, 3D printing increased the capacity to manufacture products in a single -full that eliminated the need to assemble diverse components. Which process reduced intensively the SMB's supply chain complexity. Consequently, the stock of replacement parts in raw materials to produce the products is reduced and the work activities amount is diminished, and the production process is shrunk. (Tasé Velázquez et al., 2020).

3.5.1 The mass customization

Additive manufacturing used in SMBs supply chain can impact significantly through all the production lines, whereby the inventory management is digitalized such as inventories in a 3D form e.g., STL files which provided less time to manage the inventories with lower raw materials requiring the fewer amount of personnel overseeing. Thereby mass customization is the conclusive process that demonstrated the 3Dprinting impact on SMB's supply chain.

Whether the current exemplar of mass production. Additive manufacturing enables the production of customized products with a wider range in terms of flexibility in design and appropriate cost meanwhile AM technology provided users the ability to access products in their own desirable time, in addition, the AM technology allows users to participate in their products design changes without applied any supplementary cost or re-processing cost due to the Additive Manufacturing digital aspect. (Tasé Velázquez et al., 2020)

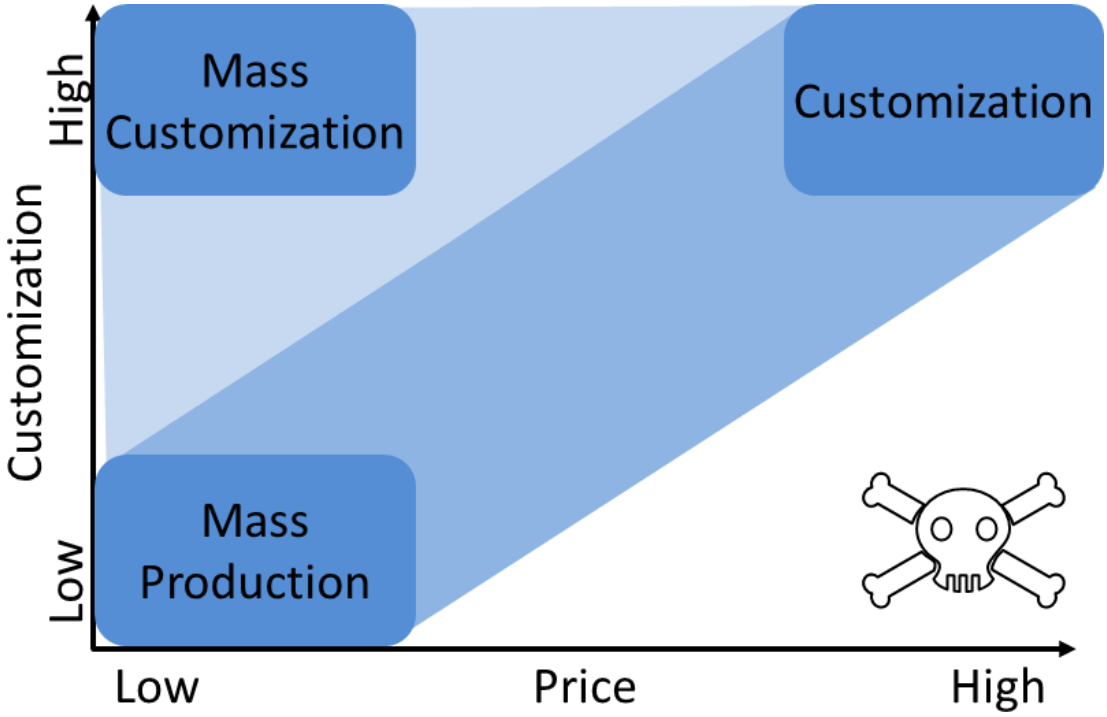

Figure13. Mass-customization. (*Mass-Customization*, 2019).

Whereas mass production customization is only designed products and services to each customer across efficient process flexibility and integration. (da Silveira et al., 2001).

3.5.2 Decentralized production

The AM technology enables the decentralization of the production location by the faster response to changes in demand and by helping to shrink the lead time. Toward, the production is localized very close to the final consumers thereby the delivery to customers is faster and more efficient. Furthermore, the decentralization of production enables SMBs more flexibility in supply chain management by increasing their competitiveness and efficiency. In addition, decentralized production mitigates the risks in SMB activities processes by elevating the customer to the centric business.

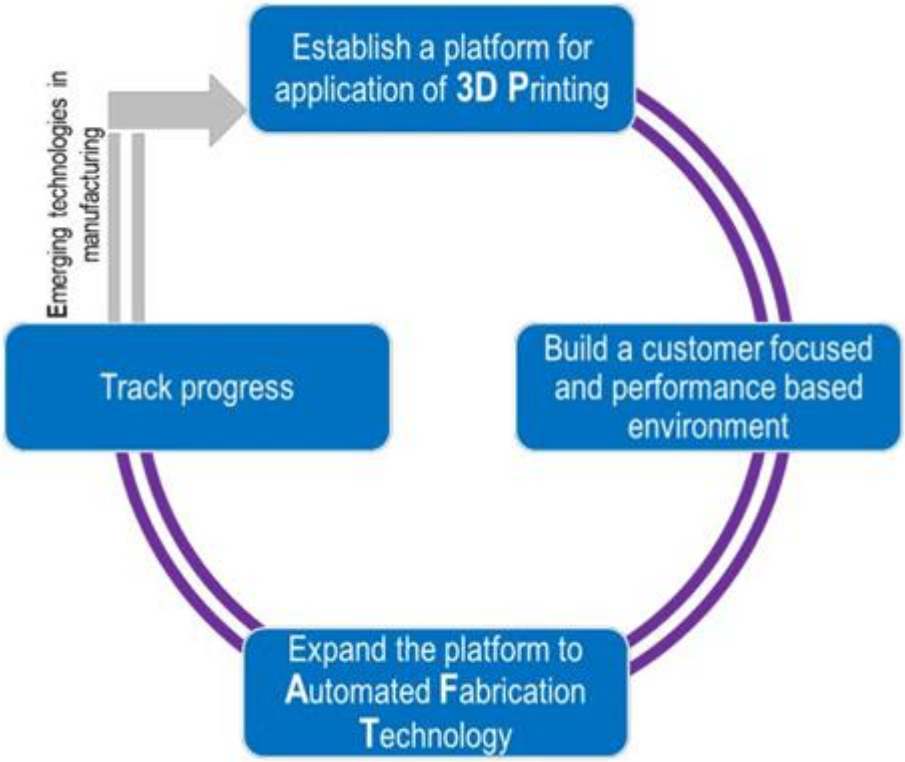

Figure 9. Decentralized production. (*Decentralized Production*, n.d.).

3.5.3 Start a Business with 3D Pinter

AM is a reversive technology when come to changing the entrepreneurship traditional process whereby the entrepreneurs look for business ideas and they tend to take action to implement the business idea whereas Additive Manufacturing provides entrepreneurs with a wider range of business feasibility. The AM technology enables the infinity of possibilities to change the shapes of the products, textures colour, and size by manipulating the digital files to own desires.

Whenever Additive Manufacturing is affordable for individuals planning to start a business activity in Finland, thereby with a 3D printer apparel an entrepreneur can register his company name with the Finnish Patent and Registration Office (PRH) and the Tax Administration, registration suitable online, then establish a physical address or online address for the business and supply your business by purchasing the filament related to your desired business core e.g., metal for a metallic object, ceramic for diverse solid form, plastic for object basis in plastic, etc., for your 3D apparel, invest in equipment such as the computer. Furthermore, develop your network, take information on the competitors, and market your business activities by advertising and

promoting, pricing, and bringing your product to the right place to the right people (targeting- customer niche).

Thus, AM eased the business modelling processing and in addition, the entrepreneurship process remains to find out more ideas from the implanted activity due to AM technology which provides to the users an illimited possibility to change the product design and re-processing with fewer costs.

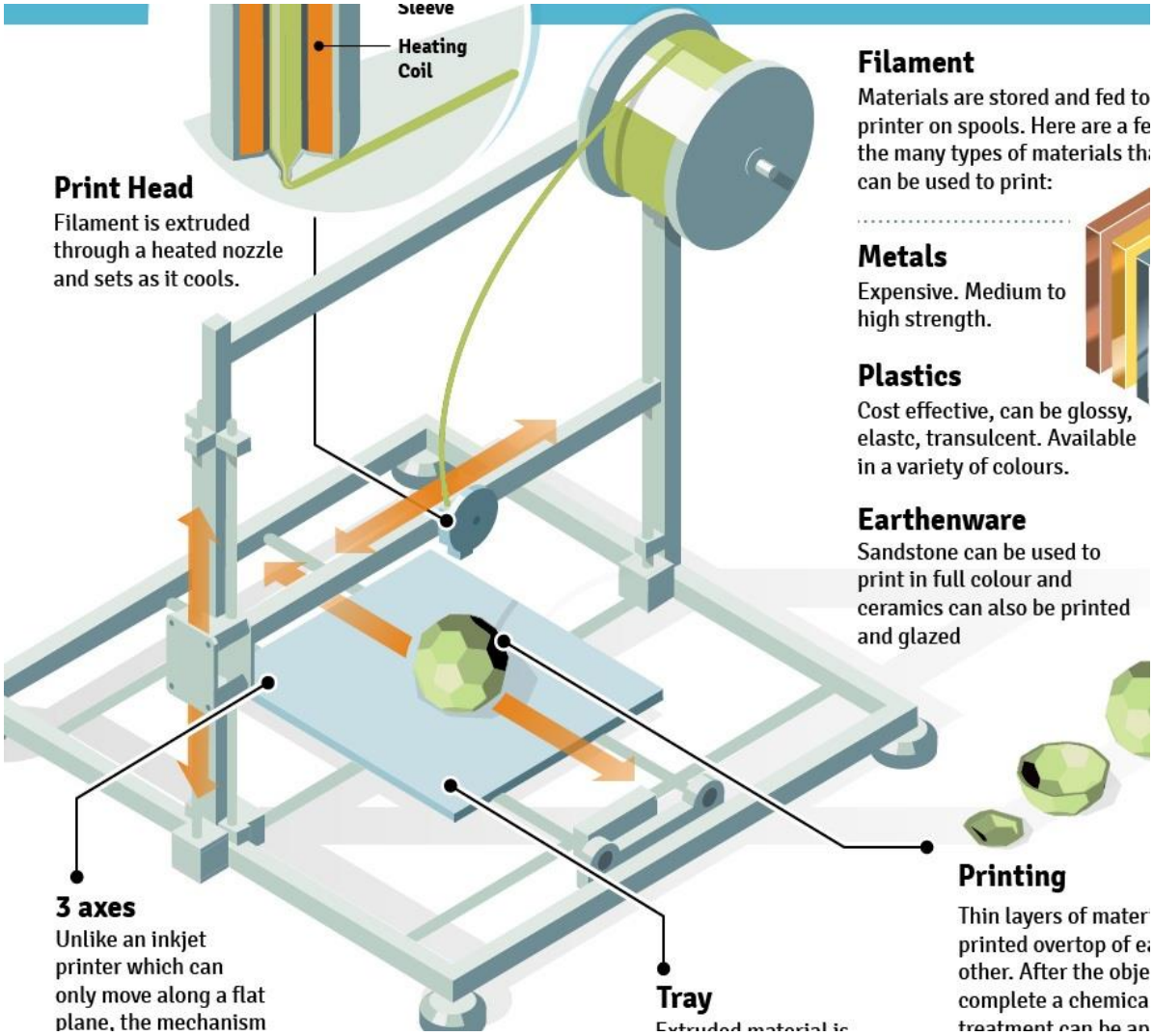

Figure 10*:*3D apparel and description. (*3D Apparel*, 2014).

Figure 11. 3D apparel. (*3D Apparel*, 2016).

4 3D PRINTER IMPLEMENTED IN SMBs SUPPLY CHAIN VS TRADITIONAL

4.1 Small & Mid-sized Business supply chain scheme

Small & mid-sized businesses can be identified as reported by the organization's input, output capacity, and on its sales or revenue. Thereby, the organization's number of employees, its total assets, or its quantitative raw materials utilized e.g., barrels of petroleum refined. These measurements are set up on consideration of administrative agreement or approval of equity whereas the SMBs can affect the economy's productivity level. (Miller, 1982).

Nonetheless, there is no formalized description differential between small and midsize business, even small business is categorized as those organizations with fewer than 100 employees and possessing less than $ 50 million in annual revenue meanwhile midsize business has more than 1000 employee and dispose of more than $ 50 million.in annual revenue (*Definition of Small and Midsize Business (SMB) – IT\Glossary | Capterra*, 2022).

Moreover, SMBs supply chain management deals with the flow of goods and services, including the transformation of raw materials processes into final products, and the streamlining of a business supply-side activities to enlarge the customer values and obtain a competitive advantage in the marketplace. (Fernado Jason, 2021).

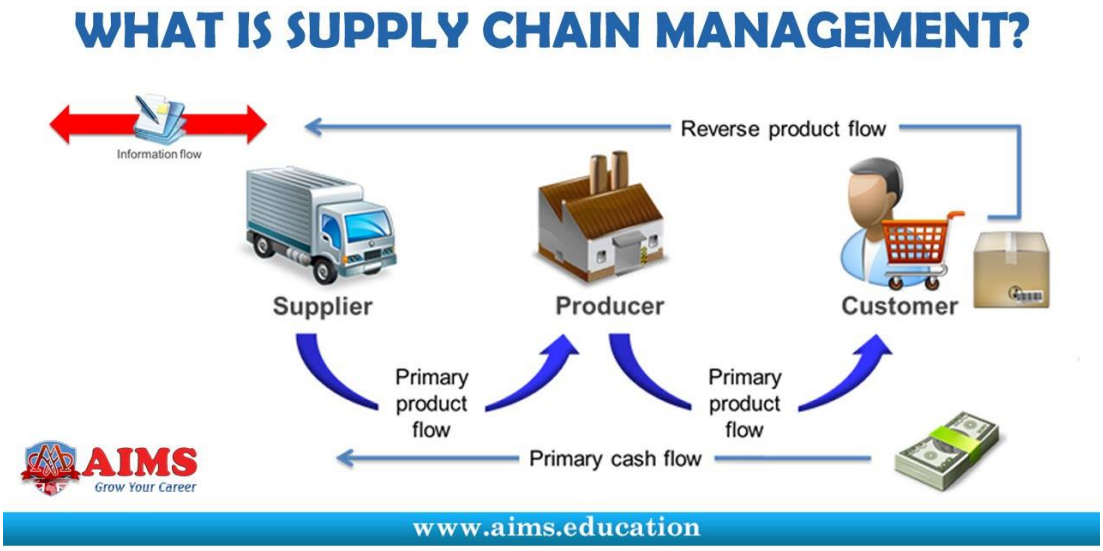

Figure 12. Supply chain management. (*Reverse Flow of Supply Chain*, 2018).

In addition, the supply chain addresses the flows of materials and information from procurement of raw materials for manufacturing passing by intermediaries such as

wholesalers and retailers into the final consumers including the reverse process starting from the customers into the raw materials suppliers.

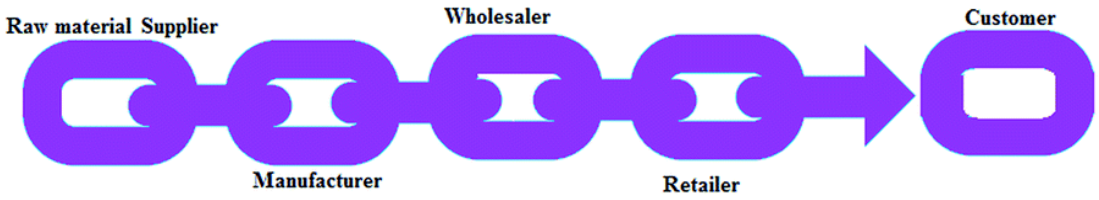

Figure 13.Supply chain. (*Supply Chain*, 2018).

4.2 Additive Manufacturing inclusion in the entire supply chain

Additive manufacturing could affect positively many of the supply chain links and even eliminate some of them, then making the supply chain processes shorter and faster occurring in a short amount of time increasing the organization's competitiveness meanwhile its flexibility and accuracy in terms of production and distribution.

Moreover, Additive Manufacturing impacts on the supply chain are assessed across the transport and issues related to the transport, location, 3D Printers can be in diverse sites close to the customers such as city-level hubs, mass -customization whereby customers decide on the design of their products, the distribution network more efficient. (Boon & van Wee, 2017).

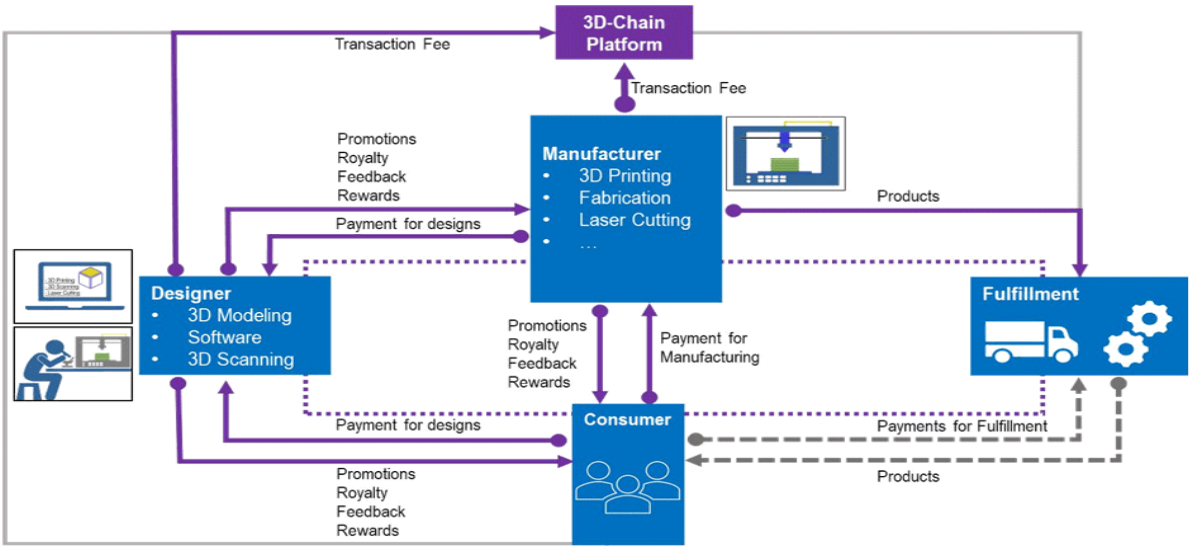

Figure 14. 3D and supply chain. (*Agile Supply-Chain Management*, 2018)

4.2.1 Additive Manufacturing costs

3D printing's cost-effectiveness is conclusive across multiple links of the SMB's supply chain, while every organization's strategy aims to reduce the cost whereas Additive Manufacturing reduces significantly societal costs and enables the organization to beneficial gains from a monetary viewpoint and resource consumption viewpoint. Whenever terms of the adoption of 3D Printing while the global estimation is $667 million in value-added produced utilizing 3D printing, that amount to 0.01% of the total global manufacturing value-added. Whereas US value added is estimated at $241 million, additive manufacturing is cost-effective and is revealed beneficial for SMB's small batches with continued centralized production. Moreover, the 3D printing costs are decreasing dues to the largely used and changes in the suppliers, manufacturers, and consumers interactions. Nonetheless, the forecasted estimation that for 3DPrinting to exceed $4.4 billion in 2020 and $ 16.0 million in 2025, and $96.8 billion in 2035. (Thomas, 2016).

4.2.2 3D Manufacturing and operation

This technology enables rapid prototyping, and the production of objects by adding layer to layer from the 3D digital model file. Whereas 3D digital technology required much fewer raw materials than traditional manufacturing which utilizes irregular cutting forming.

Additive Manufacturing allows the possibility to change the model's configuration which process provides responsive flexibility to meet customers' demands. Due to 3D technology development nowadays, more than one hundred raw materials are utilizable across 3D printing applications using thermoplastic plastic, metal, nylon, acrylic, plaster, ceramic, and edible materials. In addition, the technology created new rules of competition by eliminating much of the traditional labour and transport and logistic. (Chen, 2016).

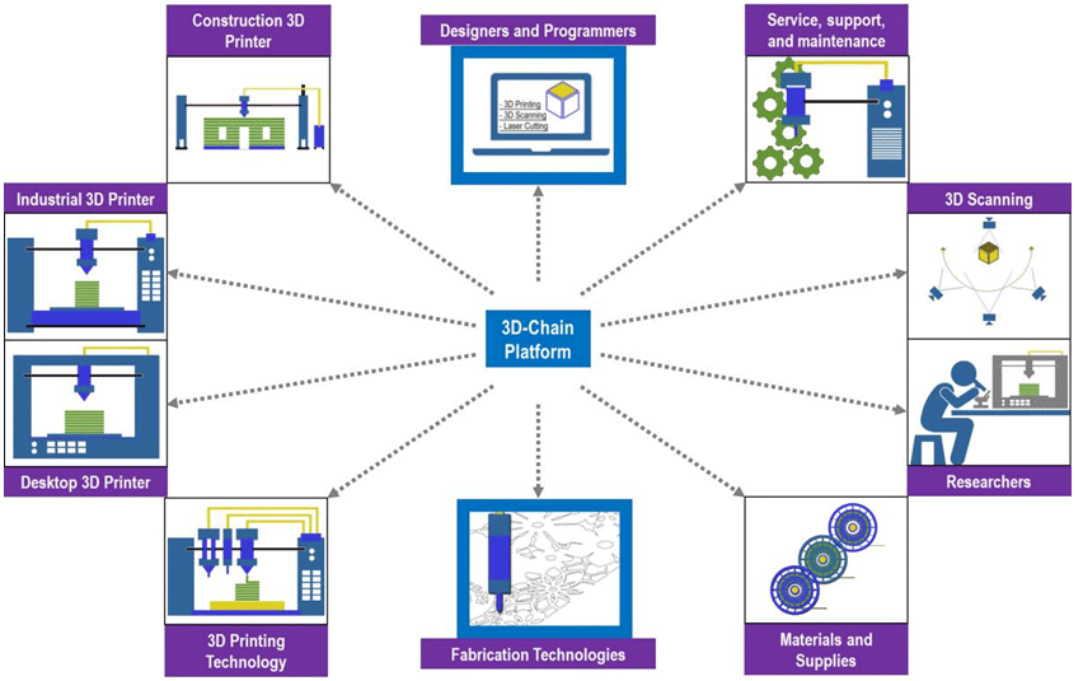

Figure 15. Manufacturing and operation. (*3D Supply Chain Platform*, n.d.).

Furthermore, a research-based quantitative approach using a questionnaire survey from a total of 124 medium and large-sized European Union automotive manufacturing companies. Whereby hypothesized relationships are tested employing fragmentary smallest square structural equation modelling. The conclusive result determined the perception of how supply chain flexibility mediates the effect of the 3D printing adopted on supply chain performance in the framework of the European automotive industry. Thereby the supply chain flexibility will lead to improvement in supply chain performance due to 3D printing digital adoption (Delic & Eyers, 2020).

4.2.3 Reverse Logistics and aftersales

Additive Manufacturing enabled the improvement of orders by meeting the requirement and reducing reverse logistics. The technology digitalizes the supply chain management, whereby the customers participate in the conception and elaboration of their products even the delivery time which process improves the customer's satisfaction and shrinks the return of products due to 3D technology tailoring processes.

In addition, Additive Manufacturing reduces immensely the lead time whereas all processes proceed in a short amount of time meanwhile cutting off some of the processes, therefore, the customers get faster the products. The inventories are reduced almost inexistent due to the production digitalized by which the products are produced by customers' demands, the warehouses are no longer required in the digitalized decentralized supply chain.

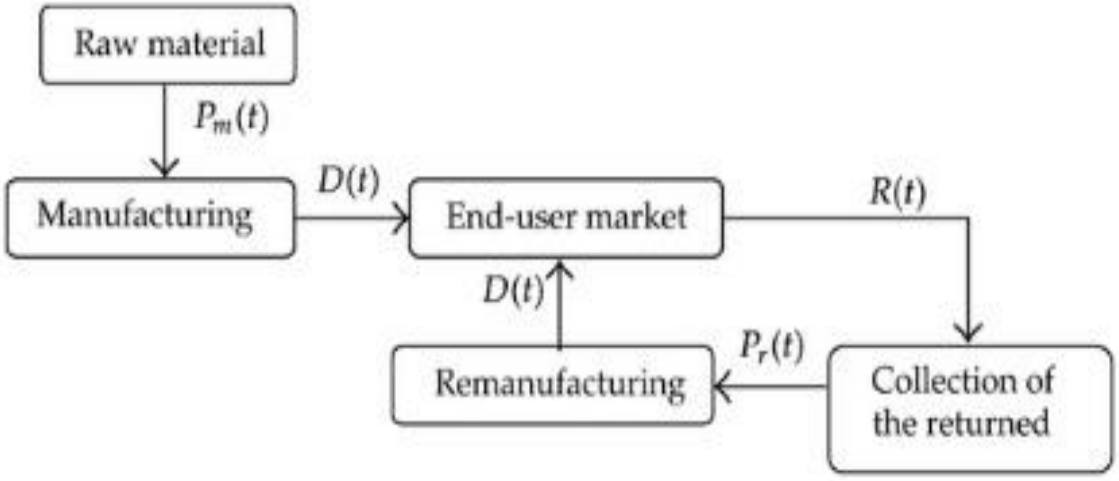

Figure 16. Reverse logistic and aftersales. (*Returned Logistic*, 2012).

Due to the Additive Manufacturing adoption in the supply chain, the reverse supply chain is not relevant in this picture, the products are manufactured based on customers' willingness and decisions thereby the process remains to produce customers' demands which process compresses massively and eliminates the scenario return of products.

5 CONCLUSION

The 3D Printer impacts tremendously on small and mid-sized businesses by reducing all processes as illustrated above chapiters, while the lead time is largely reduced meanwhile the production raised in gains of flexibility and the entire supply chain improved in terms of performance. Whenever the product's manufacturing costs are shrinking, the distribution of products obtains flexibility due to the digitalized decentralized production's location. This provides the customers with the room of freedom to select their product design or the re-design without any additional costs, the digital aspect of 3D printing enables users the possibility to elaborate on the most complex shape of the design of the product whereas the 3D apparel allows the realization of the digital file whatever complex this one can be.

Moreover, additive manufacturing is an enabler of the business idea for an entrepreneur, this technology eased the business implementation by compacting the traditional processes and by increasing with accuracy the customer's values by which process is improved intensively the customer's satisfaction. In addition, 3D Printing

improves massively small & mid-sized business responsiveness and enhances the organization's efficiency, besides the 3D effects on the speed of production and cost there are impacts also on its governance and social sustainability. This technology capacity and potentiality picture 3D apparel as one standing innovation option that could enable meanwhile a fast response to fluctuating demands and producing of customized products and mitigating the risks likely to occur throughout the supply chain processes.

Whereas with fewer costs, Additive manufacturing adoption in SMBs improves supply chain flexibility to stand against the disruption due to demand variability, shrinks lead-time, and provides to the organization to dispose of product variety.

REFERENCES LIST

3D Printing. (2019). What is 3D printing? How does a 3D printer work? Learn 3D printing. *3DPrinting.Com*.

3Dprinting scratch. (2020). Types of 3D printers or 3D printing technologies overview. *3D Printing from Scratch*.

Boon, W., & van Wee, B. (2017). *Transport Reviews Influence of 3D printing on transport: a theory and experts judgment based conceptual model Influence of 3D printing on transport: a theory and experts judgment based conceptual model*. https://doi.org/10.1080/01441647.2017.1370036

Chekurov, S., Metsä-Kortelainen, S., Salmi, M., Roda, I., & Jussila, A. (2018). The perceived value of additively manufactured digital spare parts in the industry: An empirical investigation. *International Journal of Production Economics*, *205*, 87–97. https://doi.org/10.1016/J.IJPE.2018.09.008

Chen, Z. (2016). *Research Article Research on the Impact of 3D Printing on*. https://doi.org/10.1155/2016/4173873

da Silveira, G., Borenstein, D., & Fogliatto, F. S. (2001). Mass customization: Literature review and research directions. *International Journal of Production Economics*, *72*(1). https://doi.org/10.1016/S0925-5273(00)00079-7

Delic, M., & Eyers, D. R. (2020). The effect of additive manufacturing adoption on supply chain flexibility and performance: An empirical analysis from the automotive industry. *International Journal of Production Economics*, *228*. https://doi.org/10.1016/j.ijpe.2020.107689

Fernado Jason. (2021). *Supply Chain Management (SCM) Definition*. Updated Apr 10, 2021. https://www.investopedia.com/terms/s/scm.asp

Hussain, S., Malakar, S., & Arora, V. K. (2022). Extrusion-Based 3D Food Printing: Technological Approaches, Material Characteristics, Printing Stability, and Post-processing. *Food Engineering Reviews*, *14*(1). https://doi.org/10.1007/s12393-021-09293-w

Miller, E. (1982). Productivity and the Definition of Small Business. *American Journal of Small Business*, *7*(1), 17–18. https://doi.org/10.1177/104225878200700105

Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T. Q., & Hui, D. (2018). Additive manufacturing (3D printing): A review of materials, methods, applications and challenges. *Composites Part B: Engineering*, *143*, 172–196. https://doi.org/10.1016/J.COMPOSITESB.2018.02.012

Nguyen, N. D., Ashraf, I., & Kim, W. (2021). Compact model for 3d printer energy estimation and practical energy-saving strategy. *Electronics (Switzerland)*, *10*(4). https://doi.org/10.3390/electronics10040483

Nigh, S. M. (2017). The Managerial Impact on Small Business Global Supply Chain. *ProQuest Dissertations and Theses*.

Peng, T. (2016). Analysis of Energy Utilization in 3D Printing Processes. *Procedia CIRP*, *40*, 62–67. https://doi.org/10.1016/J.PROCIR.2016.01.055

Perry, A. (2018). 3D-printed apparel and 3D printer: exploring advantages, concerns, and purchases. *International Journal of Fashion Design, Technology and Education*, *11*(1). https://doi.org/10.1080/17543266.2017.1306118

Simulation In Classroom: Development Mini Computer Numerical Control (CNC) Milling Machine for G Code Movement. (2020). *International Journal of Advanced Trends in Computer Science and Engineering*, *9*(5). https://doi.org/10.30534/ijatcse/2020/218952020

Small business supply chain challenges. (n.d.).

Tasé Velázquez, D. R., Simon, A. T., Helleno, A. L., & Mastrapa, L. H. (2020). Implications of additive manufacturing on supply chain and logistics. *Independent Journal of Management & Production*, *11*(4). https://doi.org/10.14807/ijmp.v11i4.1139

Thomas, D. (2016). Costs, benefits, and adoption of additive manufacturing: a supply chain perspective. *International Journal of Advanced Manufacturing Technology*, *85*(5–8). https://doi.org/10.1007/s00170-015-7973-6

Verboeket, V., & Krikke, H. (2019). The disruptive impact of additive manufacturing on supply chains: A literature study, conceptual framework and research agenda. *Computers in Industry*, *111*, 91–107. https://doi.org/10.1016/j.compind.2019.07.003