

How the Marketing of 3D Printing Benefited Additive Manufacturing Economically During COVID-19

Ryerson University

Graphic Communications Management

GCM 490: Thesis

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Research Question: *Has the marketing of 3D Printing adapted to current economic downfalls amidst the COVID-19 pandemic on a global scale?*

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To be submitted on December 7, 2020

Abstract

3D printing, also known as additive manufacturing, along with many other industries, currently faces a significant global economic decline amidst the COVID-19 pandemic. Research has presented that businesses around the world are losing revenue and filing for bankruptcy, as global economies begin to recover from extremely low consumer spending caused by pandemic lockdowns. This study aims to determine which marketing approaches the 3D printing industry undertakes in order to adapt to current economic downfalls generated by the coronavirus. Based on a review of the literature on additive manufacturing's potential and projected market growth, as well as its extraordinary contributions to the healthcare, engineering and education sectors, content analysis was applied. Data was systematically collected from a set of online written and visual texts on this under-searched topic. Analysis of the written work demonstrated that 3D print was highly in demand during this time of need, as the market's performance was very profitable. The results indicate that the marketing of 3D printing has adapted smoothly to economic downfalls during the COVID-19 pandemic on a global scale. Further research is needed to identify more examples on 3D printing's rise to success during global lockdown, as the sample size for this report was relatively small due to its short time period of existence.

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1. Introduction

3D printing is becoming one of the fastest growing industries in the manufacturing sector, as it is rapidly changing the way in which humans create. Going also by the name of additive manufacturing (AM), 3D printing is the process where a digital model is manufactured into a physical three-dimensional object through a computer-aided design software. Catering to a multitude of different industries, the additive manufacturing market is projected to grow at an expeditious rate in the upcoming years. Unfortunately, the unanticipated global spread of the COVID-19 virus and lockdown measures have negatively affected global economies and put companies out of business. This report investigates if the marketing of 3D printing has adapted to current economic downfalls amidst the COVID-19 pandemic on a global scale. With that being said, the research covers the time period between the virus' arrival, which was March of 2020, and the end of the calendar year. As the pandemic is an ongoing issue, it is essential to gain an in-depth understanding of how a technologically advanced industry such as 3D printing is accommodating its delivery methods in a computerized era. While there has been much research on the general growth of the 3D print market (Campbell et al., 2011), none has focused specifically on its success during a global pandemic. In order to answer the research question and attain the objective, content analysis and the systematic collection from a set of scholarly and commercial online texts will be applied. The dissertation will begin with a thorough review of the report's gathered literature. This will provide an overview of current knowledge, allowing the identification of relevant theories, methods, and gaps in the existing research. Subsequently, the research methodology chapter will follow, in which the methods used for the research will be explained. Furthermore, results collected from the research will be displayed in a presentable fashion, followed by the discussion and evaluation of the data. Finally, a conclusion will briefly summarize the dissertation in its entirety.

2. Literature Review

The unfolding of 2020's global uncertainties has accelerated the demise of many businesses, leaving economies in very difficult positions. With the unprecedented arrival of the COVID-19 pandemic, the world's supply chains have been greatly disrupted, forcing companies to abruptly search for inexpensive technologies with accessible manufacturing capabilities.

Fortunately, crisis-response efforts are in motion, as the high-tech 3D printing industry has convincingly proved itself as a leading source towards the resolution of scarce resources. Regarded also by its more all-inclusive term “additive manufacturing” or “AM”, 3D printing has historically demonstrated that it is more than capable to foster change in a very quick way, as it is widely considered to be the most agile method to come up with new products. The printer itself works very similarly to the standard inkjet printer, however, rather than printing layers of ink on paper, it instead uses materials such as metals, plastics, rubbers and resins to build a three-dimensional object (Attaran, 2020).

Despite the recent success of this extraordinary technology, today, 3D printing is intensely re-emerging into one of the hottest and most exciting advancements in the design and marketing world. The inauguration of the coronavirus has transformed additive manufacturing and highlighted its importance like never before by drastically increasing its application on a global scale. As many major companies are failing amid the COVID-19 lockdown, 3D printing’s current process of creation, communication and delivery has brought great value to customers, allowing the market to grow substantially. Nonetheless, as AM continues to contribute to industries such as healthcare, engineering and education, the coronavirus’ early stages still managed to financially damage the market (Dignan, 2020).

2.1 Companies Are Still Failing

To start, as not every industry is withstanding the pandemic as well as 3D printing, global quarantine and the closure of stores has essentially eradicated companies that were already in trouble before. In regards to the United States, the country’s economic shutdown has forced oil and gas drillers such as Whiting Petroleum and Diamond Offshore to file for bankruptcy in late April, followed by major retailer J. Crew to do the same on May 4 (Tucker, 2020). In addition, many other major American companies have followed the footsteps of the oil drillers, as they filed for bankruptcy in 2020 as well. Amongst the various declining companies are Foodora, True Religion and Latam Airlines. Foodora, a food delivery app, filed for insolvency in Canada on April

27, ceasing its operations May, while the other two filed for bankruptcy in the spring (Tucker, 2020).

In another example, major tech companies have reported financial issues as well, leading to a great decline in major stock indexes (Nguyen, 2020). In relevance to the aforementioned disruptions of worldwide supply chains, Apple reported that COVID-19 started impacting China, temporarily affecting iPhone supply and product demands within China. To compare, conglomerate Amazon revealed how the pandemic affected the company after a quarter into 2020. Although CEO Jeff Bezos announced that the business' revenue grew 26% during the first three months of the year, Amazon will still spend the \$4 billion profit in its entirety on COVID-related expenses. These negative trends suggest that 3D printing did not find itself in a promising financial environment by the start of the pandemic.

Unplanned quarantine has unfortunately impacted economies in at least the short run. Shut down and precautions has reduced overall consumption and production, forcing countries GDP's to fall. Yet, amazingly, 3D printing was reported to have globally risen during a time of financial instability.

2.2 The Successful Marketing of 3D Printing in Numbers

Furthermore, additive manufacturing has brought great value to customers in need, which has allowed the industry and its companies to flourish financially in 2020. As previously acknowledged, 3D printing is distinguished for its remarkable agility and speed, however, merely physically manufacturing objects will not suffice in this new reality brought by COVID-19. The AM industry realized that it was not catering its business to those working from home who are more attuned to using virtual tools and services in their day to day lives. To address that, American desktop 3D printer manufacturer company MakerBot launched its next generation cloud software solution, designed to deliver a seamless 3D printing experience for users remote or even onsite (Griffiths, 2020). The software resolves common issues associated to 3D printing during the pandemic, such as the management of print jobs and the quality of print preparation tools to

increase productivity. To top it all, the platform and the enhanced features it offers can be utilized directly from users' browsers, facilitating the business of companies in lockdown. Extraordinarily, not only is additive manufacturing surviving economic downfalls, it is also helping other companies stay in business.

Following MakerBot's clever initiative, their September 2020 report revealed that a staggering 74% of companies planned to invest in 3D printing in 2021 (Stratasys, 2020). Over 1,200 responses from professionals across industries, including Industrial Goods, Aerospace, Medical, Military & Defense and Automotive. Additionally, of the 74% of future investors, 50% is planning to spend up to \$100,000. CEO of MakerBot Nadav Goshen adds: "These findings confirm what we have known for some time – and that is the potential of 3D printing to transform business operations" (New MakerBot Report Reveals 74% of Companies Plan to Invest in 3D Printing in 2021, 2020).

2.3 3D Printing's Role in Other Industries

Thirdly, 3D printing's manufacturing contributions to industries in need have been fairly remarkable. Today's printers produce fully functional components like replacement parts, batteries, transistors, and LED's (Attaran, 2020). At a relatively low cost, 3D printers are evolving rapidly and are building more significant components that are achieving greater precision and resolution. In the near future, it is expected that AM technologies will expand their performances, enhancing speed, range of environments and their variety of materials. Eventually, 3D printers will become more versatile and more widely used by the human population. Aside from its promising projections, the 3D printing industry is currently saving lives by responding to COVID-related issues for many different business sectors (Attaran, 2020).

First, companies such as MakerBot are manufacturing and delivering face shields amongst other personal protective equipment to hospitals around the globe to ease the pressure of supply chains. Secondly, AM is supplying to engineering firms, as an Italian engineering company used in-house SLS 3D printers to produce 100 respirator valves in 24 hours for an Italian hospital with 250 coronavirus patients. Thankfully, the patients' lives were saved (Attaran, 2020). Thirdly, researchers from multiple universities have produced a digital holographic microscope made

entirely from 3D printed parts. The microscope has the potential to be used to diagnose diseases such as sickle cell, malaria, diabetes and many others.

2.4 The 3D Print Market's Rough Start

Lastly, although researches project that the 3D printing market size is estimated to grow from USD 11.4 billion in 2020 to USD 30.2 billion by 2025, the market is still expected to drop of more than 19% in comparison to pre-COVID 2020 predictions (Marketsandmarkets, 2020). Many print services during the pandemic are being done free of cost, which is the key reason for the decrease in revenue. While the global epidemic emphasized on the potential of additive manufacturing and 3D printing, profits for their market were hard to come by at first. American-Israeli manufacturer of 3D printers Stratasys reported that it was cutting salaries by yet another 5% for top executives, eliminating 10% of its workforce while transitioning the business to a four-day workweek to avoid higher costs and ultimately save money. The firm also reported a second quarter net loss of 51 cents a share on revenue of \$117.6 million, down from \$163.2 million a year ago (Dignan, 2020). However, CEO Yoav Zeif spoke for all 3D printing companies as he claimed that the industry will remain highly optimistic about future businesses. He went to explain that the largest opportunity for 3D print lies in the offering of polymer systems and materials. Overall, the 3D printing market's resilience overcame the difficulties brought by the post COVID-19 pandemic. On another high note, the market's temporary drop was essentially unnoticeable in comparison to the many other industries that witnessed far worse complications

2.5 Literature Summary

In conclusion, despite the high number of companies unable to overcome the economic downfalls of the coronavirus lockdown, the marketing and exposure of 3D printing during these tough times has allowed this particular industry to flourish on a financial level. Upon overcoming an early period of economic adversity, additive manufacturing, due to its state of the art and inexpensive technological advancements, remains highly active in helping other industries and markets

succeed. As research anticipates, 3D printing will remain highly relevant even after the pandemic's denouement.

3. Research Methodology

3.1 Methodological Approach

The content of this research focuses on the marketing of 3D printing amidst the COVID-19 pandemic and investigates its successful adaptation to current economic downfalls on a global scale. This report explores a relatively unique and under-searched topic on the impressive contributions of additive manufacturing towards vulnerable businesses in a time of lockdown. In order to gain insight on 3D printing's 2020 market performance, as well as its specific approaches contributing to profit increase, the use of quantitative and qualitative data were both necessary for the accurate execution of this study. Additionally, secondary and descriptive data was collected for the achievement of this aim, as the selective gathering of observations and online publications was most applicable. These were the most suitable approaches to confirm potential hypotheses regarding the research question as the examination of scholarly articles written by industry experts promises great validity and credibility on the topic of 3D printing. To add, accessibility to original information about this discipline was fairly difficult to access, as the collection of data such as surveys and personal experiments were considered inessential.

3.2 Methods of Data Collection & Analysis

In regards to the data collection methods used, the evaluation of 3D printing's strategies and success in marketing was executed through thorough selection of existing data representing quantitative and qualitative information. The usage of reviewed publications and archival data was more than efficient to answer the ultimate research question. For the quantitative research, the investigation strictly focused on the monetary performance related to the 3D printing industry post-COVID. With that said, valid generalizable and abstract economical results such as compound annual growth rates (CAGR), quarterly revenues, investment opportunities and employee salaries

were acclaimed and turned into measurable observations. Through the operationalization of these concepts, data was collected systematically and processed in order for it to be directly observable.

The selected publications and reports were sourced through professional and approved web platforms such as *Google Scholar* and official company websites such as *Stratasys*. The data was originally and mainly produced by published scientific research papers and actual company quarterly business reports. Criteria such as date range and website credibility were used to select material.

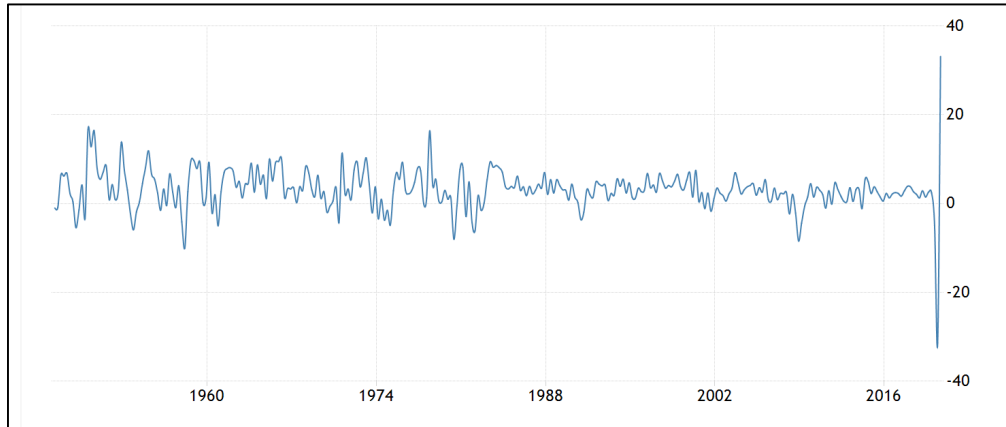
To further relate, in the qualitative research, source selection highly depended on peer reviewed and professionally written research articles with referenced facts. Through active participation, case study materials such as texts qualified for selection based off of relevance and value to the focus of the analysis. Published material that elaborated on the specific contributions of 3D printing and the response of each business sector were optimal candidates for the analysis of the dissertation.

3.3 Methodology Evaluation

The use of content analysis greatly suited the objectives of the dissertation. This research method was mainly comprised of identifying patterns in recorded communication. Additionally, data was collected systematically from a set of written and visual texts, generally deriving from newspapers, web contents, social media posts and photographs. The study of the 3D printing market is an under-researched topic to begin with, which made it even more challenging to uncover information published solely during COVID-19's quarantine measures. With relatively only new information to work with, other methods including surveys, interviews and participant observations would simply not be efficient, as the group of people chosen would likely not possess enough knowledge or awareness about the research topic. As a result, respondents may have not felt encouraged to provide accurate and honest answers, ultimately decreasing the validity of the data. On the other hand, although existing data on the matter was scarce, the research and inspection of many more resources than initially planned resolved the issue.

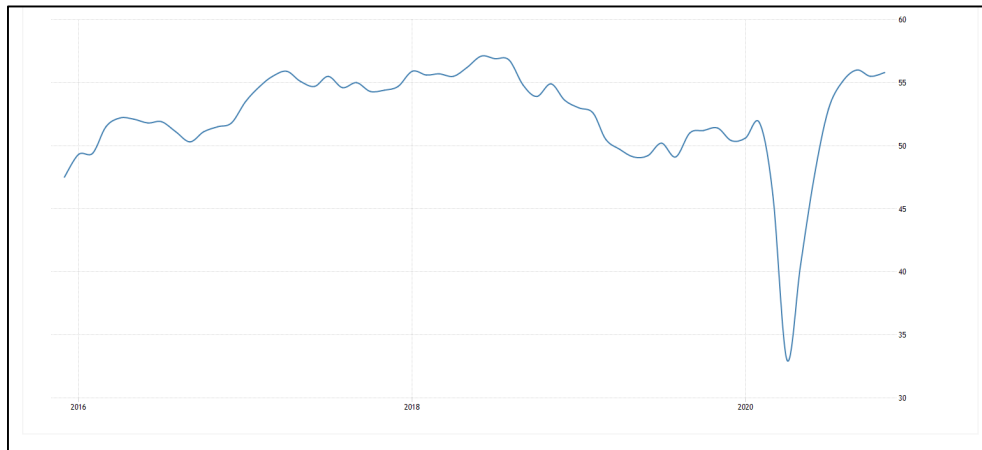
4. Results

4.1 United States GDP Growth Rate (1946-2020)



[Figure 4.1] This chart presents the United States Gross Domestic Product Growth Rate dating back to 1946. The century's largest drop in GDP is recorded to be in 2020, several weeks following the spread of COVID-19 (Trading Economics, 2020).

4.2 Canada Manufacturing PMI (2016-2020)



[Figure 4.2] The graph above shows the Purchasing Managers' Index for the manufacturing sector in Canada from 2016 to present day. The PMI serves as an index of the prevailing direction of economic trends in the manufacturing and service sectors, which includes 3D printing. Once again, 2020's COVID-19 resulted in an immense drop in market conditions. However, as seen, market recovery immediately followed (Trading Economics, 2020).

4.3 Nasdaq Value 2020



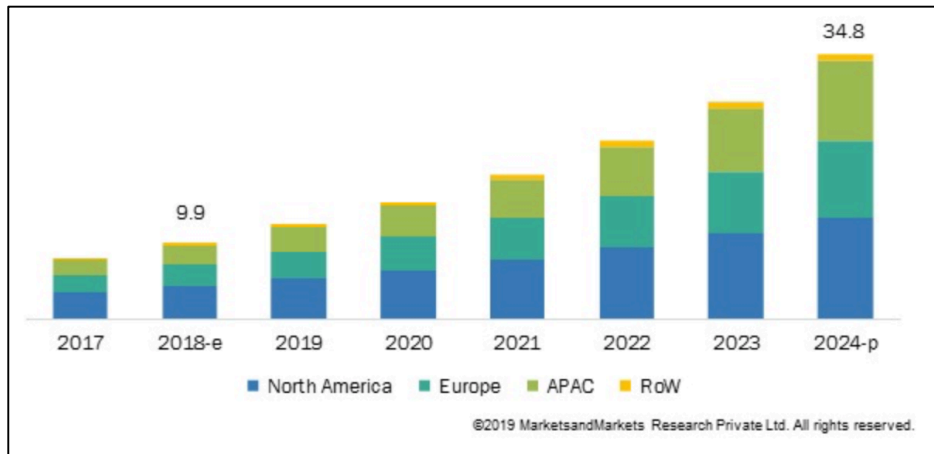
[Figure 4.3] This graph represents the drastic drop of the Nasdaq stock index in March of 2020 (Nguyen, 2020)

4.4 SWOT Analysis of 3D Printing Market

<p>Strengths</p> <ul style="list-style-type: none"> - Not many 3D printing services in operation at this time - Nascent industry - Low number of market suppliers has not yet caught onto the demand for 3D printing services - 3D printing technology popular among engineering firms 	<p>Weaknesses</p> <ul style="list-style-type: none"> - More companies expected to enter the market with 3D printing services - Expensive technology and inventory being used
<p>Opportunities</p> <ul style="list-style-type: none"> - Easy access to additional/larger scale equipment for accommodation of specialized printing orders - Can expand by heavily reinvesting into marketing campaigns (especially on the internet) 	<p>Threats</p> <ul style="list-style-type: none"> - Continual change of 3D printing equipment

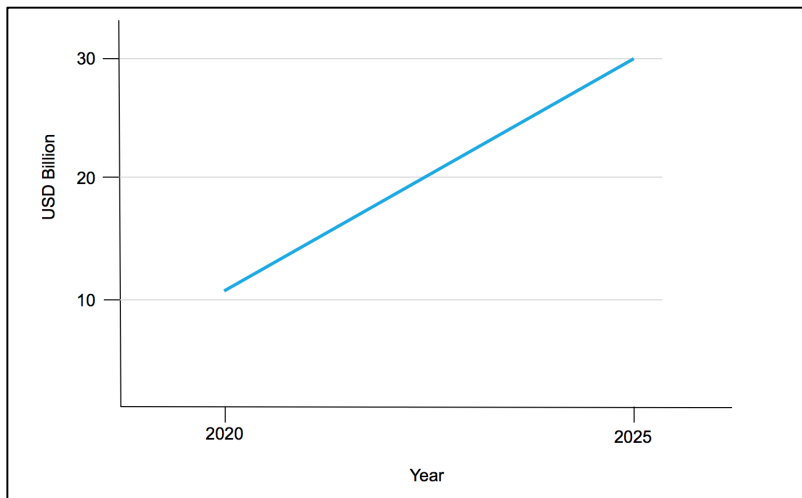
[Figure 4.4] The SWOT Analysis, shown above, describes the 3D printing market’s internal strengths and weaknesses, as well as its external opportunities and threats. This analysis determines how closely the 3D print industry is aligned with its growth trajectories (3D Printing Service SWOT Analysis, n.d.)

4.5 3D Printing Market Size Projection by Region, 2018-2024 (USD Billion)
[Pre-COVID-19]



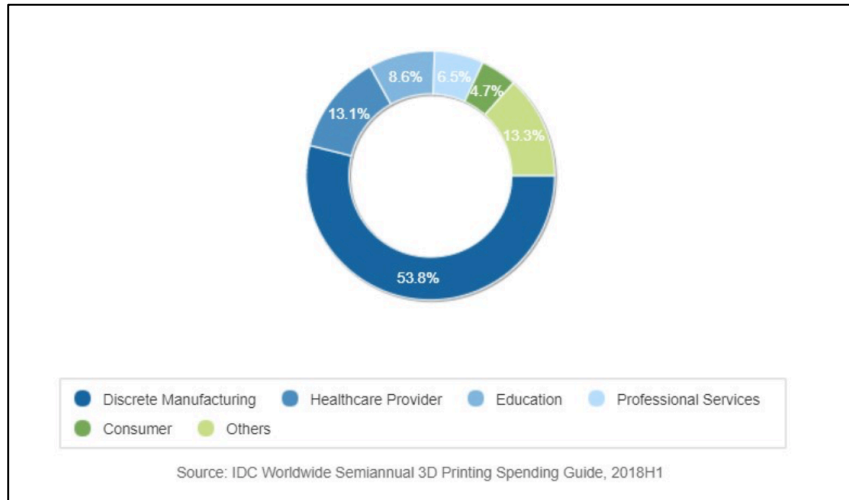
[Figure 4.5] This graph shows how the 3D printing market size, expanded in multiple global regions, was projected to reach \$34.8 Billion in 2024 pre-COVID-19 (Marketsandmarkets, 2020).

4.6 3D Printing Market Size Projection, 2020-2025 (USD Billion) [Post-COVID-19]



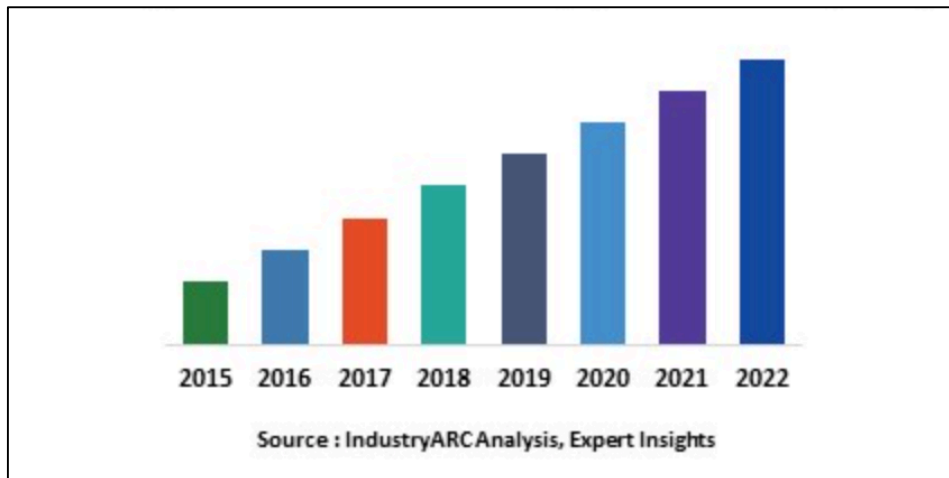
[Figure 4.6] This graph shows how the 3D printing market size is still projected to reach staggering results amid the negative impact of COVID-19. The market is estimated to grow from \$11.4 Billion in 2020, to \$30.2 by 2025 (Marketsandmarkets, 2020).

4.7 Top Industry % Based on 2019 3D Printing Market Share



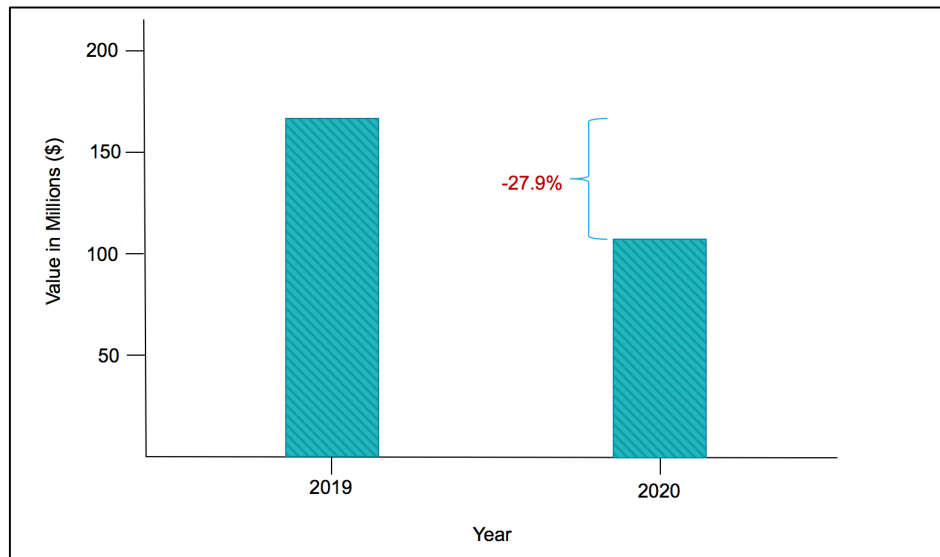
[Figure 4.7] This chart displays the top industries that made up the 3D printing's market share in 2019. Global spending on 3D printing amounted to \$13.8 Billion (Guan, 2019).

4.8 3D Printing in Healthcare Market Revenue (2015-2022) (\$Billion)



[Figure 4.8] This graph shows how the 3D Printing in Healthcare Market Revenue follows a consistent trend in which it increases yearly (recorded in \$Billions) (IndustryARC, n.d.).

4.9 Stratasys Q2 Financial Results (2019 vs 2020)



[Figure 4.9] The displayed chart compares 3D printing company Stratasys' revenue in 2019 vs 2020. A significant 27.9% drop in revenue in 2020 was caused by COVID-19 (Dignan, 2020).

5. Discussion

5.1 Key Findings

Upon the collection of vital results, this analysis supports the theory that the marketing of 3D printing has adapted to current economic downfalls generated by the COVID-19 pandemic. Firstly, the examined results confirm that economies, more specifically in North America, have indeed experienced major declines in 2020 due to market deterioration and lower than usual consumer spending. Furthermore, the studies demonstrate a correlation between 3D printing's market growth and its contribution towards different business sectors before and after the pandemic. Lastly, the data suggests that the 3D printing market, before its rise to success, did experience financial difficulties at the start of lockdown. As presented in the results section, certain

companies within the industry recorded sizeable revenue losses and forecasted low quarterly financial results.

5.2 The Initial Drop of the General Market

To start, figures 4.1, 4.2 and 4.3 illustrate drastic drops in economic trends such as revenue, production and value in North American countries for the early period of 2020. These results simply portray the unstable economic state in which the 3D printing industry, along with every other business sector, was forced to adapt to. As the results of March 2020 met general expectations, the United States Gross Domestic Product Rate suffered its greatest drop in the last century, with a record 31.4% plunge in Q2 (Trading Economics, 2020). In correlation, Canada's Manufacturing PMI index, as well as the Nasdaq stock value, also decreased in synchronization with the US GDP. Known as the Purchasing Managers' Index, a PMI exhibits economic trends in the manufacturing and service sectors, which is where the 3D printing market is located (Trading Economics, 2020).

The results in the first three figures support the research previously conducted in the literature review. The filing for bankruptcy by companies such as Whiting Petroleum and J. Crew, and the struggles faced by Apple and Amazon in the spring of 2020 are justified by the downwards slope of economic growth.

5.3 3D Printing's Unconditional Market Success

Moreover, in line with the hypothesis that the 3D printing market was bound to succeed amidst economical obstacles, the results obtained from figures 4.4 and 4.5 explain how the additive manufacturing sector was already economically sound before COVID-19. To add, the provided SWOT analysis of the market further elaborates on how AM is an industry that possesses great strengths such as service differentiation and a large online and technological presence (3D Printing Service SWOT Analysis, n.d.). Based off of its stellar market analysis and groundbreaking projections to reach \$34.8 Billion in revenue by 2024 (Marketsandmarkets, 2020), 3D printing was

designed to thrive globally and become high in demand during a coronavirus period which highly depended on technological advancements and quick software. To confirm the hypothesis, even with a slight financial bite due to global lockdowns, the graph in figure 4.6 shows how the 3D printing market size is still projected to reach a staggering \$30.2 Billion by 2025, as opposed to the initial \$34.8 Billion by 2024 (Marketsandmarkets, 2020). In relevance to the implications of the literature review, the statistical findings of this report support 3D printing's success during COVID-19. For instance, the confirmation of the industry's strong presence in the manufacturing and service sector and its ability to adapt to online environments explains MakerBot's competence to attract valuable company investors (Stratasys, 2020).

Although this report provides valid research and accurate results, it contains limitations that restrict certain research objectives. For example, considering that data on any subject matter regarding COVID-19 is relatively new information, the sample size for this dissertation was notably small and limited to research that is less than a year old. Due to the lack of data on 3D printing during virus-related lockdowns, it is beyond the scope of this study to provide highly reviewed material. Nonetheless, the results obtained for this investigation remain valid because they accurately live up to the potential of 3D printing's projections even before the pandemic. In order to minimize limitations for this report, further research, active observation and interviews with industry experts on the matter is required

5.4 Top Industries Using 3D Print

Thirdly, 3D printing's contribution to the formerly mentioned industries can be observed in the 2019 market share of 3D printing (Figure 4.7). These results conclude that the research regarding 3D printing's involvement in the healthcare, engineering and education sectors was accurate. As the chart was produced pre-COVID, it can be argued that 3D printing was expected to be relevant in the presented industries. 53.8% of the share belonged to the discrete manufacturing sector, where engineering can be found, while 13.1% represented healthcare providers and 8.6% was occupied by education (Guan, 2019). The chart truly illustrates how impactful additive

manufacturing is on other industries, as the global spending on 3D printing that year amounted to \$13.8 Billion, further supporting existing theories on its marketing success.

5.5 The Immediate, but Temporary Decline

Finally, Figure 4.9, found in the results chapter, graphs Stratasys' 2020 revenue loss in comparison to its 2019 financial results (Dignan, 2020). As mentioned, the American-Israeli manufacturer of 3D printers suffered a major decline in product sales following the coronavirus' arrival, as its services during the pandemic were being done free of cost. To add, the business began cutting salaries by 5% for top executives, eliminating 10% of its workforce while transitioning the business to a four-day workweek. The 3D printing company's slight loss is a representation of how additive manufacturing as a whole did not immediately adapt to the new COVID-19 climate. This information is relevant, as well as it is pertinent because it demonstrates the magnitude of 3D printing's market success, as it went from significant revenue loss to market projections of \$30.2 Billion within the duration of a few months.

6. Conclusion

This dissertation aimed to evaluate, on a global scale, if the marketing of 3D printing adapted to current economic downfalls set by the COVID-19 pandemic. Based on a quantitative, qualitative and content analysis on the market growth of additive manufacturing and its highly-demanded contributions to various business sectors during lockdown implementations, it can be concluded that the marketing of 3D printing benefitted additive manufacturing and successfully adapted to COVID-19's economic aftereffects. The methodology chosen in this reported was highly effective in confirming hypotheses and answering the research question, as statistics such as revenue growth and occupied market share percentage helped measure additive manufacturing's prosperity quantitatively. Additionally, lists of contributing factors such as the manufacturing of healthcare and engineering equipment served as evidence to how the industry's financial results were successful in the first place.

In comparison, although most confronted data supported the answer to the ultimate research question, a new question and an unexpected insight arose in the process. This research clearly illustrates that 3D printing's marketing approaches in service to COVID-19 were successful, however, it also raises the question of how unsuccessful it was in the early stages of the pandemic. Regardless, to better understand the correlations between additive manufacturing, marketing and the coronavirus pandemic, more time needs to pass to allow for future studies to address the situation on the new normal that's heading towards humanities way.

References

- Attaran, M. (2020, May 26). 3D Printing Role in Filling the Critical Gap in the Medical Supply Chain during COVID-19 Pandemic. Scientific Research Open Access. Retrieved October 26, 2020, from https://www.scirp.org/html/9-2121805_100444.htm#ref20
- Campbell, T., Williams, C., Ivanova, O., & Garrett, B. (2011, October). Could 3D Printing Change the World? STRATEGIC FORESIGHT Report. Retrieved November 5, 2020, from <https://www.jstor.org/stable/pdf/resrep03564.pdf?refreqid=excelsior%3Ae8c09a61e0e656681bbbf51314277897&seq=1>
- Choong, Y. Y. C., Tan, H. W., Patel, D. C., Choong, W. T. N., Chen, C.-H., Low, H. Y., Tan, M. J., Patel, C. D., & Chua, C. K. (2020, August 12). The global rise of 3D printing during the COVID-19 pandemic. Nature Reviews Materials. Retrieved October 2, 2020, from <https://www.nature.com/articles/s41578-020-00234-3>
- Dana, J. (2020). Why Markets Fail? The Economics of COVID-19. Northeastern University. Retrieved October 27, 2020, from <https://northeastern.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=ce5d9cda-db78-4995-a10f-ac2f01568d92>
- Dignan, L. (2020, August 8). 3D printing during COVID-19 shows potential, but financial realities bite. ZD Net. Retrieved November 2, 2020, from <https://www.zdnet.com/article/3d-printing-during-covid-19-shows-potential-but-financial-realities-bite/>
- Fiorillo, L., & Leanza, T. (2020, May 30). Worldwide 3D Printers against the New Coronavirus. MDPI. Retrieved October 3, 2020, from <https://www.mdpi.com/2673-1592/2/2/9>
- Griffiths, L. (2020, August 20). Has the COVID-19 pandemic accelerated the adoption of 3D printing? TCT Magazine. Retrieved October 25, 2020, from <https://www.tctmagazine.com/additive-manufacturing-3d-printing-news/has-covid-19-pandemic-accelerate-adoption-of-3d-printing/>
- Guan, A. (2019, January 9). IDC: Global Spending on 3D Printing Will Be \$13.8 Billion in 2019. RTM World. Retrieved November 3, 2020, from <https://www.rtmworld.com/news/idc-global-spending-on-3d-printing-will-be-13-8-billion-in-2019/>

IndustryARC. (n.d.). 3D Printing in Healthcare Market - Forecast(2020 - 2025). IndustryARC. Retrieved November 2, 2020, from <https://www.industryarc.com/Report/1268/3D-printing-in-healthcare-market-analysis.html>

Kmetz, K., Palmer, R., Greene, T., Machado, A., & Wilbur, G. (2020, April). COVID-19: What Will Be the Impact to the Print Market? IDC. Retrieved October 2, 2020, from <https://www.idc.com/getdoc.jsp?containerId=WC20200408>

MakerBot Launches 3D Printing Initiatives to Combat COVID-19. (2020, April 14). Medical Design Briefs. Retrieved October 29, 2020, from <https://www.medicaldesignbriefs.com/component/content/article/mdb/stories/blog/36701>

Marketsandmarkets. (2020). 3D Printing Market by Offering (Printer, Material, Software, Service), Process (Binder Jetting, Direct Energy Deposition, Material Extrusion, Material Jetting, Powder Bed Fusion), Application, Vertical, Technology, and Geography - Global Forecast to 2024. Marketsandmarkets. Retrieved November 3, 2020, from https://www.marketsandmarkets.com/Market-Reports/3d-printing-market-1276.html?gclid=CjwKCAiA_Kz-BRAJEiwAhJNY7-U25DhH1phvbXlJhriIEp0SHuK4bxmtwEJgodO3ZmyBKYKFdnPMfRoC0L8QAvD_BwE

Marketsandmarkets. (2020). COVID-19 Impact on 3D Printing Market by Offering (Service, Printer, Material, and Software) - Global Forecast to 2025. Marketsandmarkets. Retrieved October 30, 2020, from <https://www.marketsandmarkets.com/Market-Reports/covid-19-impact-on-3d-printing-market-216201885.html>

Nguyen, J. (2020, May 1). Market reactions to COVID-19: Stocks end the week in decline. Marketplace. Retrieved October 20, 2020, from <https://www.marketplace.org/2020/05/01/how-the-markets-are-reacting-to-covid-19/>

3D Printing Service SWOT Analysis. (n.d.). The Finance Resource. Retrieved November 4, 2020, from <https://www.thefinanceresource.com/swot-analysis/3d-printing-service-swot-analysis.aspx>

Stratasys. (2020, August 5). Stratasys Releases Second Quarter 2020 Financial Results. Stratasys. Retrieved October 24, 2020, from <https://investors.stratasys.com/news-events/press-releases/detail/701/stratasys-releases-second-quarter-2020-financial-results>

Stratasys. (2020, September 29). New MakerBot Report Reveals 74% of Companies Plan to Invest in 3D Printing in 2021. Stratasys. Retrieved October 28, 2020, from

<https://investors.stratasys.com/news-events/press-releases/detail/705/new-makerbot-report-reveals-74-of-companies-plan-to-invest>

Trading Economics. (2020). Canada Manufacturing PMI. Trading Economics. Retrieved November 5, 2020, from <https://tradingeconomics.com/canada/manufacturing-pmi>

Trading Economics. (2020). United States GDP Growth Rate. Trading Economics. Retrieved Nov 5, 2020, from <https://tradingeconomics.com/united-states/gdp-growth>

Tucker, H. (2020, May 3). Coronavirus Bankruptcy Tracker: These Major Companies Are Failing Amid the Shutdown. Forbes. Retrieved October 23, 2020, from <https://www.forbes.com/sites/hanktucker/2020/05/03/coronavirus-bankruptcy-tracker-these-major-companies-are-failing-amid-the-shutdown/?sh=263e15a73425>