POLITECNICO DI TORINO

Masters of Science in Engineering And Management

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Master's Degree Thesis

3D Printers Market. Competition, Patents And Profitability Of The Industry.

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ABSTRACT

Technology has always revolutionized the ways in which humans work and prosper. One of the biggest technological inventions that have resulted in modernizing nearly all of the sectors of human life is the three-dimensional printing or also known as additive manufacturing. This process utilizes the process of layering to produce a desired product; layer on top of each other. The process unlike the old methods of subtraction does not cut out substances or material from the product instead uses the method of addition for shaping and forming the final product. Up till now, this revolutionizing technology of 3D printing has brought impeccable wonders in major departments or sectors that revolve around the human life. 3D printing has modernized the sector of medicine; now the patients who earlier were waiting on the verge of death are saved through tissue, organs and cells implants. 3D printing has shown excellency in the industries of automotive and aircrafts by introducing energy efficient technology into the sector. Another sector where 3DP has shown remarkable progress and development is the food industry. The industries using the 3DP technology in their functionalities and applications are ever-growing. When observed carefully and studied analytically, it appears that the 3D printing market faces a great competitive environment. To overcome the challenges lying ahead and to run in pace with the growing digital technologies it is very important for the 3DP market to put its performance in all the competitive analysis i.e. Porter's Five Forces, SWOT analysis and PEST analysis to see the stance of 3DP in market and improve it. With increase adaptation of 3DP in industrial market, a large number of companies have patented their processes. The 3D patent movement in 2020 by a large number of firms is known to make progress in the technological department of these firms. As for the profitability of 3D printing market, the 3D printing technology is leading to the reduction of waste materials and owing to the high accuracy and precision of the technology, users are able to print even the slightest or minor details of the variables, thereby leading to increased revenues and margins. The technology will be able to achieve its commercial significance when the depths of the desired goals will be applied to the technology and its applications. 3D models have helped the world achieve understandable concepts which were otherwise conceptual and not possible to achieve. Challenges do lie ahead however; the opportunities and possibilities in the formulation of printing material and product designing are limitless.

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1. INTRODUCTION

The production process of anything in this world consists of three basic steps i.e. an idea, resources to materialize the idea and investment capital for the compensation. As the entrepreneurial explosion started in the early 2000's, the software became the main focus of this progress. Once the idea is placed, the subsequent production and distribution of software-based products, while not as simple, still necessitate a group of workers, necessary equipment, and a minimally clear outlay for achievement. The ideology of a project is one's least concern when creating an object. According to research and studies, the atoms are the most important and complicated thing to wrangle because of their level of commitment and engineering design and for producing even a simple plastic-based gadget could cost thousands of dollars in which only the basic tooling would be set-up. These scenarios compel the emergence of a new technology called "Additive Manufacturing" or 3D printing.

Additive manufacturing technology can be understood as "those processes that aggregate materials in order to create objects starting from their three-dimensional mathematical model, usually by superimposition of layers and proceedings in the opposite way to what happens in subtractive (or chip removal) processes". In additive manufacturing, by using extensive computer controlling techniques the material is settled, solidified and joined to eventually produce a 3D object. In this process, some other materials are also adjoined in layer configuration e.g. liquids, plastic and powdered grains are joined together (Khan, 2019). Another way of defining 3DP is that these are the additive processes which manufacture a product by deposition of material using printing technologies such as print head or nozzles etc.

Initially 3DP was only used to produce prototypes which are only aesthetic and functional in nature. In 1980's, the term rapid prototyping was used in place of 3D printing. However, this perception regarding the 3DP changes over the years as the research studies managed to discover its great potential. Studies of 2019 showed that the precision and repeatability of 3DP is enough to use it as an industrial manufacturing technology as this technology has the ability to produce complex geometrical features which are practically impossible to produce by hand.

Globally, the additive manufacturing techniques are carried out on machines which are usually relatively cheaper than the conventional manufacturing equipment which is gradually making this technology stand out in the field of industrial manufacturing.

1.1 Basic Concept and Process

The basic principle of additive manufacturing is "layer by layer" way of producing elements. It starts with a 3D model file which is then divided into sliced layers in a way that the whole shape of the item is made from slices which is making its geometry. Each layer is then produced by employing the specific amount of material required for that specific layer.

Figure 1 Layer by layer manufacturing process

The general steps for manufacturing a part using additive manufacturing technique is explained below:

1.1.1 Geometry Definition

To define the external geometry of the product to be manufactured, a software model is used. On that software, the CAD solid modeling is done for surface representation and the output is a 3D file. However, to achieve the goal of surface representation, some other reverse engineering equipment e.g. optical and laser scanning etc. can also be used.

1.1.2 Conversion to STL

The 3D file from the software is then converted into a standard 3D format e.g. .STL format by using that same software. This format has been a common format these days but in the past other formats like .AMF3 or 3MF4 were also used. STL is basically an acronym derived from stereolithography (i.e. a process used for additive manufacturing and it will be discussed in next section). This file contains the geometric representation of the CAD model of the object and it is used as a basis for calculation of the slices.

Before sending this file for manufacturing to AM machines, there is a stage of inspection which is an important or crucial stage. This is done because some complications may arise during the manufacturing. Some of them can be listed as:

i) High risk of drooling due to complex geometries
ii) Non-closed vertexes in the design of the part
iii) Mistakes during STL conversion process
iv) Requirement of support structures for some designs during printing
v) Specific problems required redesigning of the part

These indications must be addressed before sending the file for manufacturing.

1.1.3 Transfer to AM Machine and STL File Manipulation

After making sure that the STL file is fit to use for manufacturing, the file is sent to the AM machine. Here the STL file is slightly manipulated for size, position or orientation correction.

1.1.4 Machine Setup

After altering the STL file for required specifications, some machine parameters are also set as per the geometry of the part e.g. layer thickness, material constraints, timings etc.

1.1.5 Manufacturing

The process of manufacturing of the product is an automated process which requires minimal supervision only. This monitoring includes checking of enough material for manufacturing and any issues with softwares etc. The total manufacturing time depends on the kind of AM technology, number of parts being produced, complexity of the part design and layer thickness.

1.1.6 Un-mounting of Manufactured Part

As the manufacturing completes, the part is then un-mounted from the machine. This interaction with the machine requires some safety checks to be done first e.g. the temperature of the machine is sufficiently low and there are no moving parts etc.

1.1.7 Post-Processing

After un-mounting, the part undergoes a post-processing phase during which may include cleaning or polishing of the part. Sometimes, the support features are removed from the part. Also, the part is sometimes subjected for additional machining to achieve required level of surface finishes and geometric tolerances. In addition to that, some post-treatment procedures like heat treatment are also performed to improve the metallographic and mechanical characteristics of the part. All in all, the type of post-processing depends also on the AM technology used.

1.1.8 Application

After the post-treatment phase, the part is ready to be used for the required application. However, sometimes the part has to be mounted with another assembly or another mechanical/electrical component to build the final model or product.

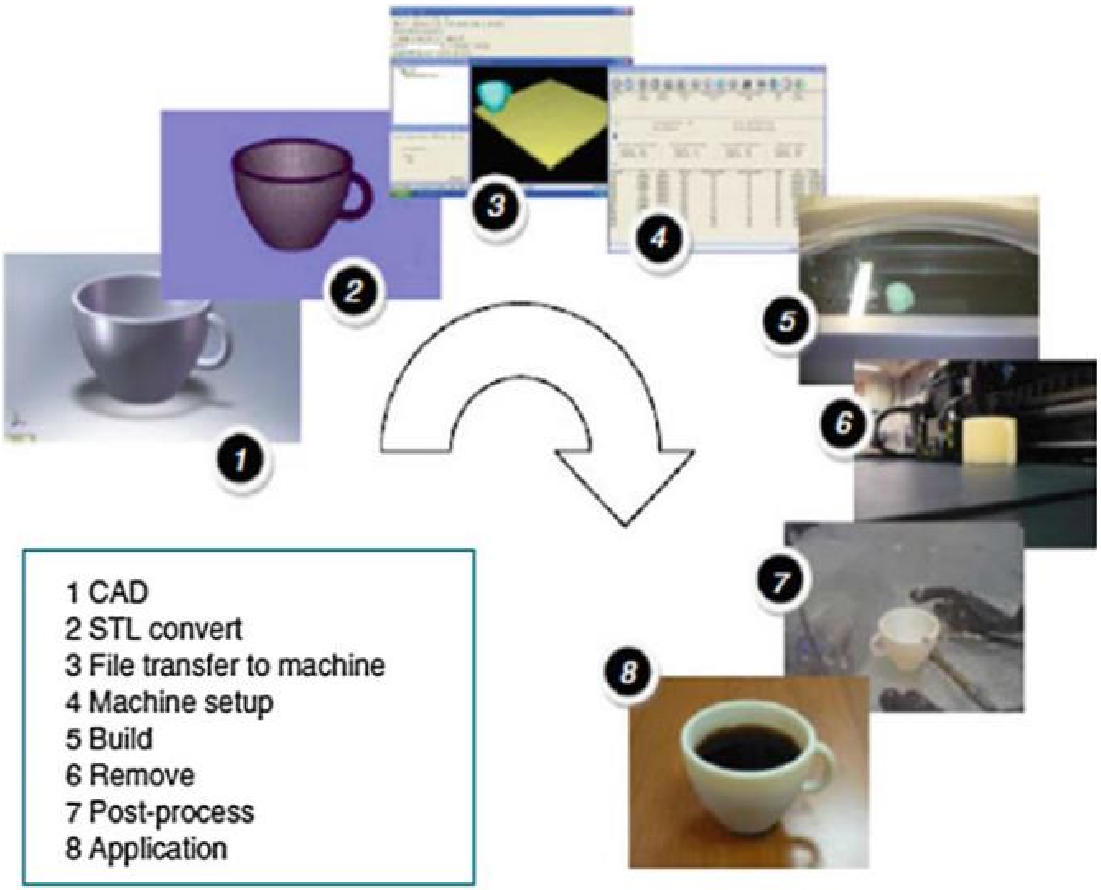
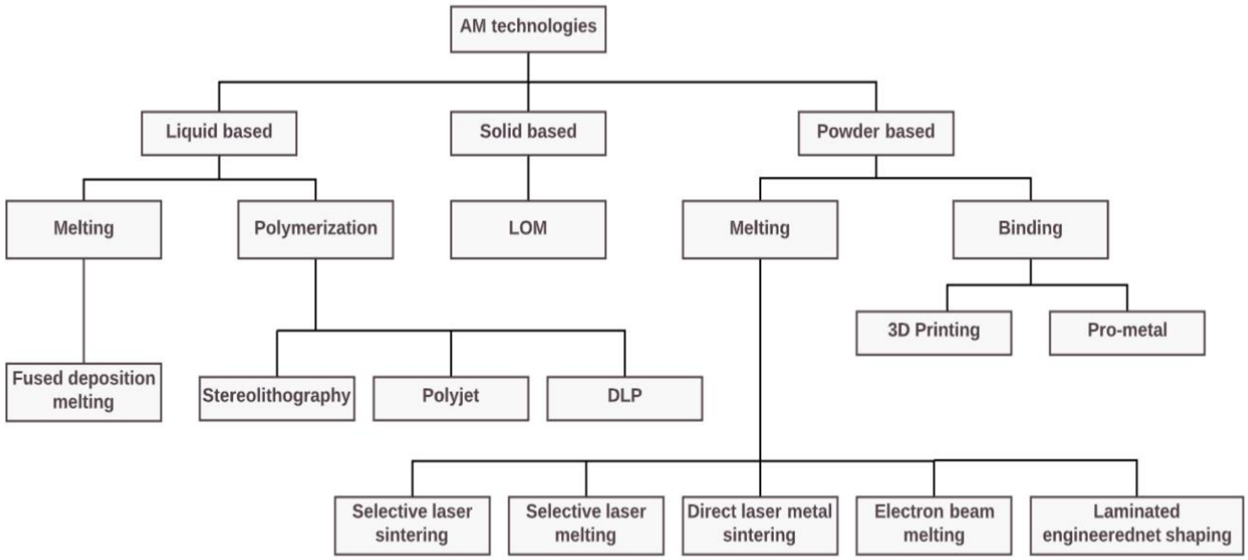


Figure 2 Generic Process of CAD to Part (All Eight Stages)

1.2 Types of 3D printing



Some of the most common technologies based on liquid, solid and powder are described below:

1.2.1 Liquid based technologies

i) SLA-Stereolithography

This technology employs a vat of liquid ultraviolet curable photopolymer "resin" with an ultraviolet laser to produce one layer at a time of the part to be manufactured. A cross-section of the part on the liquid resin's surface is traced by the laser beam in each layer. The ultraviolet laser cures and solidifies the pattern traced on the resin and joins it with the layer below. The SLA's elevator then descends by a distance equal to the thickness of a single layer after tracing the pattern. This distance is generally 0.05mm to 0.15mm (0.002"to 0.006"). The cross section of the part is then re-coated with fresh material by the resin filled blade. The subsequent layer pattern is then traced on this new liquid surface which then adjoins with the previous layer. Hence, in this way, a complete 3D part is built. After completion of this process, the parts are dipped in a chemical bath for cleaning of excess resin followed by the curing process in an ultraviolet oven.
To grip the part properly, the SLA process uses supporting structures which keeps the part attached to the elevator. This also prevents the deflection due to gravity and allows the

part to withstand the lateral pressure exerted by the blade used for re-coating. These supports are made automatically during the 3D CAD modeling process to be used on SLA machines; however, this can also be manipulated by a manual process. In the end, the supports can be removed manually from the end-product in contrast to other cheaper and rapid prototyping technologies.

Advantages:

The prime advantage of this technique is its speed. Depending upon the complexity and size of the project, the manufacturing process takes from a few hours to more than a day to complete. Generally SLA machines can build parts with a maximum size of 50x50x60 cm (20”x20”x24”) and for parts of more than 2m length could be produced from Mammoth SLA machine which has a platform of 210x70x80 cm.

Another advantage is the strength of the part. The prototypes produced by SLA have enough strength to be machined in post-processing and they can be used in injection molding, thermoforming, blow molding, and other metal casting processes as master patterns.

Disadvantages:

SLA techniques have an economic drawback. In comparison to other techniques, the SLA process is expensive. For example, the photo-curable resin has a long range from $80 to $210 per liter. Also the cost of the SLA machines ranges from $100,000 to more than $500,000. However, there are now some cheaper SLA machines available too and it is expected to have more affordable machines in the future as well.

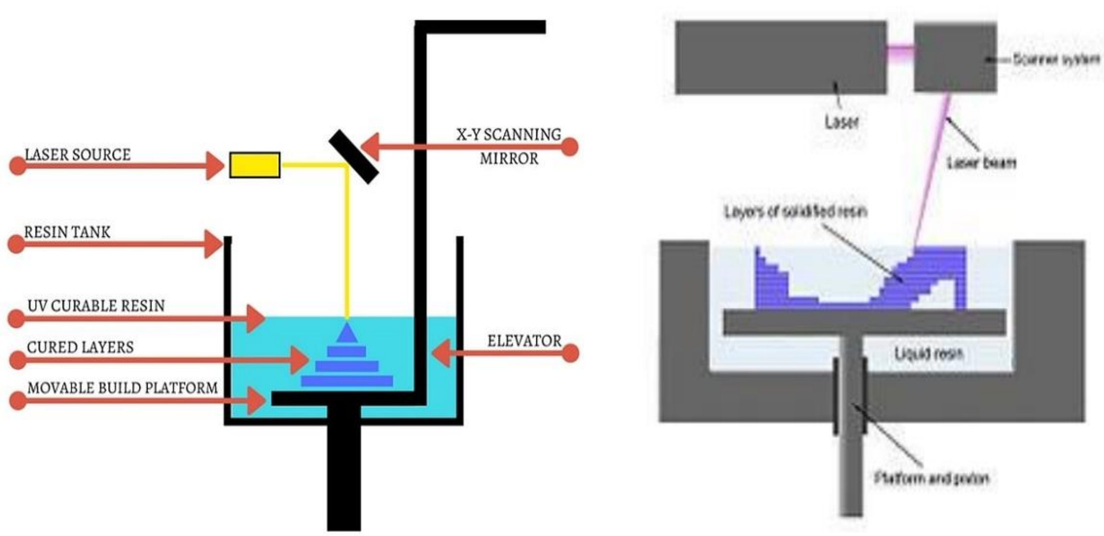


Figure 3 Diagrammatical Representation of the working of SLA

ii) Fused Deposition Molding - FDM

This process is an example of extrusion-based processes and it is the most diffused technology of the extrusion category. FDM is commonly used for prototyping, modeling and production applications. It also works on the additive manufacturing principle by building the parts in layers. The supply of material of the extrusion nozzle is governed by a plastic filament or metallic wire which controls the flow of material. To melt the material, the nozzle is heated which can then be moved to both vertical and horizontal axes by a computer-aided-manufacturing (CAM)software package which uses a numerically controlled mechanism. By extruding the small beads of thermoplastic material, the layers are formed and the material hardens immediately after extrusion from the nozzle to produce the part.

FDM is a rapid prototyping and rapid manufacturing technology. Rapid prototyping supports iterative testing and for very short runs, rapid manufacturing is used as a relatively cheaper alternative.

Advantage:

This technology is cheaper as it uses plastic.For expensive models, a different water-soluble material is used to remove the supports completely. Cheap 3D printers have enough resolution for many applications.

Disadvantage:

Limited testing is allowed due to thermoplastic materials. Also the supports leave marks that require removing and sanding.

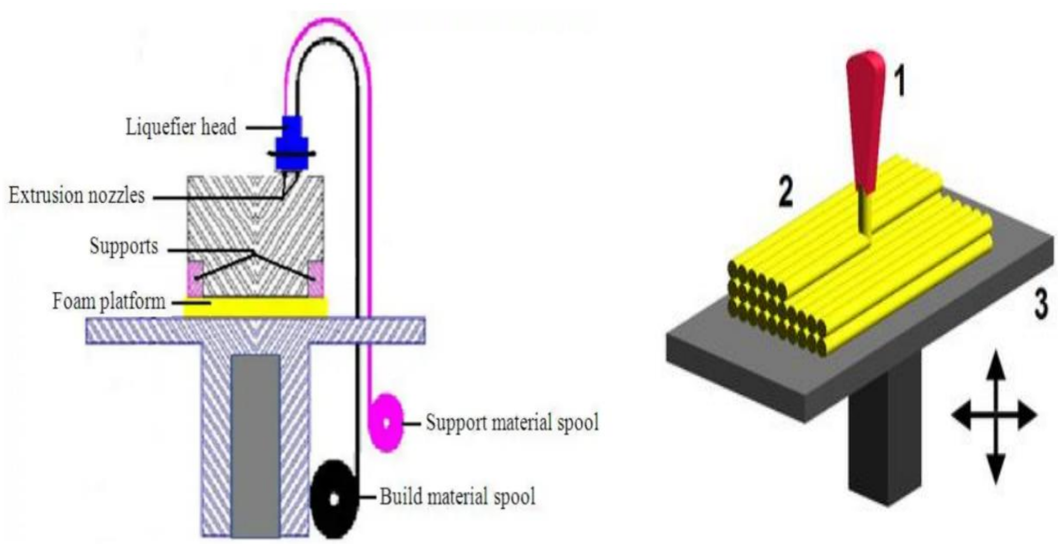


Figure 4 Diagrammatical Representation of the working of FDM

1.2.2 Powder Based Technologies

i) Selective Laser Sintering - SLS

This process uses a high power laser (e.g. a carbon dioxide laser) for the fusion of plastic, metal, ceramic or glass powders thus creating a desired 3D shaped mass. After the scanning of cross-sections generated with the use of a CAD file of scanned data by the laser, this same laser fuses the powdered material on the surface of a powder bed. The powder bed is lowered by one layer thickness after each cross-section scan and a new layer of material is applied on top. This process is repeated until the part is completely built. The SLS machine uses a pulsed layer because the density of the part depends on the peak power of the laser rather than the duration of the laser. The bulk powder material is preheated in the powder bed of SLS machine a little below its melting point to facilitate the temperature rise up till the melting point by laser at the selected regions. Most of the SLS machines use two-component powders, typically either coated powder or a powder mixture but some of the machines also use single-component powder e.g. direct metal laser sintering. The laser, in single-component powders, melts only the outer surface of the particles (surface melting) thus solid non-melted cores are fused to each other and to the previous layer.

In comparison to the other AM technologies, a relatively wider range of commercially available powder materials can be used to produce parts with SLS technique. This contains polymers e.g. nylon or polystyrene, metals including titanium, steel, alloys and composites. Apart from full melting, partial melting and liquid-phase sintering can also be done in SLS. Compared to the conventional manufacturing methods, SLS can produce parts with 100% density and comparable material properties depending upon the type of material. Also in SLS, within the powder bed, a large number of parts can be packed hence high productivity is ensured.

Advantages:

Among many other advantages, the most obvious one is speed because SLS does not require any special tooling hence the parts can be fully manufactured in a few hours. This technique has the ability to manufacture very complex geometries easily. In addition to this, SLS also allows rigorous testing of prototypes. Due to its ability to use alloy materials, the prototypes can be used as functional hardware made from the same material as that of the production components. Being an AM technique, the internal features and passages are also possible to produce using SLS which are otherwise impossible to make using casting or machining techniques. Due to cost-effectiveness, the SLS technique is now used for limited-run manufacturing to produce end-use parts and it is even finding its application in arts.

Application:

Due to its ability to manufacture complex parts, SLS is used in various industries e.g. dental, medical, and even aerospace where highly complicated geometries are made. Tooling industries utilize SLS to make direct tooling inserts. Being a cost and time effective solution, this process is used for rapid prototyping, production of new parts in less time. It provides a size range up to 250x250x185 mm with the ability to produce multiple parts at one time.

Disadvantages:

There are some factors which need to be considered before using this technology i.e. the constraint of size, surface finish and most importantly, printing along the Z-axis. These can be managed by effective planning e.g. if the production is planned for a machine where the most of the features are made along x and y axes, the tolerances of the feature can be managed in a better way. For good surface finishes, the part requires additional polishing. Also, another aspect to define first is the material density of finished product and inserts because in case of injection molding, any defect in the surface finishing of the inserts will be transferred to the plastic part produced. The inserts will then have to be mated with the mold's base with surfaces and temperature to tackle the problems. These problems can increase the duration of metallic support removal and post-processing thus requiring the use of other techniques e.g. EDM or other grinding machines with the same accuracy level.

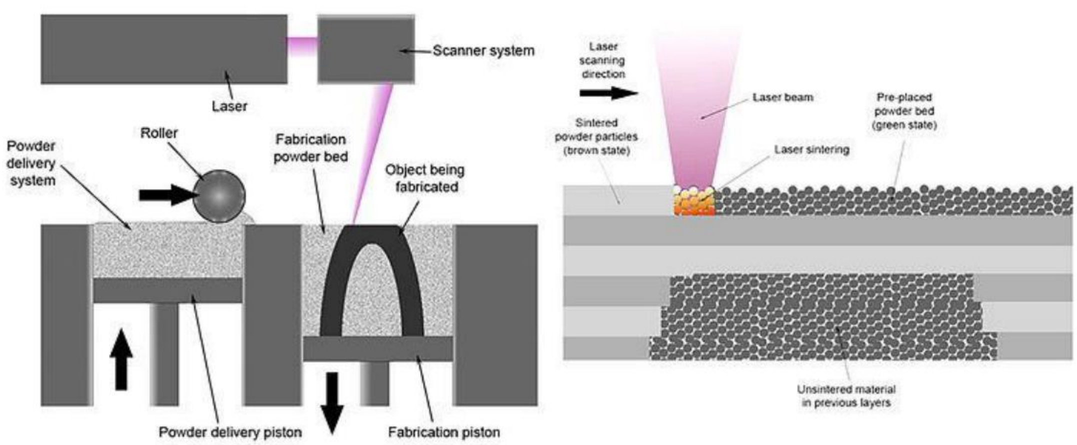


Figure 5 Schematic Representation of the SLS process

ii) Electron Beam Melting - EBM

This process is similar to SLS and electron beam welding. An electron beam is used as a prime energy source which melts the titanium powder to produce metal prototypes. Vacuum conditions are required in this process and the dimensions of the parts being produced are also limited. In terms of energy efficiency, it has 95% as compared to 10-20% in laser sintering, thus titanium powder is melted fully and a full density part can be manufactured in EBM.

Materials and Main Applications

So far only a limited number of metals can be used in the EBM process. The most used metal is titanium. The vacuum conditions in the process removes the possibility of oxidation of titanium as well. Also, nickel-based alloys and cobalt chrome can also be utilized.

Advantages:

This process is used to create high-strength functional metal parts.Fewer support structures are required because preheating is done in this process which decreases the thermal stresses in comparison to the other powder bed fusion technologies. Also, power consumption in case of EBM is less. In this process, the applied effective heat does not vary along the x-y axis as the electron beam is not directed by using some mechanical based systems.

Disadvantages:

To avoid deformations, support structures and strong metallic building plates are required. To remove the part from building platforms and to remove the support structures, a mechanical process is required. Also, a post thermal process is needed to relieve the thermal stresses. These reasons reduce the ability of EBM to be scalable and its production rate as compared to other powder bed fusion technologies.

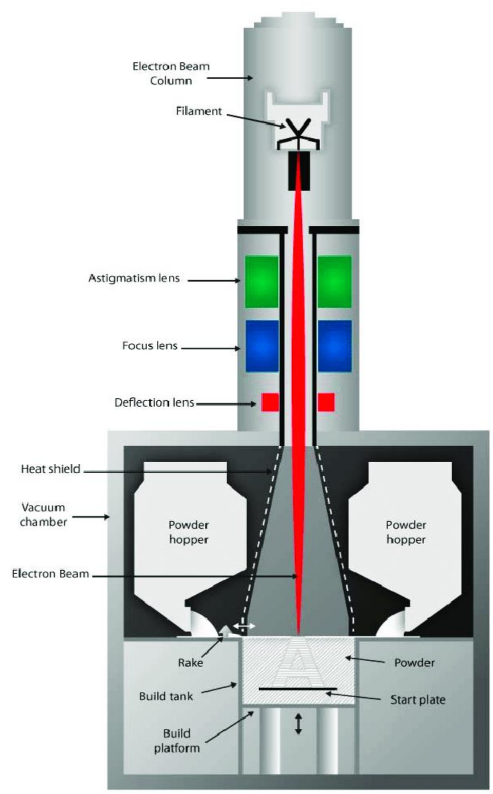


Figure 6 Schematic Representation of the EBM process

iii) Three-dimensional Printing - 3DP

A print head deposits an inorganic binder on a layer of non-metallic or metallic powder in the three-dimensional printing process (3DP, three-dimensional printing). A piston that supports the powder bed is lowered in an incremental manner, and a layer is deposited and then melted by the binder at each step. Three-dimensional printing gives a lot of options when it comes to materials and binders. Polymer and fiber blends, as well as metals, are the most commonly used materials. Furthermore, because multiple heads can be incorporated into a single machine, color prototypes with different colored binders are possible. The effect is a three-dimensional equivalent to photos printed with inkjet printers that use three different colored inks.

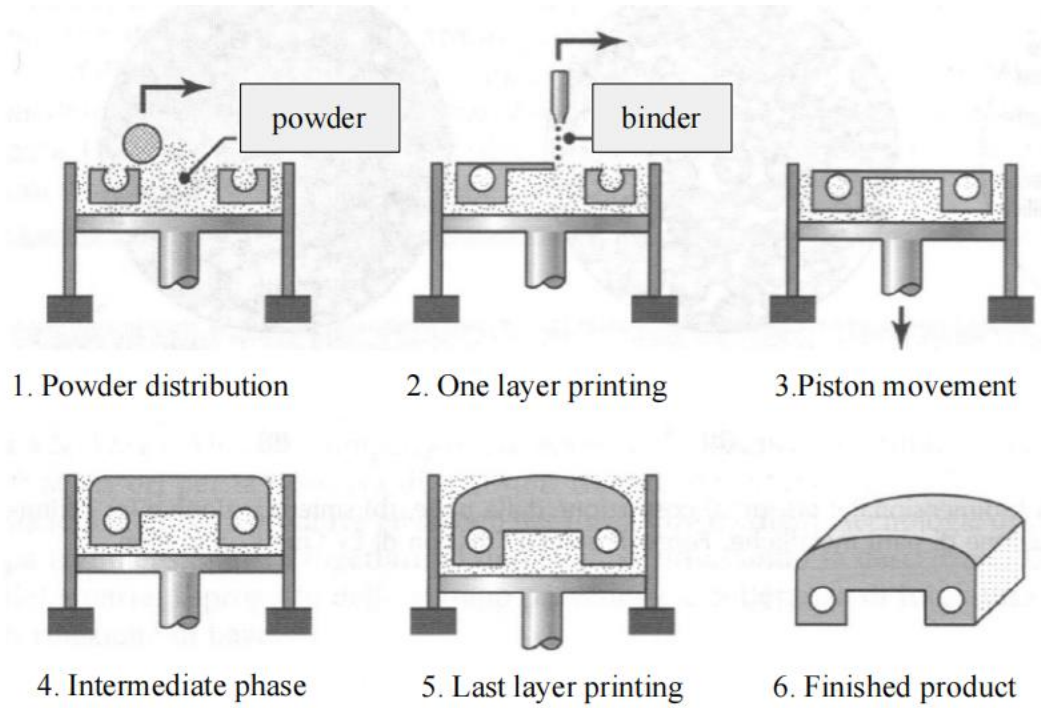


Figure 7 Schematic Representation of the 3DP process

There is a porosity in the parts produced by the 3DP process hence they are not strong enough. To produce full density, the 3DP of metal can be combined with metal infiltration and sintering. The part is built as described above in this sequence, with the binder directed onto the powders. However, as in metal injection molding, the construction sequence is followed by sintering to volatilize the binder and partially melt the metal powders. Stainless steels, aluminum, and titanium are among the metals commonly used in the 3DP process. Copper and bronze are common infiltration materials because they have good heat transmission and wear resistance.

1.2.3 Solid Based Technologies

i) Laminated Object Manufacturing - LOM

Rolls of adhesive-coated material are used in the production of laminated objects. Another roller heats the material, melting the adhesive before it is transferred to the build platform. The chosen shape is cut with a laser or a blade, cross hatches are drawn on the rest of the surface to aid in waste material extraction, and the sheet is pressed onto the platform and glued to the previous layer. When this stage is completed, the platform will descend. Simultaneously, the sheet moves, and new material falls on top of the object, while previously used material is collected on a waste roll. This sequence is repeated until the object is created, layer by layer.

Materials and Main application

Paper, composites, and plastic are the most commonly used materials. Metallic sheets are less commonly used in this technique due to their difficulty in cutting. Laminated object manufacturing does not produce as accurate models as other 3D technologies, but because it does not require an enclosed chamber, it can produce larger models. This technique has some limitations when it comes to creating complex geometries. Rapid large prototyping for form and fit testing is one application, but not for functional use.
Rapid tooling or patterns for traditional manufacturing, such as sand molded casting.

Advantages:

Large parts, especially suited to aesthetic purposes can be manufactured by this technology.

Disadvantages:

For complex or functional parts, this process is not suitable unless metal sheets are used.

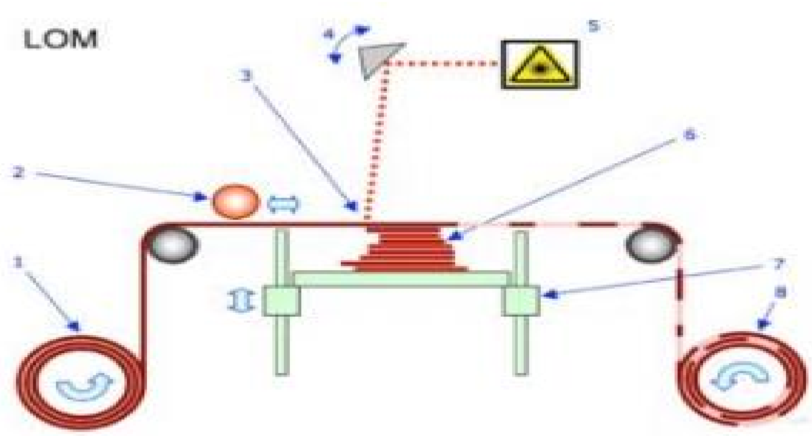


Figure 8 LOM Technology Operating Principle

Software:

Large software companies have made interesting progress in both modeling specific geometries and CAM optimization.

Modern software not only allows for the creation of 3D models, but it also includes numerous support functions to ensure the highest quality of the printed product.

Among the first tools is the topological optimization strategy, which allows for the creation of an optimized geometry with high quality surfaces thanks to an integrated module for Finite Elements Analysis (FEM) analysis, as well as a topological optimization tool based on customizable reticular structures. On the other hand, there is software that implements distortion compensation due to printing processes in order to support the most complex geometries.

Most digital images, from television to computers, are based on a grid of square pixels, while some 3D printers use diamond-shaped pixels, presumably to circumvent existing patents; however, for 3D printing, many consider the square shape of pixels to be critical to provide high resolution and sharp details on jewelry-specific miniaturized textures, such as micro settings. An algorithmic powder removal system exemplifies the growing interest in post-processing concerns in the case of SLS or SLM technology in the automatic removal of non-sintered material. As a result, the software can instruct the machine to perform the best movements to clean the workpiece cavities in the shortest amount of time.

2. Economic Impact of AM

2.1 Introduction

AM machines might be characterized as employing an economy of one from an economic perspective. In contrast to economies of scale, the price of an item made with AM technology will be roughly the same whether it is created in one piece or one million. From an economic perspective, the contrasts between economies of scale and economy of one are good indicators of how traditional processes and AM vary from one another.

A table created by Petrick and Simpson on December 28, 2015 shows the distinctions between these two economies nicely;

	Economies of scale	**Economies of one**
Source of Competitive advantage	Low cost, high volume, high variety	End-user customization
Supply chain	Sequential linear handoffs between distributed manufactures with well-defined roles and responsibility	Non-linear, localized collaboration with ill-defined roles and responsibilities
Distribution	High volume covers transportation costs	Direct interpretation between local consumer/client and producer
Economic model	Fixed cost + Variable cost	Nearly all costs become variable
Design	Simplified designs dictated by manufacturing constrains	Complex and unique designs afford customization
Competition	Well-defined set of competitors	Continuously changing set of competitors

Understanding how the conflict between the two types of economies is developing while focusing on the economic model based on cost is really fascinating. The points will be made clearer through a case study.

2.2 Economic characteristics of AM

The papers "Economic applications of 3D printing: Market structure models in light of additive manufacturing revised" by Weller, Kleer and Piller published on June 2015 , as well as the Wohlers reports from 2013 and 2015, are the best resources for understanding the economic characteristics of AM. They attempt to compile the year-referred state of the art with regard to Additive manufacturing.

According to the first research referenced, looking at AM from an economic perspective reveals both prospects and constraints. The main prospect involves fast paced product innovation as the process of prototyping is swift and the iterations are not costly as well. Also, supply chain constraint do not affect this process.

Also, the process of customization is important, when paired with a product's improved functionality, such as making it lighter, it gives businesses the option of charging more. This flexibility enables customer co-development without increasing production costs.

There is an added advantage with additive manufacturing that the variations in the product are not restricted by economies of scale but the dimension of production does not effect it in any way.

As per the research, this can also be stated that both the size of the inventory and the amount of assembly efforts are decreased. The technical framework of layer-by-layer manufacturing makes it feasible; the 3D file will be an important factor. As the market is concentrated on the virtual file and the logistics are fundamentally altered, this also permits local manufacturing.

This can also be concluded from the data that the accessibility barriers to market are lowered, and anyone who manufactures one item may switch to another one without needing to modify their technique or possess specialized technical knowledge. The production is carried locally instead of being transported, which reduces the cost advantage that low-wage countries currently have, but this has crucial long-term implications.

Some of the disadvantages or limitations can also be discussed.

First of all, as was previously said, the price of raw materials such as metal powder is quite high even though their quality determines the quality of the finished product, which in the majority of cases results in an expensive post-processing stage. Second, economies of scale are the most cost-effective; in a standard environment, competition is impossible.

Thirdly, the design of the 3D printer places restrictions on the size of the components, the production rate, and other aspects that restrict the range of products. Finally, an intellectual limit is used to illustrate another limit: beginning with intellectual property whose rights are limited thus it becomes difficult to justify the designs created virtually. Lastly, training programs are needed for the process as currently there are not many experts present in the market related to this sector.

2.2.1 Key principle, Effects on payoff function and Effects on market structure

With the aforementioned in mind, the authors of the cited research established four fundamental principles for additive manufacturing to set it apart from traditional flexible manufacturing. The 2013 Wohlers Report, which assisted the paper's author in listing these principles, made this research possible.

Following are the principles:

Versatile manufacturing

Free Personalization and flexibility

High capability to achieve complexity

Reduction of assembly work

These principles are explained below;

i. Versatile manufacturing :

- On-demand direct digital manufacturing of 3D product models enabled
- End products are rapidly available at constant marginal cost (no economies of scale)
- Local availability of versatile manufacturing resources with standardized interface

ii. Free Personalization and flexibility :

- Product designs can be customized without cost or time penalties in manufacturing
- Volume and product flexibility without cost or time penalties for machine setup or changeover
- No tools or molds needed

iii. High capability to achieve complexity :

- Higher design complexity without cost penalty in manufacturing
- Little design constraints for products
- No cost penalties for higher product variety

iv. Reduction of assembly work :

- Direct production of functionally integrated parts (e.g. moving parts, cooling system) possible
- Fewer production steps involved
- Lower manual intervention throughout production processes

These fundamental ideas are now compared to the reward function developed by Milgrom and Roberts in an effort to modify it for our situation. The elements that affect AM are denoted by a "+" or "-". The resulting payout function is:

$$\underbrace{\Pi(p,q,m,a,b,c,d,e,r,s,w,\tau)}_{+} =$$
$$\underbrace{(p-c-r\times\rho-\iota/m)}_{+}\times n\times\underbrace{\mu(p,q,n,\tau)}_{+}\times\underbrace{\delta(a+\omega(m,r,n)+b,\tau)}_{+}$$
$$-\underbrace{m\times(s+w)}_{-}-n\times\underbrace{q\times(d+e)}_{-}-\underbrace{\kappa(a,b,c,d,e,r,s,w,\tau)}_{+/-}$$

Figure 9 Pay-off function

Where:

- p price of each product
- q (expected) number of improvement per product per period
- a order receipt and processing time
- b delivery time
- c direct marginal cost of production
- d design cost per product improvement
- e extra setup costs on newly changed products
- m number of setups per period
- r probability of defective batch
- s direct cost of setup
- w wastage cost per setup
- ρ marginal cost of reworking a defective unit
- I cost of holding inventory per unit
- ω expected wait for a processed order to be filled
- t total expected wait for an order to be received, processed, filled and shipped
  δ demand shrinkage with delay time
- µ base demand per product
- κ capital cost
- n number of products

Now that the payout function has been established, This enables some vital considerations, such as "higher throughput speeds, better quality, and less defective batch," and "better design cost per product improvement, extra setup costs on newly changed products, direct setup costs, and wastage costs per setup do not necessarily lead to a significant increase in capital cost after the initial investment in AM system have been taken."

As a result, changing the variables allows for the drawing of conclusions. Although AM do not result in a condition of monopoly, we realize the strength that customization represents in AM. An important conclusion is that "a monopolist might maximize profit by supplying personalized items with a price premium." In order to determine the potential impact AM may have on the market structure, it is possible to compare the main concept of AM with certain models after analyzing the payoff function for a business. The topics from the paragraph are all summarized in the table below.

AM key principles	Effects on payoff function	Effects on market structure	
	Payoff function as defined by Milgrom and Roberts (1990)	**Product attribute address models**	**Game-theoretic models for technology choice**
Versatile manufacturing machine	• Versatility enables firms to produce customized products on demand • Total capital costs could be lower because product changes do not involve one-off costs	• AM enables strong economies of scope in product differentiation • Market can be served along entire product range once entered	• Multiple, highly differentiated markets can be served at once; allowing split of fixed costs • Fewer mobility barriers in serving more market segments may lead to increased competition
Customization and flexibility for free	• Customized products can be offered without penalties in manufacturing potentially resulting in price premium • No time penalties for customization resulting in higher demand per product	• High product flexibility allowing firms to serve entire market without cost penalty • Customers can all be served with most preferred good, while market prices can be lowered	• Participation in different market segments enabled, high incentives to increase flexibility • Production is adjustable to fluctuating customer preferences
Complexity for free	• Product improvements and design changes can be carried out without cost penalties in manufacturing resulting in higher demand per product • Higher design complexity without capital cost impact	• Negligible modification and re-anchoring costs of base product: higher variety can be offered • Higher product variety without additional costs	• Incentives to raise a firm's degree of flexibility are increased as long as economies of scale do not lead to massive cost advantages of non-AM technology
Reduction of assembly work	• Total order processing time can be reduced • Fewer defective batches due to less manual work requirements	• Negligible modification and re-anchoring costs of base product • May reduce marginal costs for production of assembly-intensive products	• May reduce marginal costs for production of assembly-intensive products

Figure 10 Key principle of AM and their effects on a manufacturing firm's payoff function and market structure models.

Among the four models, the product attribute address model and the game-theoretic models, are two widely accepted schools of thought. This research concludes by demonstrating that AM possesses all the traits necessary to reshape markets due to the strength of the innovations it offers. According to reports, the markets that AM may currently enter include those with low product production, high product complexity, high need for product customization matched to specific client needs, and markets with geographically dispersed demand for products.

2.3 Market Impact of AM

2.3.1 The industrial production and the customers' needs

When discussing industrial manufacturing, mass-market development is the initial phase. Mass production makes it possible to purchase standardized goods at a remarkably low cost. This is made feasible by the development of assembly lines in the factories, which take use of economies of scale to make large quantities of goods. Huge production volumes amortize the fixed expenses of the factory and its equipment, often resulting in relatively low costs over time. In the past, this system was the finest since people had access to products for the first time and realized their immense usefulness. However, in the previous 50 years, as the marketplaces became flooded with standardized items, things changed. The 1973 oil crisis served as a defining moment in the development of the market for customization. In that particular year, all of the production's variable expenses rose, making the low cost maintenance unsustainable. In reality, the cost of all raw materials, such as metal sheets, increased for a company making, say, washing machines since the energy required to mine iron and turn it into usable metal sheets of steel, as well as the cost of plastic components made from oil-based materials, all increased. Because of this, the mass market is being reduced, making room for other systems like the Toyota system, which reduces waste and increases product customization to better fulfill the demands of customers without raising prices. This represented the initial stages of product customization and the development of industry sectors.

In certain markets today, customizing a product makes little sense; instead, economies of scale and uniformity are still used. In actuality, customers want to use their money as efficiently as possible. Instead, some markets demand a higher and higher level of personalization due to the nature of the industry or the needs of the consumer. The customization required by the client is larger, for instance, in the construction of airplanes since there is not a bigger number of goods. This may be due to the customers' yearning for liberation or independence from society.

In conclusion, the mass market that uses economies of scale and standardizes its products makes it impossible for AM to compete. The manufacturing time is one of the factors. For instance, the Pomigliano facility produced 207 thousand Pandas in 2016. It translates to 4176 hours, or little about 50 Panda per hour, after adding together 261 working days and 16 hours of work. With AM, producing metal components requires many hours of labor, and purchasing enough AM machines to make as many automobiles as Pomigliano would need a tremendous expenditure. Therefore, AM is effective for small tailored quantities and prototype construction, two situations when economies of scale are ineffective.

2.3.2 The phases of product development where AM technology impacts

Rapid prototyping and small-batch manufacturing are the major stages where AM technology has an influence, as was previously stated. There are several justifications for a company wanting to create a finite number of goods. In the first instance, testing with the same material that would be utilized for production are desired. Typically, tests are conducted to obtain approval from certain bodies regarding the security of the commodity. Another justification is connected to the first-to-market theory. This attitude attempts to launch a little amount of the product to gauge consumer response.

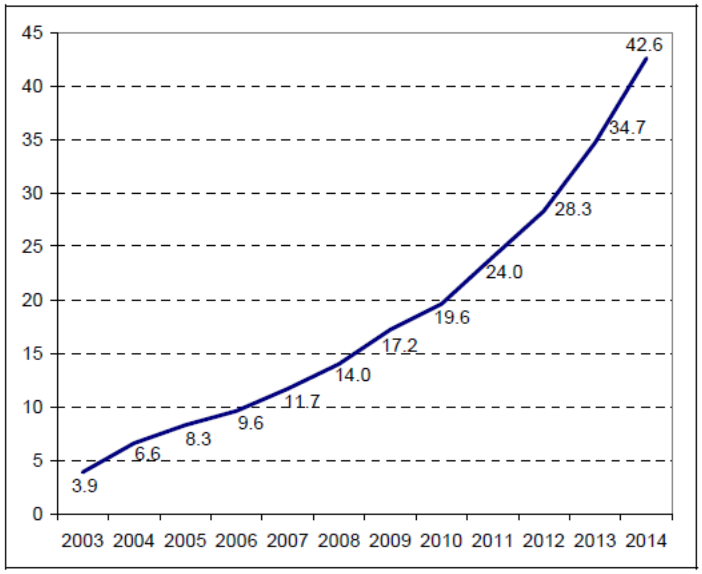
The last argument is, obviously, when it tries to target a niche market when there isn't a high demand for the goods. All of these situations necessitate the use of quick prototyping or rapid production to meet market demand, and the influence of additive manufacturing on these types of productions is then discussed.

2.3.3 Rapid prototyping

A prototype is a model that represents the future production of a thing and is used to evaluate the quality of the final product and to understand the strong and weak aspects in order to enhance the quality. The phrase "rapid prototyping" originates from the use of AM manufacturing to swiftly construct prototypes. Because of the cost savings, it is one of the most common applications of AM technology. In truth, the savings are in terms of money and time, but there are other factors as well. First and foremost, it enables for free design; I no longer require sophisticated tools to evaluate my product, and higher design allows for more savings in the process. It is feasible to test a final product using the same material and obtain trustworthy results. The increased communication between the parties is the final point. With a real product, the issues are simpler to demonstrate. Aeronautics, architecture, geography, art, automotive, education, jewelry, medicine, and energy are among the sectors now utilizing additive manufacturing technology for rapid prototyping.

2.3.3.1 Rapid Production

Using a mold that will be utilized to begin the manufacturing is the conventional method in mass production to create a thing. The issue is that a mold is often highly expensive and that its cost can only be recovered by making a large number of parts. Process engineers pay close attention to AM technology because of its potential in this area. Today, it is possible to state that AM is utilized for quick manufacturing and that its use will increase over time. The interesting thing is that saying that a few years ago—by which we mean five or six years—was not conceivable. The following graph depicts the development of rapid manufacturing's AM technology.



Source: Wohlers Associates, Inc.

Figure 11 Percentage of total revenue by year used for rapid manufacturing

As can be seen, the percentage of AM utilized in manufacturing increased from almost nothing in 2003 to 42,6% in 2014, nearly doubling compared to 2011. This occurs as a result of the benefits AM provides to businesses who choose to employ it. The first change is a decrease in tooling. This fact prevents delays brought on by damaged or worn-out tools, which would otherwise increase costs and lengthen lead times and time to market. Second, it enables flexible production. In reality, the manufacturer is able to make items with a true and literal "just-in-time" mentality and adapt to changes in market demand. Another reality is that manufacturing is becoming more decentralized close to the point of sale. Companies just need to create basic components in their factory and, if there are any customers, customized parts close to them. There is also a decrease in inventory, which is another issue. This results from the condensation of several components into one. As a result, the expenses associated with preparing the bill of materials, with assembly, and with material cost management have decreased. There is also a practical purpose to use additive manufacturing for production: the components are made with geometric flexibility and have the same mechanical properties as traditional-designed ones while still being lightweight. The better fluid dynamics the pieces created is the last point connected to the flexibility of geometry.

These variables vary the attributes of the supplier and the items supplied to meet the demand. The research to increase the use of AM technology in manufacturing is currently focusing on lowering the cost of the machine and the raw materials used, increasing the speed of production, which is currently very slowly, and changing the traditional mindset, especially among small and medium-sized businesses, to continue using the old machines. The influence of additive manufacturing on the demand side will be examined in the next paragraph.

2.3.4 The industries where AM technology impacts

For their characteristics that match what AM technology offers, several industries have a special fit with this technology. The success of AM in each of these sectors and its contributing factors are examined below.

2.3.4.1 Aerospace

This sector only needs a small number of parts with tight tolerances made from materials with excellent mechanical and thermal properties. These are ideal circumstances for using additive manufacturing (AM) equipment to create these items or some prototypes. The favored methods are multi-jet, electron beam melting, laser sintering, and direct laser metal sintering. The weight reduction of manufacturing parts with identical characteristics is the greatest breakthrough provided by AM in this sector.

2.3.4.2 Architecture

Building plastic models is the primary use of AM technology in this sector. Creating a tridimensional prototype cost a lot of money before AM and was seldom utilized because everything was made by hand. Therefore, the benefits of AM in the field of architecture include the reduction in model production costs, the realization of complex geometries with high quality and using a lot of materials, and finally, the feature that these models offer an increased level of communication to the stakeholders involved in a project, increasing the likelihood of success. Multijet and fused deposition modeling are the methods employed.

2.3.4.3 Automotive

The economies of scale utilized for regular automobiles in this industry undermine AM, but it starts to be used for luxury and racing models. The usual improvements for everyday automobiles now available in this sector concern prototype production. It's interesting how old, worn-out parts from vintage automobiles are being replaced. Stereolithography, multiset ones, and fused deposition modeling are the technologies used in fast prototyping.

2.3.4.4 Medical

The possibility for custom-made organs with minimized rejection might be created in less than 10 years because to the vast amount of innovation that AM can bring to this industry. Implant manufacturers are able to tailor models to each individual patient, minimizing side effects and patient recovery time. SLA, FDM, Polyjet, LS, and EBM are the technologies in use. The high density of the substance and high surface roughness of the

EBM technique offer the implant a better adaptability to the human body and a stronger resistance, making it particularly effective.

2.3.4.5 Odontology

The key challenges prior to AM were the handcrafted nature of the models and their manufacture, which caused an industrial bottleneck and prolonged wait times for models. The lower manufacturing costs and time are thus AM's greatest benefits in this industry. Other benefits include the excellent model quality with customization potential, the ease with which the CAD file may be changed in the event of an error, and the removal of the need for a physical patient mold due to digitization. Multijet, SLA, and SLM are the methodologies employed.

2.3.4.6 Interior Design

The use of already complex and difficult materials is made possible by 3D printers, which do not impose the same restrictions on creativity and originality that geometric constraints do. The advancement of this technology is a tremendous benefit, particularly for Italy, whose primary industry is design.

2.3.4.7 Lifestyle Product

In fields where customer value is created through personalization, conventional approaches are almost completely superseded. These include, among others, the jewelry, footwear, and watch industries. With minimal personalization costs, it is possible to implement methods that make use of the internet for the production of personalized goods as well as for marketing and commercialization.

2.3.4.8 Industry sector

Let's examine the proportion of places where these technologies are employed for whatever technical sector and the variations to get a sense of the size of these industries. The industries in which this technology is used are divided, according to the Wohlers' findings. Analysis of the 2013 and 2015 reports reveals a development in the applications of additive manufacturing. The information was gathered from businesses that offer machines that cost more than $5,000 USD. At the end of 2013, 105 system manufacturers responded, listing the sectors they service and the 2013 and 2015 revenues they received from each.

The first reference is from a report from 2013, while the second one is from 2015. In 2013, three industries—consumer product/electronic, medical/dental, and motor vehicles—ruled the market. In 2015, industrial/business machine and aerospace surpassed these three industries as the most common applications for this technology. Academic institutions, the military, and the government all grow their shares.

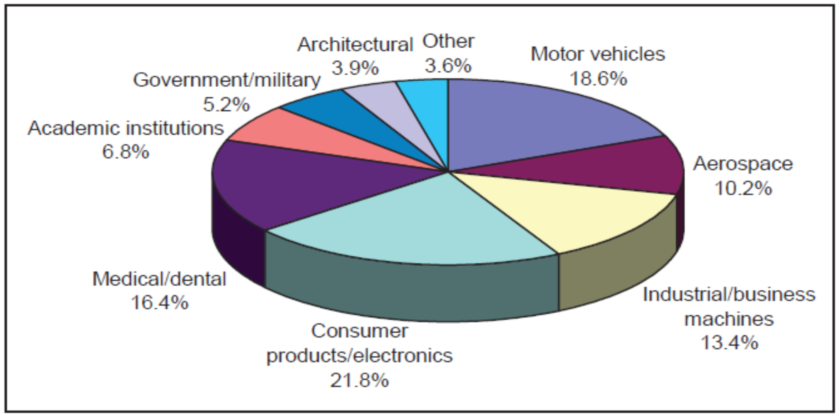


Chart of the revenue distributed by industry in 2013

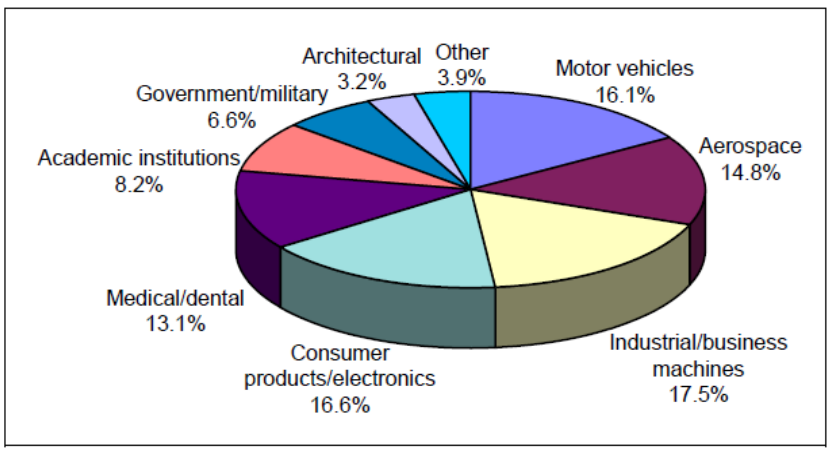


Chart of the revenue distributed by industry in 2015

2.3.5 Effect on ROCE

This paragraph will end with an explanation of how to assess the effect of AM on a particular sector. As recommended by the Roland Berger research on "industries 4.0," it is typically employed as an indication and the ROCE. The ROCE index measures a company's investment efficiency and profitability, or how well it uses its capital to create income. It was specifically used to evaluate business profitability based on capital expenditures.

ROCE may be divided into two components: an asset turnover indicator and a profitability indicator. In reality, when you multiply the first by the second, you get the ROCE.

The graph used in the reports stated above and below may be utilized to display the graphical result.

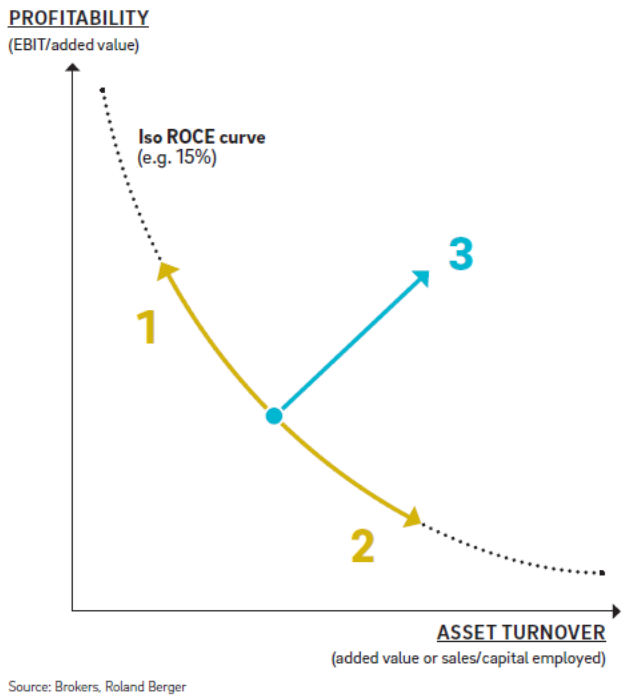


Figure 12 Graph representation of ROCE split into two variables

The breakdown of the variable into two components enables the study of the evolution of an industry across time. A company can lower its asset turnover while maintaining the same ROCE value and boost profitability, or vice versa. It is feasible to define an Iso-ROCE as all the points with the same ROCE value. A firm's ROCE evolution may rise or decrease, as indicated, for instance, by the arrow "3". According to Roland Berger, changes to an industry's structural qualities are indicated by changes to the index.

In essence, an increase in the profitability index while maintaining the same Iso-ROCE indicates a capital investment for a high degree of automation and a contemporary machine park, as well as an intense output. Because economies of scale are used and the cost decreases, this increases profits. A rise in asset turnover indicates that the company has already paid for the equipment in its park, but because they are outdated and old, they often provide poor profit. Typically, it entails using more labor-intensive production to make up for the obsolescence. The features of "industries 4.0" include a growth in the index and, therefore, ROCE generally; in reality, profitability rises thanks to lower labor costs, an improved asset utilization rate, and automation. It grows as a result of the tailored goods provided, for instance, by AM technology. As a result of higher asset use, inventory levels and maintenance costs have decreased and production changes may be made without having to replace the plant. As a result, asset turnover has increased. As a result of the doubled profitability and little rise in asset turnover, as indicated in the table below, the impacts of ROCE in "industries 4.0" are expected to increase ROCE.

The overall plant utilization will rise until the maximum output is reached.

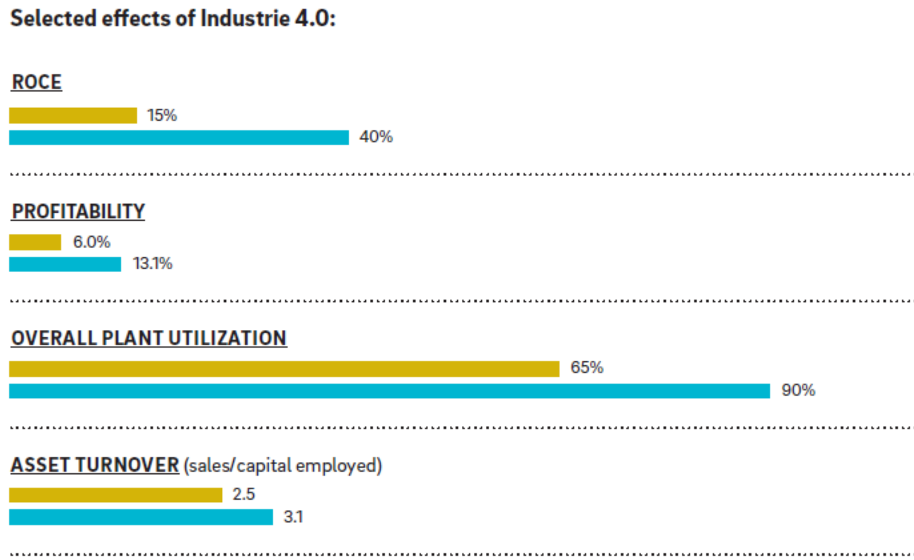


Figure 13 Estimated increase from traditional industries (yellow) of the indicators by using "industries 4.0" (blue)

3D printing, can have a positive effect on Return on Capital Employed (ROCE) for companies that adopt the technology.AM can improve ROCE in several ways:

1. **Reduced capital expenditure:**By reducing the need for expensive tools and machinery, AM can boost ROCE while lowering capital expenditure.

2. **Faster time to market:** By drastically reducing the time it takes to bring a product to market, AM can boost up ROCE and revenue.

3. **Customization:** With the help of AM, highly personalized products may be produced. These products can fetch higher prices and have better profit margins, which will increase ROCE.

4. **Reduced waste:** Compared to conventional manufacturing techniques, additive manufacturing generates less waste, which can lower material costs and enhance ROCE.

5. **Supply chain improvement:** Additive manufacturing can lead to a more responsive and agile supply chain, which can lower inventory costs and maximize ROCE.

ROCE will be positively influenced by the use of 3D printing, which could lead in a more efficient and profitable production processes. The impact, however, will vary accordingly to the specific circumstances of each organization, such as the sector, the level of adoption, and the cost structure of the enterprise.

3. Applications

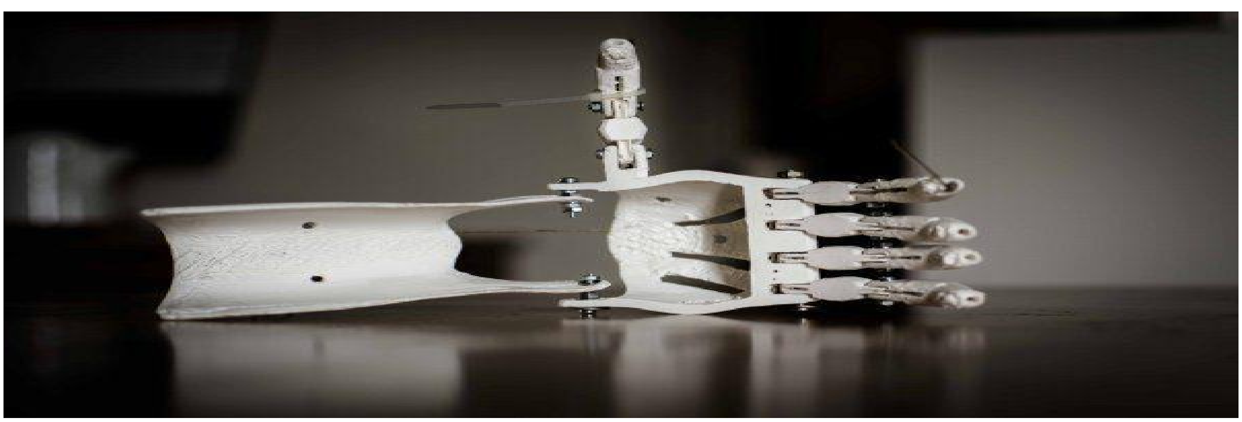
The most popular uses of 3D printing are in manufacturing, medicine, architecture, bespoke art, and design, and they can range from completely functional to just aesthetic applications. In recent years, 3D printing has developed significantly and can now play vital roles in many applications.

Having reached their full potential, 3D printing technologies are now being applied in the manufacturing and medical sectors as well as by sociocultural industries that support 3D printing for profit. In the past ten years, there has been a lot of discussion surrounding the potential benefits of making 3D printing one of our primary production methods. This technology would take the place of time- and money-consuming conventional approaches.

Due to the fact that complex components may be printed using a variety of materials, 3D printing has a broad range of applications. Materials can include resins, stem cells, plastic and polymers in the form of thermoplastic filaments.

3.1 Medical Applications

Anatomical modeling for planning bone reconstructive surgery is where the history of surgical applications of 3D printing-focused therapies began in the middle of the 1990s. Prior to surgery, doctors improved their preparedness and patients received better treatment by training on a tactile model. The logical progression of this work led to completely individualized implants that suit each individual differently—patient-matched implants. With considerable success, virtual surgical planning and guiding employing3D



printed, customised devices have been used in various surgical specialties. Models used for solid organ and heart surgery planning has grown as a result of more research in this field. Currently, there is a lot of interest in hospital-based 3D printing, and many institutions are working to incorporate this specialization inside particular radiology departments.

For rarer diseases, the technology is being utilized to make one-of-a-kind, patient-specific gadgets. Several gadget makers have also started employing 3D printing to create surgical guides that are specific to each patient (polymers). Due to the capability of effectively producing porous surface features that aid in osseointegration, the usage of additive manufacturing for the development of orthopedic implants is rising as well. Custom-fitted and open printed casts for fractured bones allow the wearer to bathe and breathe the injured region while also allowing them to scratch any itches.

It has proven possible to produce microstructures having a three-dimensional interior geometry using fused filament fabrication (FFF). It is not necessary to use sacrificed structures or additional support materials. Porosity of structures made of polylactic acid (PLA) may be totally controlled and range from 20% to 60%. Such scaffolds might be used for tissue engineering or as biological templates for cell culture.

Medical implants and devices that are customized for each patient have been produced using 3D printing. The two industries that are anticipated to benefit from bespoke 3D printing the most are the dentistry and hearing aid sectors. Surgeons in Swansea utilized 3D printed components in March 2014 to reconstruct the face of a biker who suffered catastrophic injuries during an accident. Researches are made on ways for bio-print substitutes of tissues that has been lost to diseases like cancer and arthritis.

Personal protective equipment, or PPE, is another product that can be made using 3D printing. Medical personnel and laboratory workers use PPE when treating patients to prevent infection. Face shields, gowns, connections, and goggles are some kind of personal protective equipment. Face masks, face shields, and connections are the most often used types of 3D printed personal protective equipment.

These days, additive manufacturing is used in the pharmaceutical sciences industry. For diverse applications involving medication administration, several 3D printing processes are used in accordance with their own pros and cons.

3.1.1 Bio-medical Printing

Cornell University researchers released some of the ground-breaking research for tissue development using 3D printing in 2006, producing hydrogel bio-inks successfully. Using

customized bio-printers created by a university spin-off, Seraph Robotics, Inc., the work at Cornell was broadened, which increased the research interest of 3D printing globally.

It has been discovered that stem cells that can grow new tissues and organs in living humans might be implanted using 3D printing. Stem cells have enormous promise for 3D bio-printing due to their capacity to differentiate into every other type of cell found in the human body. In a 2012 TED Talk, Professor Leroy Cronin of Glasgow University suggested that it would be feasible to print medications using chemical inks. Three 3D printing techniques are now being investigated for the manufacturing of pharmaceuticals: printing-based inkjet systems, nozzle-based systems and laser-based writing systems.

Bio-printing has being investigated by relevant companies and academic institutions for potential use in tissue development applications, which employ inkjet technology to construct organs and body parts. This procedure involves carefully building up layers of live cells on a sugar matrix to create three-dimensional structures, including vascular networks. Based on NovoGen bioprinting technology, the first manufacturing equipment for tissue printing was deployed in early 2009. Being investigated is the potential for creating soft tissue structures for reconstructive surgery utilizing 3D tissue printing.

Chinese researchers started printing living kidneys, livers, and ears in 2013. By utilizing special 3D bio-printers that employ human cells rather than plastic, human organs were successfully printed by researchers in China. The "Regenovo" "3D bio-printer," developed by Hangzhou Dianzi University researchers, is a new technology. Regenovo's creator, Xu Mingen, claimed that they can create a little sample of ear cartilage or liver tissues in sixty minutes or even less, estimating that it may take 10 to 20 years to create completely functional printed organs.

3.1.2 Medical Equipment and Tools

A US-based open source design company called e-NABLE has used 3D printers to date to give children millions of plastic hands. Open Bionics, a business that uses 3D printing technology to produce completely functioning bionic arms. Open Bionics can develop customized designs for their customers thanks to 3D printing, which enables them to use different colors, textures, patterns, and even "Hero Arms" that resemble action figures like Ironman etc. Animals with disabilities have been helped with printed prosthesis. A 3D-printed foot allowed a paralyzed duckling to walk once more in 2013. Hermit crabs are able to live in modern homes because to 3D printed hermit crab shells.

'

FastForward Bone Tether Plate', a 3D-printed titanium implant, has been given the go-ahead to be used in bunion surgery repair. The University of Groningen's Andreas Herrmann group created the first 3D printed resins with antibacterial characteristics in October 2015. Quaternary ammonium groups are integrated using stereolithography into dental devices that eradicate microorganisms upon touch. This kind of material can also be used in implants and medical equipment.

Making patient-specific prosthesis for extensive or invasive operations has benefited significantly from 3D printing. In order to create prosthesis that were customized for each of the three patients' intricate bone defects, 3D printing was used, which improved each patient's post-operative prognosis.

In a research paper on the advantages of 3D printing in occupational therapy, the ability to modify equipment quickly and affordably is used to create bottle openers and customized scissor handles for people with hand motor issues. In a cost analysis, occupational therapy tools such drink holders, writing aids, and other things like grip strengtheners were produced and contrasted with commercial alternatives. The results of this comparison showed that the 3D printed items were 10.5 times more cost-effective than the commercial goods.

Applications for human and animal prosthesis as well as medical machine tools may all be produced using 3D printing for medical devices. A jawbone for a Dutch woman was successfully printed in June 2011, by Xilloc Medical and researchers at the University of Hasselt in Belgium. Eagle prosthetic beaks, Victoria the Brazilian goose, and Grecia the Costa Rican toucan all have artificial beaks thanks to 3D printing. During the coronavirus epidemic in March 2020, the Italian business Isinnova produced more than 90 respirator valves for a hospital in 24 hours. It is evident that 3D printing technology has significant health benefits.

3.1.3 Pharmaceutical industry

In May 2015, one of the first formulation developed from 3D printing was created. The FDA granted the first tablet (produced from 3D printing) approval in August 2015. By using binder-jetting, very porous tablets can be created into a drug powder bed, allowing for single formulation based large medication dosages that dissolves quickly and easy to ingest.

Scientists in the pharmaceutical industry are increasingly using additive manufacturing. However, scientific interest in 3D applications for medicine administration increased after the FDA gave the first approval of a 3D printed formulation.

3.2 Food Industry

In order to create three-dimensional things, food is being pressed out layer by layer in additive manufacturing. A wide range of foods, including sweets and chocolate as well as flat fare like crackers, pasta, and pizza, are suitable options. The Systems and Materials

Research Consultancy was given a contract by NASA to investigate if it is possible to print food in space after taking into account the concept's adaptability. Additionally, NASA is researching the ability to produce 3D printed food to reduce food waste and provide food that is tailored to each astronaut's nutritional needs.

3D printing is a momentous innovation that can work on the healthy benefit of suppers and even location hunger issues in nations where new and reasonable fixings are difficult to reach. The worldwide food industry is taking on 3D printing innovation to make food creation more proficient and progressively feasible. A 3D food printer contains a cartridge or a food-grade needle that holds solids, a genuine food material, and stores definite fragmentary layers through a food-grade spout straightforwardly onto a surface or a plate in a layered fashion added substance way. Another technique is a form based strategy wherein food 3D printing machines are employed to give shapes to a mixture with the assistance of an empty compartment or embellishment box.

Presently, 3DP food manufacturers utilize fine materials, lasers, spouts and mechanical arms. The crude substance travels flawlessly from the cartridge point to the stage point and safeguards the solid expansion on the stage. Along these lines, materials, for example, proteins and starch, which can frame hydrogel structures, could undoubtedly be acquired from humus, chocolate, and cheddar that can without much of a stretch stream from the printer carrier to the distribution point.

A couple of difficulties related with the utilization of 3D printing are referenced underneath. First and foremost, sanitation is a huge concern. 3D printing process creates food in negligible time, which in the long run limits preparing food at specific temperatures or may bring about fluctuating temperatures because of which microorganisms can develop and pollute the food. Subsequently, to keep away from tainting related issues, makers are expected to observe specific guideline practices and rules while handling the food. Food makers can't utilize all fixings that are utilized at the hour of regular cooking. Each fixing has its capacity and cooking prerequisites, for example, an ideal temperature, which should be met. All fixings can't be put together in one compartment, alongside the fundamental part or mixture, while assembling food by means of 3D printing.

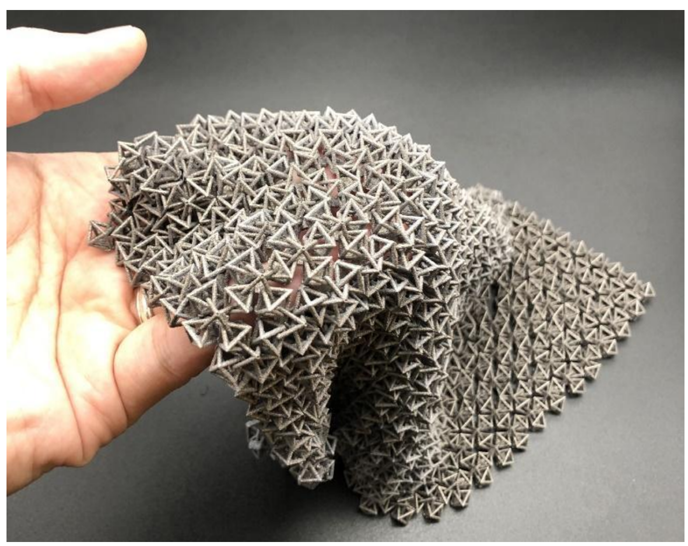
3.3 Rapid Manufacturing

Advances in RP technology have introduced materials that are appropriate for final manufacture, which has in turn introduced the possibility of directly manufacturing finished components. One advantage of 3D printing for rapid manufacturing lies in the relatively inexpensive production of small numbers of parts.

Rapid manufacturing is a new method of manufacturing and many of its processes remain unproven. 3D printing is now entering the field of rapid manufacturing and was identified as a "next level" technology by many experts in a 2009 report. One of the most promising processes looks to be the adaptation of selective laser sintering (SLS), or direct metal laser sintering (DMLS) some of the better-established rapid prototyping methods. As of 2006, however, these techniques were still very much in their infancy, with many obstacles to be overcome before RM could be considered a realistic manufacturing method.

3.4 Industrial Applications

3.4.1 Apparel



Fashion designers are performing experiments to create 3D-printed gowns and other clothing items, which has brought 3D printing into the realm of clothes. In order to produce the 2012 Vapor Laser Talon football shoe for American football players, Nike employed 3D printing as a prototype. New Balance is also using 3D printing to produce custom-fit shoes for sportsmen.

Companies are already generating consumer-grade eyeglasses with on-demand personalized fit and style thanks to 3D printing (although they cannot print the lenses). Rapid prototyping makes it feasible to alter eyewear on demand.

In the realm of luxury fashion, designers like Karl Lagerfeld, who created collections for Chanel, as well as Iris van Herpen and Noa Raviv, who used Stratasys technology, have included and highlighted 3D printing in their creations. The 2016 Anna Wintour Costume Center exhibition "Manus X Machina" at the Metropolitan Museum of Art featured pieces from their collections as well as those of other designers using 3D printing.

A college student, Karina Popovich, launched Markers for COVID-19 during epidemic period, which produced PPEs e.g. face masks and shields etc. using 3D printing.

3.4.2 Automobile and Aircraft Industry

Early in 2014, Swedish supercar company Koenigsegg unveiled the One:1, a vehicle that makes extensive use of 3D-printed parts. The One:1's interior side mirrors, air ducts, titanium exhaust components, and whole turbocharger assemblies were all 3D printed as part of the production of the small number of cars Koenigsegg makes.

The first vehicle in the world to be installed with 3D printing technology is called Urbee (its bodywork and car windows were "printed"). It is a hybrid vehicle with a futuristic appearance that was developed in 2010 through a collaboration between the US engineering firm Kor Ecologic and the business Stratasys (maker of printers Stratasys 3D).With the exception of the motor, Local Motors' Strati was totally 3D Printed using ABS plastic and carbon fiber in 2014. 2015 saw the business release the LM3D Swim, a

different version that was more than 75% 3D printed. The business used 3D printing in 2016 to produce automobile components, including those for Olli, a self-driving car it built.

In May 2015, Airbus revealed that the new Airbus A350 XWB has more than 1000 3D-printed parts. Air forces are also using 3D printing to produce replacement components for aircraft. A Royal Air Force fighter plane took to the skies in 2015 using printed components. The Air Force of Israel has acquired a 3D printer to produce spare parts as well, joining the United States Air Force in utilizing 3D printers.

3.4.3 Construction Industry

With the decrease in the cost of 3D printers, the use of 3D printing to create scale models for architecture and construction has progressively grown in popularity. Due to this, scale models can now be made more quickly, and production speed and item complexity have both steadily increased.

Since the middle of the 1990s, 3D printing has been used to produce parts of buildings or whole structures. Since 2012, technological advancements have been accelerating, and the construction 3D printing industry is now starting to reach maturity.

3.4.4 Ammunition Industry

Defense Distributed, a US-based organization, revealed plans to create a functional plastic pistol in 2012 that would be available for download and replication by anybody with a 3D printer. Defense Distributed has also created a 30-round M16 magazine and a lower receiver for an AR-15-style rifle that is 3D printed and capable of withstanding more than 650 bullets. Although this rifle has many receivers, only the serialized lower receiver is legally regulated. Defense Distributed was ordered to take the instructions down from their website by the US Department of State shortly after they created the first functional blueprint for making a plastic pistol using a 3D printer in May 2013.

3.4.5 Robots and IT Industry

In addition, laptops, other machines, and cases may be produced using 3D printing. For instance, conventional laptop cases from Novena and VIA OpenBook. In other words, a printed VIA OpenBook casing may be utilized with a Novena motherboard

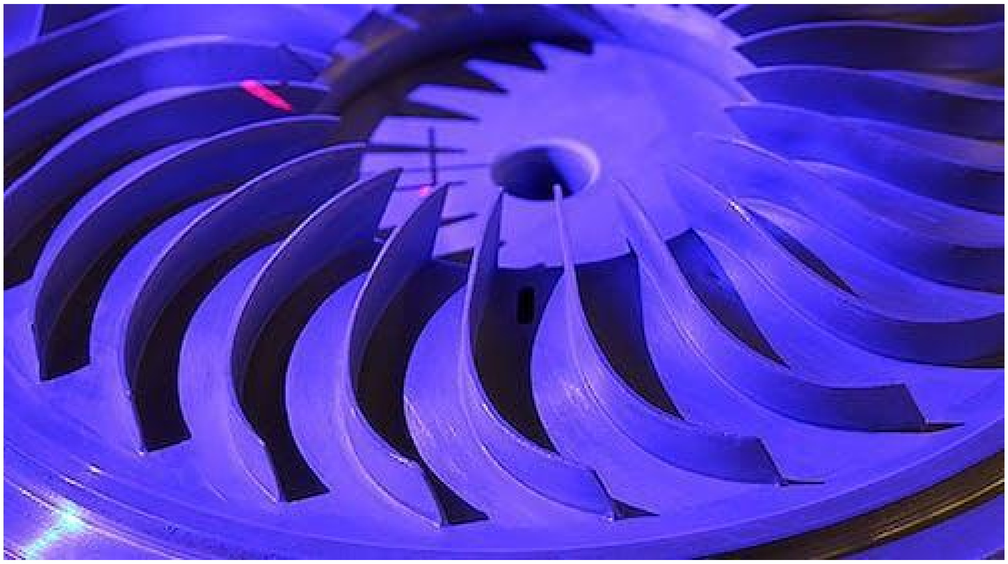
Using 3D printers, open-source robots are constructed. Access to Double Robotics' technology is made available. On contrary, ODOI is a humanoid robot, while 3&DBot is an Arduino robot with wheels and both of them are produced using 3D printing technology.

3.4.6 Sensors and Actuators Industry

Manufacturing of sensors and actuators has adopted additive manufacturing as a result of the notion of 4D printing. Most traditional soft sensors and actuators are made utilizing long, multistep, low yield fabrication procedures that require human fabrication, post-processing, and assembly. These processes also limit the end products' customizability and repeatability. The introduction of specific geometrical, functional, and control qualities made possible by 3D printing has revolutionized these industries by removing the laborious and time-consuming elements of older production procedures.

3.4.7 Aerospace Industry

The collaboration of NASA Marshall Space Flight Center (MSFC) and Made In Space, Inc. developed the Zero-G Printer which is the first 3D printer capable of functioning in no gravity. The International Space Station received the zero-gravity 3D printer from SpaceX in September 2014. (ISS). In December of 2014, NASA sent Computer Aided Design files for a socket wrench to astronauts on the International Space Station (ISS), who used the printer of station to create the item. Instead of utilizing rockets to transport pre-made objects on space trips to human settlements on the moon, Mars, or elsewhere, applications for space give the option to print components or equipment onsite.



The Portable On-Board 3D Printer (POP3D) from the European Space Agency was supposed to arrive at the International Space Station (ISS) before mid of 2015. By 2019, it was planned to send a commercial recycling facility to the ISS to collect plastic scrap and unused plastic components and turn them into input feed for 3D printing facility installed at the station, which will enable to create in-space parts.

In 2016, BeeHex reportedly began developing a 3D printer for food to be used on flights to Mars, according to Digital Trends.The majority of asteroids' intended infrastructure will be bootstrapped in some way utilizing the resources already present on such bodies. One of the processes in this bootstrapping is frequently 3D printing. The Sinterhab project is investigating a 3D-printed lunar base with lunar regolith as the primary building block. Researchers are performing experiments with sintering of microwaves for developing blocks from the raw material rather than mixing the regolith with a binding agent. These kinds of initiatives have been researched for the development of habitats outside earth.

3.5 Sociocultural Applications

During launch of the open-source RepRap and Fab@Home projects in early 2000s, a quickly growing home-industry was emerged. Due to the continuing RepRap Project and related open-source software developments, almost every home 3D printer that has been made available so far has its technological foundations now. According to one research, 3D printing might become a huge market product in dispersed manufacturing, allowing customers to save money on the cost of buying typical home items. For instance, a person may print a measuring cup or funnel at home using a downloadable 3D model rather than purchasing an item created in an industry using injection molding from anys retailer.

3.5.1 Jewelry and Arts

Academic publications first started writing about the potential aesthetic uses of 3D printing technology in 2005, when practitioners included Martin John Callanan at School of Architecture. An article, during 2007, in the Wall Street Journal and Time magazine listed a design as one of the year's 100 most significant designs. In London Design festival, The Victoria and Albert Museum hosted a 3D printing-focused display in 2011.

The art sections of the London 3DPrintshow, which was held in November 2013 and 2014, included pieces produced from AM, plastic and metal. A number of artists demonstrated that 3D printing may alter aesthetic and artistic processes. Some famous museums have printed transparent glass jars in their collections.

3D scanning enables the duplication of objects without the use of molding methods, which are frequently more costly, more challenging, or invasive to be carried out, especially for priceless artwork or artifacts where direct contact with the moulding materials could cause the damage of surface of objects.

3.5.2 3-D Photography

A 3D photo booth, like the Fantasitron at Madurodam, the miniature park, creates 3D replicas of the customers' selfies from their 2D images. Selfies like this are frequently created by specialized 3D printing businesses like Shapeways. These models are also referred to as mini-me figurines, 3D portraits, and 3D figurines.

3.5.3 Tele-communication

Terahertz devices that serve as waveguides, couplers, and bends have been produced using additive layer technology made possible by 3D printing. These gadgets' intricate shapes were impossible to fabricate using standard methods. Structures with a minimum feature size of 100 m were produced using a professional quality printer, the EDEN 260V, which is readily accessible on the market. To build a Terahertz Plasmonic Device, the printed structures were afterwards DC sputtered coated with gold (or any other metal). Artist/scientist Janine Carr developed the first 3D-printed beatbox in 2016 that could be played by a laser and included four vocalized emotions that could also be played by a laser.

3.5.4 Household and Domestic Use

The 64DD, which debuted in Japan in 1999, is one of the earliest instances of 3D printing for consumers. As of 2012, amateurs and enthusiasts were the major users of household 3D printing. However, few were employed for useful domestic purposes, such as aesthetic items. A functional clock and printed gears for, among other things, home woodworking equipment are some concrete examples. Websites dedicated to home 3D printing frequently included doorknobs, coat hooks, and backscratchers.

Printers designed for common usage have been produced by the open source Fab@Home project. They have been utilized to create novel chemical compounds in research settings using 3D printing technology, originally without direct use as a proof of concept. Anything discharged from a syringe as a paste or liquid may be printed with the printer. The creators of the chemical application envision using this technology for both industrial and home purposes, including enabling people in isolated areas to make their own medicines or household chemicals.

More youngsters are attracted to the idea of 3D printing in their youth as 3D printing is increasingly making its way into homes. As more individuals have access to this cutting-edge technology, 3D printing's potential is expanding, and new applications for households will follow. As a student project, the Open Reflex SLR film camera was created for 3D printing.

3.5.5 Education and Training

The newest technology finding its way into the universities is 3D printing, and in particular, open source 3D printers. Students can make product prototypes using 3D printing instead of the costly tooling needed for subtractive approaches. Students create tangible models that they can hold. Students may learn and use new 3D printing applications in the educational setting. RepRaps, for instance, have previously been utilized as a mobile robotics education platform.

According to some commentators, 3D printing represents an unparalleled "revolution" in STEM education. The capacity of students to rapidly prototype at minimal cost in the classroom and the creation of open-source laboratories using low-cost, high-quality scientific equipment serve as proof for these statements. The concepts of engineering and design, as well as architectural planning, are examined. Without potentially harming delicate collections, students make replicas of antique museum objects, e.g. fossils etc.

Models with intricate functional parts are simple to build for other students that are interested in graphic design. With topographic maps, 3D printing offers pupils a fresh viewpoint. Cross-sections of the human internal organs are available for science students to study.

Additionally, students studying chemistry can investigate the relationships between molecules in 3D representations of chemical substances. In organic chemistry lecture courses, the accurate portrayal of precise lengths and angles of bonds in 3D printed models utilized to demonstrate reactivity and molecular geometry.

A study found that 3D printing and design can inspire children's diverse literacies and creative abilities in line with the idea of the connected, information-based world.

In future, 3D printing could produce open-source scientific apparatus.

In order to meet the needs for generating components with complicated shape at a reduced production cost, 3D printing is becoming more and more popular nowadays.

The growing need for 3D printed components in industry will eventually drive secondary processes including joining, foaming, and cutting as well as 3D printed part maintenance. To facilitate the expansion of 3D printing applications in the future, this supporting method must be established. According to the research, FSW is one of the techniques for joining the metal using 3D printing.

To combine the metal 3D printing materials, the appropriate FSW tools must be used, together with the right parameter settings.

3.5.6 Environmental Use

Large-scale 3D printing has been utilized in Bahrain to produce distinctive coral-shaped structures that attract coral polyps to settle and repair damaged reefs. Unlike previous structures used to build artificial reefs, these structures have a much more organic form, and unlike concrete, they have a pH that is neither acidic nor alkaline.

3.5.7 Archeological Use

The field of cultural heritage has been heavily utilizing 3D printing for preservation, restoration, and dissemination during the past several years. Numerous museums in Europe and North America have invested in 3D printers and are actively recreating lost sections of their artifacts.

The greatest collection of culturally important items produced from 3D printing in the world can be found in Scan the World. Each product on My-Mini-Factory is optimized for 3D printing and available for download. It was created using scanned 3D data submitted by their volunteers. The program provides a platform for the democratization of the art object by collaborating with institutions like museums and individual collectors.

The British Museum and the Metropolitan Museum of Art have begun utilizing 3D printers to produce mementos that are sold in their stores. Some museums have even started selling digital replicas of their treasures made using Artec 3D scanners through the online marketplace Threeding in file formats that anybody may 3D print at home.

3.5.8 Novel Materials

New materials created especially for 3D printers have been produced as a result of consumer-grade 3D printing. For instance, filament materials have been created to mimic the texture and look of wood. In addition, modern technologies, including the incorporation of carbon fiber into printed polymers, enable the development of stronger and lighter materials. New technologies have made it possible to directly apply patterns to 3D printed items to the new materials that are created as a result of 3D printing.

Buildings up to 9 feet tall have been constructed using Portland cement powder without iron oxide.

4. 3DP Market Competition

Rising competitiveness is expected bringing about brought down costs and expanded shipments of 3D printers before long. With items developing quickly, and increasingly improving innovation decreasing the hole between objects produced utilizing 3D printing and traditional strategies, the mar ket is relied upon to observe increased interest into what's to come. The prominent competitors of 3D printing systems in the market include Computer Aided Technology, Stratasys, voxeljet, Materialize, Proto Labs, and Carbon.

3D System	3D systems is a company in digitalized industry that designs. Manufactures and distributes 3D printers
Computer Aided Technology	CATI is a company of digitalized industry that implements and distributes hardware and software
Stratasys	It is a digitalized company that is functioned to provide additive technology to sectors like aerospace, healthcare, education, automotive and consumer products industry
Voxeljet	It is a company which manufactures 3D systems for the market applications
Materialize	Materialize is company which provides software solutions and 3D applications
Proto Labs	This company is based producing on-demand 3D systems and parts in the industry
Carbon	Carbon also formally known as Carbon3D is used for providing digitalized manufacturing platform in the industry

Here is a careful examination of 3D printing makers.

4.1 Direct Producers

4.1.1 Stratasys

Stratasys was founded in 1989 by Scott Crump and his wife Lisa Crump. One of the most extensively used 3D printing techniques today, Fused Deposition Modeling (FDM), is widely recognized as having been created by Scott Crump. As a result, the first FDM 3D printer was created and released by Stratasys in 1992.It fabricates 3D printers and creation frameworks for fast prototyping and assembling applications. They are the unmistakable innovator in both the business and shopper spaces. Geographic Sales for Q1-2014 were half North America, 27% EMEA, 22% APAC, and 1% other. At present, they're centered exclusively on plastic printing. Determines 30% of current incomes from re -appropriated printing administrations (acting connection the Kinko's of 3D printing).According to Stratasys, the company reported a revenue of $147.8 million in 2021, which represents a 25% increase than 2020.

4.1.2 3D Systems

Chuck Hull found 3D Systems in Valencia, California in 1986, and the company introduced its first SLA 3D printer, the SLA-1, the following year.It Creates, fabricates, and showcases overall 3D printing, fast prototyping and assembling printers, and parts arrangements. It likewise gives scanners to an assortment of clinical and mechanical X-Ray film computerized filing. It gives 3D 37 creating devices to advanced imaging and configuration including 3D CAD displaying, highlight catch, control, replication, and estimation.In 2021, the company reported a revenue of $146.6 million, which represents a 41% increase then the previous year.

4.1.3 ExOne Co.

ExOne Co. was founded in 2005 as a spin-off from Extrude Hone Corporation, a global provider of manufacturing solutions.It Fabricates and sells 3D printing machines and printing items and likewise offers other related items, including consumables and new parts and administrations. It is one of the greatest 3D organization works in metal modern printing.In 2021 company generated a revenue of $16.6 million (24% increase then the the previous year).

4.1.4 Organovo Holding, Inc.

Organovo Holdings, Inc. was founded by Keith Murphy and Gabor Forgacs in 2007. The company is focused in creating and marketing 3D bioprinting technology for application in drug development and medical research.Right now this is one of the main public 3D bio printing organizations, which plans and makes utilitarian and three-layered human tissues for clinical examination and restorative applications. The organization additionally works together with drug and scholarly accomplices to foster human natural illness models in three aspects.Organovo reported total revenues of $0.9 million for their fiscal year 2019, a considerable drop from the prior year. The decline was principally brought on by the termination of a business relationship with a significant pharmaceutical company, which had been a key source of income for Organovo the year before.

4.1.5 Voxeljet AG

Rudolf Franz and Dr. Ingo Ederer launched Voxeljet AG in 1999. With a focus on industrial clients in industries including automotive, aerospace, and architecture, the

company is a German manufacturer of 3D printing equipment and a provider of on demand component services.It Fabricates and works modern 3D printing frameworks and gives on-request parts administrations to modern and business clients.Since its founding, Voxeljet has grown to become a leading player in the industrial 3D printing market, with operations in Europe, North America, and Asia.The company reported a revenue of €5.3 million in 2021, which represents a 42% increase than 2020.

4.1.6 Materialise NV

Wilfried Vancraen established Materialise NV in 1990 in Leuven, Belgium. It provides printing services and creates programming frameworks for information interchange with additive manufacturing equipment. In fact, Materialise was admitted to trading on the NYSE in June 2014 through an initial public offering (IPO). At a price of $12 per share, Materialise raised almost $97 million in its initial public offering. With a market valuation of over $2 billion, Materialise was still leading the way in the development of 3D printing software and services.

4.1.7 Arcam AB

Arcam AB was established in Sweden's Mölndal in 1997. The business created its Electron Beam Melting (EBM) innovation.It is occupied with the assembling of innovation for the creation of completely thick metal parts. It offers gear for the immediate assembling of metal parts by added substance fabricating. Its items incorporate Electron Beam Melting machines, assistant gear, programming, powder metals, and administration and preparing to clients.Prior to the transaction, in 2016, Arcam AB reported revenue of SEK 792.8 million (about $93 million USD at the time), an increase of 17% from the year before. Also, the business disclosed an operating profit of SEK 43.2 million, or about $5 million USD at the time.

4.1.8 SLM Solutions Group AG

In Lübeck, Germany, SLM Solutions Group AG was established in 2006. The business focuses in the design and production of selective laser melting (SLM) devices used in 3D printing metal.Draws in the turn of events, creation, and conveyance of added substance based assembling and model development as well as consumables and administrations. It works through the Selective Laser Melting (SLM) and Rapid Prototyping (RP) sections. The SLM section markets and sells metal-based added substance fabricating frameworks and extras offer related types of assistance and sells consumables for these frameworks. The RP portion collects and sells vacuum projecting frameworks, metal giving frameworks a role as well as related administrations, and consumables for various quick prototyping employments.SLM Solutions Group AG reported revenue of €49.0 million in 2020, a decline of 30.2% from the previous year (or roughly $57.8 million USD at the time). The COVID-19 pandemic, which disrupted global supply chains and decreased demand for SLM Solutions' products, was blamed for the decline.

4.1.9 Renishaw Plc

Renishaw Plc was founded in 1973 in Gloucestershire, United Kingdom by Sir David McMurtry and John Deer.It is occupied with the planning, assembling, and advertising of cutting edge accuracy metrology and investigation hardware. It works through two sections: Metrology and Healthcare items. Renishaw's items are utilized for applications as assorted as machine device computerization, coordinate estimation, added substance fabricating, measuring, Raman spectroscopy, machine adjustment, position criticism, shape memory composites, enormous scope reviewing, stereotactic neurosurgery, and clinical diagnostics.Renishaw Plc reported revenue of £510.2 million (about $703.5 million USD at the time) for year 2020, a reduction of 11% from the prior year.

4.1.10 Kinpo Electronics, Inc.

In Taiwan, Kinpo Electronics, Inc. was established in 1973. Beginning as an electronics producer, the business has developed into a market leader in a variety of products, including 3D printers and other consumer electronics like routers, modems, and smart home gadgets. Taiwan-based Kinpo Electronics, which also has facilities in China, Vietnam, and the US, is renowned for its inventive product design and manufacturing talents.Shopper gadgets producer that is delivering their own 3D printer designated at the customer market. It is settled in Taipei, Taiwan.Since it is a privately held business, Kinpo Electronics, Inc. does not make its financial information available to the public.

4.2 Secondary Producer

4.2.1 ProtoLabs

In Maple Plain, Minnesota, the United States, ProtoLabs, Inc. was established in 1999. With its humble beginnings as a low-volume, small-scale prototyping operation, the business has expanded to become a market leader in on-demand manufacturing services for custom components and prototypes, including 3D printing, CNC machining, and injection molding.An on the web and innovation empowered maker of speedy turn PC mathematical control (CNC) machined, infusion formed and 3D printed custom parts for prototyping and short-run creation.ProtoLabs recorded total sales of $459.2 million for the year in its 2020 annual report.

4.2.2 Faro Technologies Inc.

In 1981, Faro Technologies Inc. was established in Lake Mary, Florida.It works as a 3D estimation, imaging, and acknowledgment innovation organizati on. It creates and showcases PC supported estimation and imaging gadgets and programming. The organization's gadgets are utilized for assessing parts and gatherings, creation arranging, recording huge volume spaces or designs in 3D, studying and development, as well concerning examination and reproduction of mishap locales or crime locations.In its 2020 annual report, Faro Technologies stated that its total revenue for the year was $297.3 million.

4.3 Economic Assessment

It's assessed that 3D printing could produce a monetary effect of $230 billion to $550 billion every year across presently acknowledged applications by 2025. The biggest wellspring of likely effect among the current applications would come from buyer utilizes, trailed by direct assembling (i.e., utilizing 3D printing to create completed products) and utilizing 3D printing to make molds.

4.3.1 Porter's Five Forces

With the new procedures and new printable materials, basically anybody can turn into a producer. While this is uplifting news for renewing a declining industry, it can mean Armageddon for those not focusing. 3D printing reminds me Porter's five powers model for industry investigation and business system advancement. In this model, Michael Porter had illustrated five powers that decide the cutthroat force inside a market:

- Threat of new entrants
- Threat of substitute products or services
- Bargaining power of customers (buyers)
- Intensity of competitive rivalry
- Bargaining power of suppliers

4.3.1.1 Threat of New Entrants

The power and potential of an organization is hugely impacted by the new entrants casting over the market. The less the money and time it costs for an entrant to enter an organization's market, the more powerful it makes the entrant, the more a laid out organization's position could be fundamentally weakened. The industry where there are solid obstructions to passage is huge for already existing organizations inside that industry since the organization would have the option to charge more excessive costs and negotiate better terms. For all intents and purposes anybody furnished with 3D printer can lay out oneself as maker. This may not trouble laid out producers from the outset, as these new "entrants" might be nerds or techno darlings checking out on a new article such as a toy. Indeed yet in the event that 3D printing comes modest and modest as it appears to come, a number of families might turn out to be little producers for themselves for a number of parts or items. Also assuming the quantity of families becomes serious, it infers to a huge estimate of turning over trades from buying completed parts or articles to buying crude printing material and3D printers, clients producing added esteem themselves, willingly. This isn't about merely delivering little plastic adornments, gadgets, or animation dolls, it could/does danger prosthetics, dental specialists, podologists and still a number of different organizations and exchanges for example extra parts for secondary selling, development, and so on New organizations laying out as manufacturers can work close to their consumers, further developing awareness and interacting in the present moment. The benefits of conveyance speed, customization and other expense investment capitals could analyze the enormous gathering offices overseas, particularly when nearby work cost rise speedily and strategic courses stay expanded, henceforward transportation speed sluggish and responsiveness reduced. Potential firms that need to enter the 3D printing industry consider an absence of memorability to be a tremendous boundary. Furthermore, licensed innovation privileges insurance prevent numerous from entering the business. In any case, they can beat memorability hindrance by focusing on mechanical stance. Plus, conveyance channels are clear on the grounds that a firm can fall back on internet exchanging; consequently stay away from costly stores.

4.3.1.2 Threat of Substitute Products or Services

3D printed insoles, false teeth and supports as of now exist even 3D printed guns exist alternative for the conventional ones, which isn't just a danger for gunsmiths coincidentally. A portion of these new items accompany better qualities, printable in many shapes and shading and hostile to microbial for example), ordinarily less expensive and quicker. Moreover, clients will be/can change the first model to accommodate their taste or explicit necessities and print them freely, without holding expensive inventories of completed products. Administrations like planning, modifying items or quick conveyance basically vanish as taken over by clients themselves. The danger of substitutes is medium. There are a few substitutes for 3D articles, yet it was noticed that once a buy has been made, exchanging costs are high. For example, changing to Stereolithography, an innovation that produces practically comparable outcomes, implies that a purchaser needs to spend more on materials, different machine time and different quality materials.

4.3.1.3 Bargaining Power of Customers (Buyers)

One of the Porter's five forces in 3DP analyses is the ability of the consumers to control the prices either by reducing prices or their level of control. It depends on the company; how many consumers or buyers that company is constituting on, how much it would be costing that company to look for new customers in the market if any change occurs leading to customers' loss and how important each of these consumers are for the company. If the company is composed of a powerful yet small client base then it means that those consumers are capable of negotiating for better deals and lowered prices. While a company that has a number of small, independent consumer base will be able to tackle them easily while changing prices from low to high for the sake of profitability. When 3D printing technology will be controlled by everyone or everyone will be able to produce it then customers will be powerful enough whether B2C consumers or B2B consumers, being competent enough to produce the system by themselves or at least some parts or services of that system, thus creating great competition among the existing companies.

4.3.1.4 Intensity of Competitive Rivalry

It is turbocharged by new entrants, innovations and all kinds of disruptions. Competitor' Rivalry in the industry is high due to a high concentration of companies in the industry. It is being researched that the high exit costs has meant that companies are not exiting from the industry fast enough, but instead companies dig in and become more committed and competitive in the industry. The studies suggested that almost every methods and every material has several dozen companies specialized in it. The bargaining power of buyers is high. Studies reckon that the buyers are few, compared to the volumes produced by 3D printing companies such as ExOne. However, it is stated in the studies that there are two kinds of buyers; material sensitive buyers who need a machine to print on a specific materials e.g. steel, and those who are not material sensitive. However, material sensitive buyers are few and for such buyers, there are a few companies that can meet their needs, and hence in such situations, bargaining power of the buyers is low. However, a bulk of buyers is not material sensitive, meaning that buyers largely have a higher bargaining power.

4.3.1.5 Bargaining Power of Suppliers

Bargaining force of suppliers will similarly increase as does the place of the only survivors in decreasing markets. Fewer providers imply more prominent power for themselves. It will be rendered suitable for exchanges and organizations having added substance fabricating or 3D printable suitable substitutes. Similarly it will be the state of the new additive procedures hardware, explicit material sellers and explicit programming, dominating their intrinsic properties as well as troubles. Low haggling force of providers clarifies that there are two parts for 3D advancements; the sand/materials which is the contribution as well as the product to run the machines. The sand is fundamentally a powder form of the metals or plastics, and there are numerous providers who offer this and costs will generally be low. With respect to the product, these are created in-house by the actual organization.

4.4 Competitive Analysis

Initially established in 1986 in Valencia, California USA , **3D Systems** is an innovative organization that represents considerable authority in the designing and assembling of 3D printers. At present, because of 43 forceful item improvement and a progression of business acquisitions, the organization has the biggest total assets of any business in the quick prototyping/3D printing market, as well as holding the most licenses for 3D printing innovation. The proprietors and engineers at 3D Systems are credited with the creation of the 3D printer. Their product offering incorporates a wide assortment of individual, expert, and creation grade printers, with a wide assortment of utilizations going from medication to diversion. Right now, a portion of the top players in 3D printing are 3D Systems, Stratasys, and ExOne. With the coming of 3D printing innovation turning out to be increasingly reasonable and available to organizations and people, the quick prototyping market has become one of, if not the quickest developing and most aggressive market in current innovation. The possible market for these advances is to a great extent undiscovered and simply starting to be understood. Accordingly, the following not many years will be pivotal for 3D Systems and other contending organizations to lay out their essence in various region of the market as it keeps on extending. 3D printing itself is a multi-portioned market with numerous applications and explicit subgroups. For instance, some are outfitted towards assembling and creation, some are equipped towards research and prototyping, but others are intended for individual use. While 3D printers have been around in the modern world significantly longer, they are quite recently starting to enter the customer market and there is a tremendous open door for organizations to assume control over the individual 3D printer market as increasingly more are bought by normal shoppers. While 3D frameworks are as yet the pioneer among 3D printing organizations, they have fallen behind in the purchaser market for work area printers to Stratasys. As the buyer market keeps on developing, 3D Systems should figure out how to enter the customer market to keep up with their strength as the main organization for quick prototyping. To decide the serious examination of 3D printing organizations on the lookout, the review anticipates utilizing the accompanying devices:

- A **SWOT** investigation to break down the organizations' present assets, shortcomings, valuable open doors, and dangers inside the 3D printing industry.
- A **PEST** investigation to dissect large scale ecological elements that may either be advantageous or may obstruct development.

The review has been done to lead a SWOT, PEST and Ansoff's grid examination to comprehend 3D Systems current position inside the market; what regions are their assets and what regions are their shortcomings, in what regions do they have chances to improve, to figure out what different elements 3D Systems needs to think about while attempting to adjust to the developing interest for 3D printing innovation among normal shoppers and to layout various potential outcomes and choice that 3D Systems has for development, which gives a synopsis of 3D Systems position in the quick prototyping market as well as how it contrasts and large numbers of their rivals.

3D Systems Corporations SWOT Analysis.

Strengths	**Weaknesses**
Control of licenses Most noteworthy piece of the pie for proficient/modern grade 3D printers Among greatest 3D printing technology	Excessive cost focuses (particularly beginning costs) More modest portion of the overall industry for individual work area 3D printers Risk of robbery/licensed innovation freedoms infringement
Opportunities	**Threats**
Enormous expansion sought after for individual 3d printers Neglected mechanical conceivable outcomes	Contenders with a bigger portion of the individual 3D printer market: Stratasys, MakerBot Noticeable quality of mass assembling protection from changing to quick 45 prototyping/creation utilizing 3D printers

This SWOT examination portrays a few significant things with respect to 3D Systems current position on the lookout. 3D Systems has a nice measure of safety in having more excellent innovation than the contenders, as well as likewise claiming licenses and controlling generally the modern and expert fragment of the 3D printing market. That being said, 3D Systems is falling behind the opposition as far as valuing, particularly for the individual shopper models, and accordingly is missing out on piece of the pie to the contenders who offer less expensive models. To battle this, 3D Systems can track down ways of bringing down the creations expenses of their work area/buyer models of their items, regardless of whether it requires bringing down the quality in the present moment to do as such. They can likewise make a promoting plan to persuade the normal less princely purchaser to see the allure in spending the additional cash to get a better item than the contender.

3D Systems Corporation Consumer Market PEST Analysis

Political: Likely regulation/guideline for restorative/medical services relate employments of 3D Printers Licensed innovation privileges issues with 3D printing; opens up opportunities for robbery of actual items
Economical: Quickly developing business sector for 3D printers Absence of solidness likewise of this quick development As of now there is no worldwide market Exorbitant cost focuses/innovative work costs
Social: 3D printing isn't yet a broadly acknowledged/utilized innovation Customer expectation/exclusive standards for the fate of 3D printing innovation
Mechanical: Stereolithography innovation/licenses Wide assortment of mechanical applications for 3D printers Reseller's exchange materials or "ink" for 3D printers

From this examination it tends to be resolved that there are numerous social and mechanical elements that 3D System's should think about while fostering a development plan for what's to come. Most importantly, as far as friendly factors, there are as yet numerous customers who don't consider 3D printers to be a commonsense venture and don't see any potential gain to possessing one. Also there are the mechanical variables to consider in regards to what materials to use for 3D printing, or the "ink" for a 3D printer. This impacts the expense of possessing a 3D printer after some time; assuming 3D frameworks can observe a material that is similarly as compelling however less expensive, they can check the higher beginning expenses of their own 3D printers.

3D Systems Corporation Ansoff Matrix for Growth Strategies:

	Existing Products	New Products
Existing Markets	**Market Penetration** Proficient/Industrial 3D printers Individual 3D printers Showcasing methodologies, bringing down costs/cost of production	**Product Development** Less expensive line of 3D printers? Exploring different avenues regarding new advancements/strategies for 3D printing
New Markets	**Market Development** Venture into Healthcare, aviation, engineering, diversion and protection related uses of 3D printing	**Expansion** Computer aided design programming to be utilized in backup with existing items Potential for food printing innovations

Based off this network, the two best areas of development for 3D frameworks to zero in on are market entrance and item improvement. While 3D frameworks as of now have an individual model of 3D printer, they don't control most of that buyer market and there is a huge measure of chance for 3D frameworks to venture into that market vacuum. One of the manners in which that 3D framework can additionally enter this buyer market is through item improvement. In the event that 3D Systems can make their product offering of individual 3D printers both less expensive and more interesting to the normal customer, than they will actually want to acquire an edge on the opposition in view of their predominance in the expert/modern market, their huge number of licenses in the fast prototyping field, and numerous business acquisitions, as well as organizations with organizations like Autodesk inc.

From examination, obviously there are a few things that 3D Systems can do to project into the developing shopper market for individual 3D printers and keep an edge over the many contending organizations inside comparative fields.

1) First and foremost, their essential concern ought to be to bring down the beginning costs for their own models of 3D printers. Being an innovation that has as of late become available to the normal shopper, the sticker cost is normally going to be high, however contenders, for example, Stratasys have beginning work area models at costs as low as $400-500, though 3D Systems' present beginning price tag is $999. On the off chance that 3D Systems can figure out how to bring down the expense of creation and likewise the costs of their items, then, at that point, their greater of items will actually want to beat the opposition. Likewise, their foundation and notoriety as the greatest name in the expert universe of 3D printing will be valuable while progressing into the individual market.

2) The second thing that 3D Systems needs to do to venture into the individual 3D printing market is to make a solid advertising push. They should zero in vigorously on two things: persuading customers regarding the potential gain and reasonableness of possessing a 3D printer, and persuading purchasers regarding the reason why they ought to pick 3D Systems greater items notwithstanding the more exorbitant cost point. Furthermore, assuming 3D Systems can additionally foster their items to lessen the expense of proprietorship (less expensive reseller's exchange materials), then, at that point, they can check the issue of the greater introductory expense to purchase a printer. While it is now a quickly developing business sector, numerous buyers actually need persuading to put resources into an exceptionally new innovation, particularly with such a powerful sticker price. Assuming 3D Systems gives that push through showcasing, they will actually want to get a bigger piece of that individual shopper market before contenders can.

3) The third thing that 3D frameworks can do to guarantee their piece of the pie in the individual 3D printing market is to keep making acquisitions or associations with comparative organizations, or organizations with advances that will pursue their advantage. For instance, their association with Autodesk inc. both gives them the CAD innovation and programming to run their 3D printers, yet it likewise permits 3D Systems to take advantage of Autodesk's current client 49 base, large numbers of whom would be similar clients who might be possible clients for individual 3D printers. 3D Systems has numerous open doors in one of the quickest developing mechanical business sectors in the present economy, but since of the fierce opposition and the recent concerns with the innovation, they should have the option to bring down their costs, make an advertising push, and keep making brilliant acquisitions and associations.

3D Systems offers a range of products for additive manufacturing, including 3D printers, materials, software, and services. Here are some of the company's key products:

1) **3D printers:** SLA, SLS, DMP, and MultiJet Printing (MJP) systems are just a few of the 3D printers that 3D Systems offers. The business's printers can be utilized to produce top-notch prototypes, useful components, and finished goods for a range of purposes.

2) **Materials:** Plastics, metals, ceramics, and composites are just a few of the materials that 3D Systems offers for use with its 3D printing equipment. The company's products are made of materials that are intended to withstand the demands of particular applications, like those requiring high strength and high temperatures.

3) **Software:** 3D Systems provides a range of 3D printing software tools, including design, print preparation, and workflow management programs. The software tools created by the company are intended to streamline and increase the effectiveness of 3D printing.

4) **Services:** In addition to offering a variety of 3D printing products, 3D Systems also offers design and engineering, 3D scanning and digitization, and on-demand production services to its clients. These services are intended to assist clients in overcoming typical 3D printing difficulties such design complexity, part quality, and manufacturing speed.

4.5 Patents

The situation for additive manufacturing or 3DP licenses is just about as intricate as anyone can envision. 3D printing is not exclusively the most level innovation that survives, with explicit patentable functionalities in pretty much every section of assembling however it likewise ranges in different innovation regions including IT (programming and mechanization), mechanical (equipment), and material science. What's more, 3D printing advances cannot be exclusively protected yet additionally everything generated with a 3D printer that has not been produced previously (and most of the things that have never been generated before through 3DP). At long last, additive manufacturing can be utilized to handily duplicate protected items, adding greater sophistication to the lawful act.

It is realized as a whole that the example of overcoming adversity of 3D printing that started formally after the application of a stereolithography patent applied by Charles W Hull in 1984. Stratasys that was founded by S Scott Crump was imagined to be intertwined into an affidavit demonstrating in 1989, which wires material in a layered fashion until a 3D item is made. Such style of added substance fabricating is what a great number of people link today with 3D printing. The patent for combined affidavit demonstrating terminated in 2009 and organizations began to adopt an alternate strategy by attempting to offer to purchasers rather than offering business by business. Along with the ascent of Kickstarter, an amazing coincidence framed and publicity around 3D imprinting in the mid-2010s was conceived.

A few patent specialists have embraced the test of attempting to explain the patent scene of 3D printing and how it is advancing. SmarTech Analysis was just able to deliver a completely far reaching intelligent report that will empower organizations to effectively look for and recognize recently delivered metal AM licenses. The report will be delivered quickly so remain tuned. Meanwhile, an incredible asset to begin finding out around 3D printing licenses was provided by the Tech Insights reports. It traced all the way back to 2013 - providing with an extremely itemized and full outline of all that occurred up to that point. All the more as of late, German organization IPlytics was also helpful in providing a free report on the development of 3D printing licenses and relative suit.

This report of IPlytics sees added substance assembling and additive manufacturing according to an IP viewpoint, again showing that licenses of 3D printing are on the ascent.

To recognize 3D print-relevant licenses, the IPlytics stage data set played out a broad catchphrase search of overall recorded licenses in the 3D-print innovation field. The hunt depended on the patent's substance, utilizing best in class stemming and semantic ordering strategies. Somewhere in the range of 2007 and 2019 the investigation distinguishes 95,302 licenses and 43,718 patent families (special licenses in the INPADOC information base) important for 3D printing. The report then, at that point, proceeds to distinguish the biggest patent holders and the nations where licenses of the most 3D printing companies have been recorded.

One exceptionally fascinating graph is the one that concerns case cases: somewhere in the range of 2000 and 2018 there have been 155 suit cases in the United States in the 3D printing field. IPlytics observed that from the 155 contested licenses in 3D printing an aggregate of 71 (45%) have been reassigned or moved eventually on schedule. By contrasting the date of the principal move with the date of the primary case the IPlytics stage was utilized to survey the timing of exchange previously or after the occurrence of suit. It worked out that 80% of all licenses that have been both prosecuted and moved before the suit, have changed owners with 22.5% doing as such around the same time.

For 3D printing advances patenting is expanding forcefully. Further, 3D printing licenses are progressively moved and prosecuted. Senior patent directors and patent managers engaged with 51 ventures where 3D printing has an effect ought to continually screen what is going on. 3dpbm's AM Focus Patents plans to give a refreshed patent scene and a passage to the apparatuses to assist you with doing precisely that. The most recent yearly report from IFI CLAIMS Patent Services has recognized 3D printing as the 10th quickest developing innovation of 2020, in view of US Patent and Trademark Office information.

The report arranges the ventures, advances, and nations that have gotten the most licenses throughout the most recent year. All through 2020, patent awards declined short of what one percent from 2019 to 352,013, in spite of the worldwide Covid-19 pandemic, while patent applications rose right around five percent, proceeding with a vertical pattern seen for the beyond four years. Altogether, both Kinpo Electronics and XYZprinting - auxiliaries of Kinpo Group - were remembered for the best five firms for recording 3D printing licenses in 2020, with a joined patent application all out of 545.

A wide range of inventions, including 3D printing methods, systems, and materials, are c overed under patents relating to the technology. In the area of 3D printing, some import ant patents include

4.6 3DP-A Ninth Fastest Growing Technology

IFI Claims distinguished the 10 quickest developing advances in light of US patent application information through the finish of 2020, gathering patent distributions by Cooperative Patent Classification (CPC) codes. CPC bunches were then screened by size in 2020 and for quick development more than a long term period from 2016 to 2020. With respect to 3D printing, the report shows the patent order B33Y 40 (3D Printing; Auxiliary activities or gear) is developing at a Compound Annual Growth Rate (CAGR) of 27.14 percent. This places 3D printing as the 10th quickest developing innovation of 2020 in IFI CLAIMS' report. In 2017, 3D printing came in runner up in the yearly report after patent applications in the B33Y patent grouping saw a 35 percent CAGR somewhere in the range of 2013 and 2017.

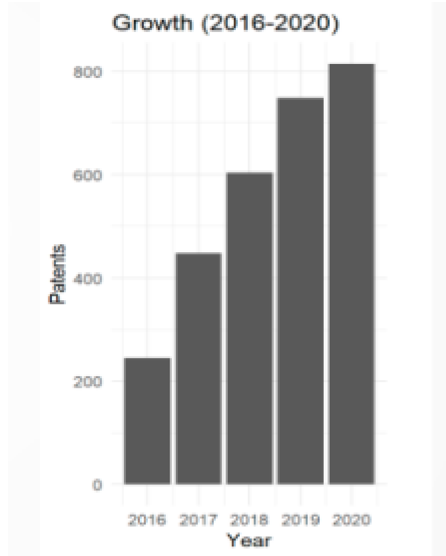
Taking the best position for 2020 with a four-year development rate over two times that of 3D printing was PC frameworks in light of organic models (67% CAGR), trailed by electrical smoking 52 gadgets with 55%, and Angiosperms - science advances connected with plant and seed improvement - at 49%. AI was distinguished as the fourth quickest developing innovation at 46% CAGR, while quantum PCs, control frameworks for non-electric factors, data shows, data move, and programmed pilots and route frameworks for vehicles additionally made the rundown.

HP listed the most 3D printing patent applications in 2020, but Kinpo Group total supersedes.

In 2020, the US got 47% of all new US patent awards with 164,379 generally, the biggest portion of any single nation and triple the sum allowed to Japanese firms (52,429) which got the secondbiggest offer. South Korea took third put on the rundown with 22,400, in front of China which positioned fourth with 18,792 awards. The ventures with the best number of 3D printing 2020 distributed patent applications are recorded as follows:

- Hewlett Packard Development (HP) – 470
- General Electric (GE) – 331
- Kinpo Electronics – 273
- XYZprinting – 272
- Boeing – 195

Strangely, as Kinpo Electronics and XYZprinting are the two auxiliaries of Kinpo Group, the information recommends the Kinpo Group recorded a sum of 545 3D printing licenses in 2020, overriding that of HP by a huge degree. A portion of the licenses remembered for this information are a Selectable Drive System from HP, fabricating footwear using froth particles from Nike, Markforged's sintering heater, and licenses for Boeing's strategy for treating powder particles with plasma radiation. Investigating the remainder of IFI CLAIMS' Top 1,000 rundown of organizations that got US licenses in 2020, the main 10 organizations named as being most dynamic in 3D printing licenses additionally incorporates Xerox, down 25% on the quantity of licenses it recorded in 2019, Continuous Composites which expanded its patent awards from one out of 2019 to 35 out of 2020, and Carbon, which expanded its patent action by 93%. Idea Laser was the 10th most dynamic organization in 3D printing licenses in 2020, trailed by Applied Materials which dramatically increased its measure of patent awards contrasted with the earlier year. 3D printing is acknowledged as a course of innovation and advancement whether it's a car industry, aviation or a purchaser merchandise market 3D printing stumbles into an enormous number of businesses to expand the improvement of new items, empowers imaginative independence and upgrades the stockpile chains on the lookout. 3D printing is reforming in the product market. It has having an incredible number of gains in various parts of innovation. The pace of innovation is still low when contrasted with the one anticipated at first. The wellsprings of the business restricted data are low and vulnerability lies among the hierarchical adopters. The unequivocal rules and recognizable additions related with the utilization and consideration of 3D imprinting in the associations rely upon the accessible observational examinations and exploration. In such respect the associations require more satisfactory and significant getting a handle on of the reception of 3DP advancements and the applicable dynamic systems to keep their organizations ahead. Different firms that saw enormous expansions in their 3D patent movement in 2020 incorporate Ford Global Technologies (up 157%), Autodesk (up 91%), and 54 Thermwood Corp with a 89 percent increment, and Align Technology with a 83 percent increment in action.

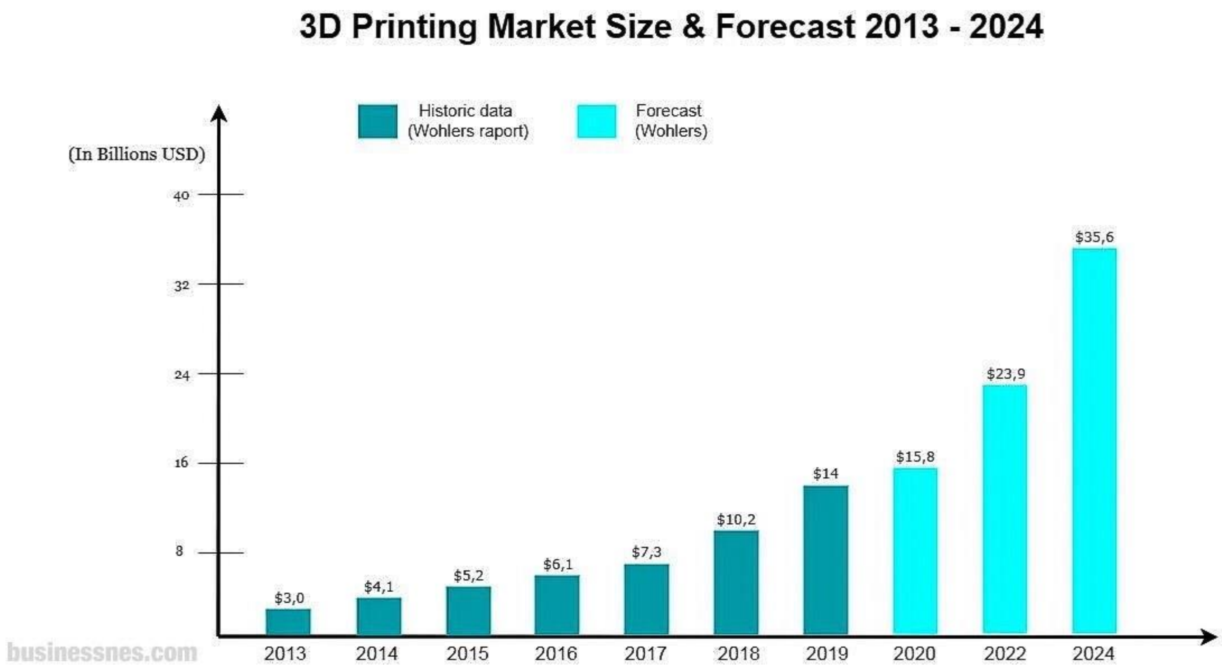


5. Profitability of 3DP Market

3D printing business is an entire area in industry, which as of now is truly productive and creates tremendous cash, even thou it's as yet youthful and new available. How much worthwhile can 3D printing business be, relies generally upon your imagination and choice which specialty of 3D printing you pick. In numerous specialties of 3D printing there is as of now huge contest, however assuming you will select the right one and cautiously break down the market, you will surely track down a great deal of room and open doors for you. Since market patterns for 3D printing are extremely sure, 3D business has high likelihood of bringing you abundance and a ton of pay. There is an entire assortment of significant 3D printing administrations and items that clients need to pay for.

5.1 Future of 3D Printing

It is honestly accepted, that eventual fate of 3D Business will be splendid. However, this is only a conviction, so better glance at certain information. Most importantly 3D printing is considered one of the quickest developing assembling innovations. During most recent 5 years' worth of 3D printing market was expanding each year in normal almost 25% yearly. As per many estimates, 3D printing will grow considerably quicker before long. In 2018, a few notable enormous brands generated items made incompletely through 3D printers' technology. Best of the models were comprised of 3D printed parts for Adidas shoes made of 3D printed insole, BMW vehicles, or Gillette pilot razors with adjustable handles printed in 3D. These are only a few instances of 3D printing turning out to be progressively well known and entering new domains of life and economy. Yet, the increment in the prominence of 3D printing can likewise be seen in numerous different spots.



Source Wohler's report

Probably the best sign of how 3D printing is creating is the manner by which rapidly and powerfully it's worth available increments. As indicated by 3D Hubs 3D printing market will be worth around 250 billion USD in 2023. This implies an amazingly serious expansion in the worth 56 of this market. As you can see on the graph above, Wohler's estimate was considerably more hopeful. There are sentiments that 3D printing will become 100 percent of the assembling market. In any case, this won't occur immediately, if by some stroke of good luck in light of the fact that the market is immersed with conventional creation techniques, for example, subtractive assembling and 3D printers are not yet ready to rival all that strategies (like manufacturing). By and large, all pointers and conjectures, as well as latest things, demonstrate that we ought to expect further serious development in 3D printing ubiquity. This will straightforwardly bring about a huge expansion openly interest for 3D printing administrations and items. 3D printing, or added substance fabricating, can probably democratize the development of stock, from incredible coral reefs, to food and clinical supplies. Later on, 3D printing machines could also advance into tragic destinations, organizations, homes, and surprisingly space (Dehkordi, 2017). With the spread of this technology, it could assist interface minimized and hard to-arrive at masses with essential items. All things considered, this arising innovation can possibly reform our social orders, and change the improvement area. For this to occur, it is being guaranteed that this arising innovation comes under the control of improvement experts and partners all over the planet. The Sustainable Development Goals convey a major assurance for the eventual fate of our kin and world. In order to succeed these objectives this will require large changes. 3D printing is being utilized to advance a considerable lot of the Global Goals, and can possibly have an advance effect. 3D printing is being analyzed as a substantial answer for future and current degrees of homelessness and yearning. For instance, Anjan Contractor trusts that one day, his 3D food printer will actually want to engage the population of the world to take care of themselves "modified, healthfully proper suppers combined each layer in turn, from cartridges of powder and oils they purchase at the corner supermarket." These holders would be not hard to move, could be made of manageable materials like bug protein, and dependable. 3D printing is additionally reforming home development, making it less expensive and more effective. Additionally 3D printing is letting us to involve worn materials in new ways that is rather maintainable. Taking an instance, specialists have sorted out some way to convert carbon dioxide 57 into substantial utilizing 3D printing. Utilizing prior waste into the production of future items made our general public to have a more efficient utilization. 3D printing pioneers are in any event, exploring how to create an actual cycle more practical, including utilizing green growth based fibers to lessen the energy essential for the printing system. The technological application of materials and generative strategies clears up additional opportunities as the environmental activity is approached and reasonable living is analyzed.

5.2 EXAMPLES OF PROFITABLE NICHES OF 3D PRINTING BUSINESS

5.2.1 3D printing of prototypes and models

Here 3D printing and made by it 3D models are totally vital. Ventures like design or designing as well as science frequently need to print models of structures, gadgets or synthetic mixtures. 3D printing is likewise fundamental for plan investigation. Beginning such a printing lab near college can without a doubt entirely beneficial, in light of the fact that understudies and specialized colleges give steady interest to 3D models. So assuming you can begin 3D printing close to the specialized college it will be almost certain that your business will succeed and will grow rapidly, on the grounds that you will have numerous clients ordinary. It merits seeing that 65% of interest for 3D printing is currently coming from engineers working being developed of modern, electrical or customer merchandise.

5.2.2 Industrial 3D printing

This one is the most unsafe and simultaneously the most productive 3D printing business thought. You should spend essentially $20,000 up to 100,000 to purchase modern 3D printing machine. However, the conceivable outcomes of such printer are astounding and truly strong. Assuming there is interest for something made of plastic, which is inaccessible in your market, and interest for that is tremendous - than modern 3D printer is extraordinary thought. It can make furniture, vehicle parts, bicycles, portions of houses, ships, portions of planes and some more. For this sort of business to be compelling and procure well, you should have the option to get huge organizations and rich clients who will actually want to put in enormous requests with you. Such a huge speculation can be hazardous, on the grounds that you normally need some an ideal opportunity to track down clients and publicize your business.

5.2.3 3D Printing point (printing on demand, with service and help)

As of now there are countless individuals who in some cases need to print something in 3D. Since great 3D printers are excessively costly, individuals frequently really like to pay for administration of 3D printing organization to make something they need. This kind of business will require:

- Great restriction in 3D printing is certainly something that will work generally in large urban areas particularly in downtown areas
- Promoting and publicizing your 3D administrations are enthusiastically suggested, particularly toward the start. Allow world to find out about your business. There are now a couple of 3D printing organizations like that, yet couple of individuals are familiar them
- Client well-disposed assistance
- Tolerating on the web orders for getting later or for shipment will be an alluring benefit

5.2.4 3D Scanning and 3D Printing

This specialty of 3D business is a flat out gem waiting to be discovered. It's inevitable until a 3D examining studio works in each downtown area. Individuals need imitations of numerous things that are essential for us consistently. Most loved toy of your kid who stalled, guard for a memorable vehicle, extras for the nursery, skateboard.

5.2.5 Local 3D Printing Manufacture

One of the most valuable ideologies for the business of 3D printing is delivering articles and selling them. Generated products that can be delivered with 3D printers are greatly expanded and there are a large number of them that you can make. Anything is possible here, so salaries will rely upon your innovativeness and nature of delivered items. Cases for smartphones, toys for youngsters, home adornments are only couple of instances of things you can create with 3D printer. The main factors that decide whether your business will pay off is to pay attention to the requirements of market. It is ideal to print things for which there is request. A good thought to deliver things from a 3D printer is to make famous and notable things that were difficult to get today. They can be, for instance, 1: 1 copies of cruisers, shotguns, 59 guns, crowns. Great business can likewise be the development of reasonable food reproductions. They are required in numerous cafés, shops and bars, so counterfeit food that looks reasonable should be visible at shows at the windows of shops.

5.2.6 Creating and Selling 3D Printers Made By You

The market of 3D printers is as yet youthful, yet contest is now high. Beneath in this article you can observe connections to instructional exercises showing how to make your own 3D printer, which is really simple to do. Making your own 3D printing item ought to be truly productive, yet it needs time, and greater venture (for things like promoting and so on).Brilliant designers and 3D modelers are very much aware of the approaches to planning the articles to tackle the possibilities of 3D imprinting in driving the improvement of the added substance creation or assembling. 3D printing is stately to create a gigantic effect on the various businesses including medication, building planning, assembling, engineering and much more viewpoints. 3D printing permits every field of development and innovation to be suggested in the most ideal manner to give the world the effective, most recent, exact and monetarily upgraded administrations. 3D printing is upsetting the advancement market and will develop to improve it and develop further in future.

5.2.7 Creating models of 3D printers

This one can be extremely worthwhile, on the grounds that large organizations are anxious to pay for models of good quality 3D printers. In any case, it requires genuine designing abilities and information. Assuming you have them and you have thought how to fabricate inventive 3D printer, than it's almost certain that one major organization will get it from you.

5.2.8 3D Printed Toys For Kids

It is not difficult to make anything with 3D printers including toys. You can make astonishing looking toys, some of them in view of well-known characters from books, films or games. Specialty of Toys-shops with 3D printed toys is by all accounts not yet even began. It would be astounding assuming children can come to that shop, pick which one toy they need, and afterward have it fabricated simultaneously in 3D printer.

6. Conclusion

"The difficulty lies not so much in developing new ideas as in escaping from the old ones." (John Maynard Keynes)

The purpose of this master thesis was to explore the additive manufacturing world and to evaluate the economic impacts it has. It pursued this aim by first looking at AM under both a technological and an economic point of view and then analyzing data.

3D printing makes substantial items and those that can consume space. This is finished by the utilization of PC supported plans and by applying various kinds of the plan programming. The printer fabricates the article by orchestrating layers of plastic or unique types of carbomorphs and metallurgies on one another while following a printing signal from the PC. One chooses the printing materials relying upon the use of the printed object. For example, in the event that the item fills in as an intelligent part, there is a need to utilize a leading material. The material will make it workable for one to utilize sensors to screen the intelligent parts of the clients. The three-layered printing innovation is a wellspring of existing applications, research on item improvement and a mechanism of creative investigation. The technology of 3D printing will transform the virtual world into a reality. The longing to achieve the profundity and the truth of minds, at which the innovation is applied, will decide how quick the innovation obtains its business importance. The technology works in a layered fashion; assimilating the final product through placing layers on top of each other and creating a three-dimensional solid product through utilization of an additive manufacturing technology rather than the old subtractive technologies which caused the producers and designers a great deal of time and resource wastage. Additive manufacturing technology is representing valuable scores in exploration and schooling, as model articles can be rehearsed quickly and at little expense. This is particularly important in designing fields like mechanical technology. Analysts in hypothetical material science and math can likewise benefit, as 3D models can assist with exhibiting ideas which would somehow be absolutely calculated. Some enormous collective organizations are concerned about the expansive accessibility of reasonable frameworks of 3D printing that would bring about expanded degrees of fake products. Nonetheless, a few reporters accept that this will prompt a more aggressive, more viable environment, and a few makers are jumping all over the potential open doors the innovation will offer. The technology continues to provide unique improving possibilities and developmental opportunities for the different sectors of the industrial market. 61 3D printers can be adjusted to work with an extremely wide scope of materials. Specially fabricated frameworks can even involve different materials in a solitary form to make more complicated items, containing numerous tones or electrically conductive areas. Indeed, even with the groundbreaking impact of 3D imprinting on the assembling business, there will in all probability actually be a business opportunity for premium quality printing materials with predominant properties or novel highlights. It is by and large known that 3D printing will be a developmental tool in additive production, irrespective of whether negative or positive. In spite of the concerns over duplicating, many companies are as of now using the innovation to repeatedly deliver changeable parts, for instance in aviation and car fabricating. As 3D printers become more exclusive, they will definitely be employed for adjacent, limited scope fabricating, generally disposing of some sorts of supply chains items. Consumer units for home usage will even become attainable, permitting end consumers to directly go for downloading a plan for the article they desire and print it out. Though there will be a lot of difficulties for the old manufacturing industry to adjust to these changes. The technological doors opened for innovation and designing are plainly huge; however, the opportunities and potential outcomes in product planning and printing material are almost unending. 3D printing is known to be one of the progressive digital technologies that have been invented so far. Due to its intricacy and remarkable functionality, it is revolutionizing the industrial market may it be any sector i-e medicine, automotive, robotic, food, dental, aircraft, or education etc. 3D printing have secured milestones since its invention but more after the development and updating of the technology. It is also offering customized or personal applications; even it is allowing consumers to make desired product for themselves. The virtual world where once it was not possible to formulate the end product of your ideologies and plan into a real product, this digital technology of 3D printing has made it possible now. It is not only sustaining the world's situation through its additive technique rather than the old subtractive methodologies but also providing better opportunities for the people without wasting resources and time. 3D printing will continue achieving leads if it carries on being adopted by the industrial companies and result 62 in a better and efficient progression for those companies. The digitalized world has always proved to influence development in the industrial market and with the help of this modernized technology, improvement and development for the firms is on its way to excellence. No doubt, there are a lot of challenges for this technology which needed to be considered before implying it into specific sector but if those challenges are tackled with expert knowledge and careful implications; the road of success is not that far for the companies which are striving to mark their name in the history of digitalization.

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