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Onboard vessels digital disruption through ICT technologies: Strategic incentives, anew perils and adoption tendencies.

Focusing on the Greek Maritime Shipping Sector

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To my father.

Your guiding hand on my shoulder, your love, support and patience, remain with me forever.

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Three-member Examination Committee

This Thesis was approved unanimously by the Three-Member Examination Committee appointed by the General Assembly of Special Composition, of the Department of Maritime Studies of the University of Piraeus in accordance with the Rules of Operation of the Postgraduate Studies Program in Shipping Management.

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Abstract

Greek maritime shipping companies, are considered traditional players in the way they conduct their everyday business. Today, as the world marches through the fourth industrial revolution, can enhance the means of competition. Maritime shipping companies around the globe are adopting various disruptive information technologies, claiming to have impact on efficiency, effectiveness and safety. The players who appear to be lagging at the adoption process of new technologies, may fall back in terms of business process efficiency, or comparatively appear to be driving up administrative costs, or even increasing lead time. The purpose of this exploratory research is to investigate the adoption tendencies of the Internet of Things, Big Data, Augmented Reality and Distributed Ledger technologies applied for Bills of Lading, along with the tendencies to adopt Cyber Safe environments for fleets, governing the future of onboard technology adoption in the Greek maritime shipping industry. The final goal is to determine the overall attitude regarding technology adoption of the Greek maritime industry, and henceforward, create an initial framework for further research for those who wish to examine future information technology adoptions within the Greek maritime shipping industry, or any other industry of traditional nature.

The overall adoption likelihood is found to be non-standard, since the two groups of employees examined indicate contradictions in terms of technology understanding, usefulness and trust to the information technology market associated with the abovementioned technologies. They also show diverse trust regarding the technological capacity, readiness and literacy within the environments the employees work. Nonetheless, insights from the survey used led the author to the belief that some obstacles for technology adoption can be addressed to discomfort of certain actors of the Greek maritime shipping industry, as TRI constructs are taken into account. Such issues though, will likely be overcome in the future by technology providers. The combined use of the chosen methodologies provides a valid starting framework for academics conducting research regarding innovation adoption and decision-making in the Greek shipping industry. Furthermore, the improvements of the scenario planning suggest improvements in future decision-making literature for the Greek maritime shipping industry, where currently no structured methodologies exist.

Moreover, the thesis provides Greek maritime shipping industry managers with insights, regarding assessing future likelihood of technology adoption in the maritime landscape. Finally, the developed scenarios could allow the Greek maritime shipping industry managers to strategise in advance, in order to respectively evaluate, exploit business opportunities, or avoid business risks.

Keywords: Technology adoption, Internet of Things, Big Data, Augmented Reality, Distributed Ledger, Blockchain, Cyber Safety, Greek shipping industry.

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Glossary - Acronyms

B/L	Bill of Lading
BIMCO	Baltic and International Maritime Council
CLIA	Cruise Lines International Association
FS	Field Service
FSM	Field Service Management
GPS	Global Possitioning System
HSQE	Health Safety Quality and Environment
ICS	International Chamber of Shipping
ICT	Information and Communications Technologies
IEC	International Electrotechnical Commission
IMCA	International Marine Contractors Association
IMO	International Maritime Organisation
IoT	Internet of Things
ISM	International Safety Management
ISPS	International Ship and Port Security
IT	Information Technology
IUMI	International Union of Marine Insurance
KPI	Key Performance Indicator
NIST	National Institute of Standards
OCIMF	Oil Companies International Marine Forum
OT	Operational Technology
TAM	Technology Acceptance Model
TAMSC	Technology Acceptance Models for Supply Chains
TMSA	Tanker Management and Self Assessment
TRI	Technology Readiness Index
VGM	Verified Gross Mass

1. Introduction

Digitalization and digital disruption, have already started to transform shipping companies, affecting their operations and strategies, generating novel approaches to business, resulting to differentiated and more effective business models. Specifically, for the shipping industry, innovative uses of technology can generate economic and social value (Chesbrough, 2010; Andal-Ancion et al., 2012; Fitzgerald et al., 2014).

Regarding the specifics of the Greek maritime shipping industry, research is required in order to understand its idiosyncrasies against shipping digitalization and digital disruption, and thus understand the industry's overall standpoint, in the sense of identifying the practical significance of some innovative digital technologies to modern Greek maritime shipping. This research is an effort to understand the current perception of the Greek maritime shipping industry towards certain aggressively emerging technologies, namely the Internet of Things, Big Data, Distributed Ledger Technologies and Augmented Reality, along with their perceived positioning versus the latest IMO regulations and guidelines for Cyber Safety.

As a general observation, shipping digitalisation studies are mainly focused on decision support systems, targeting the optimisation of operations (El Noshokaty, 2017), through Information technology for logistics applications (Mlimbila and Mbamba, 2018). This research is an effort to project the adoption of the above aggressively emerging technologies in the Greek maritime shipping adoption tendencies, taking into account the way the information technology market positions the usefulness of these technologies, versus the awareness of the Greek maritime shipping industry's stakeholders, their understanding of usefulness, the perception of trust towards them and their associated providers, along with the understanding of anew perils introduced, which are soon to be enforced by the IMO.

1.1 Technological innovation

As the shipping industry becomes more complex and more competitive due its global profile in terms of supply and demand, the more likely it is to be impacted by global developments in technology, like any other sector. Companies examine external innovation, to adhere the competitive pressure generated towards them, in order to enhance their competitiveness and efficiency. As technologies emerge by receiving exposure through various markets, the needs of corporations appear to change accordingly, thus making innovations a necessity for a company to retain stability in any market (Dodgson et al., 2008).

Innovation adoption is an "outside-to-inside" process, as a result of the incorporation of a service, or a technology that is new to a market. The perception of the innovation's importance leads to adoption, and can in fact support the adoption of other technologies from parallel markets (Damanpour & Gopalakrishnan, 1998). For the shipping industry technological innovations show high relativity and dependence to connectivity (Russom, 2011). This thesis mainly focuses on vessels, as they are considered highly dependent on connectivity. Furthermore, apart from past research on dependencies between technology innovation and connectivity, it appears that entities that seek to thrive in innovations, can achieve strategical advantage over their competitors (Tidd et al., 2005). Regardless of the market, academic research underlines the practical importance of innovation (McKinsey, 2013).

Companies must aim on how, when and which technological innovation is be adopted by estimating its value against organizational productivity, efficiency versus competition, and ultimately, survival, while the technological innovation can be adopted externally, or generated internally (Howell, 1990). Furthermore, determinants of innovation adoption have been vastly researched, mainly focusing on information technology (Jansson et al., 2010; Venkatesh & Bala, 2008). However, regarding the Greek maritime shipping industry there is limited research that focuses on the determinants of technological innovations adoption, specifically regarding recent aggressively promoted technologies like the ones examined in this thesis. In order to provide an initiative to address this research gap, this thesis aims to understand the current and short future position of certain technologies adoption, as related to the general understanding and the perception of their usefulness and risk by Greek owning, managing and operating companies.

1.2 Disruptive innovations and technologies

Innovation can be viewed through various angles, such as technological, non-technological, administrative and product-market (Phillips and Phillips, 1997; Engelen et al., 2015). Technological innovations mainly refer to research and development on products that reflect processes (Engelen et al., 2015). Past experience on them dictate that technology innovations often occur due to supply of new products and services within a targeted market, but their adoption is related to the value they add to internal corporate processes.

Innovations may either be disruptive or sustaining (Christensen et al., 2000). For the case of the shipping industry, a sustaining innovation can improve a service and consequently increase the perceived value for a customer, even achieve higher profits and margins (Christensen et al., 2000). Disruptive technological innovations tend to alter or create new philosophies around operational needs, even though at their first appearance, are characterized by low profit margins and some are even inconsistent with a company’s strategy. In general terms, as the name implies, disruptive technologies do not aim to enhance established operational procedures, but to rethink operations in ways that were not conceived as practical before, and in essence disrupt them. Disruptive technologies, tend to shake organisational values to their core, by providing different approaches to an existing scope, as opposed to sustaining innovations, which simply enhance an existing operational process to a more efficient and effective level (Christensen et al., 2000).

1.3 Disruption as a generator of innovative processes

There is a significant distance between the adoption of a disruptive technology, and consequently, the adoption of an innovative process within organisations. As stated before, adoption is defined as the "outside-to-inside" process that results in the incorporation of new technology to a business segment, usually generated and developed by a different, yet related market. The generation of an innovative process is what mainly makes a disruptive technology included, in an organisation. Disruptive innovation adoption is followed by the creation of a procedural idea, the definition of a new project, the design and development of a process, and is established by internal corporate marketing (Damanpour and Gopalakrishnan, 1998).

This thesis concentrates on the adoption of disruptive innovations, as it is ultimately a matter of corporate willingness or need to change, providing that the management of a company is able to foresee how a disruptive technology will tend to improve the effectiveness, efficiency and performance of an organisation, along with the capacity of the organisation to understand the merits or threats that may rise, by switching to new processes, the capacity of the personnel to adopt to changes, their literacy on technology and the willingness of the management to train the company's personnel so as to sustain a disruptive innovation (Damanpour and Schneider, 2006).

1.4 Adoption of disrupting innovation

Even from a Schumpeterian perspective, which implies that the process of production is marked by a combination of material and immaterial productive forces, shipping companies sustain growth, by engaging in the never-ending process of economic development and strategic optimisation. In order to sustain the above, shipping companies, like all companies of any other segment, must ensure that competition policy boosts innovation, protect their intellectual property, and welcome technological change through innovative techniques, as part of their total quality management system. Every shipping entity that strives for profits has to innovate towards organisational change, and disrupt processes towards growth, efficiency and effectiveness (Damanpour and Schneider, 2008). Disruptive technologies allow for such transformation.

Even though scientists have defined numerous different adoption techniques for innovation, there is no single standardised system or way which shows the path to successful innovation adoption that fits every organization or market segment (Damanpour, 2008). For the maritime shipping industry, due to the combination of complex roles and sciences brought together to form a sustainable value chain, the innovation adoption can be defined as ‘‘a process through which an individual or a decision-making unit, passes from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to the confirmation of this decision", (Rogers, 1995, 2003). Moreover, due to the complexities of the value chains formed in maritime shipping companies, the adoption process can be phased into evaluation, initiation, implementation and routinisation (Aiken 1971), whereas (Zaltman, 1973) further defines the adoption decision into the stages of knowledge awareness, attitudes formation, decision, initial implementation and sustained implementation.

All above definitions are summed up into the time-lined steps of technology adoption, forming the basis of Technology Adoption Models, namely, pre-adoption, adoption, and post-adoption (Damanpour and Schneider, 2006; Rogers, 1995, 2003). At the pre-adoption phase the new need or to look for new solutions is somewhat generated by the market of interest. At pre-adoption, organisations become aware of existing innovative solutions, understand their suitability and merits, while they make sure that employees understand it or have the capacity to understand it (Damanpour and Schneider, 2006). In the adoption decision step, the technical, operational, safety, financial and strategic views are examined by top managers, in order to make a decision. If the idea or solution is accepted, the appropriated resources will be found for technology adoption and allocation (Damanpour and Schneider, 2006). At the post-adoption stage, the adopted innovation must be tweaked to fit the organisation's acumen, and thus ensure acceptance. At the post-adoption stage, the target is to help the innovation become operational routine for the organisation (Damanpour and Schneider, 2006; Rogers, 1995, 2003).

The author recognises that organisational adoption of any disruptive innovation is mainly driven by characteristics such as costs, complexity and relative advantage. Experience shows that the initial relationship between costs and innovation adoption, is usually negative, and that the less expensive a disruptive innovation is, the more likely it is to be adopted. Still, the impact of an innovation to a market may be a significant driver (Damanpour and Schneider, 2008). Enhancing the writer's perception of a Technology Adoption Model, figure 1 below, shows the co-relationships of the determinants affecting the innovation adoption decision on an organizational level by incorporating several factors and multiple perspectives (Frambach and Schillewaert, 2002).

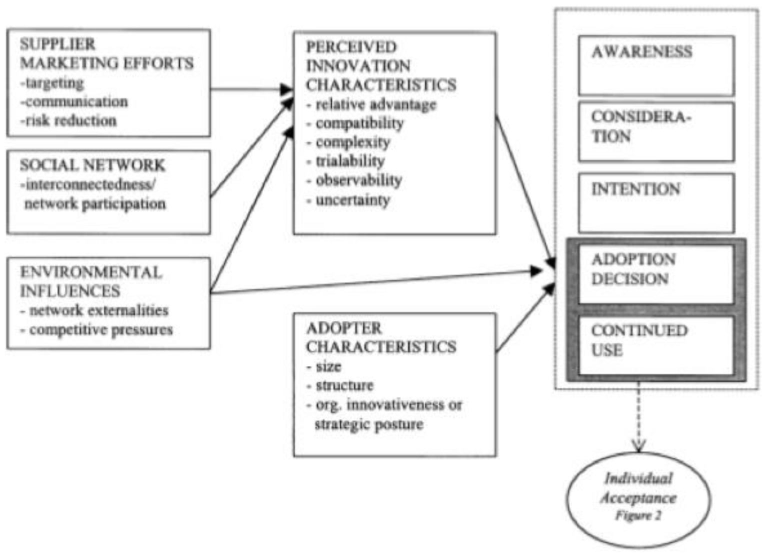


Figure 1. Micro Perspective: Determinants of the Adoption of Innovations (Frambach & Schillewaert, 2002, p.165)

Perceived Information Characteristics are the essential parameters which affect the perception, and the evaluation of a disruptive innovation, by members of an organisation's decision-making unit (Frambach and Schillewaert, 2002). Economic advantage, compatibility, trialability, and observability can show a positive influence on the adoption decision and are related to the trust shown towards the disruptive technologies from current experiences and awareness. In terms of complexity it is of critical importance to test the targeted market's intellectual ability to understand technological innovations, while in general and from many other paradigms, experience shows that the more conceptually complicated and original an innovation is, the higher the aversion may be against it. In fact research shows the negative correlation between the two (Damanpour and Gopalakrishnan, 1998) and later showing relation to the type of innovation, be it administrative or not (Damanpour & Schneider, 2008). Concluding, the future of the adoption of an innovation is related to the profitability and the relative advantage introduced, the complexity and the capacity of the organization to understand it and its merits, along with the "hype" induced by the market introducing the innovation (Damanpour and Schneider, 2008).

1.5 Demographic and micro perspective views

As per prior research on innovation adoption, we need to take into account the characteristics of the stakeholders within a company that may affect the adoption in an either direct or indirect manner. There is a direct effect of people playing a direct role in the decision making process of adoption (Damanpour and Schneider, 2008; Howell & Higgins, 1990). Thus, there is a direct effect (Damanpour & Schneider, 2008). On the other hand, one would expect that age may play a significant role on innovation adoption, however, no significant correlation is reported. It is the tenure of a stakeholder which has a significant negative impact on innovation adoption (Damanpour and Schneider, 2008). As an explanation we may state that the longer a stakeholder is working for the same company, the higher the possibility is to show an aversion to change of current work procedures and disruptive innovation (Damanpour and Schneider, 2008).

Education has a positive impact on innovation adoption (Damanpour and Schneider, 2008) Hence, educated stakeholders are more likely to embrace the need of a disruptive innovation (Damanpour, 2006). The impact on innovation is highly discussed too in relation to gender. Regarding gender, there is no significant indicator that relates it to innovation adoption, (Damanpour and Schneider, 2008). There are more characteristics that influence the adoption decision, such as the size of the organization, and its structure (Damanpour, 1991). However, Frambach and Schillewaert (2002) found no significant correlation between the structure of an organization and innovation adoption.

Supplier marketing activities have a direct positive relationship on the perceived innovation characteristics and thus, an indirect effect on the adoption decision. Here, three main factors are important, namely the accurate targeting of the selected adopters of an innovation, appropriate communication by the supplier in order to create awareness, as well as also influence the perception of an innovation adopter, and thirdly, the reduction of perceived risks such as operating or financial risks for a potential customer (Frambach and Schillewaert, 2002). Furthermore, the exchange between members within an informal social network might lead to a higher probability to adopt an innovation. Lastly, environmental influences, such as regulations and competitive pressure, can also influence the adoption speed, even though the relationship between urging to adopt an innovation in the case where other companies within the network of a company have already adopted, is not explicitly clarified (Frambach and Schillewaert, 2002).

1.6 Motivation for research and the 4th industrial revolution

The motivation for choosing to investigate the adoption of certain technologies in the Greek maritime shipping industry, namely the Internet of Things, Big Data, Augmented Reality, Distributed Ledgers, along with the protection against their new cyber perils, as introduced by the International Safety Management code, comes from the writer’s genuine interest to examine the factors that drive adoption, in the Greek maritime shipping industry. The shipping industry is known for being slow in its technological advancement (Hoagland, 2010), whilst a relatively recent survey from BPI, showed that 85% of 200 executives working for terminal operators, carriers, logistics providers, shippers, and other supply chain companies said the industry is slow to change when adopting new technologies (Morley, 2017). On the other hand, as stated by Clayton Christensen (2015), disruptive innovation is no longer a buzzword in the marketing world, it is a concept that every company can stand to benefit from. Which begs the question: how does the Greek shipping industry perform against aggressive disruptive innovation?

Products and services in the shipping industry are somewhat “traditional”, and disruptive innovations cannot help companies on the areas that need structural and process improvement. For this reason, disruptive innovation technology understanding can be a clear driver for shipping companies who realise they need improvement ahead of competition. Hence, it is necessary for future consumers of disruptive technologies, to research in prior and offer insights regarding how their market understands and is expected to act in the presence of the disruptive innovations of interest and their impact on processes, providing that such innovations enhance future efficiency, effectiveness and safety in the shipping sector. The future of any industry is in the hands of those of who innovate. Hence, it is paramount to search for such leaders within the Greek maritime shipping industry, foreseeing how the Greek maritime shipping industry can stay ahead.

Moreover, the study context chosen for this thesis is also the outcome of the writer’s decision regarding its relevance with our master’s programme in Shipping Management, deploying tools to determine a range of potential future outcomes in further research, rather than being limited in analysing uni-dimensional decision-making tools. Ideally, this research is aimed to shake one’s beliefs regarding the conservative nature of the Greek maritime shipping industry, leading to further discussions regarding the sector’s future in technologies adoption. The fourth industrial revolution is speeding automation and data exchange for numerous market segments offering significant potential for vessels and the maritime industry is facing its fourth wave according to Martin Stopford (2015), who further calls this fourth wave as smart-shipping. Smart-shipping differs from earlier waves, making cargo transport management possible through information technology and connectivity, offering significant efficiency for process owners. This kind of operational efficiency is hypothesized to disrupt the maritime shipping business as per Clayton and Christensen (1997, 2000).

1.7 Formulation of the problem

There is a great variety of actors participating in the maritime shipping industry, with different relationships and regulations, and by not taking advantage of information technology may contribute to barriers which can impede global trade (World Economic Forum, 2016). Technology can show ways to increase trust between parties doing business in the maritime shipping industry, and thus optimise the overall efficiency of business processes (Jensen et al., 2014). Moreover, within the maritime shipping industry, information technology systems and their integration for the benefit of all actors are outdated, while manual processes still prevail in the majority of the supply chain. As a result, a lack of coordination among the industry's actors is observed at times, while security risks show increased workload for authorities.

The use of the technologies chosen in this thesis promise to address operational issues in various ways, by enabling real-time updates and a faster operational response, by automating tasks which are currently performed manually, by improving oversight and data accuracy, by reducing administrative costs, and ultimately by improving the overall business processes. While the majority of industry actors and researchers agree on the previously cited benefits, not many are able to envision a future of the maritime shipping industry, with technologies such as the Internet of Things, Big Data, Augmented Reality and Distributed Ledger Technologies, all protected under a Cyber Safe vessel ecosystem, and thus asses and when their adoption may occur.

Hence, as the benefits related to the introduction of such innovative solutions become apparent, the information technology providers must carefully introduce solutions within the maritime shipping business. It will be necessary for them to understand how likely technologies are to be adopted and of course determine what the possible business opportunities and risks are, deriving from the different futures the industry might present. In order for this thesis to address these aspects, the following research questions were developed:

1. How likely is for Internet of Things, Big Data, Augmented Reality and Distributed Ledger technologies to be adopted by the Greek maritime shipping industry actors?

2. Are the actors of the Greek maritime shipping industry able to understand the newly introduced technologies?
3. How do the actors of the Greek maritime shipping industry perceive the usefulness of these technologies?
4. Do the actors o the Greek maritime shipping industry trust the information technology market and such solutions?
5. Are the actors of the Greek maritime shipping industry aware of the risks associated and comply accordingly with the new Cyber Safety standards?
6. Do the actors of the Greek maritime shipping industry feel that their companies promote new technologies, and under what conditions?
7. Is the Greek maritime shipping industry willing or considering to develop and launch a future with such technologies?

In order to provide answers to these questions, an academic and a practical approach is applied. Q1 is addressed using a technology adoption theoretical framework, which presents the determinants affecting the likelihood of inter-firm technology understanding of the value and the likelihood of adoption. Q2 to Q5 are addressed aiming to identify the overall perception of the actors of the Greek maritime shipping industry, against the above mentioned technologies and their cyber-perils, along with the regulations in place to address that issue. Q6 and Q7 are addressed to understand the current and future attitude of the Greek maritime shipping companies towards these technologies.

1.8 Scope of research

It is important to clarify that the context in which this investigation takes place, only includes the merchant maritime shipping of Greece as it is considered highly influential players in the global maritime commerce. Indeed, the Greek merchant maritime shipping segment provides a high share of total world turnover. In order to refer to the context of this industry, the more common term “Greek shipping industry” will be used throughout the thesis. Furthermore, the investigation will focus on the adoption of multiple technologies rather than a specific solution, underlying a short time framework onto which solutions may be developed. Hence, this approach is followed in order not to limit the assessment of the potential benefits provided by the technology itself, but to make sure that all stakeholders have a somewhat common direction. “Internal stakeholders should include a company's key employees, such as the board of directors, senior management and the strategy team” (Schwenker et al., 2013).

The focus of this thesis is of an exploratory fashion to discover what is needed by actors of the Greek shipping industry, when and under which conditions the mentioned technologies can be adopted, by going into details with the design principles, the theoretic applications and benefits, but not the actual technicalities and engineering implications of their implementation, as the author will not strive to create a technical oriented document. The thesis investigates and focuses on the viability of the mentioned technologies and how they can become adoptable by the Greek shipping industry. As such, the scope of the mentioned technologies and their future existence within the Greek shipping industry delimits the scope of this thesis, focusing on the perceived practical and business aspects of such technologies, concentrating on employees, who are directly involved in the value chain of their companies.

1.9 Clarifications and limitations

The author of this thesis is not an industry expert in transportation, maritime shipping and global supply systems, while his background is structured by expertise in information technology, satellite communications and encryption, systems integration, project and business management. Moreover, the author faces constraints to gain access to all processes and stakeholders in the field, as well as resources available.

Sensitive data are not made available since the research is written in autonomy from any formal and extensive corporate partnership, which limits the research to quantitative aspects that affect the usage of the technologies under investigation of the responses by the stakeholders participating. This limitation also arises from conducting exploratory research in this emerging field. It is important to clarify that this project is about the examination of the importance of improving the Greek shipping supply performance through the technologies under scope, not the analysis of these technologies to their fundamental technological core.

Moreover, the author is aware that he cannot holistically develop a system that tailors every entity in the Greek shipping industry, and their respective needs. Since the research scope is focused on a unit of analysis in maritime industry, future research is necessary to investigate the use-cases for more vertical areas in the Greek maritime shipping industry. These may include amongst many categorisations, bulk freight and tanker, gas carriers, as well as short range and domestic logistics.

1.10 Thesis structure

Other than the introduction this thesis is further divided into five additional chapters, namely: Disruptive technologies context study, Theoretical foundations applied on research, Research methodology, Survey responses and findings, Assumptions limitations recommendations and conclusions.

Disruptive technologies context study, provides an overview of the technological and overall context in which the study takes place. The chapter addresses the technologies whose adoption is being investigated. More specifically, technological foundations, and characteristics are presented.

Theoretical foundations applied on research give an overview of the available literature for the approaches used to answer the two research questions, namely technology adoption models and scenario planning. This chapter provides a more detailed presentation of the selected model and tool which set the foundations for conducting the research.

Research methodology provides an overview of the specific research design of the thesis. Moreover, the chapter also explains the steps taken to use a modified TAM model which undertakes TRI constructs into account and the scenario planning and tools used in order to gather findings and be able to discuss on them.

Survey responses and findings, presents the results of the investigation divided into two perspectives base on the authors experience, for the purpose of an inductive, exploratory research of quantitative nature of analysis.

Assumptions limitations recommendations and conclusions considers the findings within the Greek shipping industry and tries to explain them through initial assumptions and current literature. This chapter pinpoints opportunities and risks arising related to the attitudes shown towards technology adoption. It also presents the academic limitation and managerial implications, while it suggests directions for future research. The Conclusion presents a concise summary of the thesis, highlighting the most important findings and considerations.

2. Disruptive technologies context study

This chapter provides the reader with background knowledge regarding the context on which the research will take place, and the technologies, the adoption of which, will be investigated. The following paragraphs will allow the reader to familiarize with the various concepts and terminology recurring throughout this thesis.

2.1 The merchant shipping industry

This paragraph is based on Martin Stopford's book Maritime Economics (2009), as the short overview of the marine shipping is mandatory to reach a sufficient understanding of what is hypothesized under disruption since disruptive innovation is a relative phenomenon (Christensen 2006). "in order to be able to say an innovation is disruptive, it should be possible to identify what it is disruptive to" (Baiyere 2016). Maritime merchant shipping is an integral part of the international transport system, divided in three major categories: Inter-regional deep-sea shipping between continents, short-sea shipping, of coastal seas and transport through rivers.

This thesis undertakes the perspective of the deep-sea marine industry and focuses on its Greek segment. Data for this thesis is collected from Greek deep-sea shipping companies, from employees of owners, operators and managers. Deep-sea shipping is the most cost effective way to transport cargo of high volumes between continents, covering all major industrial regions such as Asia, Europe and North America. In such a vast transport scheme nearly everything need interconnection, immediate reflexes and requires heavy and at many cases, ideally, real time cooperation between different actors so as to operate cargo flows.

Demand for shipping can vary as much as 10–20% in a year and can be predicted, but it can be unpredictable. Sea trade is linked with world economy and random shocks. For example, oil crises (1973 & 1979) and financial crisis (1989–1992) affected to sea trade crucially and the recent financial crisis that started in 2008 and was magnified by the COVID-19 pandemic, is still affecting the Greek shipping industry. If considered that disruption is to happen or is already happening in the shipping market, a short review of the four-dimensional shipping market is needed, which is illustrated in the figure 2. Key thing to note here is that disruptive innovation is a relative phenomenon and in this thesis the Greek maritime sector is hypothesised to be facing disruption.

Freight market is the main source of cash flow for shipping companies where freight rates earned are the most driving value for shipping investors. The sale and purchase market operates around second hand ships that ship owners sell to one another. The shipbuilding market turns the cash flow in pay for labour, material and profit. The demolition market is another income for shipping companies by selling old ships to demolition yards further be exploited during recessions.

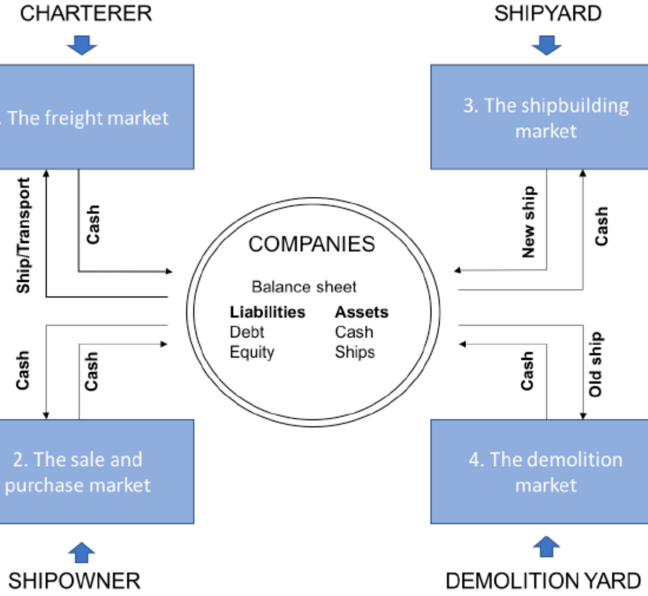


Figure 2. Four shipping markets (Stopford, 2009)

2.2 Digitalisation and advancements in shipping

At this point, we need to make a distinction between digitisation and digitalisation. Digitisation is practically the conversion of changing the analogue to the digital, while digitalisation is how this new digital world will impact people and work. Digitalisation in the shipping industry is a form of disruptive innovation per se, changing the current business models to any extend and creating opportunity for existing and new players in the world of freight. By utilizing digital solutions, or creating their own digital tools, shipping companies can find that there are plenty of opportunities to remain competitive, like the adoption of disruptive information technology and the merits of it.

Most actors in the shipping industry understand the need to digitalise. Due to the current stagnation of the freight industry from COVID-19, further enhancing the problems that grew along in time since 2008, there is more instability in the world of shipping and trade than there was in decades. Players in the industry have already begun to implement digital strategies and consolidate their services in digital means. To the eyes of a technologist the shipping industry is ripe for digitalisation and disruption. From the lack of real time onboard transparency, on physical situations to machine monitoring, to insufficient and consuming freight booking processes, to not owner secured bills of lading, to the protection of communicated data back and forth between vessels and shore, even the exploitation of big amounts of data resulting from the entire supply chain of goods.

With so much instability in the world arena, it is time to get past the mentality of "this is how things have always been done". Digitalisation is no longer just about 'innovation' for the shipping industry, but rather it is about simply catching up with the rest of the world. Although there are genuine reasons for using outdated technology and processes, the step into digitalization is a step into the 21st century. At a recent study conducted by IBM, it was found that a shipment from East Africa to Europe required communication between nearly 30 people and organizations, with at least 200 different interactions and uncountable paper trails, making a technologist's mindset to think that the shipping industry is in dire need of digitalisation to prevent this administrative and operational mess. Application of new technology has a huge potential to drive economic, environmental and social sustainability in the shipping industry and can be essential to drive the industry towards its sustainable development goals, enhancing safety.

Digitalisation for shipping can be summarized as "streamlining innovating business and operational models, by transitioning them into being digitalised, real time and secure", hence, why not give a try of the experience the 4th revolution. From creating bookings to finding trade services, from overviewing onboard machine generated data to interfering directly from shore when needed, from exchanging data with global data lakes to making important strategic decision through the global supply chains, from freight contract security to their access management and ownership, and lastly doing all the above with care, safety and security, the shipping industry has a lot to learn about digitalization.

The road towards digitalisation in shipping includes many levels of operational disruptions, and the stakeholders of the shipping industry will gradually see more tailored solutions for vessels, as technology matures its profile towards the needs of maritime shipping. The regulatory and legal frameworks will need to be further developed to facilitate a safe and responsible uptake of new technology and solutions. New technology is mainly destined to drive sustainability within a certain industry. The following technologies can transform the shipping industry towards new sustainable business models.

2.3 Onboard trends in the shipping industry

The most obvious of transformations to the world during our times within the 21st century will be through information technology and the maritime sector will not be exempt to this. There are many applications of information technology that influence the management of onboard operations of fleets, with some considered more current than others. Fleet management is becoming more advanced through the use of information technology services that enable shipping companies to keep track of ship operations from anywhere worldwide, for example. At this point, it must be stated that reliable and high-speed communication channels are a critical pillar of a digitalised ship, as they enable data to flow both ways between ships and shore bases.

Data generation and analysis at a local scale, has become a valuable tool for fleet managers to provide information on ship performance, along with direct onboard interventions through Augmented Reality, currently deployed at a primary level and mainly embraced by Classification Societies for remote audits and inspections. On the other hand, Big Data use from the industry has become a trend that may influence the efficiency of the overall supply chain operations, whereas Distributed Ledgers for bills of lading, show a promising response to the inefficiencies witnessed so far, regarding contracts of carriage. These technologies are already being promoted as having a major impact on ship management and appear to be in the pipeline of global shipping, showing huge potential to be highly disruptive in a positive way. These technologies are summarised below, including references for further reading. All of them should be considered interconnected through cyber safe onboard information technology systems, which in turn are the enablers to current and future onboard information technology applications. The next paragraphs outline technologies considered key to the short-term future of the maritime sector and considers the benefits they can bring.

2.4 Onboard infrastructure and the vessel as a datacenter

Vessels are becoming increasingly complex and dependent on the extensive use of integrated information and communications technologies throughout their operational. Modern vessels consist of a various different types of networks that are all relevant to making them operational, safe and profitable. Connectivity and information technology are the cornerstones of the digital revolution and digitalization. During the recent years, they are becoming more popular for vessels for the following reasons in terms of cost and functionality.

- Computing power: Machines can now operate and perform faster algorithms executed within seconds leading to a constant flow of information and immediate answers available.
- Data storage: The evolution of onboard storage, hardware and various hybrid interactions with cloud technologies, contribute to the development of affordable and powerful data storage solutions for the benefit of shipping, in handling the exponential growth of data collection.
- Connectivity: While still growing in terms of available bandwidth for onboard business and operational data throughput in and out of the vessel, the improvement of connectivity shows benefits as it is the medium of providing real-time information about vessel’s performance.
- Sensors: Collecting real-time data regarding components on board ships such, like emissions and cargo temperature for example, increases the efficiency of maintenance, safety, the operational costs and the risk of failure due to negligence.

Although connectivity may appear to be primarily another way of communication, the term is widely misunderstood, even from the information technology business. Connectivity is a meaningless terms if solely focused on communications. As modern ships become more ready to produce data since the day they are built, vast amounts of a wide variety of onboard data are made usable from various different sources, which in turn can be harnessed from shore or can be treated as meta-data for various calculations, as vital aids to the company, the crew, to different vendors and manufacturers, during the ship’s daily operation.

As a result, of the revolution of sensors, communication, and data analytics, new vessel architectures arise, enabling the implementation of new applications based on the data now available. For example, in July 2017, Hyundai Heavy Industries announced the development of the Integrated Smart Ship Solution (ISSS) a collection of operations technology systems aiming to optimize navigation processes by collecting and analysing real-time information on navigational operations, capturing a variety of data points, including location, weather, and ocean current data, as well as engine propeller and cargo status information.

Some manufacturers, service providers and ship operators incorporate information technology innovations by using holistic onboard ICT ecosystems and by going beyond traditional information technology systems engineering. The fundamentals of using any technology that requires connectivity, lay at the creation of information technology efficiency on ships, the integrated systems of which allow safe interoperable and enhanced monitoring, thus forming secure environment with communication and connectivity capabilities, accessed and controlled by remote onshore services.

Onboard ICT ecosystems, having the role of vessel datacenters, play the important role of improved safety, security, reliability, confidentiality, integrity, availability, auditability and business performance of onboard systems. However, the risks that need to be identified, understood and mitigated to make sure that technologies are safely integrated into the ship's design and operational profile are numerous. The marine industry faces complex and serious challenges when trying to achieve the full benefits of using ICT, and cyber safety is one of the highest importance, clearly depending on the architecture, resilient and secure performance of onboard datacenters.

2.5 Distinction of onboard information and operation systems

This widespread adoption of ICT throughout modern ships has led the industry to focus on safety properties. Within the technologies used to generate, process and control data of vessels, the industry identified the distinction between IT (Information Technologies) and (OT) Operational Technologies. According to Gartner's IT Glossary, OT is the hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices, processes, and events, while IT is the common term for the entire spectrum of technologies, for information processing and communication technologies and does not include embedded onboard technologies that generate data for enterprise use (Gartner, 2018). By taking into account Gartner's definition a relatively closer definition for a vessel can sum up both onboard technology areas as "Vessels' Operational Technologies (OT) Systems control physical machines and can generate data, while vessels' Information Technology (IT) environments process information and transmit data". IT and OT have different onboard roles. OT correlates more with the physical world, while IT refers to information processing. The below figure may clarify the technology domains even further for the maritime domain.

Figure 3. Operational Technology vs Information Technology (DNVGL, Maritime cyber security)

A few years ago, OT systems did not depend on intra-communication protocols such as ethernet and were simple, isolated devices. However, over time, due to the need for comprehensive control and optimized performance, enterprise networks have replaced proprietary communication tools with protocols such as the ethernet and the internet protocol (IP), resulting the inclusion of OT into the vessel's information technology networks, bringing them closer to familiar threat surfaces, whilst upgrading their onboard network behavior to the level of information technology, rather than being isolated and proprietary systems, which is overall seen as a positive evolution.

As per NVGL, OT and IT systems are becoming more interconnected, and even in situations where OT are separated from IT networks with perceived and not pragmatic air-gaped security, they tend to behave as access points of the vessels information technology ecosystem to any other side, namely the office or the cloud, still depending on connectivity. The "perceived" air-gap security of isolated systems has a fundamental and huge security loop-hole, as isolated OT systems rely on the use of removable media, such as USB drives, etc. Additionally, an organisational policy that permits remote access to vessel systems via established connectivity, creates the threat that unauthorised individuals may gain access and be able to manipulate data or, worse case scenario, control of the systems. Still, the information technology domain has plenty of accessibility authentication methods, which can be applied, thus making the step up of OT systems as an integral part of the vessel's ICT ecosystem, which is a more secure place for their operation.

2.6 Differences between IT and OT and safety culture

In general, OT is focused on the automation of machines, processes, and systems, and IT focuses on the business, operations and enterprise information systems required to support the business. We need to be aware though, that heir business objectives are not the only difference between these two technological domains. The employees associated have different roles, they report to different executives, they are parts of different teams and departmental cultures. As a general principle, regarding cyber safety, researchers have adopted the

CIA model which defines three security objectives that describe the general trustworthiness of the data (Samonas and Coss, 2014). As per Samonas and Coss the CIA triad needs to be re-examined and extended for any environment that involves the interaction of differently oriented technological domains. According to Rothrock and Clark (2018) and NIST SP 800-160 Vol. 2, the CIA trial is expanded to the below to more secure dimensions in environments where integrated information technology systems, such as datacenters, include various other data generating domains such as operational technologies, which is the case for vessels. All security dimensions, are explained below.

- Confidentiality. Refers to an organisation's efforts to keep their data private or secret. In practice, it's about controlling access to data to prevent unauthorised disclosure. Typically, this involves ensuring that only those who are authorised have access to specific assets and that those who are unauthorized are actively prevented from obtaining access (IEEE, 1990).
- Integrity. Refers to the quality of something being whole or complete and the loss of data integrity somewhat resembles the game "Chinese whispers". In the information and systems security domain, integrity is about ensuring that data has not been tampered with and, therefore, can be trusted, meaning it is correct and authentic (IEEE, 1990).
- Availability**.** Systems, applications, and data are of little value to an organization and its customers, if they are not accessible when authorised users need them. Availability means that networks, systems, and applications are up and running. It ensures authorised users with timely, reliable access to resources which in are always needed in an integrated environment (IEEE, 1990).
- Reliability. Describes the ability of a system to function under stated conditions for a specified period of time. Availability, Testability, maintainability and maintenance are a part of "reliability engineering". Reliability plays a key role in the cost-effectiveness of systems. A system will be of higher value, if it fails less often (IEEE, 1990).
- Auditability. An auditable information system, is the one set to comply with a set of examination controls applied within an information technology infrastructure. The evaluation of obtained evidence determines if the information systems are safeguarding assets, maintaining data integrity, and operating effectively to achieve the owner's goals or objectives.
- Security**.** Also defined as InfoSec, and includes those tools and measures necessary to detect, document, and counter threats, mainly focusing on the protection of information and communications systems against unauthorized access or modification of information, whether in storage, processing, or transit, and against denial of service to authorized users. Information security is composed of computer security and communications security.

In order to understand these concepts in the Maritime Sector, consider for example, loss of sensor data acquired by the Supervisory Control and Data Acquisition (SCADA) system. It has a low impact in confidentiality as sensors are publicly displayed on board. However, it is important that all information transmitted by the sensors are trustworthy, increasing the value of integrity. There is also a serious safety issue if the collected information cannot be accessed, which leads to a high potential impact from a loss of availability. In such an incident, the ICT systems who are responsible for the vessel's connectivity are to be examined, especially under the scope of their maintenability and maintenance processes, since loss of data has occurred.

The question is still though, how and when did the systems engineers responsible for the reliability of the vessel's IT ecosystem, realised the loss. Auditability in this case plays a significant role, as the more safeguards are placed on systemic behavior, the more operationally reliable the system can be, and such an incident and its nature, if audited carefully, can be clearly defined as an alarming one or not. Finally regarding security, we need to make sure that the right tools and measures are in position, so as to detect the incident and focus on what was accessed, by whom, when and in general, log the behavior of the device so as to evaluate what happened and when.

2.7 Onboard cyber safety and cyber risk management regulations

The rapid adoption of new operational technologies and the increased dependence on networks of integrated information technology architectures, opens the possibility of cyber deficiencies that could threaten the economy, crew safety, the environment, or national security. The dominant interest on cyber safety and cyber risk management, raised the need for issuing a regulatory framework that addresses the increased challenges in shipping, giving a rather big weighting on the vessels' side. The IMO, the European Union (EU), along with oil major companies and more stakeholders within the industry, have acknowledged the severity of threats and proposed frameworks and specific guidelines to address and mitigate onboard cyber risk. On the 5th of July 2017 the International Organization issued the MCS-FAL.1/Circ.3 "Guidelines on Maritime cyber risk management" that provide recommendations on securing Shipping from the emerging threat of cyber attacks (IMO, 2017).

By cyber risk management, the IMO defines "the process of identifying, analyzing, assessing and communicating a cyber related risk and accepting, avoiding, transferring or mitigating it to an acceptable level, considering costs and benefits of actions taken to stakeholders". IMO amended two of their general security management codes to explicitly include cyber safety. Referring to MSC-FAL.1 / Circ.3, the IMO gives specific guidelines and specific practices at the level of the entire IT architecture on a vessel and related OT systems, emphasizing on the management of the deployed architecture against vulnerabilities, while it specifically states that "for detailed guidance on cyber risk management, users of these Guidelines should also refer to Member Governments' and Flag Administrations' requirements, as well as relevant international and industry standards and best practices. Additional guidance and standards may include, but are not limited to:

1. The Guidelines on Cyber Security Onboard Ships produced and supported by BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI.
2. ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements. Published jointly by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).
3. United States National Institute of Standards and Technology's Framework for Improving Critical Infrastructure Cybersecurity (the NIST Framework)."

All three of above documents are the practices introduced by the IMO, as parts of the mandatory requirement. Information technology integrated systems especially when operating in a physical isolated environment such as a ship, require a lot of attention and care. This is the reason why the IMO gave specific guidelines in a threefold manner. The first document is a summary of the distinct yet interconnected criticalities introduced by IT and OT systems. The second document emphasises on controls required in order to maintain a combined and cyber safe environment on a vessel, making ISO 27001 controls and standards, required for every vessel. The third relates to the acumen that the NIST framework brings into the everlasting care of cyber safety onboard, thus making more than clear that onboard cyber safety goes beyond the CIA triad vectors of safety. All the above serve as absolute technical and procedural guidance for Flags, Port State Authorities and Classification Societies, hence affecting owners, managers and operators.

Following the above, IMO issued Technical Note 24-2017 (IMO, 2017) making their intentions even clearer, clarifying that this is a mandatory requirement. It is henceafter made clear that of from the first revision of the Document of Compliance of a vessel, after 01/01/2021, cyber risk management of IT and OT systems of identical importance to minimizing physical risks, such as fire. Moreover, the IMO defines the criticality of IT and OT systems being interconnected "As technology continues to develop, information technology (IT) and operational technology (OT) onboard ships are being networked together– and more frequently connected to the internet. This brings the greater risk of unauthorised access or malicious attacks to ships' systems and networks. Risks may also occur from personnel accessing systems onboard, for example by introducing malware via removable media" (IMO, 2017).

Flag administrations have already included the above in their audit procedures. For example, Liberia like all prestigious flags, already included cyber safety as part of the audits on their website, reproducing as best practice all the above requirements given by the IMO. Therefore, as is the case with any mandatory requirement of the ISM code, especially in the area of security, Port State Controls are also expected to request evidence of compliance with the ship's IT systems and practices, at a cyber safety level, included within their inspections, and as time goes on they will become more demanding.

The International Ship and Port Facility Security Code (ISPS) and International Security Management Code (ISM) detail how port and ship operators should conduct risk management processes. By considering cyber risk as part of these existing safety management systems, ports raise the awareness among the shipping community, and force the operators to be conscious about cyber risks. According to the regulation, Member Governments are encouraged to ensure that cyber risks are appropriately addressed in their safety management systems, no later than the first annual verification of the company's Document of Compliance after 1st January 2021. Potential compromise of the systems due to cyber exposure may cause operational, safety or security failures with hazardous consequences.

In April 2017 the Oil Companies International Marine Forum (OCIMF) published the 3rd version of the Tanker Management and Self Assessment (TMSA). Shipping companies operating tankers are forced to comply with TMSA as a business requirement for the industry, to get chartered by oil majors. The 3rd version of TMSA was to be met until the 1st of January 2018 and included two cyber safety related chapters (OCIMF, 2018). According to Element 7 (Management of Change) and Element 13 (Maritime Security), operators are required to have procedures on software management, guidance on how to identify and mitigate cyber threats, compliance with latest guidelines on cyber safety from industry and classification societies, cyber safety management procedures and a cyber safety plan which can be shared with staff to promote cyber awareness.

The IMCA (International Maritime Contractors Association), which represents the majority of contractors and production chains associated with the offshore maritime construction industry, and whose main goal is to assist organizations to prioritize the defense against the most common and most damaging current attacks on OT and IT infrastructures, has also recently updated its recommendations regarding cyber threats, which are included in the guide, Security Measures and Emergency Response Guidance (IMCA SEL 037/M 226, 2015), consisting mainly of 20 controls and sub-controls focused on various measures and technical activities.

We will soon see practices for bulk carriers similar to those of OCIMF's processes, where cyber safety in terms of infrastructure and management is an integral part of the vessels safety (DBMS, 2020). Furthermore, the European Union with the Directive (EU) 2016/1148 is concerning measures for a high common level of security of network and information systems across the Union from May 2016. The instructions include EU ports but not vessels (European Parliament, 2016).

OT systems onboard vessels are not isolated anymore. In case of a potential breach, the network architecture that is implemented on board may guide the threat to other critical components. Every ship is designed with a unique OT systems architecture that can change along her lifecycle. It is important for the shipping company to create a holistic approach of the IT environment, and hence protect and govern OT systems architecture, being aware of, proactive at and reactive from, the impacts in case of an exploit.

Hence all onboard cyber safety solutions must be designed to address IT architectures as a priority. It is a common practice after a malicious attack on the IT systems to block all suspicious activities by shutting down the systems. However, adopting the same approach in regards to the Operational Technology infrastructure can have hazardous consequences. When addressing the security of OT, the intrusive solutions applied in IT systems, do not fully guarantee the safety and continuity of the OT installations. The judgment of a detection system, as either false or positive is able to boost the mitigation of an attack on IT systems but is most likely to cause significant errors by shutting down bidirectional interoperability with OT systems. Thus, resiliency and redundancy of information technology systems is of vital importance, in order for the shipping company to be able to bring all onboard infrastructure to the clean a state, similar to the one prior to being compromised.

2.8 Onboard internet of things

The Internet of Things can be used in nearly every area of applications such as smart cities, scientific studies, energy optimization, natural disaster prediction, agricultural, manufacturing, retail, construction applications, transportation, trade, public sector, health care and security applications. The manufacturing and transportation are the industries that have mostly utilised IoT applications (IDC, 2017). Anything in the supply chain, can be monitored in real-time through IoT technologies providing transparency, flexibility, higher responsiveness, cost reduction, safety and interoperability for all actors in a supply chain.

The Internet of Things (IoT) has inspired many innovative applications the supply chains so far and is expected to have major systemic influences on the future of supply chain management as it envisions a global infrastructure of networked physical objects providing operational transparency. Despite the perceived advantages of IoT, the maritime industry has still not widely adopted IoT solutions, even though they are the most adopted technology among the technologies discussed in this thesis. The ideal IoT set up requires that each IoT object has its digital identifier (Gershenfeld et al., 2004), while all IoT objects create a grid networked through information technology infrastructure (Kortuem et al., 2010), and the goal is to create a network of devices that represent infrastructure facilitating the easy exchange of their state and related information (Liu and Sun, 2011). IoT has been applied by enterprises to assist in the collection of real-time, on-site information, and has successfully improved and promoted operating efficiency.

According to technology giant Oracle the Internet of Things (IoT) describes the network of physical objects, devices and systems namely “things”, that are embedded with sensors, software, and other technologies for the purpose of connecting to exchange data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. In a nutshell, the

Internet of Things is the concept of connecting any device to the internet, via a local network or directly, to other systems and devices, in a way that a grid of connected devices is created, aiming to collect and share data about the way they are used, their state and the environment around them. Providing that vessels need to carry a standardised information technology ecosystem onboard to be compliant with cyber safety regulations, "IoT for vessels can hereby be defined as a set of sensor systems/devices installed across various equipment/devices on the vessel, connected to the vessel's information technology network, producing live vessel data through the internet, to be harnessed and analyzed by the company's systems, enabling ship owners/managers/operators to deal proactively with their fleet."

As per examples of other industries, devices and objects either with built-in or embedded electronic sensors are directed to an Internet of Things platform, operated by the stakeholder who is interested in their behavior. The platform has the ability to integrate data from the different devices and has the capacity to apply analytics, to share the most valuable information with applications built in this platform to address specific needs. The applications designed for the stakeholders using the platforms, can pinpoint exactly what type of data is useful and what can safely be ignored. Harnessed data can then be converted to information furtherly used to detect patterns, make recommendations, detect possible problems before they occur and hence, act.

In order to give a real life example to the reader, suppose that you are driving and the engine light comes on. Should you go to the garage or is it something you should not worry about? At car with IoT connectivity would not have only triggered the engine light, but would communicate the data resulting from the observed error function with a component called the diagnostic bus, which collects data from such sensors and passes it to a gateway in the car, which in turn sends the most relevant information to the manufacturer's platform. The manufacturer's platform, though applications and systems created for the certain type of error or its category, will harness and analyse the data from the car and identify the criticality of the error. The manufacturer would then contact you explain what was observed and offer you an appointment to get the analysed issue resolved, possibly send you directions to the nearest dealer, and make sure the correct replacement part is in ordered and in place at the dealer, so it's ready for you when you show up.

Think of the above analogy for a vessel. Sensors may be giving data on the state of equipment and machinery which are not rare occurrences for ships sailing the high seas, and they often result in costly downtime. In the same sense the onboard ICT ecosystem at which the sensors are networked to, which in turns provides safe connectivity, will act in a similar manner as the gateway in the car, send the data in a similar way to the platform operated by the owner, manager, and thus decide about the importance of the transmitted error data, convert it to information and help the stakeholders decide on what to do with the issue and provide direct and immediate assistance. Now imagine those sensors being connected to the vessel's IT network, and transmit though the internet data regarding the vessel's automation, propulsion, power management, heating, ventilation and air-conditioning systems, and having platforms that integrate all information with the navigation and auxiliary systems. Onboard IoT devices and sensors can prevent issues, by enabling predictive maintenance, or condition-based maintenance, by continuously monitoring the actual condition of the equipment and machinery through sensor measurements, engaging stakeholders towards the right direction.

This proactive approach to technical maintenance gives owners, managers and operators a better overview of the condition of shipboard equipment and even cargo. By looking at patterns, trends, and KPIs they can detect any deterioration, predict a not desired outcome and then intervene well before something happens. Such an approach will ensure that machinery and equipment operate optimally at all times, lowering the risk of disruption to normal vessel operations. As per example, here is what can be achieved by the use of onboard IoT, amongst many:

- Remote Sensing: Ships will be monitored continuously from remote locations. Data will be collected autonomously by using remote sensor IoT networks. A robust onboard IT ecosystem with high transmission capabilities would be required for the shipping industry, distributing processed information to all interested parties giving them up-to-date insights on what is happening onboard.
- Predictive Maintenance and dynamic risk management: It's all about avoiding potential failure, and all of the consequences that rise in the supply chain. Imagine detectable and measurable potential failures, associated with dynamic risk management of failure by synchronising related data such as engine data, fuel consumption, running hours, with specifications against age of the asset for example. Such systems can even provide information of high valuable importance that can dictate exactly what is required to the in order to spend their time on maintenance and scheduling activities, in an efficient manner. Such systems will even be able to indirectly dictate the skillset needed on every vessel, according to the expected fail state of it.
- Condition Monitoring: This will be improved by analysing asset data and will be applicable to machinery such as engines, pumps, boilers and compressors. Sensors will help to monitor the machinery and give early warning of the need for maintenance. It will determine the condition of machinery and record data during operation.
- Energy Management: Ship energy management systems run on the basis of real time data, load requirements, power availability and machine performance to achieve the desired levels of efficiency. As one of the first data analysis endeavors of the industry, the gains are quite impressive as these systems distribute and balance ship and shore operational power.
- Performance Monitoring and Optimisation: Automation expands the capability of the control of machinery and vessel optimization, achieved by IoT data interoperable fundamentals. Vessel optimisation and efficiency, will be measured by combined analysis of onboard data and historical data in the current operating condition.

Bear in mind that since a vessel is operating mainly at sea, as an isolated entity, connectivity acts as an enabler for these new technologies by supporting the reliability and integrity of the data transmitted to shore through computational power. Iot driven applications may be capable of delivering key benefits, such as better performance, and improved reliability and safety. Remote monitoring and control systems on board is already a reality for many companies around the world. With the insights provided by advanced analytics and Big Data solutions, explained in the next paragraph, the power to make shipping processes in the entire supply chain of logistics becomes more efficient. The Internet of things and Big Data analytics, are only some of the aspects that will transform the way vessels operate.

2.9 Big Data analytics from vessels

In continuation to the existing paragraph, we must realise that there is a major reason why ships need to become more interconnected, with the aid of connected IoT devices. The shipping industry will face ever-increasing requirements for safety, environmental and efficiency performance beyond 2020 (DNV, 2014). All data generated from IoT systems, passed onto platforms to create valuable information, can be of highly use at competitive future environment in shipping, requiring more efficiency, at a higher collaborative scale including as many interacting actors in the supply chain as possible.

Big Data as a general concept is used to describe large and complex data sets that are difficult to process and analyse using traditional data processing techniques and applications (Lloyds Register et al, 2015), as Big Bata refers to the collection and contextual analysis of significantly large collected structured and unstructured data, brought together to generate a broader level of operational hidden insights (Hassanien et al., 2015). As generally understood and explained by the information technology market Big Data are considered too big in terms of volume, they are generated in a fast manner, from various unconventional sources, move too fast, they do not fit the structures of existing database architectures. In general, Big data is data exceed the processing capacity of conventional database systems. Alternative ways of processing are required to make any kind of valuable information of them (Hassanien et al., 2015).

Combining all markets currently involved in Bid Data generation and harnessing, their growth in volume in three years appears to be increased by 4300% ending 2020. During the time this thesis is written most technologically developing vertical markets, such as the maritime shipping industry falsely consider Big data analytics an area of study that is focused on relatively large volumes of data, while in the recent past the idea of data analysis was not even on any table. Big Data is not about gathering big amounts of data, it covers the process of analysis of various structured and unstructured data, from various interrelated operational actors in an any industry, so as to generate and discover information of hidden or not interrelated insights, providing trends, connections and correlations, giving a competitive advantage to the actors of an industry that make use of them (Lloyds Register et al, 2015).

Currently there are numerous stakeholders, such as shipping companies, forwarders, agents, solution providers, ports, brokers, charterers, cargo owners, compelled to accept the changes introduced to the maritime transport sector and turn to more effective and efficient practices by introducing technologies that can gather and process massive amounts of information, in a cost-effective way of course (Marshall University, 2019). Various actors involved in cargo transports, from origin to destination, are relying on the information provided by other actors involved in the supply chain. The more exact and thorough the picture and detailed of such information, generated by live transport data, the smoother the shipping operations are expected to be in total. The level of cooperation and coordination that is essential for the success of the logistics chain is starting to be future dependent on Big Data technologies (Voss et al, 2017). Hence, any inter or ntra-related decision from onboard generated data of global fleets can lead to several advantages such as increased safety, resource utilization, competitiveness, sustainability, and even optimized environmental protection (Heilig et al, 2017).

Numerous actors in the maritime shipping industry means a large variety of business procedures and interests, among which there are various interests in data types for the entire supply chain. Thus, a clear definition of the term “Maritime Big Data” does not exist, while in addition, the number of digital sensors in the maritime transport is also increasing. In dependence on the target market, maritime Big Data includes details of ships’ performance information to be harnessed for the benefit of all actors and stakeholders in the industry (Koga, 2015). Henceforth, for the context of this thesis and by taking into account the terminology and explanations given by the information technology industry, and specifically regarding the case of vessel generation data by their sources, Big Data for vessels can be seen as the large volume of data generated by fleets, both structured and unstructured, with the potential to create global platforms in which solution providers, ports, agents, brokers, charterers, cargo owners, ship owners/managers/operators and in general all actors in the industry, can concurrently rely on and cooperate at all common areas of operational interest.

The problem with Big data is the existence of non-traditional data falling within the high volume, velocity and variety of differentiated sources, along with the requirement to integrate for analysis, while in turn traditional data management and analytical systems cannot cope as they are based on relational and structured database systems, which are not designed for such high volume or heterogeneous in nature and operational interest data (Hassanien et al, 2015). For such reasons the latest trends from technology giants and innovative companies is to produce Big Data platforms that consist of Big Data storage and resources, such as data lakes, servers, various database technologies, Big Data management, business intelligence and other management utilities, which through custom development, are querying and integrating with various distributed data platforms, such as IoT platforms. Most provider efforts at the minute are exploiting the benefits of the cloud to provide all-inclusive Big Data solutions and services for all stakeholders involved in an industry. Still, even in our times, even in 2020 there are various issues that make the use of Big Data rather complicated and complex. Figure 4 shows such issues.

Figure 4. Obstacles to using Big Data.

- Data Quality: simply implies that data does not necessarily imply a better output. Up to date data scientists clear and validate data by spending 75%-80% of their manpower involved in the business (Hassanien et al, 2015). Data validation is required as poor quality data can result in misleading information.
- Consistency: It refers to how these values of various standardised or not metrics will be presented in order to generate meaningful information for the stakeholders involved.
- Data Reliability: What is the actual collection and method used to acquire data and related information and how were the data collected, be them hot, live data, or obsolete data, depending on critical constraints such as time dependence (Hassanien et al, 2015). Data reliability is related to quality and consistency.
- Data Availability: Relates to just in-time accessibility. For example, if sensors provide data for a measurement at a particular sample rate then the raw data would be accessible for a specific period of time, hence archiving or historical data must be available for collection and further analysis. Data availability and storage are parts of any Big Data platform.
- Linking Data: How are the data connected together. Usually, the data is collected for a specific task or purpose and might require different types of data from various datasets. If a single user accesses multiple datasets then primary and secondary keys are enforced to uniquely connect the data together, for the benefit of the interested actor in the industry.
- Data Presentation: How can the data be viewed to facilitate meaningful interpretation and depict the demands of the stakeholder using the Big Data platform. Poor data presentation could reduce the contextual meaning of information. Hence, Big Data presentation of different datasets is of high importance for efficient operations in the supply chain.
- Dataset Scalability: Essentially, it is the capability of a system to support any type of dataset. All datasets have their own structure, type, semantics and type of accessibility. The analytical algorithms applied to big data must have the capability to support increasingly expanding and complex datasets (Mao et al, 2014).

- Data Compression: Refers to the filtering of data to reduce the volume. The data generated from sensor networks generally contains a high level of redundancy. That data must be filtered and compressed to reduce redundancy.
- Data Life Cycle Management: How frequently at which rate and which data are to be stored or discarded. Big Data value is directly dependent on their freshness (Mao et al, 2014), while on the other hand sensor networked systems generate data at unprecedented rates and scales. Processing and storage are key issues for such massive datasets.
- Data Confidentiality: How safe and protected are the data and information generated from their primary source. Data may be analysed or shared with third parties increasing the potential safety risk. The data ownership and the confidentiality issues generated along need to be protected.

Suppose that the shipping industry generates and specifically the operating fleets generate a huge amount of data, be them from different sources and formats, such as traffic, cargo, weather, machinery, path, berth, safety related data, audio, video and so on. Now, suppose that the application of onboard sensor technology increases as time goes on, in the industry, producing higher volumes and varieties of data. What the industry needs to start thinking at the current era, since it is new to the field, is the adaptability and integration challenges due, associated with the endeavor of Big Data implementation in the shipping industry, the most important or which are summarised below:

- Data Transfer: Ships typically have a very large number of sensors onboard. A major cause of uncertainty comes from data transfer from those sensors, the communication bandwidth required and the onboard management of the information flow. It is important to have appropriate information technology networks dedicated to the synchronisation and communication for the individual sensors. A local vessel datacenter is ideal, as the data transfer speed needs may be locally regulated by the existence of datacenters and thus accelerated with the help of high throughput communication systems.
- Cybersecurity: Consequently, we reach again, the burning issue of data safety and security of the onboard data network, data management and transmission. It is vital for the future shipping (Lloyd’s Register et al, 2015). Cybersecurity will be the key issue for any naval system to prevent disruption in maritime security. A cyber disruption of any kind on the onboard sensor network could be responsible for significant losses in the business, as expected in the near future.
- Data Quality: Low-quality data would potentially lead to errors in interpretation, thus intra related databases will not be able to keep a meaningful track of all new entries. Data should be error free, which will soon be a concern for the industry.
- Data Integration: The current data collection systems in the marine industry are inconsistent and often unreliable (Lloyd’s Register et al, 2015). On a global fleet scale, data from different sources will need to

be integrated for analysis. For example, fuel consumption, GPS data and engine data would will be integrated to monitor vessel's performance and optimise throughput efficiency of cargo transport.

- Data Ownership: Ownership allows for the right to perform operations such as new, updated and delete entries in databases, along with data lifecycle management (ISO, 2015), which is of critical importance as the supply chain of the shipping industry is based on various heterogeneous of nature, yet interconnected or even associated stakeholders including ship owners, operators, customers, port authorities, etc. While ports, brokers, cargo owners and ship operators will have access to the full set of information generated by global fleets, classification societies will get access to data for safety or classification purposes, port state authorities will be able to perform most audits in real time, while even the construction industry will be able to make use of data vital to the improvement of their designs. Ownership of data is crucial to the shipping industry and it will become more challenging for ship operators to distribute the data ownership and the level of authority in the future.
- Data Protection: Directly related to the integrity of information generated, as data will move between individual stakeholders' platforms because of different interests. Most data volumes though are of sensitive nature and must be shared with sophisticated privacy schemes in order to maintain information quality.
- Adoption and Management: The shipping industry will need to create an environment and awareness across the stakeholders, to adopt the differentiated philosophy of Big Data, the platforms and tools associated along with the processes and standards affected by its use.
- Human practice and connectivity: It is important to increase the efficiency of connectivity between the vessel and shore in shipping companies, through advanced onboard information technology systems and networks. The ship and shore personnel will be required to undertake additional training to provide support for this, as the use of Big Data, in terms of operational value, is extended far beyond an IT department or an IT manager.
- Business Model: Referring to a new necessity which is the model which will enable the business development of the industry, associated with the multidirectional transfer of knowledge and information, along with the transparency of data-driven systems.

Big Data disruption is tightly related to what is preliminary known as "ship intelligence" during our times, while the author debates that "shipping intelligence" will become another driver of the global "economy intelligence" being the driving force that will direct the future of countries heavily involved in the industry, like Greece. Currently for the Greek maritime shipping industry, Big Data appears as another buzzword. The IT industry is setting hype for it, driving false impressions to the stakeholders of the shipping industry, regarding the global harnessing nature of the information generated. From the author's experience, most false impressions regarding the understanding of the potential, are derived from the IT market itself, as the IT market focuses on the technology, rather the potential operational capacity enhancements onto vertical industries such as shipping. Still, the shipping industry is producing a vast amount of unstructured, diversified and unmanaged data, a trend that naturally needs to evolve towards Big Data exploitation, where the analysis and management are expected to have a great impact in the maritime industry (DNV, 2014).

As Big Data analytics will have the potential to increase the vessel optimisation, asset utilisation and performance overall, maintenance, navigation and communications managed by onboard data analytics connected to onboard and onshore decision support systems will enhance the effectiveness of overall logistics operations and as per example, the future of Big Data in the maritime sector might include amongst many, the below cornerstones of connectivity that will eventually allow for a Big Data era:

- Voyage Planning: Operators, brokers and charters will be able to implement voyage plans by conducting route analysis, via pragmatic vessel performance, port and area congestion along with meteorological data, identifying the most efficient route, while port information correlated will provide more accurate estimations or arrival, loading and departure times, thus avoiding any delay or disturbance.
- Intelligent Traffic Management: Consequently to the above, port authorities will have access to the ship data for safety, and berth management. Moreover intelligent systems feeding Big Data oriented applications and platforms will provide effective and efficient tools for port state authorities improving regulation conformity audits, decreasing congestion, while improving cargo handling performance.
- Operational Predictability: Ship operators, brokers and charterers will gain the capability to predict the vessel performance based on a series of correlated historic and current operational conditions, from machine behavior all the way to onboard crew handling capacity and experience. This predictability will assist in making decisions on predictive maintenance, which will result in more deployment time.
- Environmental legislation monitoring: Take for example the fact that ship operators needed to comply with environmental legislations including the requirement to switch fuel in emission controlled areas i.e. the sulphur content of the fuel should not be more than 0.1% (IMO, 2015). The sad truth in the year 2020 is that there is not enough evidence that the goal has been achieved on a global scale as intended, while new dat -oriented regulations are coming in to force in the EU, clearly affecting Greece, to monitor CO2 emissions, implying systems able to give an indication of fuel switching, as well as monitoring the current emissions. Ship operators need to collaborate in Big Data platforms under the above scope with the IMO, in order to show up to what extend the goal has been achieved and make sure that they all follow interactive KPIs.
- Vessel Safety and Security: Again, IoT sensors and extensive connectivity will increase vessel safety. Sensor data analytics can provide information on vessel state to avoid disasters, and thus make reaction mechanisms from local authorities faster and more efficient. On the other hand, such an achievement can indeed be of great use to P&I clubs and insurers. Vessel safety and security will be increased by the adoption of such analytical systems extending safety even to states and civilians.

- Automatic Mode Detection: As complicated as it may sound, the auto-mode detection concept means that no human intervention is required to come up with a standard decision regarding, for example, fuel consumption for the individual engines, ship running hours and emissions. Pre-set modes known by the staff onboard and shore members will be used to provide rapid adoption to different operational KPIs required depending on the geographic region of operation. Imagine that the goal here is to make sure that regulations such as the EU MRV regulation, will always be met on board, for different vessel modes.

2.10 Augmented reality for vessels

Augmented reality denotes a technology, where digital content is combined with real vision and objects – e.g. by mixing computer generated content with a live video stream of a scene. In essence, Augmented Reality provides real time, bidirectional away-to-field information exchange in the form of text, graphics, audio and visual elements, integrated within the optical view of the person in the field, by wearing a set of special glasses, making remote view, inspection, assistance, and knowledge transfer, direct and immediate without the need of the away expert to attend and physically inspect the field of operation (Azuma 1997). Augmented reality is not just a machine providing virtual reality content, but it combines natural with digital experience along with the interaction between the objects of both worlds made possible in real time. Perhaps no other technology has the potential to revolutionize so many tasks.

This technology can be extremely useful to support a ship crew with its limited resources and competencies by an assistive system for repair or maintenance operations. Even though there are numerous clean and well-lighted situations, were remote intervention of visual and audio elements in the field is ideal, augmented reality is still in an infantry phase in Greek maritime shipping, recently boosted by the recent COVID-19 pandemic. Even though the term of Augmented Reality is one of the most abused during our times by the IT market, the author recalls the technology's original orientation dated back in the decade of 1990's (Azuma 1997), and emphasises on a description of operational necessity, mainly due to recent COVID-19 practical issues introduced in the industry.

During our times and due to the chaotic promises of the IT business, one must understand Augmented Reality as a newly introduced tool that enhances onboard Decision Support Systems (DSS), developed and modified to assist the operator during a challenging condition, be it just the fact that maintenance is required, yet the engineers carrying the expertise cannot be onboard in time, at all times. Yet through guidance and real-time understanding of the situation can lead to a positive outcome, providing that a capable enough officer onboard is directed by the person carrying the expertise from shore. Augmented Reality, can in fact share human senses such as vision, hearing back and forth, and most importantly it carries the capacity to mix onboard reality with the virtual content required and projected by an expert from shore, so as to make the right decision, and action are taken exactly when needed in time.

Another concept that needs to be understood is the concept of Field Service (FS) and Field Service Management (FSM). It is the intention of this thesis to underline the inter-connection between FSM, the concept of Decision Support Systems and Field Service Management, help the reader understand how can Augmented Reality can impact the onboard service, inspection and maintenance processes. Field service management (FSM) refers to the management of a company's resources employed en-route to the property of interest. Examples from other industries include managing field service activity, dispatching work procedures immediately on site through guidance, ensuring safety via experts' inspection, and integrating the management of such activities with inventory, billing, accounting and other back-office systems. Field service management and the tools associated with it provide gains to the operator, by enabling cost-efficiency.

According to Robinson (2018) the Field Service Management divides into six categories. Figure 5 shows all items that are part of each category and they will not be handled further in detail, as their analysis is beyond the scope of this thesis. The basic principle is that in each of the six categories there are several different applications that are applied to these specific tasks. The six FSM categories that Robinson (2018) presented in the below figure are there so the reader can understand the characteristics of each phase. This thesis will cover the necessities of phases related to field service and operations in shipping, as repair maintenance and inspection calls could be an emergency-natured. Visits on a vessel site also cause specialties to arrangements compared with in-house procedures. We must acknowledge that in essence field service is logistics operation. It needs to have schedule and resources at the right time and place.

Field service processes including inspection and preventing maintenance along with the repairing of the malfunctions require human resources, which are limited. The common conception is that the field service process roughly consist of six timely separate phases. 1. Service request 2. Work planning 3. Enablement, including travelling 4. Actual work at a customer and debrief 5. Operations such as complicated invoicing of the travel expenses and utilisation 6. Reporting to company systems.

Technology enables employees and customers to achieve customization and flexibility, improve service recovery, and provide spontaneous delight (Agnihothri et al, 2002). In practice and in the shipping industry which is somewhat suffering from precise record keeping of expenses and time vs material and resource usage, the influence of technology on service quality, is still not known well, but it can be safely assumes that these values correlate positively for the shipping industry too. Field service, inspection and maintenance are important in critical systems and assets, even more important than issues of a price and quality. Some service providers and manufacturers have recognized that improving field services, it is possible to increase market share and make sales more profitable (Blumberg, 1994).

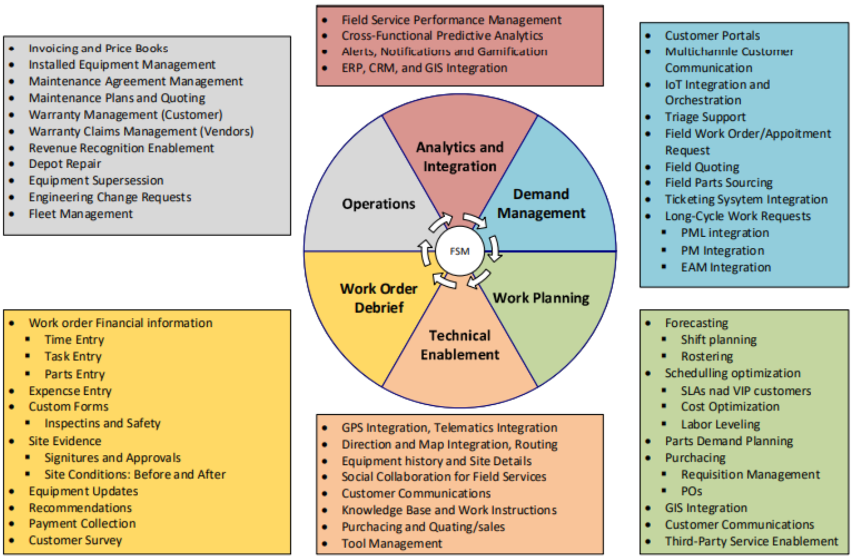


Figure 5. Overview of the FSM categories and functions – Gartner.

In a vessel environment as per Agnithorthri (2002) has described, field services can be divided into four categories. 1. New building operations 2. Maintenance 3. Repair 4. Inspection and operations scheduled in advance. Maintenance and repairing on board are diverging considerably from other targets. Ships are operating at all seas around the globe but the of operational difficulty is that ships may stay weeks on waters even in times were intervention is necessary but the action to rectify and issue is deemed as seldom as entering on the board on the waters is a complicate procedure that no one in the industry seems to be willing to invest, with the latest parading being the crew changing issues that rise due to the COVID-19 pandemic. If the waiting time of a risk extends too long, the consequences may be of tragic nature as the capacity to send experienced people to solve problem an on-site shown negligible probability in practice. Similarly, distances cause inefficiency to the use of specialised personnel, while in most cases travelling consumes a significant part of the expert's deployment time instead of on-site working, while experts need to be deployed in a more sophisticated or advanced manner, to provide as many iterations of preventive maintenance and inspections as possible.

The initiations of maintenance operations are based on scheduled program or alarming and time sensitive information collected and communicated from the scene, which is in fact not very efficient. We may take for example the technologies associated with diesel engines onboard, which are not easily changeable. The shipping industry is driven by a perception of reliability and maintenance quality as a factor in the vessel acquisition which drives future decision-making in the operation phase of a vessel's lifetime, which in turn conflict with total quality measures in the filed such as productivity, quality and speed. In addition, not caring to evolve these measures can have an indirect financial significance, even though quality in field operations in shipping is defined by the availability of resources, time management and downtime duration, with the most important quality performance indicator being downtime. What is even most important is the fact that Field Service Management downtime is divided into response time and on-site time (Agnihothri et al., 2002;

Blumberg, 1981), while in emergency situations the response time is what's of critical nature. Although one may argue that traditionally, engine maintenance is a normal field service type of standardised operation, there are circumstances where the need for first level service is so critical, leveling itself up to emergency, especially when it relates to a possible breach on the risk management plan. Hence, regardless of the situation, the response time matters.

In shipping, as practiced so far, the service output is as much dependent on the operator's perception of service performance, as stated on the company's documented safety management activities. Blumberg (1994) noticed that in productivity and quality improvements in services, operators have to focus on both internal operational excellence and external to the field direct and enriched communication. There are numerous times that the industry has claimed poor field service quality due to missing, outdated or inaccurate information, leading to extended maintenance times, lack of proper spare parts made available, even decisions to send a man on-site, not cut for the actual problem. It is obvious in shipping like in any other industry, that the better and more detailed problem is seen and described, the better the nature of the response quality can be.

As it is a managerial decision to balance between fleet operational efficiency and productivity, resource and specialty utilisation along with minimising response times and expenses for too many technologies involved in a vessel's operation, it is made clear that Augmented Reality can only have positive uses onboard, as it rectifies essential negative metrics in actual field service such as response time, trouble shooting, problem definition and resolution time, along with first line and on-time onboard guidance, inspections and audits. Augmented Reality has the potential to help the maritime industry for every reason discussed above, from maintenance, to remote assistance as first level support, to immediate diagnostics, to work tasking, to training, even at the level of inspecting and auditing. Bear in mind that due to COVID-19, classification societies rushed to deploy Augmented Reality and are integrating it to their portfolio of services. Moreover, flag administrations are continuously adopting Augmented Reality for the above purposes due to the pandemic.

Augmented reality systems allow information to appear in front of the user's eyes increasing the bidirectional awareness of the officers' and the experts ashore. One of the competitive aspects of Augmented Reality, is the management on the level of information technology. Any result, mixed reality results obtained through Augmented Reality equipment can be exported and stored on information technology systems for further reference, giving the technology a rightful potential to be of use in all operations. Augmented Reality enhances situational awareness onboard:

- The crew can be easily guided to recognise parts and equipment decays on time and perform actions so as to minimise them.
- Maintenance assistance for machinery with guided steps and tasks.

- Check-list control and inspections where the report is the actual visual outcome of the interaction of the inspector with the crew.
- Daily tasks and reporting of officers to shore, where again the report is the actual outcome of the augmented interaction.
- Real tine video reporting with statistical analysis.
- Remote assistance from the shore experts with the collaboration of IT and Technical Departments.
- Training in advanced technology equipment on-site.
- Bridge systems integration with the Augmented Reality platform.

As shipping gets more complicated, the onboard skills are getting more complicated along. Henceafter, as far as the crew is concerned, there is a rising need of skills, while on the other hand competition demands for cost cuts. It is well fictitious to assume that the onboard staff have the capacity to carry deep operational understanding of every new technologically advanced equipment new to operators and to seafarers. The need for training of course is what an operator will seek first, but especially in terms of engineering for example, training is not enough, as engineering practice demands at least first level support practices. Deck and engine officers could be turned to “jacks of everything and masters of nothing” as there are too many manufacturers while there are frequent changing rules and regulations coming from the IMO, which are mandatory by nature.

In the past onboard know-how was just a matter of onboard staff competency. But, with the continuous regulatory changes and the modernization of vessels, a great challenge arises. Onboard staff except from being competent in their field, must become good followers of the onboard technologies so as to be able to check, inspect and service, with the aid and guidance of an expert. In terms of Field Service Management values, as projected on fleets, Augmented Reality has the potential to provide optimum levels of service management, though the live bidirectional interaction of the expert ashore and the ability given to staff onboard for follow up. Seafarers may be overwhelmed by digitalisation, but the industry’s real needs are digital maritime services that will provide additional motivation, easily assimilated into onboard operations, able to assist in a real-time manner.

Technology providers need to revise the hype given to Augmented Reality, see the real usability of it as a tool in the value chain of the shipping industry, while maritime operators need to understand that good training for onboard technologies need to drastically change before they can make effective use such a technology. The shipping industry has a traditional, more conservative approach to the operation of ships. New technologies have always been regarded with skepticism, and training is more attractive to them when it follows a ‘hands on’ method of dealing with situations. The future is somewhere in between as practice shows, and Augmented Reality shows very promising signs in dealing with situations and practices on board like never before. On one hand, shipowners are financially orientated and driven by cost, and every new investment is made according only to finance and the requirements of current legislation. Augmented Reality technology is very new and presumed as expensive. Currently, few companies are using it, but the practical demand should be very high, once the industry understands its merits.

Extending the usability to the classification societies' side remote surveys can be used for a range of classification surveys and specific statutory items agreed on by Flag Administrations. For example, Bureau Veritas has already started to operate Remote Survey Centers, bringing remote surveys to owners worldwide. Bureu Veritas has even extended the concept by issuing electronically signed e-certificates once the remote survey has been conducted, and surveyors have evaluated a ship's compliance, providing a disrupting and entirely digital experience from end to end. As Classification Societies are pushing forward, the shipping companies will eventually follow. It is henceforward clear, that Augmented Reality can transform the onboard operations and interventions in the shipping industry, while most applications discussed so far are of obvious nature, from training, to maintenance, to field service management, to providing and acting upon alarming diagnostic information, through remote support to engineers at sea in bidirectional communications with operations centers of operators. Certainly, Augmented Reality can provide improved awareness and decision-making support.

2.11 Distributed ledger technologies

The majority of stakeholders in the shipping industry operate with extensive manual handling of documents, including the Bill of Lading, Customs declarations, and the Certificate of Origin. In particular, contracts about goods to be carried from one country to another, systems of trust, ownership and verification are invaluable. It is particularly important to understand that in the shipping industry, where contracts are of international nature and parties are unknown to each other, while a sea of perils stands between the importer and the shipper, the B/L acts as a verification that goods have been shipped and it is one of the most important logistics systems to date.

This tool of international shipping has resisted change where other solutions and systems were innovated. As archaic as the traditional, paper-based bill of lading system can be, its functionality cannot be replicable over the internet by forms and most of electronic bills of lading techniques so far seem to be suffering from not evolving or strengthening or even meeting its functionality. However, emergent technologies such as Distributed Ledger technologies, as part of blockchain technologies, present a viable disruptive way to replace the paper B/L. Distributed Ledgers appear to solve numerous industry issues, so the primary question is not if this blockchain sub will transform the basis of the most important contract of carriage in shipping, but when will this occur. In fact, the most important question is whether this technology warrants regulation and, if so, in what respect? Without clear regulation upgrades towards blockchain-based sea carriage contracts, there are serious uncertainties ahead.

Regarding Distribute Ledgers and their use in logistics there are many publications, which show praise for this technology. Marc Andreessen, the founder of Netscape and Andreessen Horowitz call it “the most important invention since the internet” (Tapscott & Tapscott, 2016). The Harvard Business Review has well mentioned it through its articles (HBR, 2017a, 2017b). The Director of MIT Media Lab has stated that “blockchain is to trust as the Internet is to information. Like the original Internet, blockchain has potential to transform everything”, while the founder and president of the US Chamber of Digital Commerce stated that “Blockchain technology has the potential to revolutionize industry, finance, and government” (Tapscott & Tapscott, 2016).

Blockchain technology was added to Gartner’s Hype Cycle for emerging technologies in 2016 and is thought to “enable entirely new business models, driving a platform revolution” (Gartner, 2016a, Appendix 1). The plateau for this technology is said to be reached within five years and in 2017, blockchain has been placed as one of the top 10 strategic technology trends that “promises a model to add trust to untrusted environments and reduce business friction by providing transparent access to the information in the chain” (Gartner, 2017b). As many different definitions exist in the public press, the author has decided specifically adjust for Bills of Lading, which will also serve the purpose of the thesis assumptions using academic reference. Blockchains as self-governing decentralised information infrastructures that mediate the exchange of cryptographically verified and immutable information in permanent blocks of data, leading to a tamper-proof system with revolutionary applications within information systems (Mougayar, 2016).

Extending the above, when data are transferred across a Distributed Ledger System, each transfer of information is represented in the form of a block being added to another chain of blocks and in order to be verified, a mathematical computation is solved while the proof of this computation is distributed across multiple nodes. The information on the blockchain cannot be deleted or amended, it can only be appended (Levin, 2014). As a result, the authentication of the identity of the transferor always remains accurate, and the records that represent that piece of data are immutable. The technique contains all the history of every token in circulation, thus providing proof of who owns what, at any given juncture through a chain of notarised appendages. Application of Distributed Data Ledgers to maritime shipping logistics means that Distributed Ledgers can be used to record cargo in the form of tokens, which can guarantee the uniqueness of each record. Furthermore under the same principles the shipper presenting the cargo to the carrier, can sign off on the transaction and record the description of the goods, whether the bill records are being recorded, along with any other relevant information, such as the identity of the consignor and consignee, or the appointed intermediate bank.

This set of transactions is broadcasted and it appears raw and unprocessed until it is chosen by the selected 'miners' from a pool of transactions chosen form a solid unconfirmed block. Stakeholders add this unconfirmed transaction to their own blocks, forming in total a large number of blocks, directly related to the number of stakeholders. When the transaction is verified by all, it is then added to the ledger, with the aid of a key, which, as previously mentioned, is created by solving highly complex mathematical problem. The transaction is recorded on the distributed ledger and the tokens would be issued to the shipper in exchange for payment on the carriage contract. The shipper would then have the possession of the tokens, and most importantly the ability to transfer them to any buyer through a sale contract and in accordance with the terms of the carriage contract. The shipper would no longer have access to those tokens but the buyer or assigned bank will. Any interested party, like a bank have the ability to observe the immutable history of the tokens' transfer. Finally, when the goods arrive at the port of destination as indicated in the carriage contract, the carrier can confirm the delivery of the goods to the person whose public key matches the key of the latest recipient of the tokens generated on the events recorded in the ledger. Supposing that the ship is equipped with IoT, the state of the cargo can be verified or not, as it represents another set of records forming the block of information in the blockchain. The outcome achieved through this method is equal, yet less cost effective and less susceptible to fraud to the one currently practiced through traditional B/Ls.

Henceafter it is safe to state that Distributed ledger technologies for vessels can be applied for the creation of more securely owned, securely accessed, decentralised, securely traceable, securely transferable and immutable versions of bills of lading and contracts of carriage, compared to their current printed formats. The main characteristics of this technology have already been identified by several authors (Seebacher and Schüritz, 2017). Based on the work of Seebacher and Schüritz (2017) two key features of blockchain technology are initially identified, namely its decentralised nature and its trust enabling feature, and its decentralized nature facilitates the creation of a private, reliable, and versatile context in which users operate. The combination of the ability to secure peer-to-peer users interactions by utilizing cryptography and the fact that the users' identities are covered by pseudonymity, enables a high degree of privacy for users (Nakamoto, 2008; Seebacher and Schüritz, 2017). Reliability is enhanced the technology's decentralized nature by the creation of a reliable environment for users.

Since this technology is built on data and computer code, it is feasible to apply automation in the form of smart contracts, which automatically enforce the conditions defined in the transactions, like for example enabling conditional payment (Beck et. al., 2016; Sharples and Domingue, 2016; Weber et. al., 2016). This might reduce individual mistakes as there is little room for manual interventions by, for example, employing smart contracts to digitize procedures that rely heavily on paperwork (Guo & Liang, 2016). Moreover, the predefined rules ensure that there is no double spending and invalid signatures, thus guaranteeing the validity of the data (Seebacher & Schüritz, 2017). Once a new transaction has been added to the ledger, no party can modify or change the data (Cucurull & Puiggalí 2016; Morabito, 2016). If one or more blocks in the ledger are tampered with, the solutions to this computational puzzle will vary from user to user alerting all the participants that changes to the blockchain have been made. This means that the users will be prompted to revert back the changes caused by the manipulation, therefore, preserving the immutability of the system (Seebacher and Schüritz, 2017).

Blockchain and its potential solutions have just recently gained interest in the shipping industry. In March 2017, the shipping giant Maersk partnered with IBM to develop its own blockchain solution aimed at digitizing global trade. Furthermore, inspired by this initiative, other established industry actors have also begun to form partnerships of their own or join industry wide consortiums hoping to reap the promised benefits of blockchain technology (Bajpai, 2017). The IBM's press release for the announcement of their blockchain initiative stated that the solution had the potential to "vastly reduce the cost and complexity of trading" (IBM, 2017). Indeed, the processes involving international shipments of goods by sea are complex since they involve a large number of organisations and people, including a network of shippers, freight forwarders, ocean carriers, ports, and customs authorities. Moreover, this results in a substantial amount of physical paperwork since the procedural requirements related to the movement of goods across the world may vary greatly from country to country (Bajpai, 2017).

In addition to the greater administrative costs and shipping times caused by the complexity of international trade, the maritime supply chain is also susceptible to fraud, especially in emerging markets, as well as being vulnerable to cyber-attacks (OECD, 2014). Indeed, the World Economic Forum estimated that corrupt practices increase the cost of doing business up by 10%, consequently reducing foreign direct investments (FDI) in corrupt countries (OECD, 2014). In response to these issues, Maersk and IBM claim that their solution can digitize the end-to-end supply chain processes and help "manage and track the paper trail of tens of millions of shipping containers across the world" (IBM, 2017). Firstly, a blockchain system has the ability to place shipping documents on a shared ledger which enables the parties involved in the transportation process such as the: exporter, importer, freight forwarder, carrier, port, and customs authority, to view the entire progress of the shipment. Furthermore, blockchain's inherent immutability allows the real-time exchange of documents while making sure that they have not been tampered with (Bajpai, 2017). Consequently, Maersk and IBM claim that this new degree of transparency in operations would speed up the industry's business processes and improve inventory management, further cutting down frauds, costs and delays and is also thought to reduce the threat of cyber security since it is extremely resilient to hacking (Fürstenberg, 2017). Finally, a more ambitious and far reaching promise from the IBM-Maersk solution is for a greater inclusion of developing countries in global trade, lowering the cost of transportation, already claimed by the World Bank as a trade barrier. (Bajpai, 2017; IBM, 2017; World Bank, 2002).

The shipping industry is heavily regulated by both the EU and the International Maritime Organisation (IMO). In July 2016, the IMO implemented the Verified-Gross-Mass (VGM) regulation as part of the SOLAS treaty (International Convention for the Life and Safety at Sea), requiring shippers to report a container's VGM to the terminal operator or carrier before loading it onboard a vessel (Hellenic Shipping News, 2017). The logistic technology company Maritime Transport International (MTI) saw the opportunity to develop a blockchain-based solution to facilitate the compliance to the new VGM requirement, creating "a streamlined, visible and verified data flow between all parties required to report and send this data" (Baker, 2017). In addition, various port authorities have already begun work on developing their own blockchain-management platforms to remove paperwork and improving operational efficiency, similarly to the IBM-Maersk initiative (Chambers, 2017; Alper, 2017). Having provided the necessary background knowledge, the theoretical foundations serving as a basis for the value added from Distributed Ledgers and its perceived value in the Greek shipping industry, will be further examined.

3. Theoretical foundations applied on research

3.1 Technology adoption lifecycle, adopter profiles and the chasm

Innovators, Early Adopters, Early Majority, Late Majority and Laggards, are the 5 groups that consumers can generally be divided in, a concept explained since 1962, where the sociologist E. Rogers published the book "Diffusion of Innovations" in which consumers are classified in groups with different buying habits. Today, the model is better known as the Technology Adoption Life Cycle and describes the adoption or acceptance of a new technological product or innovation, according to the characteristics of these five distinguished adopter groups. The theory was further extended by G. Moore (1991, 1999, 2014), in order to successfully target the mainstream of consumers.

The Technology Adoption Life Cycle is a bell curve and its divisions are roughly equivalent to where standard deviations fall. Innovators are about 2.5% of the total population, early adopters are about 13.5%, early majority and the late majority are both at 34%, and the laggards fall under the remaining 16%. Each group represents a unique psychographic profile where its marketing responses are different from those of the other groups. By understanding their differences and by examining the characteristics of the responders we can identify the psychographic profile of the Greek shipping industry against certain innovations discussed in this thesis.

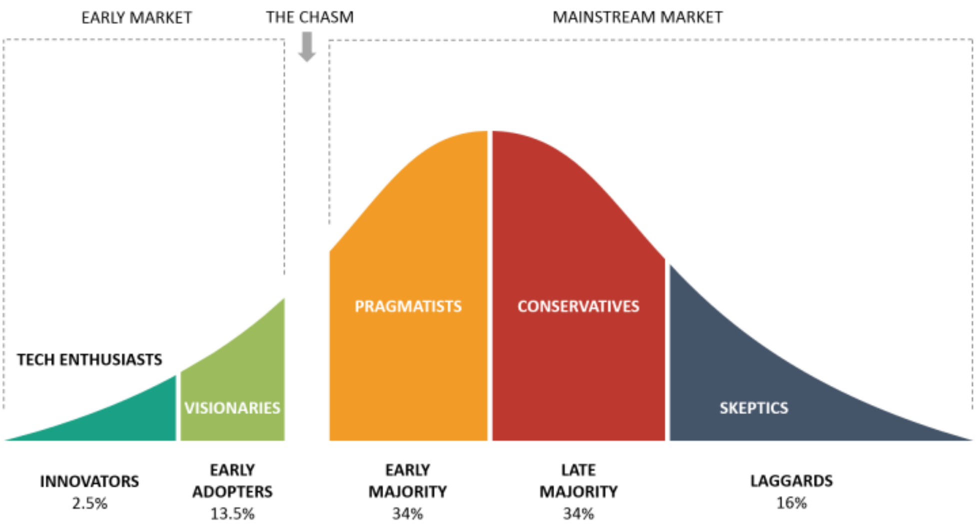


Figure 6. Technology Adoption Life Cycle. G. Moore.

Innovators are the first group of people that are likely to invest in a technology, since they aggressively pursue new technology, as technology is a central interest in their business, regardless of what function it is performing and in any given market segment and they are usually not willing to pay a lot for new adoptions. Finding them though and collaborating with them is important as their endorsement boosts further adoption, while they server as a test group in order to make the necessary modifications before going mainstream. Early

Adopters, unlike Innovators, are not technologists, but visionaries looking for a revolutionary breakthrough. They are willing to take high risks and are highly demanding and do not rely on well-established references in making buying decisions, but prefer to rely on their own vision and execution. Most importantly, they are willing to serve as highly visible references to other adopter groups, since Visionaries are good at alerting the rest of the groups, which makes them very important.

The first two groups belong to the early market. In order for an innovative technology to become successful within a market segment, the mainstream market must be taken over, starting off course with the early market. The early majority are pragmatists who can relate to the early adopters vision of technology and are driven by a strong sense of practicality, so they are content to wait and see how other adopters are performing before they buy in. They want to see well-established references before investing substantially. As they are the initiation of a group of 34% in the market, winning them is fundamental for any business producing innovative products and services. Following the early majority, the late majority adds up to form the mainstream market of about 34% of the total addressed market population. Compared with the early majority they have one additional characteristic. They believe more in tradition than in progress and they appear less comfortable with their ability to handle a new technological product compared with the early majority. As of their conservative nature, they prefer to wait until a technology has become an established standard and invest at the end of a technology life cycle, where the new technology appears to be well established.

Another characteristic of their conservatism is that they wait to structured and thorough support in the technologies they adopt and buy from large, well-established companies only. Finally, the Laggards are the remaining of the population and in general they simply don’t want anything to do with new technologies or disruptions. They are far beyond the conservatism stage and are bordering on denial, buying a technological product only when it is buried deep inside an asset they are bound to acquire in order to proceed with their business as usual. They believe that disruptive innovations rarely fulfill their promises and bring unintended consequences. Laggards are usually regarded as not worth pursuing by innovators, but their criticism on the market hype and the actual product value, can provide valuable feedback for innovators.

Looking at the chasm, between the early adopters and the mainstream market indicate the ‘credibility gap’. This gap exists, because consumers prefer to listen to references from their own adopter group. For every disrupting technology this creates a dilemma, as innovators strive to have references from a market that has not yet adopted. This gap is therefore indicated as ‘the Chasm’. Marketing the leap of faith from the early adopters to early majority is of upmost importance in order to truly achieve market success with a disruptive technology.

3.2 Innovation adoption and disrupted business models

Innovation adoption does not take place at once, but is diffused over time (Rogers, 2003). The associated literature regarding innovation adoption focuses on either the full adoption or the rejection of an innovation (Frambach and Schillewaert, 2002). More specifically for the case of disruptive information technology adoption, adopters are assumed to make full use of the merits of innovation and are therefore supporting to its use, as information technology tends to provide answers that are tightly associated with the business' value chain (Bhattacherjee, 1998; Carlo et al., 2012). In practice, as innovative technologies disrupt the fundamentals of a value chain within a company or a market, it must be stressed that there are times where some firms or markets adopt an innovation with less intensity, not realizing the full potentials on total quality management (Ravichandran, 2000).

Moreover, disruptive innovation technology that affects business models, and especially the ones introduced by new entry providers cannot be easily and fully replicated (Chesbrough, 2010). The decision to adopt an innovation, is a three-stage process having three main steps, namely pre-adoption, adoption decision and post-adoption (Damanpour & Schneider, 2006). The same stages are also known as, initiation, adoption decision and implementation (Frambach and Schillewaert, 2002). Specifically the stages can be summarized as "the process through which an individual or other decision-making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers, 2003). Frambach and Schillewaert (2002) argue that the decision to adopt happens between becoming aware and forming an understanding of the innovation and the decision to purchase and make use of the innovation, which is exactly the point of this thesis.

In the shipping industry, or at least the new era of it marching towards the 4th industrial revolution, the adoption of new technologies must go beyond the traditional purchasing and staff training procedures. For the perceived value of a new technology, the adoption is followed after its commercial impact and value are realized, in terms of trust perceived at the targeted market sector (Chesbrough, 2010). The value of the new technology is dependent on the business model employed. A business model is an interdependent system of activities, related to the perceived value of the technology to be adopted (Reinhold, Zach, & Krizaj, 2017) and thus, incumbent firms require to understand perceived knowledge and perceived capabilities to seize opportunities from an innovation (Teece, 2007).

3.3 Diffusion of Innovations

A theoretical framework in technology diffusion and adoption is the Diffusion of Innovations (DoI) first explained by Rogers in 1962 (Sahin, 2006). Rogers states that the diffusion process of an innovation is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2010). Moreover, he defines the concept of innovation as "an idea, practice, or object perceived as new by an individual or other unit of adoption" (Rogers, 2003). According to Sahin (2006) Rogers used the word "technology" and "innovation" as synonyms", while in fact innovation has a research factor attached to its fundamental meaning compared to technology, which can be mainstreamed in terms of innovative elements. Rogers (2003) though makes and indirect clarification by stating that the innovation diffusion process is "the process through which an individual or other decision making unit passes from knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision". Rogers' five stages are briefly explained in figure 7.

Order	Phase	Explanation
1	Knowledge	when an individual (or other decision-making unit) is exposed to an innovation's existence and gains an understanding of how it functions.
2	Persuasion	when an individual (or other decision-making unit) forms a favorable or an unfavorable attitude towards the innovation.
3	Decision	when an individual (or other decision-making unit) engages in activities that lead to a choice to adopt or reject the innovation.
4	Implementation	when an individual (or other decision-making unit) puts a new idea into use.
5	Confirmation	when an individual seeks reinforcement of an innovation-decision already made, but he or she may reverse this previous decision if exposed to conflicting messages about the innovation.

Figure 7. The innovation diffusion process (Rogers, 2003).

The scope and final destination of this thesis is the decision phase versus the perception of various disruptive and innovating technologies for the shipping industry with a focus on Greece's chipping companies and their intention to decide to either adopt or reject these technologies. While adoption involves "a decision to make full use of an innovation as the best course of action available", rejection is simply "a decision not to adopt an innovation" (Rogers, 2003).

Rogers (2003) also specifies that rejection may occur even after a prior decision to adopt and proceeds to divide it into two categories. The first is "active rejection" which consists in first adopting the innovation but, at a later time, deciding not to adopt it and the second is "passive rejection", also known as "non-adoption", which is not-even considering to use the innovation. For the purpose of this thesis, the phases of the innovation diffusion are only considered as a broad and established overview "of how individuals, groups or organizations adopt and diffuse technologies" (Miranda et al., 2016), through the perspective provided by Asare, Brashear-Alejandro and Kang (2016) regarding Inter-firm Technology Adoption models.

3.4 Fundamentals of technology acceptance models (TAM)

The term adoption is applied at the individual level of a professional, while diffusion is practically related to the adoption of groups. Technological progress fosters operational progress, but is of little use until it is accepted (Oye, et all, 2012). Acceptance, which leads to adoption, or at least provide a significant positioning of a technology to an individual can lead to corporate diffusion (Sharma and Mishra, 2014). As per Carr (1999) technology adoption is defined as the 'stage of selecting a technology for use by an individual or an organization' and it can further be defined as the common understanding and willingness of a group of professionals to employ technology for the benefit of all (Samaradiwakara and Gunawardena 2014).

Due to the idiosyncrasies of the shipping industry, the author will consider other studies, beyond the classic philosophy of technology adoption models, showing that technology adoption is a more complicated process compared to a simple acceptance. Such complications involve numerous dimensions, such as user attitude and personality (Venkatesh, et al., 2012), social influence caused by external influencing factors (Ajzen and Fishbein 1980), trust perceived (Ghefen, Karahanna, and Straub 2003) and numerous other factors and conditions (Thompson, Higgins, and Howell 1991).

The technology acceptance model was initially proposed by Davis (1985). It holds strong even in our days of disruptive technologies, and examines the technology adoption process through the perceptions of the end users on variables such as understanding, perceived usefulness and risk etc. Davis (1993) emphasized on the fact that the users' thorough attitude towards a technology will determines its adoption while the development of this attitude is contributed by the realisation of the technology and the perceived usefulness of it. The technology acceptance model provides fundamental predictive strengths and has been verified by practice in nearly every targeted market as the instrument for predicting technology adoption (Xie et al. 2017; Verma and Sinha 2018). Moreover, in academic practice it is the dominant model in the literature (Venkatesh 2000; Venkatesh and Davis 2000).

Constructed using the same principles of the technology adoption models, stating that "the higher the intention to use the system, the more likely they are to actually use it", the newly introduced model of technology adoption for supply chains addresses a more comprehensive set of attributes which may affect the adoption of a new technology in supply chain related industries (Asare et al., 2016). This specific model identifies four key factor groups of adoption, namely: characteristics of technology, organizational factors, external factors, and inter-firm relationships. This model is considered for further research, starting from this thesis, since it is tailored for assessing inter firm technology adoption for supply chain-oriented industries. Indeed, all the technologies examined in the maritime landscape involve their adoption at a firm level, rather than at an individual level. Some of its constructs though have been considered in the final experimental modified technology adoption model used for the purpose of this research

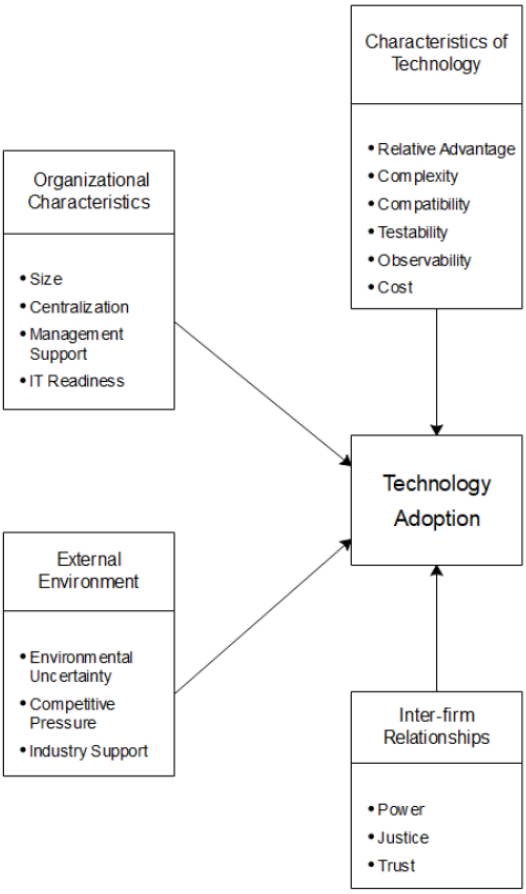


Figure 8. Technology adoption in supply chains (Asare, Brashear-Alejandro, & Kang, 2016).

3.5 Technology readiness index (TRI)

The technology reediness index refers to the employees intend to embrace and use new technologies for accomplishing their goals as employees. As per Parasuraman (2000) the technology readiness index 'can be viewed as an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technologies.' In general, it is a measure of people's general technology beliefs consisted of four dimensions: optimism, innovativeness, discomfort, and insecurity.

Optimism can be considered as an indicator of a positive view of technology and works as a belief that it can bring efficiency, better control, and flexibility. Innovativeness refers to user's inclinations towards seeing the technology as a pioneering instrument. Discomfort depicts the feeling of lack of control, or an overwhelming sense while using a technology. Insecurity relates to worries or even distrust for the technology and suspicion towards the capabilities presented. Optimism and Innovativeness are considered motivators, while insecurity and discomfort are inhibitors. The technology acceptance model has been combined with technology readiness indexes to predict technology adoption, with mentionable results (Pattansheti et al., 2016; Larasati and Santosa, 2017).

3.6 Exploratory, primary, quantitative research purpose

Research is a systematic and replicable process, which identifies and defines problems, within specified boundaries by employing well-designed method to collect the data and analysis the results. It disseminates the findings to contribute for generalizing knowledge. For the purpose of this thesis exploratory research will be used as this is a study of new phenomena in the shipping industry and flexibility is required. Exploratory research is used to investigate a problem which is not clearly yet defined or appears to be at preliminary stage. It can provide a better understanding of the investigation but it will not provide definite and conclusive results. The researcher starts with a general idea and uses this research as a medium to identify issues, and hence after focus on future specific research. Due to the exploratory nature, the researcher may change his/her direction subject to the revelation of new data or insights provided.

In more specific terms when a problem is broad and not specifically defined, the researcher use exploratory research as a beginning step. Exploratory studies are a valuable means of understanding what is happening, they seek new insights and ask questions to assess phenomenon in a new light (Yin, 1994) and provide a better understanding of an issue but will not provide conclusive results. For such a research, a researcher starts with a general idea and uses this research as a medium to identify issues, that can be the focus for future research. An important aspect here is that the researcher should be willing to change his/her direction subject to the revelation of new data or insight. Such a research is usually carried out when the problem is at a preliminary stage. It is often referred to as grounded theory approach or interpretive research as it used to answer questions like what, why and how. The usual steps to conduct an exploratory research are the following.

- Identify the problem: A researcher identifies the subject of research and the problem is addressed by carrying out methods to answer the questions.
- Create the hypothesis: When the researcher has found out that there are no prior studies and the problem is not precisely resolved, the researcher will create a hypothesis based on the questions obtained while identifying the problem.
- Further research: Once the data has been obtained, the researcher will continue his study through descriptive investigation. Even though quantitative methods of research are of primary importance, the researched can use qualitative methods to further study the subject in detail and find out if the information is true or not.

The main characteristics if exploratory research are the following:

- They are not structured studies.
- They are usually low cost, and open ended.
- They enable a researcher answer second level research questions like what specific topics could be studied in the future.

- They are initiators if no prior research exists or the existing do not answer the problem precisely.
- It is a time-consuming research and it needs patience while there are risks associated with it.
- There are no set of rules to carry them out research per se but are flexible and broad.
- The research needs to have importance or value for the industry under scope.
- Such a research usually produces qualitative data, however in certain cases quantitative data can be generalized for a larger sample through the use of surveys with predefined answers.

While it may sound a little difficult to research something that we know a little of, there are several methods which can help a researcher figure out the best research design, data collection methods and choice of subjects. There are two ways in which research can be conducted namely primary and secondary. For the purpose of this research, a primary research was used gathering quantitative data. Primary research is information gathered directly from the subject. It can be through a group of people or even an individual and such a research can be directly conducted by the researcher.

Primary research is specifically carried out to explore a certain problem, which requires direct insights (Yin, 1994). Surveys are used to gather information from a predefined group of respondents. It is one of the most important quantitative methods. Various types of surveys can be used to explore opinions, trends, etc. Using current technology, surveys can easily be sent online and can be very easy to access through survey web applications, via personal computers, tablets, laptops or even mobile phones, and the information can be available to the researcher in real time. Nowadays, most organisations offer short length surveys and rewards to respondents, in order to achieve higher response rates.

Focus groups are important for surveys and specifically for closed market segments like the Greek shipping industry, where a group of professional roles is chosen and are allowed to express their insights on the survey. It is of major importance to address roles of professionals under the same focus group, meaning that they should have a common background and, comparable experiences.

4. Research Methodology

Sanders et al. (p. 163, 2015), explains the research design model is the "general plan for how a researcher will be able to answer his or her research question". Therefore, the motive of this section is to present the research design aimed at answering our research questions. This includes specifying and explaining approach to theory development, the nature of research, and the process concerning the collection of data. According to Saunders, Lewis and Thornhill (2015), defining the appropriate methodology and method is an essential part of academic research (Saunders et al., 2015).

4.1 Research design fundamental framework

In terms of our approach, even though there is little past knowledge and an exploratory research with primary investigation means is required, the adoption of a pure inductive approach would overlook important contributions from the academic field and common practice. Hence the author makes use of well-established theories and frameworks, namely from the technology adoption and scenario planning literature, in order to provide a meaningful exploratory point for collecting data. Since there is no intention to test theories but rather generate untested conclusions through known practices, an integrated approach is used. Furthermore, Saunders et al. (2016) point out that an integrated and abductive approach may be useful when there is literature in one context, but very limited in the context that is being researched. Indeed, there is a wealth of information on the technology adoption for the technologies under scope in general, yet research addressing their adoption in the Greek shipping industry specifically is lacking.

The aim of this study is to explore the potential fit of the mentioned technologies, in order to test inter-firm processes in the Greek shipping industry, and concurrently map plausible future scenarios with potential implications for an ICT vendor when, introducing such solutions to the Greek shipping industry. The study focuses on determining the adoption potential of certain technologies as disruptive, yet of good fit alternative solutions to existing operational goals, based on the motives and belief of the respondents, through a predetermined scoreboard of answers. Therefore, the author will undertake a quantitative approach in order understand the diverse opinions of the studied technologies and the attitude of Greek shipping towards them, and also to understand factors that may shape the future uncertainty of their adoption.

The review of literature carried in the previous section identified many different models and constructs that have been reported in various research studies related to TAM, TAMSC, and TRI. The present research assimilates TAM, TAMSC, and TRI for the following reasons. The user's technology acceptance can be well explained by TAM (including TAMSC), and TRI (Davis 1989, Parasuraman 2000). TAM is based on system-specific perceptions and TRI uses an individual's general inclination towards technology. The author believes that testing their combination offers smarter insights on the acceptance of technology (Yi, Tung, and

Wu 2003). Moreover, perceived usefulness, risk, and market perception, which are the cognitive dimensions in predicting individual's acceptance can definitely act as the mediating variables between the TRI constructs that are based on individual differences, such as psychological traits and pragmatic behavioral intentions (Agarwal and Karahanna 2000).

Henceforward, for this thesis study, the author suggests that various constructs of TRI and TAM, when combined, play an important role in understanding the adoption process of the technologies under the scope of this research and thus proposes an integrated research model that is "theoretically grounded" in two well-established theories, namely TRI and TAM, while merits of the TAMSC are accepted. The idea is to use the TRI model to provide the theoretical basis to measure the perceived risks that act as inhibiting factors during adoption, through the scope of supply chains attitude examination of the behavioral intention, by perception of values measured by a modified TAM. The approach and its fundamentals are shown in Figure 9.

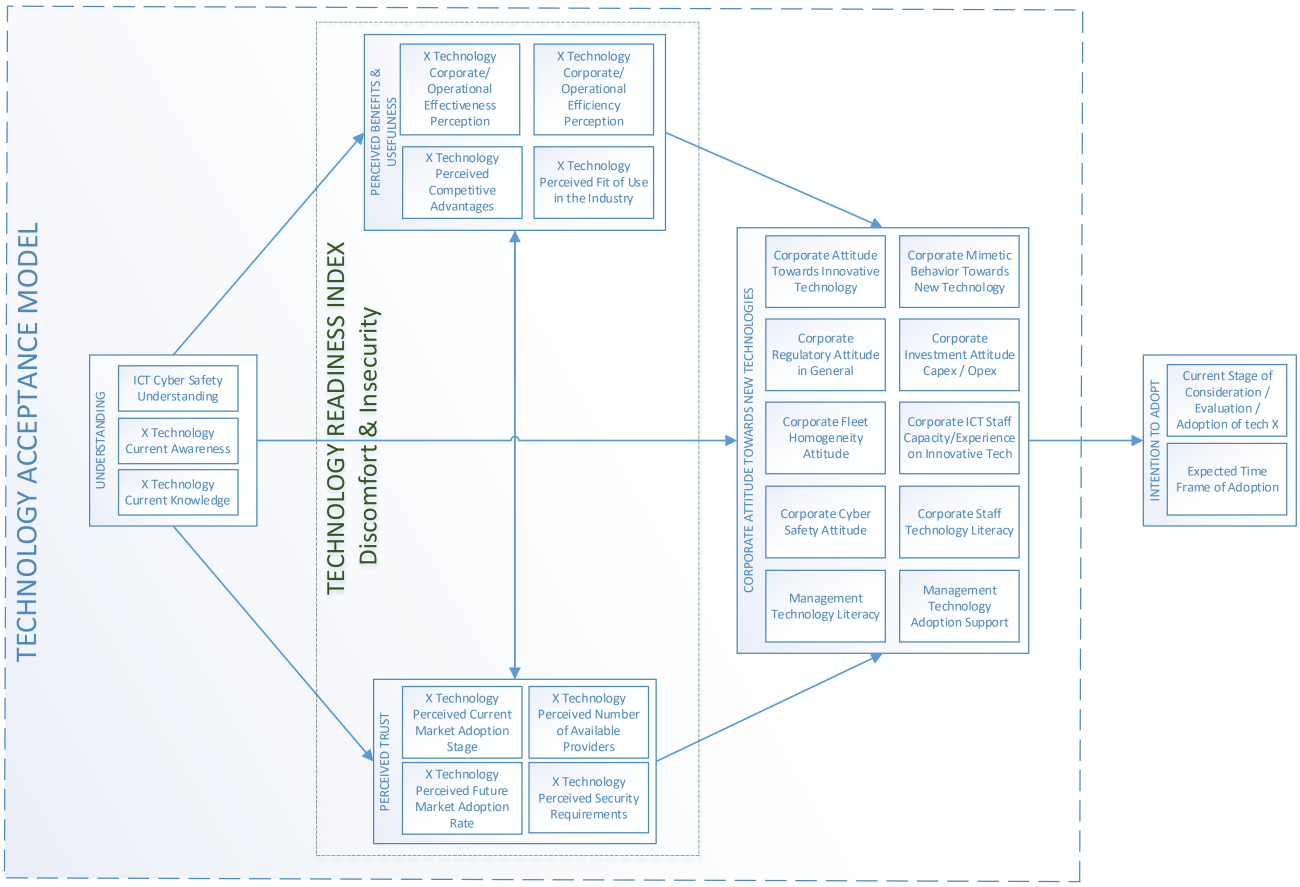


Figure 9. The proposed modified TAM model using TRI constructs.

A questionnaire was devised, following the above model, as presented in Appendix A, composed of eleven sections. Section 1 is used for demographic purposes. Section 2, checks the overall understanding and awareness of the subject, related to IoT, Big Data, Augmented Reality and Distributed Ledgers, while section 3 checks the subject's perceived understanding of the above mentioned technologies regarding safety, effectiveness and efficiency. Section 4, seeks to identify the subject's perception regarding the compatibility of these technologies with the current needs of the industry. Sections 5 to 8, check the subject's perceived trust on the above mentioned technologies, in terms of current adoption state, future growth and current market positioning as projected by the makers of the technologies. Section 9, checks the subjects understanding regarding onboard cyber safety, combining the regulatory, pragmatic and the industry's needs perspectives on the subject. Section 10 is composed by a set of statements in order to understand the attitude towards technologies within the working environment of the subject, while section 11 sums up the current and future tendencies of adoption of the above mentioned technologies.

4.2 Research assumptions, development and method

Despite TAM's popularity, there are a number of limitations and areas of exploration, regarding intention and adoption, according to various researchers (Bagozzi, 2007; Benbasat, 2007; Davis, 1989). What they argue is that there are some major limitations of TAM studies that motivated the writer to enhance the model for this study. Firstly, perceived usefulness has become a vague metric with little research effort into investigating different dimensions of perceived usefulness, while the academic community understands that there is room for improvement, according to the targeted audience and technology, as TAM studies often lack actionable guidance for practitioners, as each field of technology practice and hence after adoption research, requires at least some empirical observation prior to standardising on TAM's parameters (Bagozzi, 2007).

Secondly, TAM was initially oriented regarding consumer adoption behavior, not adoption behavior of corporate customers, meaning corporate entities. There is a big difference between a customer and a consumer in corporate environments. One over simplified example of the difference may come from the day life of parenthood. Parents purchase diapers for their infants, being the customers who make the decision on whether their infants will use diapers or not. An infant regardless of its liking to wear diapers is the consumer. The infant can only show signs of dislike to a certain type of diaper, and as a consumer biases the parent-customer decide, by trial and error, or by awareness, which is the right one for the infant, according to the options given by the market to switch makers or type. Bottom line is that the customer has made a decision to purchase the product, and the consumer can only define if other options are to be examined, based on the fact that there is enough trust in the market to seek alternatives.

Thirdly, TAM assumes that more use is better and consequently TAM based studies focus on intention to use, by the consumer. In other words, the more perceived trust towards the utilisation of a technology the more purchasing is expected. However, only a few prior adoption studies verify a relationship between use and purchase, while the concern on a corporate level should be more focused to perceived benefits and usefulness from the professional's standpoint, and the trust that the market is currently providing the professional with, in terms of his/her perception of how established the technology is, in terms of options available (Mäntymäki, 2011).

Perceived usefulness has been defined as 'the degree to which a person believes that using a particular system would enhance his or her job performance' (Davis 1989). According to Gong, Xu, and Yu (2004), perceived usefulness and benefit is defined as 'the user's 'subjective probability that using a specific application system will increase his or her expectations.' Moreover, perceived usefulness and benefit is the primary determinant that pinpoints the behavioral aim to use an information system in a corporate environment (Venkatesh et al., 2003). Perceived usefulness and benefit are recognised as having a substantial positive effect on the intention of consumers to use an innovation in a corporate environment. (Davis, 1989; Bagozzi, 2007; Venkatesh et al. 2003).

Compatibility and how technologies are perceived to fit the demands of an industry was introduced by Rogers (2003) who defines compatibility as "the degree to which the innovation fits with the potential adopter's existing values, previous practices, and current needs". Compatibility is an important determinant of innovation adoption (Thiesse et al., 2011). Valued business enablement and compatibility are therefore factors that can determine whether a new technology will be adopted by an organization. Summing up, the behavioral aim to use a technology is related to the attitude of the consumer, which is a multidimensional construct comprised of cognitive, affective, and conative components. The attitude is the psychological tendency depending on a degree of favor or disfavor. Overall attitude towards user acceptance of technology is defined as an individual's overall efficient reaction (liking, enjoyment, joy, and pleasure) to use technology and is linked to perceived trust (Davis, 1989; Taylor and Todd, 1995).

Trust allows the expression of an expectation about the future behavior of a person based, in many cases, on previous interactions and has been examined in many disciplines. From the social psychologist's perspective, trust is characterized in terms of the expectation and willingness of the trusting party being engaged. Therefore, the user's feelings of trust toward a technology are an important determinant in considering his/her intentions to use, and usage behaviors escalated within a corporate environment. (Mayer et al., 1995). Since consumers who trust are more likely to create the right internal corporate environment for a technology adoption, the importance of trust is taken into account for this thesis, which in fact is increasingly being recognized in academic and practitioner communities (Bhattacherjee, 2002; Gefen, 2003). Mayer et al. (1995) define trust as behavioral, based on one person's beliefs about the characteristics of another – connect that to knowledge. Therefore, trust is generated through the consumers' understanding of what a technology is and what it can offer as proposed and as defined by the market offering the technology.

Segars and Grover (2003) noted that "determining the structure of TAM's psychological constructs such as 'usefulness', is a complex activity of critical importance in accurately explaining future adoption. Poor theory development and the inadequate or inconsistent measurement of constructs related to user perceptions of various technologies, due to the lack of standard perceived definitions, or projected by the market definitions, have been extensively reported in the literature and as noted by Moore and Benbasat (1991). Research of this kind requires a cumulative tradition that must be based on a shared set of definitions and concepts which are under investigation. Hence, for this thesis the external factors used in the TAM model relate to commonly addressed definitions of technologies and their potential specific use in the maritime industry, setting a starting point in examining if the surveyed subjects are aware of what the technologies under examination are and what they appear to offer, according to the market. There is a prior need for the subjects to be familiar with the correct technological context, which refers to the technological characteristics perceived as available for the adoption of technology. It involves the structural aspects of a technology, as complement or compensated with the existing processes (Wang et al., 2007). Therefore, firms with a higher degree of technology understanding in their population, are better positioned for the adoption of technologies.

Enhancing the above the concept of relative advantage is used too and is defined as “the degree to which an innovation is perceived as being better than the idea it supersedes” (Ifinedo, 2011). Innovations that have a clear advantage in creating strategic effectiveness and operational effectiveness, have a higher chance of adoption (Greenhalgh et al., 2004). The perceived technological merits of the firm’s population can positively influence corporate adoption. Many studies which investigated the diffusion process of innovations have found relative advantage to be a significant determinant and therefore it is crucial to study this concept. An advantageous technology is the one that enables companies to perform their tasks quicker, easier and more efficiently, safely, improving quality, productivity and performance of the company.

Still, the author uses more contextual information to understand the overall organisation attitude as perceived by the employees. The organizational context is also used, defined in terms of internal and external resources available and their utilisation tendencies to support the adoption of an innovation (Lippert & Govindarajulu, 2006). This refers to the characteristics of the firm that facilitate or constrain the adoption and implementation of innovations. Multiple factors influence the relationship between perceived organisational behavior and adoption of innovations including level of centralization, distribution of power and control, information links, availability of third-party resources, firm size, and top management support (Low et al., 2011; Xu and Quaddus, 2012).

This study replicates techniques carried out by Davis (1993) focusing on perceived usefulness and trust, as influence factors on employees’ attitude toward using technologies, which can influence corporate usage. In TAM attitude the attitude toward a system usage, has the form of acceptance or refusal (Davis, 1993). Jahangir and Begum (2008), defined actual system usage as a form of external psychometric response which was measured by estimating the pragmatic usage. Actual corporate usage of technology may proceed without the interference of personal employee attitude derived from personal perceived usefulness and trust, and this study aims to prove that future corporate attitude or strategy, may lay beyond the personal perception of an employee. Based on the discussion above, this study aims to extract references of perceived corporate attitude and strategy, departing from the personal view of the employee, as a final stage before realising actual penetration of the technologies discussed in the Greek shipping sector.

Top management support, understanding and employee readiness, are most critical for the adoption of innovations, as they are related to allocation of resources, integration of services and reengineering of business processes. Top management that recognizes the benefits of innovations will likely allocate the necessary resources for an adoption and can empower the organisation’s members to implement that change. When employees fail to conceive the benefits of an innovation to the business, the management can be opposed to its adoption (Low et al., 2011).

Environmental context and competitive pressure are also examined. The environmental context is the setting in which the firm conducts its business, and is influenced by the nature of the industry, the firm’s competitors, its access to resources supplied by others, while the major determinants that have an impact on the adoption, are the firm’s competition and the regulatory environment (Lippert and Govindarajulu, 2006; Zhu et al., 2006). Especially, competitive pressure has been recognized in the innovation diffusion literature, as an important driver for technology diffusion. It refers to the pressure experienced by the firm from competitors within the industry, leading to mimic behaviors of the market (Low et al., 2011). Both environmental context and market pressure have been determined as essential in estimating the factor of IT adoption due to stiff competition. Firms experience pressure and become gradually aware of and imitate their competitors’ embrace of new technologies, as the high-tech industry has the characteristics of swift changes (Oliveira et al., 2010).

TRI factors are introduced to TMA and are utilised in providing a deeper explanation to studies similar to the one conducted in this thesis, as they play a significant role in giving an integrated and psychometric explanation. Discomfort is defined as ‘a perceived lack of control over technology and a feeling of being overwhelmed by it (Parasuraman and Colby 2001). People who show some level of discomfort towards new technologies, for any personal reason, tend to find technology less useful (Walczuch, Lemmink, and Streukens 2007).

Similarly, signs of discomfort show negative effects on perceived usefulness and trust, forming up inhibitors of using new technologies (Parasuraman, 2000; Walczuch, Lemmink and Streukens 2007; Kuo, Liu, and Ma, 2013). Discomfort reflects the fear of employees if they are requested to use a specific technology, regardless of being justified or not, even denying to seeing a greater corporate benefit. Hence, discomfort may indirectly affect the perceived usefulness and market trust results. One way to reduce discomfort, is by using informative feedback towards the employees of the targeted corporation, and by enhancing education and awareness (Walczuch, Lemmink and Streukens, 2007).

Therefore, the insecurity to technology by employees is directly related to ambiguity, possible denial and low future adoption survey results, acting as an altering factor in perceived usefulness and trust, as per Walczuch, Lemmink and Streukens (2007) state, while Son and Han (2011) view employee insecurity and fear as a direct inhibitor of corporate technology readiness overall. Using earlier research, it is therefore assumed that fear and insecurity towards disruptive technologies, can bias low levels of agreement with information technology market definitions, projected technology merits as dictated by the information technology industry, perceived usefulness and perceived trust. Thus, the author includes employees' understanding of corporate attitude within the survey, in order to balance the biased by insecurity employees' responses.

4.3 Research method and expectations

This exploratory research involves an online survey for data collection. Online surveys provide benefits such as saving time and expenses, by overcoming geographic distances. The online survey was developed to examine the relationship between constructs proposed in the research model. Regarding the conclusions two wide method of analysis exist, namely qualitative and quantitative methods, used in science research studies. Quantitative methods are based on numerical or predetermined questions scoreboard reflection, while qualitative methods consist of the non-numerical evaluation, usually from primary research tactics such as interviews, where the subject is answering in free text. Moreover, qualitative research focuses on the process of adoption and not the adoption targets, and this method cannot be useful for carefully analyzing or calculating data, in terms of quantity, amount of intensity and frequency. In comparison, quantitative research focuses on evaluation and primary experimentation of relations between factors, through scores and not procedures, while predetermined hypothesis factors and the communication of them are important elements (Zikmund et al., 2012).

Again, regarding the answers' correlations to deduct conclusions, two theoretical research methods can be deployed, associated with two different ways of planning conclusions during an exploratory research, namely inductive and deductive. The deductive research technique can be described as the logical process of drawing conclusions from primarily unidentified yet observed assumptions, or something generally identified or observed to be accurate (Zikmund et al., 2012). The inductive technique can be outlined as the logic procedure of creating the general undertaking of specific facts according to the observation (Zikmund et al., 2012). By this process the researcher will draw a general conclusion from individual instances or observations. The benefits of an inductive approach are that it allows flexibility, attends closely to context and supports the generation of new theory. Inductive research works best where a respectable amount of existing literature does not exist.

Inductive methodology begins with an observation made by the market researcher, who begins the study with a specific topic of interest, and assumptions related to current experience. In the inductive approach, does not completely rely on theories until much further along. During the analysis of the new data, using the patterns observed by data clusters, the researcher suggests paths for further study (Kennedy III et al., 2000; Wilson, 2010; Gulati, 2009; Babbie 2010; Snieder and Larner, 2009; Pelissier, 2008). Therefore, this study will be analyzed by using quantitative research method, while an inductive technique will be used to draw results. The inductive research technique is also appropriate for the author, as it is a time saving approach and is associated with the lower risk. For the purpose of this thesis the following steps will be taken:

- Observation by researcher experience
- Topic of interest emerges
- Data collection
- Data clusters or patterns
- Data analysis
- Emergence of themes
- Generalizations
- Dissemination of findings

A useful way in providing particular planning in collecting data and analyzing data is the questionnaire method, due to the fact that it is helpful in providing tools for scaling factors for addressing population and sampling issues. Moreover, this quantitative study is decided to use an inductive model in estimating the relationship between factors and in providing evidence for the author’s assumptions (Neuman and Di Federico, 2003). The main object of this study is to seek the important factors that have an influence on adoption of certain disruptive technologies for the Greek sector of the maritime business, and for this purpose, a research model, in the form of a questionnaire was prepared backing the author’s research hypothesis, sent to departments of nearly 570 shipping companies in Greece.

As expected from the assumptions of the author, age, combined with position of corporate responsibility regarding the technologies examined, and the impact on the corporate environment, combined along the subject’s education level, are all expected to show significant differentiating results regarding awareness, and hence it is also expected to see pragmatic and diverse insights of the usefulness and market trust towards the technologies under consideration, along with the perils associated with them.

Another factor expecting to enhance the above assumption, is the fleet size of a company, which is related to the internal organization structure and processes. Hence, the subjects of postgraduate education, with three years and more experience in the industry, and especially the ones aged at their highly productive years of 31 to 50 years old, who are employed in the HSQE, IT departments, or are high in the corporate hierarchy of companies from 10 vessels and beyond, are expected to agree with the descriptions of the technologies examined and the cyber safety concerns, while they should provide pragmatic insights regarding the current usefulness and market projected trust of the technologies under investigation.

On the contrary, subjects of no postgraduate studies, of little experience, or of a young or higher age, are expected to be more neutral regarding the awareness part of the survey, and regarding usefulness and trust are expected to show a neutral, agnostic or even negative position. The same are expected regarding attitude towards the market's need for cyber safety adoption. Both of the above are expected to be negatively enhanced from the perception of employees working in companies that own, manage or operate small and very small fleet sizes.

Due to TRI constructs examined, specific departments are expected to show neutrality to negativity, interpreted as discomfort, regarding certain technologies that may disrupt their work as performed insofar for various reasons. For example a technical or a marine department of a small or very small sized company, may feel uncomfortable with the use of Augmented Reality, as the application of such technology, would disrupt a major source of income, which is related to attendances. Similarly, operations departments for example, are expected to show neutrality to negativity towards Distributed Ledgers as a substitute to common bills of lading, as they substitute parts of their operational importance. Moreover, they be showing neutrality or negativity due to the fact that the information technology industry has not shown a plethora of solutions, while there are still debates about their validity from the legal world of shipping.

4.4 Building the recipient database and participants

A sample of 570 shipping companies from Greece was considered for this study. The author had to face several issues related to the nature of the communication of the questionnaire, and the addressable market. Due to GDPR regulations, a way had to be devised, so as to reach professionals, without sending direct emails to their personal professional mailboxes. As a first step, the author, used Clarkson's world free register, to list all companies owning, managing and operating fleets, based in Greece. As a second step, the author identified the companies' email domains and web domains through extensive research based on Clarkson's database and through other resources, such as open and public registries of companies. As a third step, the organogram of each company and the estimated departmental structure was guessed. Finally, according to the departmental structure guess, the author proceeded in guessing departmental emails, while verifying their existence through open internet mail checking tools.

As an outcome 954 departmental emails were found, mainly focusing on operations, management, marine, HSQE, technical, IT departments and DPAs. Through this method no GDPR issues were posed, and most importantly the questionnaire would land on multiple professionals' mailboxes. Moosend, a Greek email campaign service was used for sending the emails to the above "GDPR-free" list of recipients. The response reach of the participants was recorded through the email survey tools provided by Moosend, and the participation was kept voluntary with follow up emails from the researcher at frequent interval to enrich the sample size. Out of the 954 departmental mailboxes, 17 unsubscribed and 85 bounced, leaving the destinations to 855, while it is worth mentioning that no recipient complained. The email was opened by 353 recipients, which is considered as the final addressable population. Out of the 353 recipients who cared to open the email, 92 of them clicked on the link provided to the survey which corresponds to about 26%, and 51 completed the survey which corresponds to about 14%, out of which nearly 97% used their corporate desktop computer, while the remaining used mobile devices. The figure below shows the geographic span of professionals who clicked on the survey link.

Figure 10. Survey participant clicks worldwide mapping.

The sample of 51 respondents satisfies the minimum requirements of observations. (Bollen, 1989; Willis, Genchev and Chen, 2016). Further, Sideridis et al. (2014) and Wolf et al. (2013) have recommended small samples as sufficient for small and medium size companies analysis. By default, small and medium size enterprises employ up to 250 professionals, which is the case for every shipping company in Greece. Considering practical constraints in collecting data on an exploratory subject regarding relatively new technologies of disruptive nature, the sample of 51 practitioners of the Greek shipping industry is considered acceptable for conducting the analysis, even though a larger sample would have been better.

4.5 Instrument Development

The content domain of each construct should be thoroughly covered in an efficient instrument which has been developed for the research purpose. All the items, used to measure a construct should agree with each other, while at the same time items of one construct should not match with the items of any other construct (Nunnally and Bernstein, 1978; Churchill, 1979). To test and validate the research model in Figure 10 a survey instrument was developed based on all previous literature covered herein. The items and the scales for the TRI and TAM and TPB constructs were chosen from previous studies as analysed in previous sections of this thesis.

The unit of analysis was focused on the Geek shipping industry practitioners, and the responses were measured using a 5-point Likert Scale on an interval level ranging from 'strongly disagree' to 'strongly agree.' A Likert scale assumes that the strength/intensity of an attitude is linear, i.e. on a continuum from strongly agree to strongly disagree and makes the assumption that attitudes can be measured (Joshi, Kale, and Chandel 2015).

The questionnaire was developed in the English language and was subjected to content validity. Although, the measurement items developed were adopted from the previously done studies. Still, it was pretested with subject experts to ensure that questions were relevant to the concepts explained herein, especially in the shipping industry context. The subject experts guided the researcher to select the relevant constructs for the study. The experts recommended the use of the TRI constructs as means of explanation of possible fear towards the adoption of disrupting technologies in the Geek shipping industry. The experts were of the opinion that the constructs of perceived behavioral control and optimism can capture such beliefs and insisted to retain perceived behavioral control through TRI constructs.

Optimism and innovativeness are the drivers of technology readiness, with optimism measuring the belief that technology offers people increased control, flexibility, and efficiency in their work, and innovativeness measuring the tendency of an organisation or a person to be a technology pioneer (Godoe and Johansen 2012). Further, the experts felt that optimism and innovativeness will always drive the adoption process of disrupting technologies in the Greek shipping industry. After the recommendations, the final decision on developing the survey questions was taken. The experts requested to keep their anonymity.

4.6 Data collection

In order to confirm the reliability and validity of the research model, it was organized as follows: First, the research model for this research was discussed and right after the assumptions used in this research model were addressed. As per next step, the assumptions were adopted in the questionnaire which followed references and was discussed with market experts. In the next step, a final structured questionnaire was devised, as presented in Appendix A, from existing instruments, to avoid problems of validity and reliability of the measures. This means that questions were adopted from pervious questionnaires of new technology adoption research, based on TAM theory and TRI constructs as a framework. Finally, these questions were discussed with the supervisor. After being approved by the supervisor at the last stage, the survey was implemented using Microsoft Forms.

As suggested by Wallace and Mellor (1988) the mean responses to all the constructs used in the hypothesis given by 13 respondents of the last week, were compared with those of the random sample of 39 respondents, drawn from the returns of the first weeks, to identify if any significant differences exist. The analysis was necessary and it was found that the respondents who sent in their questionnaires late are roughly similar to non-respondents, and did not show any statistically significant differences in the responses, indicating the absence of nonresponse bias (Oppenheim, 1966). In the next chapter, the final results of our research are discussed in a inductive manner.

5. Survey Responses and Findings

There has been growing interest in the research of the adoption of the technologies examined in this thesis, evidenced by the increasing number of calls for research papers from reputed journals like the Journal of Enterprise Information Management, International Journal of Physical Distribution and Logistics Management and many others. The present thesis hopes to advance literature in two ways. First, no studies are empirically tested so far in the adoption of the examined technologies in the Greek shipping industry. This study presents the link between a set of technology adoption constructs that aim at understanding the adoption of the technologies examined, derived from the traditional adoption of theories like TAM, and TRI. The statistically validated model is expected to have high explanatory power. The explanatory power of this model overall, is recommended as a further research idea.

Secondly, this study advances the literature of technology adoption and tests a unified model integrating the theories of TAM and TRI. The findings through TRI construct adoption that employee discomfort may not play a significant role in influencing the final corporate behavioral intentions of disruptive technology adoption, and in in essence it is validated that the TRI constructs need be given significance in the gap between employee attitude and expected corporate adoption.

Even though there is no absolute sign that an integration between TAM and TRI theories is necessary, nevertheless TRI theory combined with TAM, can indeed justify the employee perception towards disruptive technologies, especially when the inclusion of TAM should be pointing at results, compared to the answers given, not on personal, but at a corporate level. The author believes that this study can serve as the foundation of more studies on disruptive technology adoption, for the maritime industry in the future.

The below paragraphs discuss the findings of the research in an inductive manner, where the major pillars of the author's assumptions are being verified. This study provides pragmatic evidence that perceived understanding, usefulness, risk, attitude, and subjective norms are indeed related to implementation intention of the technologies under investigation. Starting with general awareness questions, the mean values of all participants, are depicted in graph 1 below.

As a generic observation, we see that all participants tend to agree with all specific definitions, while Augmented Reality, is the only technology which seems to be bordering between neutrality and agreement.

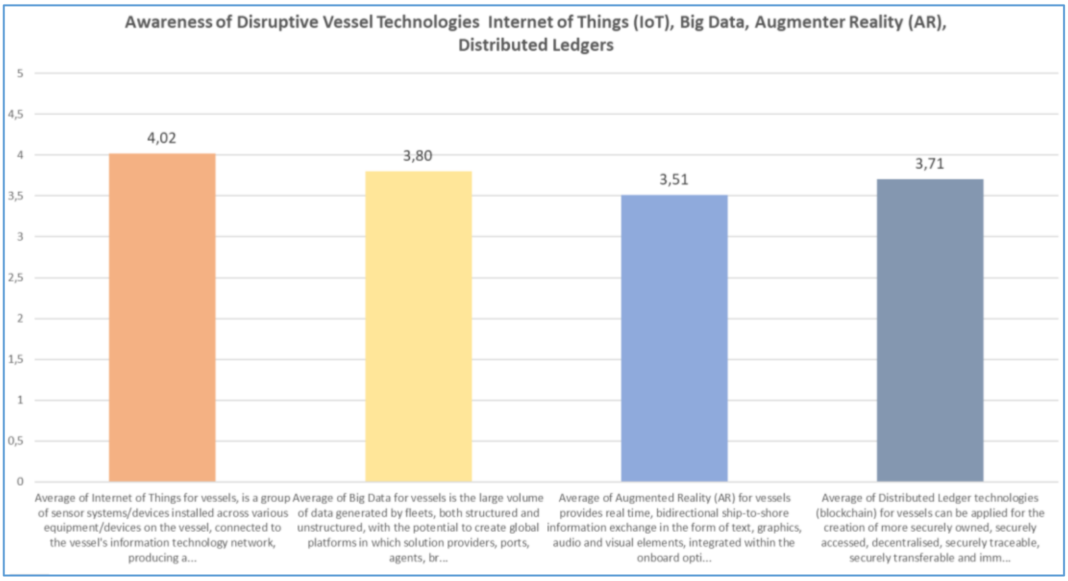


Figure 11. Generic mean values of responses - awareness and technology understanding.

5.1 Findings regarding technologies from groups showing high understanding

Proceeding with the examination according to the author's emperical assumptions, we examine participants of ages between 30 and 50, of postgraduate studies, with an experience of 3 years and beyond, who are specialised in HSQE, IT or are members of management, in companies from 11 vessels and beyond. The results are depicted in figure 12. Such specific group of professionals agree, tending to strong agreements with the definitions given and is hereafter named as "Group a". It is worth mentioning that IT and management participants from this group show strong agreement with the definitions, while the values are being slightly lowered by the group of HSQE participants.

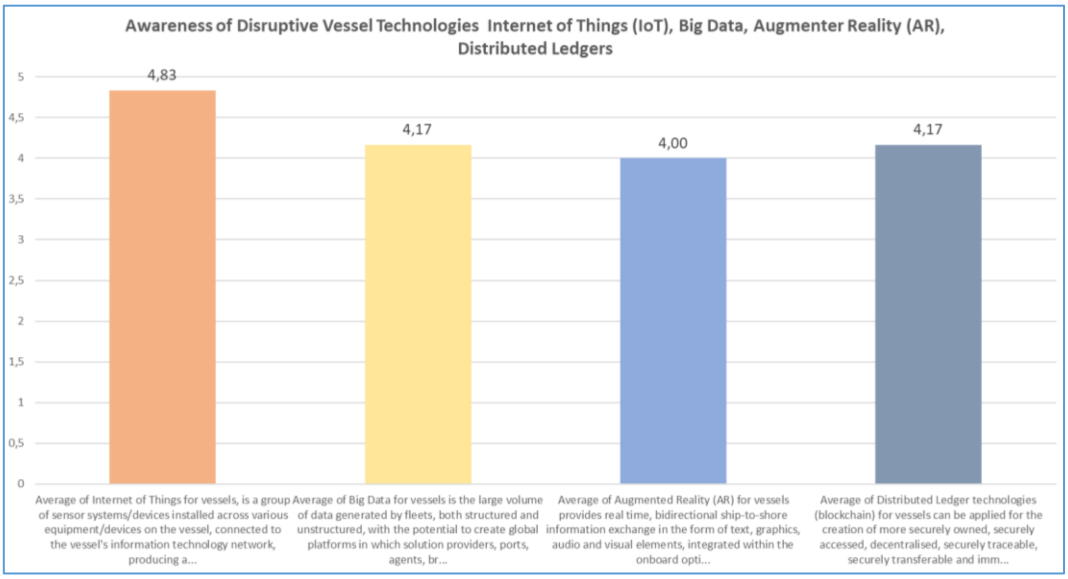


Figure12. "Group a" mean values of responses - awareness and technology understanding.

The same group of professionals believe that IoT and Big Data, generally enhance safety, effectiveness and efficiency, appear neutral regarding similar impacts from Augmenter Reality, and tend to agree, yet not fully, with similar impacts from Distributed Ledgers for B/Ls, shown below in figure 13.

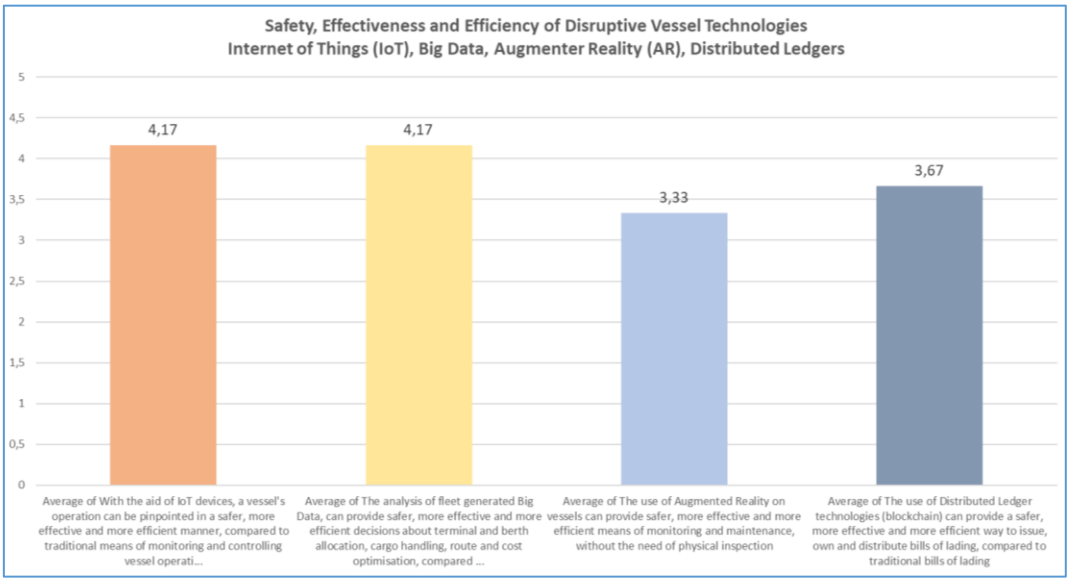


Figure13. "Group a" mean values of responses – safety, effectiveness and efficiency.

Regarding the technologies' compatibility with current demands in the industry, group a professionals believe that IoT does fit the current remands. A neutral position is projected for Big Data and Distributed Ledgers, while skepticism to negativity is shown for Augmented Reality, shown below in graph 4. At this point the author emphasises again, that the research is conducted during the unfortunate time of the COVID-19 pandemic.

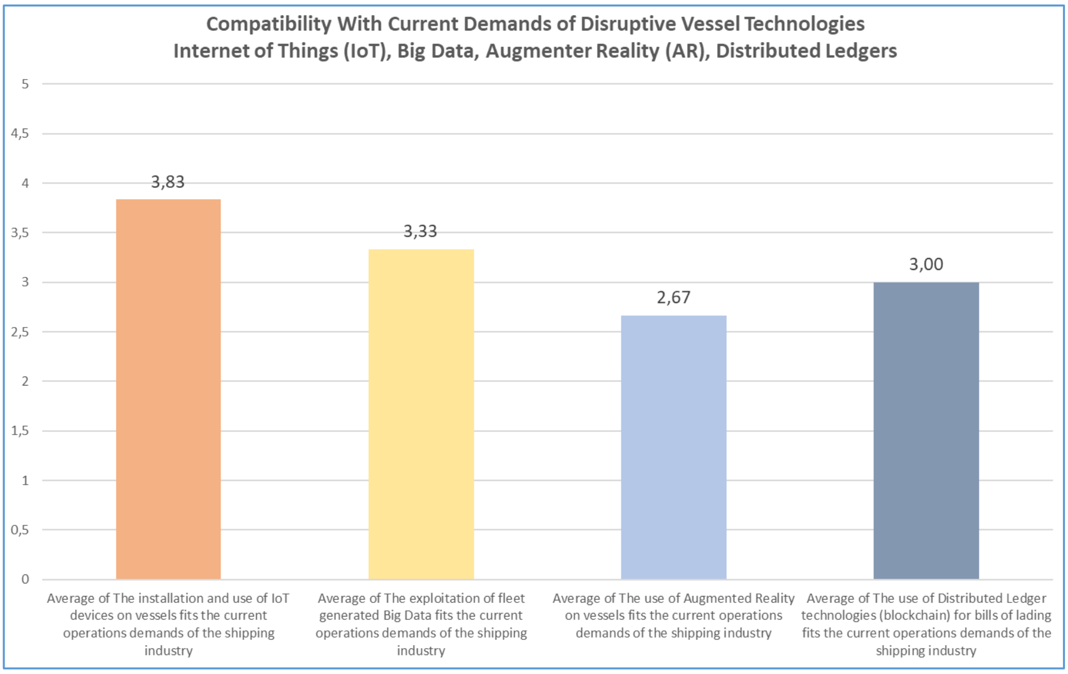


Figure14. "Group a" mean values of responses – compatibility with current demands.

What is even more interesting is that stakeholders with the above characteristics, not only show a high understanding of high end technologies for the shipping industry, but they appear to have played a part in positively convincing the companies they work for to either adopt technologies, or be more sceptic about them. This certain profiled group reflects the very positive attitude of the companies they work for with the adoption of IoT technologies as shown in figure 15.

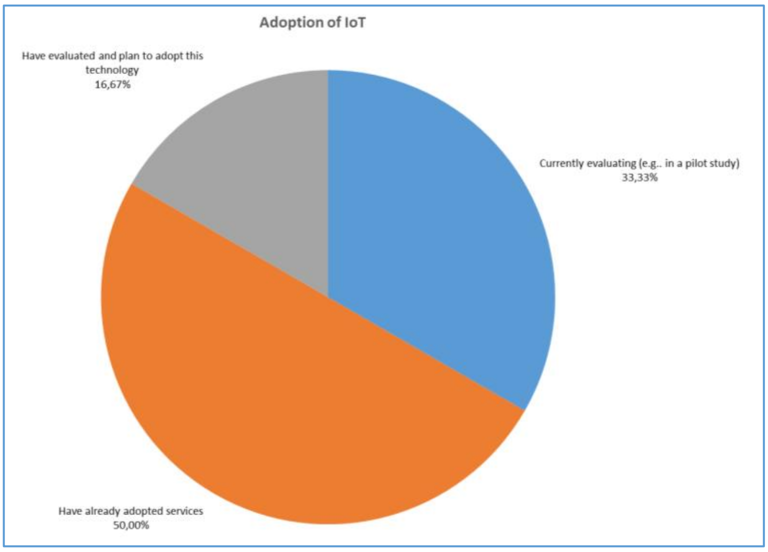


Figure15. Companies of "Group a" employees current adoption stage of IoT.

Moreover, the professionals from group a, who answered that their companies have either evaluated or plan to evaluate IoT solutions for vessels, show that their companies will definitely adopt IoT solutions for their fleets as shown in figure 16. Regarding market trust to IoT, group a has shown high trust to the technology, projecting a perception that the market overall will adopt more to this technology in the next three years, while they are bordering between agreement and neutrality, regarding the quantity and quality of current solutions in the market as seen in figure 17.

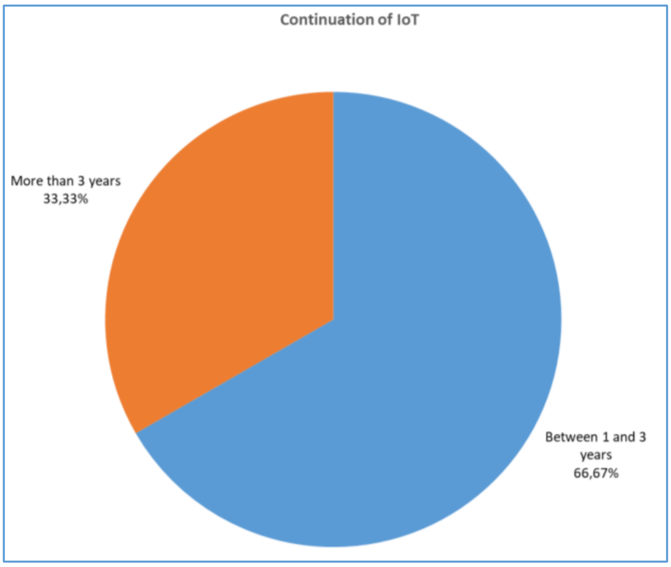


Figure 16. Future adoption tendencies of IoT from companies of group a employees.

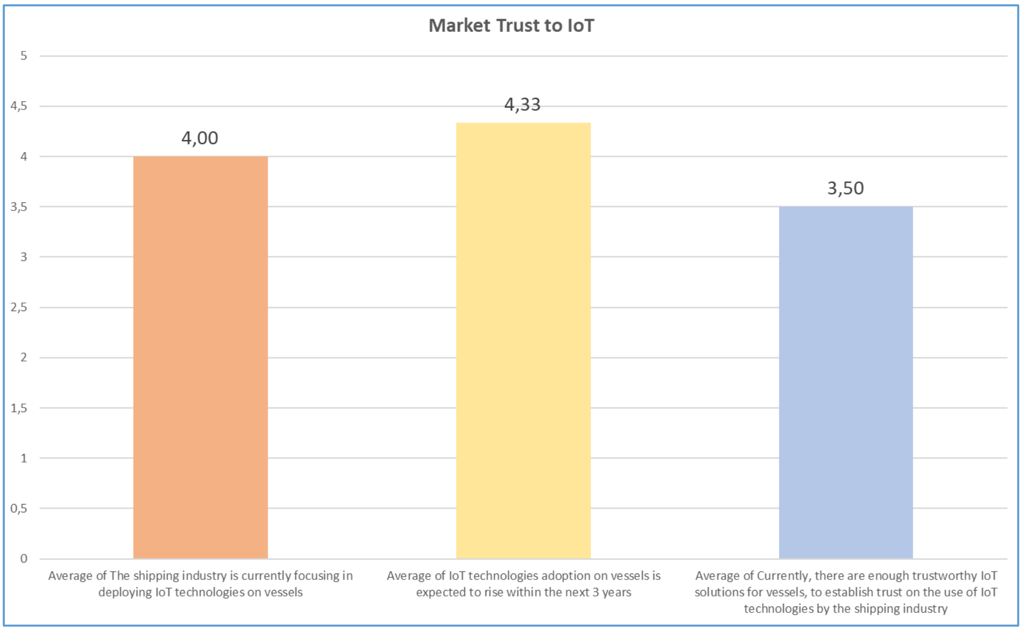


Figure 17. IoT market trust from group a employees.

Regarding current Big Data adoption, a third of "Group a" professionals state that the companies they work for do not currently consider the adoption of the technology (figure 18), while by excepting the subjects who responded that they have already adopted Big Data, results show confidence that the companies they work for will adopt the technology as shown in figure 19.

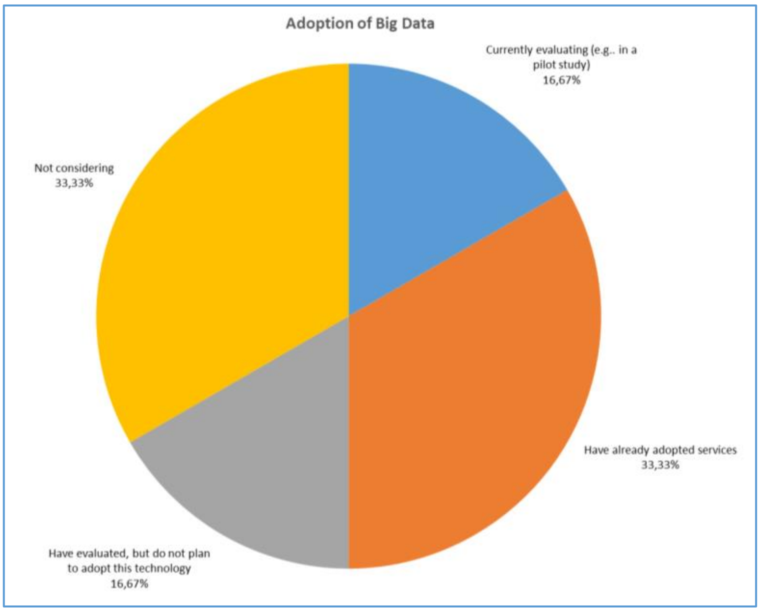


Figure 18. Companies of "Group a" employees current adoption stage of Big Data.

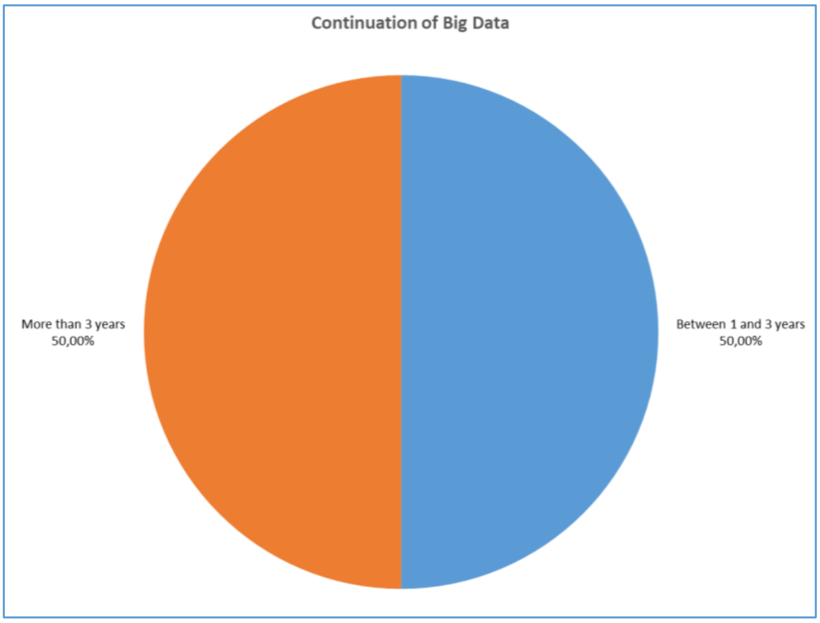


Figure 19. Future adoption tendencies of Big Data from companies of group a employees.

As per IoT, group a shows trust to Big Data, projecting a strong perception that the market overall will adopt more Big Data solutions in the next three years and beyond, while again they are bordering between agreement and neutrality, regarding the quantity and quality of current solutions in the market as seen in figure 20.

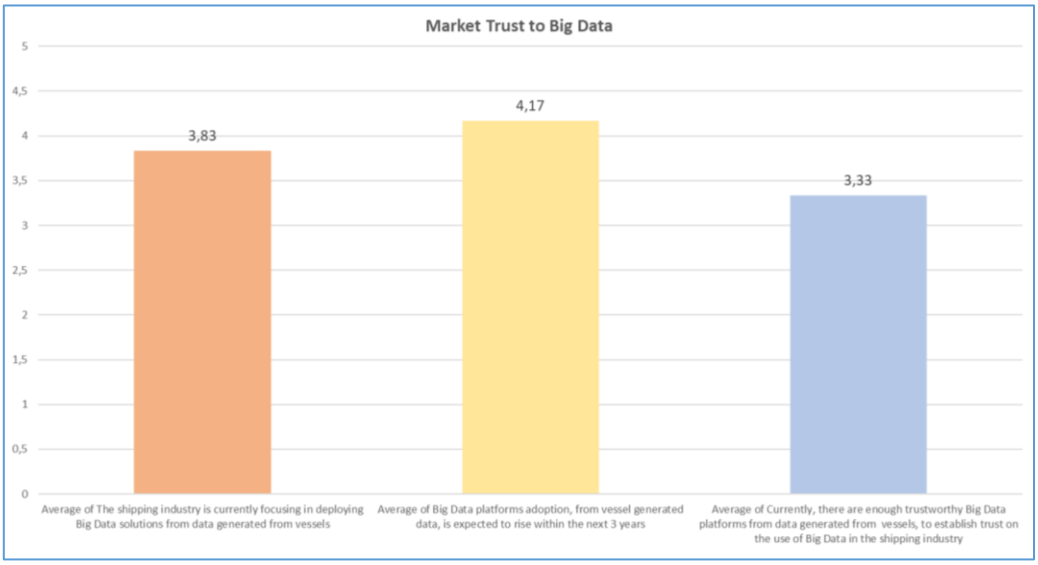


Figure 20. Big Data market trust from group a employees.

The close to neutral response given by "Group A" professionals regarding the perceived usefulness of Augmented Reality as shown on graph 3, are strongly tied to the group's market trust in Augmented reality as a technology overall shown in figure 21. These professionals show that Augmented Reality is not a priority for the shipping industry, while they believe that the adoption will grow, which is related to their awareness regarding this technology.

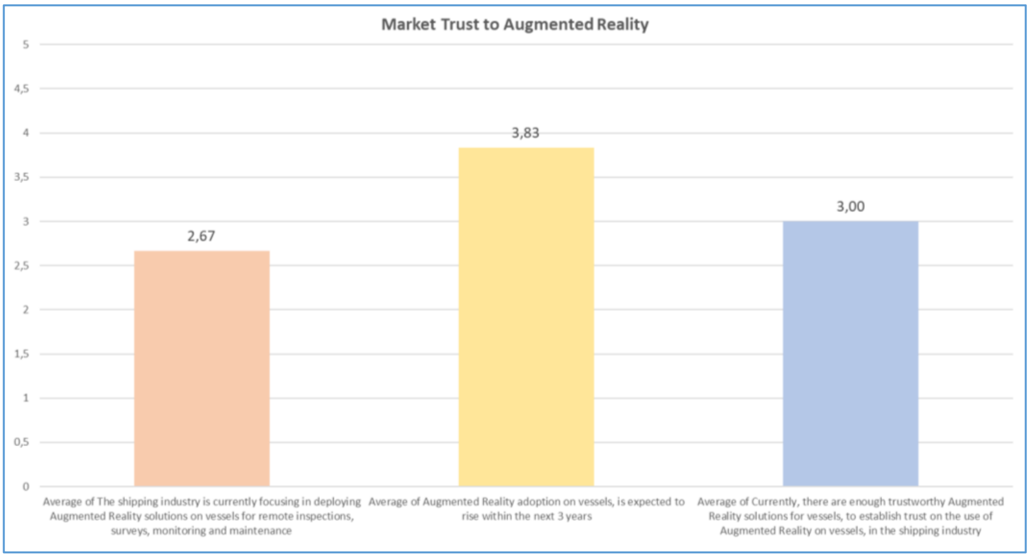


Figure 21. Augmented Reality market trust from group a employees.

50% of "Group a" professionals, admit that the companies they work for do not currently consider to adopt augmented reality, a third admits that they have already adopted, while the rest, are evaluating the adoption (figure 22). By excluding the 33,33% of companies where "Group a" employees work, which have already adopted Augmented Reality, we find out that the remaining form a population out of which 50% are not even considering a future adoption of the technology as depicted in figure 23.

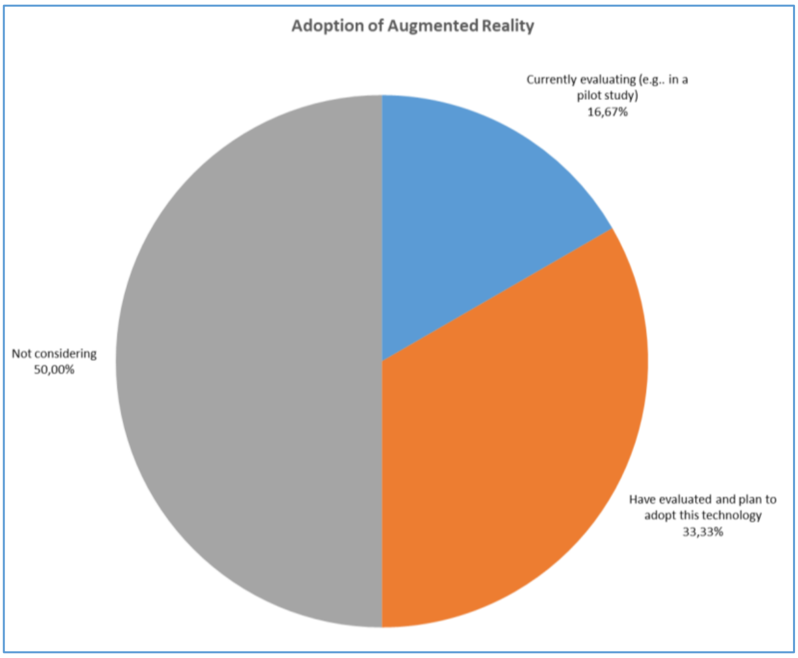


Figure 22. Companies of "Group a" employees current adoption stage of Augmented Reality.

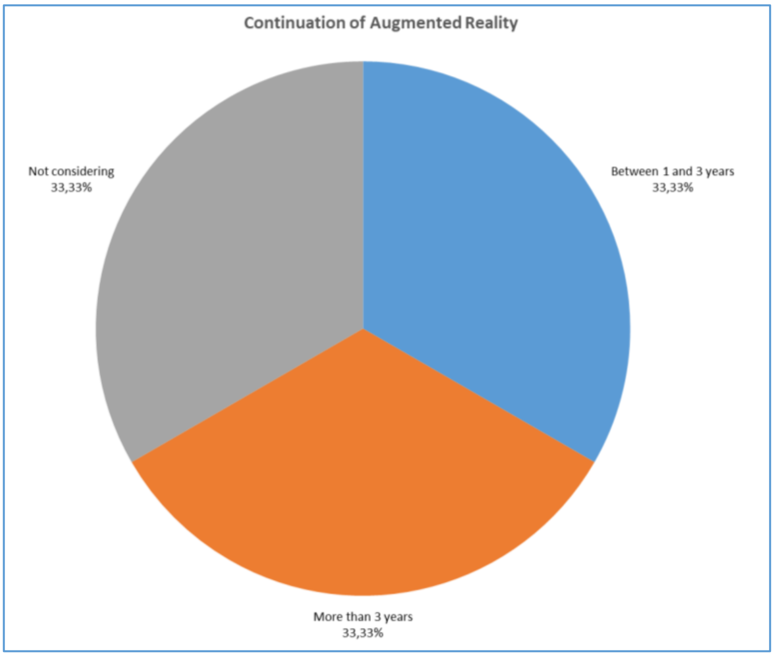


Figure 23. Future adoption tendencies of Augmented Reality from companies of "Group a" employees.

"Group a" has already shown a good understanding regarding Distributed Ledgers, followed by an average perceived usefulness tending to agreement. They show average market trust regarding this specific technology shown in figure 24, even though they believe that the use of this technology will be higher in the near future.

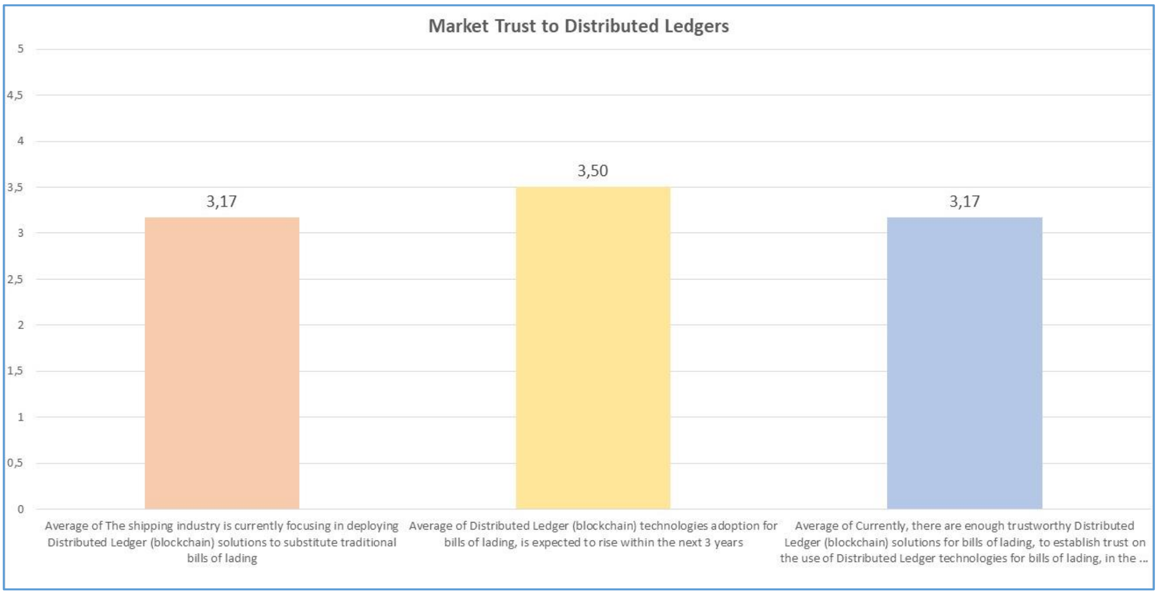


Figure 24. Distributed Ledgers market trust from group a employees.

Furthermore the same group considers that 50% of the companies they work for are not currently seeking solutions in Distributed Ledgers for B/Ls (figure 25), something which is expected to change within the next years, by understanding that 60% of the companies of "Group a" professionals, will finally adopt. Excluding the companies that have already adopted Distributed Ledgers for B/Ls the results are shown in figure 26.

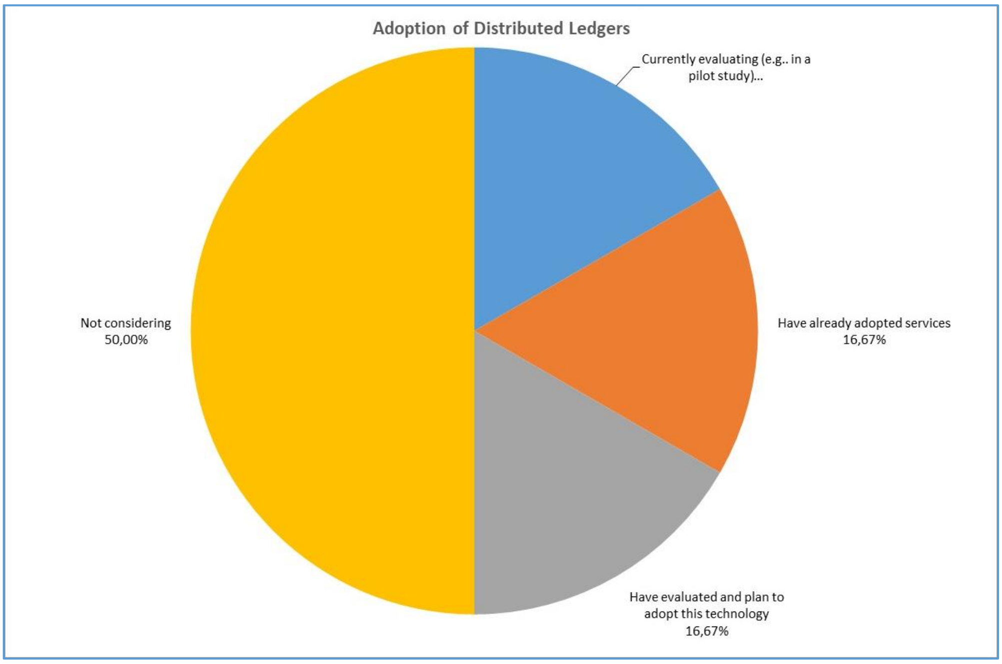


Figure 25. Companies of "Group a" employees current adoption stage of Distributed Ledgers for B/Ls.

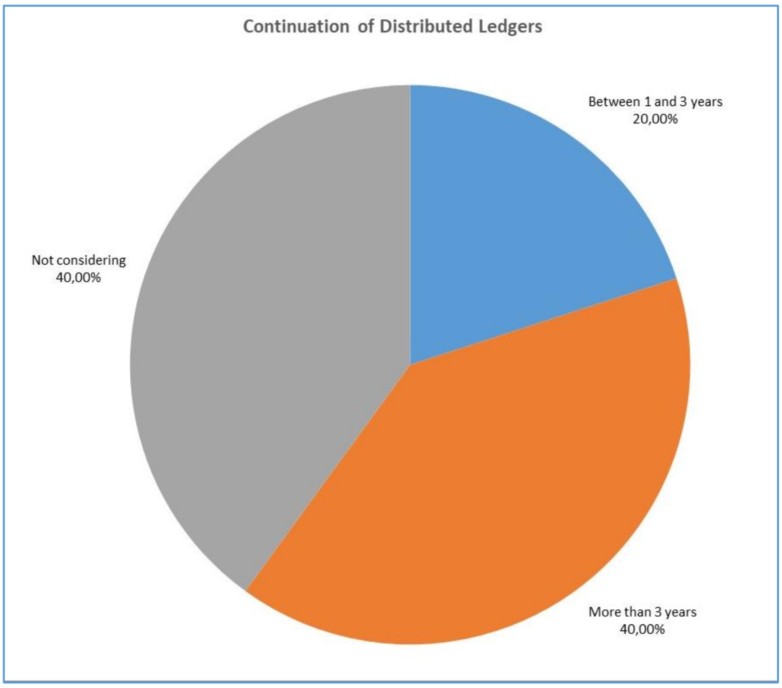


Figure 26. Future adoption tendencies of Distributed Ledgers for B/Ls from companies of "Group a" employees.

5.2 Findings regarding technologies from groups showing low understanding

Proceeding with the examination according to the author's empirical assumptions, we examine participants of ages below 30 and over 50, of no postgraduate studies, regardless of years of experience, who are not specialised in HSQE or IT, neither are members of management, regardless of the number of vessels owned, manager or operated by the companies they work for. This group will be hereafter named as "Group B". The results regarding their understanding of the technologies under examination are depicted in figure 27.

Participants of "Group b", show significant departures from "Group a", regarding their overall understanding, appear neutral regarding Big Data, seem to somewhat disagree with Augmented Reality, and appear to be sceptic regarding Distributed Ledgers. They seem to agree on average with the IoT definition, which can be justified by the fact that such a group, are mainly observers of deployments as employees of the companies they work for, meaning that they are expected to agree on the IoT solutions definitions, as IoT is the most currently deployed technology amongst the technologies discussed.

As per author's assumption, this group's understanding can only be biased by personal witnessed experiences, rather than having a clear understanding of the market's vision, resulting from personal research and training. At this point the TRI negativity effects need to be taken into account, shown by operations and technical departments, who lower the observation scores, while being the major participants of "Group b" employees.

"Group b" professionals are neutral regarding the statement that IoT and Big Data, generally enhance safety, effectiveness and efficiency, appear negative regarding Augmenter Reality, and tend from neutrality to agreement, about Distributed Ledgers for B/Ls, shown below in figure 27.

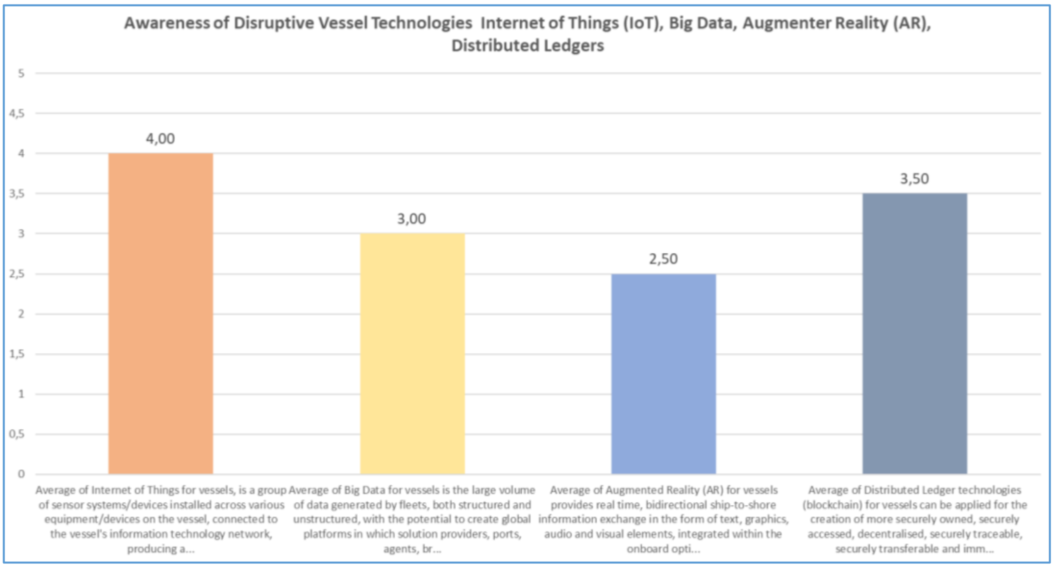


Figure 27. "Group b" mean values of responses - awareness and technology understanding.

Regarding the technologies' compatibility with current demands in the industry, "Group b" professionals show a neutral to agnostic stance against IoT and Big Data, with Augmented Reality receiving negativity, while confidence is shown to the only technology that still faces legal debates (figure 28). At this point the author emphasises again, that the research is conducted during the unfortunate time of the COVID-19 pandemic.

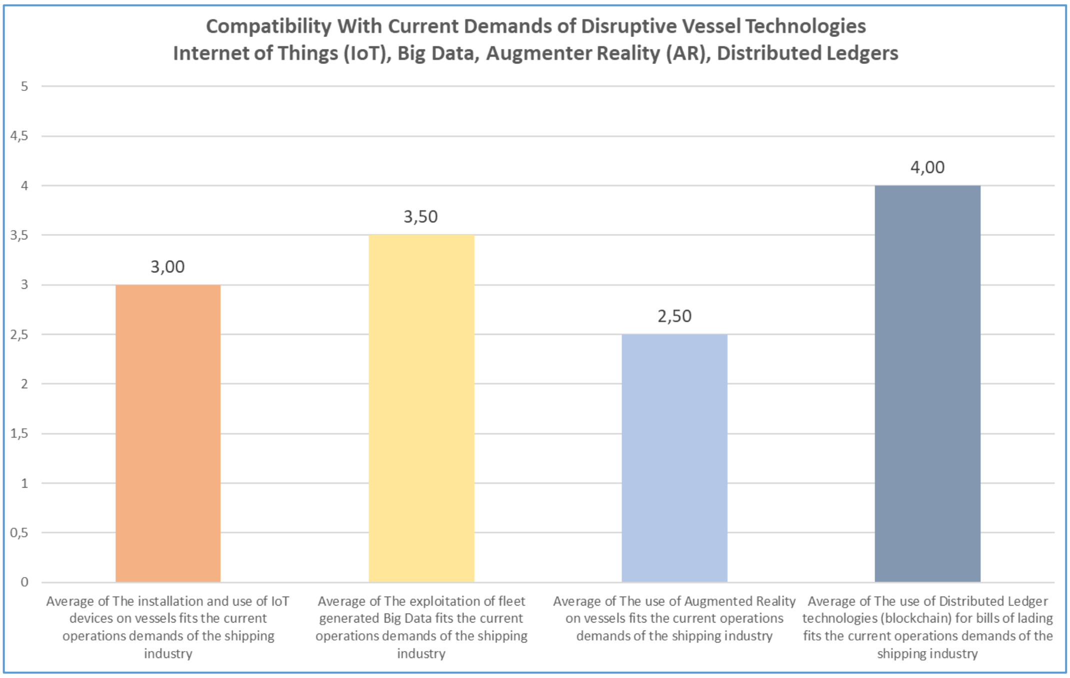


Figure 28. "Group b" mean values of responses – compatibility with current demands.

Even further, it is observed that the same group of professionals, are showing a neutral response overall regarding the use of IoT and Big Data towards a safer, more efficient and more effective shipping industry. Moreover, they do not believe that Augmented Reality can play part in enhancing safety, efficiency and effectiveness, while they seem to depart from neutrality, to a positive stance, regarding the potential impact of Distributed Ledgers on B/Ls, in terms of safety, efficiency and effectiveness, as shown in figure 29.

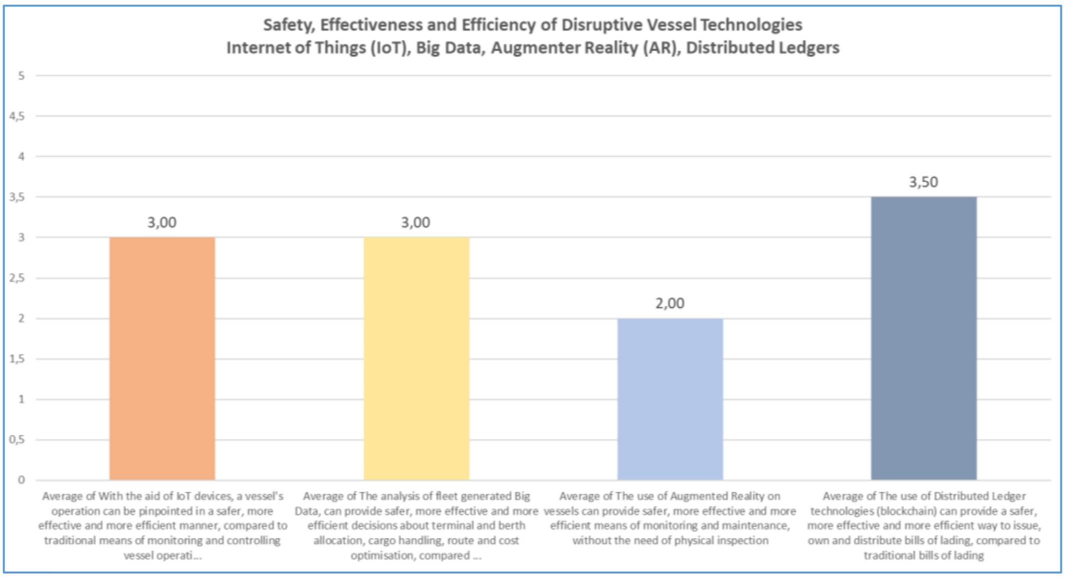


Figure 29. "Group B" mean values of responses – safety, effectiveness and efficiency.

What is even more interesting is that stakeholders with the above characteristics, not only show a lower understanding of high end technologies for the shipping industry, or even negativity towards them, also they dot appear to be playing a significant part in positively or negatively convincing the companies they work for to either adopt technologies, or not. This certain profiled group does not reflect the attitude of the companies they work for, regarding the adoption of all technologies presented herein.

However, the discomfort shown mainly from technical and operations departments, regarding the overall perception against disruptive technologies, was observed to be an insignificant variable for the final corporate implementation. This finding is in accordance with the previous studies, which have viewed discomfort inhibiting the perceived usefulness and overall perceived value of technologies (Dabholkar, 1996; Walczuch, Lemmink and Streukens, 2007), nevertheless for this study, the groups who showed discomfort, appear to be of less educated compared with “Group a” employees, and of ages below 30 and over 50. Overall despite the discomfort shown, this group of professionals does not seem to be affecting the future strategy of the company they work for.

5.3 Findings regarding cyber safety

As previously discussed Cyber Safety is soon to become and integrated part of security in the shipping industry, enforced by the IMO as a mandatory safety standard, focusing in providing resilient and secure environments against attack surfaces, especially for vessels, where OT systems are continuously being integrated within IT environments and networks, especially in new builds.

One can safely expect that the industry will show agreement to strong agreement with the related statements in this survey, as this is a final and regulatory issue. Moreover, the IMO has given specific instructions and guidelines regarding such a complicated issue, as presented in previous sections of this thesis, where the architectures described involve interaction of OT and IT systems, specific KPIs and benchmarks for the service of them, and moreover the IMO has given a clear path that lines the virtues of cyber safety with total quality management, namely the NIST framework.

Nevertheless, departures of some employees perception, from the obvious mandatory requirement are observed. The overall response of the subjects, is depicted below in figure 30. On average employees of the Greek shipping industry, overall tend to agree with all statements. Deviations from agreeing are shown on the definition of IT and OT systems, the inter-networking of them, and the fact that there are specific guidelines from the IMO.

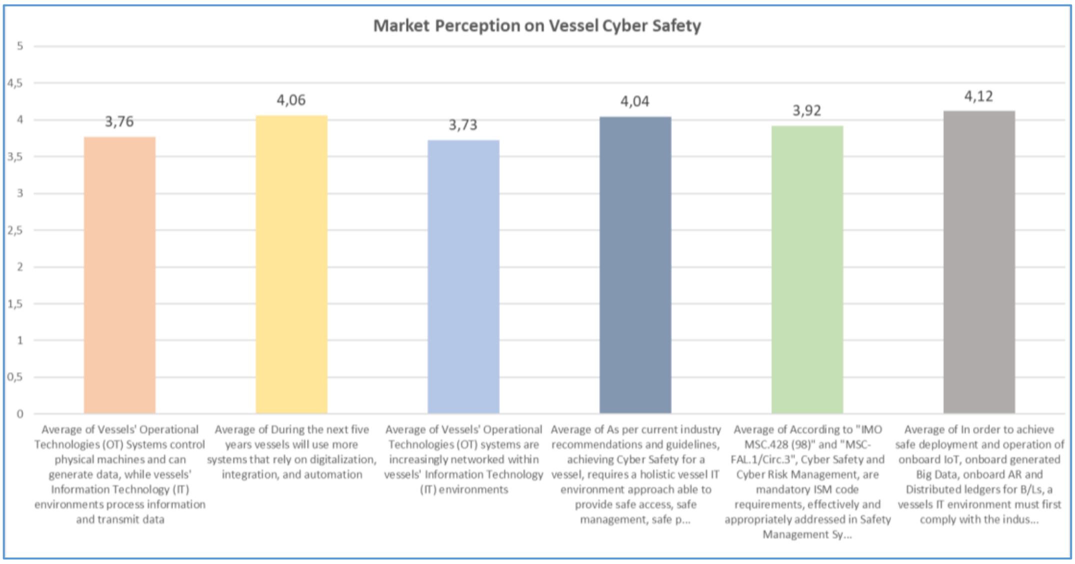


Figure 30. Overall mean values of responses – Cyber Safety.

Proceeding with the examination according to the author's emperical assumptions, we again examine participants of ages between 30 and 50, of postgraduate studies, with an experience of 3 years and beyond, who are specialised in HSQE, IT or are members of management, in companies from 11 vessels and beyond, namely "Group a". The results are depicted in figure 31. As expected this specific group of professionals agree to strongly agree with all statements in accordance with IMO's standards.

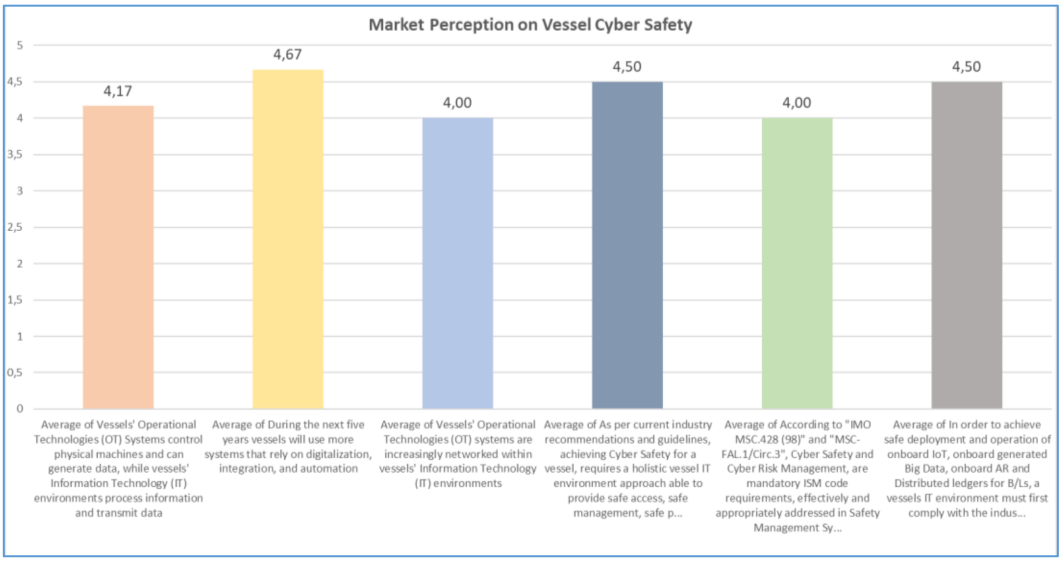


Figure 31. "Group a" mean values of responses – cyber safety.

Interestingly enough, the companies employing "Group A" participants are not considering adoption of cyber safety to their fleets even though they recognise that a cyber safe environment is of major importance in for the adoption of technologies described herein. Moreover, participants from this group appear to have played a convincing role for the adoption of onboard technologies, but a part of them sees failure from their company they work for to adopt mandatory requirements (figure 32). According to the author, this observation requires further investigation, while an explanation may be given, due to the fact that Cyber Safe ecosystems require heavy investments on the entire fleet. High costs combined with the current COVID-19 period may have an influence.

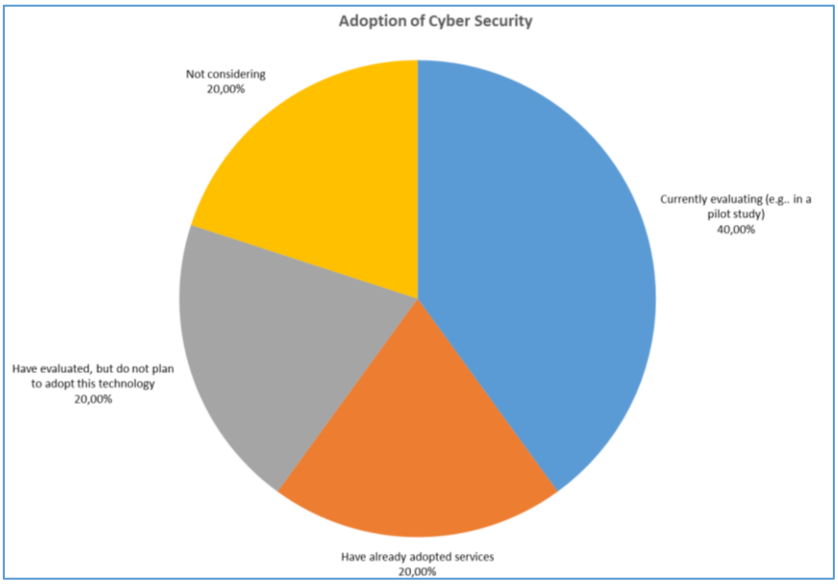


Figure 32. "Group a" mean values of responses – current cyber safety adoption.

As per the previous section "Group b" participants, meaning employees of under 30 and over 50 years old, not participating in HSQE, IT or management, regardless of the years in the industry and regardless of the owned, managed or operated fleets from the companies they work for, show departed results as depicted in figure 33. At this point, we need to mention that it is mainly marine and technical departments that lower the averages. Again, interestingly enough, "Group b" employees suggest that the companies they work for will finally adopt vessel cyber-safe environments, showing that their lower level of knowledge on the issue will not affect the future adoption.

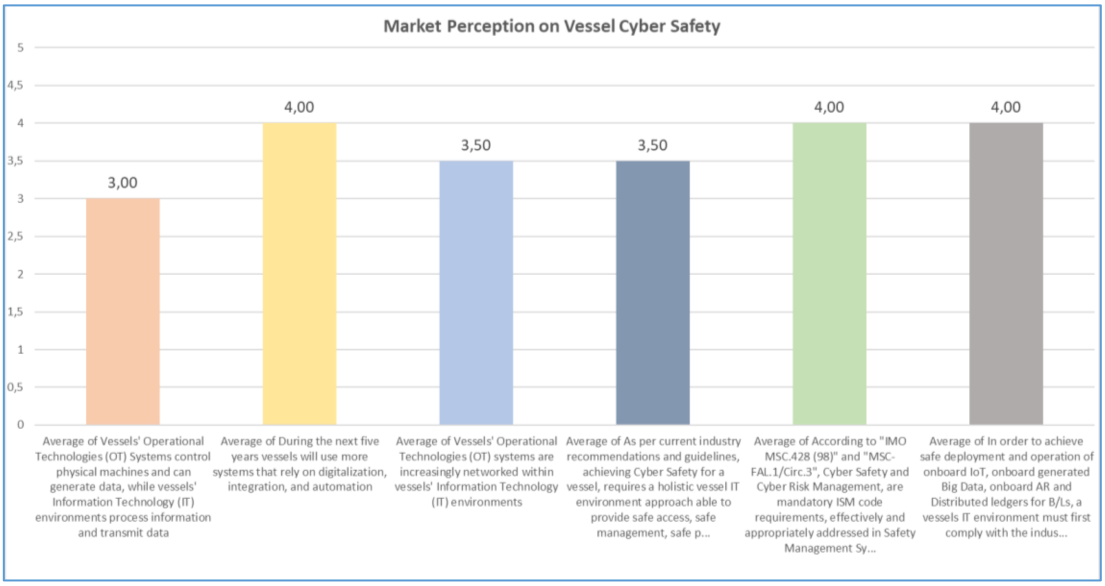


Figure 33. "Group b" mean values of responses – cyber safety.

5.4 Corporate environment perception

Again, responses from “Group a” and “Group b” were taken into account in accordance with the author’s initial assumptions. The results are worth commenting and contrasted. “Group a” responders, agree with all statements they were asked to provide and answer for, showing some doubt regarding the capacity of the fleets of the companies they work for compliant for cyber safety, while even more, they show doubt about the capacity of the departments responsible for fleet IT to deploy the technologies discussed herein.

As an overall “Group a” responders, show trust on the way their company handles new technologies and appear worried about the capacity of the departments responsible for fleet IT to deploy modern solutions. As per the author, the latter observation is logical, as the amount of skillsets and manpowered required to deploy all diverse technological solutions discussed, is barely met from the Greek shipping industry.

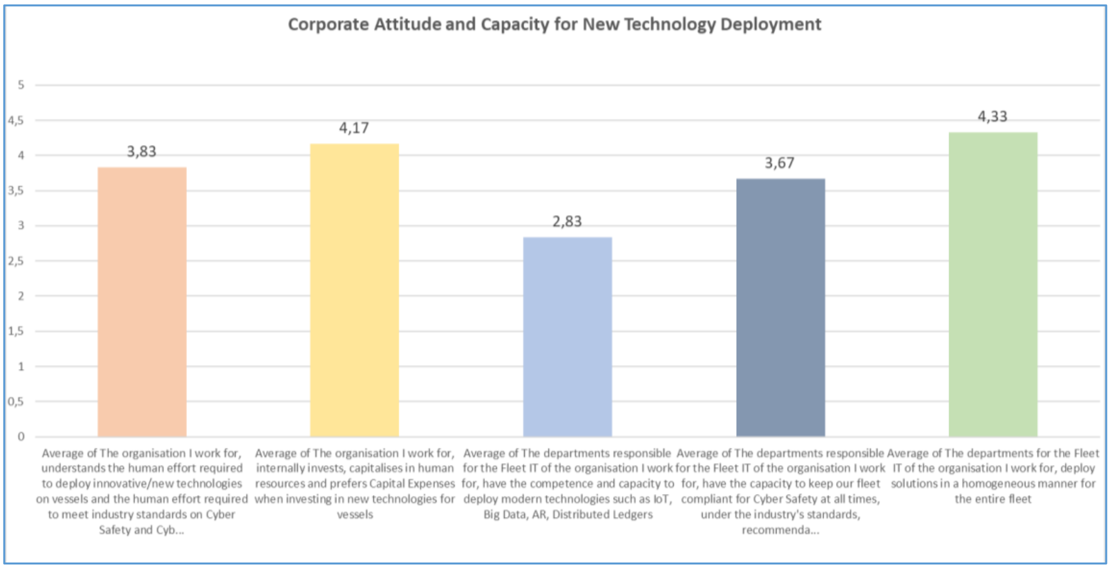


Figure 34. “Group a” mean values of responses – corporate attitude and capacity for new technology deployment.

“Group b” on the other hand shows far worse responses to the above. They tend to disagree about the overall capacity of the companies they work for to deploy modern technologies, while they seem to be neutral regarding a homogenous manner of deploying solutions. Overall, “Group b” appear not to trust the capacity and competence of the departments responsible for fleet IT, of the companies they work for.

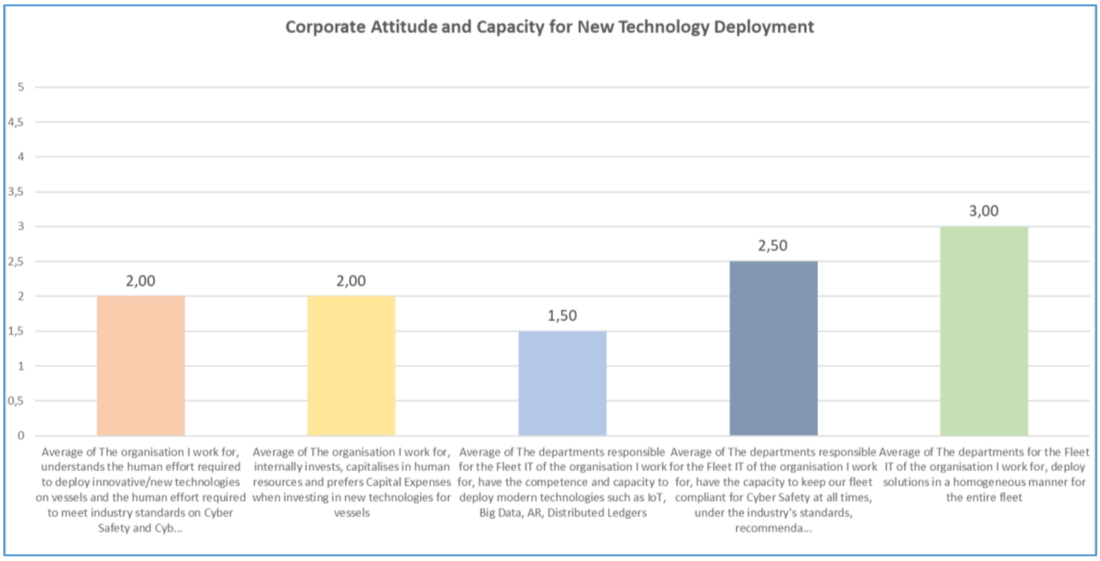


Figure 35. "Group b" mean values of responses – corporate attitude and capacity for new technology deployment.

Regarding the corporate attitude to new technologies as witnessed by the two groups, "Group a" professionals appear to be more convinced compared to "Group b" employees, regarding the understanding and support their companies show regarding the adoption of new technologies for vessels. "Group a" responders shows neutral to positive response about cost driven decisions, while "Group b" does not support the statement regarding cost driven decisions. "Group a" and "Group b" do not see regulations as a moving force to adopt new technologies, while they both are neutral regarding mimic behavior, as per below graphs.

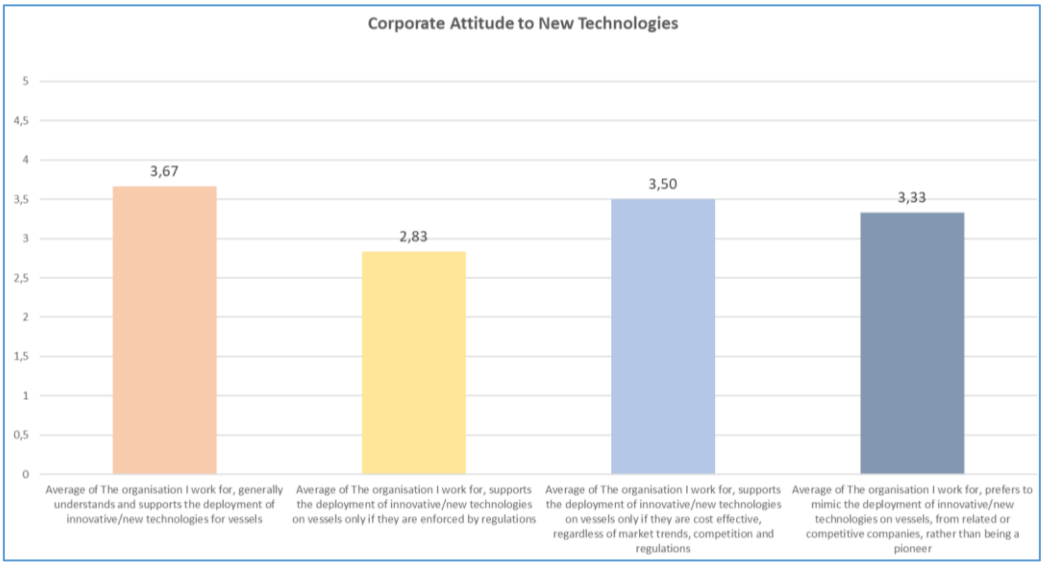


Figure 36. "Group a" mean values of responses – corporate attitude to new technologies.

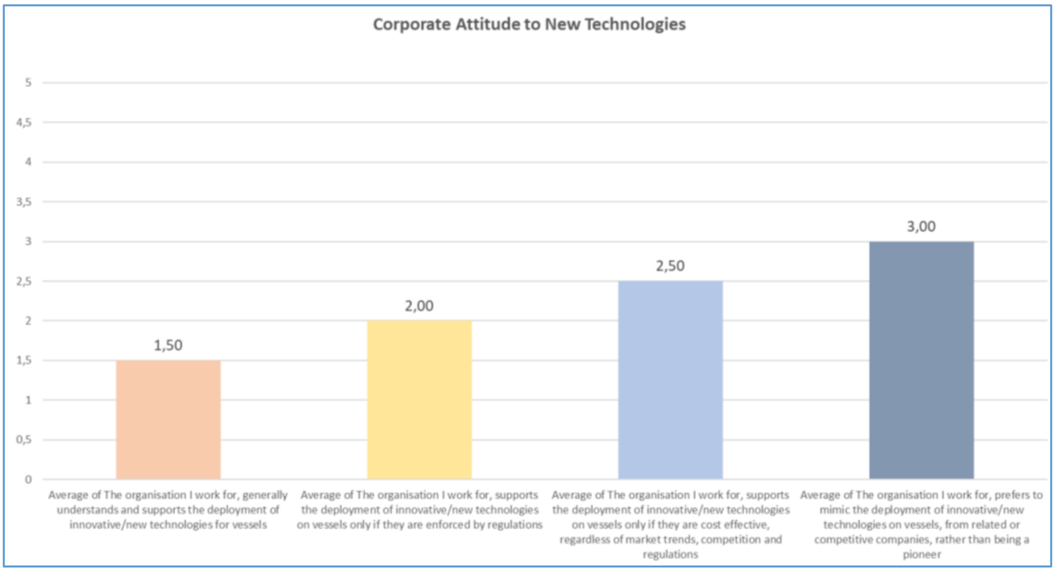


Figure 37. "Group b" mean values of responses – corporate attitude to new technologies.

Similarly, graph 28 and graph 29 show the trust shown by the two groups regarding employee literacy, management literacy and management support regarding new technologies introduced to the companies they work for. "Group a" employees appear more sceptic about the literacy of the employees overall, while on the other hand show confidence regarding their companies management. "Group b" employees are more on the opposite side, strongly disagreeing about the technology literacy of the management level, at the companies they work for.

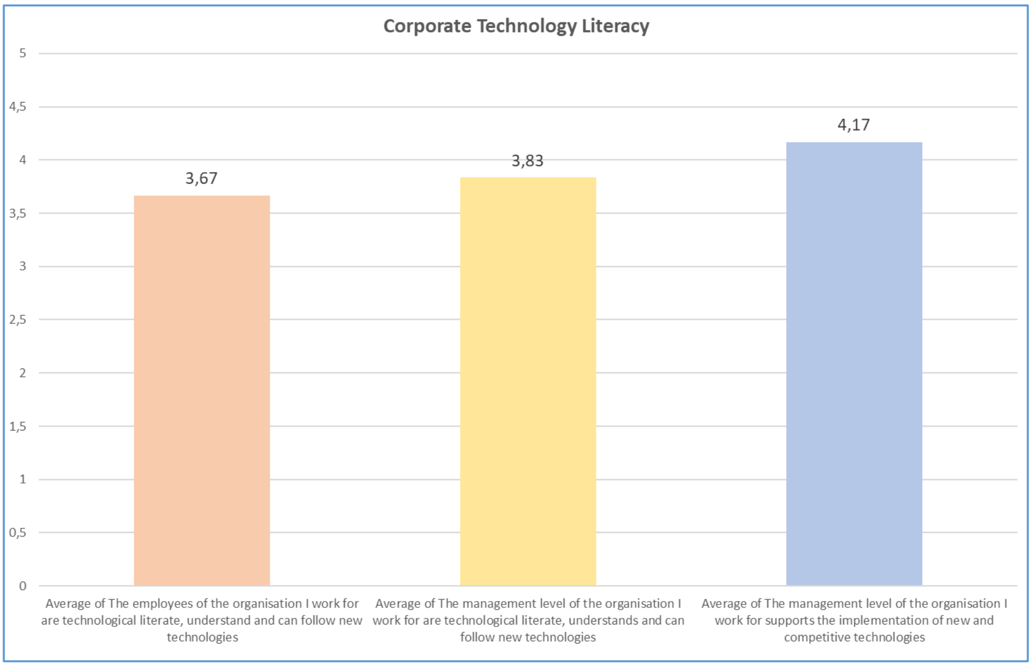


Figure 38. "Group a" mean values of responses – corporate technology literacy.

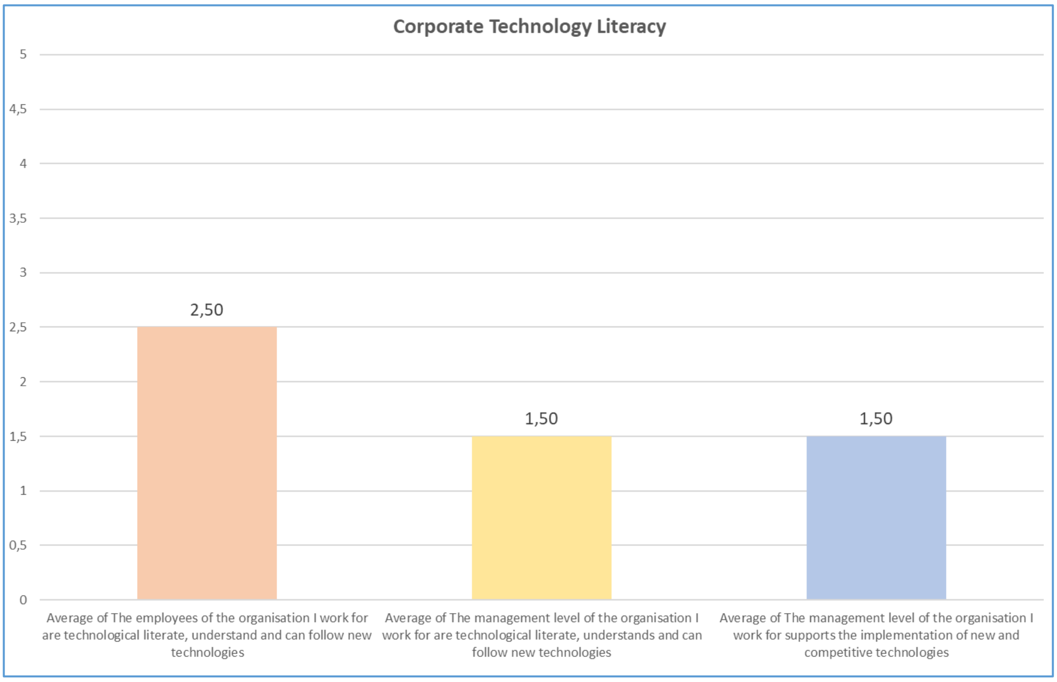


Figure 39. "Group b" mean values of responses – corporate technology literacy.

What is worth mentioning at this stage is that the perceived corporate attitude to new technologies does not seem to be playing a significant part in making decisions in the Greek shipping industry. One should take into account the idiosyncrasies of the Greek shipping sector and the current state of the market, starting from 2008 and reaching a peak of operational difficulties due to the COVID-19 pandemic. "Group a", consisted of higher profiled and more expensive to deploy professionals, often employed to either lead or bias corporate decisions, show signs of optimism and appear to work in bigger and more confident environments regarding new technology and the associated actions needed for Cyber Safety. "Group b" professionals are less skilled, they are lower cost employees and their work is more procedural. Still "Group b" professionals show far less optimism and trust regarding the technology adoption profiles and literacies of their employers.

6. Conclusion

This study was conducted to identify the Greek maritime shipping industry's tendencies in the adoption of certain modern technologies of disruptive nature, along with the overall understanding of overall set of perils imposed to the market by the growing adoption of information technology solutions, in a pragmatic manner. Moreover it is and effort to create a meaningful model which is able to explain or predict the technology adoption in the Greek maritime shipping industry.

It is important to adjust and extend the extant literature of Technology Adoption Models, through the perception of the employees as a starting point to estimate corporate adoption behavior of disruptive technologies in the Greek maritime shipping industry, using TRI constructs. The Greek maritime shipping industry is a complicated market, of various internal actors and opinion leaders within the Greek maritime corporations. No model exists so far, able to address the perception of these actors and their ability to bias decision makers, or project their perceptions to the overall corporate adoption behavior, which is the gap in literature that this study seeks to address. Limitations though exist because of the inherent features of the technologies discussed and the assumptions made for the study.

Findings are compared to literature from other markets where technology adoption is discussed. The overall outcome of this exploratory research, points to more segmented research on technologies, while interviews of profiled employees would be preferred instead of a survey sent to the entire market. Even further qualitative analysis for either inductive or deductive research should be deployed, for the results of the interviewing mechanism proposed for further research.

The study reveals that the most critical constructs explaining behavioral intention for disruptive technology adoption in the Greek shipping sector are perceived understanding, usefulness, attitude, market trust and risk. Further, perceived subjective understanding, market trust and usefulness were found to develop the perceptions on perceived risk and attitude towards the disruptive technology adoption. The significant overall impact of the model proves the importance of the developed model. The research presents a holistic approach for future studies on the adoption of new disruptive information technologies offering valuable insights for further research.

The author, once again emphasises on the fact that the shipping industry has had a lot of hits since 2008, and the problems have peaked during the current COVID-19 period, suggesting that the same study, would have shown different results if the shipping market had been in a safer position.

6.1 Assumptions and limitations

Digital innovation theory was concentrated on product innovations for consumers. Digital innovations theory has changed leading to Christensen (2015) acknowledging that most of the recent digital innovation are disruptive to business models. All technologies discussed are quite new and come from the world of Information Technology, which marches on towards the future with a magnified velocity compared to the shipping industry. Not many shipping companies, like companies from various other industries, have understood the full potential of the technologies discussed in their value chains yet. Even though there are actors in the shipping industry who appear to be familiar with the technologies discussed and their associated perils, through the perspective of cyber security, lack of experience or practical knowledge of the merits and various know-hows, are certainly expected.

The results of this study should not be globally generalized, as this thesis makes an attempt to describe how Greek shipping companies understand the penetration of certain disruptive innovation technologies as projected by the world of information technology and how they intend to adopt. Empirical data was collected from all levels of employees, which worked well as this thesis concentrated on a plethora of topics, although a narrower scope of taking internal opinion leaders and decision makers into account could have added different views especially on the perceived risks and usefulness.

Moreover, even though two viewpoints from the population who answered have made the data more valuable, while the survey as a tool may have increased the reliability of the results by generating a wider range of collected data, the author emphasises on the fact that this research takes place in a rather early phase regarding the technologies relying to responders visions and speculations which are not yet thoroughly established, at a very problematic period due to the COVID-19 pandemic. It would be interesting to make a longitude research after five years at the time when interviewees see shipping economics being in a much better condition, although the timeline this is hard to predict. Most of the employees who showed higher levels of knowledge, have acquired knowledge about the technologies examined based on their personal interest and profile, and are aware of the abilities they can offer to the shipping industry.

For the benefit of the exploratory nature of this study, none of the technologies has been seen as standalone. Even though a standalone technology more accurate data collection and analytics, the idea was to start by an exploratory research, seeking patterns of general attitude and adoption of challenging technologies that will be integrated one way or another with one another in the future, under a cyber safe environment. Internet of things (IoT) and big data technologies play a significant role in ensuring high-quality data is collected for successful adoption in supply chains. The various IoT devices enable the collection of accurate data from multiple sources while big data technologies focus on large and diverse scale data collection in real-time, storage, descriptive, predictive analytics, tending towards deep learning and artificial intelligence in the future.

Augmented reality readings may enhance IoT and big data, by providing real time unstructured data, which are bidirectional fed into and out of the vessel. In order to achieve the above, high resilient and cyber safe environments are required, which in turn can set the basis for Distributed Ledger technology adoption of B/Ls, especially when emphasis is give to accessibility and identity management on board.

6.2 Major findings discussion

This study provides pragmatic evidence that perceived understanding, usefulness, risk, attitude, and subjective norms are related to implementation intention of the technologies under investigation. However, the discomfort with regards to adopting disruptive technologies was observed to be significant for the overall corporate implementation from companies where high educated and experienced employees of certain age range work in certain departments, but it is not influenced by employees of lower educational level, less experience and of certain years of age. This finding is partially in line with previous studies, which have viewed discomfort inhibiting the perceived usefulness (Dabholkar, 1996; Lemmink and Streukens, 2007).

The TRI construct of insecurity, was considered at the validation process, concluding that the Greek shipping practitioners consider discomfort and insecurity as inhibiting factors in the adoption process. These perceptions on insecurity and discomfort may be related to disruption regarding their previous experience, expertise, knowledge, and familiarity with technologies (Agarwal and Prasad 1999).

Our results indicate that the perceived understanding and usefulness, influence the perceived risks and market perception in line with similar studies (Shih, Chen, and Chen, 2012). The effect of the perceived usefulness on the attitude of the practitioners was found to be significant, agreeing with the finding of the other studies (Gamal Aboelmaged, 2010). Moreover, this study finds that perceived usefulness influences the attitude and finds support in other previous studies (Lee 2009). Therefore, from the findings of this study one can infer that perceived usefulness acts as a mediating variable between perceived risk and overall attitude. The positive attitude of the Greek shipping practitioners towards the technologies examined and the associated cyber safety, is an outcome of perceived usefulness, which is influenced by correct understanding.

The finding suggests that that the peer pressure from completion in implementing technologies does not play a decisive role in creating awareness and final adoption. Also, the Greek shipping companies tend to act on internal knowledge acquired, prefer to use internal resources, while the employees of higher education and experience, feel that their peers and management is technology literate supportive in the adoption of new technologies and literate, while employees of lower education levels understand the opposite.

The results consider that attitude is influenced by the perception of the employees regarding the overall corporate attitude and management literacy and support (Lee 2009). Moreover, all participants generally believe that the departments responsible for information technology diffusion on vessels, do not have the capacity to deploy all technologies discussed. All other factors such as sex, classification society, types of vessels owner, managed or operated, did not play a significant factor.

In the present study, we may relate findings to educational qualifications, expertise and the work experience of the respondents. The finding implies that the providers marketing efforts must focus on creating awareness on technologies, and develop interest to drive the practitioners towards successful implementation through effective buyer-supplier dyads (Oosterhuis, Van Der Vaart, and Molleman 2011). For companies implementing such technologies in shipping, this finding implies that the efforts should also be focused on sharing and presenting success stories of other companies those who have implemented the technologies of interest, showcasing the benefits they are achieving as compared to traditional practices. Finally, the findings imply that providers' marketing efforts need to focus on influencing the decision makers in the buying organisations as part of the selling process, and thus identify and focus on the factors that the opinion leaders would consider while buying the technologies on which this thesis focuses.

6.3 Future study suggestions

This research is an effort to project the adoption of the above aggressively emerging technologies in the Greek maritime shipping adoption tendencies, and concurrently map plausible future scenarios with potential implications for an ICT vendor when, introducing such solutions to the Greek shipping industry. The study focuses on determining the adoption potential of certain technologies as disruptive, yet of good fit alternative solutions to existing operational goals, based on the motives and belief of the respondents. Therefore, the author created a TAM model using TRI constructs, as the basis of an exploratory quantitative approach, in order understand the diverse opinions of the studied technologies and the attitude of Greek shipping towards them, and also to understand factors that may shape the future uncertainty of their adoption, using an inductive technique to draw results.

In the present study, we have received responses from employees regardless of their age, education level, presence in the market, and size of the companies they work for. All the above metrics must be tweaked, in the sense that in a future study, it is highly recommended to directly interview opinion leaders and decision makers within shipping companies. This ensures that the selected employees will be considered of higher education, with a related experience in the industry empowered to lead the corporate opinion to future technology adoptions. Since the author assumes that there will be a more extensive adoption of all technologies examined over time, providing that disruptions caused due to COVID-19 pandemic have been rectified, a longitudinal study to evaluate the technologies' progress will be of interest.

Overall the Greek shipping companies as traditional shipping companies, whose models of operation are still amongst the most traditional in the globe, are likely to keep their mentality for a long time. Hence, at a longitude research, except for interviewing certain categories of professionals, the future researcher should take into account that a lot of proprietary business models exist instead of a just one business model, also focusing on the human resource population of the company depending the fleet size of ownership, management or operation.

As per author's opinion, Greek shipping companies need to keep investing in sustaining innovations which makes business more profitable. In order to achieve this they should place resources from various departments in order to follow technology development and eventually choosing between joining the disruption or ignoring the disruption. The author believes that such a tactic could further be upgraded into consortiums of professionals in the Greek shipping industry, placing the Greek shipping industry in a future position even able to disrupt disruptions.

All targeted companies are already operating in the Greek maritime sector and they are all established firms. According to Christensen (1997) these established firms usually struggle with their resource allocation when responding to disruptive technologies. Therefore, this study shows the dilemmas that established firms have to balance sustained operations and disruptive innovations, can be suppressed by ideally setting up teams for responding to or advancing with disruptive technologies, the existence of which need to be further investigated within the Greek maritime shipping sector.

Concluding, the Greek shipping market analysis is important to foresee its strengths and weaknesses against disruptive innovations in the future. The results of our study suggest that the proposed adoption model holds a significant explanatory power to be further exploited in the future. The integration of TRI constructs with the TAM is theoretically appealing, and even though it was found that TRI influences factors such as understanding, risk and usefulness perception, its significance may influence the adoption process, depending on the structure of a company, which should be taken into account in future research.

References

1. A. Bhattacherjee. Managerial influences on intraorganizational information technology use: A principal-agent model. Decision Sciences, (1998).
2. A.E. Hassanien, A.T. Azar, V. Snasel, J. Kacprzyk, J. H. Abawajy, Big Data in Complex Systems-Challenges and Opportunities, Springer, London, (2015).
3. Agarwal, R., and E. Karahanna. 2000. "Time Flies When You're Having fun: Cognitive Absorption and Beliefs About Information Technology Usage." MIS Quarterly..
4. Agarwal, R., and J. Prasad. 1998. "The Antecedents and Consequents of User Perceptions in Information Technology Adoption." Decision Support Systems.
5. Agnihothri, S., Sivasubramaniam, N., & Simmons, D. (2002). Leveraging technology to improve field service. International Journal of Service Industry Management.
6. Aiken, M. & Hage, J. (1971). The Organic Organization and Innovation, Sociology.
7. Ajzen, I., and M. Fishbein. 1980. Understanding Attitudes and Predicting Social Behavior. Englewood Cliffs, NJ: Prentice-Hall.
8. Andal-Ancion A, Cartwright P, Yipet G (2012) The digital transformation of traditional business. MIT Sloan Review.
9. Ankur Joshi, Saket Kale, Satish Chandel. 2015. "Likert Scale: Explored and Explained". Current Journal of Applied Science and Technology.
10. Asare, A.K., Brashear-Alejandro, T.G. & Kang, J., 2016. B2B technology adoption in customer driven supply chains. Journal of Business & Industrial Marketing.
11. Azadegan, A., & Teich, J. (2010). Effective benchmarking of innovation adoptions: A theoretical framework for e-procurement technologies. Benchmarking: An International Journal.
12. Azuma, R. T. (1997) A Survey of Augmented Reality. Teleoperators and Virtual Environments.
13. Babbie, E. R. (2010) "The Practice of Social Research" Cengage Learning.
14. Bagozzi, R.R.: The legacy of the technology acceptance model and a proposal for a paradigm shift. Journal of the Association of Information Systems.
15. Baiyere, Abayomi (2016) Discovering the Role of Information Technology in Disruptive Innovations, Enabler, Sustainer or Barrier?, University of Turku.
16. Bajpai, P., 2017. How IBM And Maersk Will Use The Blockchain To Change The Shipping Industry. NASDAQ.com. http://www.nasdaq.com/article/how-ibm-and-maersk-will-use-theblockchain-to-change-the-shipping-industry-cm756797 - last accessed 20/10/2020.
17. Baker, J., 2017. A token solution to no-shows. Lloyd's List. https://lloydslist.maritimeintelligence.informa.com/LL110675/A-token-solution-to-noshows - last accessed 20/10/2020.
18. Beck , R. et al., Blockchain - the gateway to trust-free cryptographic transactions. Twenty-Fourth European Conference on Information Systems (ECIS).
19. Benbasat, I., Barki, H.: Quo vadis, TAM? Journal of the Association of Information Systems, (2007).

20. Bhattacherjee, A. (2002), "Individual trust in online firms: scale development and initial test", Journal of Management Information Systems.
21. Blumberg, D. F. (1994). Strategies for improving field service operations productivity and quality. Service Industries Journal.
22. Bollen, K. A. 1989. Structural Equations with Latent Variables. New York, NY: John Wiley.
23. Bower JL and Christensen CM: 'Disruptive technologies: catching the wave', Harvard Business Review (January-February 1995).
24. Carr Jr, V. H. 1999. "Technology Adoption and Diffusion." The Learning Center for Interactive Technology. http://tlc.nlm.nih.gov/resources/publications/sourcebook/adoptiondiffusion.html - last accessed 20/10/2020.
25. Chambers, 2017, 2017. Health, safety and the blockchain . 24/7 Splash. http://splash247.com/health-safety-blockchain/ - last accessed 20/10/2020.
26. Chen, S. C., and H. H. Chen. 2008. "The Influence of Technology Readiness on the Theory of Planned Behavior with Self-Service Technologies." In Proceedings of WMSCI. The 12th World Multi-Conference on Systemics, Cybernetics and Informatics.
27. Chesbrough H (2010) Business model innovation: opportunities and barriers. Long Range Plan.
28. Christensen, C. M., Raynor, M. and McDonald, R. (2015). What is disruptive innovation?. Harvard Business Review.
29. Christensen, Clayton, M. & Overdorf, M. (2000). Meeting the Challenge of Disruptive Change. Harvard Business Review.
30. Churchill Jr, G. A. 1979. "A Paradigm for Developing Better Measures of Marketing Constructs." Journal of Marketing Research.
31. Clayton M. Christensen: 'The innovator's dilemma' Boston: Harvard Business School Press, (1997).
32. Cucurull, J. & Puiggali, J., 2016. Distributed Immutabilization of Secure Logs. Security and Trust Management Lecture Notes in Computer Science.
33. D.J. Teece. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal, (2007).
34. Dabholkar, P. A. 1996. "Consumer Evaluations of new Technology-Based Self-Service Options: an Investigation of Alternative Models of Service Quality." International Journal of Research in Marketing.
35. Damanpour, F. (1991). Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators. Academy of Management Journal.
36. Damanpour, F., & Gopalakrishnan, S. (1998). Theories of organizational structure and innovation adoption: the role of environmental change. Journal of Engineering and Technology Management.
37. Damanpour, F., & Schneider, M. (2006). Phases of the Adoption of Innovation in Organizations: Effects of environment, organization and top managers. British Journal of Management.
38. Damanpour, F., & Schneider, M. (2008). Characteristics of Innovation and Innovation Adoption in Public Organizations: Assessing the Role of Managers. Journal of public Administration Research and Theory.
39. Davis, F. D. 1989. "Perceived Usefulness, Perceived Ease of use, and User Acceptance of Information Technology." MIS Quarterly.
40. DBMS, Dry Bulk Management Standard, Guidelines & standards. https://drybulkmanagementstandard.org/guidelines/ - last accessed 20/10/2020.

41. Digitalizing the Shipping Industry with Disruptive Innovation (2019) https://www.bluextrade.com/blog/digitalizing-shipping-industry-disruptive-innovation/ - last accessed 20/10/2020.
42. DNV, Shipping 2020, Norway, 2014.
43. DNVGL. Maritime Cyber Security. Retrieved from https://www.dnvgl.com/maritime/insights/topics/maritime-cyber-security/index.html - last accessed 20/10/2020.
44. Dodgson, M., Gann, D. and Salter, A. The Management of Technological Innovation Strategy and Practice. Oxford University Press, (2008).
45. E.M. Rogers (1995). Diffusion of Innovations, 4th Edition. New York: Free Press.
46. E.M. Rogers (2003). Diffusion of innovations. (5th ed.), The Free Press, New York, NY.
47. El Noshokaty S (2017) Shipping optimisation systems (SOS): tramp optimisation perspective. Journal of Shipping and Trade.
48. Engelen, A., Engelen, M., & Bachmann, J. T. (2015). Corporate Entrepreneurship: Unternehmerisches Management in etablierten Unternehmen. Dortmund: Springer Gabler.
49. European Parliament. Directive (EU) 2016/1148. Official Journal of the European Union, 2014(L194):1–30, 2016.
50. Fitzgerald M et al (2014) Embracing digital technology: a new strategic imperative. MIT Sloan Review.
51. Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multilevel framework of determinants and opportunities for future research. Journal of Business Research.
52. Fürstenberg, S., 2017. Fleet Transformation: What blockchain can really do. Fathom News. http://www.fathom-news.com/fleet-transformation-blockchain-can-really-2/ - last accessed 20/10/2020.
53. G. Moore. Crossing the Chasm (1991, revised 1999 and 2014).
54. Gamal Aboelmaged, M. 2010. “Predicting e-Procurement Adoption in a Developing Country: an Empirical Integration of Technology Acceptance Model and Theory of Planned Behaviour.” Industrial Management & Data Systems.
55. Gartner (2016a). July 06, 2016. Supply Chain 2025: Planning Today for Tomorrow. Michael Burkett and John Johnson. https://www.gartner.com/doc/3367817/supply-chain--planning-today - last accessed 20/10/2020.
56. Gartner (2016b). August 16, 2016. Gartner's 2016 Hype Cycle for Emerging Technologies Identifies Three Key Trends That Organizations Must Track to Gain Competitive Advantage. Amy Ann Forni. http://www.gartner.com/newsroom/id/3412017 - last accessed 20/10/2020.
57. Gartner (2017a). February 2, 2017. Top 10 Mistakes in Enterprise Blockchain Projects. Kasey Panetta. http://www.gartner.com/smarterwithgartner/top-10-mistakes-in-enterprise-blockchain-projects/ - last accessed 20/10/2020.
58. Gartner (2017b). October 18, 2016. Gartner’s Top 10 Strategic Technology Trends for 2017. Kasey Panetta. http://www.gartner.com/smarterwithgartner/gartners-top-10-technology-trends-2017/
59. Gartner. IT glossary, 2018. https://www.gartner.com/it-glossary/ - last accessed 20/10/2020.
60. Gefen, D., E. Karahanna, and D. W. Straub. 2003. “Inexperience and Experience with Online Stores: The Importance of TAM and Trust.” IEEE Transactions on Engineering Management.
61. Gershenfeld, N., Krikorian, R. and Cohen, D. (2004), “The internet of things”, Scientific American.

62. Godoe, P., and T. Johansen. 2012. “Understanding Adoption of New Technologies: Technology Readiness and Technology Acceptance as an Integrated Concept.” Journal of European Psychology Students.
63. GONG, M., XU, Y., & YU, Y. (2004). An enhanced technology acceptance model for web-based learning. Journal of Information Systems Education.
64. Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of Innovations in Service Organizations: Systematic Review and Recommendations. Milbank Quarterly.
65. Gulati, PM, 2009, Research Management: Fundamental and Applied Research, Global India Publications.
66. Guo, Y. & Liang, C., 2016. Blockchain application and outlook in the banking industry. Financial Innovation.
67. H. Chesbrough. Business model innovation: Opportunities and barriers. Long Range Planning.
68. HBR (2017a). March 6, 2017. The Promise of Blockchain Is a World Without Middlemen. Vinay Gupta. https://hbr.org/2017/03/the-promise-of-blockchain-is-a-world-without-middlemen - last accessed 20/10/2020.
69. HBR (2017b). January-February issue 2017. The Truth about Blockchain. Marco Iansiti & Karim R. Lakhani. https://hbr.org/2017/01/the-truth-about-blockchain - last accessed 20/10/2020.
70. Heilig, L., Schwarze, S. and Voss, S. (2017) ‘An Analysis of Digital Transformation in the History and Future of Modern Ports’, in 50th Hawaii International Conference on System Sciences. Hawaii.
71. Hellenic Shipping News, 2016. First operational use of public blockchain technology in the global shipping industry announced. http://www.hellenicshippingnews.com/firstoperational-use-of-public-blockchain-technology-in-the-global-shipping-industry-announced/ - last accessed 20/10/2020.
72. Hoagland, P., Marine policy and economics: a derivative of encyclopedia of ocean sciences / Porter Hoagland, editor, Amsterdam: Elsevier, 2010.
73. Howell, J. M., & Higgins, C. A. (1990). Champions of technological innovation. Administrative Science Quarterly.
74. IBM, 2017. Maersk and IBM Unveil Supply Chain Solution on Blockchain. https://www-03.ibm.com/press/us/en/pressrelease/51712.wss - last accessed 20/10/2020.
75. IDC. (2017). Retrieved from Worldwide Semiannual Internet of Things Spending Guide: https://www.idc.com/getdoc.jsp?containerId=IDC_P29475 - last accessed 20/10/2020.
76. Ifinedo, P. (2011). An empirical analysis of factors influencing Internet/E-Business technologies adoption by SMEs in Canada. International Journal of Information Technology & Decision Making.
77. IMCA, Security Measures and Emergency Response Guidelines, 2015. IMCA M 226, IMCA SEL 037.
78. IMO. Guidelines on Maritime Cyber Risk Management. (2017).
79. IMO. Technical Note No. 24/2017. Subject: Cyber risk management into the ISM Code.
80. Institute of Electrical and Electronics Engineers (1990) IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. New York.
81. International Maritime Organisation, Third IMO GHG study 2014, London, 2015.
82. ISO, Big Data-Preliminary Report 2014, Switzerland (2015).
83. J.L. Carlo, K. Lyytinen, G.M. Rose. A knowledge-based model of radical innovation in small software firms MIS Quarterly, (2012). https://www.jstor.org/stable/pdf/41703484.pdf - last accessed 20/10/2020.
84. Jahangir, N. & Begum, N. 2008. The Role of Perceived Usefulness, Perceived Ease of Use, Security and Privacy, and Customer Attitude to Engender Customer Adaption in the Context of Electronic Banking. African Journal of Business Management.

85. Jansson, J., Marell, A., & Nordlund, A. (2010). Green consumer behavior: determinants of curtailment and eco-innovation adoption. Journal of Consumer Marketing.
86. Jensen, T., Bjørn-Andersen, N. & Vatrapu, R., 2014. Avocados crossing borders. Proceedings of the 5th ACM international conference on Collaboration across boundaries: culture, distance & technology - CABS '14.
87. Jim Robinson, The Six Categories of Field Service Management Application Functionality and Why You Need Them. Gartner Research, (2018).
88. Jonathan Levin, I Love the Blockchain, Just Not Bitcoin (21 November 2014) CoinDesk http://www.coindesk.com/love-blockchain-just-bitcoin, archived at https://perma.cc/8GT3-4K8V - last accessed 20/10/2020.
89. Kennedy III, W. ., Beasley, D. E., Parker, T. S., Russell, T. D., & Saunders, W. C. (2000). System and method for providing menu data using a communication network. US Patent.
90. Koga, S. (2015) Major challenges and solutions for utilizing big data in the maritime industry. http://commons.wmu.se/all_dissertationshttp://commons.wmu.se/all_dissertations/490 - last accessed 20/10/2020.
91. Kortuem, G., Kawsar, F., Fitton, D. and Sundramoorthy, V. (2010), "Smart objects as building blocks for the internet of things", IEEE Internet Computing.
92. Kuo, K. M., C. F. Liu, and C. C. Ma. 2013. "An Investigation of the Effect of Nurses' Technology Readiness on the Acceptance of Mobile Electronic Medical Record Systems." BMC Medical Informatics and Decision Making.
93. Larasati, N., and P. I. Santosa. 2017. "Technology Readiness and Technology Acceptance Model in New Technology Implementation Process in Low Technology SMEs. International Journal of Innovation." Management and Technology.
94. Lee, M. S. 2009. "An Empirical Study About RFID Acceptance—Focus On The Employees in Korea." International Journal for Business Economy Finance Management Science.
95. Lippert, S. K., & Govindarajulu, C. (2006). Technological, Organizational, and Environmental Antecedents to Web Services Adoption. Communications of the IIMA.
96. Liu, X. and Sun, Y. (2011), "Information flow management of vendor-managed inventory system in automobile parts inbound logistics based on internet of things", Journal of Software.
97. Lloyds Register, QinetiQ, University of Southampton, Global shipping technology 2030, UK, 2015.
98. Low, C., Chen, Y., & Wu, M. (2011). Understanding the determinants of cloud computing adoption. Industrial Management & Data Systems.
99. Mäntymäki, M.: Continuous use and purchasing behavior in social virtual world, Doctoral dissertation, Turku School of Economics, Turku, Finland (2011).
100. Marshall University (2019) Big Data, Big Data Analytics. Available at: https://www.marshall.edu/bigdata/ - last accessed 20/10/2020.
101. Mayer, R.C., Davis, J.H. and Schoorman, F.D. (1995), "An integrative model of organizational trust", Academy of Management Review.
102. McKinsey & Company. (2013). Making data analytics work: Three key challenges. https://www.mckinsey.com/business-functions/digital-mckinsey/ourinsights/making-data-analytics-work - last accessed 20/10/2020.

103. Miranda, M.Q. et al., 2016. Technology Adoption In Diffusion Of Innovations Perspective: Introduction Of An Erp System In A Non-Profit Organization. Review of Administration and Innovation.
104. Mlimbila and Mbamba (2018) The role of information systems usage in enhancing port logistics performance: evidence from the Dar Es Salaam port, Tanzania. Journal of Shipping Trade.
105. Moore, G.C. and Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research.
106. Morabito, V., 2017. Business Innovation Through Blockchain: the B3 Perspective, Cham: Springer International Publishing.
107. Morley, H.R., 2017. Container weight blockchain shows tech's potential. Journal Of Commerce. https://www.joc.com/technology/container-weight-blockchain-shows-tech'spotential_20170830 - last accessed 20/10/2020.
108. Mougayar, William (2016). The Business Blockchain: Promise, Practice, and Application of the Next Internet Technology, Wiley.
109. Nakamoto, S., 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. https://bitcoin.org/bitcoin.pdf.
110. Neuman, S. P., & Di Federico, V. (2003). Multifaceted nature of hydrogeologic scaling and its interpretation. Reviews of Geophysics.
111. NIST SP 800-160 Vol. 2. Systems Security Engineering: Cyber Resiliency Considerations for the Engineering of Trustworthy Secure Systems, 2018.
112. Nunnally, J. C., and I. H. Bernstein. 1978. "Psychometric Theory".
113. OCIMF. Cyber Security on board ships- Tanker Management and self assessment and upcoming changes to the international safety. (2018).
114. OECD, 2014. OECD Foreign Bribery Report: An Analysis of the Crime of Bribery of Foreign Public Officials. OECD Publishing. http://dx.doi.org/10.1787/9789264226616-en - last accessed 20/10/2020.
115. Oliveira, T., & Martins, M. (2010). Understanding e-business adoption across industries in European countries. Industrial Management & Data Systems.
116. Oosterhuis, M., T. Van Der Vaart, and E. Molleman. 2011. "Perceptions of Technology Uncertainty and the Consequences for Performance in Buyer-Supplier Relationships." International Journal of Production Research.
117. Oppenheim, A. N. 1966. Questionnaire Design and Attitude Measurement. London: Heineman.
118. Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research Journal of Business Research. https://doi.org/10.1016/S0148-2963(00)00152-1 - last accessed 20/10/2020.
119. Osterwalder A, Pigneur Y, Tucci CL (2005) Clarifying business models: origins, present and future of the concept. Communications of the AIS.
120. Oye, N. D., A. N. Iahad, and N. A. Rahim. 2012. "Acceptance and Usage of ICT by University Academicians Using UTAUT Model: a Case Study of University of Port Harcourt Nigeria." Journal of Emerging Trends in Computing and Information Sciences.
121. Parasuraman, A. 2000. "Technology Readiness Index (TRI) a Multiple-Item Scale to Measure Readiness to Embrace new Technologies." Journal of Service Research.

122. Parasuraman, A., and C. L. Colby. 2001. Techno-ready Marketing, How and Why Your Customers Adopt Technology. New York, NY: The Free Press.

123. Pattansheti, M., S. S. Kamble, S. M. Dhume, and R. D. Raut. 2016. "Development, Measurement and Validation of an Integrated Technology Readiness Acceptance and Planned Behaviour Model for Indian Mobile Banking Industry." International Journal of Business Information Systems.

124. Pelissier, R. (2008) "Business Research Made Easy" Juta & Co.

125. Phillips, R. W., & Phillips, R. (1997). Innovation and firm performance in Australian manufacturing. Canberra: Industry Commission.

126. Porter, M. (1996). What Is Strategy?. Harvard Business Review.

127. R. Rothrock, R. A. Clark. Digital Resilience: Is Your Company Ready for the Next Cyber Threat?, 2018.

128. R.T. Frambach, N. Schillewaert. Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. Journal of Business Research.

129. Rajan, C. A., and R. Baral. 2015. "Adoption of ERP System: An Empirical Study of Factors Influencing the Usage of ERP and its Impact on end User." IIMB Management Review.

130. Russom, P. (2011). Big data analytics. TDWI best practices report, fourth quarter.

131. S. Mao, Y. Zhang,V. M. Leung, Big Data Related Technologies-Challenges and Future Prospects, Springer, London, 2014.

132. S. Samonas, D.Coss. The CIA Strikes Back: Redefining Confidentiality, Integrity and Availability in Security. Journal of Information System Security. Information Institute Publishing, Washington DC, USA.

133. Sahin, I., 2006. Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory. Turkish Online Journal of Educational Technology.

134. Samaradiwakara, G. D. M. N., and C. G. Gunawardena. 2014. "Comparison of Existing Technology Acceptance Theories and Models to Suggest a Well Improved Theory/Model." International Technical Sciences Journal.

135. Saunders, M., P. Lewis, and A. Thornhill. 2015. Research Methods for Business Students. 7th ed. Harlow: Pearson Education.

136. Schwenker, B. & Wulf, T., 2013. Scenario-based strategic planning: developing strategies in an uncertain world, Wiesbaden: Springer gabler.

137. Seebacher, S. & Schüritz, R., 2017. Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review. Lecture Notes in Business Information Processing Exploring Services Science.

138. Segars, A.H. and Grover, V. (1993). Re-examining perceived ease of use and usefulness: A confirmatory factor analysis. MIS Quarterly.

139. Sharma, R., and R. Mishra. 2014. "A Review of Evolution of Theories and Models of Technology Adoption." Indore Management Journal.

140. Sharples, M. & Domingue, J., 2016. The Blockchain and Kudos: A Distributed System for Educational Record, Reputation and Reward. Adaptive and Adaptable Learning Lecture Notes in Computer Science.

141. Shih, B. Y., C. Y. Chen, and C. L. Chen. 2012. "An Enhanced Acceptance Model for Exploring User Intention Towards Virtual Reality Environment: Partial Least Squares (PLS) Statistical Method." International Journal of Physical Sciences.

142. Sideridis, G., P. Simos, A. Papanicolaou, and J. Fletcher. 2014. "Using Structural Equation Modeling to Assess Functional Connectivity in the Brain Power and Sample Size Consideration." Educational and Psychological Measurement.

143. Snieder, R. & Larner, K. (2009) "The Art of Being a Scientist: A Guide for Graduate Students and their Mentors", Cambridge University Press.

144. Son, M., and K. Han. 2011. "Beyond the Technology Adoption: Technology Readiness Effects on Post-Adoption Behavior." Journal of Business Research.

145. Stopford, Martin (2009) Maritime Economics, Third edition, Routledge, New York.

146. Stopford, Martin (2015) http://splash247.com/shippings-smarter-path-stopford/ - last accessed 20/10/2020.

147. T. Ravichandran. Swiftness and intensity of administrative innovation adoption: An empirical study of TQM in information systems. Decision Sciences.

148. Tapscott, D., Tapscott, A. (2016). The Blockchain Revolution: How the technology behind Bitcoin is changing money, business,and the world, Penguin UK.

149. Taylor, S. and Todd, P. (1995), "Assessing IT usage: the role of prior experience", MIS Quarterly.

150. Thiesse, F., Staake, T., Schmitt, P., & Fleisch, E. (2011). The rise of the "next generation bar code: an international RFID adoption study. Supply Chain Management: An International Journal.

151. Thompson, R. L., C. A. Higgins, and J. M. Howell. 1991. "Personal Computing: Toward a Conceptual Model of Utilization." MIS Quarterly.

152. Tidd, J., Bessant, J. & Pavitt, K. (2005). Managing Innovation. Integrating Technological, Market and Organizational Change. Oxford: Oxford Press.

153. United States Department of Commerce, 2017. Shipping. Assess Costs Everywhere. Available at: http://acetool.commerce.gov/shipping - last accessed 20/10/2020.

154. Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. Decision Sciences.

155. Venkatesh, V., and F. D. Davis. 2000. "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies." Management Science.

156. Venkatesh, V., and X. Zhang. 2010. "Unified Theory of Acceptance and Use of Technology: U.S. Vs. China." Journal of Global Information Technology Management.

157. Venkatesh, V., Morris, M. G., Davis , G. B., & Davis , F. D. (2003). User acceptance of information technology: Toward a unified view. MIS quarterly.

158. Verma, P., and N. Sinha. 2018. "Integrating Perceived Economic Wellbeing to Technology Acceptance Model: The Case of Mobile Based Agricultural Extension Service." Technological Forecasting and Social Change.

159. Voss, S., Sebastian, H.-J. and Pahl, J. (2017) 'Introduction to Intelligent Decision Support and Big Data for Logistics and Supply Chain Management Minitrack', in Proceedings of the 50th Hawaii International Conference on System Sciences.

160. Walczuch, R., J. Lemmink, and S. Streukens. 2007. "The Effect of Service Employees' Technology Readiness on Technology Acceptance." Information & Management.

161. Wallace, R. O., and C. J. Mellor. 1988. "Nonresponse Bias in Mail Accounting Surveys: a Pedagogical Note." The British Accounting Review.

162. Wang, M. W., Lee, O.-K., & Lim, K. H. (2007). Knowledge Management Systems Diffusion in Chinese Enterprises: A Multi-Stage Approach with the Technology-Organization-Environment Framework 2007 Proceedings. Presented at the PACIS 2007 Proceedings.

163. Willis, G., S. E. Genchev, and H. Chen. 2016. "Supply Chain Learning, Integration, and Flexibility Performance: an Empirical Study in India." The International Journal of Logistics Management.

164. Wilson, J. (2010) "Essentials of Business Research: A Guide to Doing Your Research Project" SAGE Publications.

165. Wolf, E. J., K. M. Harrington, S. L. Clark, and M. W. Miller. 2013. "Sample Size Requirements for Structural Equation Models an Evaluation of Power, Bias, and Solution Propriety." Educational and Psychological Measurement.

166. World Economic Forum, 2016. The Global Enabling Trade Report 2016. Available at: The Global Enabling Trade Report 2016.

167. Xie, Q., W. Song, X. Peng, and M. Shabbir. 2017. "Predictors for e-Government Adoption: Integrating TAM, TPB, Trust and Perceived Risk." The Electronic Library.

168. Xu, J., & Quaddus, M. (2012). Examining a model of knowledge management systems adoption and diffusion: A Partial Least Square approach. Knowledge-Based Systems.

169. Yi, Y., L. L. Tung, and Z. Wu. 2003. "Incorporating Technology Readiness (TR) into TAM: Are Individual Traits Important to Understand Technology Acceptance?" DIGIT 2003 proceedings.

170. Yin, R.K. (1994a). Case study research: Design and methods (2nd ed., 1st ed., 1984; rev. ed., 1989). Thousand Oaks, CA: Sage Publications.

171. Zaltman, G., Duncan, R., & Holbek, J. (1973). Innovations and Organizations. New York: Wiley.

172. Zhu, K., Dong, S., Xu, S., & Kraemer, K. (2006). Innovation diffusion in global contexts: Determinants of post-adoption digital transformation of European companies. European Journal of Information Systems.

173. Zikmund, W. G., Carr, J. C., & Griffin, M. (2012). Business Research Methods (with Qualtrics Printed Access Card). South-Western Pub.

Appendix A – The survey

"Vessels digital disruption by ICT technologies. Incentives, perils & adoption tendencies"

Dear Sir/Madam,

I strongly appreciate your contribution to my thesis.

This survey takes less than five minutes to be answered.

Thank you in advance for your participation!

Panagiotis Gavalas
Student, MSc in Shipping Management

https://www.linkedin.com/in/panagiotisgavalas/

Click "Next" to proceed.

UNIVERSITY OF PIRAEUS
DEPT. OF MARITIME STUDIES
MSc in Shipping Management

Next

Section 1 - Demographics

To aid the analysis of this research's data, please provide some information about you

Please state your gender:

- Male
- Female

Please state your age:

- Below 30 years old
- Between 31 and 40 years old
- Between 41 and 50 years old
- Over 50 years old

Please state your education level:

- Non-academic
- Diploma
- Bachelor's Degree
- Master's Degree
- Doctorate (PhD)

Which office department do you work for?

- In which department do your work?
- Technical
- Operations
- Marine
- HSQE
- Finance
- Procurement/Supplies
- Crewing
- Sales
- Marketing
- Onboard: Master
- Onboard: Engineer
- Onboard: Officer
- Other

How long have you been working in the shipping industry?

- Less than 1 year
- Between 1 and 3 years
- Between 3 to 5 years
- Between 5 to 10 years
- More than 10 years

What is the fleet size of the company you work for? (owning/managing/operating)

- 1-5
- 6-10
- 11-20
- 21-50
- 51-100
- 100+

What types of vessels are owned/managed/operated by the company you work for?
Note: Multiple answers are allowed

- Container
- Bulk carrier
- Oil tanker
- LNG carrier
- LPG Carrier
- Containers
- Chemical carriers
- General cargo
- Passenger ship
- Car carrier
- others

Which classification societies does the company you work for, mainly cooperates with?
Note: Multiple answers are allowed

- DNVGL
- ABS
- Bureau Veritas
- Lloyd's Register
- Class NK
- RINA
- Other

- **Please state the company you work for.**
  Note: Not mandatory

Section 2 - Awareness of Vessel Disruptive Technologies

For disruptive Vessel Technologies: Internet of Things (IoT), Big Data, Augmenter Reality (AR) & Distributed Ledgers (blockchain)

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

IoT for vessels, is a set of sensor systems/devices installed across various equipment/devices on the vessel, connected to the vessel's information technology network, producing live vessel data to be harnessed and analyzed by the company, enabling ship owners/managers/operators to deal proactively with their fleet.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Big data for vessels is the large volume of data generated by fleets, both structured and unstructured, with the potential to create global platforms in which solution providers, ports, agents, brokers, charterers, cargo owners, ship owners/managers/operators etc. can concurrently rely on and cooperate at all common areas of operational interest.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Augmented reality for vessels provides real time, bidirectional ship-to-shore information exchange in the form of text, graphics, audio and visual elements, integrated within the onboard optical view of the crew member, by wearing a set of special glasses, making remote view, inspection, assistance, and knowledge transfer, direct and immediate without the need of the shore expert to attend and physically inspect the vessel.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Distributed ledger technologies for vessels can be applied for the creation of more securely owned, securely accessed, decentralised, securely traceable, securely transferable and immutable versions of bills of lading and contracts of carriage, compared to their current printed formats.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 3 - Safety, Effectiveness and Efficiency of Disruptive Vessel Technologies

For disruptive Vessel Technologies: Internet of Things (IoT), Big Data, Augmenter Reality (AR) & Distributed Ledgers (blockchain)

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

With the aid of IoT devices, a vessel's operation can be pinpointed in a safer, more effective and more efficient manner, compared to traditional means of monitoring and controlling vessel operations at sea.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The analysis of fleet generated Big Data, can provide safer, more effective and more efficient decisions about terminal and berth allocation, cargo handling, route and cost optimisation, compared to traditional means of making such decisions.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The use of Augmented Reality on vessels can provide safer, more effective and more efficient means of monitoring and maintenance, without the need of physical inspection.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The use of distributed ledger technologies can provide a safer, more effective and more efficient way to issue, own and distribute bills of lading, compared to traditional bills of lading.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 4 - Compatibility of Disruptive Vessel Technologies

For disruptive Vessel Technologies: Internet of Things (IoT), Big Data, Augmenter Reality (AR) & Distributed Ledgers (blockchain)

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

The installation and use of IoT devices on vessels fits the current operations demands of the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The exploitation of fleet generated Big Data fits the current operations demands of the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The use of Augmented Reality on vessels fits the current operations demands of the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

- The use of Distributed Ledger technologies for bills of lading fits the current operations demands of the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 5- Trust of Disruptive Vessel Technologies
For disruptive vessel technology: Internet of Things (IoT)

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

The shipping industry is currently focusing in deploying IoT technologies on vessels.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

IoT technologies adoption on vessels is expected to rise within the next 3 years.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Currently, there are enough trustworthy IoT solutions for vessels, to establish trust on the use of IoT technologies by the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 6 - Trust of Disruptive Vessel Technologies
For disruptive vessel technology: Big Data

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

The shipping industry is currently focusing in deploying Big Data solutions from data generated from vessels.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Big Data platforms adoption, from vessel generated data, is expected to rise within the next 3 years.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Currently, there are enough trustworthy Big Data platforms from data generated from vessels, to establish trust on the use of Big Data in the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 7 - Trust of Disruptive Vessel Technologies
For disruptive vessel technology: Augmented Reality

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

The shipping industry is currently focusing in deploying Augmented Reality solutions on vessels for remote inspections, surveys, monitoring and maintenance.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Augmented Reality adoption on vessels, is expected to rise within the next 3 years.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Currently, there are enough trustworthy Augmented Reality solutions for vessels, to establish trust on the use of Augmented Reality on vessels, in the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 8 - Trust of Disruptive Vessel Technologies
For disruptive vessel technology: Distributed Ledgers

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

The shipping industry is currently focusing in deploying Distributed Ledger solutions to substitute traditional bills of lading.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Distributed Ledger technologies adoption for bills of lading, is expected to rise within the next five years.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Currently, there are enough trustworthy Distributed Ledger solutions for bills of lading, to establish trust on the use of Distributed Ledger technologies for bills of lading, in the shipping industry.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 9 - Perceived Cyber Safety of Disruptive Technologies

The following statements relate to YOUR professional perception/understanding
Use the rating scale below to express the degree to which you agree or disagree with them

Vessels' Operational Technologies (OT) Systems control physical machines and can generate data, while vessels' Information Technology (IT) environments process information and transmit data.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

During the next five years vessels will use more systems that rely on digitalization, integration, and automation.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Vessels' Operational Technologies (OT) systems are increasingly networked within vessel's Information Technology (IT) environments.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

As per current industry recommendations and guidelines, achieving cyber safety for a vessel, requires a holistic vessel IT environment approach able to provide safe access, safe management, safe processing and safe transmission of information generated at and by a vessel.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

According to "IMO MSC.428 (98)" and "MSC-FAL.1/Circ.3", cyber safety and cyber risk management, are mandatory ISM code requirements, effectively and appropriately addressed in safety management systems no later than the first annual verification of the company’s Document of Compliance (DoC) after 1 st January 2021, making cyber risks management of IT and OT systems of identical importance to minimizing physical risks such as fire.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

- In order to achieve safe deployment and operation of onboard IoT, onboard generated Big Data, onboard AR and Distributed ledgers for B/Ls, a vessels IT environment must first comply with the industry's recommendations and guidelines on cyber safety, cyber security and cyber risk management.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 10 - Corporate Attitude Towards New Technologies and Associated Perils

The following statements relate to YOUR COMPANY's perception/understanding/attitude towards modern technologies for vessels and their related perils
Use the rating scale below to express the degree to which you agree or disagree with them

The organisation I work for, generally understands and supports the deployment of innovative technologies for vessels.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The organisation I work for, supports the deployment of new technologies on vessels only if they are enforced by regulations.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The organisation I work for, supports the deployment of new technologies on vessels only if they are cost effective, regardless of market trends, competition and regulations.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The organisation I work for, prefers to mimic the deployment of new technologies on vessels, from related or competitive companies, rather than being a pioneer.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The organisation I work for, understands the human effort required to deploy new technologies on vessels and the human effort required to meet industry standards on cyber safety and cyber risk management.

- Strongly disagree
- Disagree
- Neutral

- Agree
- Strongly agree

The organisation I work for, internally invests, capitalises in human resources and prefers Capital Expenses when investing in new technologies for vessels.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The departments responsible for the Fleet IT of the organisation I work for, have the competence and capacity to deploy modern technologies such as IoT, Big Data, AR, Distributed Ledgers.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The departments responsible for the Fleet IT of the organisation I work for, have the capacity to keep our fleet compliant for Cyber Safety at all times, under the industry's standards, recommendations and regulations as instructed by the IMO.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The departments for the Fleet IT of the organisation I work for, deploy solutions in a homogeneous manner for the entire fleet.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The employees of the organisation I work for are technological literate, understand and can follow new technologies.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The management of the organisation I work for are technological literate, understand and can follow new technologies.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

The management of the organisation I work for support the implementation of new and competitive technologies.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Section 11 - Corporate Consideration For New Technologies and Associated Perils

The following statements relate to YOUR COMPANY's perception/understanding/attitude towards modern technologies for vessels and their related perils
Use the rating scale below to express the degree to which you agree or disagree with them

At what stage of onboard IoT solutions is the organisation you work for currently engaged?

- Not considering
- Currently evaluating (e.g.. in a pilot study)
- Have evaluated, but do not plan to adopt this technology
- Have evaluated and plan to adopt this technology
- Have already adopted services.

If you're anticipating that the organisation you work for will adopt onboard IoT solutions in the future. How do you think will it happen?

- Not considering
- Less than 1 year
- Between 1 and 3 years
- More than 3 years
- Have already adopted services.

At what stage of onboard Big Data solutions is the organisation you work for currently engaged?

- Not considering
- Currently evaluating (e.g.. in a pilot study)
- Have evaluated, but do not plan to adopt this technology
- Have evaluated and plan to adopt this technology
- Have already adopted services.

If you're anticipating that the organisation you work for will adopt onboard Big Data solutions in the future. How do you think will it happen?

- Not considering
- Less than 1 year
- Between 1 and 3 years
- More than 3 years
- Have already adopted services.

At what stage of onboard AR solutions is the organisation you work for currently engaged?

- Not considering
- Currently evaluating (e.g.. in a pilot study)
- Have evaluated, but do not plan to adopt this technology
- Have evaluated and plan to adopt this technology
- Have already adopted services.

If you're anticipating that the organisation you work for will adopt onboard AR solutions in the future. How do you think will it happen?

- Not considering

- Less than 1 year
- Between 1 and 3 years
- More than 3 years
- Have already adopted services.

At what stage of Distributed Ledger solutions for electronic B/Ls is the organisation you work for currently engaged?

- Not considering
- Currently evaluating (e.g.. in a pilot study)
- Have evaluated, but do not plan to adopt this technology
- Have evaluated and plan to adopt this technology
- Have already adopted services.

If you're anticipating that the organisation you work for will adopt onboard Distributed Ledger solutions for electronic B/Ls in the future. How do you think will it happen?

- Not considering
- Less than 1 year
- Between 1 and 3 years
- More than 3 years
- Have already adopted services.

At what stage is the organisation you work for currently engaged regarding complete vessel IT environments that comply with recommendations and regulations on cyber safety?

- Not considering
- Currently evaluating (e.g.. in a pilot study)
- Have evaluated, but do not plan to adopt this technology
- Have evaluated and plan to adopt this technology
- Have already adopted services.

If you're anticipating that the organisation you work for will adopt complete vessel IT environments that comply with recommendations and regulations on cyber safety in the future. How do you think will it happen?

- Not considering
- Less than 1 year
- Between 1 and 3 years
- More than 3 years
- Have already adopted services.

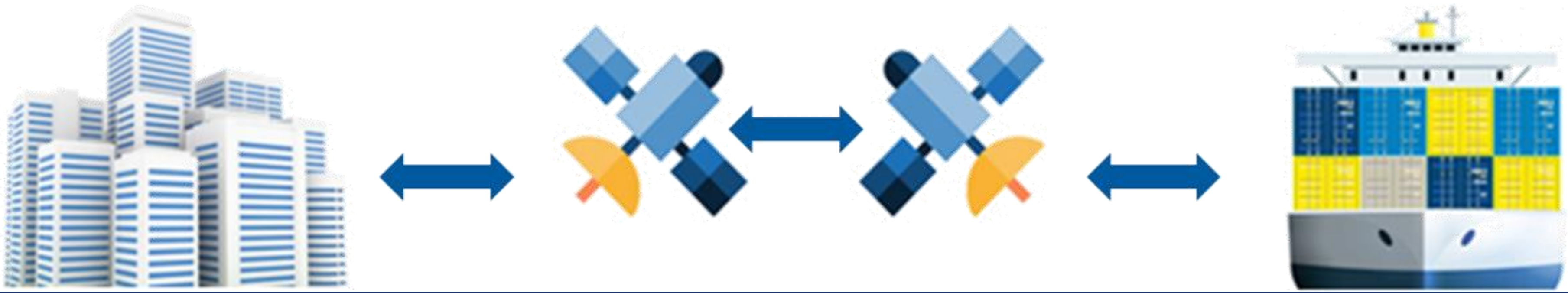
UNIVERSITY OF PIRAEUS

DEPARTMENT OF MARITIME STUDIES

MSc. IN SHIPPING MANAGEMENT

“Onboard vessels digital disruption through ICT technologies: Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector



#TechnologyAdoptionModel #Connectivity #IoT #BigData #AugmentedReality #DistributedLedgers #CyberSafety

“Onboard vessels digital disruption through ICT technologies Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 1:
Introduction

Panos Gavalas

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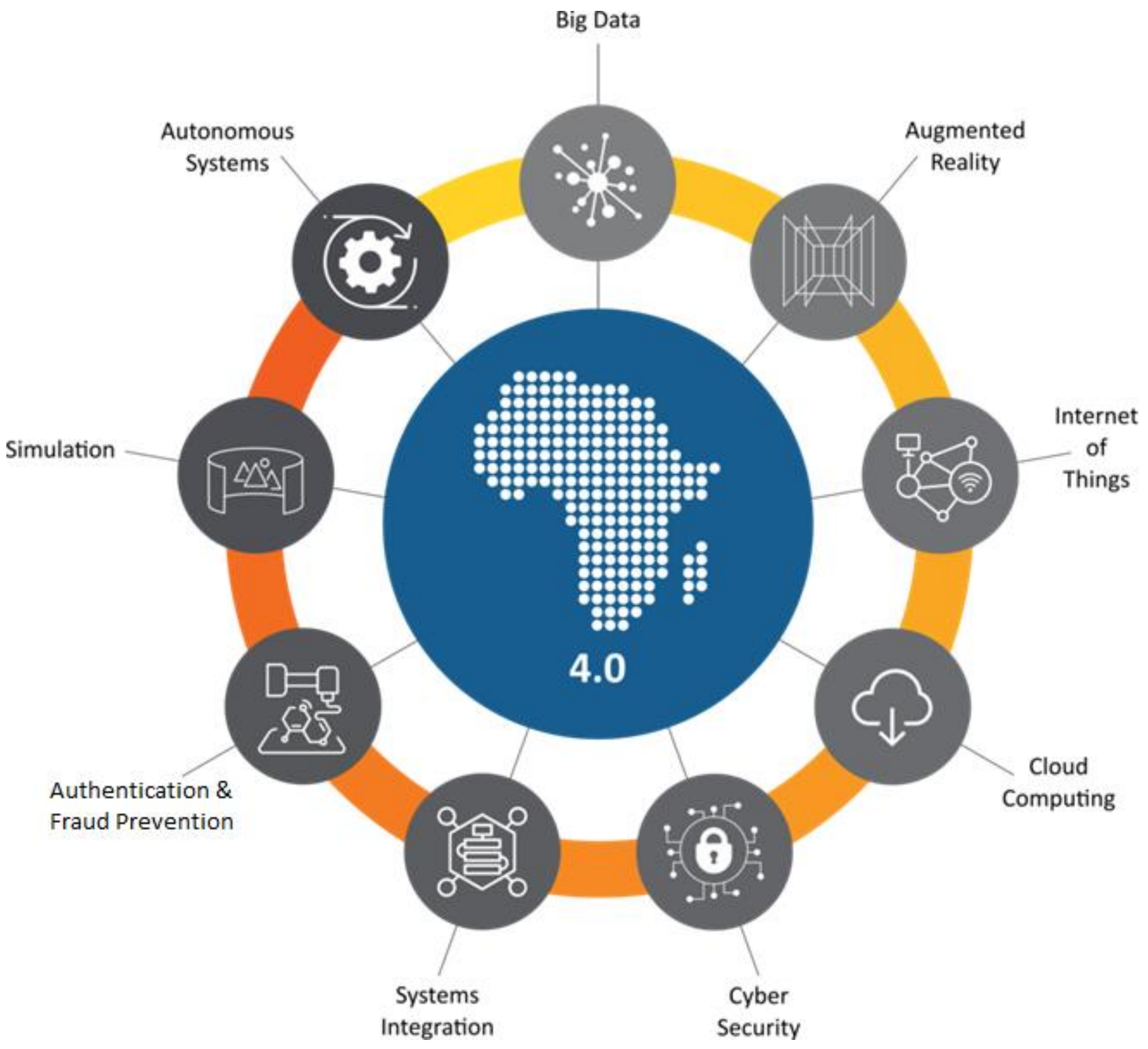
Innovation, Digitalisation & The 4th Industrial Revolution

Maritime Shipping vs 4th Industrial Revolution Stage

- ✓ The perception of the innovation's importance leads to adoption - (Damanpour & Gopalakrishnan, 1998)
- ✓ As technologies emerge and receive exposure, the needs of corporations change accordingly - (Dodgson et al., 2008)
- ✓ For the shipping industry technological innovations show high relativity and dependence to connectivity - (Russom, 2011)
- ✓ Companies must aim on how, when and which technological innovation is be adopted by estimating its value against organizational productivity, efficiency versus competition, and ultimately, survival - (Howell, 1990)

The Greek Maritime Shipping Industry

- ✓ Limited research focusing on determinants of technological innovations adoption, regarding aggressively promoted technologies.
- ✓ Disruptive technologies, shake organisational values to their core, by providing different approaches to an existing scope, as opposed to sustaining innovations, which simply enhance an existing operational process to a more efficient and effective level (Christensen et al., 2000).



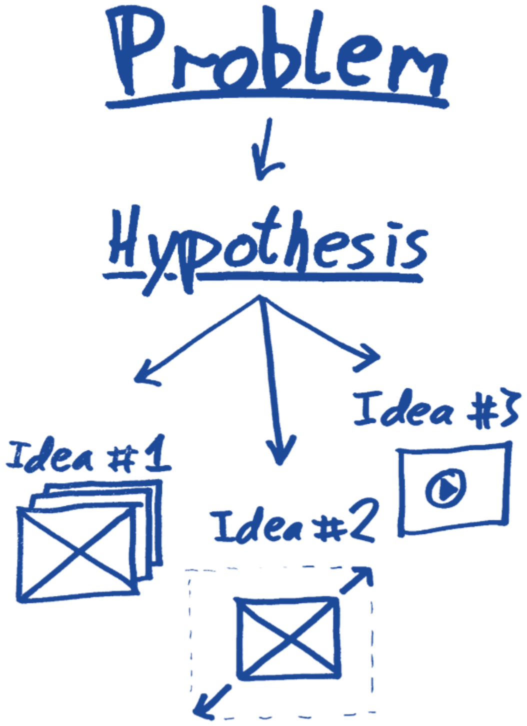
Formulation of the Problem & Research Questions

Recent Market Assumptions and Statements

- ✓ There is a great variety of actors participating in the maritime shipping industry, with different relationships and regulations, and by not taking advantage of information technology may contribute to barriers which can impede global trade - (World Economic Forum, 2016)
- ✓ Technology can show ways to increase trust between parties doing business in the maritime shipping industry, and thus optimise the overall efficiency of business processes - (Jensen et al., 2014)

The Author's Perspective

1. How likely is for Internet of Things, Big Data, Augmented Reality and Distributed Ledger technologies to be adopted by the Greek maritime shipping industry actors?
2. Are the actors of the Greek maritime shipping industry able to understand the newly introduced technologies?
3. How do the actors of the Greek maritime shipping industry perceive the usefulness of these technologies?
4. Do the actors o the Greek maritime shipping industry trust the information technology market and such solutions?
5. Are the actors of the Greek maritime shipping industry aware of the risks associated and comply accordingly with the new Cyber Safety standards?
6. Do the actors of the Greek maritime shipping industry feel that their companies promote new technologies, and under what conditions?
7. Is the Greek maritime shipping industry willing or considering to develop and launch a future with such technologies?



“Onboard vessels digital disruption through ICT technologies Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 2:
Disruptive Technologies go Onboard

Panos Gavalas
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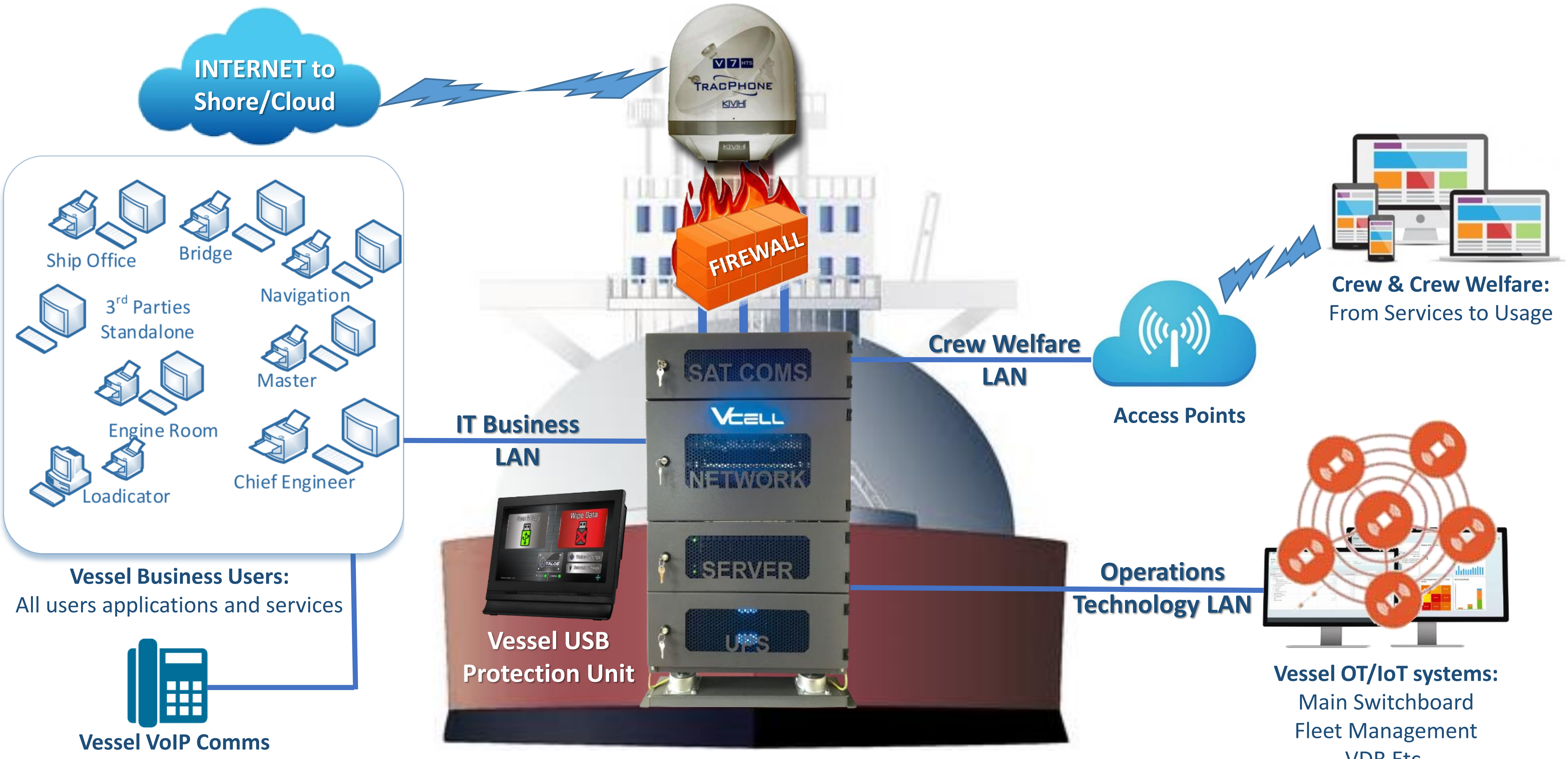
The Vessel as an Integrated Datacenter



The Importance of OnBoard IT Ecosystems:
Onboard IT Systems Responsible for Data Transfer.

Vessel IT/OT Environments Revisited

1. **Ships use systems that rely on digitalization**, integration, and automation.
2. **Information Technology** and **Operational Technology** increasingly networked.
3. **Managing risk** of malicious access to ships' making **<u>Shipping More Complicated</u>**.

UNDERSTANDING THE DIFFERENCE!

"ICT systems process information and/or transmit data."

"OT systems control physical machines and generate data."

Information Technology (IT)

- Administration, accounts, crew lists, etc.
- Planned maintenance
- Spares management and requisitioning
- Electronic manuals and certificates
- Permits to work
- Charter party, notice of readiness, etc.

Operation Technology (OT)

- PLCs, SCADA
- On-board measurement and control
- ECDIS, GPS
- Remote support for engines
- Data loggers
- Engine and cargo control
- Dynamic positioning, etc.

2016 & 2017 News – MSC-FAL.1/Circ. 3 & T.N. 24-2017

MSC-FAL.1 / Circ.3 of the IMO.

From the first revision of the Document of Compliance of a vessel, after 01/01/2021

Following the above, IMO issued Technical Note 24-2017 making their intentions even clearer, clarifying that this is a mandatory requirement.

Maritime Cyber Safety is primarily about Vessel IT environments.

- **C**onfidentiality
- **I**ntegrity
- **A**vailability
- **R**eliability
- **A**uditability
- **S**ecurity

"For detailed guidance on cyber risk management, users of these Guidelines should also refer to Member Governments' and Flag Administrations' requirements, as well as relevant international and industry standards and best practices.

4.2 Additional guidance and standards may include, but are not limited to:

.1 The Guidelines on Cyber Security Onboard Ships produced and supported by BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI.

.2 ISO/IEC 27001 standard on Information technology – Security techniques – Information security management systems – Requirements. Published jointly by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

.3 United States National Institute of Standards and Technology's Framework for Improving Critical Infrastructure Cybersecurity (the NIST Framework)."

Current Important Disruptive Technologies

Internet Of Things

"A set of sensor systems/devices installed across various equipment/devices on the vessel, producing live vessel to be harnessed and analyzed by the company."

Block Chain

"Distributed ledger technologies for vessels can be applied for the creation of more securely owned, securely accessed, decentralised, securely traceable, securely transferable and immutable bills of lading."

Augmented Reality

"Real time, bidirectional ship-to-shore information exchange in the form of text, graphics, audio and visual elements, integrated within the onboard optical view of the crew member."

Big Data

"Large volume of data generated by fleets, both structured and unstructured, fed to global where all actors can concurrently rely on and cooperate at all common areas of operational interest."

“Onboard vessels digital disruption through ICT technologies Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 3:
Research Theoretical Foundations

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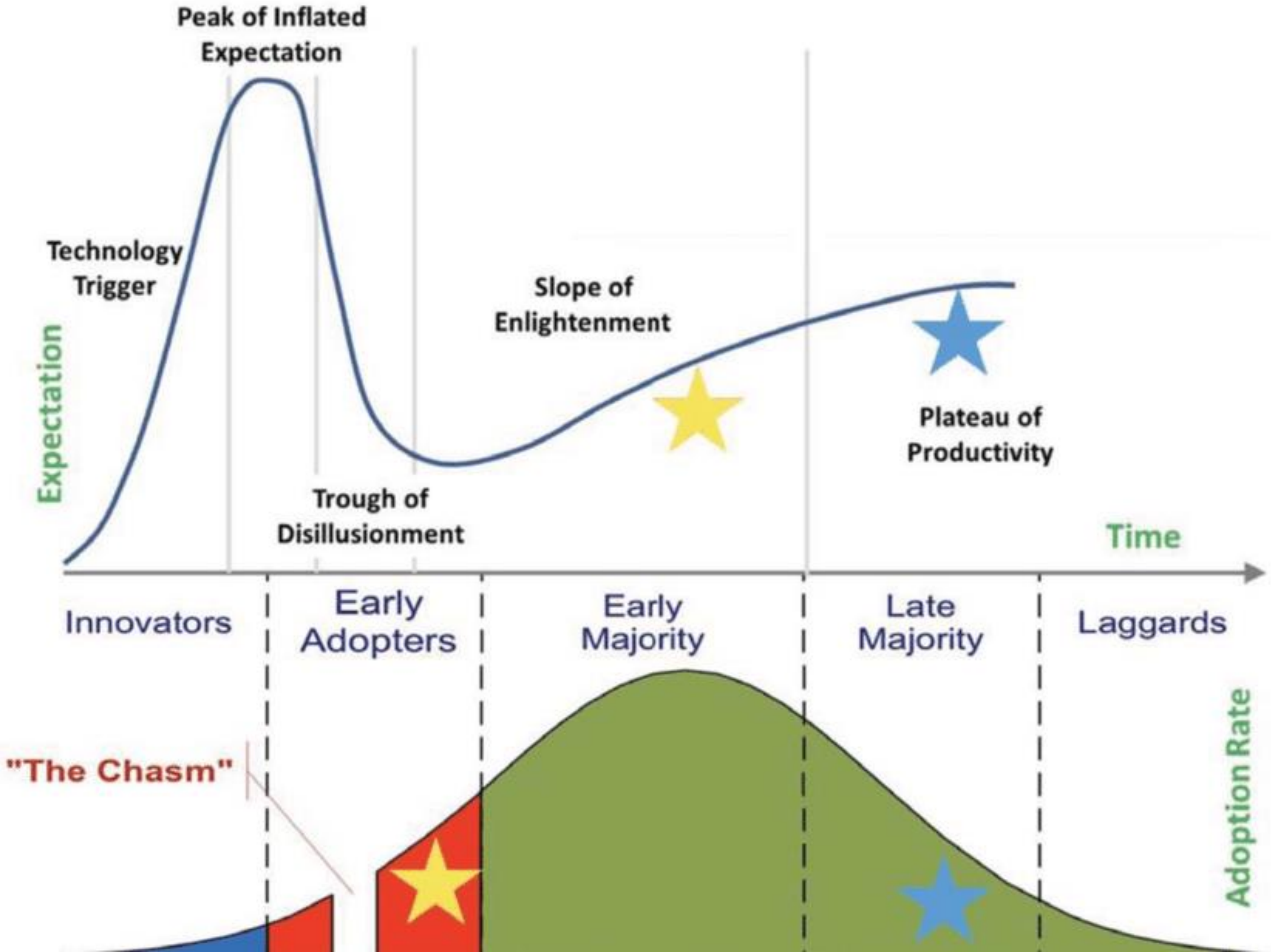
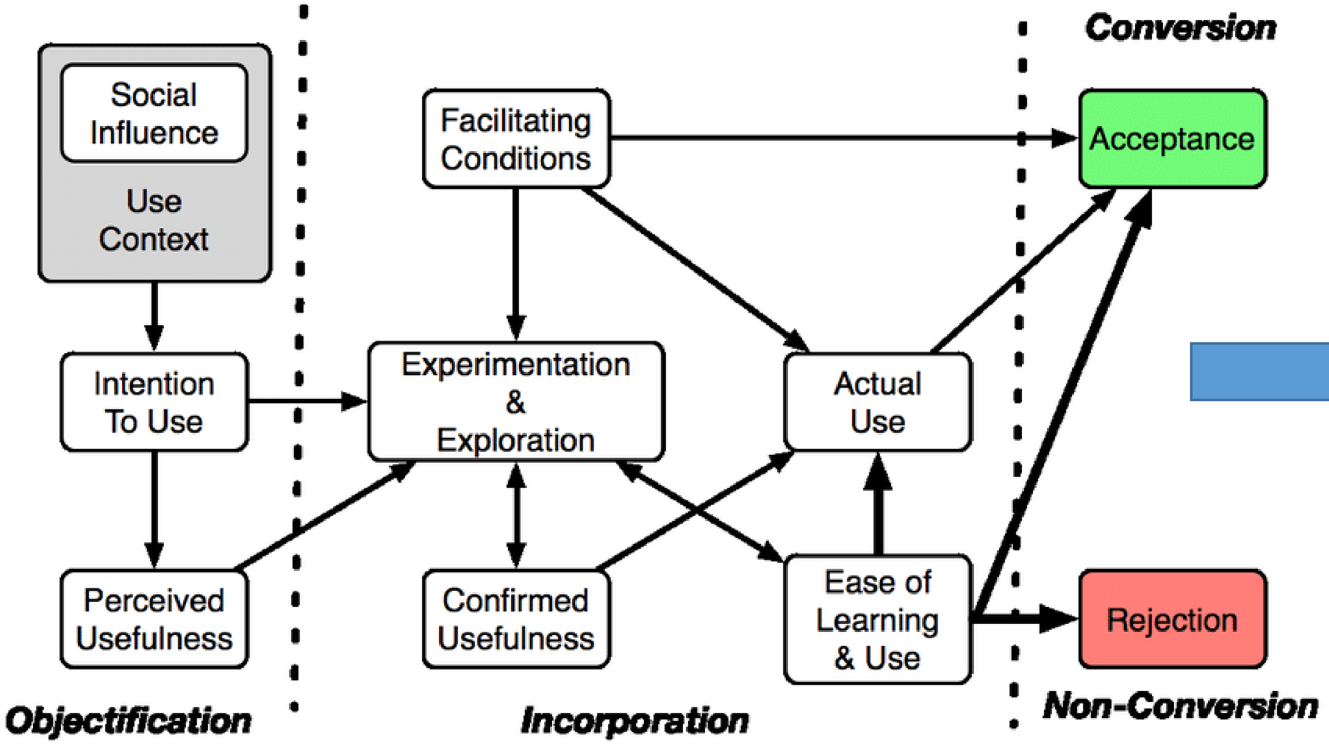
Technology Adoption Curve and Hype

Gartner's Hype Cycle

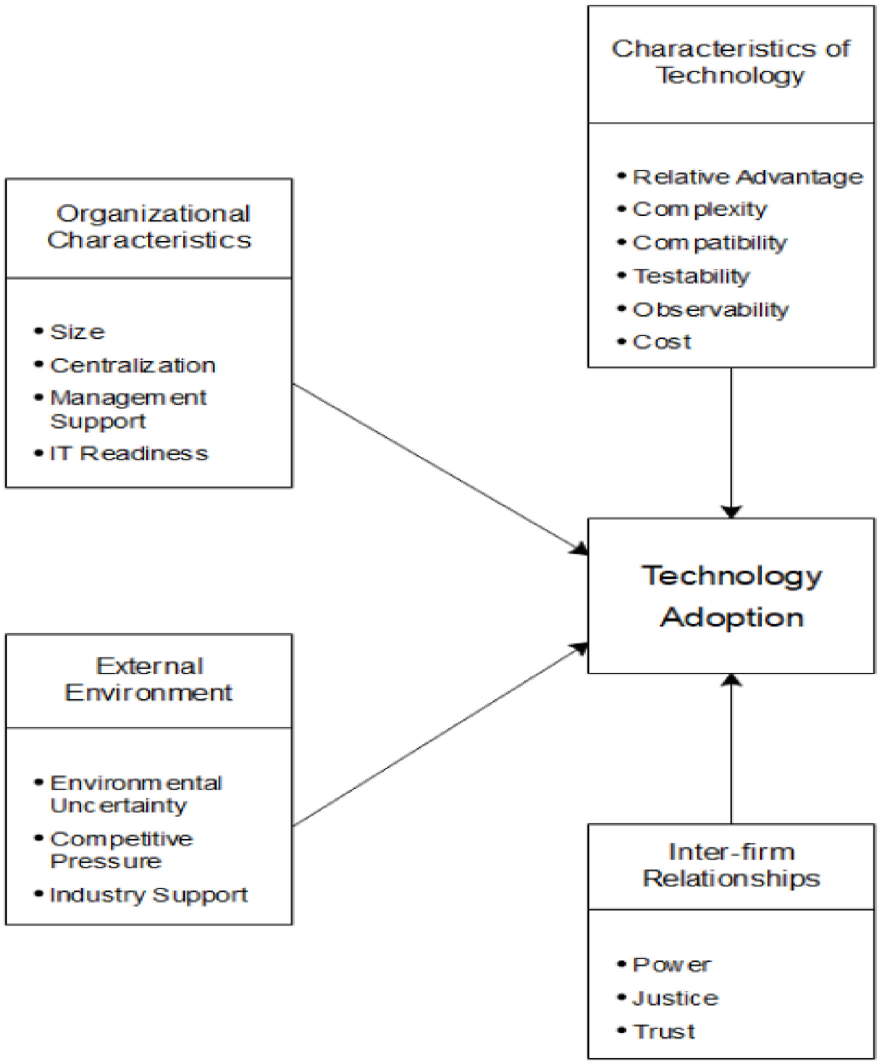
Moore's Adoption Curve



Technology Acceptance in Supply Chains



Senior Acceptance Model



For Supply Chains

“Onboard vessels digital disruption through ICT technologies
Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 4:
Research Methodology

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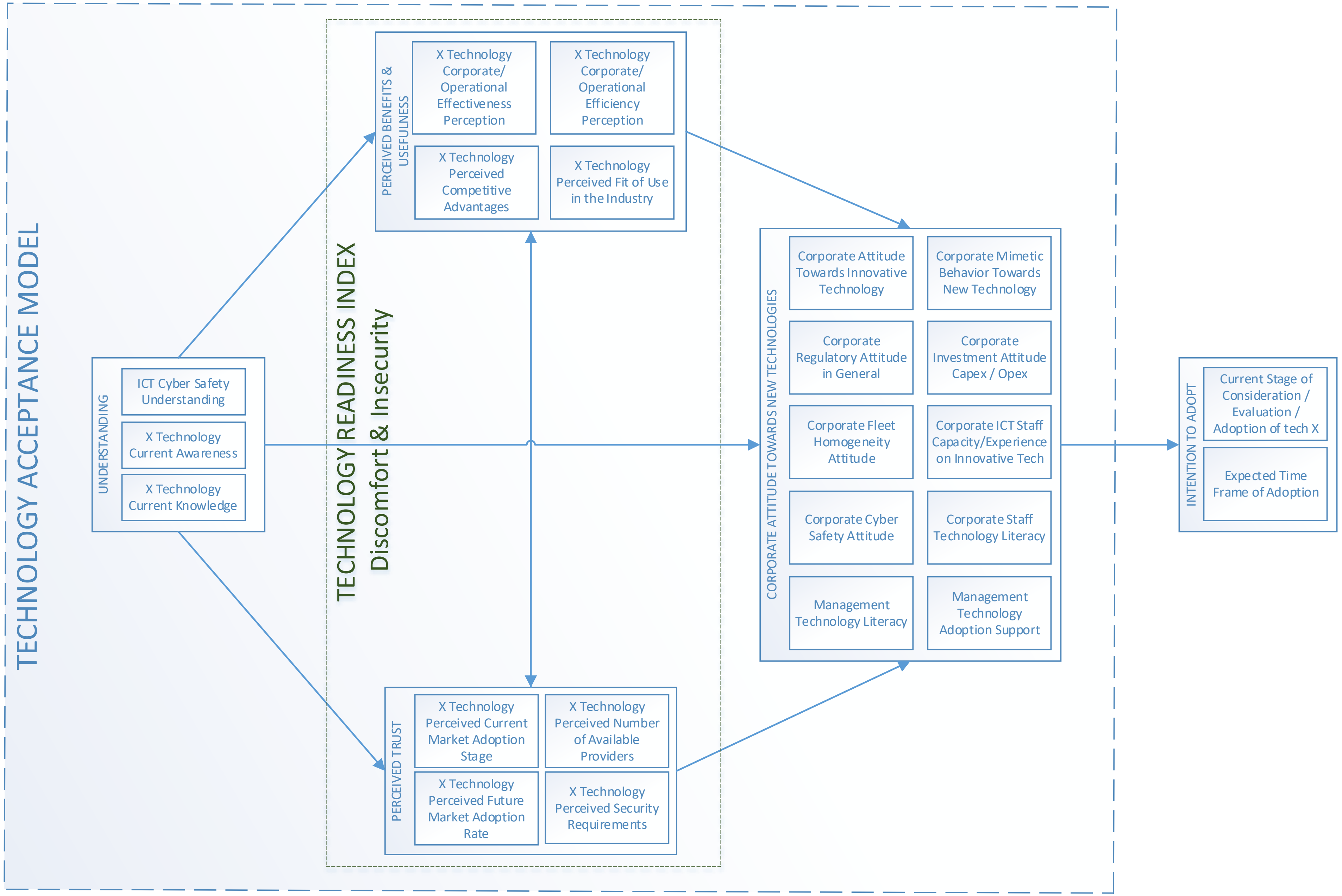
Technology Acceptance Model Proposed



The Instrument & Survey Sections

Survey structure according to the proposed modified TAM model

- ✓ Section 1: Demographic purposes
- ✓ Section 2: Understanding/awareness - IoT, Big Data, Augmented Reality & Distributed Ledgers
- ✓ Section 3: Perceived understanding of the above regarding safety, effectiveness and efficiency
- ✓ Section 4: Perception of compatibility with the current needs of the industry

- ✓ Sections 5-8: perceived trust on the above mentioned technologies
- ✓ Section 9: Understanding of onboard Cyber Safety
- ✓ Section 10: Understand the attitude towards technologies within the working environment
- ✓ Section 11: Current and future tendencies of adoption of the above mentioned technologies

Research Method and Performance

- ✓ Exploratory research
- ✓ Online questionnaire
- ✓ Quantitative analysis
- ✓ Inductive nature
    - ➢ Observation by experience
    - ➢ Topic of interest emerges
    - ➢ Data collection
    - ➢ Data clusters or patterns
    - ➢ Data analysis
    - ➢ Emergence of themes
    - ➢ Generalizations
    - ➢ Dissemination of findings

- ✓ Sent to 954 departmental mailboxes
- ✓ 17 unsubscribed and 85 bounced
- ✓ Opened by 353 recipients - final addressable population.
    - ➢ 92 clicked on the link - 26%
    - ➢ 51 completed the survey - 14%

- ✓ Performance considered acceptable for analysis

“Onboard vessels digital disruption through ICT technologies
Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 5:
Responses and Findings Highlights

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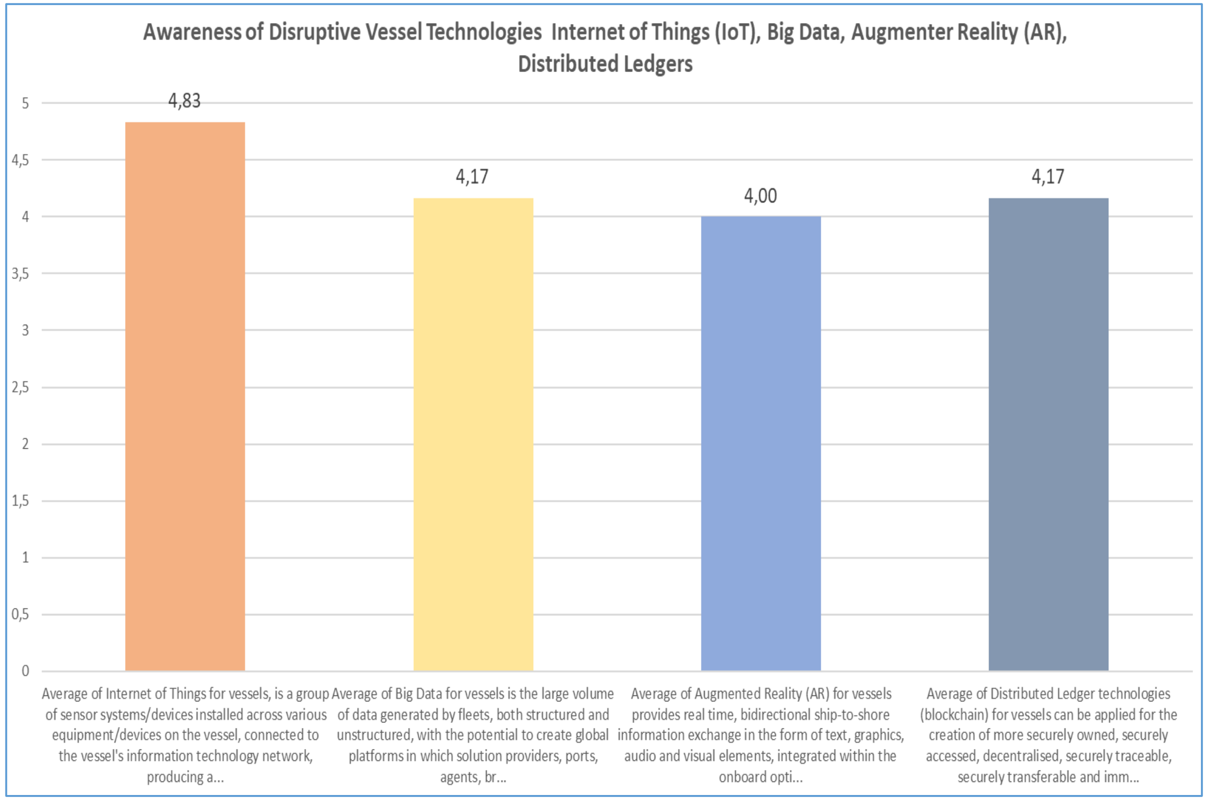
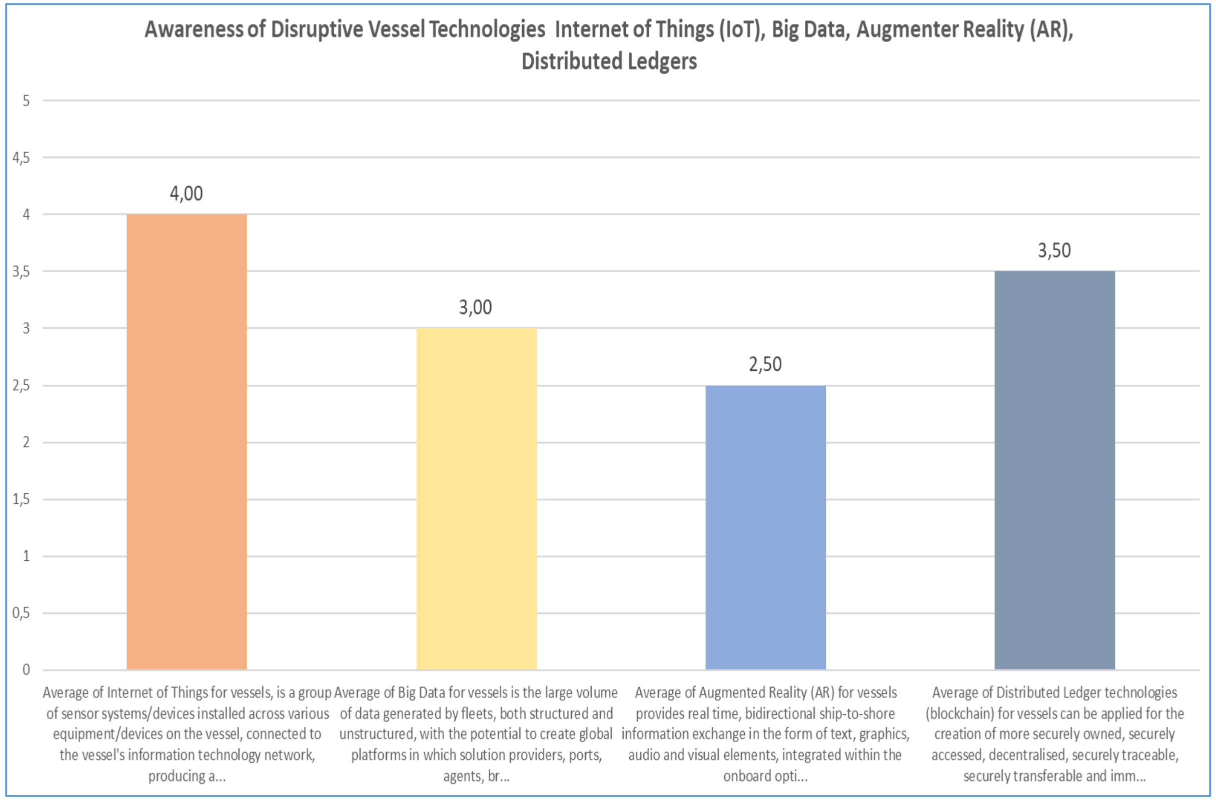
Group A vs Group B – Understanding of Technologies

IoT – Big Data – Augmented Reality – Distributed Ledgers



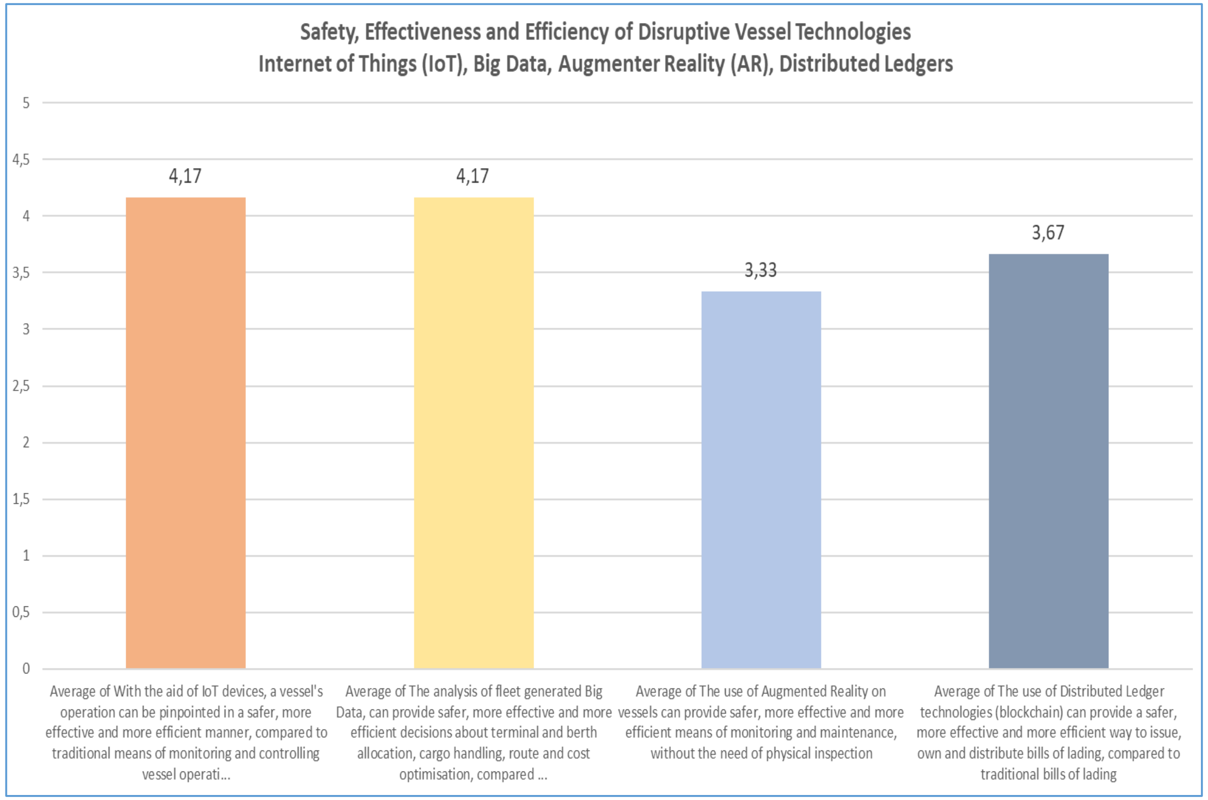
Group A



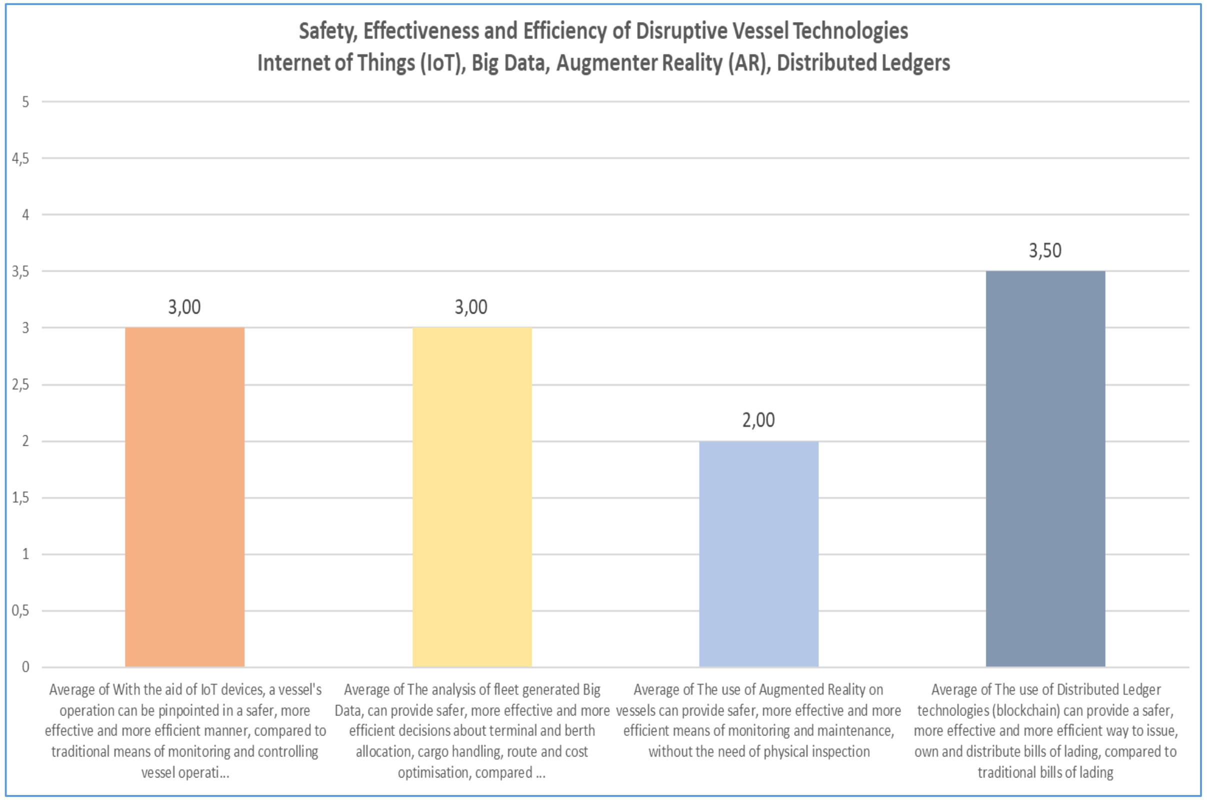
Group B

Group A vs Group B – Safety, Effectiveness, Efficiency

IoT – Big Data – Augmented Reality – Distributed Ledgers



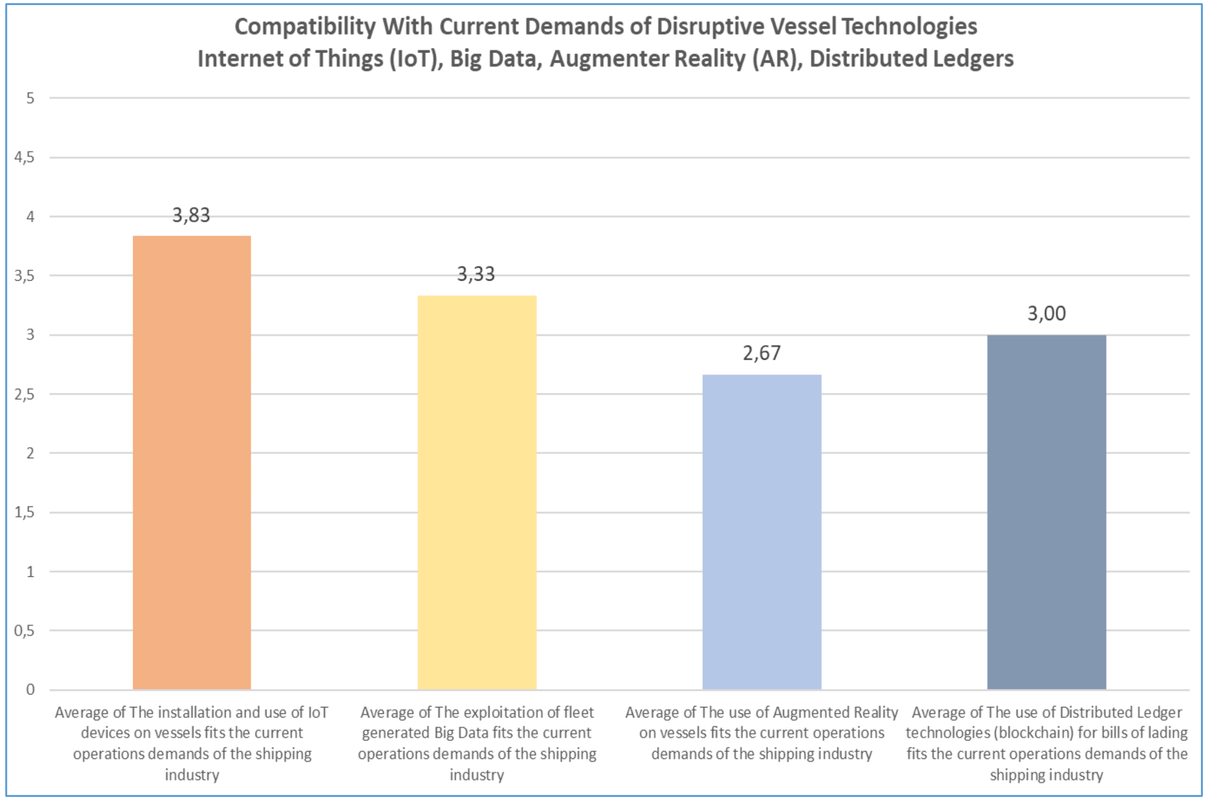
Group A



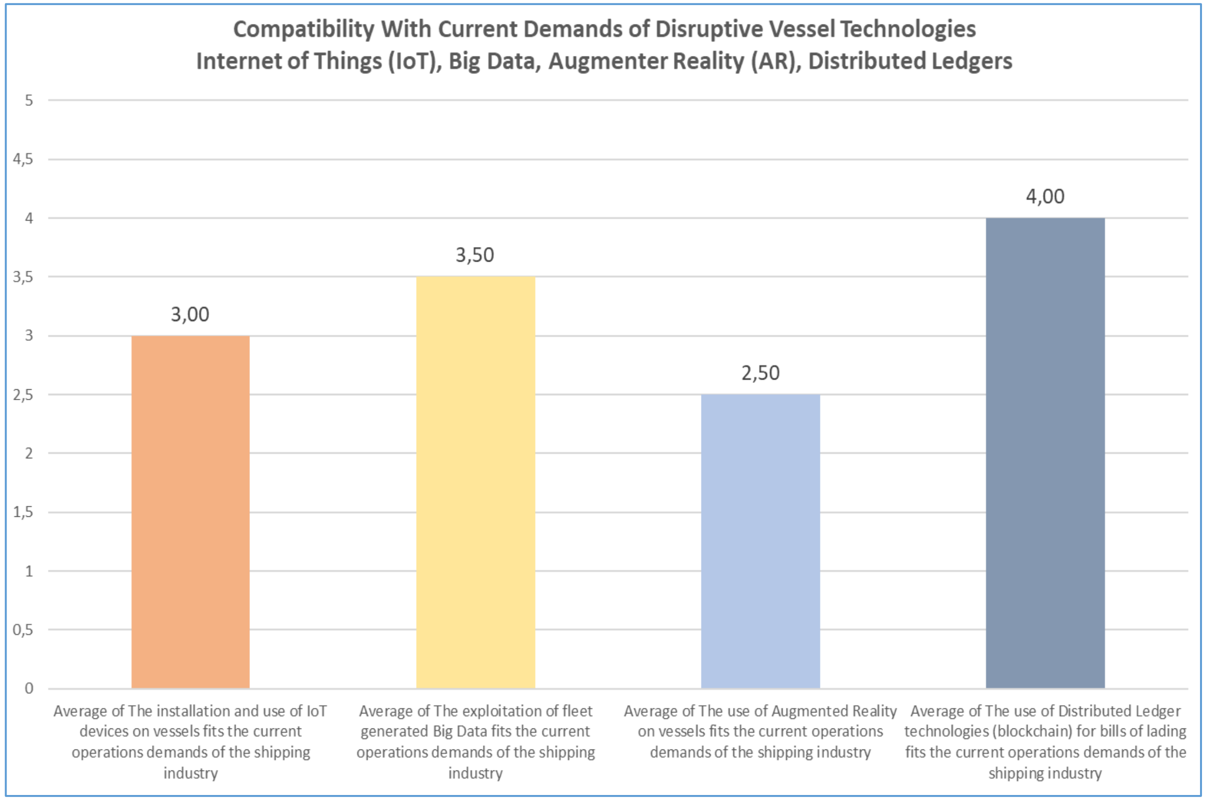
Group B

Group A vs Group B – Compatibility vs Current Demands

IoT – Big Data – Augmented Reality – Distributed Ledgers



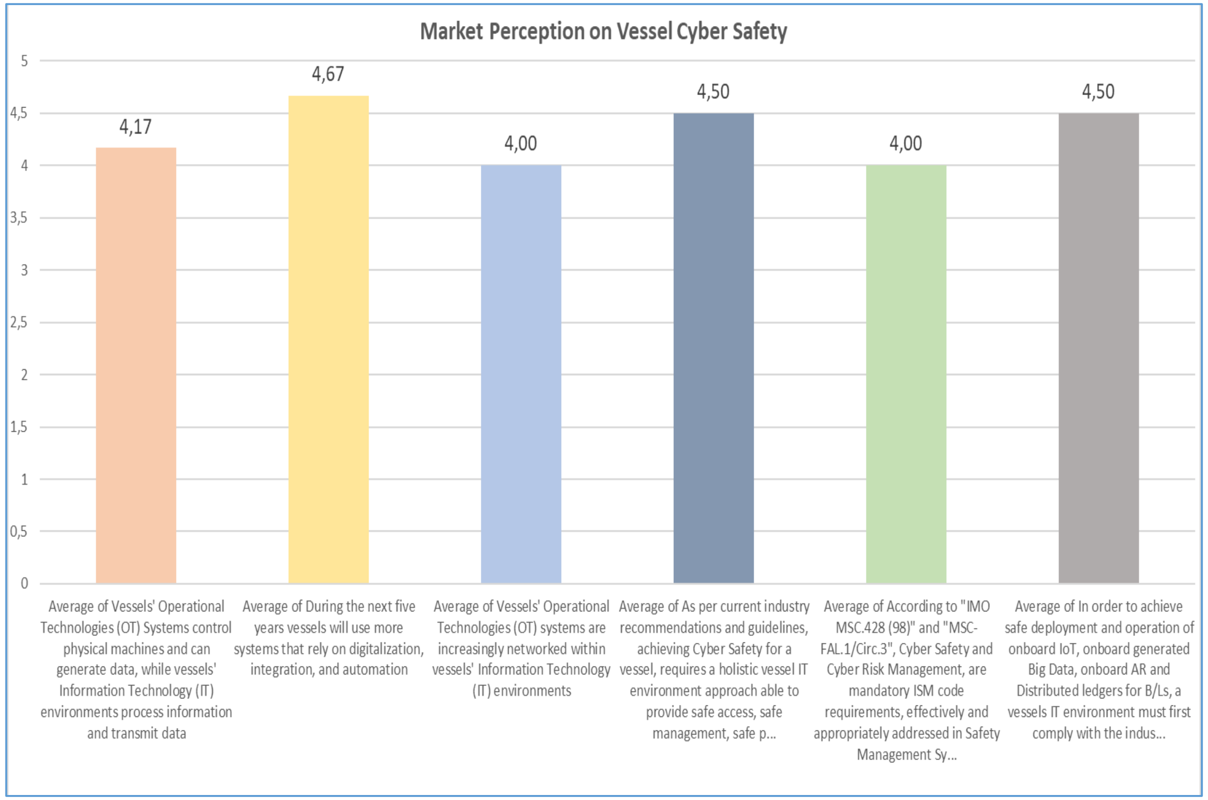
Group A



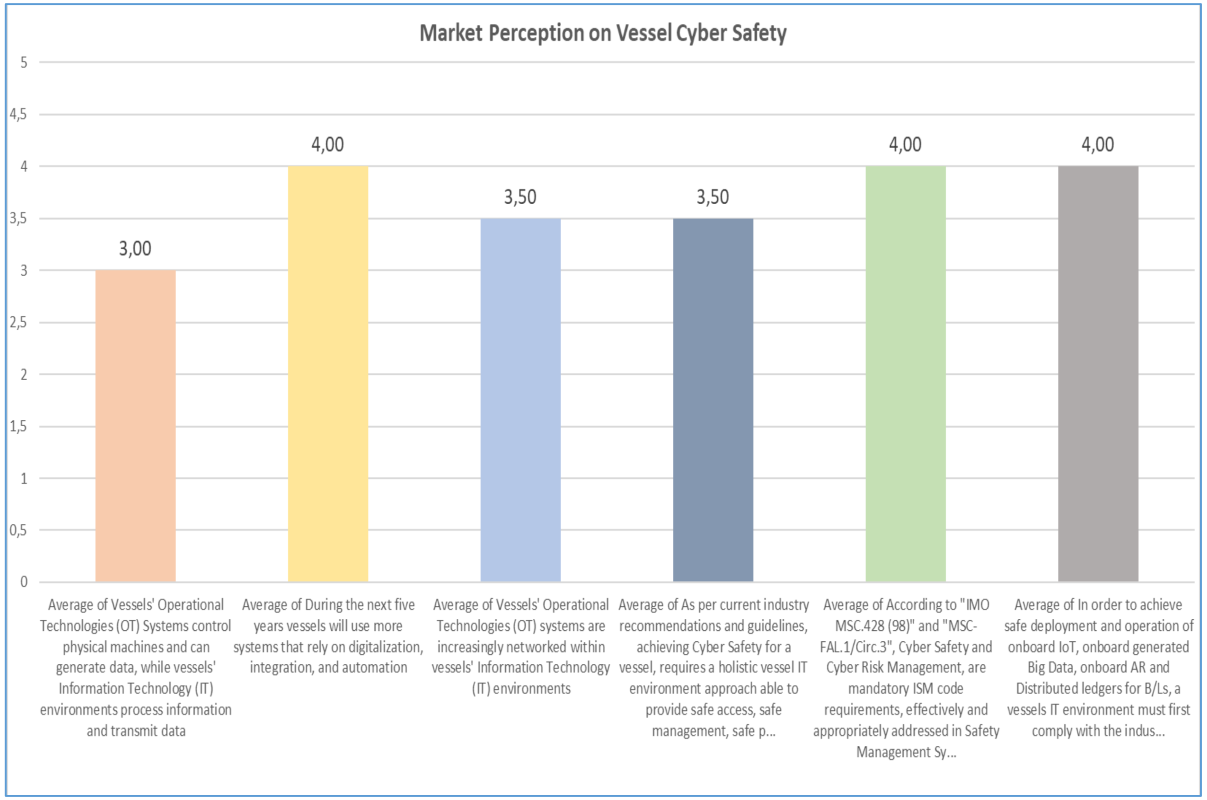
Group B

Group A vs Group B – Cyber Safety Perception

IoT – Big Data – Augmented Reality – Distributed Ledgers



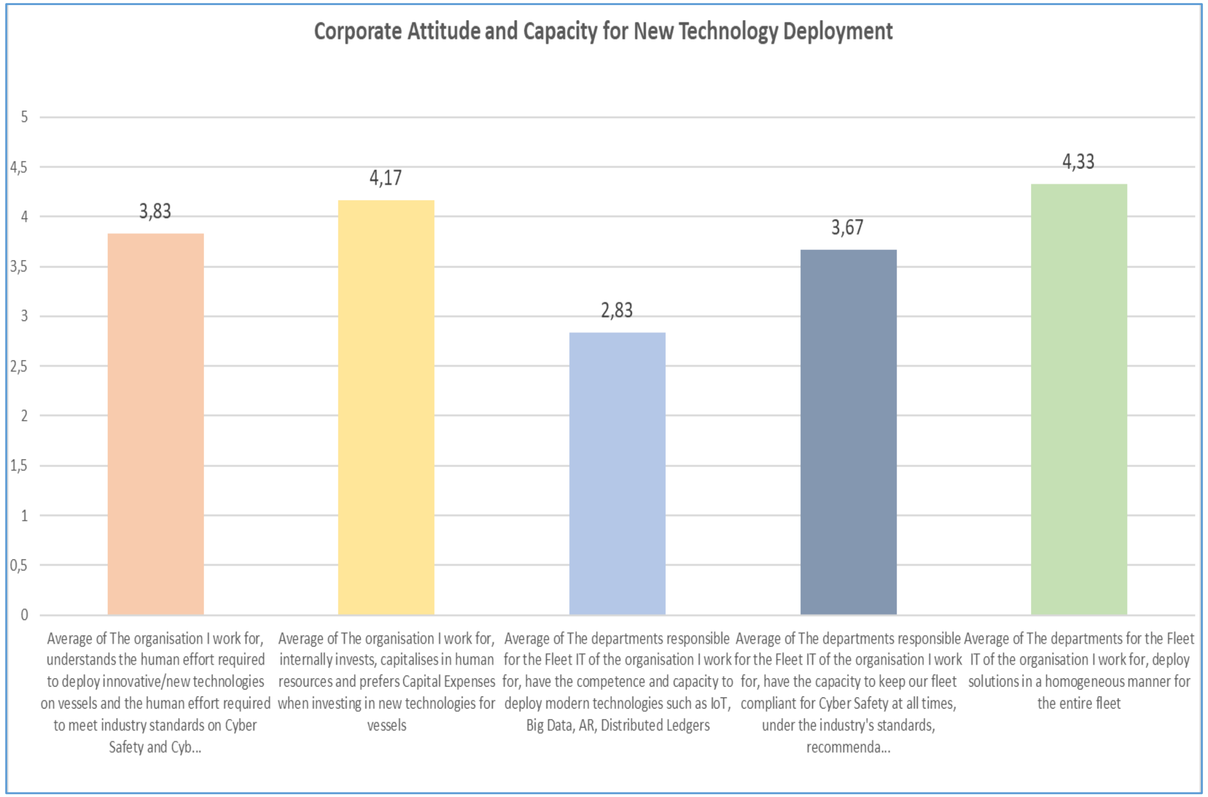
Group A



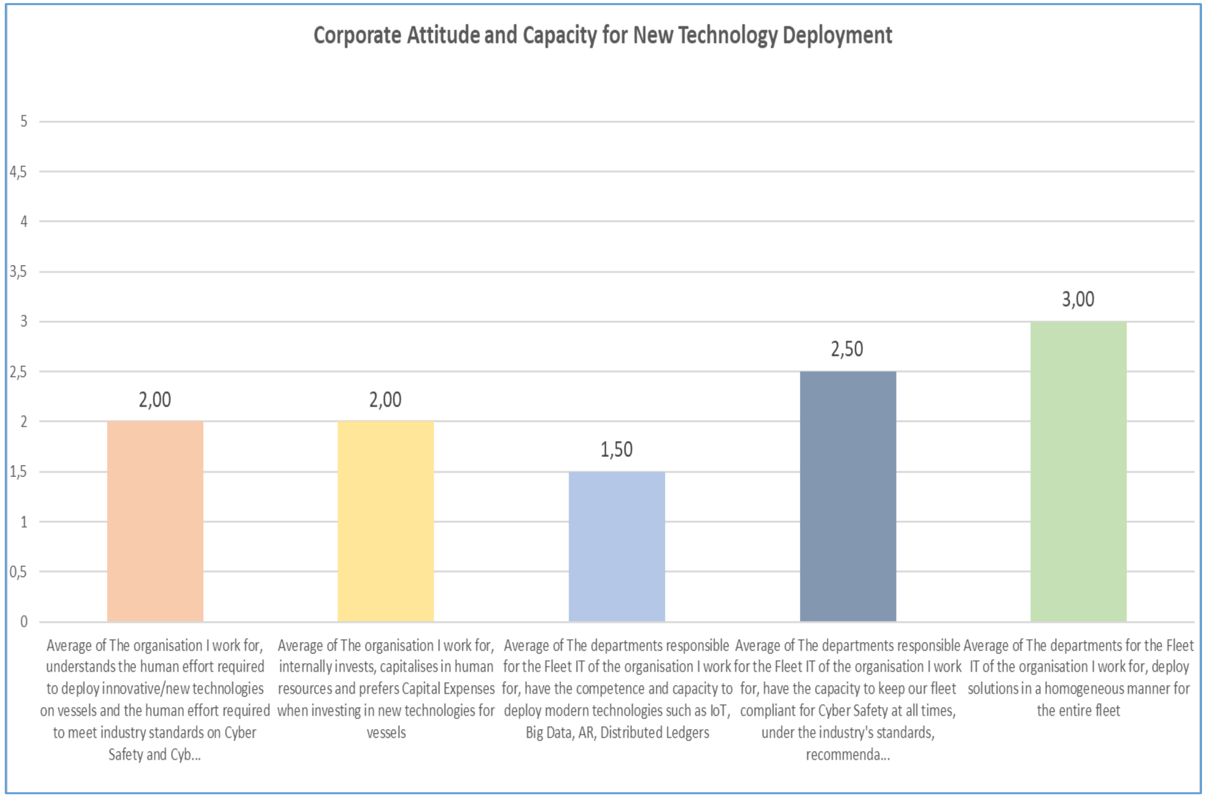
Group B

Group A vs Group B – Corporate Attitude and Capacity

General Perception



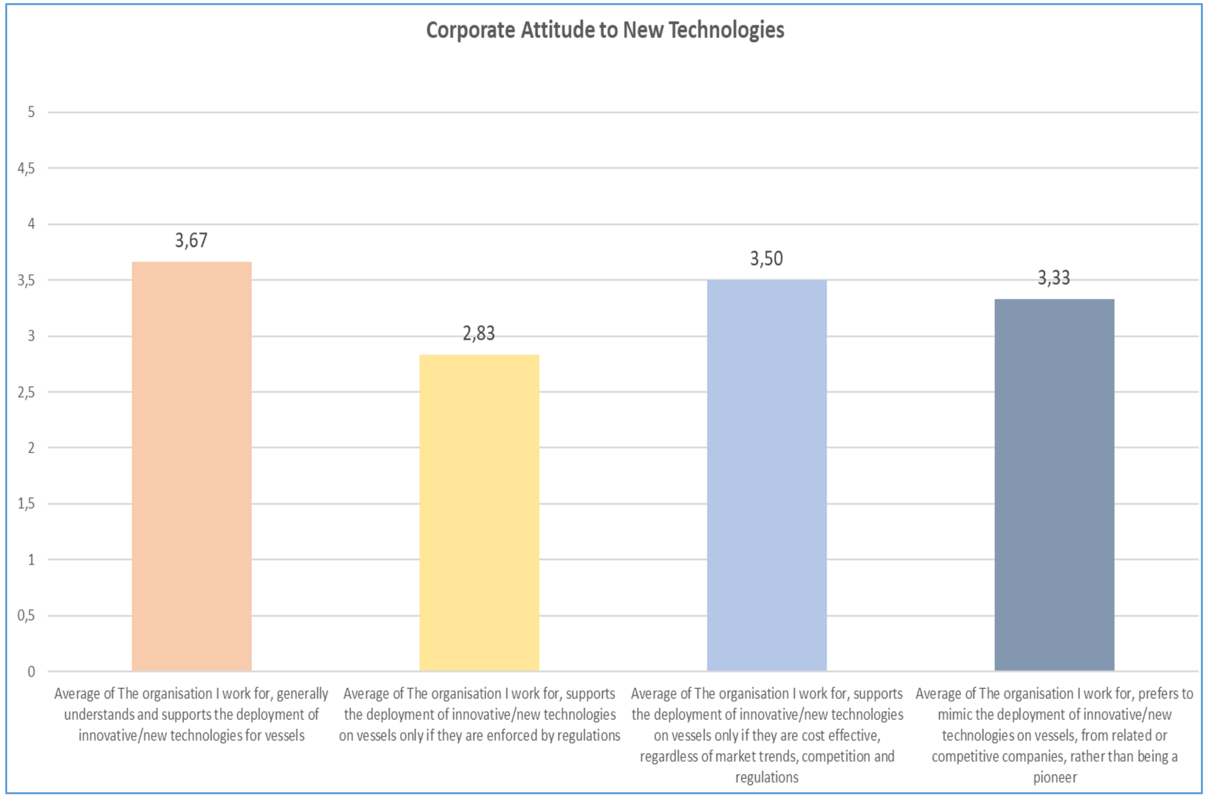
Group A



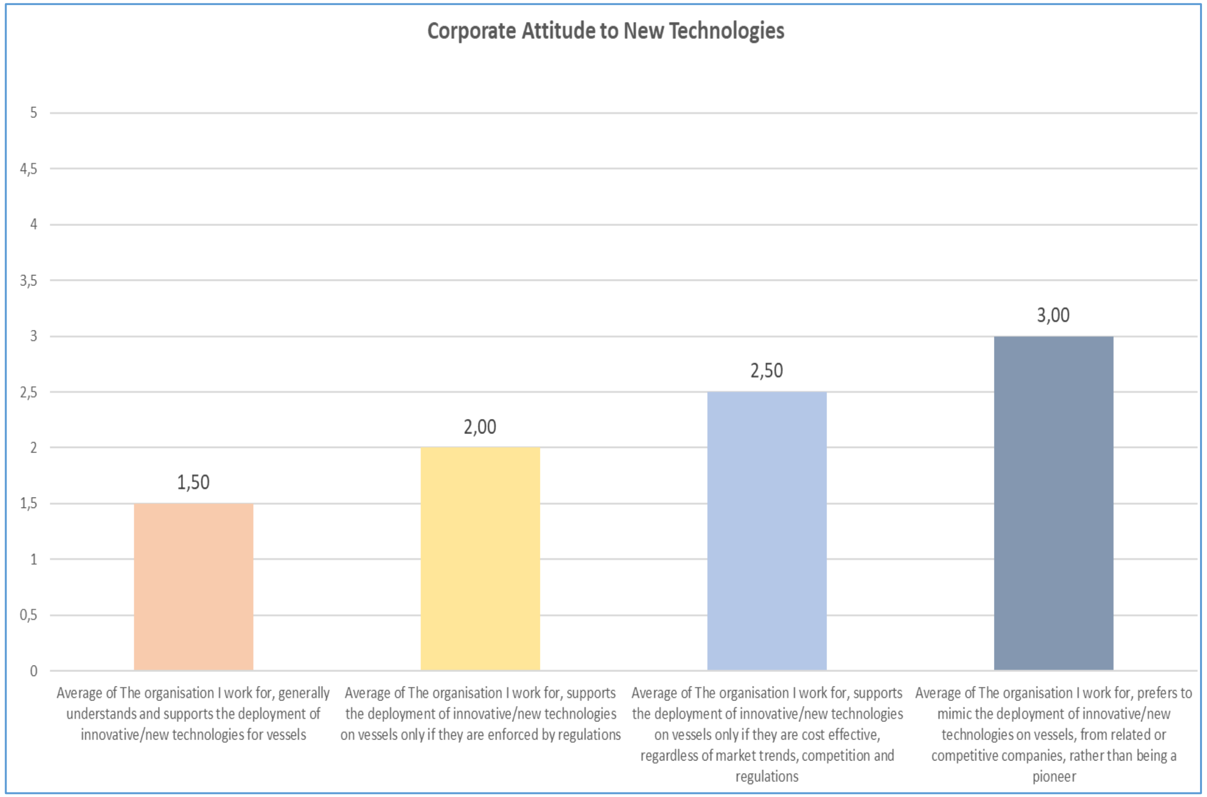
Group B

Group A vs Group B – Corporate Attitude to New Tech

General Perception



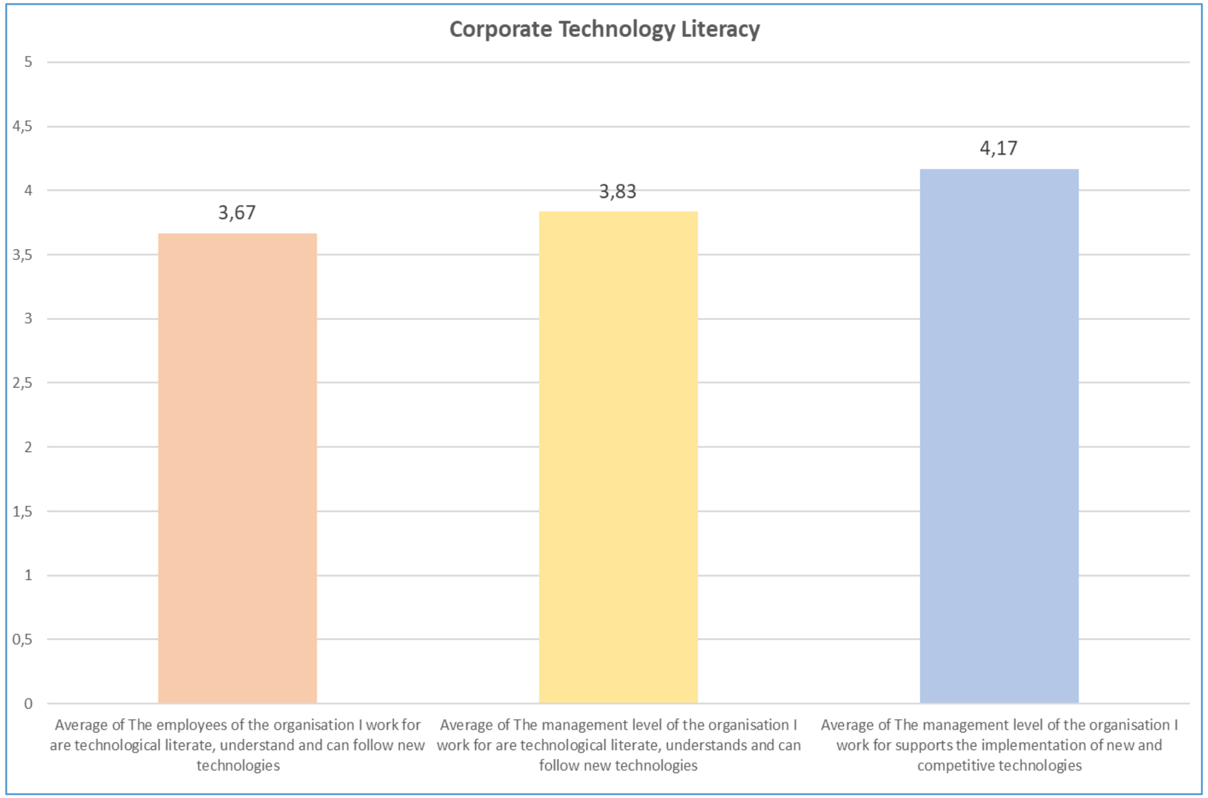
Group A



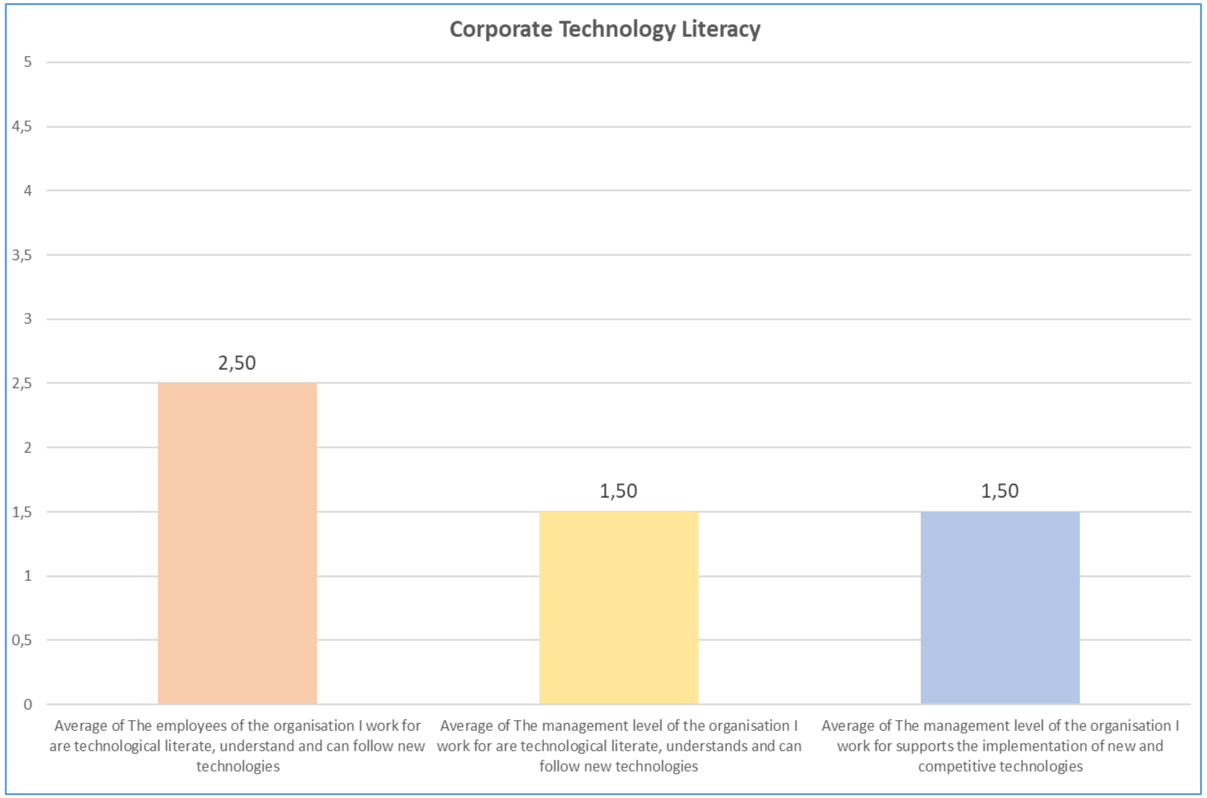
Group B

Group A vs Group B – Corporate Tech Literacy

General Perception



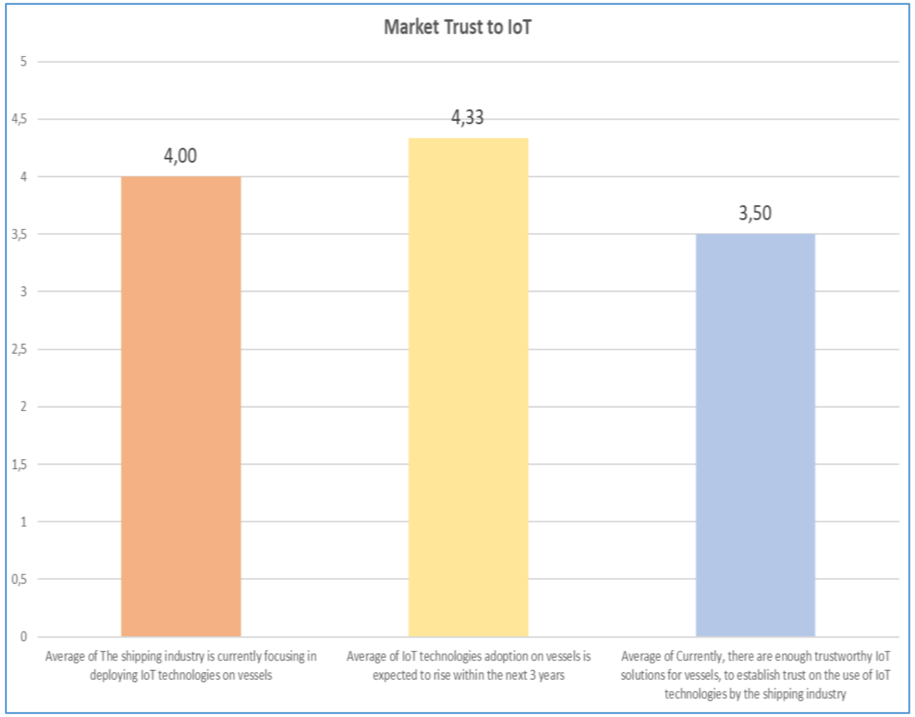
Group A



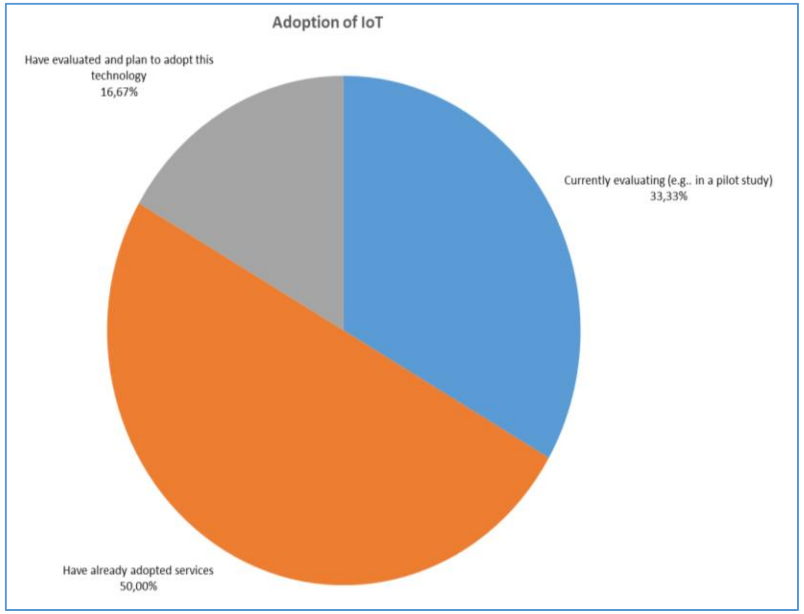
Group B

IoT Trust and Adoption

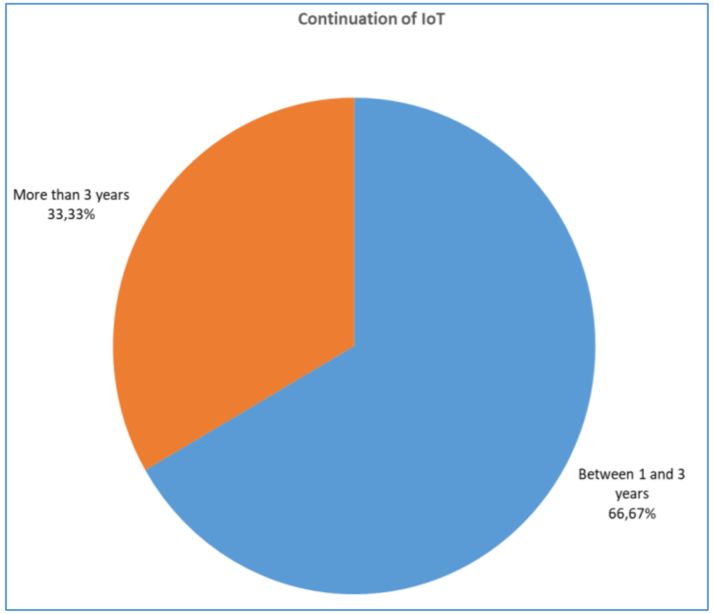
Group B participants perception does not correlate with corporate adoption



Group A Trust



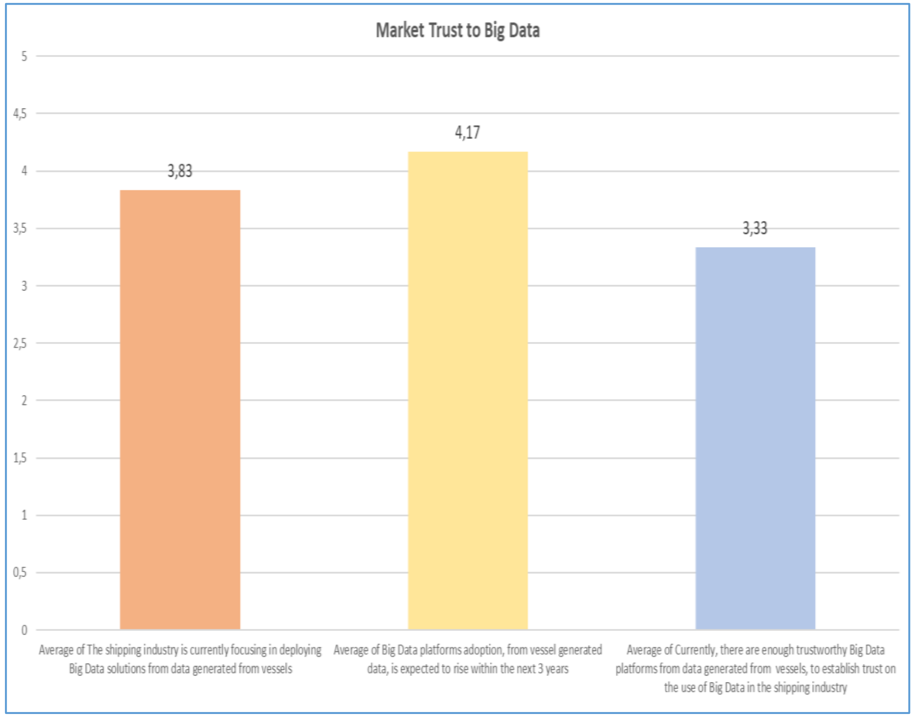
Group A Current Adoption



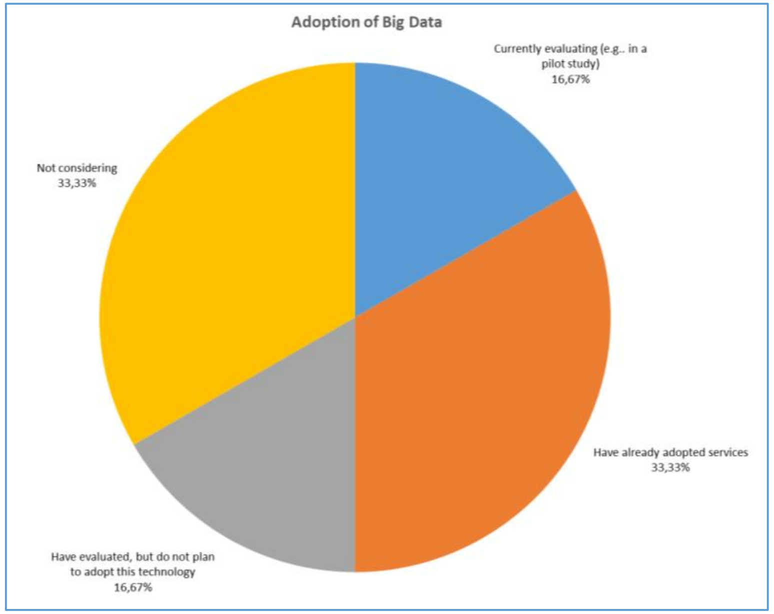
Group A Future Adoption

Big Data Trust and Adoption

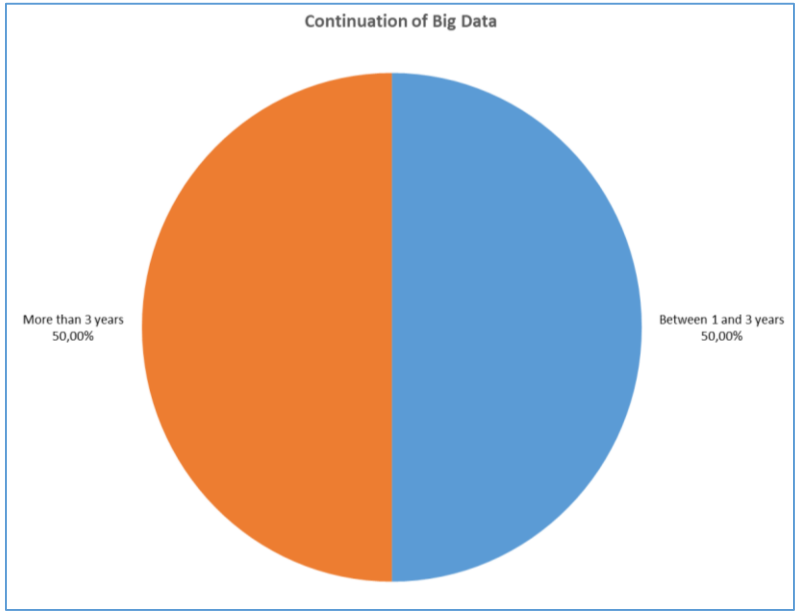
Group B participants perception does not correlate with corporate adoption



Group A Trust



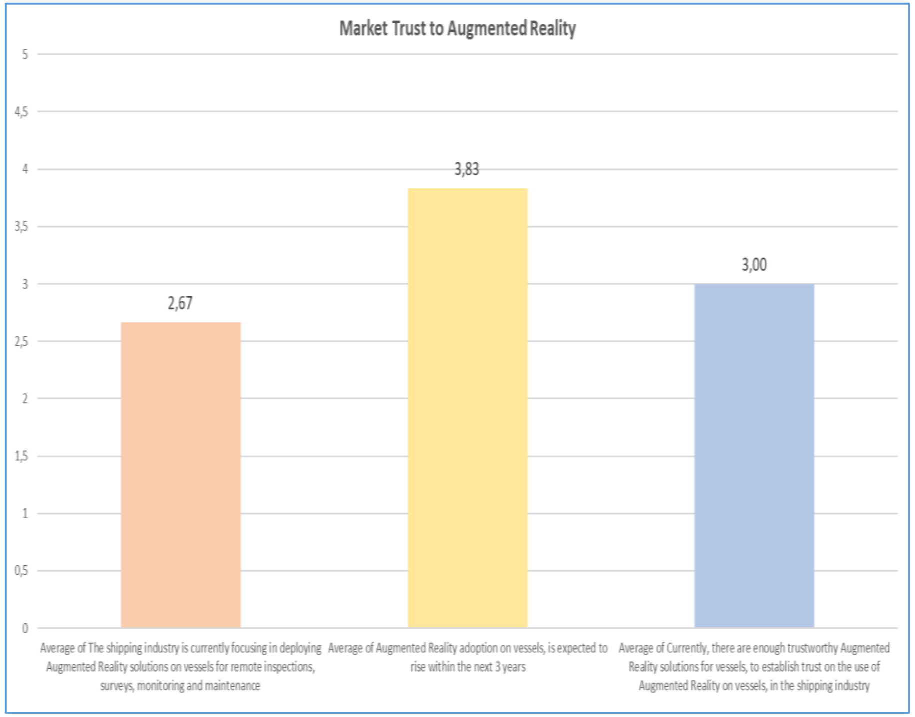
Group A Current Adoption



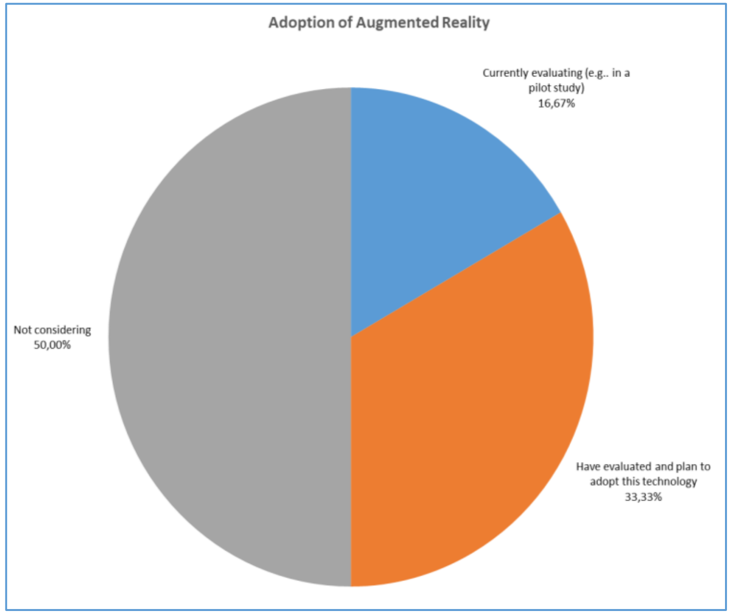
Group A Future Adoption

Augmented Reality Trust and Adoption

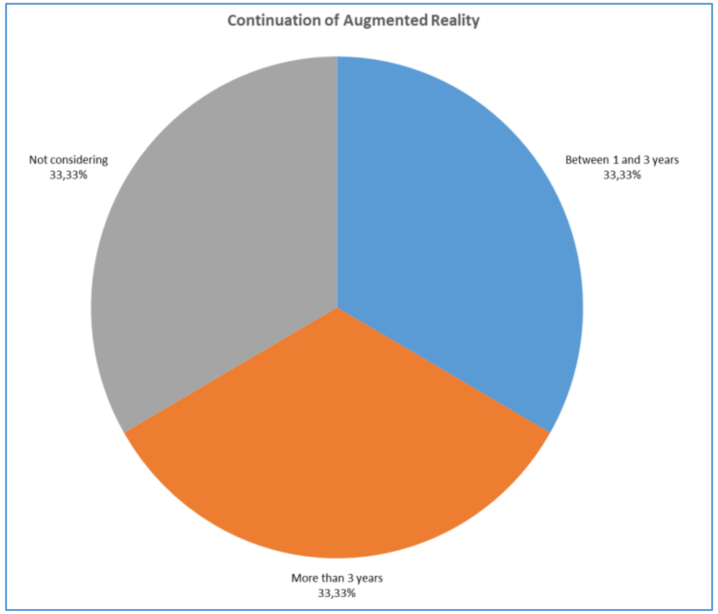
Group B participants perception does not correlate with corporate adoption



Group A Trust



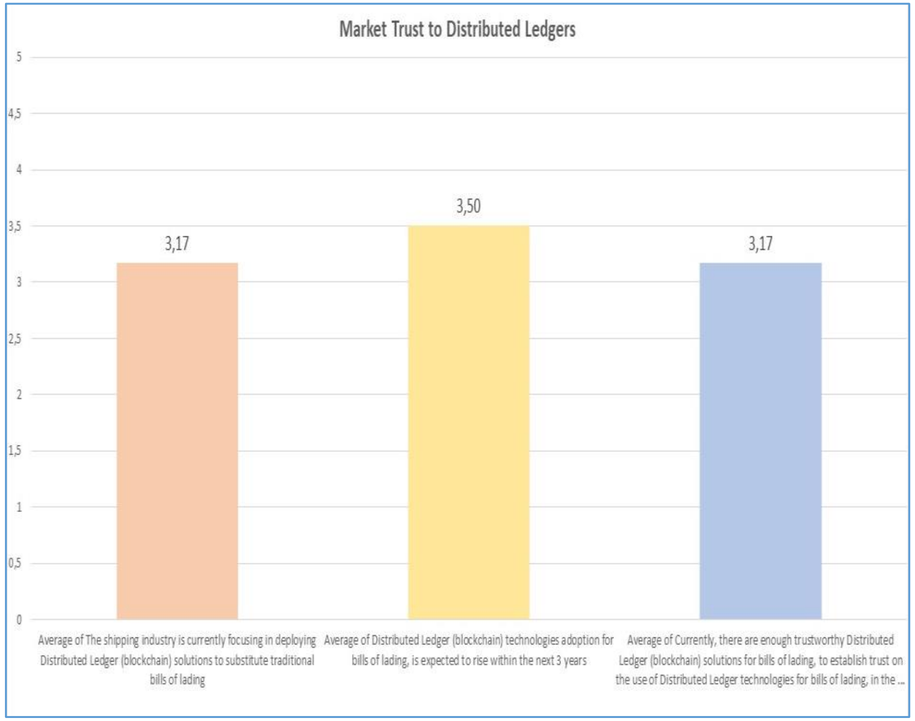
Group A Current Adoption



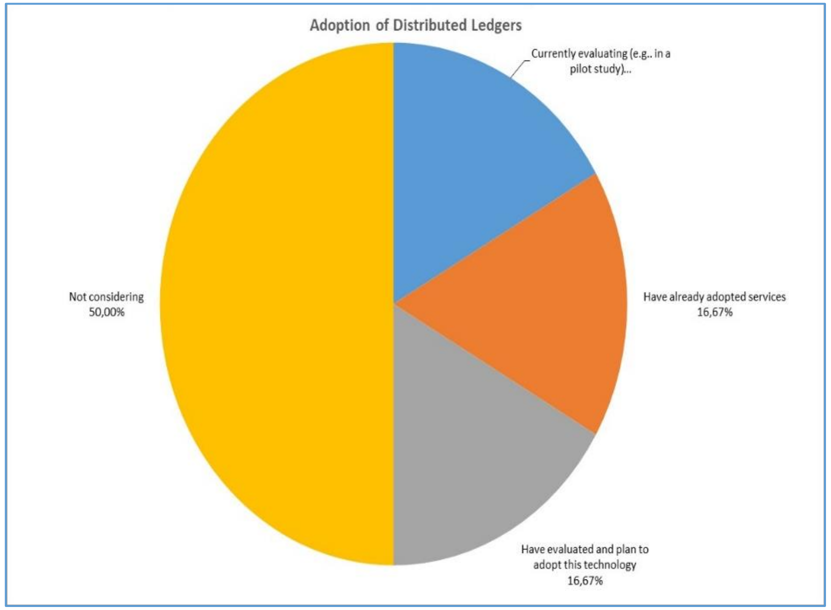
Group A Future Adoption

Distributed Ledgers Trust and Adoption

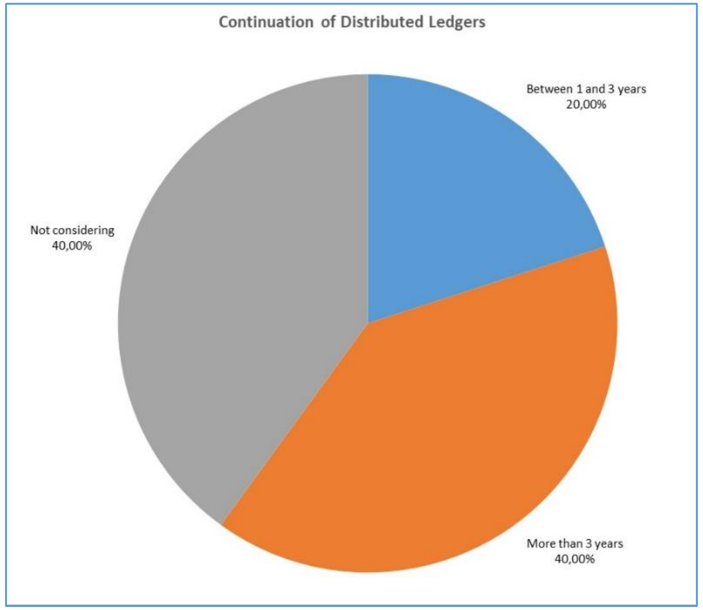
Group B participants perception does not correlate with corporate adoption



Group A Trust



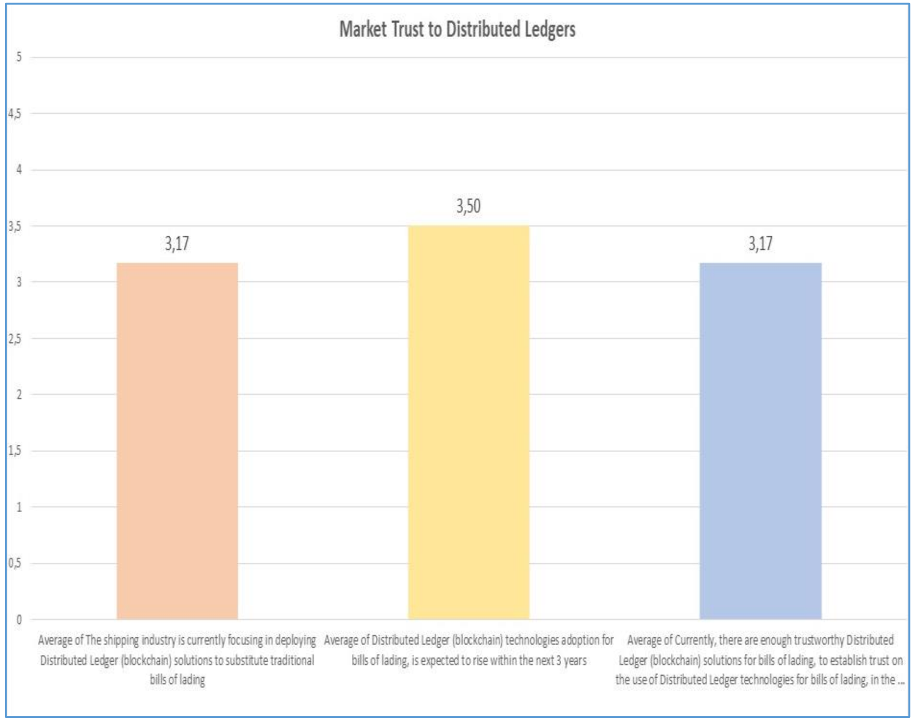
Group A Current Adoption



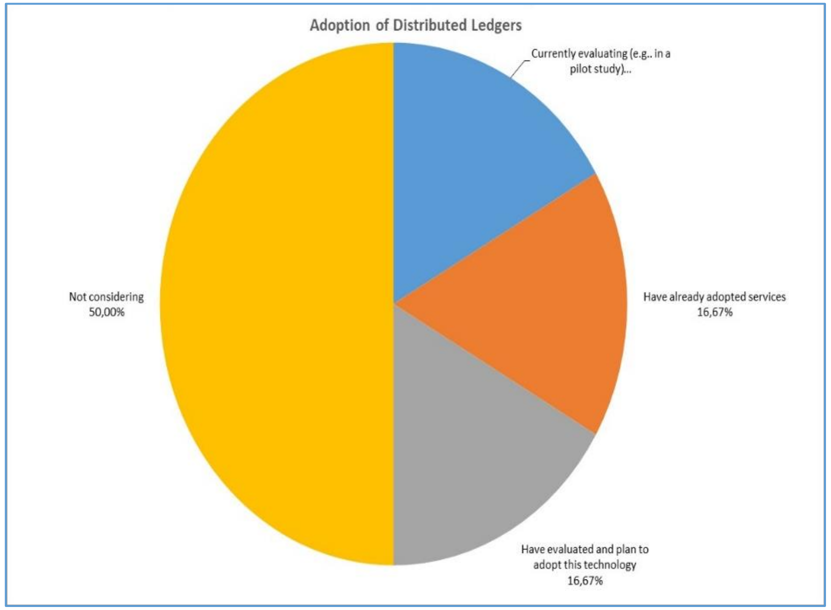
Group A Future Adoption

Distributed Ledgers Trust and Adoption

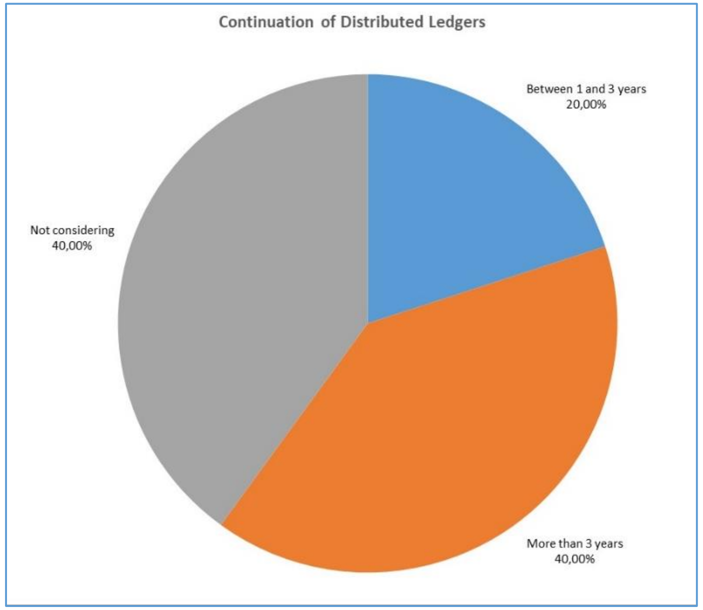
Group B participants perception does not correlate with corporate adoption



Group A Trust



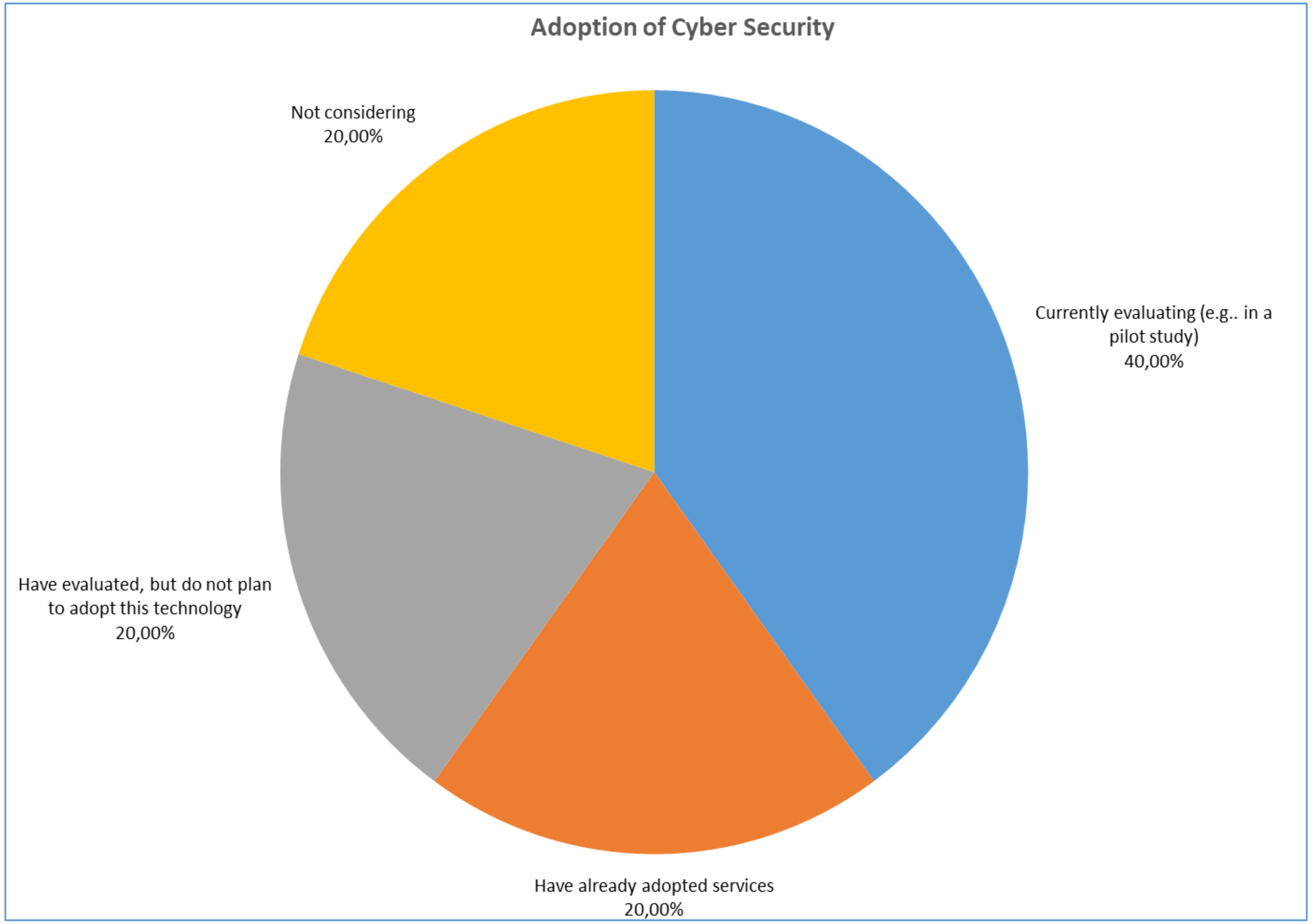
Group A Current Adoption



Group A Future Adoption

Cyber Safety Adoption

Group B participants perception does not correlate with corporate adoption



Group A Current Adoption

“Onboard vessels digital disruption through ICT technologies Strategic incentives, anew perils and adoption tendencies.”

Focusing on the Greek Maritime Shipping Sector

Chapter 6:
Conclusion

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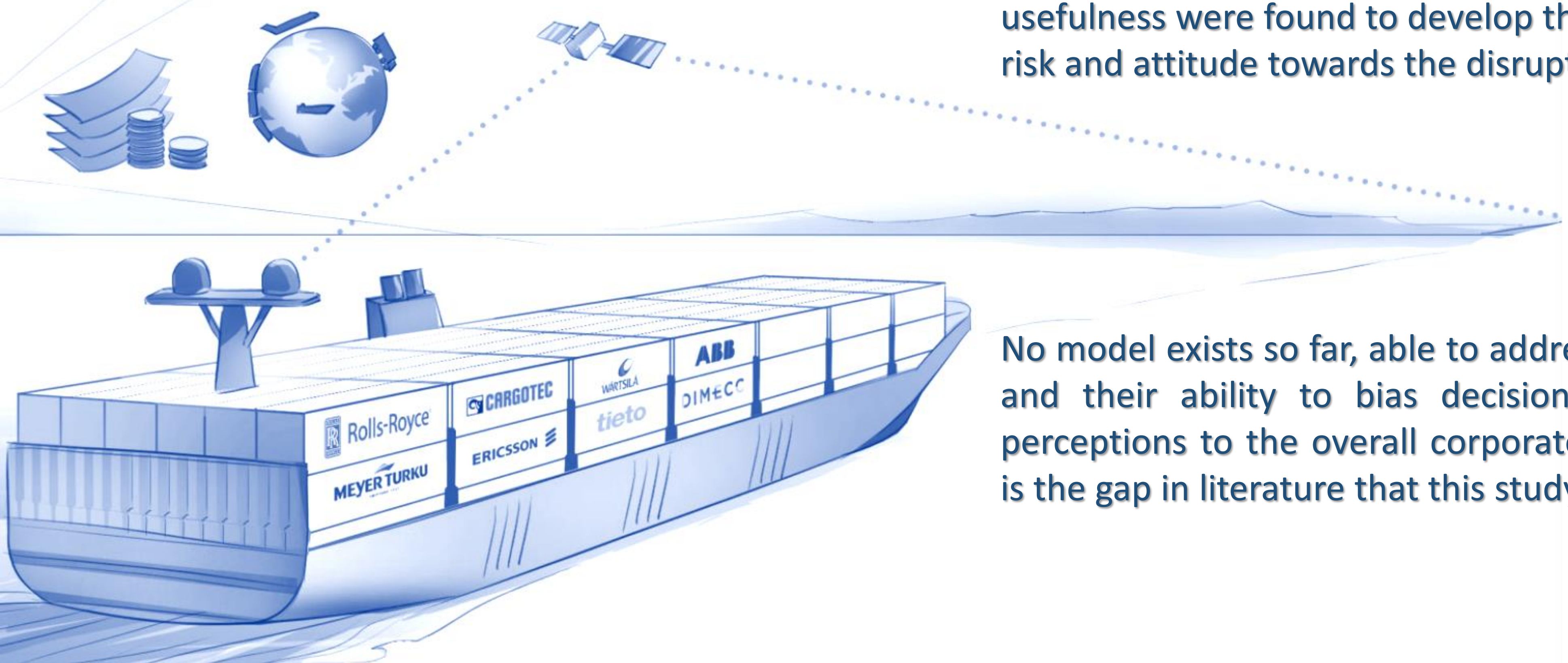
General Conclusions

The study reveals that the most critical constructs explaining behavioral intention for disruptive technology adoption in the Greek shipping sector are perceived understanding, usefulness, attitude, market trust and risk.

The significant overall impact of the model proves the importance of the developed model. The research presents a holistic approach for future studies on the adoption of new disruptive information technologies offering valuable insights for further research.

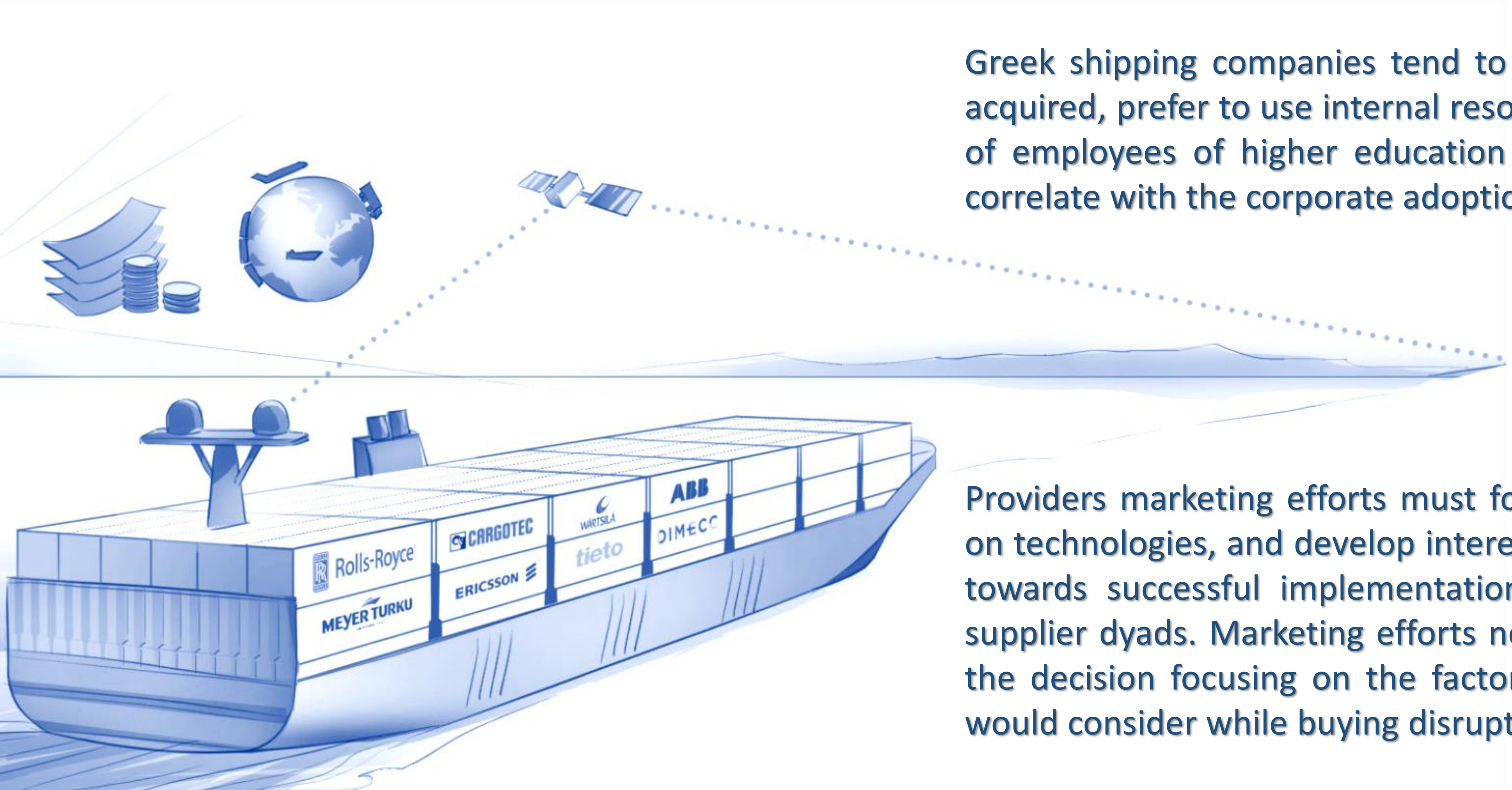
Further, perceived subjective understanding, market trust and usefulness were found to develop the perceptions on perceived risk and attitude towards the disruptive technology adoption.



No model exists so far, able to address the perception of actors and their ability to bias decision makers, or project their perceptions to the overall corporate adoption behavior, which is the gap in literature that this study seeks to address.

Assumptions Limitations and Findings

Results should not be globally generalized. This is an attempt to describe how Greek shipping companies understand the penetration of certain disruptive innovation technologies as projected by the world of information technology, seeking patterns related to final adoption.



Greek shipping companies tend to act on internal knowledge acquired, prefer to use internal resources, while the perception of employees of higher education and experience, positively correlate with the corporate adoption tendencies.

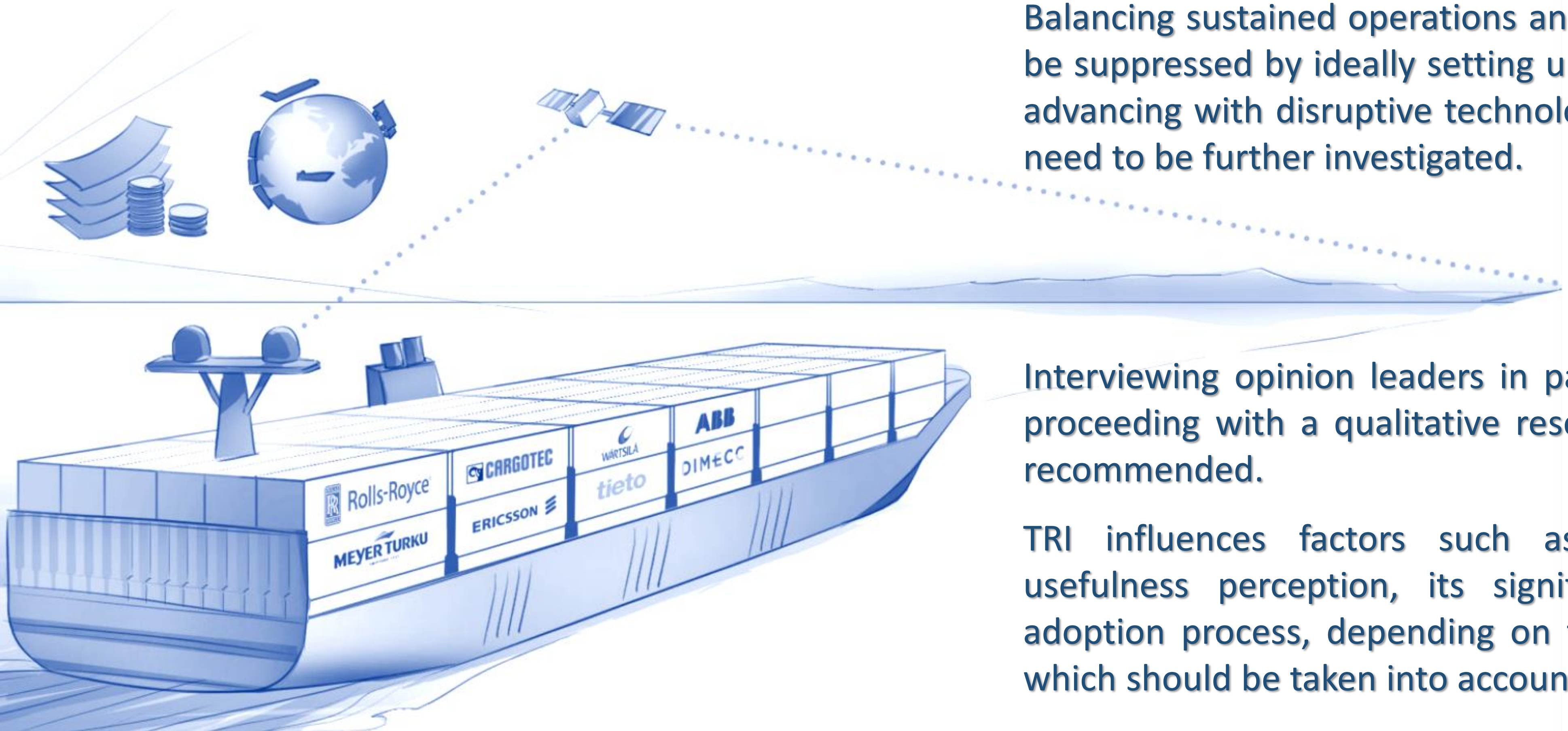
Providers marketing efforts must focus on creating awareness on technologies, and develop interest to drive the practitioners towards successful implementation through effective buyer-supplier dyads. Marketing efforts need to focus on influencing the decision focusing on the factors that the opinion leaders would consider while buying disruptive technologies.

Recommendations for Future Research

Empirical data was collected from all levels of employees, on a plethora of topics. A narrower scope of taking internal opinion leaders and decision makers into account, could have added different views especially on the perceived risks and usefulness.

A longitudinal study to evaluate the technologies' progress will be of interest and is recommended, segmenting companies.

Balancing sustained operations and disruptive innovations, can be suppressed by ideally setting up teams for responding to or advancing with disruptive technologies, the existence of which need to be further investigated.



Interviewing opinion leaders in parallel with decision makers, proceeding with a qualitative research of deductive nature is recommended.

TRI influences factors such as understanding, risk and usefulness perception, its significance may influence the adoption process, depending on the structure of a company, which should be taken into account in future research.

Thank you!

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ευχαριστώ

ありがとうございます Salamat Po متشکرم شكراً Grazie

благодаря شکریہ Kiitos Teşekkürler 谢谢

ขอบคุณครับ Obrigado Terima Kasih Dziękuję

Hvala Köszönöm Tak Dank u wel дякую Tack

Mulţumesc спасибо Danke Cảm ơn Gracias

多謝晒 Ďakujem நன்றி Děkuji 감사합니다

ありがとうございました