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INVENTORY MANAGEMENT IN SHIPPING: THE SOLUTION OF 3D PRINTING

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Διπλωματική Εργασία

που υποβλήθηκε στο Τμήμα Ναυτιλιακών Σπουδών του Πανεπιστημίου Πειραιώς ως μέρος των απαιτήσεων για την απόκτηση του Μεταπτυχιακού Διπλώματος Ειδίκευσης στην Ναυτιλιακή Διοικητική

Πειραιάς

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PROLOGUE:

As this research is part of a Master thesis for the degree of Master of Science in Shipping Management in the University of Piraeus. The research is conducted in a period of four months starting in July 2020 and ending in October 2020. As the research is exploratory in nature, qualitative methods are suggested to be more applicable, and the questionnaire study is selected as the primary methodology.

In the preliminary phase, the distinctive features of several variables that are relevant to this research within the international maritime industry are collected from existing scientific literature and synergized in a logic manner. The methodology adopted within this phase is primarily literature review, which showed that there was little, or no research done on the application of 3D printing in the maritime industry. The embedded cases that are identified as different stakeholder groups vary from manufacturers of spare parts, ship suppliers of spare parts and final users (or customers) in the maritime industry, that basically are personnel of Maritime companies.

The second phase consists of a field research, which was conducted in a time frame of one month (October 2020). Answers to 25 questionnaires, which are divided into three stakeholder groups namely spare part manufacturer (6 questionnaires), ship supplier (8 questionnaires) and end user (16 questionnaires) are based on a format, which are operationalized based on the theory of user acceptance and use of technology.

The third phase consists of analyses of the collected data, which are derived from the discussed triangulation of sources and strengthens the validity of the research. Analyses is done via coding of the questionnaire responses, including the three stakeholder groups, into statistic results to have a clear overview of all the data. By analyzing the results and conducting pattern matching the propositions can be validated for concluding purposes.

The fourth and final phase consists of concluding and answering the research question and sub questions. When reporting the final results in this chapter they need to be discussed to challenge the conclusions and are compared to latest insights from more research. Further recommendations for future research will also be given for which this research can be used as a starting point.

I would like to express my sincere gratitude to Dr. Ioannis Lagoudis, for his continuous support as a supervisor. His aid was fundamental for the completion of this work. Furthermore, I would like to

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ABSTRACT

In the present work, the theoretical and practical advantages of the production method using 3D Printing are presented. The research is conducted in the form of questionnaires, which have been obtained through a case study approach. 25 experts in the field of construction, resale and purchase of spare parts for merchant ships, have participated in the research. Valuable conclusions are drawn about the prism through which stakeholders see this particular, evolving mode of production. In addition, it is understood that the degree of agreement and market readiness to accept this construction method, which as it turns out, will (if implemented) to transform the supply chain of the entire merchant shipping. As it can be seen from the participants' conclusions, the immediate assistance that the industry could receive from 3D Printing, concerns specific portions of the spare parts. Due to their special characteristics, these spare parts can easily, quickly and economically be created on an expanded scale, through this new way of production.

ΠΕΡΙΛΗΨΗ

Στην παρούσα εργασία, τα θεωρητικά και πρακτικά προνόμια του τρόπου παραγωγής με τη χρήση Τρισδιάστατης Εκτύπωσης παρουσιάζονται. Η έρευνα, διεξάγεται με τη μορφή ερωτηματολογίων, τα οποία έχουν ληφθεί μέσω μίας προσέγγισης υποθέσεως εργασίας. 25 ειδικοί του κλάδου της κατασκευής, μεταπώλησης αλλά και αγοράς των ανταλλακτικών των εμπορικών πλοίων, έχουν συμμετάσχει στην έρευνα. Πολύτιμα συμπεράσματα εξάγονται, σχετικά με το πρίσμα, μέσω του οποίου βλέπουν οι ενδιαφερόμενοι τον συγκεκριμένο, αναπτυσσόμενο τρόπο παραγωγής. Εκτός αυτού, γίνεται κατανοητός ο βαθμός συμφωνίας και ετοιμότητας της αγοράς, να αποδεχθεί αυτή την κατασκευαστική μέθοδο, η οποία όπως αποδεικνύεται, πρόκειται (εφόσον εφαρμοστεί) να μεταποιήσει συθέμελα την εφοδιαστική αλυσίδα, ολόκληρης της εμπορικής ναυτιλίας. Όπως διαφαίνεται από τα συμπεράσματα των συμμετεχόντων, η άμεση βοήθεια που θα μπορούσε να λάβει ο κλάδος από την Τρισδιάστατη Εκτύπωση, αφορά συγκεκριμένες μερίδες των ανταλλακτικών. Λόγω ιδιαίτερων χαρακτηριστικών τους, τα συγκεκριμένα ανταλλακτικά, μπορούν ευκολότερα, γρηγορότερα και οικονομικότερα, να δημιουργούνται σε διευρυμένη κλίμακα, μέσω του νέου τρόπου παραγωγής.

KEY WORDS

3D Printing, Additive Manufacturing, Spare Part Management, Implementation of New Technologies, Questionnaire

CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

1. INTRODUCTION

1.1. MOTIVE

During the week of the General Assembly, September 25, 2016, his U.N.N. Secretary-General Ban Ki-moon spoke on maritime trade and global economy as he called, "Maritime Trade is the backbone of Global Economy'" (World Maritime Day 2016 Message). As the world's population grows, particularly in developing countries, there will be a clear and pressing demand for seafarers and active marine transiters. As it appears, the need for ongoing is still present, and new emerging trends are still being integrated into the sector. Historically, technological advancement has been based on deployment. Because of the rapid growth of information technology, many IT departments have struggled to keep up.The shipping industry is estimated to account for 90% of international trade, and as a result, it has far-reaching effects on the global economy. Shipowners have made great strides in the last three decades, with ships and terminals becoming more well-maintained, fit, and modern. As a second low-cost solution, terrestrial transportation is currently the most common mode of shipping. If the transaction is not handled properly, we will have to deal with these issues on a regular basis. Of course, modern information technology is one of the most effective solutions to almost any problem.

The Internet, invented in 1989 by the English mathematician and scientist Tim Berners-Lee, empowers and places the world in the age of intelligence. Since then, the rise of low-cost technology has accelerated, resulting in faster, simpler, and more affordable technology. Citizens have relied on heavily on on innovation in the nearly 30 years since the introduction of this groundbreaking technology, and their prices have plummeted.

1.2 PROBLEM DEFINITION

Revenue generation must keep up with constantly changing and evolving technologies in order to meet primary targets in a way that is consistent with corporate success. This can be applied to a variety of other fields, but it is worth mentioning in the shipping industry as well. Overall, the maritime industry is very traditional, but it is still reactive to changing demands, and it is expected to change and respond frequently on a daily basis.

Because of the importance of technology, this report predicts that people and businesses in the shipping sector will see their capabilities fundamentally expand in the near future. Many studies have been conducted on the psychology of embracing new technologies and how people adapt and develop in response to them. Because we don't interact with them, we appear to overestimate other people's creative abilities. Many of these hypotheses (including TAM, TRA, and others) concentrate on specific variables such as use and social factors, while also including important findings such as knowledge and polarization in the shipping industry. According to Venktate (2003), the Internet of Things is more likely to have a significant impact in the long run. This technology would greatly accelerate the evolution of 3D printing, allowing it to become more widely used in our daily lives.

Before rolling out 3D marine spare parts, it is critical to research which budget items 3D printing is advantageous to and to their day-to-day operations. There would be few findings for supply chain and inventory management because research on the topic is inconclusive, there is a gap in existing understanding, and there is a need for new ideas and research.

The science of three-dimensional printing is still in its early stages in the manufacturing world, and as a result, many people regard it as risky and experimental. Even though high-tech technologies such as engineering, air transportation, and automobiles are being tested on a small scale, they are still being used for limited purposes (T. Rayna, L. Striukova 2016). Organizations and businesses have only recently begun to recognize these benefits. As a growing technical audience pays attention to the technologies, progress accelerates, and Singapore is demonstrating this by leading in the development of the method. Many companies and individuals are thinking about using additive manufacturing. Few people understand how additive technology is assisting in the improvement of their operating procedures and procedures in general. Because of the lack of analysis in 3D printing and supply chain studies, it is critical to investigate the impact of 3D printing on inventory management. As a result, of this, more research problems and issues arise.:

RESEARCH QUESTION

(1) Is injection molding (3D printing) a technique that is going to be recognized as innovative? and (2) is it going to have a major impact on the shipping industry's availability of marine spares?

The research questions can be answered in two ways. The first is the necessary component, while the second is sufficient. It must be properly interpreted and applied with metal or rubber components before it can be widely recognized, accepted, and tested. Another approach or option for shipping could be economies of scale, which have a critical and essential return on investment for 3D printing. If the first component of the strategy is successfully implemented, the second component may have far-reaching implications in the maritime supply chain due to changes in demand and authority transfers within the same chain.

2. LITERATURE REVIEW

This section will include a brief inventory and supply management analysis. In addition, theory-driven analysis and investigation into the adoption of the "New Technology" will be provided. Many researchers and authors have been perplexed over the years as to how inventories have been distributed across many markets. Eliminating the sector that was mixed with the ocean was impossible. This section will also discuss 3D printing as a solution for the needs of a single company. AM (Additive Manufacturing) encompasses a wide range of engineering capabilities. There are also various types of A.M. technologies mentioned. The first section of the chapter discusses the difficulties AM may still be facing.

2.1 THE SCOPE: THE MARITIME SECTOR

Economic trade, technological advancements, and general strategic shifts all contribute to the rise of the modern maritime sector. In 1980, maritime transport (shipping) accounted for approximately 23% of total global trade (Caschili et al, 2011); however, many researchers, including the International Maritime Organization (IMO), claim that approximately 90% of shipping was done at sea (Cashili et al., 2011, Lee et al, 2014, Poulis et al., 2011). TEUs issued increased from 28.7 million to 148.9 million between 1990 and 2008. As a result, vessel sizes increased from 1900 TEUs to 2400 TEUs at the same time. While only 1% of the world's vessels were larger than 500 TEU in 1996, the proportion increased to 31% in 2001 and up to 33% in 2006. (Caschili et al, 2011).

Size, speed, and construction efficiency are two key factors that have contributed to the development of the sector in this context. As a result of this remarkable advancement, the cost of sea voyages is usually less than the cost of each TEU. Transport plans that include industrial needs measured in tons of land have a significant impact on land supply management (Lee et al, 2014). Shipping has an impact on global business and trade balance.

Because the transportation industry is now regarded as critical to the country's economic growth, gaining a better understanding of its position is critical to ensuring the industry's success. Second, it is dependent on trade with other countries around the world, which must import all raw materials and resources developed. The second benefit of a maritime business is that it has a strong system and a network of services, which aids in expanding sales to many other markets. Shipping-related service industries, such as shipping finance, contribute significantly to labor and capital markets (Lee et al., 2014).

2.2 THE INTERNATIONALIZATION PROCESS

Business corporations all over the world appear to compete for critical and trustworthy information based on their ability to obtain it. Instead of being dominated by large corporations, technology is now about uniting several entities (e.g., multinational supply chains). Companies must encourage networking and teamwork in order to maintain a competitive advantage. Rather than allowing businesses to collaborate and monitor their market reputation throughout the supply chain, digital media and the internet enable them to ensure they are creating it (Poulis et al, 2011).

Shipping is critical to the smooth and efficient operation of global supply chains. Shipping companies must adjust their requirements to provide features as a result of global competition, consumer cost controls, and strengthened business ties. (Poulis and colleagues.) Innovative strategies in the shipping industry can boost financial competitiveness, market share, and negotiating power.

Nonetheless, the need for creativity has decreased, despite the fact that the demand for it remains high. The introduction of communication technologies in the freight shipping sector is seen as an unstable situation (Marchet et al., 2009). It focuses on two main issues: (1) a lack of experience and an inability to recognize incentives, and (2) a lack of funds, which discourages spending on anyone who could solve those problems. Online technologies such as network and telephone technology, as well as wireless innovations, will reduce travel and waste energy.

2.3 SUPPLY CHAIN PERFORMANCE

Inter-organizational systems (Inter-structures) have previously been investigated for various supply chain functions. For example, according to researchers Hartono et al. (2010), it enables high-quality supply chain decision making by supplying high-quality knowledge (Lee, Kim and Kim, 2014). The supply chain will be very fluid as a result of the digital convergence of IOT (Internet of Things), making the entire supply chain even more adaptable and flexible (Wang and Wei, 2007). Furthermore, new research indicates that in order to reap the benefits of the

Internet of Things in the supply chain, businesses must develop a company synergy (Zhang & Cao, 2018).2.3.1 Functionality in the distribution chain

Companies fully recognize the benefits of developing the skills required to use IOT capabilities. Each corporation should be able to use all assets to support the efforts of the group as well as make those assets available to others within the organization (Wu, Yeniyurt, Kim, & Cavusgil, 2006). Information technologies are essential for effective decision-making and sound business processes (Aydiner et al., 2019). An IO-enabled data supply chain aids in the acceleration of business capabilities. Manufacturing teams that have demonstrated their ability to use coordination and reaction competencies, also known as SCM competencies, have performed exceptionally well (Liao and Kuo, 2014; Yu et al., 2018). A similar examination of cross-border artifacts, such as IO performance improvements, would provide additional information and insight for this research and experience. The literature review determined that the mediating effect of SCM capabilities is critical in the partnership between IO and supply chain performance.

2.3.2 MARITIME SHIPPING: QUALITY AND OPERATION

The ability to satisfy customers is a top priority in logistics strategic management. In order to comply with these CRs and gain a competitive advantage, a company must pay attention to consumer feedback and provide high-quality offerings. Several research studies have examined the outcomes of service for a number of companies (e.g., Brooks, 1990; Lu, 2003; Celik et al., 2009; Lam and Zhang, 2014). Previously, reputation was emphasized above all in determining sea-borne shipping carriers. Frequency, travel period, and directness are all factors to consider when selecting an ocean carrier, but cost is now regarded as the most important (Brooks, 1985). For both shipping companies, the transit period is the last on the list (Brooks, 1990). Nowadays, the emphasis is on providing prompt and accurate service to customers. Several factors, including complaint confidentiality and responsive claims, have propelled ocean transportation to the upper echelons (Lu, 2003). Buyers, in particular, are very interested in these types of studies, to which we frequently refer. CRs differ, and there is no agreed-upon set of them, no matter how distinct they are in grouping. Of course, for shippers like Zhang and Lam, these three factors (cost, performance, sensitive facilities, and public image) are critical. They identify Liao and Kao (2014) as primary logistics requirements promptness, continuity, accuracy, on-time delivery, overall, subject-response rates, convenience, and security, as well as competency in managing complaints.

2.4 MARITIME SUPPLY CHAIN RISKS

Danger is a concern that could have a negative impact on the business. Many researchers have demonstrated that modern supply chains are more vulnerable than their SC managers realize (Sheffi, 2006). The literature on supply chain risk management is extremely important (Harland et al., 2003; Azevedo et al, 2008; Ji and Zhu, 2008; Ivanov and Sokolov, 2013). Hazardous weather (storm, tornado, etc.), failure of IT or telecommunication networks and outsourcing service failure, loss of talent / skills, civil unrest / conflict, industrial dispute, fire, and cyber-attack are all potential risk sources. Nonetheless, the literature on supply chain threats in the context of maritime logistics is limited. Chang et al. (2014) provide a comprehensive overview of the risks that could jeopardize container shipping operations' maritime safety and security. Vilko and Hallikas (2012) conclude that employee strikes in ports, information systems, water ice conditions, and fire are the top five risks in the shipping industry, whereas Gurning and Cahoon (2011) value port congestion, equipment failure, cleanliness, inadequate empty containers, and customs as the top five risks. Chang et al. (2014) emphasize the importance of piracy and terrorist attacks, as well as information about shippers concealing cargo. J.S.L. Lam and X. Bai / Transportation Research Part E 92 (2016) 16-2717 also emphasized the common issue of insufficient visibility in MSC and inadequate understanding of supply chain risks (Lam, 2012). According to UNCTAD (2006), there has been a heavy emphasis on environmental and operational risks, with little attention paid to network-related disruptions. There is currently no unified solution for risk classifications. The UNCTAD (2006) classification system is used in this study, which specifies three risk classes: (1) External risks (environmental risks): unidentified relationships arising from outside sources such as natural disasters and terrorists. (2) (Network-related) supply chain risks: risks that exist outside of the company but are part of the supply chain. (3) Internal threats: threats that occur within the company. Juttner et al. (2003) provide additional support for this classification strategy.Stability of supply chains and sustainability interventions

In SC (Supply Chain) situations, resilience refers to the ability to deal with unexpected changes in the environment. We found no work on risk-taking in the SC literature. For example, Henry and Ramirez-Marquez (2012) assessed their subjects' resilience using a quantitative method such as the time-dependent ratio of rate of recovery to time loss. The authors developed a consilient index to better understand the stability of the auto supply chain (Azevedo et al 2013) One of the index's aggregation methods is a collection of various resilient management practices. Pant et al. (2014) use random recovery in terminal vulnerability models (aka Monte Carlo Simulation on Containers) and incorporate a feature from Henry and Ramirez-Marquez (2012) to do so. The study in the field of Supply Chain has not yet been conducted. McDaniel's et al., 2008 Several methods for improving Supply Chain stability have been proposed, but none of them are considered viable at this time. used in accordance with Carvalho et al. (2012) in order to be kept Furthermore, Carvalho et al assert that there should be collaboration, flexibility, and exposure across multiple suppliers. The impact of one company on the rest of the industry leads to more inter-business interaction, which increases the amount of knowledge exchanged (Carvalho et al., 2012). Flexible SCs will quickly adapt to meet new and unchanging requirements without having a significant impact on the product's end result quality (Stevenson and Spring, 2007). Relevant examples of nuggets of versatility include the ability to adjust contract agreements in quantity and distribution, as well as mutually beneficial agreements. According to Carvalho and Cruz-Machado, visibility plays a positive role in mitigating the negative impact of disruptions (2007). According to Harland et al., only half of the threats to the company are revealed in the SCs, and the risk of disruptions can be reduced by adding another SC device. Auxiliary control that was not anticipated may be redundant (Ivanov and Sokolov, 2013).

2.5 FACTORS INFLUENCING THE PROCUREMENT PROCESS

2.6.1 SOURCING PATTERN

During port calls, vessels' procurement needs are typically met by a plethora of chandlers. The major categories are suppliers of navigational equipment and electricity, suppliers of accommodation goods, and food suppliers. (2012) (Jalel Ben Hmida et al.). The most competitive categories are those that supply equipment, lubricants, or spare parts because they are easily interchangeable. As a result, it is easier to find a supplier who provides parts for a vessel's repairs than it is to find a supplier who provides shoes for the crew. Most suppliers have written contracts stating the quantity to be supplied, which is subject to seasonality and the size of the cruise ship assigned to the route. Because each ship has different storage options and capacities, the procurement contract can be ship-specific and determines how late revisions can occur. This can range from a week to 24 hours before departure, depending on the product and emergency.

2.6.2 COSTING

Understanding different pricing approaches for utility providers and service vendors based on the good or service they offer is critical. In contrast to cruise ships, which offer one possible price for operation, rating and registration fees are considered negotiable. Having a large number of employees on a ship exposes the company to the seafarer's employment rules and regulations. Bulk pricing, on the other hand, may be common practice among food and beverage producers. The price of food is kept constant by conducting individual negotiations for each item. The value of a package is determined by calculating the average number of parts per ship cycle. Bulk material prices remain stable throughout the project. New prices can be negotiated on an annual, seasonal, or monthly basis, as well as for changes that occur at irregular intervals.

2.6.3 TRENDS OF DISTRIBUTION

Suppliers typically ship entire orders in a single shipment. The terminal at dock warehouses serves as the final supply chain boundary between the ship and the rest of the supply chain. The delivery time for a replenished item is based on the time period of the item's use and is limited by the characteristics that necessitate its shipment. When an order cannot be completely fulfilled, improvisations are possible. It’s unlikely, so if this doesn't work, you'll be charged for the risk of supplying an identical item to another provider. These products can be redistributed if there is an overabundance of production. Cruise lines have easy and established access to suppliers on the same scale as a large regional supermarket or hotel chain. under the influence of external customers such as Google, Adobe, and others One of the most valuable assets of an ISP is the ability to provide alternatives to the "turn port." Despite the fact that this is against the rules, considerations for possible interruptions at the port of call are taken into account. Because most suppliers are international companies, it is common to have supplier contracts with a number of available ports on them (and one with a limited choice). Opting for alternative ports is encouraged, especially if they are important to a shipping route or have minor differences.

2.6.4 DISTURBANCES CAUSED BY HUMANS, EPIDEMIOLOGICAL OUTBREAKS, AND ENVIRONMENTAL CATASTROPHES

Many of these disruptions are the result of human-caused protection and protection issues. The main source of concern is accidents. Wang, Zeng, and Ghor examined data from 2003 to 2012 in six categories, including technological issues, wrecks, fires, hull breaks, and propulsion failures. Many of them are fixed at a lower cost to the company's and services' discretion. "Anthropogenic" disruptions, such as wars, major acts of pollution, droughts, and plagues, have long been recognized as distinct from "natural" disturbances. They do not have to answer to businesses, but their impact can be calculated using seasonal weather and chance. Ebola epidemics continue to be an industry problem that persists despite the overlap of human and natural phenomena. For example, norovirus, which causes intestinal disease, can affect up to 10% of cruise passengers. According to studies, major risks include cramped quarters, hallways or lobbies with the same ventilation systems, and roommates who cook. In the early stages of the COV infection, the cruise ship took precedence, with over 2,700 cases of passengers or crew. Because of the number of impacted calls, the existence of any involving calls, and the choice of port, common prevention strategies are difficult to formulate during an interruption. Turning points have a disproportionately negative impact on cruises, as well as ship portability, consumer base usability, and recruitment. Cruise lines' policies also included "copy and paste standardization." The outcome is usually the same, but it can vary depending on the circumstances. Value-added pricing strategies are commonly used in service and product delivery negotiations where an external supplier or a value-added service is required.

2.7 AFFIRMATION OF AND EXPLOITATION OF INNOVATION

2.7.1 TEMPLATE OF TECHNOLOGICAL ADOPTION (TAM)

Davis et al. (1989) developed the TAM (Consumer Adoption Model) for information systems. In terms of TAM, it is critical to be technically consistent with end-user behavior while at the same time (Venkatesh et al, 2003). Ideally, the model will be used for assessment, prediction, and application, giving scientists and clinicians the ability to determine if a specific method is unsuitable and make appropriate changes. As a result, one of the primary goals of TAM is to provide a model that explains the effects on internal principles, attitudes, such as beliefs and activities, and goals, as well as their interactions with external forces. TAM was developed to achieve these objectives by limiting cognitive and affective influences and utilizing TRA (Theory of Rationally Action) as a theoretical foundation for system acceptance. Machine adoption is influenced by perceived usefulness and perceived ease of use, and the two most important principles for machine adoption are accepted. A person's belief that a specific system will improve job performance is used to calculate perceived utility to the customer. Customers' expectations of their ability to achieve their goals are influenced by the perceived ease of use of a framework. According to research, factor analysis has revealed that these factors are autonomous.

2.7.2 THEORETICAL FOUNDATIONS OF RATIONAL BEHAVIOR (TRA)

The TRA is a social science overarching theory proposed by Fishbein and Gubler and Fishbein in 1980 that addresses why people engage in long-term or immediate goal-oriented behaviors, such as active behavior (Venkatesh et al, 2003). According to TRA, a person's performance of stated behavior is determined by their goal to carry out the behavior as well as their subjective beliefs about its outcome (both MNT and NMT). This means that the model will predict the outcome of any desired action (Sheppard et al, 1988).

2.7.3 APPROVAL AND UTILIZATION OF INNOVATIONS BY USERS (UTAUT)

Venkatesh et al. (2003) provide a coherent theory with an integrated theoretical viewpoint on market acceptance and innovation. Four major factors (performance expectation, expectation, opportunity circumstances, social impact, age, and facilitation) serve as determinants of these people's behavioral intentions. a new research and practice perspective in which researchers and practitioners are prepared to assess the need for a specific design environment by evaluating existing frameworks in light of patterns that have already been established in the real world (Williams et al, 2015).

This type of welcomed innovation, such as institutional procedures and reforms, appears to be delayed or ignored by management as a result of organizational inertia. As a result, those who lack hands-on experience with complex situations struggle to acquire increasingly valuable knowledge. Some experts, on the other hand, argue that it is critical to respond to new innovations that enable businesses to thrive because they have the need for production on their side, which contributes to the idea of abundance (Poulis et al, 2011).

2.8 ADDITIVE MANUFACTURING (3D PRINTING – 3DP) AS A SOLUTION

2.8.1 3DP: AN OVERVIEW

Given that 3D printing is an old process, this segment will only cover the procurement and production aspects. The rise of the 3D industry is not addressed in this article.

3D printing is a low-cost option for most do-it-yourself projects (Rideout, 2011; Doherty, 2012; Gao et al., 2015; Rayna and Striukova, 2016). From a market standpoint, customer experiences (Gao et al., 2015). Even if the process itself is more expensive, other costs, such as inventory and storage, can be significantly reduced by implementing new technology to improve design and consistency during ongoing revisions (be it due to the improvement of product functionality or the fixing of design quality problems). The Holmström et al. (2014 study found that using 3D printing for production and supply chain development has numerous advantages.

(a) Reduced time and cost during the development process of tooling isn't essential

(b) Low-scale operations are practical and cost-effective

(c) Plenty of concept options

(d) FIT allows the design of the product to be made better for use (for example optimized cooling channels)

(e) Offers a broad latitude for creative, economical customization

(f) Significant decrease of waste

(g) A faster time-to-to-market and lower stocks

(h) Configurability of the layout

Furthermore, China placed a strong emphasis on third-party service-enabled industries in its Made in China 2025 initiative, as outlined in the 2015 study "Made in China: The Hardware and High-Tech Industries" from China's State Administration of Industry and Information Technology. Please call me Gordon Hufnung, and I will explain the historical transition for traditional Chinese corporations (Lipson and Kurman, 2013). As a result, you must recognize that the benefits and drawbacks of three-dimensional printing in China are both significant. Because of 3D printing, China is expected to lose its manufacturing advantage. Because this is about Chinese businesses, it is about people like them. It is 3D and logistical.

It is possible that the modern industrial revolution (including digital manufacturing, known as Industry 4.0) has already begun, and this is referred to as a game-changer (Fawcett and Waller, 2014). With the 3D system, it is simple to create a project from an idea and start using it almost immediately (Gao et al., 2015). Reducing the number of goods in the pipeline will improve the flow of things (Liuet al., 2014). In other words, excess inventory should be kept on hand to avoid the 'common Bullwhip Effect' (Lee et al., 1997). If the 'Bullwhip Effect' is a problem in any supply chain, can 3D printing help?

Several studies on the impact of 3D printing on production and supply chain productivity have been conducted. The majority of these studies show that customization is possible (Eyers and Dotchev, 2010; Berman, 2012; Rayna et al., 2015) A single unit can always be produced at any intensity level. Economies of scale for mass manufacturing are frequently compared to economies of one-of-one-many." There will undoubtedly be a large number of businesses that fail at the extremes of this spectrum. It is assumed that, regardless of how 3D printing and distribution change with supply chain configuration, market structures must change to accommodate it. A modular supply chain allows companies to provide customized products, allowing small businesses to produce in smaller quantities. A traditional supply chain will also have an impact on the characteristics of the creative supply. The number of suppliers for 3D printing can be limited. The only way to manufacture 3D-printed products is to have materials as a source and ship them (Mellor et al., 2014).

Labor costs are no longer an issue for 3D printing due to the low labor investment. Industrial plants can be relocated in this manner. In many developing countries, for example, factories and economies are increasingly located near the source of demand (D'Aveni, 2013; Gebler et al., 2014). Currently, the most popular outsourcing models can accommodate such changes. In a completely different vein, this could result in the development of a new distribution model (Khajavi et al., 2014). One additional benefit of 3D printing to the supply chain is that it can help to streamline some production methods (for example, a module can be printed in one 3DP process instead of assembling multiple components that may require separate supply chains). The delivery network would be greatly impacted by decentralized development. As a result, the supply chain will be less volatile and more efficient, offering a wider range of final products.

Improved output in traditional operations may be supplemented by innovative 3D processes. Huston Kearns and colleagues I reviewed International Review of Development and Strategy in the Journal of Economic Cooperation 205. (2018)

In their logistics operations, several major shipping companies and port operators have used 3D printing and other additive manufacturing (AM) processes. That is, Maersk has been using 3D printers on its ships to maintain shipping performance since 2014. Both mishaps caused by shipyard parts failing were handled by utilizing the technology's on-demand printing capability. The part becomes inoperable once the ship enters the port. There are currently 3D Fieldlab initiatives related to the Port of Rotterdam, such as advancing knowledge of digital manufacturing in additive manufacturing and promoting it across all sectors of the port (Port of Rotterdam, 2017). a study in which they discovered the range of 3D printing was calculated (2016). As a result, I will not go into detail on that subject; readers are advised to consult Rogers et al (2016). However, there is no evidence in the published literature on the subject of benefits that 3D has been applied to manufacturing and supply chain management on a large scale. The primary goal of this investigation is to identify the issues and challenges that arise when introducing 3D technology.

2.8.2 FORMALIZED AN APPROACH TO ADDITIVE MANUFACTURING THAT IS PRACTICAL

It is used to control the supply chain through the use of additive manufacturing. Layering is the process of arranging materials on surfaces to create objects from a 3D model (ASTM, 2010). Charles Hull, who was frustrated with the length of the design cycle and the high cost of injection-molded components, pioneered the development of "stereolithography" in 1983. A new manufacturing technology would make it possible for industrial producers, such as the automobile industry, to easily cast metal parts. The traditional 3D printing process is distinct in that it is entirely different from traditional methods: it is all about subtracting layers rather than adding them (Hessman, 2013; Kietzmann et al., 2015). Rather than traditional machining, which removes waste or non-included material, additive manufacturing constructs parts layer by layer (Berman, 2012). Many 3D printers, like inkjet printers, have the print head attached to the nozzle but have advanced to a higher dimension. As a result, there will be a demand for and support for resource productivity in industry. The majority of computer-aided techniques, such as 3D printing, employ an additive manufacturing method, also known as direct manufacturing, that fuses a variety of materials into a 3D modeling file. Rugged prototyping (rapid physical mock-up) was used to create the final product as well as finished physical mock-ups of it.

Several industries use 3D printing as a manufacturing technique. Over the last decade, the terms "advanced production" and "3D printing" have become increasingly synonymous. It describes the process of depositing many thin layers of material one on top of another to create a three-dimensional shape. 0.001-millimeter to 0.1-millimeter thick (Wohlers Associates Inc., 2013). A variety of materials, including plastics, resins, bottles, rubbers, and metals, may be used (Bogue, 2013). Rapid prototyping is the technology used to describe the process. This was AM's first app, and it had a significant impact on the company's ability to go downmarket and pave the way for competition. It describes the design or production phase of creating a component or a finished product. Prior to the start of mass production, products for mass processing should be thoroughly examined and tested. It is common to see printers with a similar set of capabilities. The printer uses computer-aided design to provide a three-dimensional representation of the image (CAD). Because the blueprint is laid out in the printer as several layers, it is divided into two-dimensional designs that inform the 3D printer about layer locations. This CAD drawing STL conversion is accurate enough for 3D devices.

Because technology is advancing at such a rapid pace, it is necessary to investigate all of its potential drawbacks and future growth directions. Because of the lack of inefficient molds, tooling, molds, and punches, the initial cost of additive manufacturing is lower than that of traditional methods (Berman, 2012, Petrovic et al., 2011). Development processes become more cost effective as the size of the device increases because they use traditional methods that are less expensive per device. is ideal for small-run production (Berman, 2012, Reeves, 2009, Ruffo, Tuck, and Hague, 2006). Reducing the time and cost of developing their products would benefit businesses that are experiencing cash flow issues (Hopkins and Dickens, 2003).

Additive programming entails a general digitalization of the workflow, which allows for greater flexibility in coordination and implementation across multiple nations. All of the digital files are in STL, DXF, and IGES formats, and they are mostly contained in those two archive formats (Levy, Schindel, and Kruth, 2003). The risk of digitizing an analogue system is that human errors in production can be eliminated (Petrovic et al., 2011).

Businesses that have begun to use AM technology have seen tremendous growth in the last three years, thanks in large part to the substantial investment they have made. It has diversified into a wide range of industries. It is frequently used in prototyping and community growth, and as a result, it will be easily adopted by new users over the next decade (Attaran, 2017). According to recent studies, technology is once again critical to business success. Furthermore, it is currently one of the most innovative concepts and marketing ideas. According to Terry Wohlers, owner of Woh Associates in Fort Collins, more than one-fifth of 3D printer output is finished goods. Wohler's team has worked on three-dimensional printing and/or additive processing over the last two decades. This figure would rise to 50% between now and 2020. The invention of handbooks in the fifteenth century was a reaction to the style of previous ages of handwritten records of art instruction, which could only be created by genius.

2.9 THE FUTURE LIES WITHIN THE GROWTH OF 3D PRINTING

According to Wohler's research, global revenues from 3D printing were $12.8 billion in 2013 and $3.7 billion in 2018. Woh expects total demand to reach $21 billion by 2020. We demonstrated how to perform amazing feats. Regardless, Canalys forecasts that global 3D printer sales will more than double to $16.2 billion by 2018. The annual growth rate is expected to be 45.7 percent by 2018.

Rapid prototyping, small-scale production scales, and evolving commercial 3D printing niches have the potential to accelerate 3D printing adoption as demand grows (Savastano et al., 2016). These figures show the additive manufacturing industry's continued exponential growth. The use of the technologies will result in significant cost savings as well as exponentially increased deployments (Wohlers Associates Inc., 2014).

2.10 CHALLENGES OF ADDITIVE MANUFACTURING

While AM has the ability to disrupt a wide range of industries, it is still in its infancy and faces many barriers that will deter it from quickly growing. Size limitations, manufacturing time, expense, regulations, and regulatory concerns are the primary obstacles to AM technology adoption. These impediments are described in depth in the following chapters.

2.10.1. SIZE RESTRICTIONS

The small size of the printer's case limits the scale of the 3D-printable bits. It establishes parameters for the size of items that could be significantly larger or smaller. Pallet-sized printers, despite their size, can be stored in storage units. Because the components of a device are frequently built independently, the effects are sometimes transient and easily lost; thus, the importance of a finished product begins to diminish as the time required to manufacture all of the components increases.

When asked about the potential benefits of 3D printing in their industry, 13% cited object size restrictions as a barrier (the Global 3D Printing Survey, 2016). The industry is optimistic about the widespread adoption of emerging technology such as plastic printing and the use of stereolithography to create extremely large objects.

As part of their fiftieth anniversary celebrations, they created a new 3D printing vehicle in 2015: a Shelby Cobra replica using the BAAM technology. Six weeks were spent drawing the Shelby, followed by another six weeks of planning, assembling, and delivering. The North American International Auto Show in January began about three years ago (Savastano et al., 2016).

2.10.2. PRODUCTION TIME

AM is a little slower than traditional modern manufacturing. There is no difference in inventory duration between cycles due to the longer production times associated with traditional industrial processing. As a result, a printer can easily produce a large number of identical items, while smaller quantities are produced on a daily basis. As a result of mass customization, personalized products are becoming more common in mass manufacturing.

For a long time, it seemed impossible, but new approaches have made it possible. Many 3D printing service providers have developed new designs and innovations to speed up the finishing process. Companies such as XYZ Manufacturing and 3D Systems sell cartridge-based filaments. This refutes the case for manually loaded filament spools. time required to patch the filament, in minutes required to cut prints (Atwell, 2017). Here are two quick and easy plug-and-play or click-and-print solutions for your convenience: They can be as fast as possible, according to this theory. The user enters the ingredients, updates the original software, and completes all planning tasks. The printer then automates all of the conversion steps required to create the final product.

Their company is focused on increasing production time while increasing product diversity. There are some exciting fast prototyping solutions and small to medium-sized enterprises available.

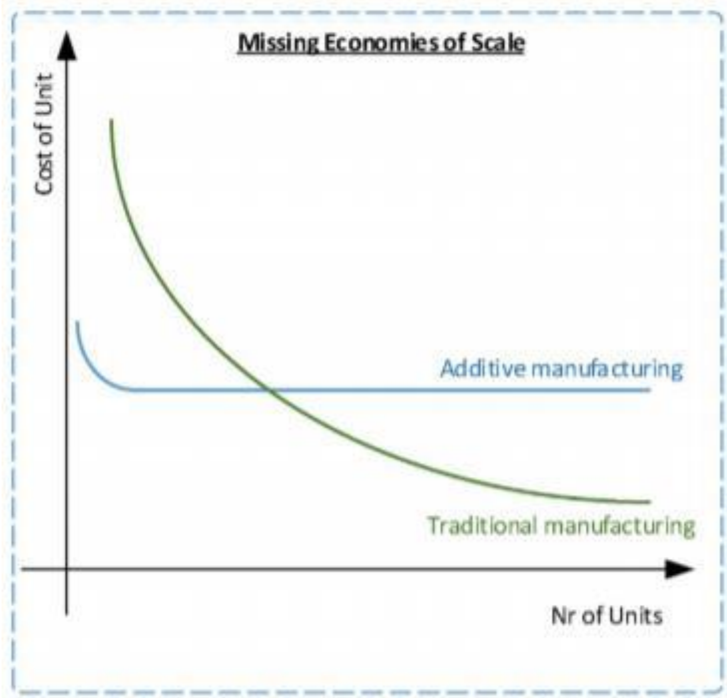
2.10.3. COST

However, no significant investment in printing facilities has been made thus far, which would be meaningless in practice for an extended period of time. Costs and the number of 3D printer suppliers may decrease as more advanced devices become available. It contributes to the advancement of 3D printing technology by assisting businesses in lowering their costs and remaining successful. China's government recently announced a large-scale investment in 3D printing to accelerate the sector's progress. It will only be a matter of time before people realize how much more accessible 3D printing has become as a result of this newfound interest (Attaran, 2017).

When purchasing a 3D printer, the cost of the material must be considered in addition to the cost of the printer. Despite the fact that the cost of a printer is much higher than the cost of production, 3D printing is still expensive due to the capital outlay. 3D printing polymers, for example, costs between 20 and 100 times more than molding the content (Wohlers, 2016).

Economies of scale do not apply to AM in conventional industry. This is due to the tank's low deposition rates and slow intake restrictions, both of which impede tank filling. As presented in Figure 1.1 AM activity appears to increase manufacturing costs but then stabilizes the long-term period, according to Ruffo and Dickens (2003), but confirmed by Hopkinson (2003).

Figure 1: AM economies of scale



Source: (Hopkinson and Dickens, 2003)

It is widely regarded as a more viable strategy for SMV [small and medium-sized development] operations. Non-financial designs can now be made at a lower cost thanks to the technology. When you give users a lot of power, you dramatically raise the cost of production. Changes to the manufacturing line had a significant impact on the fit, finish, and overall feel of the commodity. This implies that AM will have higher product prices than traditional approaches, but it may have strategic advantages due to high demand and cutting-edge technology. It is critical to identify the geometries that will necessitate a significant amount of effort to secure the component in place.

An estimate is as follows: According to Covert (2014), 3D printing filament will cost between 21 and 39 euros per kilogram. When 3D printing companies seek to reduce the cost of filament, they are attempting to stimulate industry activity. In order to reduce costs, several industries have switched to substitute filament suppliers. Recycled plastic bottles are used to make printed plastic filament in India. The organization has developed methods for making and preserving these bottles through collaboration with waste collectors, which contribute to both their development and collection: (Covert, 2014). If the expected printer price decline occurs, it may result in a potential filament price decrease in the coming years, particularly if new methods of production with the same or lower costs are discovered.

2.10.4 REGULATIONS AND LEGAL CONCERNS

3D printing may or may not pose a significant risk to society, depending on how these capabilities are developed. Laws and regulations can only accommodate a limited number of technological advances. The control of 3D printing was challenged in 2013, following the publication of a concept for a plastic rifle on the Internet (Bogue, 2013). If an internet connection is available, a downloaded CAD template and a local 3D printer large enough to manufacture the product can be obtained. Because the 3D printed pistol is undetectable by metal detectors, it poses a threat to public safety. Laws and regulations stymie the advancement of 3D printing.

Laws governing 3D printing will be enacted, but they have not yet been finalized (Dante, 2014; Schildhorn, 2014). This artifact challenge would almost certainly accompany the use of 3D printing in the traditional supply chain, with a few exceptions. Despite the fact that the existing legal code does not specifically address copying physical entities, there are no laws in place to help deter this type of copyright infringement. As a result, there is a great deal of concern in areas such as serious injuries, intellectual property infringement, and product liability.

The proliferation of open-source 3D modeling and architecture applications raises the possibility of legal complications (Dante, 2014).

2.11 TECHNOLOGY ACCEPTANCE VARIABLES THAT INFLUENCES THE INTENTION TO USE 3D PRINTING

2.11.1 TECHNOLOGY ACCEPTANCE / UTILIZATION

The two most important factors for technology buyers are the likelihood of success and the amount of effort required to use it (Venkatesh et al, 2003). Performance expectancy expresses the relationship between importance or desirability and the likelihood of achievement (1989). The extent to which an employee believes 3D printing (or additive manufacturing) can be used in their day-to-day work. To quantify the effort required, you must assess its perceived ease of use. The degree to which a company believes 3D printing is simple is referred to as perceived simplicity. In the case of companies or organizations in the maritime industry, these elements will impede the efficacy of 3D printing.

2.11.2 REASONED ACTION / SUPPORT

The social variables are derived from a person's rational actions or from someone who understands how their presence affects others. This vector can be divided into two bits, but it will require a significant amount of effort and time. Because decisions and beliefs are the most important variables, internal comparison is frequently required to reach them (Fishbein and Ajzen (1975), Davis et al (1989). The second factor to consider is how much a company or individual views new technology as useful or exciting. The second variable is an organization's or individual's attitude toward new technology (Venkatesh et al 2003). With these two factors in place, it is expected that 3D printing will have a greater impact on behavioral uses in the maritime industry.

2.12 MARITIME CHARACTERISTICS THAT INFLUENCE THE INTENTION TO USE 3D PRINTING

2.12.1 MARITIME INDUSTRY CHARACTERISTICS

When it comes to digital technologies, the marine industry is considered a latecomer when compared to other industries such as food or electronics. According to the report, there are two major reasons for this: The second point is that new technologies would be advantageous to the company. Not only would they be able to handle the freight as it arrived at the Port of Entry, but they would also have a supply chain. The problem stems from the degree of heterogeneity and the numerous stakeholders who are unable or unwilling to communicate with one another. It stifles innovation by stifling potential ingenuity due to a lack of understanding. Competitiveness and efficiency are not mutually exclusive terms in business or the economy. The second critical advantage of this second function is that there is no production (Marched et al., 2009). In recent years, there has been a significant increase in the automation of container handling in the Rotterdam port. According to Davis et al. (1989), these two services, as well as combined manufacturing, will have a negative impact on the relationship between perceived value and perceived ease of use. The influence of these secondary influences is expected to strengthen or moderate the interaction between social variables in the maritime industry and intentions to use additive techniques, according to Fishbein and Ajzen (1975) and Davis et al. (1989).

When developing an inventory plan, the stock's position within the overall strategic framework must be considered. Stock production’s main goal is to help the company save money on acquisition, shipping, and delivery costs. Maintaining a consistent supply of raw materials is critical, especially if the producer benefits from the cost savings associated with bulk ordering. Additionally, larger quantities result in lower per-unit shipment costs. A company will stock finished goods for its own use. While increasing inventory lowers unit price, it takes a long time to move it through the supply chain. It is critical to strike a balance between inventory management costs and financial profit. Second, inventories are controlled and the economy is managed. Businesses that time their output turn to seasonal products like ice cream when demand exceeds supply, causing prices to rise. Commodity demand is mostly constant throughout the year, but raw materials may be obtained on an irregular basis. When there is a high demand for manufactured goods, retailers stockpile them to meet the needs of their customers. Confusion in the insurance market should be kept to a minimum. Furthermore, gaining a sizable market share will protect the company from price fluctuations or raw material shortages (e.g., due to strikes, conditions, etc.). Intermediate products (of all kinds) between vendors aid in the preservation of a certain level of integrity throughout the manufacturing process, from definition to disruptions. Firms maintain a stable of end products on hand to help manage consumer demand, ensuring that the customer never runs out of what they require and does not lose interest as a result of late deliveries or significant fluctuations in order-to-frequency.

2.13 DEVELOPMENT OF THE DIGITAL SPARE PARTS CONCEPT

Many have previously addressed the potential of AM technologies to facilitate the storage of common components, eliminate the need to search for uncommon components, and reduce overhead and transportation costs (Walter et al., 2004). There have been numerous AM papers published on the topic of producing unused or superfluous parts. Table 1 summarizes both studies on the use of AM and item stocking/retrieval methods, as well as their key findings and current challenges.

Table 1: Description of studies connecting AM, spare part Management – Their Findings and identified obstacles of DSP deployment.

Table 1
Description of studies connecting AM and spare part management and their findings and identified obstacles of DSP deployment.

Authors	Description of study	Key findings	Obstacles of DSP deployment
(Walter et al., 2004)	Introduced the concepts of distributed manufacturing of spare parts through AM	Concept of distributed manufacturing	The general cost of AM is high
(Pérès and Noyes, 2006)	Described on a conceptual level the use of AM in delivering spare parts to isolated locations	Concept of delivering spare parts to isolated locations digitally	AM is not suitable for end-use applications because of technical limitations
(Holmström et al., 2010)	Compares on a conceptual level centralized and distributed AM spare part manufacturing	Centralized AM more likely to be used than distributed at the beginning	Quality of parts cannot be guaranteed
(Liu et al., 2014)	Simulated supply chains with and without AM for six different aircraft parts	Lower safety inventory	The general cost of AM is high
(Khajavi et al., 2014)	An aircraft spare part scenario analysis study that demonstrated that introducing AM in the supply chain reduced transportation costs, inventory costs, and part obsolescence costs	Reduced transportation costs Reduced inventory costs Reduced part obsolescence cost	Level of automation of AM is low; cost of AM machinery is high; AM machinery is slow
(Knofius et al., 2016)	Developed a methodology to identify which spare parts would benefit from being additively manufactured	Identified more than 1000 positive business cases of AM in service logistics	Quality and availability of spare parts product data varies
(Li et al., 2016)	Theoretical comparison between simulated AM-based and conventional supply chains	Reduced transportation costs	The cost of AM equipment is high
(Sasson and Johnson, 2016)	Explores a rollout scenario of AM in a supply chain and qualitatively evaluates supply chain reconfigurations	Increased costs of AM spare parts can be justified by downtime reduction	AM material costs are high
(Sirichakwal and Conner, 2016)	Analysed inventory-related benefits with a simulation.	Reduced lead time Reduced holding cost Reduced stock-out risk	Qualification and certification is needed for spare part production
(Chekurov and Salmi, 2017)	Conducted a case study by simulating inserting AM in a consumer electronics warranty repair network	Reduced total repair time	AM machinery is slow

Source:(Chekurov et al 2018)

The suggested value of DSPs increased by 20% in supply chain experiments and Table 1 (Serge Chékuro, Irene Rod, Arii Jussié Metsä-Kelan). Despite AM studies demonstrating the existence of automated replacement parts, the majority of businesses have yet to implement them in their supply chain processes. They will find no support for the study's findings, but there is a research gap regarding whether a high-level role in the field of management has not yet been attained.

This paper seeks to determine whether the industry believes in the researchers' DSP proposal and whether it will persuade them that it is a realistic or useful way to incorporate. Firms must be identified as part of the study objectives in order to determine whether AM spare parts are feasible for supply.

To achieve this goal, questionnaires were used to examine the perspectives of business leaders on the use of artificial intelligence (AI) in supply chains for the shipping industry.

Characteristics described in the first stage of the methodology are those that can be gleaned from potential interpretations. As a result, significant scholarship was used on the subject of DSP. Table 2 results show that the various characteristics of certain previously published authors are organized in this way (2014). Table 2 features were also used in a focus group study using Podsak's method (Podsakoff et al., 2016).

Table 2: Summary of attributes of digital spare parts in literature

Table 2
Summary of attributes of digital spare parts in literature.

Study	Conceptualization of digital spare parts	Key Attributes
Pérès and Noyes (2006)	• "In order to shorten the time of immobilisation of a system having to be repaired, it is essential to have whatever the place and at any time the part needed to replace the one, which has failed."	• Delivered to replace a defective component
	• "… to be able to create, on demand and in situ, the part required to proceed to the maintenance intervention."	• Manufactured on site
	• "… a distant preparation of the digital files built from the CAD data for the optimisation of the part positioning …"	• Parts built from CAD data
	• "… a transfer of digital data through adapted networks …"	• Production data transferred by network
Holmström et al. (2010)	• "… on demand and centralized production of spare parts is proposed as the most likely approach to succeed."	• Can use centralized manufacturing
	• "… if RM [Rapid Manufacturing] technology develops into a general purpose technology the distributed approach becomes more feasible."	• Can use distributed manufacturing

Source: (Chekurov et al. 2018)

2.14 AN IDENTIFIED GAP IN THE LITERATURE

It is critical to conduct research in this area on models that rely on quantitative cost analysis. Over the years, numerous attempts have had an impact on additive manufacturing.

Furthermore, with the increasing sophistication of additive manufacturing technologies, it is both important and necessary to price compare traditional advances. Almost always, a manager's primary area of expertise is in what is known as "expense" (Ruffo, Tuck, and Hague, 2006). Furthermore, articles on the viability of using additive processing to create usable components have been published. Despite the fact that Hopkinson (2003) and Ruffo (2003) had previously done so, Lindemann et al. (2012) compared the cost of product processing between single- and multiple-process manufacturing by focusing on lifecycle values (2006). Another group of researchers, including Holmström et al. (2010), Peres and Noyes (2006), and Chawla, has contributed to our understanding (2012)

It is usually associated with single-part manufacturing, but it appears to ignore the supply chain (i.e., costs incurred during the acquisition process) when estimating component costs (Thomas 2015). A comparison of the replacement parts supply chain to the conventional one is important, as Holmström et al. (2010) address.

The majority of supply-chain management programs, regardless of stage of execution, aim to reduce costs. The most significant operating cost in a supply chain is procurement. According to supply chain analysts, the shipping rate is unrelated to the order value. Two distinct variants of two-level inventory approaches are discussed by Axter (1993), Forsberg (1995, 1996), Matta and Akbari (1995, 2006), and Seif and Akbari (2006). This definition frequently includes a single depot and a number of store locations. All of these models bear the cost of raw materials as well as the risk of scarcity if raw materials are not procured locally. In all likelihood, this supply chain will use a single warehouse and a single foreign sector.

Regardless of the sophistication of the design, delivery costs are directly proportional to the size of the package. In order to minimize net transportation costs, the economic order amount must be calculated. a three-tiered supply chain made up of comparable retailers and vendors based at the primary logistics center (1999). The following cost categories are included in this model: acquisition, maintenance, and transportation. This model takes into account delivery costs but ignores the possibility of scale. Abdul-Jal and his colleagues discussed the issue of spending centralization vs. decentralization. Abdul-Jal and his colleagues debated the advantages of centralization versus decentralization (2003). As a result, in situations where there are many vendors, a two-tiered supply chain has been proposed. According to studies, the efficacy of localized regulation grows with the number of stores. Furthermore, sensitivity analysis shows that consolidated strategies alleviate replenishment and cost management constraints.

Furthermore, we have witnessed mutual replenishment between a single producer or producer and a single customer, as well as the sale of a diverse range of goods within the market. They discovered a condition that had a high initial cost but no recurring costs. When it comes to shipping and distribution costs, the retailer frequently incurs per-product costs, allowing them to keep a high overhead. Because determining the best cost-cutting strategy is time-consuming, they created a centralized and a decentralized decision model to implement such an algorithm. Baboli and colleagues described a two-tier supply chain (2008). It aided them in determining the best product and transportation distribution solutions based on the most accurate costs in the model.

There was little reason to cheat at either location, given that the production rate was supposed to be constant. It has been studied both locally and centrally. They developed an algorithm for calculating economic order quantities (EOQs) that would result in lower net system costs for both the manufacturer and the warehouse, and they advised using it in the clustered scenario but not in the disbursed scenario. Due to price and quantity reductions, merchants are sometimes motivated to delegate quantity choices to decentralized activities.

Tham and Utham developed a stochastic model for inventory supply lead and tested a single-item, multi-level ongoing method for lead time-based procurement in small volume shops. Zhang et al. investigated the distinctions between two-stage multi-item warehouses and organizations dealing with stock demand (2012). Stochastic models were used to reduce overall machine costs, and a genetic algorithm (GA) was developed.

3. METHODOLOGY

3.1 RESEARCH OUTLINE

The research was carried out between July and October of 2020. Because the research is exploratory in nature, qualitative techniques are preferred over quantitative methods.

For the purposes of the study, numerous aspects unique to the international shipping sector are logically combined. Because there has been little or no research on the use of 3D printing in the maritime industry to date, the proposed methodology is based on a review of the literature. People who work with shipping agencies, businesses, and staff are examples of final customers in the maritime industry. These people are known as'stakeholders,' while'sections of the ship' are known as 'different stakeholders.'

At a later date, we will evaluate only viable proposals and execute them over a two-month period, ensuring that we will investigate only projects that can truly operate within the time constraints (October - November 2020). These 25 questionnaires were created in collaboration with three stakeholder groups: substitute part suppliers (6 questionnaires), consumers of emerging technologies (8 questionnaires), and original spare part manufacturers (25 questionnaires) (11). The answer to any query is printed and recoded for future review. More official documents, such as annual budgets, missions, visions, and internal correspondence, may be included in this process. In order to achieve a common understanding, these documents are carefully examined, coded, and processed.

The third stage entails compiling the report's findings from all sources, which includes data collection and statistical analysis. Decoding questionnaire responses to obtain a complete picture of the results for each of the three stakeholder groups. By analyzing the results and matching the trends, the propositions are concluded.

A draft, main, and secondary research questions should be addressed at the end of this process. While writing the final section of this article, they can be questioned and compared to recent observations in the literature. Additional instruction-related penalties will be imposed. Finally, additional recommendations on the report's potential applications will be made

.

Qualitative research in which the same group of professionals or individuals are interviewed at the same time to determine which aspects of the project are important to each group. Concentrating on a small number of people was chosen because it encourages the use of scientific methods and hypotheses that go beyond what quantitative analysis can see and frequently allows for the testing of novel concepts (Morgan, 1988).

Meeting with potential business partners in person is one way to gain insight into organizational possibilities (Flynn, 1990). When designed to refute claims, questionnaires are extremely useful for determining the real-world relevance of ideas (Greenbaum, 1998; Fern, 2001; Puchta and Potter, 2005; Barbour, 2007).

Due to the presence of the Covic-19 virus during the analysis, focus groups were held remotely. As a result, a semi-structured questionnaire was developed. This survey was sent to people who work in the Piraeus industry. It was desired to provide an organization with a wide range of workplace experience, from specific ventures to entire markets, and there were no restrictions on who could join as long as they worked across the industry.

3.2 DEMOGRAPHIC INFORMATION ABOUT THE PARTICIPANTS

Table 3: Characteristics of the Participants

Work experience	O.E.M (n=6)	Seller (n=8)	Shipping Company (n=11)	Total
<1 year	1	1	3	5
1 to 5 years	2	2	2	6
5 to 10 years	0	0	3	3
10 to 20 years	1	3	1	5
>20 years	2	2	2	6
Position in company				
1st line management	2	1	4	7
Middle Management	3	5	5	13
Top Management	1	2	2	5

Source: Author

Participants of focus groups were selected for their comprehensive knowledge of the manufacturing and utilization markets prior to being asked to participate. Initial equipment manufacturers, replacement part dealers, and a well-maintained fleet of equipment Each group had six to eleven people in it. The appendix, in table 3, provides more comprehensive demographic statistics, as well as the participants' working history and position.

3.2.1 HOW THE QUESTIONNAIRES WERE DISTRIBUTED.

Obviously, a proper way to receive reliable results, about the adaptation of new technologies and especially the potential of 3D printing in the Greek Shipping market, is to receive answers from the whole Greek sector. Unfortunately, as it will be explained further in the Limitations section, an academic research has limited abilities to reach the entire market. Especially in a pandemic period, the possibilities are limited to the minimum. As a result, in order to comply with the proper academic criteria, a Case Study approach was chosen to be followed.

More specifically, a well-established shipping company, with decades of experience in the shipping market, based in Piraeus has been chosen as an example. Afterwards, the total amount of Suppliers the company works with was gathered. Between these companies, were firms that operate as Manufacturers of spare parts and others that work as Sellers of spare parts.

The total amount of suppliers and sellers that were reached, were 25. Employees from 2o of them, replied. As a result, the response rate was:

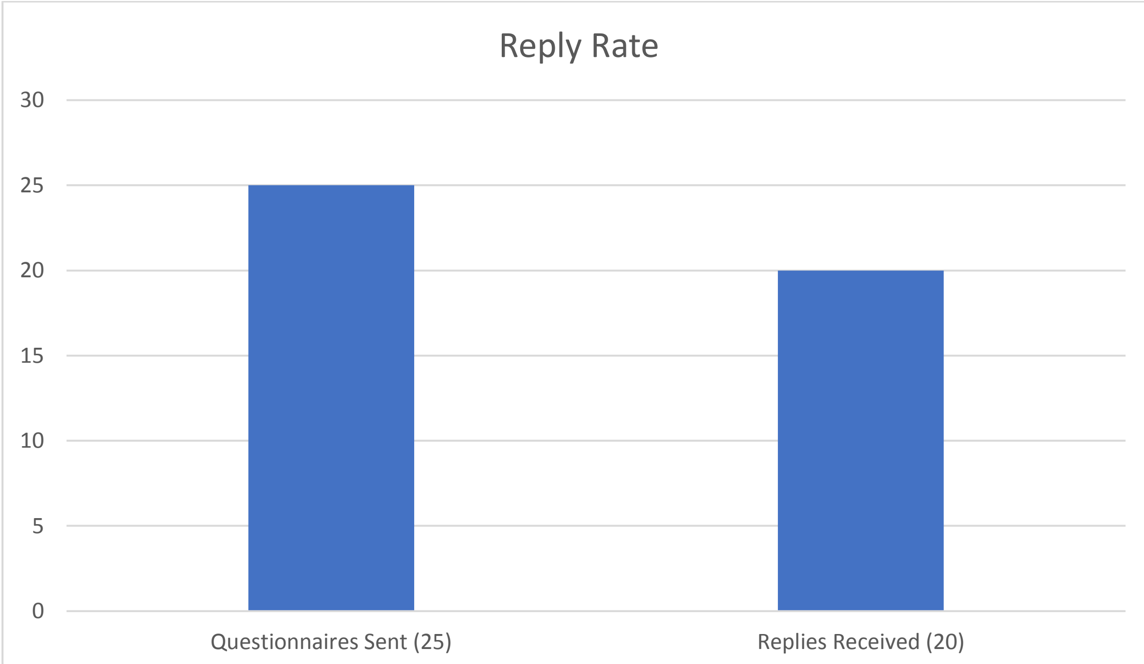
$$\frac{\text{Companies that replied}}{\text{Companies that were reached}} = \text{Response rate}$$

(Fontanella 2018)

This gives a rate of 20/25= 0.8

Equal of **80% Response rate**.

Figure 2: The Response Rate



Source: Author

As Jack E. Fincham mentions in his 2018 article. A response rate of 80% is acceptable to conduct safe results for an academic paper at a master's Degree Level. Consequently, the answers were considered reliable and proceeded accordingly.

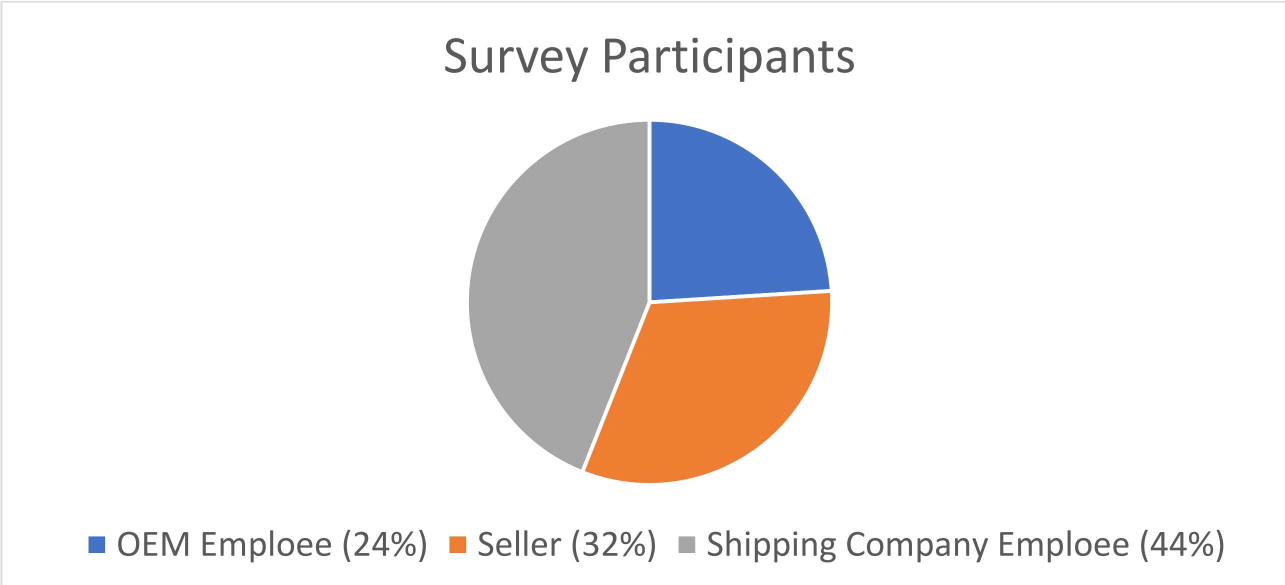
3.2.2 THE DISTRIBUTION OF THE PARTICIPANTS

Regarding the distribution of professionals between the companies (Table 3), the following results were conducted, after receiving their answers:

- **OEM: 6 Individuals – 24%**
- **Seller: 8 Individuals – 32%**
- **Client/Shipping Company: 11 Individuals – 44%**

From these results, we can understand that while the major group of replies, comes from the Shipping Company Employees, there is a significant number of answers from all 3 groups.

Figure 3: The participants' distribution between the companies



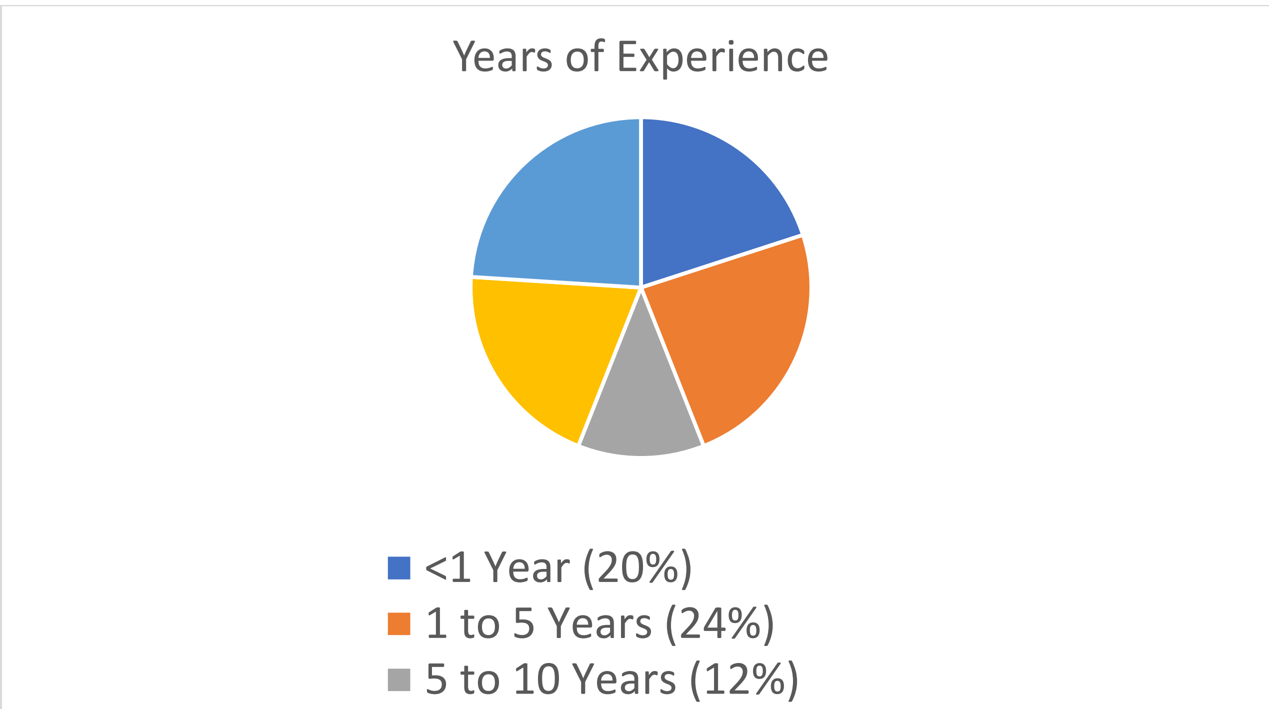
Source: Author

Regarding the experience of the participants the following results were received:

- **<1 Year of experience: 5 Individuals – 20%**
- **1 to 5 years of Experience: 6 Individuals – 24%**
- **5 to 10 years of Experience: 3 Individuals – 12%**
- **10 to 20 years of Experience: 5 Individuals – 20%**
- **More than 10 Years of Experience: 6 Individuals – 24%**

As it can be seen form the answers received, the Persons that answered to the questionnaire are equally distributed between the groups of "Years of Experience". This way, the most specific results can be generated, as the old and the new generations of the maritime sector provide their opinions.

Figure 4: The participants' years of experience



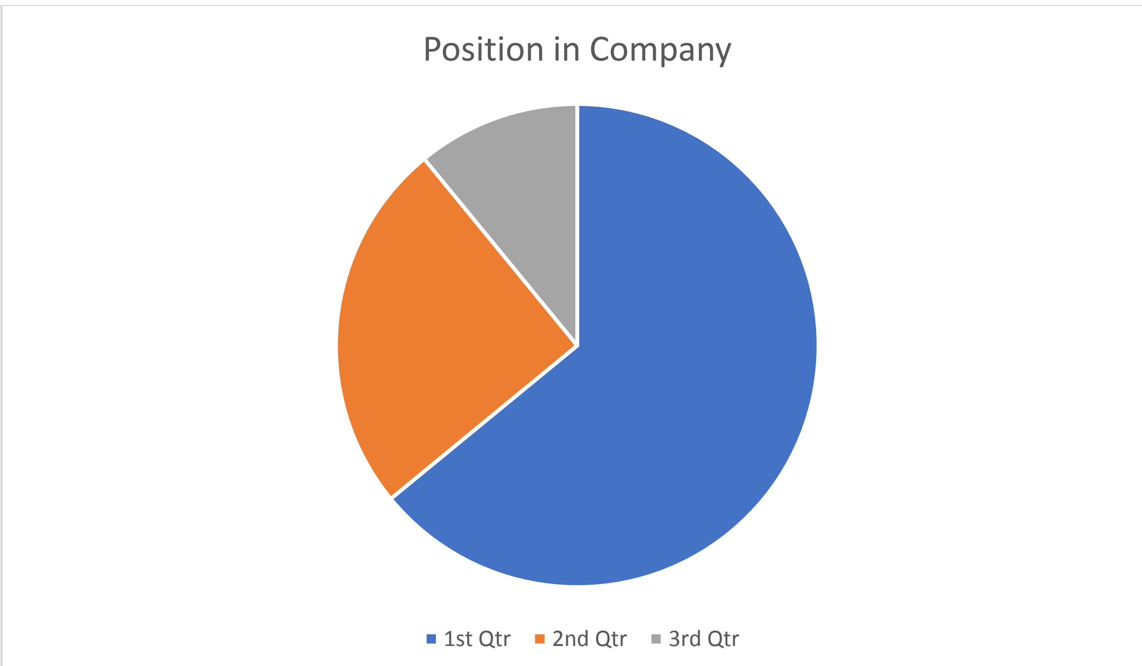
Source: Author

The Final Criteria that need to be mentioned and in a great extend indicates the reliability of this researcher's results is the position of each participant in the company. The following replies were received:

- **1st Line Management: 7 Answers – 28%**
- **Middle Management: 13 Answers – 52%**
- **Top Management: 5 Answers – 20%**

While most of the participants seem to be Middle Managers, the other two groups, are well represented in the results, with at least 20% answers.

Figure 5: The participants' position in the companies



Source: Author

3.3 THE QUESTIONNAIRE

Due to the Covid-19 pandemic, conducting interviews was problematic at the start of the research. Other than that, a variety of online questionnaires were created and distributed through the Internet. The semi-structured question is included in Table 4 along with pertinent references. made in response to the questions pertaining to the function of Chekura et al (2018). This article discussed production in general and raw materials/spare parts in particular. The new thesis is concentrating on the shipping industry, and these issues are being used to that end.

3.3.1 WHY THIS QUESTIONNAIRE WAS SELECTED

Chekura et Al. in their research have created a well-established and structured questionnaire that covers the whole field of academical knowledge that is required to understand the concept of adaptation of new technologies. More specifically, the mentioned research focuses on the maritime industry and more importantly in the spare parts sector. The way this questionnaire is presented, is easily globally adapted. As a result, the mentioned questions are possible to be understood and processes from employees of the Greek shipping industry. The main focus of the structure followed is to analyze the way professionals' value the importance of 3D printing of Spare parts in the Maritime Market.

3.3.2 WHY EACH INDIVIDUAL QUESTION WAS SELECTED

Table 4: The questions of the research

THEME	QUESTION	RELEVANT LITERATURE
Section 1: Present condition of spare parts control	1. What are the major challenges in the manufacturing and logistics of replacement parts?	(Kennedy et al., 2002; Driessen et al., 2015)
Section 2: Digitalization of replacement pieces, new options	2. What kind of items would gain from the 3D production?	(Knofius et al., 2016)
	3. What proportion of the replacement parts can be produced additively?	(Knofius et al., 2016)
	4. How do you feel about the digitalization options for existing replacement parts?	(Knofius et al., 2016)
	5. What are the barriers to digitalization of replacement parts?	(Knofius et al., 2016)
	6. How are automated replacement components going to alter the company's service functions?	(Knofius et al., 2016)
	7. Will the output of the replacement parts need to become more transparent, or the OEM should lock them?	(Appleyard, 2015; Lindemann et al., 2015)

Section 3: Network with digital replacement parts and its needs.	8. What kind of roles and expertise are necessary?	(Holmström et al., 2010)
	9. What would your business's status be in the re - framing?	(Holmström et al., 2010)
	10. What intervention are the corporations and public entities required to do?	(Holmström et al., 2010)
	11. Is the development of a DSP platform feasible?	(Holmström et al., 2010)
	12. What sort of data problems might occur?	(Appleyard, 2015; Lindemann et al., 2015)

Source: Chekurova et al. (2018).

Section 1: Present condition of spare parts control

Question 1: What are the major challenges in the manufacturing and logistics of replacement parts?

This question was chosen to be presented first. Professionals, as crucial members of the supply chain and of course, are the one who experience the changes in the industry in the first hand. (Kennedy et al., 2002)
As a result, the professionals, are the ones who are in position of recognizing the difficulties better than anyone else.

Section 2: Digitalization of replacement pieces, new options

Question 2: What kind of items would gain from the 3D production?

To get more specific about the section of the market that interests this research, this question is asked. Knofius et al (2016) have already discussed in their research the benefited spare parts from an additive way of manufacturing. The answers to this question, as it can be seen in the next chapter, follow the lines of this research.

Question 3: What proportion of the replacement parts can be produced additively?

Knofius et al (2016), in their research have focused on the characteristics of some spare parts that give a competitive advantage in the new way of production. As they discuss, some spare parts, are possible to be manufactured additively in a greater percentage than other. This question is set to examine this exact percentage.

Question 4: How do you feel about the digitalization options for existing replacement parts?

Again, in the Konfius et al. (2016) research, the present condition of the spare parts is discussed. Participants to this research questionnaire, give their opinions about the present situation and characteristics of the spare parts.

Question 5: What are the barriers to digitalization of replacement parts?

Except of the clear benefits that are going to help the market in moving forward towards the additive manufacturing, there are a lot of barriers that may prevent the rapid evolution. The professionals state the most important of them by answering of this question.

Question 6: How are automated replacement components going to alter the company's service functions?

The engagement of the production and supply chain to new 3D Printing Methods, is going to affect the whole company that follows this mean of production. As Konfius et al. (2016) mention in their research, an empirical view is required to understand these alterations in the companies.

Question 7: Will the output of the replacement parts need to become more transparent, or the OEM should lock them?

Appleyard, et al. (2016), in their research, define the problem regarding the patent of the spare parts. This question was chosen, in order to understand the way professionals, see a portion of the potential future of the digitalized spare part market.

Section 3: Network with digital replacement parts and its needs.

Question 8: What kind of roles and expertise are necessary?

Holmström et al., (2010) mention in their research, the ways a firm is affected by the implementation of new technologies. In order to be able to adapt in this new environment, companies will have to establish new roles and hire new experts. Participants may express their opinions on these new roles.

Question 9: What would your business's status be in the re - framing?

The participants in this question have the opportunity to present the level of readiness their company is, regarding the adaptation of new spare parts distribution technologies. As Holmström et al., (2010) mention, it is crucial to understand the ability of the market at its current position and as a result, the answers of the experts will enlighten this gap.

Question 10: What intervention are the corporations and public entities required to do?

Economically, socially and politically, every new technology needs to be adapted under a specific prism (Holmström et al., 2010). As a result, the experts' opinion on the number of measures that need to be taken from governments and the corporations themselves, are crucially important, in the understanding of the possibility of the adaptation.

Question 11: Is the development of a DSP platform feasible?

It is clearly stated by Holmstorm, that the digitalization of spare parts, will necessarily be based on a great network. This web may cause delays or even new opportunities to the establishment of Additive Manufacturing. Taking in consideration the obstacles, this question is crucial, in order to understand how possible this network is to be created.

Question 12: What sort of data problems might occur?

The final question is generated based on the Appleyard, Lindemann et al papers, published in 2015. In order to comprehend the future of the 3D printing market in the industrial and especially the maritime sector, the data obstacles need to be gathered.

3.4 DATA PARSING

Some insights gleaned from participant observation were included in the questionnaires. The responses were reviewed to ensure that the text included the participants' own thoughts and suggestions. To decode the gathered data, Campbell et al. (2013) developed a technique known as inductive coding. The final codes were:

- Deficiency in the replacement component supply
- Digitization of spare parts and new possibilities.
- Difficulties with spare part computerization
- Characterization of the properties that digital spare parts must have
- Synopsis of a web of electronic replacement parts
- Factors that contribute to the growth of an electronic raw material system

There were no ambiguities in the debate because the participants were specialists, and the subject matter was contained. Their observations were synthesized and then cross-referenced and summarized to arrive at this conclusion. The questionnaires were matched in terms of content and style, and both were rated.

4. RESULTS

This section of the document incorporates the responses of the participants. The participants' perspectives are described in full compliance with the codes and are supplemented with pertinent quotations.

4.1 QUANTITATIVE ANALYSIS

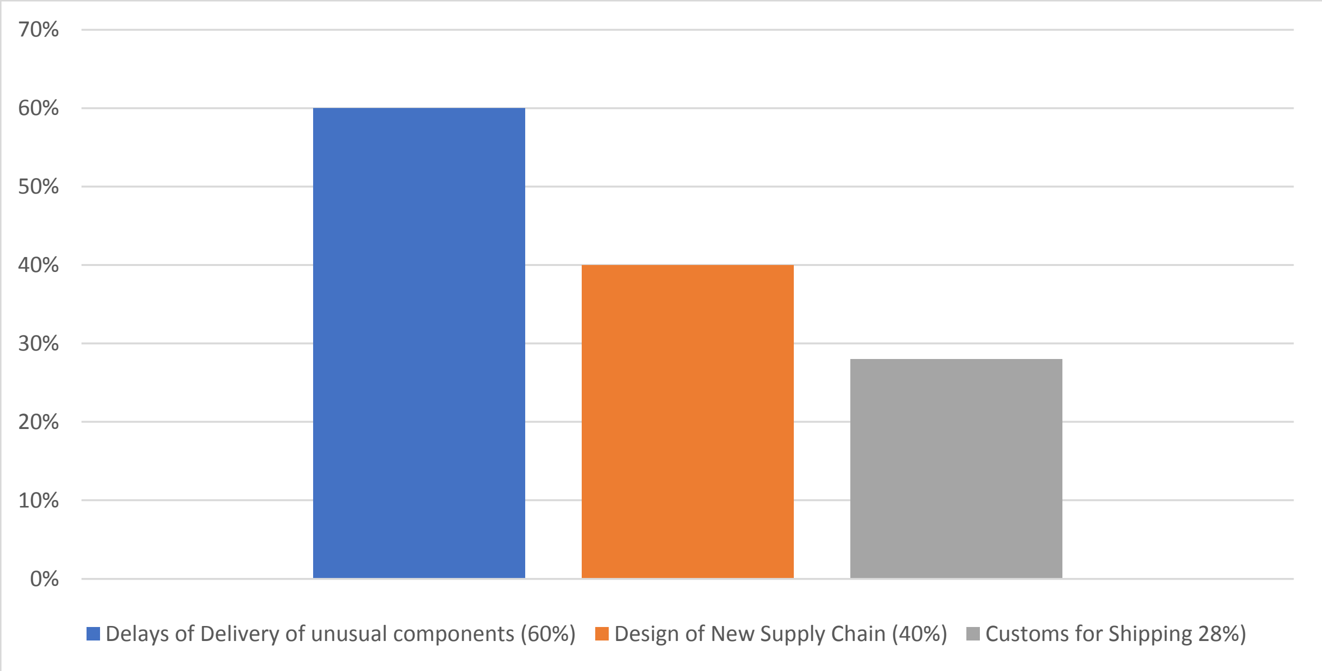
In the Quantitative part of the analysis of the results, the statistics of the participants answers are gathered.

Taking in consideration that the participants were able to reply openly in the questions, many different answers were received. In the graphs that follow, the top 3 answers to each question are presented. Obviously, some answers were given more than once and as a result, the total percentage of each graph surpasses the 100%. (Chekurov 2018)

Section 1: Present condition of spare parts control

Question 1: What are the major challenges in the manufacturing and logistics of replacement parts?

Figure 6: What are the major challenges in the manufacturing and logistics of replacement parts?



Source: Author

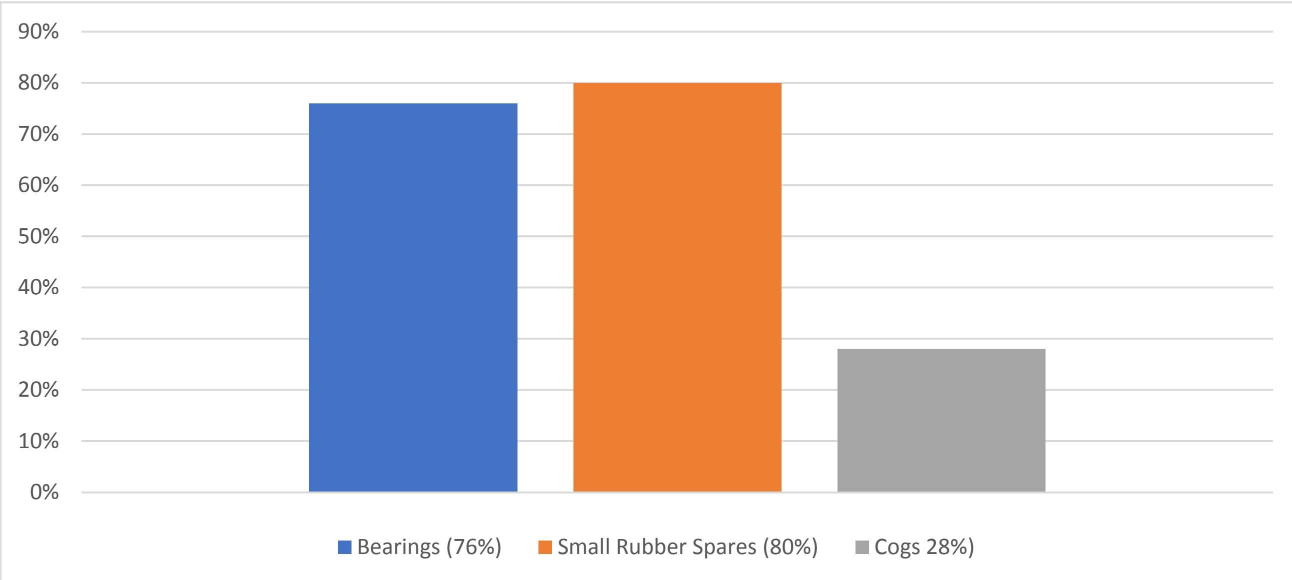
a) Delays of Delivery of unusual Components – Mentioned 15 times between 25 Answers (60%)
b) Design of New Supply Chain – Mentioned 10 times between 25 Answers (40%)
c) Customs for Shipping - Mentioned 7 times between 25 Answers (28%)

It seems that the most expressed answer of the participants, is the fear of delays, the adaptation of 3D printing may cause. Obviously, the 3D Printing manufacturing is a totally new market. As a result, the major components of the printers, along with the materials needed, are for the time being, hard to find. Other two factors that the participants considered as major challenges that are going to be faced, are the design of the new supply chain and the totally new procedures that have to be followed for the customs for shipping the materials. Consequently, it seems that the common factor between the answers expressed, is the fact that 3D printing is something original and new.

Section 2: Digitalization of replacement pieces, new options

Question 2: What kind of items would gain from the 3D production?

Figure 7: What kind of items would gain from the 3D production?



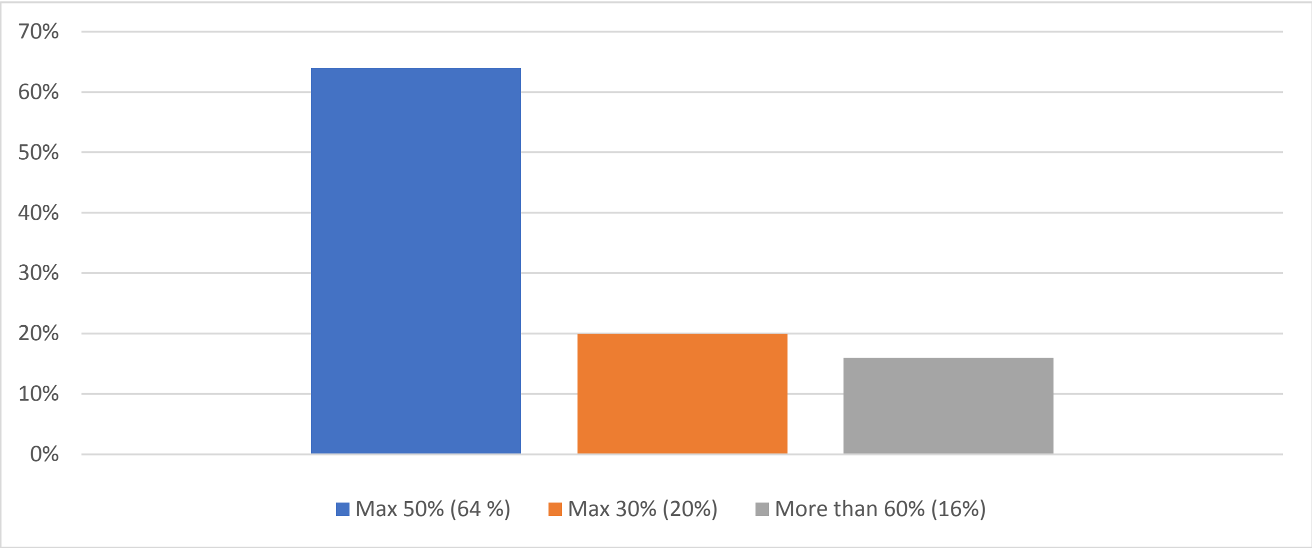
Source: Author

a) Bearings – Mentioned 19 times between 25 Answers (60%)
b) Small Rubber Spares – Mentioned 20 times between 25 Answers (40%)
c) Cogs - Mentioned 7 times between 25 Answers (28%)

The answers received in the specific question, are crucial for the development of the new market of Additive Manufacturing. Participants seem to concentrate on specific items that are possible to gain from the 3D production. From a cost and time perspective, all the small Rubber Spares and Bearings are the most commonly mentioned spares. Furthermore, Cogs are considered as a possible item that can be 3D Produced. It seems that small items, that are quickly produced and have a generally lower cost, are the most suitable item to be additively manufactured.

Question 3: What proportion of the replacement parts can be produced additively?

Figure 8: What proportion of the replacement parts can be produced additively?



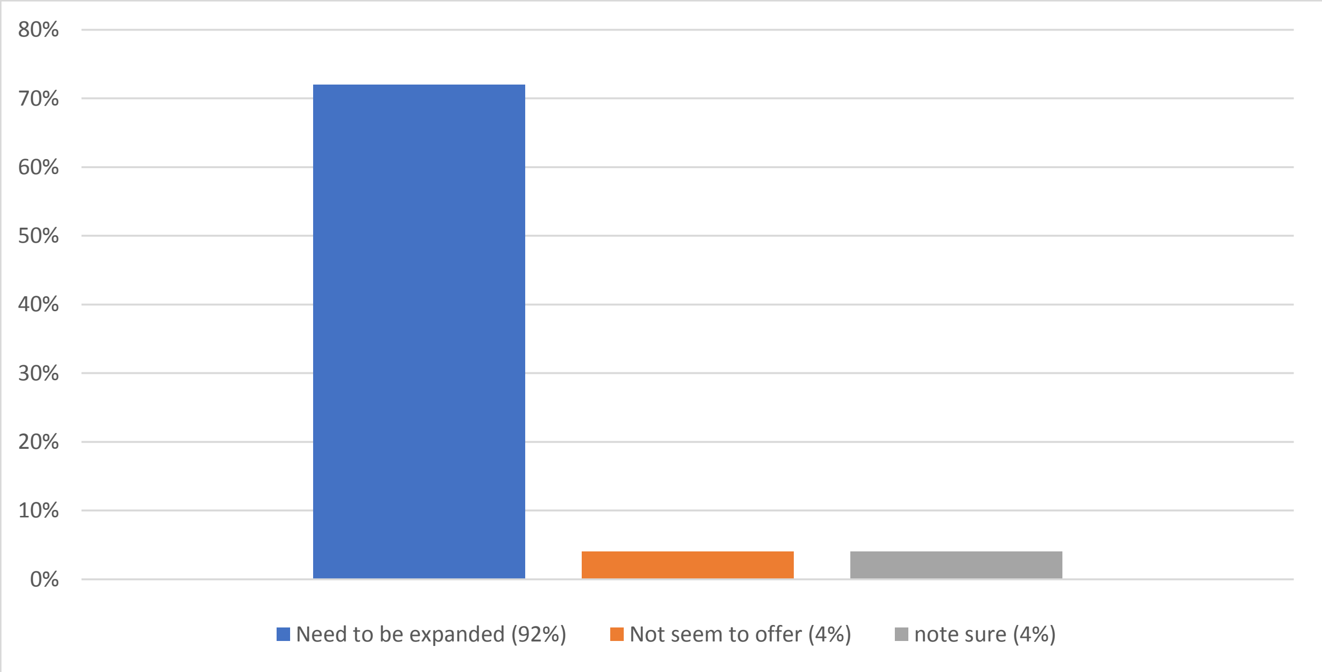
Source: Author

a) Max – Mentioned 16 times between 25 Answers (64%)
b) Max – Mentioned 5 times between 25 Answers (40%)
c) More than 60% - Mentioned 4 times between 25 Answers (16%)

This question indicates how positively the participants see the future of 3D printing. As a matter of fact, the vast majority believes that half of the spare parts used today, are possible to be produced additively one day in the future. This answer seems significantly optimistic, taking in consideration the huge number of spares, the market uses each day. Not only that, but the 16% of the participants claim that most spares of the shipping industry, are possible to be produced in a totally different way some day. These answers indicate the willingness of the market to adapt to new technologies, to grow and finally achieve better and more competitive results.

Question 4: How do you feel about the digitalization options for existing replacement parts?

Figure 9: How do you feel about the digitalization options for existing replacement parts?



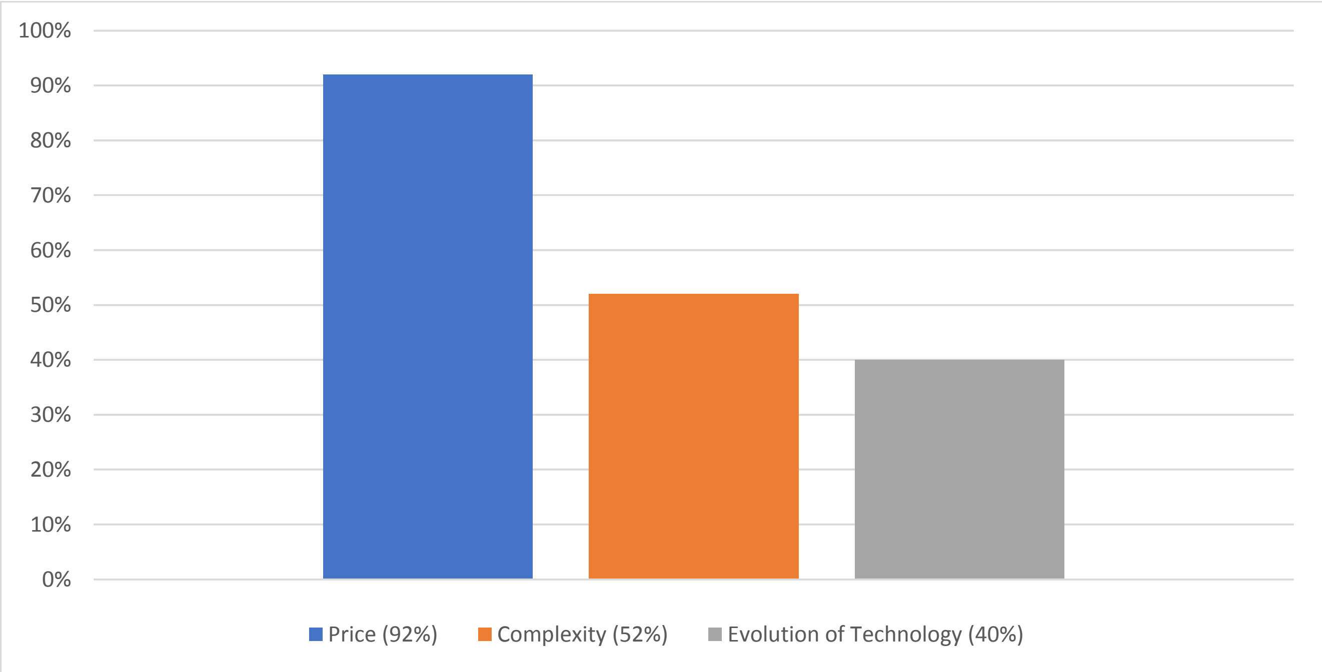
Source: Author

a) Need to be expanded – Mentioned 23 times between 25 Answers (92%)
b) Not seem to offer much – Mentioned 1 times between 25 Answers (4%)
c) Not Sure - Mentioned 1 times between 25 Answers (16%)

The answers to this question, function as a follow-up to the previous one. The positivity of the participants, while clearly expressed, is challenged by the fact that 92% , believes that the current digitalization options for existing spare parts needs to be expanded. Only a minor amount claims that the options should stay that the options won't provide any results (4%0. At the same time a 4% is not sure on how to answer.

Question 5: What are the barriers to digitalization of replacement parts?

Figure 10: What are the barriers to digitalization of replacement parts?



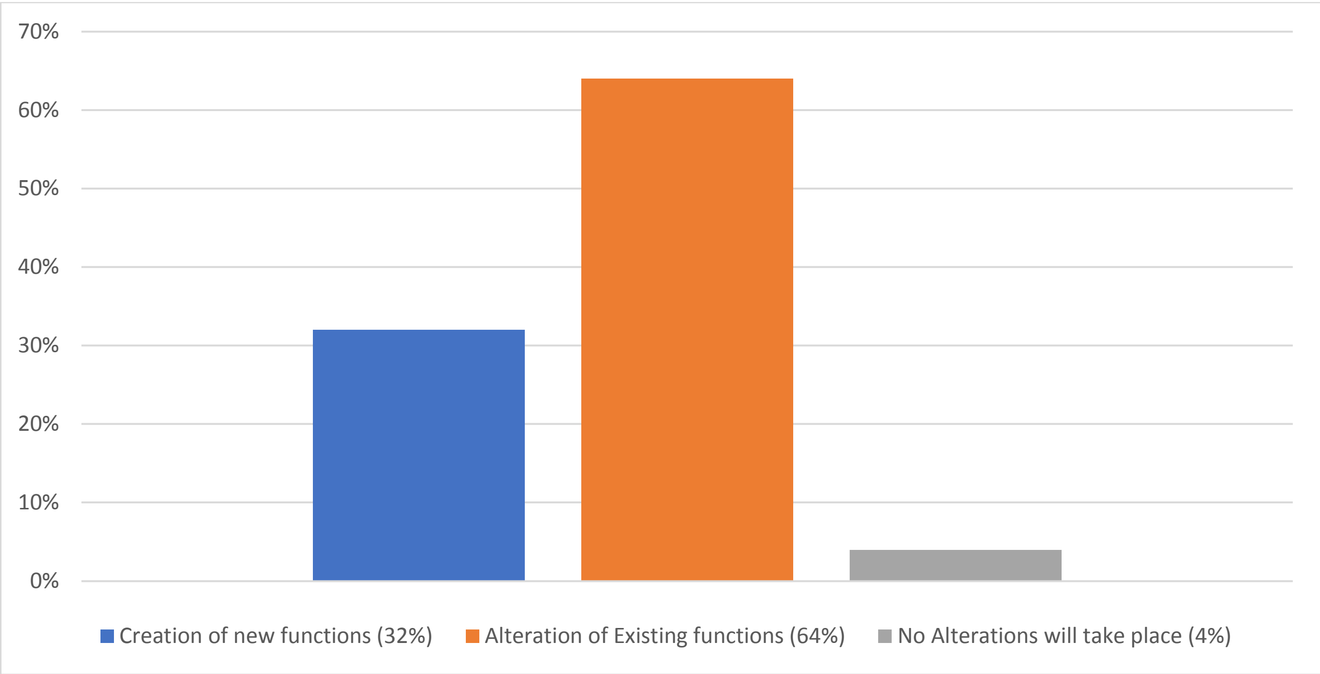
Source: Author

a) Price – Mentioned 23 times between 25 Answers (92%)
b) Complexity – Mentioned 13 times between 25 Answers (52%)
c) Evolution of Technology - Mentioned 10 times between 25 Answers (40%)

Some of the most important factors in the adaptation of new technologies are presented here. (Venkatesh et al, 2003) Price, obviously, by being the major reason of profit or loss, is the number one answer (92%). The majority of participants, claim that the most important reason that may act as a barrier to the digitalization of replacement parts, is the price. Complexity of the new technology is also stated by more than half of the participants. The last, but still commonly expressed barrier is the evolution of technology itself.

Question 6: How are automated replacement components going to alter the company's service functions?

Figure 11: How are automated replacement components going to alter the company's service functions?



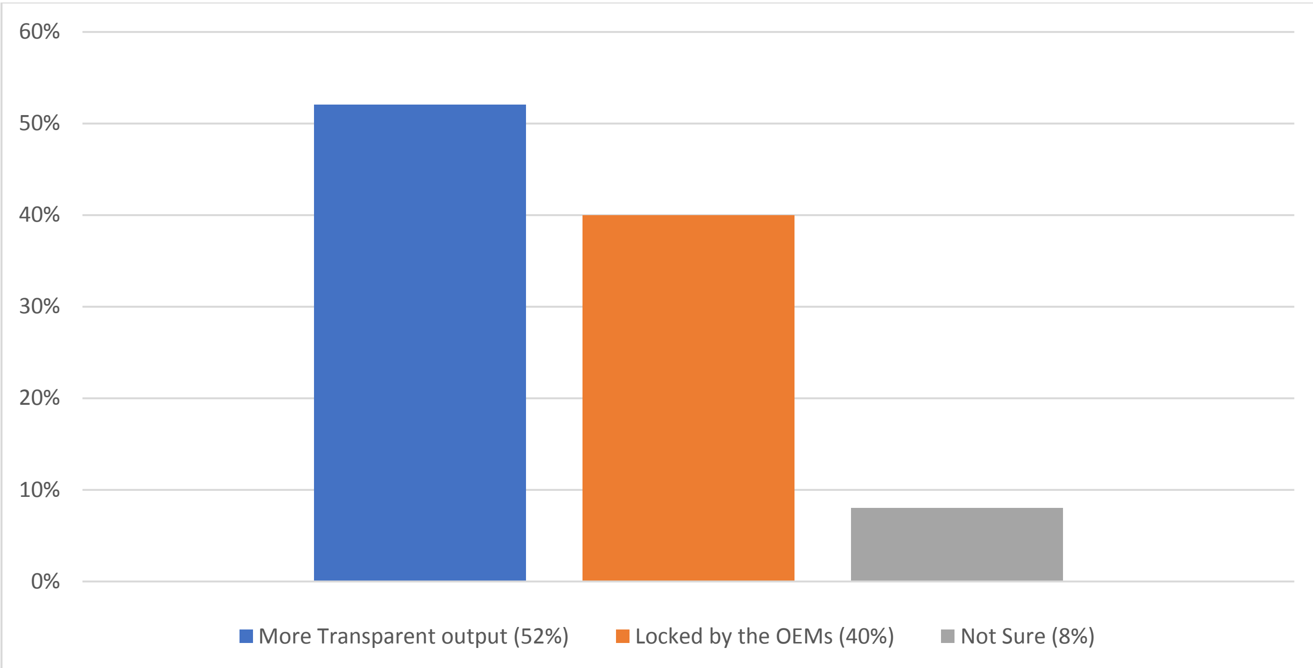
Source: Author

a) Creation of new functions – Mentioned 8 times between 25 Answers (32%)
b) Alteration of Existing functions – Mentioned 16 times between 25 Answers (4%)
c) No Alteration - Mentioned 1 times between 25 Answers (4%)

There are 3 ways the main functions of the company could be affected by the implementation of this new technology. New ones could be created, the existing ones could just alter and finally, no alteration is possible to be made. The most common answer is the alteration of the existing functions of the company (64%). While many believe that new departments may arise (32%), only the 4% supports the idea that no alterations will be made.

Question 7: Will the output of the replacement parts need to become more transparent, or the OEM should lock them?

Figure 12: Will the output of the replacement parts need to become more transparent, or the OEM should lock them?



Source: Author

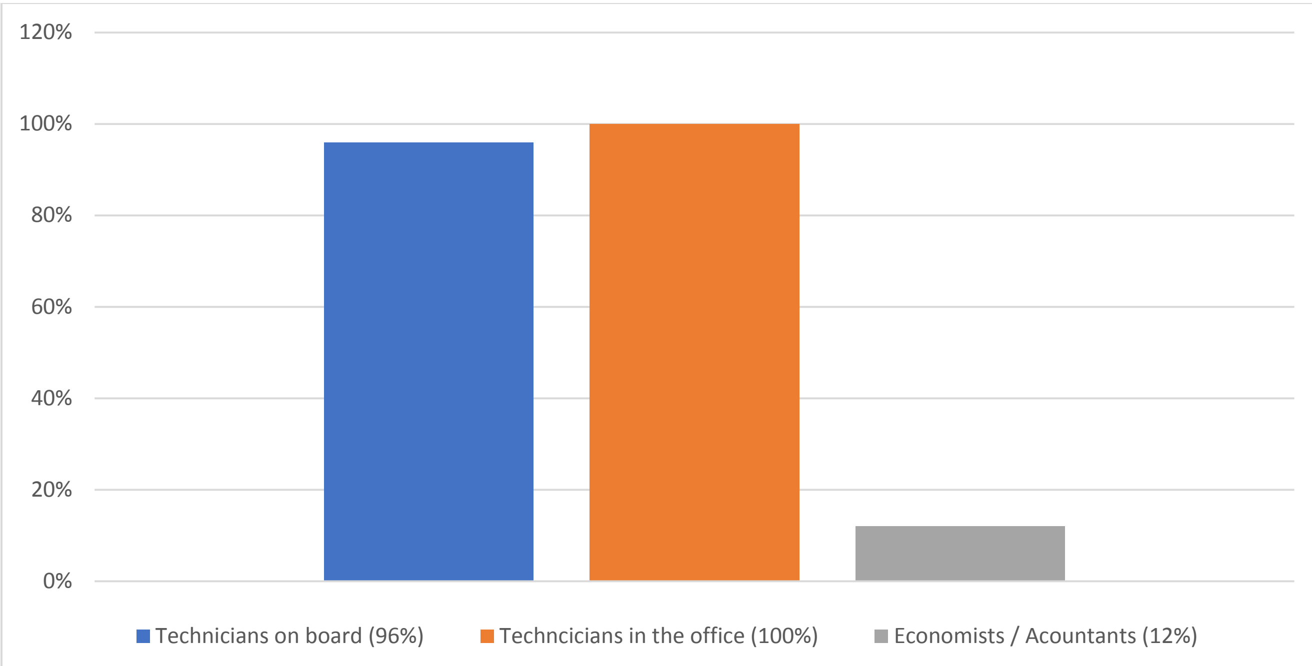
a) More Transparent output – Mentioned 13 times between 25 Answers (52%)
b) Locked by the OEMs – Mentioned 10 times between 25 Answers (40%)
c) Not Sure - Mentioned 2 times between 25 Answers (8%)

In this question the participants do not tend to support only one answer. The majority (52%) thinks that the market will benefit from the fact that the output of the replacement parts will be more transparent. One the other hand a 40% is more conservative and believes that each OEM should act on its own benefit and keep the output of the replacement parts locked. Only an 8% is not in position of answering.

Section 3: Network with digital replacement parts and its needs.

Question 8: What kind of roles and expertise are necessary?

Figure 13: What Kind of roles and expertise are necessary?



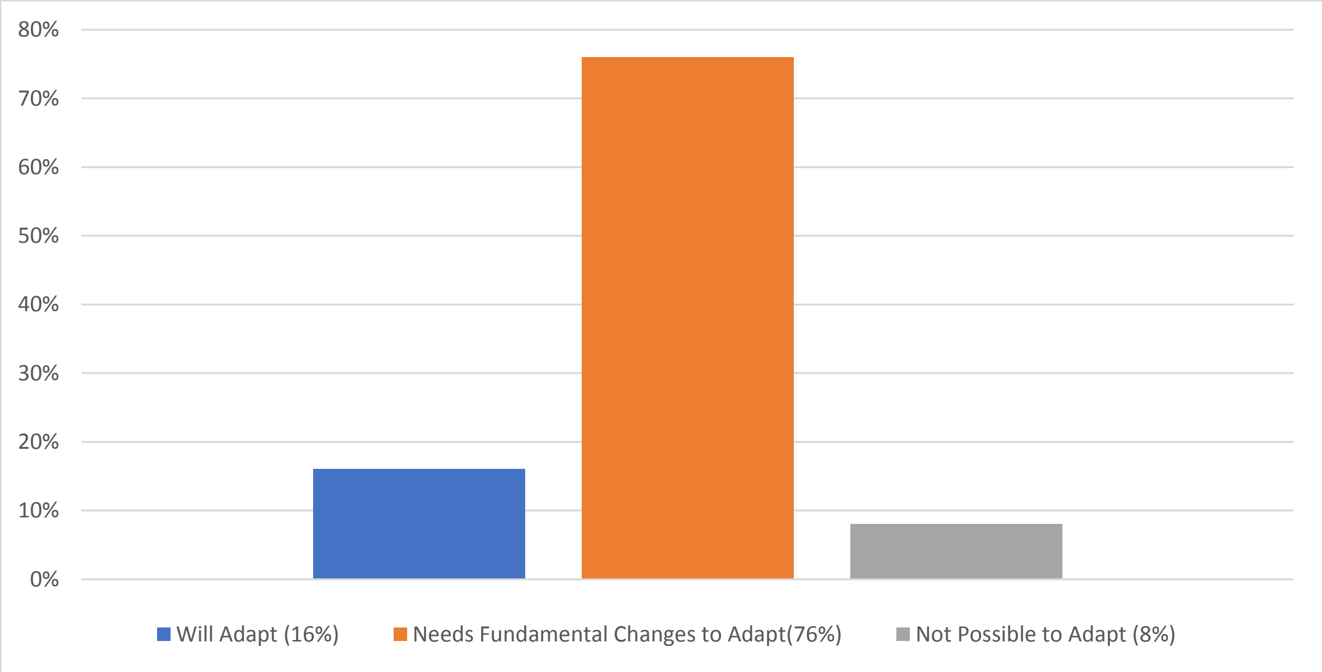
Source: Author

a) Technicians on Board – Mentioned 24 times between 25 Answers (96%)
b) Technicians in the office – Mentioned 25 times between 25 Answers (100%)
c) Not Sure - Mentioned 3 times between 25 Answers (12%)

A real interest is presented in the answers to the specific question. Almost all the participants, believe that a new role of technicians on board is required for the adaptation of 3D Printing (96%). Also, all the participants claims that it would be impossible for additive manufacturing to be implemented, without the existence of dedicated technicians and personnel inside the office of a shipping company. What is really interesting though, is the 12 % of participants that stated the importance of the creation of new roles of economists that would support the whole structure using their financial knowledge.

Question 9: What would your business's status be in the re - framing?

Figure 14: What would your business's status be in the re - framing?



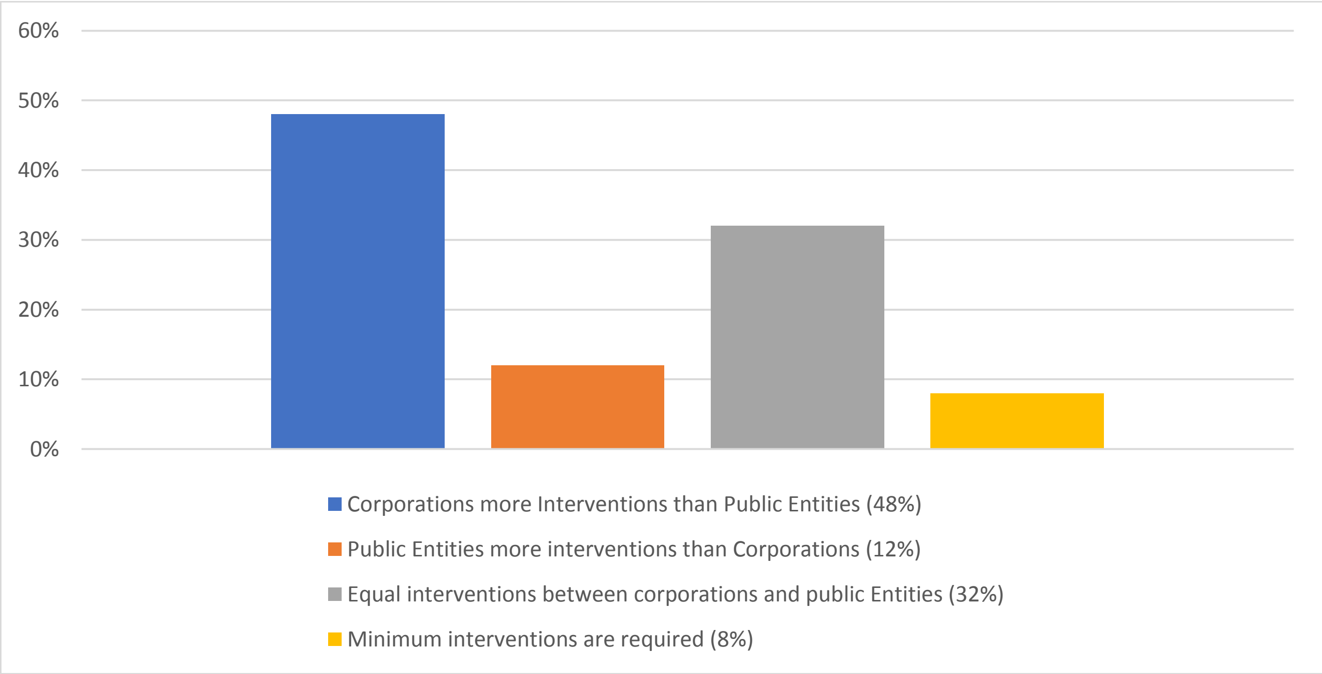
Source: Author

a) Most probably will adapt – Mentioned 4 times between 25 Answers (16%)
b) Needs fundamental changes to adapt – Mentioned 19 times between 25 Answers (76%)
c) Not Possible to adapt - Mentioned 2 times between 25 Answers (8%)

While participants were positive and optimistic in the idea of the adaptation of 3D Printing, in this question they provide their view on the changes that need to be done inside the companies they work. It is crucial to mention that wile most of the participants, believe that it is possible to adapt to the new environment, the 76%, supports, that this will be achieved only if fundamental changes are done inside corporations. The 16% is extremely positive, as it seems that they are ensured their companies will adapt without any extra effort. On the other hand, the 8% believes that no matter the changes, it is not possible for the firms that they work, to adapt in the new environment.

Question 10: What intervention are the corporations and public entities required to do?

Figure 15: What intervention are the corporations and public entities required to do?



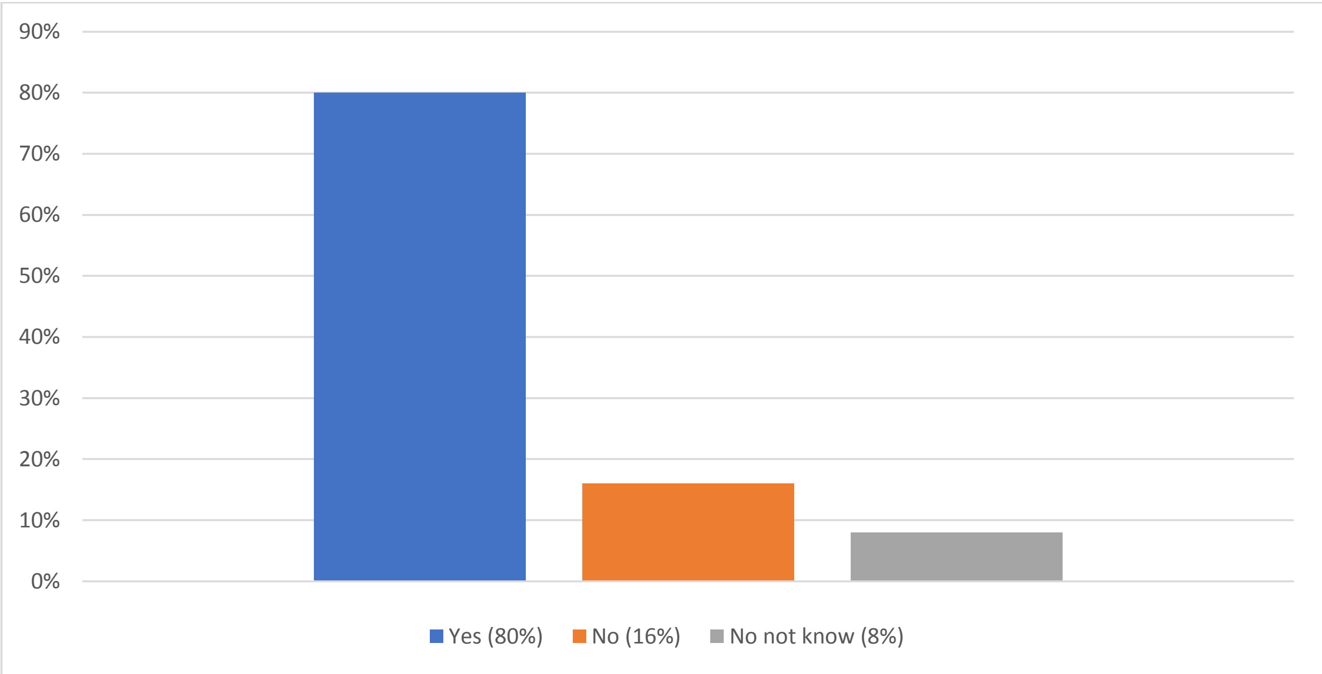
Source: Author

a) Corporations more interventions than Public Entities – Mentioned 12 times between 25 Answers (48%)
b) Public Entities more interventions than Corporations – Mentioned 3 times between 25 Answers (12%)
c) Equal Interventions between corporations and public Entities - Mentioned 8 times between 25 Answers (8%)

In this question, the participants, seem kind of divided. It is believed by 48% of them, that Corporations need to proceed to more interventions than the Public Entities. On the Other hand, only the 12% believes that the Governments, should be more intervening. This question is the only one that 4 different answers are presented, as they al had high results and should be mentioned. The 32% believes that both the public entities and the private firms, need to proceed to interventions. On the opposite side, only an 8% supports the idea of no interventions.

Question 11: Is the development of a DSP platform feasible?

Figure 16: Is the development of a DSP platform feasible?



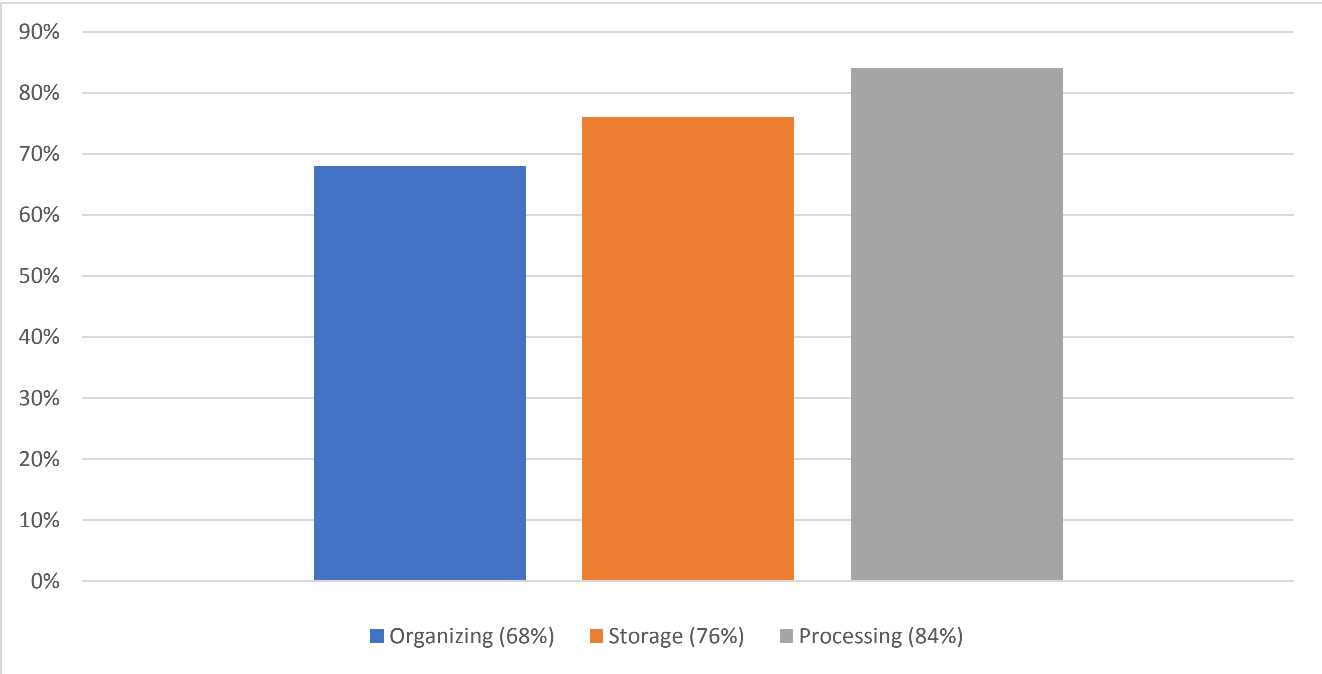
Source: Author

a) Yes/Probably Yes – Mentioned 20 times between 25 Answers (80%)
b) No/Probably No – Mentioned 4 times between 25 Answers (16%)
c) Do not know - Mentioned 1 time between 25 Answers (8%)

This question is answered clearly with a positive or a negative result. Participants are called to express their opinion on whether they believe the development of a Digital Spare Part Platform is feasible. The vast majority answers yes (80%). While only 16% believes otherwise. At the same time, only 8% is indecisive.

Question 12: What sort of data problems might occur?

Figure 17: What sort of data problems might occur?



Source: Author

a) Difficulty in Organizing – Mentioned 17 times between 25 Answers (68%)
b) Difficulty in Storage – Mentioned 19 times between 25 Answers (78%)
c) Difficulty in Processing - Mentioned 21 time between 25 Answers (84%)

In the final question of the questionnaire, the participants have to express the opinion in the following question: What short of data problems might occur in the implementation of the new technology of Additive Manufacturing? While lots of answers were received, only 3 of them were stated broadly. The 84% mentioned the problems that might occur in the Processing of the data. The Answer of the difficulties in the storing of the data, was presented in the 76 % of the answers. Finally, the difficulties in the organization of the data, was an answer that was presented in the 68% of the answers given to the questionnaire.

4.2 QUALITY ANALYSIS

4.2.1 PROBLEMS IN SPARE PARTS MANAGEMENT

Among the questions answered by respondents were three different aspects of spare parts management that were given more weight than the more commonly discussed. Following that, they believe that part supply is critical because substitutes are difficult to obtain, and unusual components are subject to lengthy shipping delays.

"In the worst-case scenario, procuring parts will take months. If it is a crucial characteristic, just having the raw material for the commodity can occupy even a year." (OEM)

"Bearings in those sizes are manufactured only once a year. Your selection will be delayed for one year if the formula is currently unavailable." (OEM)

Second, participants emphasized the importance of being willing to spend a significant amount of money on a spare part in order to avoid unexpected and prolonged machine inactivity caused by component loss. The threat of downtime results in massive replacement parts inventories, high warehouse costs, and idle assets, in addition to inefficiencies caused by stock-outs, and the most critical parts are stored in smaller inventories around the world.

"The most significant disadvantage is that the procedure will be performed while you sleep; however, this is a necessary evil. Large warehouses are required, which means our assets must take a significant hit. Storage is a critical component of the manufacturing process, and it will be provided for free to those who utilize it." (OEM)

Third, employees' proclivity for costly errors and haste when attempting to repair equipment was frequently reported. Through haste, employees attempt to prepare for lengthy turnaround times, which results in failures or the purchase of entire new items rather than replacement parts.

"Unavoidably, haste and running result in failures. (OEM)

Other frequently discussed issues included the fact that inventories are excessively high when discussing long tail goods and that minimum order quantities are excessively large when only one component is required.

4.2.2 NEW POSSIBILITIES OF DIGITIZATION OF SPARE PARTS

The data from the focus groups indicate that participants were sufficiently familiar with the principle of spare part digitization to produce and succinctly summarize their own ideas for new distribution models.

Consumers who are interested in the production and manufacture of replacement parts has also been discussed. The participants in these groups hypothesized that industrial design could benefit from being open source in order to capitalize on the designer culture. The digitization of replacement parts has frequently raised concerns about the relationship between, for example, real-world rules and regulations and customs clearance.

"You could earn a lot of money working from home as a 3D modeler." (AMSP)

"If a consumer has a 3D scanner and a printer, he will not require a replacement component supply chain." (AMSP)

"How will customs work in the future? Is it necessary to report if we give a digital spare component to another continent?" (OEM)

4.2.3 OBSTACLES IN DIGITIZATION OF SPARE PARTS

Participants were invited to raise concerns about the challenges associated with digitizing spare parts, which were then addressed. These debates uncovered the origins of the difficulties and the real-world consequences of repair activities. Intellectual property rights (IPR) issues with replacement parts were clearly a concern for the majority of participants, who desired to establish means of defense.

"You will create IDs for spare parts using 3D printing, and you will be able to see whether the spare part is approved or not." (AMSP)

4.2.4 DESCRIPTIONS OF REQUIRED PROPERTIES OF DIGITAL SPARE PARTS

During the discussion of the ideal properties of DSP materials, it became clear that a part must be physically and economically viable to qualify for DSP delivery. This implies that, while AM can theoretically be used to manufacture a component, it can only be used if the delivery benefits outweigh the increased costs associated with AM. Due to the ease with which standard parts can be manufactured using traditional manufacturing methods, DSP is not required.

"If the element is straightforward, it can be made by a supportive toolmaker while another model is created to 3D it." (MSC)

Participants were required to record the average percentage of parts in their spare parts libraries that can be produced acceptably using additive manufacturing. The response rate varied between 2% and 75%, with the majority falling between 5% and 10%.

4.2.5 DSP NETWORK AND ITS REQUIREMENTS

The participants were asked to create a list of the requisite actors and skills that could be found in a DSP network in order to determine the composition of the DSP network. The participants were tasked with documenting and connecting the actors in a production network using digital replacement parts. The actors that were suggested by the participants were:

- Manager of a system
- Vendor of AM facilities
- The business supplier's digitization agency
- Original Equipment Manufacturer
- OEM's spare part purchasing staff
- Manufacturer's prototype registry
- AM plant
- Facility of repairs
- Provider of commodities
- Designers of source code

To ensure that replacement parts are manufactured close to the client, the participants expressed a strong desire for a network of foreign service offices, but the component's 3D file could be kept in a single region. OEMs, in particular, would like to order DSPs from a single location that oversees the entire spare part manufacturing and distribution process.

“In five years, we need a joint venture where 3D devices are centralized for improved quality management, IPR protection, and no profit margin for external service providers, and major corporations are willing to invest in this. Large corporations will eventually offer computer time to smaller corporations.” (OEM)

The importance of service offices was emphasized, as they must be trustworthy and offer a diverse range of service contracts.

"We need a secure website to distribute them (3D component files) and a real vendor close to the consumer." (OEM)

4.2.6. FACILITATING FACTORS IN THE DEVELOPMENT OF A DIGITAL SPARE PARTS NETWORK

Representatives of the organization expressed their views on potential impediments to the growth of DSP networks. The variables were classified as ICT and government-related issues. Additionally, many OEMs stated that their technology does not meet the criteria for such operations to begin without significant investment. The primary concern is that ICT is not readily available in the majority of organization warehouses, which will be required to enforce the DSP definition.

Structural ICT factors in building a DSP network:

- The capacity to move data must be adequate.
- File storage must be secure.
- The cost of file transfer must be minimal,
- Transfer rates must be high enough.
- Internet network specifications need to be reliable and fast.
- Government considerations must be uniform in the design of a DSP network Data formats
- Established staff and prospective engineers ought to be qualified in AM and DSP.
- AM architecture and manufacturing product production ought to be taught more widely in higher education institutions.
- Upper-level management must be qualified in the principles of strategic application of DSP.
- In order to investigate the potential evolving IPR problems, legal resources must become interested in the DSP definition.

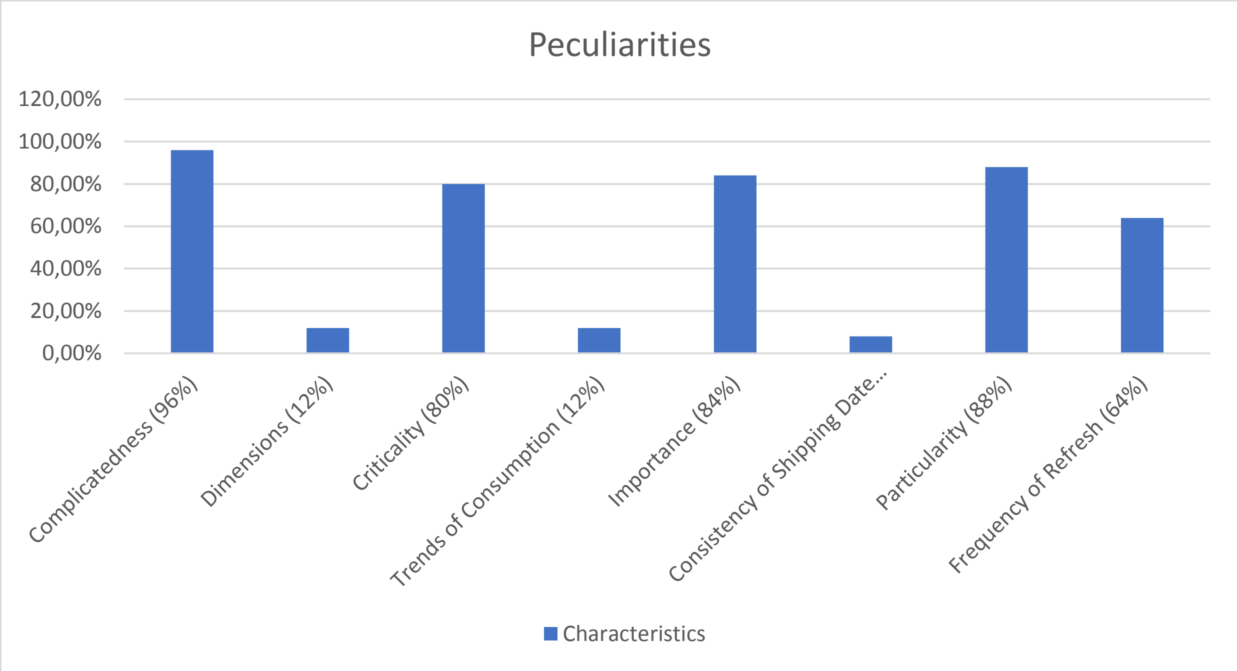
Investment funding for the growth of AM infrastructure should be provided

4.2.7 MAIN CHARACTERISTICS OF SPARE PARTS AFFECTING THE DIGITALIZATION OF SUPPLY CHAIN

According to Chekurov et al. (2018), certain characteristics of spare parts must be considered when assessing the impact of supply chain digitalization. Following an examination of the responses of the 25 research participants, the following characteristics were identified:

- Complicatedness (24 out of 25 participants mentioned this property of spare parts)
- Dimensions (3 out of 25 participants mentioned this property)
- Criticality (20 out of 25 participants mentioned this property)
- Trends of Consumption (while only 3 out of 25 participants mentioned this characteristic, they all valued it, as of high importance)
- Importance (High value was mentioned by 21 out of 25 participants)
- Consistency of Shipping Date (2 out of 25 participants mentioned this characteristic)
- Particularity (22 out of 25 participants mentioned this characteristic)
- Frequency of Refresh (16 out of 25 participants mentioned this characteristic)

Figure 18: Main characteristics of spare parts affecting the digitalization of supply chain



Source: Author

In Table 5, the reason for preference of each characteristic is presented, as explained by the participants' answers.

Table 5: The answers given by experts, regarding the characteristics that affect the digitalization of Supply Chain

Peculiarity	Explanation given by the participants
Complicatedness	The desire for high complexity stems from the assumption that additive manufacturing can produce complicated components almost as efficiently as simpler parts.
Dimensions	The desire for smaller sizes stems from the current restriction of additive manufacturing technologies, which can only manufacture parts up to a certain scale.
Criticality	If highly important replacement parts are not readily usable, they result in expensive stretches of downtime. As a result, the reduced lead time provided by distributed manufacturing of DSPs is a significant benefit.

Trends of Consumption	AM is advantageous for items with a high degree of variation in demand, as additive manufacturing allows for extreme flexibility in meeting demand. Moreover, those with lower volumes favor AM because it is better for them." Higher volumes typically drive up the cost of making components by alternative methods.
Importance	Stocking is an unattractive alternative due to the high valuation. Since no actual inventories are needed and inventories are held on a computer, the expense of inventory is significantly minimized by using AM. The only remaining expense is for cloud hosting.
Consistency of Shipping Date	Low delivery time predictability benefits DSPs as well, as AM's delivery time predictability is extremely stable.
Particularity	When there are less manufacturing businesses, the components are suitable for DSP. Comprehensive manufacturing often does not apply to 3D-printed parts because of the lack of molds and the lack of application expertise used. Additionally, as a result, the number of DSPs may exceed the number of standard suppliers.
Frequency of refresh	Parts that become outdated (whether as a result of upgrades or deterioration) must be discarded. If they are manufactured on a need-to-know basis, stocking and recycling expenses may be avoided.

Source: Author

5. CONCLUSIONS

The purpose of this thesis is to present the perspectives of Greek maritime professionals on technology adaptation. According to research conducted by Chekurov et al (2018), 3D printing is expected to have a significant impact on the shipping industry in the future.

3D printing does not necessitate a lot of trial and error. The use of 3D printing in supply chain and inventory management demonstrates that the outcomes of each of these experiments will yield new information. Despite the fact that the conceptual models are based on current maritime and aircraft models (Davis et al., 1989), empirical evidence suggests that models such as Venkatesh's, Ajzen's, and Fishin's have not been included in this framework (Marchetteya et al, 2009). However, as Earls and Bara (2014) point out, this analysis includes a number of previously unknown or unresolved findings. Similarly, this is linked to the advancement of new technology as well as market expectations (technology adoption model by Davis et al, 1989). According to the authors' reports (Duintjer and Schijn, 2016), businesses are starting to produce raw material additives. Knowledge sharing is required before considering adding additive manufacturing (AM) to the supply chain for mass-produced marine spares.

3D printing will open up new possibilities on both the supply and demand sides of the equation. Convergence of upstream and downstream processes, resulting in a faster supply chain. One critical point overlooked by Oettmeier and Hofmann (2016) is that establishing a short supply chain will necessitate future advancements. Furthermore, according to Oettmeier and Hofmann (2016), it is critical for businesses to recognize the value of additive manufacturing in order to meet rising demand. The supply chain is redesigned based on what the customer wants." This study may add weight to the argument. Defining the requirements of the maritime sector is critical for the adoption of new technologies. As a result, these capabilities are not market-specific and can be delivered to other supply chain segments in addition to the maritime industry. Naturally, the manufacturer seeks to shape the shipping industry from the supply side, but the manufacturer lacks a thorough understanding of how to work with additives. It has been determined that demand will continue to shift to the end user until he or she commits to using the technology. In our opinion, it is unclear whether this would have any effect on the length and flow of the supply chain.

Furthermore, the findings suggest that 3D printing has a number of significant future applications that should be considered. The goal of shifting from traditional methods to a technology adoption paradigm is to achieve results that are more adaptable, durable, user-friendly, and reproducible. Second, the findings show that at the moment, only modular 3D printers are capable of multi-material blending. Earls and Bara's (2014). Several other scientific findings indicate that the International Convention for the Prevention of Pollution from Ships (SOLAS) has a DNV-audited safety and quality assurance system (CAS) in place to identify polluting vessels and ensure their regulatory compliance. During the expert interviews, the availability of standardized marine spare parts was also discussed. Because 3D prototypes used in marine designs may be proprietary, the industry is attempting to reach an agreement to protect their functionality.

In addition to these findings, scientific evidence shows that preserving creativity and non-progress is critical to the strength of a business (Poulis et al, 2011). Policies should, ideally, prioritize the customer, and the approach should always be tailored to the specifications. It is critical to pursue and, more importantly, maintain a diverse and ever-changing industry. The shipping industry's management and employees have long been praised for their commitment to the customer. The end consumer is capable of perceiving technological change to the extent that he or she does not regard progress as a necessity. In conclusion, human tasks cannot be automated because they necessitate creativity. Cultural domains have a significant influence on health beliefs (2015). If 3D printing continues to improve in areas such as productivity, organizational confidence, and the ability to eliminate process costs, this could be the year when the technology sees significant increases in adoption. This experiment alone demonstrates the operational and creative benefits of 3D printing. In the face of uncertainty, all supply chain businesses must be adaptable. This is thought to contribute to supply chain and resource management exploration because it allows for innovation and targeted solutions (consistent with Waller et al 2014, Howard et al 2014). It is reasonable to assume that the use of 3D printing in the maritime sector is yet another example of several previously distinct applications combining to form a complementary new technology (Oetmeijer and Hoffmann, 2016). It is not only organizational, but also economic.

Oettmeier and Hofmann (2016 and 2001), as well as Pätzold et al. (2009), state that (2009). Things critical to society and demographics, such as population growth, population, growth rate, and social/demographic variable problems, are being overcome. According to the findings, generational divides in the shipping industry impede the adoption of disruptive technologies such as additive manufacturing. Several questionnaires were used to collect empirical evidence as various age groups were shown the various technologies available to them in the twenty-first century. Previous generations can be assumed to be team members because their decisions will have a significant impact on the team's decisions. Nonetheless, Fishbein and Ajzen (1975) claim that normative values influence technology.

5.1 CONTRIBUTION & KEY FINDINGS

3D printing and additive manufacturing are at the forefront of this issue, and they are beginning to enter the realm of scientific knowledge. Probably as a result of the inventiveness with which industrial technology is used. Nonetheless, the vast majority of industries see 3D printing as a sign of future economic expansion. Today's digital technology facilitates, but also jeopardizes, business supply chain management. Especially for new, purchased, and sold items, as well as items that can be printed using 3D printing. There is no doubt that when people are unfamiliar with advanced technology, professionals or management play a larger role in its adoption.

This study is critical because there is a lack of scientific knowledge on this subject in the shipping industry, which is based on previous empirical data. The respondents were divided into three groups: stakeholders, manufacturers, supply companies, and shipping personnel. When examining 3D printers and printable parts, an empirical approach is required. Furthermore, there is a chance that this solution will be accepted for long-term inventory management.

While this research had significant limitations (which will be discussed below), it followed a specific methodology that was based on an existing bibliography. Chekurov et al. chose to approach the subject of new technology implementation in their 2018 article through pre-structured interviews. Given that this research was conducted during the covid pandemic, questionnaires with the same question format were deemed the optimal choice. As previously stated, this work was divided into three phases. The first step was to conduct a review of the existing literature; the second step was to conduct the questionnaire; and the final step was to extract the results.

We were able to establish the relative importance of digital components and redefine the term DSP while implementing AM in supply chains. DSPs were developed in order to investigate the various applications of DSPs and their importance to manufacturing companies. Participants expressed a strong desire for spare parts, but a large-scale deployment will take time. DSP (distribution) companies believe that current AM technologies and ICT (information technology) infrastructures are insufficient to deliver a comprehensive DSP (distribution) strategy to all selected companies. However, a subset of the components has already been subjected to the DSP approach in order to target DSP models.

According to DSP participants, long-items have a lot of potential for digital delivery. As a result, DSP networks are expected to be implemented on products like these.

For many of the buyers, the cost of long-term contracts was not a significant barrier to participation. Most importantly, the cost savings associated with AM hardware are widely acknowledged. It could also be due to lower warehousing and shipping costs, as the parts are not kept for long periods of time, as well as faster manufacturing turnaround times.

Spare parts that have been enhanced with DSP may also be improved. Topology can be used to improve your design in a variety of ways, including, but not limited to, the following: reducing the number of links to reduce the likelihood of failure More replacement parts must be included in catalogs to keep DSP solutions appealing to larger companies. This can be accomplished by using a faster machine with fewer post-processing stages, or by additively expanding the parts' manufacturing library. Prior to AM processing, all existing prototypes must be digitized. New prototypes will not be accepted unless and until participants can precisely define the characteristics that must be supplied.

Businesses can take their time adapting their infrastructure, but they must respond quickly as well. Those who recognize the benefits of digital components and have started the project should start preparing for them, as well as developing ICT and internal resources. The DSP network would eventually be configured based on the preferences of current spare parts suppliers as well as potential new entrant activities.

According to a focus group survey, businesses view spare part supply chain concepts as critical to spare part management, so the survey provided additional information on the subject.

Several of the issues raised by Kennedy et al. (2000) are discussed in paragraph 2.5. Only one issue differed between the literature and focus groups, that of repair operators scrambling to cover excessive turnaround times.

Except for the high level of interest in creating non-parts that avoid customs in the country where they are required, Table 1 documents all of the techniques outlined above that can aid in digitization and spare parts creation.

Based on the responses reported in the literature review, spare part digitization appears to be consistent across participants. The authors of the study cited the extremely high cost of additive manufacturing (as have previous studies by Walter et al. (2004), Liu et al. (2014), Johnson (2016), and others (2014), and Sasson and Li (2014)). (2016); (2016) Participants identified small component size as a significant issue due to AM envelopes, as the majority of their replacements are too large for current ones, and Pès Noyes and Knifos acknowledged the component size issue when developing DSP business cases (2006). The issue of missing and inconsistent AM components brought it directly to the fore (2010). Participants in Sirichawal and Conner's studies rarely mentioned additional qualifications, as well as the gradual rise of AM (2016). Version control and a scarcity of 3D models are significant roadblocks (2016). In focus groups, there was almost no discussion of the possibility of profiting from piracy, but two publications made a passing reference to it.

Businesses will suffer significant financial losses if they do not fully leverage the additive manufacturing (AM) ecosystem, according to the creators of CAD/3DP. Lindem et al. provide a more balanced viewpoint (2015). The focus group wants to use the Lindemann et al. strategy while still having access to spares via a DSP.

Post-processing barriers were mentioned more frequently in focus groups than in pre-group discussions; additionally, complications during post-processing were more common in focus groups than in pre-group discussions.

Table 5 defines ideal DSP chips as small and intricate. These metrics are critical for additive manufacturing, as discussed in the Lindemann et al. paper (2015). The inclusion of all of the general spare part classifications found in Table 7 in this section is referred to as "Table 7." (2014) (Roda et al.).

In a nutshell, Table 5 defines the DSP as the company's long tail of components. Long-featured products, as demonstrated by Holmström et al. (2014) and Johnson (2016), are well-suited to AM.

A flexible replacement part supply network is used to obtain components from a small number of suppliers as well as secondary and distribution centers, and the components are handled in central and distributed warehouses as demand grows. Data transportation takes precedence over component use when DSP is used. Because the DSP network is built on a higher proportion of creative and software teams, the roles of these two teams expand as the network grows. Furthermore, both conventional and DSP databases eliminate the need for global storage spaces, while the DSP model replaces manufacturing across multiple geographic locations with distributed manufacturing. This model allows for even faster shipment of replacement parts than was previously possible. The DSP model is based on models similar to those of Holmström et al. (2010) and Khajavi et al (2014). It was built on the strategies identified in this group analysis, but with a stronger emphasis on software developers and content providers who prioritize customer needs.

5.2 LIMITATIONS OF THE RESEARCH

This research was conducted during the covid-19 period. Obviously, this fact alone is a great limitation to all academic research, causing delays and problems in reaching participants to research. In addition, this research was initially chosen to be conducted, using interviews. Obviously, due to the pandemic measures, this was not possible to take place.

A full conducted questionnaire research should receive the opinions of all the companies that operate in the spare part sector. This research focuses on the Greek market, which is a major one part of the global market. While great results could be produced by contacting the whole market, this would not be possible for an academic research.

A solution to this limitation, that was finally followed was the case study approach. One managing company that operates in Piraeus was chosen. All the major suppliers of the company were contacted. Afterwards, the major manufacturers of spare parts, this company cooperates with were contacted too. The emploees of these companies were reached and questionnaires were sent to all of them. The answers received, were from the 80% of the companies. A response rate of 80% is a safe figure to work with. (Fontanella 2018)

Obviously, other researchers with an expanded budget and better circumstances (covid pandemic) could reach an extended number of suppliers and manufactures. Not only this, but also more shipping companies would be more easily reachable.

Aside from that, it's problematic; this type of analysis raises a number of questions. According to the first point of view, the shipping industry is massive and fragmented. Making broad generalizations about the shipping industry would be incorrect. Before deciding which sector will work best for, the numerous benefits provided by each should be recognized and be comprehended. The goal of this study is to look at the capabilities of additive manufacturing in relation to the shipping industry, as well as the various positions that may become available to those involved in that industry.

The additive manufacturing process is advancing at an alarming rate. While the majority of the population is still learning new skills, the majority of people's potential is still unrealized. This way of thinking and acting will result in improvement if more people are involved in technology than in its creation. It is only natural to assume that the capabilities of additive manufacturing are relevant when considering its technologies and characteristics.

It is the third impediment to research because it is time and space limited. It is quick, but it necessitates extensive questionnaires and historical records. Significantly more time is required to conduct deeper research and fully utilize 3D printing, but quantitative analysis must also be improved. A large amount of objective data also allows us to work with more specialists, allowing us to make more robust mathematical and analytical inferences. More precise inferences can be drawn from the larger database. This requires an increase in the number of organizations willing to consider the possibilities, capabilities, and capabilities of this (or any other) technology, as well as their own.

5.3 RECOMMENDATIONS FOR FURTHER RESEARCH

As a result, numerous arguments exist for why these assertions are false. We assume that everything is fine because there is no published research on the process of recognizing the individuals and firms involved in the 3D supply chain.

It is unquestionably time for a greater examination of rational behavior. Rational intervention has a direct effect on emotional well-being and social requirements, making additive manufacturing of spare parts more rational than large-scale manufacturing. When dealing with new technologies, it is necessary to consider the social history of strategic and organizational role holders. The second argument or counterargument builds on the first and expands on it in order to address the emotional aspects of shipping personnel involved. Due to industry's apparent conservatism, it is critical to understand the role and influence of additive manufacturing in industries and the decision-making processes of business community members. Thirdly, this study makes recommendations for additional research on the shipping industry's ballpoint point perspective. While they are interconnected, the various markets can be examined and studied separately, as each market is said to have its own segmentation and functions. Instead of being the first to adopt new technologies, this would demonstrate the industry's widespread adoption. The final suggestion concerns the changing location of the shipping industry. Additional research is required on this subject, both in academia and in everyday life. The industry's stakeholders should bear the greatest impact on individual features.

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APPENDIX

Figure 19: Complete demographic information of the questionnaire participants.

Questionnaire	Area of Business	Role in the Organization	Years of Experience
1	Shipping Company	Middle Management	5 to 10 years
2	O.E.M.	1st line Management	<1
3	Shipping Company	Middle Management	5 to 10 years
4	Shipping Company	1st line Management	<1
5	Shipping Company	Top Management	>20 years
6	O.E.M.	Middle Management	10 to 20 years
7	Seller	1st line Management	<1
8	Shipping Company	Middle Management	10 to 20 years
9	Shipping Company	1st line Management	<1
10	Seller	Middle Management	10 to 20 years
11	O.E.M.	Middle Management	>20 years
12	O.E.M.	Top Management	>20 years
13	Shipping Company	Top Management	>20 years
14	Shipping Company	1st line Management	<1
15	Shipping Company	Middle Management	1 to 5
16	O.E.M.	1st line Management	1 to 5
17	Seller	Top Management	>20 years
18	Seller	Middle Management	10 to 20 years
19	O.E.M.	Middle Management	1 to 5
20	Seller	Top Management	>20 years
21	Seller	Middle Management	1 to 5
22	Seller	Middle Management	10 to 20 years
23	Seller	Middle Management	1 to 5
24	Shipping Company	Middle Management	5 to 10 years
25	Shipping Company	1st line Management	1 to 5

Source: Author