

3D-PRINTING: SWOT-ANALYSIS AND TRENDS

Bachelorarbeit

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vorgelegt von:

Name: Pschunder



Vorname: Bastian



Prüfer: Prof. Dr. M. H. Breitner

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1 INTRODUCTION

1.1 RELEVANCE AND MOTIVATION

3D printing has become popular, at least since Obama's state of the union address in 2013 in which he mentioned that *"3D printing has the potential to revolutionize the way we make almost everything and is the next revolution in manufacturing"*.¹ Some experts go one step further and predict that 3D printing will change manufacturing in the same way that the invention of flow production by Henry Ford did more than 100 years ago and will herald the start of the next industrial revolution.² 3D printing is a manufacturing process where products are built on a layer by layer basis, and has developed into a huge trend in the last few years. But the process of additive manufacturing is not a new invention of the 21st century; the first working 3D printer was already invented by Charles W. Hull in 1984.³ Back then, 3D printing was too expensive for most types of manufacturing and big companies only used this technique to produce their prototypes, a process also known as *rapid prototyping*. However, massive cost reduction (with prices reducing from around \$20,000 to less than \$1,000 just in the last three years) combined with improvements in quality, durability and stability in the field of 3D printers has enabled rapid development.⁴ The trigger for the huge price decline has been that many patents from the 1980's have now expired. Furthermore the development of computer technology has intensified the spread of 3D printing in almost all fields of manufacturing, and recently also in private households. In addition to this, political interest in 3D printing has increased, and as a result significant amounts of public funds for research and innovation in this area is currently stimulating development. Funds in the amount of around \$245 million for a seven year research and development project concerning 3D printing were recently appropriated by the Chinese Government.⁵ Also, Singapore is investing around US\$400 million in a five year project just as the USA who announced to provide additional \$140 million to build two new research centers.⁶

¹ Molitch, 2013, p.2

² Cf. Gore, 2013, p.31

³ Cf. Schubert, 2013, p.159

⁴ Cf. Bilton, 2013, p.3

⁵ Cf. Grace, 2013, p.3

⁶ Cf. Thum, 2014

The expansion and global distribution of 3D printing is still in its early stages and will increase over the next years. Gartner recognized this trend in 2013 and mentioned 3D printing as one of the Top Strategic Technologies for 2014.⁷ Compared to this, Goldman Sachs is more direct, stating that 3D printing is a technology which will force businesses to adapt or die.⁸ Market research also predicts that the 3D printing market will grow annually by around 20 percent until 2017, and that the volume of sales and services will reach \$6 billion worldwide.⁹ Figure one sums up the main trigger for the rapid development of 3D printing in the recent years.

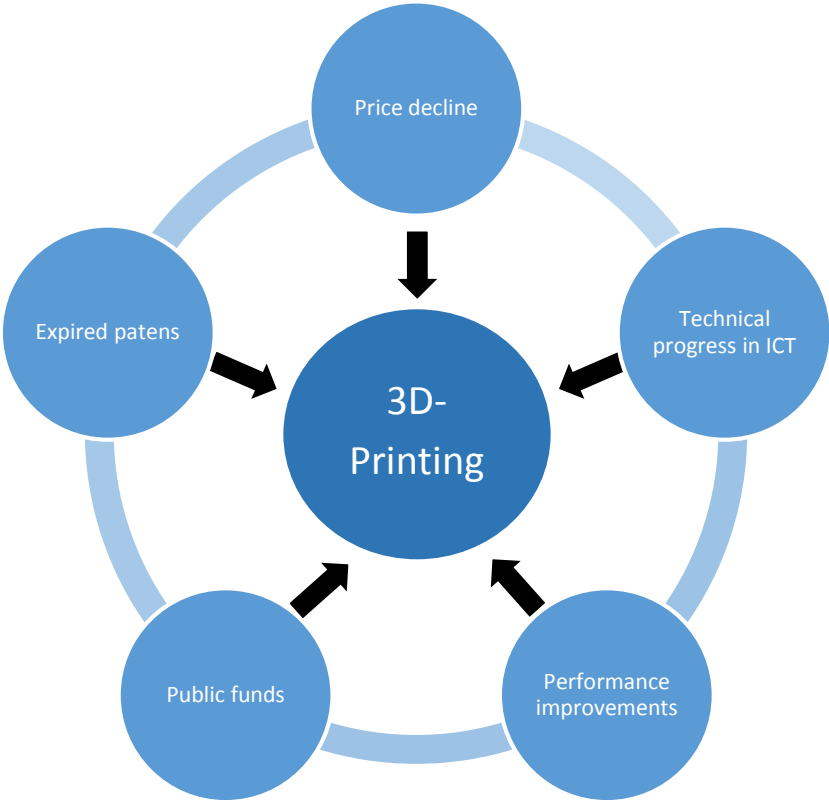


Figure 1: Trigger of the development of 3D-printing; Source: Own research

3D printing and its development is just at the beginning stage. Almost every day there are new headlines about innovations like turbines, guns, prostheses and even whole houses which can be printed. As a result, companies must start thinking about the implications and consequences for their business. 3D printing has the potential to change almost all sectors of industry for a long run, and is one of the most important trends of recent times. The relevance and importance of 3D printing were the motivation for this bachelor-thesis.

⁷ Cf. High, 2013. p.3
⁸ Cf. Wille, 2013,
⁹ Cf. McCue, 2013

1.2 PROCEDURE

The ambition of the work at hand is to analyze 3D printing from various perspectives and to determine its strengths, weaknesses, opportunities and threats. Therefore a qualitative literature research, complemented by an explorative study, including expert-interviews was made. The results were put together in a clear SWOT-analysis. Based on the rapid and dynamic development of 3D printing, the literature research almost entirely includes papers that are not older than two years.

The work is separated into five chapters. The first chapter includes an introduction to the topic and contains the development and current relevance of 3D printing. Furthermore, this chapter includes the ambition and procedure of this thesis. Afterwards, chapter two contains the theoretical foundations, where the term 3D printing will be defined. Moreover, the basic principles and the way of proceeding are presented. Thereby, the selective laser sintering, fused deposition modeling and the stereolithography as a selection of different manufacturing techniques will be described. Chapter three represents the main-part and includes a comprehensive SWOT-analysis. In this context, the potentials, risks and the opportunities of 3D printing technology will be discussed. Subsequently to the SWOT-analysis, chapter four is comprised of the explorative study in terms of interviews with experts. Thereby, the design, procedure and the results are presented and discussed. Chapter five, as the conclusion, sums up the most important results, and will revisit the core statements of the previous chapters. Additionally, a forecast for the potential development of 3D printing will be described.

3D printing is a complex and wide-ranging topic, therefore in some chapters QR-codes are included, to prevent additional information and to visualize described subjects. This should help the reader to get a deeper understanding of the issue. To open the additional content, a smartphone or Tablet-PC with an integrated camera is required. Therefore, special software applications like *Barcode Scanner* for Android, *Qrafter* for iOS or *QR Code Reader* for Windows Phone must be installed.

5 SUMMARY AND OUTLOOK

5.1 CONCLUSION

The aim of this work was to illustrate the strengths, weaknesses, opportunities and threats, which can occur with 3D printing technology. For that purpose, a comprehensive SWOT-analysis was made, which was based on a qualitative literature research and an empirical study. The overall results were that the self-elaborated findings from the SWOT-analysis were confirmed by the experts during the interviews. It has been shown that 3D printing has special strengths, which characterize and distinguish this technology from traditional manufacturing methods. It was shown that 3D printing requires much less material and produces much less waste, which is especially an important aspect for the aerospace sector. Furthermore, it was noticed that 3D printers could have a huge impact on the process of product development, which can be extremely reduced. The small-scale and highly customized production was demonstrated as one of the biggest strengths of 3D printers. On the other hand, the weaknesses must also be considered. In this context, the production speed, the size limitation as well as the costs of 3D printing was indicated as the main weak points. Investments and material cost, especially for industrial 3D printer, are still high and make this technology not affordable for small companies at the moment. As a result, it was noted that 3D printing will not be able to replace the prevalent manufacturing methods in the field of mass-production. In accordance with the current literature, 3D printed guns also have been considered as one possible threat of 3D printing. But the expert interviews stated that there are no apparent dangers through printed guns. This is due to the fact that 3D printed guns are a part of the hype, according to the experts. Furthermore it was noted that 3D printing could lead to an increasing product piracy and copyright infringement, which makes an adjustment and restructuring of the existing legal framework necessary. Particularly interesting was the field of opportunities which are accompanied with the increasing development of 3D printing. Therefore, among others, the NASA printed-food project and the noncommercial project of printed prosthesis were discussed. Furthermore, bio printing as one of the most important and comprehensive opportunities was mentioned.

The overall conclusion is that 3D printing technology offers some strengths as well as weaknesses and it depends on the specific requirements of whether the weak or strong points outweigh each other. The expansion and global distribution of 3D printing is still in its early stages and will increase over the next few years. Thereby industrial use will increase in importance and will change or replace whole industries.

5.2 LIMITATIONS

It is necessary to consider that this thesis underlies some limitations. The empirical part just includes expert-interviews as a qualitative inquiry. The explorative research just includes five experts and consequently does not have a representative character. To clearly validate and evaluate the results, an additional quantitative analysis would be necessary. Another advice for future research could be to interview experts from different countries, to investigate and reveal possible similarities and differences between the perceptions of the SWOT concerning 3D printing. Another restriction is that only three different printing techniques were described in this work. For a more precise comparison of the various manufacturing methods, it would be necessary to involve more techniques in the analysis. But for this thesis, a description of more methods would go beyond the scope. In addition, 3D printing has only become high-profile in the last two years and therefore there exist only a couple of high quality papers about this topic. As a consequence, the thesis includes also internet-articles, which cannot be compared in their reliability and reputation with confirmed academic publications. But it should be noted, that the thesis just includes topics confirmed by different resources and the experts during the interviews.

5.3 FORECAST

To forecast the development of 3D printing, it is necessary to clearly distinguish between the industrial and the private sector. The hype concerning 3D printing will keep on actuating the spreading of 3D printers in private households. But based on an unsatisfactory quality of the produced products of current low-price printers and the increasing awareness about the limited usability of home 3D printers, there will be a saturation of demand in the next five years. Instead of home 3D printers, 3D printing copy shops will gain more importance and will be established. As a contrast, 3D printing in the industry will strongly and sustainably grow over the next years. The strengths and opportunities of 3D printing in the aerospace or medical sectors are much more promising than in the private use. Furthermore, more expiring patents will trigger a rapid development in this area again. Just a few years ago, the expired patent of the fused deposition modeling caused the first significant upturn in the development and wide distribution of 3D printers. Investment costs for FDM using 3D printers strikingly decreased from more than \$10,000 to around \$500 within two years. In April 2014, another important patent, concerning the laser-sintering, expired. This will probably create a second huge boost within the 3D printing industry. We will see price declines for SLS 3D printer, which can currently cost around \$250,000. But because there are still some other patents on the STL process, price decreases will not be comparable with FDM-printers. Nevertheless, STL gets consequently financeable even for small companies. In contrast to FDM, the STL technique offers much more opportunities and the quality and stability of the produced products are much better. Therefore, the effects of the expired patents will probably have a bigger impact on the 3D printing industry. In addition to the decreasing investment cost, there will also be a price decrease for the material costs. As more and more providers of 3D printing materials edge into the market, the competition increases and, as a result, prices decline.

Another important development will take place in the field of education. In just a few years, 3D printing will be part of schooling, based on considerable investment from several governments and companies. To illustrate this, the US company MakerBot plans to provide every school in the USA with a 3D printer within the next years.¹⁰⁷

¹⁰⁷ Cf. Whittaker, 2013

Also England demonstrated interest in 3D printing with their new national curriculum, which provides that pupils will be taught in technologies like 3D printing, laser-cutting and robotics.¹⁰⁸ Within the next two years there will be a massive increase of available 3D printers in universities and in high schools. The possibility to show students the learning material in 3D can make the educational content more memorable and the lessons more dynamic. Furthermore, countries are interested in improving university education in the field of 3D printing to drive the research.

Furthermore, with the rapid development of 3D printing and 3D scanners, the discussion of an adjustment of the current legislation concerning patents, copyrights and trademarks will increase. Within 2014, the first global player will probably complain, due to the infringement of their copyrights. The judgment will create a precedent and will change the industry.

Additionally, printing food will become more important and more popular. At the moment, printing food is a side issue, but there are several companies conducting serious research in this area and there will be the first commercially available 3D food printer within the next two years. But the biggest potential for remarkable and substantial advances exists in the field of bio printing which will become more popular and the investments for research will steadily increase within the next years. First success stories will appear and will significantly advance growth of the bio printing industry until 2020. Collateral with the spreading of 3D bio printing, the discussion about ethical issues will increase. Therefore regulations and restrictions for bio printing will be implemented within the next few years.

To sum up, President Obama 3D rightly mentioned that 3D printing technology has the potential to revolutionize the way we make almost everything. The specific characteristics and the wide range of applications of this technology will definitely change wholes industries in the foreseeable future. For companies as well as countries it is particularly important to anticipate and to adapt to the current development of 3D printing in order to avoid losing their market position.

¹⁰⁸ Cf. Paton, 2013