MCEL30031 Enterprise Management for Computer Scientists 2017-18 1st Semester
Alex-Radu Malan
9770386

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Business Report

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Introduction
The 3D printing idea was first introduced and tried in 1981 by Hideo Kodama and Nagoya which created a primitive type of printing machine. They tried to give life to the science fiction printing machines which attracted people which were interested in the same concept such as the French General Electric Company, now known as Alcatel-Alsthom in 1984. The 3D printing involved the study of how a material such as plastic, for example, would be melt and used to form certain patterns or certain objects. The Alcatel team abandoned the idea because of the lack of business perspective since the technology back then was not evolved and they could not figure out if it is justified the amount of money needed for the development. Therefore the concept was reintroduced in the market in 2009-2010 when the technology evolved at a point in which metal was used as material in 3D printing. Those machines were very expensive at that point with a machine cost being around 22.486£. In 2009-2011 there were about 6500 machines sold. Because of the growing availability of technology, the cost of these machines decreased to the price of 973£ in 2013 for a single unit. This significant decrease in the price of the product leads to more units sold worldwide which made the 3D printing market to get to nearly 3.7bn£ market capitalisation. In 2014-2016 the market started to grow from 5 billion dollars to 5.2bn£ and from 2017-2018 its growth rate nearly doubled now being estimated to have a 10.4bn£ capitalisation.
The key competitors in this market are 3D Systems Corporation, Arcam AB, EOS GmbH and The ExOne Company which create specialised printers used mostly in product or concept proof within companies. Most of their customers are using those printers when a product is in its development phase making them agree on the fact that it is way easier and cost-effective to use 3D printers than their usual hardware companies in order to produce some parts of that certain product. Most of the hardware companies are situated in China and Japan which can make it harder for the US or UK companies to get the prototype in a small amount of time. Because of its use, the 3D printing market will have a huge increase with a forecast of around 26 billion dollars by 2021.

Three Key Factors
In order to add value to a company or a product we should first look at an environment scan of the 3D printing market that can be made by analysing the economic, social and political factors as well as performing an opportunities and threats analysis by comparing the market competition, their products and what can be made in order to be different and sustain in this market.

Economical
Nowadays the economy is recovering the crisis in most of the developed countries by introducing different taxation and regulation systems in private and public sectors. In these countries, the trend is about going upwards although in the 3D market the investments for research are not huge if we were to take a look at the current economic situation. Although the investments, in general, are not huge, in the 3D printing market there were investments which helped the producers to research materials and create specialised 3D

printers that were sent to the market. In the small to medium size enterprises the economic trends are positive because the people will no longer need to invest in different types of machines that will create certain parts of hardware, hiring staff that will take care of them or build factories for them to be able to create since the 3D printers will take care of every problem by replacing those machines and these people. With this trend and the mass production that will occur during this process, the price will decrease and the individuals will afford to buy those printers as extra equipment for their computers such as the 2D printers that are used widely. The increase in the 3D printing machines sells will end the traditional manufactures since there will be one in every home. The downside then will be the fact that there will be a decrease in the job opportunities since there will be no manufactures to work for. More goods will be able to be produced locally and their cost will decrease and most of the companies will no longer need to look after the countries with cheaper labour such as China nowadays. Basically, on the economic part, the 3D printing market will reverse the globalisation.

Social
The main focus of the 3D printing is to change how the distribution of the manufactures is worldwide and how that affects the employment in a world where most of the people have to move from one part to another in order to get a job or have a high paying job. Some of the examples are how these people are required to move by their companies in these key locations that are centralised basically. On the other hand, the 3D models that are created via the software can be shared online on the Internet, on social network websites which can create a new way people in different industries would share ideas, models and design. The model can be downloaded on the computer of any kind and then the printing information for a specific model is sent to the 3D printing machine. For example, a company that is creating smartphones require certain hardware and circuits in order to test them on a prototype smartphone that will be launched in the next year. Their manufacture company is based in China so they need to wait for the piece to be finished and then shipped to the US which requires time. The piece maybe has to be changed in specs so that would be another problem since time is not by our side especially when talking about the shipping speed and the privacy involved here. With the 3D printing, they would be able to change the specifications and print the piece how many times they need without needing to wait for the shipment or the manufacturer that is on the other side of the globe. The social part discussed above can rise in a community of people that would share this because of the ease of the software that will increase in the next couple of years. The main purpose is to have a software that will be simple to use so that anyone would be able to create their own models and share them within a network.

Political
With this huge growth in the 3D printing industry, there will be infinite possibilities for people since they would be able to print whatever they think of. There are concerns about this growth on a political level since there will be problems on the public safety side.
For example, when this market will be developed enough people would be able to print guns, bombs, or any other weapons or objects that can cause harm to others, basically threatening their safety. The printing possibilities should be regulated and supervised by governments in such a way that some materials or objects would not be allowed to be printed, such as money in the scanners nowadays. The government can create a database of people that have these 3D printers and store their name, machine, ID so that every model can be tracked or banned from being created. Another problem that rise is the possibility to access materials and substances that would create certain counterfeit products. For example, if Apple is creating a new smartphone and somehow the model and the blueprint is shared online by some individual and I want to have the phone but at a

way cheaper price then I would be able to use the 3D printer to get that smartphone printed for me. In order to have every piece of it, I should have certain materials required for the circuit board, the lithium-ion battery and so on so forth. The example above is linked to the way listen in music nowadays; most of them are not buying the music since that is available online for free via special platforms making abstraction of the property rights. In conclusion, the governments should be prepared to face these people that would abuse the power of a 3D printer.

Strengths
The strength that is present in the market is the fact that there are few companies involved in the 3D printers and their use.
The area in which these machines are popular is in the engineering companies which start to make use of them more and more. It is expected to have a huge growth in this field in the next ten years which would make profits for the 3D engineering machines companies.

Weakness
The problem that labels itself as a weakness is the fact that there are more and more companies that are entering this market since it is growing and have a high profit.

Opportunities
Opportunities arise in this market since the printing orders would be made at big scale since most of the companies are able to acquire scale equipment to accommodate. The 3D printing services expand by offering prepackaged designs to the third parties and the last part of the expansion is when most of them are reinvesting in the marketing campaigns on the internet that will attract more interested companies or people.

Threats
One threat that can be extracted from the above mentions is the fact that this market is in continuous expansion and change. This is a threat to the small-scale 3D printing companies compared to the large-scale ones that will continue to outsource large-scale printing. The costs for the high scale printing are and will remain high in the future which will provide income for the large-scale enterprises.

Conclusion
Competition
First of all, we will take a look at the key competitors that are in the 3D circuit boards printing. One of the most popular companies in the field is called Nano Dimension which was founded in 2012 and their main focus is on advanced electronics and conductive inks. The big problem in the market and the part that everyone invests in is the conductive ink which is the main component of a circuit board. Nano Dimension is the best company in a matter of conductive ink and its properties which puts it in the first place. Another well-known company that was started at Harvard is called Voxel8 which was also endorsed by M.I.T. for the material and ink it offers and also for the 6.745£ price of a printing machine. Their ink has a property of having 2million S/m(Siemens/meter). In the market, there are companies that are using 3D printing to place circuits in the place like BotFactory which has a 2.248£ printer that will place the circuits on board. The last and the one that brings innovation to the table is called Optomec which originally created sensors and conductive materials used for the aeroplane wings. In the industry, silver is better than chopper in some points but then chopper has some properties that make it better than silver, so this company took both elements and created CuNi(Constantan) which is the best of both worlds basically placing it in the top of the best companies out there.

Business Opportunity
In order to have a growing business in this field, we first need to view the fact that there are advantages because the market is not big enough to fit every gap. In the printing circuit boards, there would be a need for a 3D printer that will be able to create components and then assemble them afterwards. Think of it as combining the Nano Dimension with BotFactory. Those are good companies but each of them lacks what the other one has. The fact that if individual pieces of hardware are printed instead of printing them on a board from the start would be more exact and accurate and then if we stick them together with a "robotic-type of hand" the circuit board will be able to be accurate and work without any concerns. In the matter of conductive ink, which plays an important role in the electrical conduction from an individual piece to another, the best thing would be to have a 35% investment in this certain aspect so that efficient ink conduction would be developed.

Business Model
In order to have a business model, we should take each part individually. First of all, the customer segments should be the small and medium enterprises for the start in order to get to the top. The aim is to get to those companies that want a printer to test their prototype and print components for it so that there will be the cost-effectiveness involved and time saved as mentioned above. In a matter of value propositions, the customer should be provided with tech immersion, unique product and the customisation of each machine after their needs. The way customers should get their machine is through fast delivery, showrooms and by ordering them in-store or online after they receive a quote based on their needs since customers would need to print different type of circuit boards, here comes the matter of size and complexity.

Customer relationship is an important key point in this model, so the company should be able to keep in touch with their customers so that feedback will be provided back and support should be provided by the company as well, these representing the top things needed to be taken in consideration at this part. Based on feedback the company should improve itself and grow the customer's community.
The revenue stream should be based on what type of 3D printer the customer needs, so the prices are different based on the size of the boards the printer can make and the features it has. The key resources of such a business are its employees and its technology used in the manufacturing and selling the 3D printers, the showroom location is another important variable. The way a company is doing advertising offline and online, the events at the showrooms that provides a demo to the potential customers are key activities the company should work on. Each company has to have partnerships so that this 3D printer should be made by other manufacturers if the components would be cheaper for the start and then the advertising has to be made with a specialised company in order to be more popular and attract more customers.

On a cost structure, the business should invest first of all in the technology required to create the 3D printers such as the conductive ink about 35%, the showrooms should take about 10-15% of the investment since the customers need to have a demo and get a quote, the manufacturing should take a big slice of the pie since the 3D printer has to be made out of hardware so that should be around 35% and the rest of 15-20% for the employees and the offices.

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Summary Figure