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Application of the Unified Theory of Acceptance and Use of Technology in the Shipping Sector

Rui Manuel Ganho da Silva Reis

Doutoramento em Gestão Empresarial Aplicada

Orientador:
Professor Associado com Agregação João Carlos Rosmaninho de Menezes
ISCTE - Instituto Universitário de Lisboa

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BUSINESS
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Resumo

Sendo as novas tecnologias fundamentais para o desenvolvimento de toda a economia, este estudo tem como principal objectivo desenvolver um modelo que nos ajude a entender o grau de aceitação e internalização de novas tecnologias na indústria do shipping. O modelo encontrado, que designamos por UTAUT-S, foi desenvolvido com base no modelo UTAUT aos quais se adicionaram novos constructs (Digital Trust e User Satisfaction). Estes constructs emergiram da revisão de literatura como factores adicionais que poderiam ajudar melhor a entender a aceitação de novas tecnologias no Shipping. Este estudo utiliza uma estrutura de pesquisa quantitativa suportada num inquérito que foi enviado aos principais stakeholders da actividade de Shipping em Portugal e Espanha, num total de 337 inquéritos validados. Esta pesquisa confirma o conservadorismo da indústria do Shipping na aceitação e internalização de novas tecnologias. O modelo desenvolvido, UTAUT-S, demonstra ser o modelo mais apropriado para compreender a aceitação e o uso das novas tecnologias na cadeia de valor do shipping apresentando um valor de R2 de 90,2, significativamente superior ao valor equivalente do modelo de base UTAUT (R2 de 70). A aplicação deste modelo permitirá aos gestores identificar o grau de aceitação das novas tecnologias, permitindo assim identificar as estratégias mais adequadas para a sua mais rápida aceitação e uso.

Palavras-Chave: Shipping, Novas Tecnologias, Adoção Tecnológica, UTAUT

Codigo JEL : O320, O330

Abstract

New technologies are fundamental for the development of the entire economy. The main objective of this study is to develop a model that will help us understand the degree of acceptance and internalization of new technologies in the shipping industry. The model found, which we call UTAUT-S, was developed based on the UTAUT model to which new constructs (Digital Trust and User Satisfaction) were added. These constructs emerged from the literature review as additional factors that could help to better understand the acceptance of new technologies in shipping. This study uses a quantitative research structure supported by a survey that was sent to the main stakeholders of the Shipping activity in Portugal and Spain, in a total of 337 validated surveys. This research confirms the conservatism of the shipping industry in the acceptance and internalization of new technologies. The developed model, UTAUT-S, proves to be the most appropriate model to understand the acceptance and use of new technologies in the shipping value chain, presenting an R2 value of 90.2, significantly higher than the equivalent value of the UTAUT base model (R2 of 70). The application of this model will allow managers to identify the degree of acceptance of new technologies, thus allowing them to identify the most appropriate strategies for their faster acceptance and use.

Keywords: Shipping, New Technologies, Technology Adoption, UTAUT

JEL code: O320, O330

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1. Introduction

1.1. Context and Motivation

Maritime transport plays a crucial role in the growing economy due to its significance in facilitating global trade, connecting nations, and supporting various industries. Here, we will explore the importance of maritime transport and its impact on economic growth. The world economy, in the post-war period, has grown at a significant rate, with rare exceptions such as the crisis of the first oil shock (70's, of the twentieth century) and more recently, already in this century, the financial crisis of 2009 and with the pandemic Covid-19 (Annex C – Graphic C1)**.**

To this evolution of world trade, there has been a significant growth in maritime (Saxon & Stone, 2017; Venkatesh et al., 2003). Maritime trade accounts for about 90% of world trade(UNCTAD, 2021). Maritime transport is responsible for carrying most of the global trade. Shipping vessels transport goods and commodities across the world's oceans, connecting producers with consumers in different countries. The efficiency and scale of maritime transport enable the movement of large volumes of goods, fostering international trade and supporting economic growth (Unctad, 2023).

Maritime transport is generally more cost-effective compared to other modes of transportation, such as air or road. Ships have large carrying capacities, allowing for the transportation of bulk commodities and goods in large quantities. The economies of scale in maritime transport help reduce transportation costs per unit of cargo, making goods more affordable and accessible in the global market (Sourdin, 2009). It connects manufacturers, suppliers, and retailers across different regions and continents. Maritime transport ensures a steady flow of raw materials, intermediate goods, and finished products, enabling seamless supply chain operations. The timely delivery of goods is crucial for maintaining production schedules, satisfying customer demand, and supporting economic growth (Gunasekaran et al., 2004). Is also a significant source of employment and job creation. It encompasses a wide range of activities, including shipbuilding, seafaring, port operations, logistics, and marine services. The demand for skilled professionals, such as ship captains, engineers, naval architects, and port workers, generates employment opportunities, supports livelihoods, and contributes to economic development in (Na & Hipertensiva, 2019).

Maritime transport drives the development of port infrastructure. Ports serve as gateways for international trade, facilitating cargo handling, storage, and transhipment. Investment in port infrastructure, such as deepening and widening of channels, construction of terminals, and deployment of advanced technologies, supports efficient operations and enhances the capacity of ports to handle increasing volumes of cargo. This infrastructure development generates economic activities, attracts investment, and promotes regional development(Munim & Schramm, 2018). The

growth of maritime activities creates demand for related industries, such as shipbuilding, repair and maintenance services, logistics and warehousing, marine insurance, and maritime legal services. These sectors, in turn, contribute to employment, income generation, and the development of ancillary industries, leading to overall economic growth and diversification (Fratila et al., 2021; UNCTAD, 2021).

Maritime transport provides access to resources and markets, especially for landlocked countries or regions with limited transportation infrastructure. By connecting these areas to coastal ports, maritime transport allows for the import of essential goods, raw materials, and energy resources, as well as the export of products and commodities. This access to resources and markets promotes economic development, reduces dependence on limited local resources, and facilitates regional integration (Sharapiyeva et al., 2019). Maritime transport is closely linked to the tourism and cruise industry. Cruise ships and passenger vessels transport tourists to various destinations, stimulating local economies, generating revenue from tourism-related activities, and creating jobs in sectors such as hospitality, entertainment, and retail. The growth of the cruise industry boosts tourism infrastructure development and promotes economic diversification in coastal regions (Santos et al., 2019).

In general, there is a correlation between global maritime trade and the overall growth of the economy (GDP), as illustrated in Fig 1.

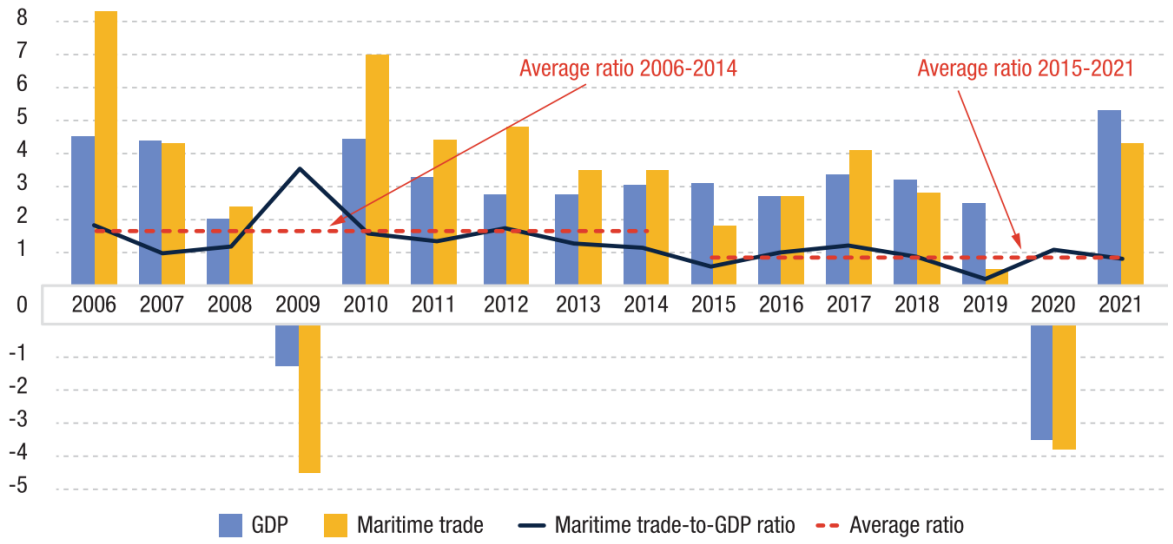


Figure 1 - International maritime trade, world gross domestic product (GDP) and maritime trade-to-GDP ratio, 2006 to 2021 (UNCTAD, 2021)

While maritime transport is a key driver of economic growth, it also plays a role in environmental sustainability. The industry is investing in eco-friendly practices and technologies to reduce emissions, improve energy efficiency, and mitigate environmental impacts. The transition to cleaner fuels,

implementation of stricter environmental regulations, and adoption of sustainable practices contribute to a more sustainable maritime sector that supports long-term economic growth (European Environment Agency & European Maritime Safety Agency, 2021).

The logistics dimension of maritime transport leads to the need for the automation of logistics processes. The number of operations and the number and quantity of goods transported require that the logistics process be supported by a digital ecosystem. Maritime logistics is therefore a key area for digital transformation. The interconnectivity with different stakeholders of the logistics process and its large number of interfaces, thus offers the opportunity for a wide range of applications for digital technologies. Thus, digitization and logistics 4.0, provide great development and improvement potential for shipping companies (Berg & Hauer, 2015).

The containerization of cargoes played an important role in the development of global trade. The containerization of cargo and its evolution over the past 4 decades has redefined shipping logistics and shipping-related industries themselves (Saxon & Stone, 2017). The evolution of the overall number of containers explains by itself the dimension of the logistics operation concerned (Annex C – Graphic 2). It is therefore essential that its management is supported in digital processes.

Shipping, being an activity with certain particularities, can benefit from the development registered in other sectors, regarding the digitization of its processes. Despite the complexity of the maritime logistics chain (Fig 2) and bearing in mind the current technological development and the benefit of the implementation of new technologies throughout the logistics chain, it is intended to know what status quo exists and what could be the accelerators factors.

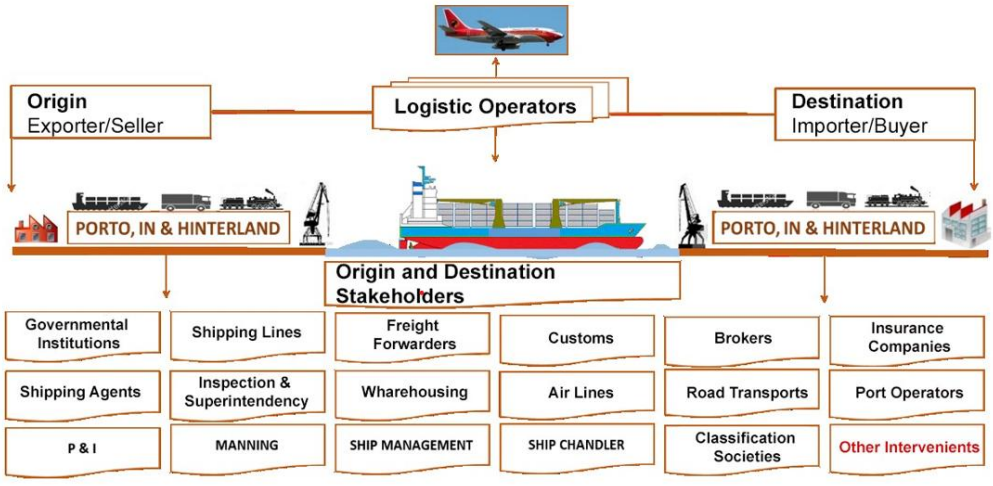


Figure 2 – Shipping Value Chain : Author

Personal Motivation

The author of this work began to develop his professional career in the Shipping Industry, but it was mainly in the energy sector where he held senior management positions. At the beginning of his

professional career, in the 1980's, he experienced the great transformations that occurred due to globalization, among others, were the mass use of the internet, the globalization of communications and the mass use of computers at the personal level. These changes have allowed companies and their economies to grow that had never been seen before. When the author assumed senior management positions in the Energy sector (beginning of this century) he also experienced the great financial crisis of 2008 and the consequent economic crisis, but mainly began to witness the transformation of many business models and processes by the use and introduction of new technologies. The impact that these new technologies can bring to companies and to society in general is, according to many authors, substantially greater than the impact that the internet and communications had at the end of the last century in the 1980's, as he himself had the opportunity to witness.

On the other hand, maritime transport and the Shipping industry in general, being an industry characterized by its conservatism, is an industry that has grown globally, and that in Portugal has had a strong decline in counter-cycle with that seen at world and European level (as specifically portrayed in Chapter 2). Also in this Industry, new technologies will be fundamental for its development.

It was the intersection of these factors, the great importance that new technologies can have in the development of companies and the conservatism in the use of new technologies in the Shipping Industry, that were the main factor that aroused the interest in studying the adoption of new technologies in the Shipping Industry.

1.2. Research Objective

From the 1980's, technological advances began to reduce transportation and communication costs dramatically. These developments enabled the unbundling of production, i.e., the possibility of outsourcing some stages of production and of splitting different production stages geographically. Combined with ambitious trade policy liberalization and the integration of the former East and West blocs into a single global economy, technological advances have given rise to a complex structure of cross-border value chains that benefit from the specialization based on comparative advantage of any given economy in the value chain. Consequently, global trade, and trade in intermediate inputs especially, boomed (WTO, 2023).

Digital technologies have a strong impact practically in every industry. The development of information and communication technology has changed economies all over the world. The introduction of new technologies along the shipping value chain is critical for the development of this industry and the concept of Maritime 4.0 (B. P. Sullivan et al., 2020), or Shipping 4.0, appear in the literature as the well-known concept of Industry 4.0 applied to Shipping.

The shipping industry is characterized by being very conservative, as evidenced by the evolution in recent decades. However, in recent years, there has been a great technological development and digital technologies have taken on an important role (Fonseca et al., 2021), as be illustrated in Fig 3.

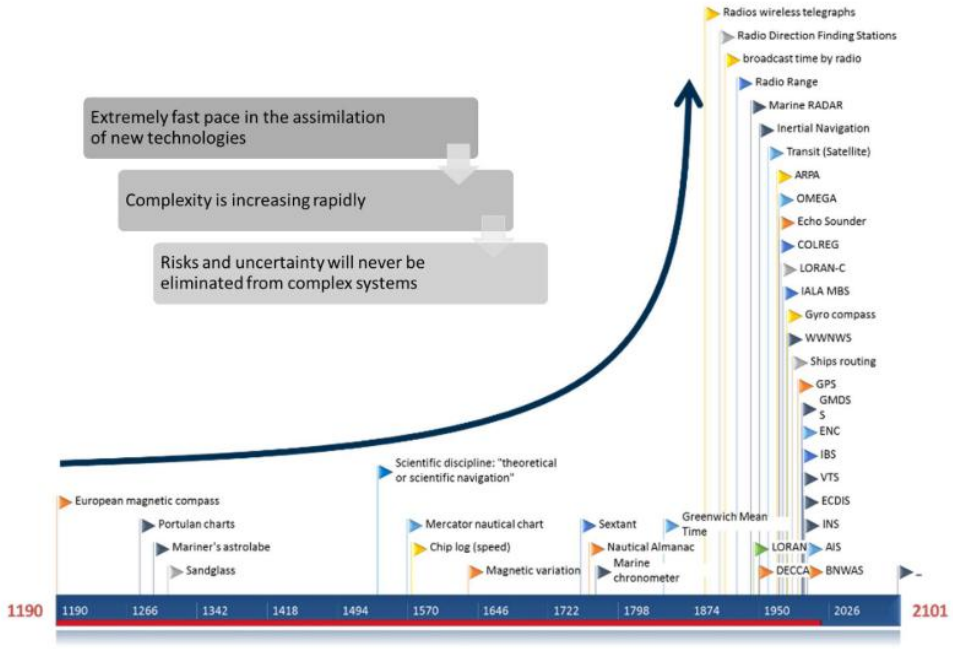


Figure 3 - Time line visualization of the trend in maritime navigation technologies and techniques : Source - Conceição et al., 2018

Digitalisation will fundamentally change the function of shipping. Although the importance of digitalization is recognized by all stakeholders in the shipping industry, its introduction has been slow and less than desired and necessary (Quitzau et al., 2018). As referred by Tijan et al.(2021), "previous research offering a comprehensive overview of digital transformation in the maritime transport sector, is scarce".

The aim of this study is to develop a model of acceptance and use of new technologies specifically for the Shipping Industry. This model would help managers to better implement all the necessary measures to strengthen the automation and/or digitalization of management processes, both technical and administrative.

To achieve this objective, we have formulated the following Research Questions (RQ):

RQ1- Is Shipping an Industry where the level of technological literacy is too low?

RQ2- Could we improve the accuracy of a technological acceptance model specifically for Shipping?

To the best of our knowledge, there is no technological acceptance model developed specifically for the shipping industry that helps us to have a global perspective of the industry throughout the value chain.

1.3. Thesis Structure

Chapter 1 will provide a framework for the Shipping sector in general, linking its growth with the growth of the world economy. It will be evident that this growth of the economy has been accompanied and supported by the growth of maritime transport. The growth in maritime transport along with the complexity of the processes involved in its value chain are presented. This chapter also presents the technological challenge for the shipping industry and the formulation of the research objective, and the research questions formulated.

In Chapter 2 will be presented a characterization of Shipping activities in Portugal along the main areas of the value chain (Shipping Companies, Ports, Agents, Naval Construction, Freight Forwarders).

Chapter 3 presents the Literature review. In this same part, it can be inferred that the size of maritime logistics operations can only be carried out with support for new technologies. This Chapter introduces the concept of Shipping 4.0 or Maritime 4.0, having as its starting point the concept and definitions of I4.0. Before the introduction of the I4.0 concept, industrial capacity developments in Western economies are presented, notably the slowdown in the US and Europe.

Chapter 4 describes the methodology used in this investigation. The research model adopted, as well as brief presentation of some of the most relevant technological acceptance models used in the literature analysed.

Chapter 5 describes the results obtained and the respective discussion of the results.

Chapter 6 presents the conclusions and contributions to both academic and business areas, the limitations and the proposed areas of development.

2. Shipping in Portugal

2.1. Introduction

Shipping is an essential industry today of crucial importance for the global economy and development. Maritime Transport is fundamental and the perception of his importance, is recognized as a strategic activity (UNCTAD, 2018).

The internationalization and specialization of maritime transport has emptied of meaning the concept of National Merchant Marine, which reached its peak (in Portugal) in the second half of the last century.

Maritime Transport is the essential element in the international trade chain that supports globalization, being responsible for approximately 90% of all transport, characterized by an ever-increasing efficiency and very low cost (Erik et al., 2022). In more recent times, the maritime transport industry has faced challenges of a political nature (China/US relations, Brexit), environmental, with the movement to reduce emissions of polluting gases, and conjunctural, because of the Covid-19 pandemic, with the disruption of trade flows and the collapse of logistics chains and port congestion.

During the pandemic, the Merchant Marine has proven its importance once again, ensuring the transport of essential goods, namely solid and liquid bulk and medicines, on a global scale. Despite the reduction in maritime transport activity during this critical period, this activity has been ensured at a global level by keeping critical logistics chains in operation (UNCTAD, 2021).

It is impossible to deny that without ships, there would be no globalization today, just as we would not have explored the world from the fifteenth century onwards if we did not have ships. The world's fleet continues to grow, consisting of about 54,000 ships (of more than 1000 GT), for a total of 2.1 billion DW tons (deadweight), according to the most recent data from UNCTAD, of which only about 1 million TDW and 60 vessels are connected to Portugal in terms of ownership and/or operation.

The relatively low importance of Maritime Transport controlled and operated by Portuguese interests will have felt little of the global effects, maintaining the regular connections between the mainland and the Islands and with Cape Verde and Guinea Bissau, and little else (based on the Portuguese “controlled” fleet).

Bearing in mind that a relevant part of the study sample will be Portuguese due to the author's greater ease in contacting the different stakeholders of the industry in Portugal, we carry out a general characterization of the Shipping activity in Portugal, in the various areas that are part of this Industry.

2.2. Portuguese Shipping Registration

In the last decades, the national fleet of the merchant navy registered in the conventional register Portuguese has suffered a sharp decline (Table 1), despite the substantial increase in the movement of ships, cargo and cruise traffic in the last decade in national ports.

YEAR	Nr of SHIPS	AVERAGE AGE (years)	DEADWEIGHT (Tons)
2014	10	22	49775
2015	11	23	49775
2016	9	26	42195
2017	3	21	13818
2018	2	15	11514
2019	2	16	11514
2020	2	17	11514
2021	3	18	19586
2022	3	19	19586
2023	7	18	75176
2024	7	19	75176

Table 1 - Conventional Registry (IMT)

The International Shipping Register of Madeira («MAR») was created as a second ship registry in Portugal. On the one hand, it was intended to prevent ships from moving to flags of convenience. On the other hand, it was aimed at attracting new ship-owners (Fernandes, 2014).

The main advantage of the MAR Registry is access to certain tax and social security benefits (Fernandes, 2014). These benefits have meant that in the Conventional Registry (Table1) the Portuguese Merchant fleet is merely residual. It should be noted that most ships registered in MAR are operated by crew members of other nationalities and operate in other regions than Portugal.

The notion of second registration, however, does not coincide with the definition of a flag of convenience. In fact, the success of MAR (Table 2) is the result of the reconciliation achieved between attractive conditions for shipowners, which include principles of reduction of bureaucracy and cost reduction, with the high levels of safety required by the applicable international conventions. Flags of convenience, on the other hand, often suffer from negative connotations, as they do not meet the required standards of navigation and labour and environmental protection.

YEAR	Nr of SHIPS	AVERAGE AGE (years)	DEADWEIGHT (Tons)
2014	232	13	4460608
2015	300	11	7974817
2016	387	11	12118489
2017	479	11	15338243
2018	512	12	14920800
2019	564	12	15665103
2020	616	12	16857592
2021	711	12	19448180
2022	779	13	20232103
2023	878	13	22415423
2024	917	14	23436031

Table 2 - International registration: MAR (IMT)

This trend led to a decline in the economic weight of maritime transport in the national economy and almost cancelled out maritime employment opportunities, accentuating the distancing of new generations from this activity. Benchmarking studies carried out on the situation in the various countries of the European Union (EU) revealed that the main critical factors for the success of ship registrations were the tax regime applicable to the activity of the merchant navy and the social protection regime applicable to crew members. Decree-Law No. 92 of 13 November 2018 defined a new legal framework for the merchant navy, established a special regime for determining the taxable base based on the gross tonnage of ships – tonnage tax and a specific tax and contributory regime for maritime activity, as well as a simplified register of ships and vessels. It is intended, therefore, to promote the national merchant navy, with a view to enhancing the expansion of the Portuguese maritime transport market and the development of national ports and the naval industry, job creation, innovation and the increase in the fleet of ships flying the Portuguese flag, with the consequent increase in tax revenue (Nuno Pinto, 2022).

2.3. Portuguese Shipping Sectors

In the last quarter of the 20th century, the loss of protected markets and the absence of new strategies and investments had an enormous impact on the Portuguese Merchant Marine. On January 1, 1975, 31 shipowners were registered with the Directorate-General of the Merchant Marine[1], among which four stood out: Companhia Nacional de Navegação (CNN), Companhia Portuguesa de Transportes Marítimos (CTM), Sociedade Portuguesa de Navios Tanques (SOPONATA) and Sacor Marítima.

[1] An entity that succeeded, in 1974, the National Board of the Merchant Marine, an oficial entity in charge of the Merchant Marine from 1940 to 1974, dependent on the Ministry of the Navy. Statistical information and shipowners list in DGMC Bulletin Vol.1, No.1, January 1975

With the nationalizations occurred in the revolutionary period, those companies became part of the State Business Sector in year 1975. The first two were liquidated in 1985, SOPONATA[2] disappeared in 2004 and Sacor Marítima sold the last ocean ship in 2009.

In 2022, the official definition of the Portuguese State of "Shipowner of Maritime Trade" (IMT-IP) is as follows[3]: "Shipowner of maritime trade is the natural or legal person, domiciled or registered in Portugal, who is dedicated to the maritime transport activity and who, to that end, is registered in IMT, IP."

This state body refers to 19 licensed companies, of which 11 are in fact concretely connected to Portuguese interests, with operation of Portuguese-owned ships or ships in bare hull chartering: Atlanticoline, SA (Horta), GS Lines Transportes Marítimos, Lda (Funchal), Mutualista Açoreana de Transportes Marítimos SA (Ponta Delgada),- Mystic Cruises SA (Porto), Mystic Ocean SA (Porto), Porto Santo Line Transportes Marítimos Lda (Funchal), Sacor Marítima SA (Lisbon), Santa Maria Manuela Turismo SA (Lisbon),- Seacarrier - Sociedade de Navegação e Transportes SA (Lisbon), Tejo Shipping Lines (Lisbon) and Transinsular - Transportes Marítimos Insulares SA (Lisbon).

Two shipowners are members of the Association of Shipowners of the Merchant Marine[4], but not registered in IMT: DOURO AZUL- Sociedade Marítimo Turística SA (Porto) and PORTLINE Bulk International SA (Lisbon).

Shipping Agents are, as defined in the The Marine Encyclopedic Dictionary (E. Sullivan, n.d.), “the person or entity acting as agent of a ship, representing the shipowner and/or charterer, in all the necessary formalities upon entry into ports, during clearance of the ship by customs, until the departure of the ship”. The Agent requests the authorities to assign quays for loading and unloading, advises and guides owners of import and export cargo, as well as loading and unloading operations, in addition to many other possible services provided during the ship's port call. In the case of passenger ships, the agent ensures all the formalities and procedures necessary for the disembarkation and embarkation of passengers.

In Portugal, as is the case internationally, Shipping Agents are a vital element of the Shipping business, with 125 companies in the field of Shipping Agencies registered with the IMT, which correspond to 260 registrations in the ports of the Mainland and Islands. Most of these companies are part of AGEPOR, the respective association (*AGEPOR*, 2022).

Ports are the infrastructures normally protected from the open sea, used by ships for loading and unloading, loading and unloading operations, with various facilities to support the various types of

[2] SOPONATA was sold in 2004 by the José de Mello Group to General Maritime Company (US).

[3] In Institute of Mobility and Transport, IP (https://www.imt-ip.pt/sites/IMTT/Portugues/TransporteMaritimo/Armador)

[4] Associação de Armadores da Marinha de Comércio, Lisboa (https://www.aamc.pt/associados)

ships, from their registration to construction and technical maintenance. Seaports play a key role in the economy by integrating logistics and transport chains (E. Sullivan, n.d.).

In Portugal, the National Port System is composed of the commercial ports of Viana do Castelo, Leixões, Aveiro, Figueira da Foz, Lisbon, Setúbal, Sines, Portimão, Faro, and also the ports of the Azores and Madeira (*APP*, 2023).

In today's globalized economy, competition between ports, airports, logistics platforms, specialized terminals, etc., depends on the ability to gain advantages over others.

These advantages are obtained in the ability to articulate all those involved in the security and operation of the *interland*, to process traffic quickly, reliably and by the ability to integrate all activities: administrative, customs, control, security, in order to build fast and efficient channels that allow the goods transited to reach their final destination in the shortest time and at the lowest possible cost(*EGAPI*, 2023). This emphasizes once again the importance of the digitalization of all processes involved.

Another fundamental element associated with maritime transport / shipping is the Naval Industry, in its components of construction and repair of ships. In Portugal, in addition to a long historical tradition, it has developed great importance, especially in the second half of the twentieth century, in some way following the attribution to the CUF Group of the operation of the Shipyard of the Administration of the Port of Lisbon, in Rocha do Conde de Óbidos. The shipyard Alfeite Arsenal, successor of the former Navy Arsenal in Ribeira das Naus in Lisbon, it had a significant importance in the development of modern shipbuilding, in the repair of ships and in the training of staff.

Lisnave has become one of the biggest European references in the shipbuilding industry, and maintains, in Setúbal, an important activity in the sector of repairs. The company WestSea, in Viana do Castelo, is dedicated to the construction of specialized ships, namely polar cruise ships, as well as ship repair (*AIN*, 2023).

A Freight Forwarder is a firm specialized in the arrangement of a cargo on behalf of shippers. In most cases, freight forwarders provide a variety of supply chain services, including ocean or air freight transportation and inland transportation from origin and/or to destination

The Freight Forwarders Association of Portugal (APAT) is the national association for PT-registered and licensed companies engaged in international freight forwarding activity - understood as the planning and organization of operations for the international transport of goods by all modes of transport (air, road, rail and sea), along with complementary logistics operations and distribution activities.

APAT has around 260 corporate members, known generally as freight forwarders, who offer a wide range of services within the various modes of transport. Some of our members are also involved in providing customs clearance and other cross border controls.

2.4. Conclusion

The growth of the global economy has been supported, from a logistical point of view, by a proportional growth of all shipping activities, from shipbuilding to port infrastructures, and of course maritime transport itself.

The globalization of the economy has made the national boundaries of this shipping industry less pronounced.

The shipping industry in Portugal plays a crucial role in the country's economy, given its strategic location on the Atlantic coast and its long maritime tradition. Portugal has several important ports, the most prominent being the Port of Lisbon, Port of Porto, and the Port of Sines. These ports serve as import and export hubs, facilitating trade both within the European Union and with countries outside of it. Maritime transport is one of the main modes of transport in Portugal, as it happens all over the world, used mainly for the transport of goods.

The industry in Portugal has small shipping companies, which operate mostly in the internal market (Autonomous Regions). Shipping in Portugal, namely the Portuguese merchant navy, suffered a strong decline with the loss of the old Portuguese colonies, resulting from the decolonization process, and more recently with the entry into the European common market, having not yet recovered the dimension it reached in the decades immediately prior to the revolution of April 1974. This reduction is visible in the merchant fleet under the first register, being the second registration a form of tax optimisation by shipowners and which has not resulted in the establishment in Portugal of new companies in the sector (the main objective that led to its creation).

In recent years, there has been an increasing focus on sustainable practices in the shipping industry, with initiatives to reduce emissions and promote the use of cleaner technologies. The existing shipping operations and activities in Portugal are subject to the same challenges that arise in this sector at a global level facing the same challenges, such as global competition, economic and regulatory fluctuations, and environmental issues that require innovation and adaptation.

The integration of new technologies is transforming the way shipping operations are carried out, improving efficiency and safety and this will also be the case in Portugal.

It is therefore important to understand the main challenges facing the development of this sector, both globally and nationally. In addition to the published literature, which can be found in chapter 3, when some of the main stakeholders of our sector in Portugal are questioned, technological issues

emerge as a determining factor for the development of the sector. Pedro Frazão, COO of Grupo Sousa – Major Shipping Portuguese Group, refers to "Decarbonization, digitalization and cybersecurity" as the most important issues that the Industry as to deal with in the coming future; Tiago Andrade, COO Sensefinity – IT operator refers to "Technologies and Risk management" as major factors; Jorge Antunes, CEO Tecnoveritas-Shipping Project Engineering refers to "digitalization, energy transition and sustainability" as the main points of concern: Jaime Leça da Veiga, Director of EMSA - European Maritime Agency refers to "digitalization and sustainability" as a global key point issues for the Industry. There is, therefore, a common theme for all, which is the new technologies.

When asked which technologies are the most relevant for the Shipping industry, they all mention AI (Artificial Intelligence), Blockchain, CyberSecurity, IoT (Internet of Things), various technologies in communications (Sigfox, NB-IoT, 5G).

In conclusion, for the development of the shipping industry, new technologies will play a decisive role, and it is therefore essential to digitize and introduce new technologies along the value chain of the industry, in all different players.

3. Literature Review

3.1. Introduction

The effect of the globalization of economies has had a strong impact on the industry of Western economies, promoting a deindustrialization of these same economies.

The need to boost the reindustrialization of Western industries and to regain control of strategic logistic chains within these economies has had a catalytic effect on the development of new technologies to support this effort.

In this chapter, and in section 3.2, we will understand the effect of the deindustrialization of Western economies resulting from the effect of the globalization of economies, the emergence of the Industry 4.0 (I4.0) concept and its adaptation to the Shipping Industry.

Since new technologies are decisive in the development of economies, it is necessary to explain the level of acceptance and use of these technologies. It is therefore necessary to understand which are the facilitators or blockers for its wider use.

In section 3.3 we will describe the main models used to understand the acceptance and use of new technologies and in section 3.4 we will address the importance of digital trust and user satisfaction as important predictors for the use and acceptance of new technologies, namely in the Shipping Industry.

We will address in section 3.5 examples of use of the UTAUT (Unified Theory of Acceptance and Use of Technology) model.

3.2. The Importance of Technology in the Globalization Process

3.2.1. The deindustrialization of Western economies

The deindustrialization of Western economies refers to the significant decline in the manufacturing sector and the relative shift towards a service-based economy in countries like the United States, the United Kingdom, and other developed nations. This process has been unfolding since the mid-20th century and has had profound effects on various aspects of these economies (Rowthorn & Ramaswamy, 1997).

The roots of deindustrialization can be traced back to several factors. One key factor is globalization and the rise of global competition. As communication and transportation technologies improved, it became easier for companies to outsource production to countries with lower labour costs. Developing countries with abundant labour forces, such as China and India, emerged as major manufacturing hubs. This led to the relocation of many industries from Western economies to these regions (Rowthorn & Ramaswamy, 1997).

Technological advancements have also played a role in deindustrialization. Automation and the adoption of advanced machinery have increased productivity and efficiency in manufacturing processes. While this has contributed to economic growth, it has also reduced the need for human labour. As a result, fewer workers are required to produce the same output, leading to job losses in the manufacturing sector (Born & Vogt, 2022).

Changes in consumer preferences and market dynamics have further influenced deindustrialization (Teimouri & Zietz, 2020). The demand for goods has shifted from traditional manufacturing industries to services and knowledge-based sectors. The biggest reason for the decline in industrial activity is the shift to a service-based economy (Schettkat & Yocarini, 2021).

Western economies have experienced a growth in sectors such as finance, information technology, healthcare, and entertainment. These industries rely more on intellectual capital and skills rather than physical production. Consequently, resources have been reallocated from manufacturing to service-oriented sectors (Teimouri & Zietz, 2020).

The effects of deindustrialization have been both positive and negative. On the positive side, the shift towards a service-based economy has created new job opportunities in sectors such as finance, technology, and healthcare. These industries tend to offer higher wages and require advanced skills, contributing to overall economic growth and development. Additionally, the decline in manufacturing has been accompanied by a reduction in pollution and environmental degradation in Western economies (Born & Vogt, 2022).

However, deindustrialization has also posed challenges and negative consequences. The loss of manufacturing jobs has had significant social and economic implications. Many working-class communities that relied heavily on manufacturing have faced high unemployment rates, reduced wages, and a decline in living standards. This has led to social unrest and increased income inequality in some regions (sase.org, 2023),

Furthermore, deindustrialization has weakened the industrial base and diminished the self-sufficiency of Western economies (Iversen & Cusack, 2000). The reliance on imports for manufactured goods has made these economies vulnerable to disruptions in global supply chains, as highlighted by events like the COVID-19 pandemic. The decline in manufacturing has also eroded the technological and innovative capacity of these nations, as research and development activities often accompany production.

To mitigate the negative effects of deindustrialization, governments have implemented various strategies. These include investing in education and retraining programs to equip workers with the skills needed for the evolving job market. Governments have also aimed to attract foreign investment and promote entrepreneurship in emerging industries (Weiss, 2015). Additionally, there have been

efforts to strengthen domestic manufacturing capabilities through targeted policies, such as tax incentives and subsidies.

In Western economies, economic development has changed significantly because of the globalization process(Erixon, 2018). Many of the industrial activities were relocated in the far east, thereby promoting a slowdown in industrial activity in Europe and in U.S. as well (as can be seen from the drop in employment in the U.S. economy.

As the U.S. labour market shifted to other sectors, America's advantage as the world's largest manufacturer declined. In 1970, China was the fifth largest manufacturer in the world and according to the Brookings Institution took first place in 2010, replacing the United States (Schettkat & Yocarini, 2021).

This relocation of production has a strong implication in the logistics chains and, being maritime transport responsible for supporting approximately 90% of world trade, these changes had a major implication in the Shipping sector (UNCTAD, 2021).

Another relevant factor for the relocation of industrial production to other regions is the elusive standard of living of the USA compared to other countries. Higher wages result in loosing cost competitiveness and therefore the consequent reduction in attractiveness. U.S. manufacturers that raise wages to keep up with living and end cannot be as profitable as companies located in countries where wages are lower.

Nowadays we are start seeing a process of deglobalisation of value chains (Jaax et al., 2023). This process was accelerated with pandemic COVID19. The economic growth in the major emerging markets is also a reality (that start to look as well for the respective domestic markets). On the other hand, we've a significative growth in the global population (7.6 billion by 2020 will grow one billion to almost 8.6 billion by the year 2030). That growth will take place on the emerging markets with patterns of consumption close to the Western economies and will compensate the reallocation of the strategical values chains in the western countries.

The situation also in the EU is even worse than in the US with a sharp decline in industrial capacity (Stöllinger et al., 2013). This decline has structural reasons identical to that seen in the US and Stollinger also refers to the sharp growth that has occurred in the East.

There has been political pressure from Western governments to reindustrialize economies (Aiello et al., 2020). The COVID-19 pandemic has put on the agenda the need to re-control certain production areas directly, particularly those listed in strategic logistics chains.

The relocation of industries resulting from the process of globalization of economies and the deindustrialization of Western economies, along with the strong economic growth seen in recent

decades, has had a strong impact on the shipping industry (e.g.: strong increase in cargo containerization, large container ships that requires much higher complexity in port operations).

The European Commission set the aspirational target for industrial production to represent 20% of Gross Value Added by 2020 (not accomplished so far). However, this reindustrialization process will have a different focus and should be supported in development, innovation and technology to maintain a sustainable competitive advantage(Aiello et al., 2020).

The economic recovery and the process of reindustrialisation of economies should therefore be supported by the development of new business processes leveraged by the introduction of new emerging digital technologies (Aiello et al., 2020).

3.2.2. The Industry 4.0 Concept (I4.0)

The concept of Industry 4.0, also known as the Fourth Industrial Revolution, represents the integration of digital technologies, automation, and data-driven processes in the manufacturing and industrial sectors(L. Da Xu et al., 2018). It signifies a paradigm shift in the way products are designed, produced, and delivered, leveraging advanced technologies to create more efficient, flexible, and interconnected systems. The concept of Industry 4.0 (I 4.0), can be defined as well as a technological ecosystem where interoperability between people, systems and the environment allows real-time action thus promoting the efficiency and effectiveness of operations (Aiello et al., 2020).

In 2011, the term "Industry 4.0" first appeared at the opening ceremony of Hannover Messe 2011 in Germany. The designation of I4.0 is not universal (B. P. Sullivan et al., 2020), with several designations depending on the Countries. In the USA is used the expression Smart manufacturing or Smart factory, in China and India the name is more generic - Made in China, i.e. Made in India, and in other European countries are other designations such as Fabricca Inteligente (Italy) or the Factory of the future (France). I4.0 refers to the fourth industrial revolution, characterized by the incorporation mainly of IoT (Internet of Things) in the industry. The important thing to retain is that I4.0 is the ecosystem that relates the physical world of objects and the digital world, using a number of different technologies (B. P. Sullivan et al., 2020). Some of these technologies are : Internet of Things (IoT), Intelligent Robots and Automation (IR), Cloud Computing (CC), Additive Manufacturing (AM), Big Data Analytics (BDA), Intelligent Simulation (IS), Augmented Reality (AR) and Artificial Intelligence (AI)(B. P. Sullivan et al., 2020).

Industry 4.0 is related to the use of technologies to connect physical assets to digital ecosystems. Industry 4.0 is more than a simple scanning process. It has other implications in the organization of the Company, with a strong impact in the culture and innovation practices (PWC, 2019).

Here, we will explore the key elements and implications of Industry 4.0.

The Internet of Things forms a foundational element of Industry 4.0. It involves connecting physical objects, machines, and devices to the internet, allowing them to communicate and share data. Through sensors and embedded systems, IoT enables real-time monitoring, data collection, and analysis, providing valuable insights for decision-making and process optimization. IoT facilitates the creation of smart factories and intelligent supply chains (L. Da Xu et al., 2018).

Cyber-physical systems (CPS) refer to the integration of physical components, such as machines and equipment, with advanced computing capabilities and connectivity. CPS enable the interaction and collaboration between the physical and digital worlds. They combine sensors, actuators, and control systems with software and network infrastructure, allowing for real-time monitoring, control, and autonomous decision-making. CPS improve operational efficiency, enable predictive maintenance, and support adaptive production processes (L. Da Xu et al., 2018).

Industry 4.0 relies on the analysis of large volumes of data generated by interconnected devices and systems. Big data analytics employs advanced algorithms and tools to process, interpret, and derive actionable insights from this data. By analysing data patterns and trends, manufacturers can optimize production processes, detect anomalies, and make data-driven decisions. Big data analytics supports predictive maintenance, quality control, and supply chain optimization, enhancing overall operational performance (Zaman et al., 2017).

AI (artificial intelligence) and ML (machine learning) are integral components of Industry 4.0. AI algorithms can analyse complex data, learn from patterns, and make intelligent decisions. ML enables systems to improve their performance and accuracy over time through experience and training. AI and ML technologies can be applied in various areas, such as predictive maintenance, demand forecasting, quality control, and autonomous decision-making, leading to increased efficiency, productivity, and customization capabilities(Selvarani et al., 2023).

Additive Manufacturing (3D Printing) commonly known as 3D printing, is a transformative technology in Industry 4.0. It enables the creation of complex three-dimensional objects layer by layer, directly from digital designs(Jadhav & Jadhav, 2022). 3D printing offers design flexibility, reduced waste, and customization capabilities. It can significantly impact manufacturing processes, allowing for on-demand production, rapid prototyping, and decentralized manufacturing. Additive manufacturing enables shorter lead times, reduced inventory, and more sustainable production practices (Jadhav & Jadhav, 2022).

Industry 4.0 emphasizes the collaboration between humans and machines. Instead of replacing humans with automation, the focus is on human-machine interaction and cooperation. Advanced human-machine interfaces, augmented reality, and virtual reality technologies enhance the capabilities and safety of human operators(Madonna et al., 2019). Workers can interact with

machines, access real-time information, receive guidance, and perform complex tasks more efficiently. The role of humans shifts from manual labour to supervisory and decision-making roles, utilizing their expertise and creativity (Madonna et al., 2019).

Industry 4.0 promotes the integration and connectivity of the entire supply chain (Debicki & Guzman, 2020). Through IoT, CPS, and data exchange, different stakeholders within the supply chain can share information, coordinate activities, and respond to changes in real-time. This integration enables end-to-end visibility, traceability, and optimization of logistics, inventory management, and customer fulfilment processes (Debicki & Guzman, 2020). Supply chain integration improves responsiveness, reduces lead times, and enhances customer satisfaction.

With increased connectivity and digitalization, cybersecurity and data privacy become critical considerations in Industry 4.0 (Dawson, 2018). As more devices and systems are interconnected, the risk of cyber threats and data breaches escalates. Robust cybersecurity measures, data encryption, access controls, and employee awareness training are essential to protect critical infrastructure, intellectual property, and customer data (Dawson, 2018). Ensuring data privacy and compliance with regulations is also paramount to maintain trust and avoid legal and reputational risks.

In conclusion we can say that the emergent new digital technologies play a pivotal role in the development of the economies in general and in all industries, including the Shipping industry. The correct acceptance and adoption of these technologies by users is therefore fundamental.

3.2.3. Shipping 4.0

We will understand in this section the evolution from the first definition of the concept "Industry 4.0" to the concept "Shipping 4.0" and how new technologies can impact the activity of Shipping.

The technologies that compete for Industry 4.0 have a wide field of use (L. Da Xu et al., 2018) and Shipping offers a wide range of opportunities, and a great impact is expected by the introduction of new technologies (Aiello et al., 2020).

The maritime transport, an important mode of transport in international trade is moving towards digitalization at different speeds in the different domains (Sanchez-Gonzalez et al., 2019). Shipping, as a part of logistics chain, is a volatile industry and is in a turbulent condition due to the energy price fluctuations, technological immaturity, and upcoming increases in regulations. Seaport stakeholders and enterprises in the maritime transport sector, as many enterprises in other industries, struggle with the lack of awareness, proper strategies and initiatives for successful digital transformation (Gausdal et al., 2018). Most of the contemporary research is focused either on digital transformation of transport in general, or digitalization trends focused on the maritime transport. A lack of research and scientific papers offering a comprehensive overview of digital transformation in the maritime transport sector is particularly pronounced (Quitzau et al., 2018).

According to the PwC Norway survey (PwC Norway, 2017) that included 28 decision-makers active in ocean shipping, “the DT (Digital Transformation) is set to play a key role in shipping and for shipping companies in the future and the maritime industry is now anticipating extensive digitalization processes with a great degree of certainty”.

Only a small number of industry players in the maritime transport sector consider that digitalization has already changed their business significantly, whereas the companies in high-tech and in public transportation have already seen greater changes from the pressure of digitalization (Quitzau et al., 2018).

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The core elements of Shipping 4.0 include the Internet of Things (IoT), blockchain technology, artificial intelligence (AI), big data analytics, Big Data Analytics (BDA), 3D printing, Advanced Robotics, Advanced Simulation, Virtual and Augmented Reality, Cloud Computing (CC) and Cyber Security (Aiello et al., 2020; Ichimura et al., 2022). These technologies enable greater visibility, transparency, and control over the entire shipping process, from logistics and fleet management to port operations and customer interactions.

One of the key features of Shipping 4.0 is the use of IoT dev Shipping 4.0 refers to the ongoing digital transformation and technological advancements in the shipping industry. It represents a paradigm shift in the way goods are transported, integrating digital technologies, automation, and data-driven processes to optimize operations, enhance efficiency, and improve overall sustainability (Aiello et al., 2020)ices and sensors to collect real-time data (B. P. Sullivan et al., 2020). These devices are deployed in containers, ships, and ports to monitor variables such as location, temperature, humidity, and security. By gathering and transmitting this data, stakeholders can gain valuable insights into the status and conditions of goods, enabling more informed decision-making, efficient planning, and optimized operations(Durlik et al., 2023).

Blockchain technology plays a significant role in Shipping 4.0 by providing a decentralized and transparent platform for secure and efficient digital transactions (Quitzau et al., 2018). It allows for the creation of smart contracts, which automate and streamline various processes in shipping, such as documentation, customs clearance, and payment settlement. Blockchain enables secure sharing of data among stakeholders, reduces paperwork, minimizes fraud, and enhances trust and collaboration across the supply chain(Chui et al., 2022; Yang, 2019).

Artificial intelligence (AI) and machine learning (ML) are crucial components of Shipping 4.0, enabling advanced analytics, predictive modelling, and automation. AI algorithms can analyse vast amounts of data, identify patterns, and make predictions about various aspects of shipping, including demand forecasting, route optimization, and vessel maintenance (Soori et al., 2023). This enables

better decision-making, cost optimization, and improved resource allocation. Automation technologies, such as autonomous ships and drones, also have the potential to revolutionize the shipping industry by reducing human error, increasing operational efficiency, and enhancing safety(Soori et al., 2023).

Big data analytics plays a vital role in Shipping 4.0 by leveraging the vast amounts of data generated by IoT devices, sensors, and other sources(Durlik et al., 2023). By analyzing this data, shipping companies can gain insights into their operations, identify inefficiencies, and optimize processes. Big data analytics enables better demand forecasting, cargo routing, and port management, leading to reduced costs, improved customer service, and increased sustainability.

The impact of Shipping 4.0 extends beyond operations and logistics. It also enhances customer experience and engagement through improved visibility and real-time tracking. With the ability to provide accurate information about the status and location of goods, shipping companies can enhance customer satisfaction and enable better supply chain management.

Shipping 4.0, thus designating the Shipping Industry in the era of new technologies, refers to a vast ecosystem of technologies and applications in all its areas (Aiello et al., 2020). However, most shipping companies (particularly smaller ones) are still in a very embryonic phase in terms of their implementation as support for their main processes (Aiello et al., 2020), being a very conservative industry where innovation and the dispend arising from the introduction of new technologies is not usual (Koukaki & Tei, 2020). In fact, it is a very conservative sector: "The maritime industry is one of the oldest and traditional industries to still rely more on intuition than on data, due to the vast size of network and planning problems " (Brouer et al., 2017).

According to Sullivan et al. (2020), the Maritime 4.0 concept refers to: automated integration of real data to support decision-making, the adoption and implementation of interrelated technologies for the design, construction and operation of ships, reducing the environmental impact of ships, profitability and sustainability of operations and reduced risk and increased safety.

From the study carried out, Sullivan et al., did not conclude in a specific definition for Maritime 4.0 or Shipping 4.0, referring mainly to the adoption of I4.0 technologies in the shipping world.

With its large number of interfaces, maritime logistics offers a wide range for digital technologies applications, offering huge opportunities for the development of shipping sector.

Innovation in the maritime industry has traditionally been a slow and incremental process (Munim et al., 2020).

According Balci (2021), "digital transformation in shipping presents ample benefits such as better integration of intermodal transport…,better information exchanges between stakeholders..,

performance improvements of supply chains through reduction of papers and unnecessary time….. and effectiveness advancements in custom clearance and tracking systems".

Fruth & Teuteberg (2017), presented a systematic literature review (SLR) of the introduction of new technologies in the maritime industry and Sanchez-Gonzalez et al. (2019), also used the same technic approach (SLR) in the existing literature on shipping. There is a coincidence in the studied areas; autonomous ships, big data, artificial intelligence, cybersecurity, IoT and virtual reality.

Heilig & Voß (2017) also reviewed the literature on port operations. According to the study, they segmented port information systems into 10 groups: (1) national single window, (2) port community systems, (3) ship traffic services, (4) terminal operating systems, (5) portal marking systems, (6) automated gate systems, (7) automated shipyard information systems, (8) port road information systems and traffic control, (9) intelligent transport systems and (10) inter-road information systems.

Zhang et al. (2019), found that the lack of business analysis and development based on knowledge extracted from the businesses themselves, the lack of support in top management and the lack of skills are the three main obstacles to the adoption of big data analytics among maritime organizations.

According KPMG & Papageorgiou (2020), "Digital transformation doesn't happen in a vacuum, it is at the heart of a nation's and company's competitiveness, driving business performance, and enriching people's lives like never before. Market forces and technology are pushing shipping companies to rethink the way they operate".

We can thus say that the development of new technologies that has been witnessed in general terms (in the economy as a whole) has been transposed to the shipping industry, although at a slower pace than in many other sectors of the industry. However, the adoption of new digital technologies throughout the shipping value chain is irreversible.

From the literature review carried out so far, there is no research known in Portugal.

3.3. Technological Acceptance Models

3.3.1. Introduction

As seen in the previous points, new digital technologies will be important or fundamental for the development of the Shipping Industry.

It is therefore important to understand how new digital technologies are being accepted and used in the shipping industry. Its faster and more effective introduction will certainly imply a further and stronger development of this Industry.

Several theoretical models were developed to explain technology acceptance or usage. In the following paragraphs we'll summarize the key points of the most important Technological Models more used in scientific literature.

The Theory of Reasoned Action (TRA) suggests that a person's behaviour is determined by their intention to perform the behaviour and the fact that his intention is a function of their attitude toward the behaviour and subjective norms.

Theory of Reasoned Action (TRA) was developed by Martin Fishbein and Icek Ajzen in 1991. As a definition of TRA, a person's performance of a specified behaviour is determined by their behavioural intention (BI) to perform the behaviour, and BI is jointly determined by the person's attitude (A) and subjective norms (SN. This theory empathizes that there is a direct relationship between the attitudes and their outcome. If one believes that there will be a favourable outcome and there is a high probability of it, then they are more likely to accept the technology. TRA does not consider external conditions.

Icek Ajzen proposed the theory of planned behaviour (TPB), presented in Fig 4, as an extension of TRA, with some modifications (Ajzen, 1991).

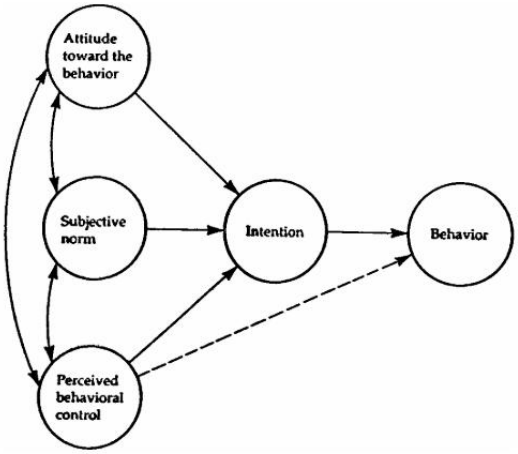


Figure 4 – Theory of Planned Behaviour

According to (Ajzen, 1991), "As in the original theory of reasoned action, a central factor in the theory of planned behaviour is the individual's intention to perform a given behaviour. Intentions are assumed to capture the motivational factors that influence a behaviour...".

According to the theory of planned behaviour, perceived behavioural control, together with behavioural intention, can be used directly to predict behavioural achievement. The main argument against TPB is not considering human emotions.

One of the most used models is TAM (Technology Acceptance Model)-Fig.5, developed for IBM by MIT during 80's (Davis, 1989).

This technology acceptance model (TAM) was first proposed in 1989 by (Davis, 1989), as an instrument to predict the likelihood of adopting a new technology within a group or an organization. Originating in the psychological theory of reasoned action and theory of planned behaviour (TPB),

TAM has evolved to become one of the key models used in understanding predictors of human behaviour toward potential acceptance or rejection of the innovative technology.

Davis developed the technology acceptance model in 1989 to predict an individual's use and acceptance of information systems and technology. It is one of the major models that came from TRA developed. TAM consists of two main concepts "Perceived Usefulness" and "Perceived Ease of Use". Perceived Usefulness defines as the degree to which a person would think that system would enhance his or individual job performance. Perceived Ease of Use refers to the degree to which a person believes that using a particular system would be free of effort. These two factors are influenced by external factors, such as social factors, cultural factors, and political factors. Language, skills, and facilitating conditions are the main concerns in social factors, while political factors consist of politics and political crisis. The "attitudes" refers to the user's evaluation of employing a particular technology, while "Behavioural intention" is the measure of the likelihood of a person using the technology.

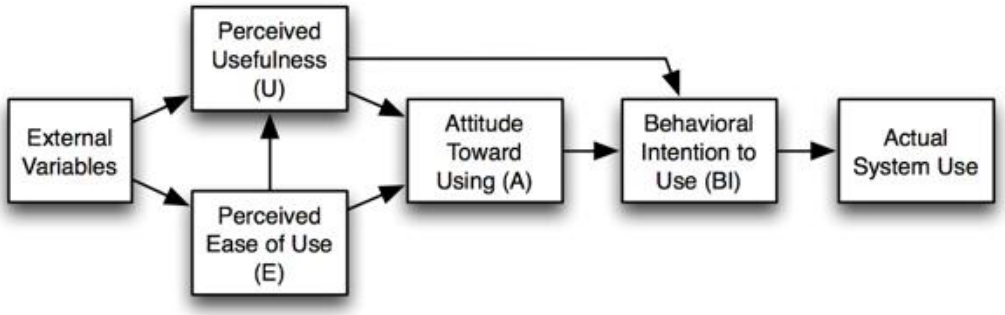


Figure 5 - TAM (Davis, 1989)

TAM is based on the concept that technology adoption and use may be explained by an individual's own beliefs, attitudes, and. As a result, by applying the TAM when an innovative technology is launched, it should be feasible to estimate future technology utilization. The original TAM assessed the impact of four internal variables on actual technology usage): perceived ease of use (E), perceived usefulness (U), attitude toward using (A) and behavioural intention to use (BI).

Apart from internal variables, the model includes a set of external ones, such as attributes of the technology, having an impact on perceived ease of use of the innovative technology, and its perceived usefulness.

TAM has been used in several studies of technology acceptance in different industries. It has also been the base model on which research methodologies have been based, with researchers adjusting the model in a way they consider relevant. We can find the application of this model in several areas

from the health area (Alsyouf et al., 2023), education (Y. Su & Li, 2021), use of new technologies (Al-Adwan et al., 2023), automotive industry (Koul & Eydgahi, 2018) and several others.

TAM has been used in research to explore the acceptance of new e-technology or new eservices. TAM is one of the most effective contributions of Ajzen and Fishbein's theory of TRA. Davis's technology acceptance model (Davis, 1989; Davis et al., 1989) is the most widely utilized models of acceptance and usage of innovated technology by users. A relationship has been found between the beliefs of users about a technology's usefulness and the attitude and the intention to use the technology.

TAM has the same weaknesses as other technology acceptance models, the first of which is that it depends on other factors to determine the attitude of individuals. In general, TAM has been widely employed to investigate internal motivations rather than external ones, as its focus is on the outcomes of IT use.

TAM is able to account for 40 percent to 50 percent of user acceptance. TAM has evolved over time. TAM2 extended the original model to explain perceived usefulness and usage intentions including social influence (subjective norm, voluntariness, and image), cognitive instrumental processes (job relevance, output quality, and result demonstrability) and experience. The results strongly supported TAM2 and explained 60 percent of user adoption using this updated version of TAM (Venkatesh & Davis, 2000).

Taylor and Todd added the elements of the TPB to the TAM and created an integrated model called C-TAM-TPB. The main feature of this model is the variation between intention and behaviour, which allows the application of this model to both people who are familiar with technologies and those who are not.

The Diffusion Innovation Theory (DIT) is one of the theories that have attempted to explore factors that affect an individual to adopt an innovation or a new technology. It explains the relationship between the characteristics of the innovations and their adoption. The adoption is measured in terms of compatibility, relative advantage and complexity, compatibility, trialability, and observability. It explains how, why, and at what rates new ideas and technologies will spread throughout the cultures.

3.3.2. Unified Theory of acceptance and Use of Technology (UTAUT)

UTAUT model was developed (Venkatesh et al., 2003) and has been generally used for technology acceptance studies in information systems (Khalilzadeh et al., 2017a; Zhou et al., 2010). In a single model the author integrated the best of eight innovation acceptance theories.

The theoretical model of UTAUT suggests that the actual use of technology is determined by behavioural intention. The perceived likelihood of adopting the technology is dependent on the direct effect of four key constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions. These are explained on the original example by (Venkatesh et al., 2003b) of using a Personal Computer (PC): 1-Expectation of performance: What use does a PC generate for the employees?, 2- Expectation of effort: How much effort do employees have to contribute to use a PC?, 3- Social influence: What do the colleagues and superiors of the employees say about using a PC? and 4- Facilitating conditions: Do the employees know how to use a PC?

The first three constructs are direct determinants of the intention to use new technology. Facilitating conditions is a direct determinant of the intention to use a new technology and user behaviour

UTAUT model (Fig 6) aimed to provide a holistic insight into all factors, which have an influence on the behavioural intention towards the use of a new technology.

The UTAUT model was created to evaluate the use of a new technology within an organization and not for the consumer market. In 2012 same Author did an extension of the model, the UTAUT2 more addressed to the consumer market.

Due to the multitude of factors, it delivers the highest explanatory power of all standard acceptance models and thus helps to support the technology development process (it will the base for research model proposed – Chapter 5).

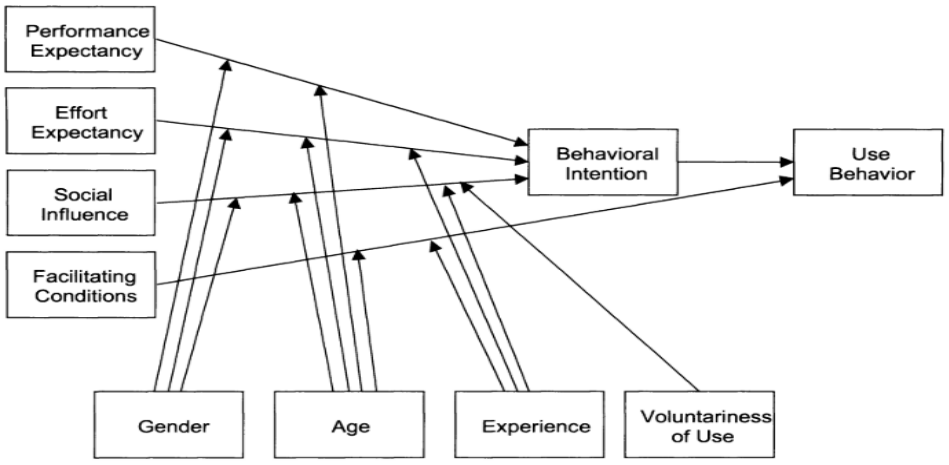


Figure 6 - UTAUT Model: Venkatesh et al, 2003

3.4. Importance of User Satisfaction and Digital trust

In the previous sections we looked for the most known Technological Acceptance Models used in the literature. The UTAUT model is the technological acceptance model that could better predict the intention of the use of new technologies.

According to the literature trust and user satisfaction are very important for the user's acceptance and use of new technologies. Several authors refer Digital Trust and User Satisfaction as important factors for the adoption and use of new technologies. In sections 3.4.2 and 3.4.3 we can analyse these two factors separately.

According to several authors User Satisfaction plays a determinant role in the acceptance of new technologies (Adam Mahmood et al., 2000; Adamson & Shine, 2003; Ghobakhloo et al., 2010).

Wixom & Todd (2005), said "Although user satisfaction and technology acceptance have evolved largely as parallel research streams, the two approaches can and should be integrated. Such integration can help build a conceptual bridge from design and implementation decisions to system characteristics to the prediction of usage…., this would improve the predictive value of user satisfaction and augment the practical utility of technology acceptance".

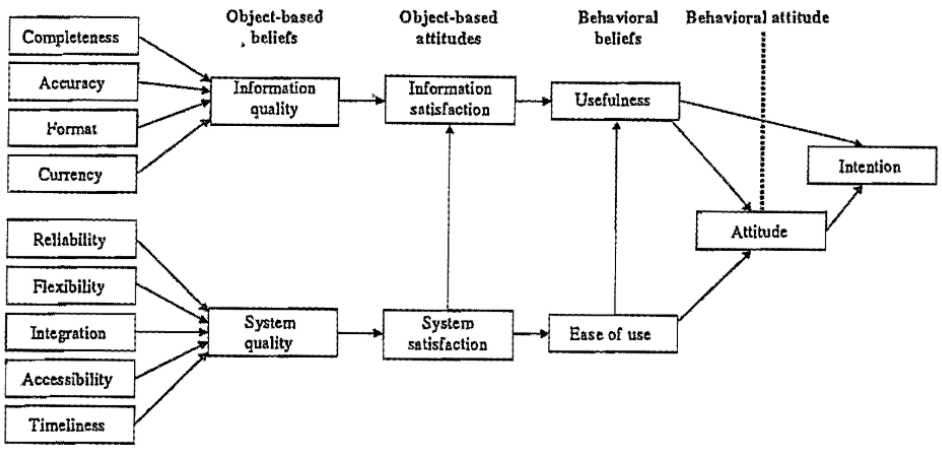


Figure 7 - Barbara and Peter Todd Integrated Research Method

DeLone & McLean (2003), presented an evolution of their D&M IS Success Model, where" "systems quality" measures technical success; "information quality" measures semantic success; and "use, user satisfaction, individual impacts," and "organizational impacts" measure effectiveness success". As in the original formulation of the D&M Model, "use" and "user satisfaction" are closely interrelated: ""Use" must precede "user satisfaction" in a process sense, but positive experience with "use" will lead to greater "user satisfaction" in a causal sense".

In this study they prove that increased "user satisfaction" will lead to increased "intention to use". As a result of this "use" and "user satisfaction, "certain "net benefits" will occur".

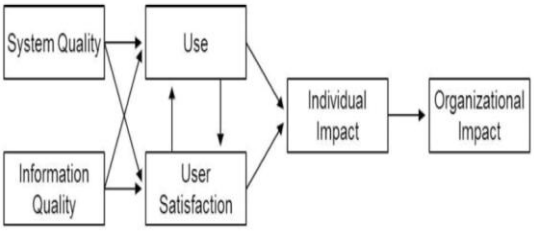


Figure 9 - D&M IS Success Model

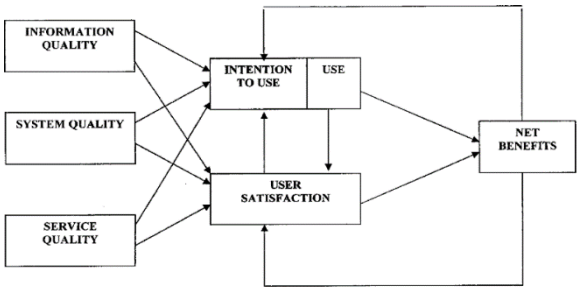


Figure 8 - Updated D&M IS Success Model

In the last decades we saw an increasing of investments in on-board sensor technology and onshore digital platforms and the way that they are changing how shipowners manage and operate assets and interact with suppliers, regulators, and customers. Digital tools and new technologies bring a wide range of benefits in all aspects referred to maritime operations: fleet operations and management, ship design and construction, condition monitoring, cargo tracking, satellite communications, and many more.

Digital tools and new technologies have also allowed new business models in the market where data defines the parameters of contracts (i.e., cargo tracking).

Trust in technology refers to the level of belief and confidence that the users have when using the technologies. Trust is important as it reduces social complexity and maintains confidence among stakeholders (Billanes & Enevoldsen, 2022). We can say as well that Trust in technology refers to a willingness to depend on the specific technology in each situation where negative consequences are possible.

Rachel Botsman, an expert on the relationship between trust and technologies in Oxford University - Said Business School, says “the role of trust is vital when developing any technology, not just digital identity technologies”. “If you don’t have faith or confidence in a system, then you’re just not going to use that product or those services,” and she also refers “one big mistake often made in launching new technologies is assuming everyone is in the same trust state”.

Trust might be understood as a condition or situation in which joint-action behaviours, perceptions, and attitudes are likely to occur (Alsaad et al., 2017). The decision to readily adopt a new technology is influenced by users’ initial perceptions of the technology characteristic (Li et al., 2008).In the presence of digital technologies, the need for trust among networks is critical as the actors in business networks do not meet physically to perform business transactions (Mubarak & Petraite, 2020).

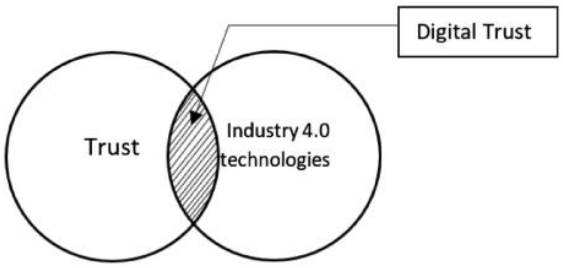


Figure 10 – Digital Trust : Mubarak & Petraite, 2020

Trust is considered vital factor that help build and enhance relationships, especially in a B2B environment(Balci, 2021). Yoon (2002), argued that satisfaction could be an outcome of online trust and suggested a positive correlation between trust and satisfaction. Teo et al.(2008), relates that it is important to consider the role of Trust when IS are used (study based on the D&M model with university students in Singapore). Kapnissis et al. (2022), refers "…. and Trust are the two crucial strategic tools that will stimulate the behavioural intention of shipping companies in adopting the new technology…".

3.5. Digital Trust and User Satisfaction – Experts statements

In addition of what is in the Literature, a survey was made to 6 stakeholders of the Sector (Shipping Company, Nautical College – Portugal and Norway, European Maritime safety agency – EMSA, Shipping IT provider, Shipowners Association) about the importance of these two factors – Digital Trust and User Satisfaction. Below are described of the statements taken from the surveys.

Experts in the Shipping Sector, mention Trust as an important factor (Vitor Franco – Presidente of Nautical College : "Trust, in a broader sense, is mandatory when you manage IT systems…" ; Tiago Andrade – CTO Sensefinity : "All the players need to trust on the technology….”; Paula Mendes – CIO of ETE-Shipping Company : "You don't succeed in your digital transformation journey if you don't trust on technology…." ; Viktoriia Koilo – Prof NTNU Norway : "Need to Building trust in digital systems and data security among stakeholders".

Experts also refer to User Satisfaction as an important factor for all stakeholders and users to look at the use of systems and new technologies as facilitator and a factor of faster adoption and use (Jaime Leça da Veiga – Director of EMSA : "Users should look to the new technologies as a facilitator…"; Rui Raposo – Chairman of Shipowners Association : "Users need to have some kind of connection with the IT systems they use in their daily tasks…."), Viktoriia Koilo Prof NTNU Norway "Ensuring new technologies are user-friendly and integrate seamlessly with existing systems….".

The opinion of these professionals on the importance of these factors (Digital Trust and User Satisfaction) is in line with what the literature tells us, thus reinforcing their importance and the need to consider them in a model of acceptance and use of new technologies for this Shipping sector.

3.6. UTAUT cases – Examples of use

Since its introduction, the UTAUT model has been applied and tested extensively for predicting system usage and making technology adoption and technology usage related decisions in various fields such as interactive whiteboards and near field communication technology (Khalilzadeh et al., 2017b; Šumak et al., 2010) and acceptance of Enterprise Resource Planning (ERP) software (Chauhan & Jaiswal, 2016). Applied research regarding the UTAUT model has been extensive. This model provides a framework that not only explains acceptance of IT and ISs but also elucidates the actual use of such technologies and systems.

Although the UTAUT model has been widely adopted, doubts exist over its capability to explain individuals' technology acceptance. Various researchers have proposed extensions to the original UTAUT model, incorporating additional constructs within specific settings. Thus, the original UTAUT model has been extended according to specific realities or environments.

Many researchers (Khalilzadeh et al., 2017b; Maillet et al., 2015; Rahi et al., 2018) have suggested that increasing the number of external variables can enhance this model's ability to predict the acceptance of IT. Several variables have been recommended to complement the original UTAUT model such as g., self-efficacy, trust, habits, satisfaction, and perceived risk(Chao, 2019).

Khalilzadeh et al.(2017b), included self-efficacy, risk, trust, security, and attitude to evaluate the factors that influence users' behavioural intentions to make mobile payments.

According to previous study on mobile technologies (Alalwan et al., 2017; Alqahtani et al., 2022; Khalilzadeh et al., 2017a) trust is a crucial factor determining users' behavioural intentions to adopt technology.

Chao (2019), proposed an extension of the UTAUT model by adding variables (mobile self-efficacy, perceived enjoyment, satisfaction, perceived risk, and trust) to predict adoption of m-learning.

Korkmaz et al. (2021), refers in his study "…model is modified and performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, habit, trust and safety, perceived usefulness, perceived risk, and behavioural intention constructs are utilized in the model…. The proposed model explains 72% of the variances in this study, which proves that the model has stronger predictive power compared with the previous technology acceptance model (TAM) and UTAUT model".

Batucan et al.(2022), in their study refers "…this study explains the factors affecting online learning amidst the COVID-19 pandemic…. tests the proposed extended unified theory of acceptance and use of technology (e-UTAUT) model in the students' intention and use behaviour toward the online learning system…The results supported the proposed model with acceptable fit measures and substantial explanatory power…".

Bellet & Banet (2023), in their study shows that "…this study focuses on the acceptance and the intention to use Automated Shuttles (AS) among a representative sample of French citizens…the proposed model may explain 89% of the variance in the intention to use automated shuttles, which is 20–30% higher than existing models. This better explanatory power is likely due to the inclusion of new constructs related…"

Or & Chapman (2021), proposes an extended UTAUT model to study educational technology acceptance by introducing additional constructs like usability, learnability and attitude.

It was observed that "adaptations of traditional technological acceptance models (e.g., TAM, UTAUT, UTAUT2) are needed to observe the phenomenon of online learning" (Rodrigues et al., 2022).

Chao (2019), uses a research model based on UTAUT with additional constructs and obtains a model with a "substantial explanatory power". The research model explained 47.9% of the variance in BI. The most crucial factors that influenced BI were satisfaction, PE, trust, and EE. Satisfaction and trust had direct effects on BI to use m-learning; this was consistent with the findings of another study (Koufaris & Hampton-Sosa, 2004).

Although the UTAUT model is the technological acceptance model with the greatest capacity to understand Use Behaviour, its accuracy can be improved if we find and define for a specific reality the most appropriate predictors/constructs to adjust the original UTAUT model and thus be able to find a more adjusted technological acceptance model for this concrete reality.

3.7. Conclusions

The process of reindustrialization of Western economies has had a catalytic effect on the development of new technologies. The relocation of industries has influenced logistics chains, although maritime logistics remains the most important in world trade, accounting for approximately 90% of trade (UNCTAD, 2021).

The process of reindustrialization of Western economies, which had as its main objective its economic revitalization, is mainly supported by new business processes leveraged by the introduction of new technologies (Aiello et al., 2020). Thus, was born the concept of Industry 4.0 (I4.0), also known as the Fourth Industrial Revolution. Industry 4.0 promotes the integration and connectivity of the entire supply chain, using a wide variety of new emerging technologies.

Shipping 4.0 is thus understood as the declination of the I4.0 concept for the Shipping Industry (Aiello et al., 2020). The Digital Transformation of Shipping will be decisive for the future of this Industry. Despite its importance, only a small number of players in this industry recognize that digitalization has significantly changed their business processes (Quitzau et al, 2018).

It is therefore important to have measurement mechanisms that help us understand and improve the acceptance and use of new technologies. There are 2 models that are the most used: the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT is the model with the highest predictive capacity(Venkatesh et al., 2003). However, being a generic model, its predictive capacity can be improved depending on the specific environment by adjusting to the base model. Digital Trust and User Satisfaction emerge from the literature as important factors for the acceptance and use of new technologies for the Shipping Industry. These factors are also confirmed by industry experts working in different areas of the Shipping value industry.

4. Methodology

4.1. Introduction

Researchers have developed different models that explain user acceptance of new technologies.

In the Chapter 3 we looked for the most known Technological Acceptance Models used in the literature. The UTAUT model is the technological acceptance model that could better predict the intention of the use of new technologies.

The methodological approach followed in this study is outlined in Figure 11. After a literature review on Shipping topics related to new technologies and adjacent themes (Industry 4.0, models of acceptance and use of technologies) the opportunity was identified to find a model for the use and acceptance of new technologies specifically appropriate for this industry, that could have a higher explanatory power. The proposed model was based on a model widely used in different sectors, the UTAUT model, and new constructs were added that emerge from the literature as important and determining factors for this industry. These new constructs have been confirmed by different experts in the sector as important factors when it comes to the use of new technologies.

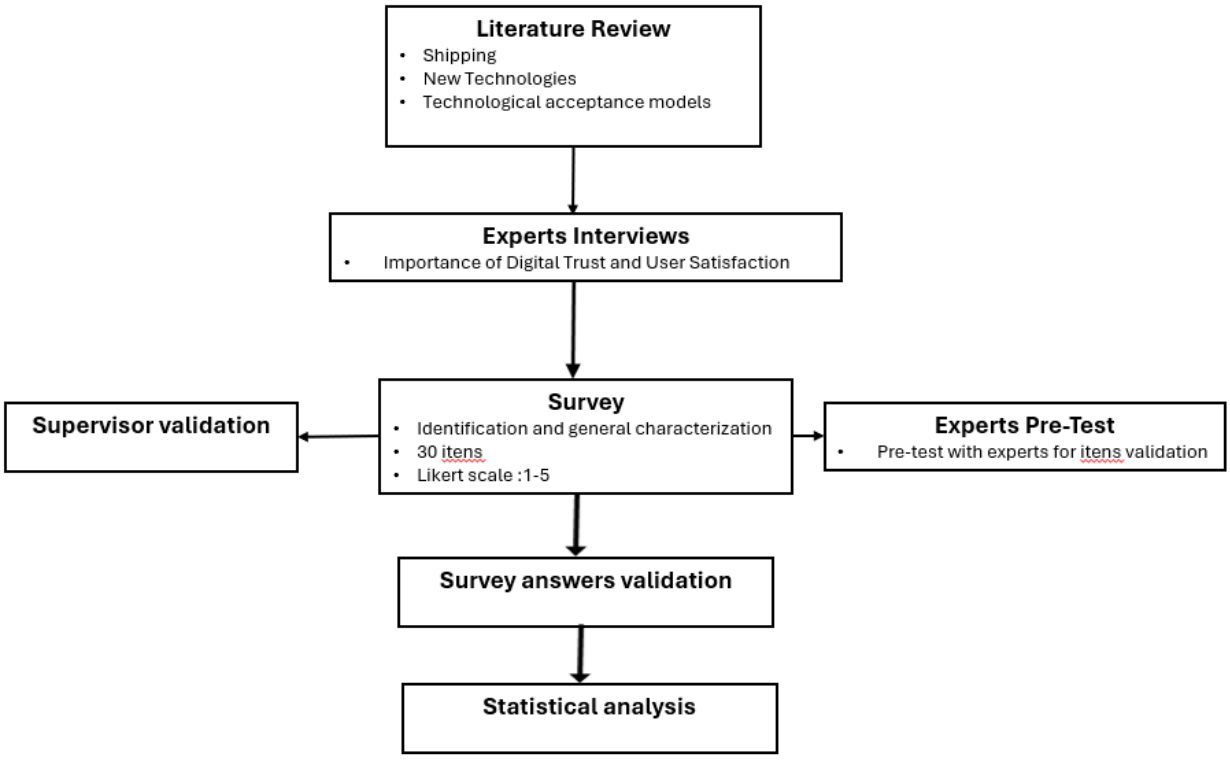


Figure 11- Methodology approach (Author)

The importance of Digital Trust and User Satisfaction for the Acceptance of new technological models was identified. Thus, a new research model for the acceptance of new technologies was defined, based on the UTAUT model, with the new constructs of Digital Trust and User Satisfaction.

4.2. Proposed Model - Extend the UTAUT Model to Shipping

The unified theory of acceptance and use of technology (UTAUT) is a technology acceptance model formulated to explain user intentions to use an information system and subsequent usage behaviour.

The theory was developed through a review and consolidation of the constructs of eight models employed to explain information systems usage behaviour (theory of reasoned action, technology acceptance model, motivational model, theory of planned behaviour, a combined theory of planned behaviour/technology acceptance model, model of personal computer use, diffusion of innovations theory, and social cognitive theory). Subsequent validation of UTAUT (Venkatesh et al., 2003) with a longitudinal study found it to *account for 70% of the variance in Behavioural Intention to Use (BI)* and about 50% in actual use.

Balci (2021), refers that digital trust is important role in the adoption of technology. Balci also refers the relationship between Digital Trust and Customer Satisfaction.

There is a wide range of studies showing the importance and the impact of using digital products in customer or user satisfaction. Utilizing software and communication tools, companies can not only address urgent customer needs but also show that people can rely on them. Technology can help brands earn customer trust and loyalty through delivering a service at the next level of immediacy and personalization (Hussin & Mohamad Shah, 2021; Jing & Liu, 2021; Lescevica et al., 2013; Shahid Iqbal et al., 2018).

In Shipping, as it happens in any corporate environment, technologies are enforced or mandatory. Nevertheless, employees must rely on technology and must see their use as a tool for improving their performance, reaching better results, avoiding or replace tasks (Oliveira et al., 2017; Pinto et al., 2019). The definition of Trust used was the same used by (Balci, 2021) “as the belief of an individual towards a digital system regarding its reliability and punctuality in performing commercial and operational transactions”. One of the main reasons for a better engagement with technology is the users trust on technology, in the programs used and in the integrity of data (Akbari et al., 2020).

For all these reasons, it is expected that the user satisfaction coming from the use of technological products and digital trust impact in the behaviour of use. We propose a new model, that we classified it as UTAUT S, to explain the use behaviour, anchored in the UTAUT model adding the constructs Digital Trust and User Satisfaction as illustraded in Fig 12.

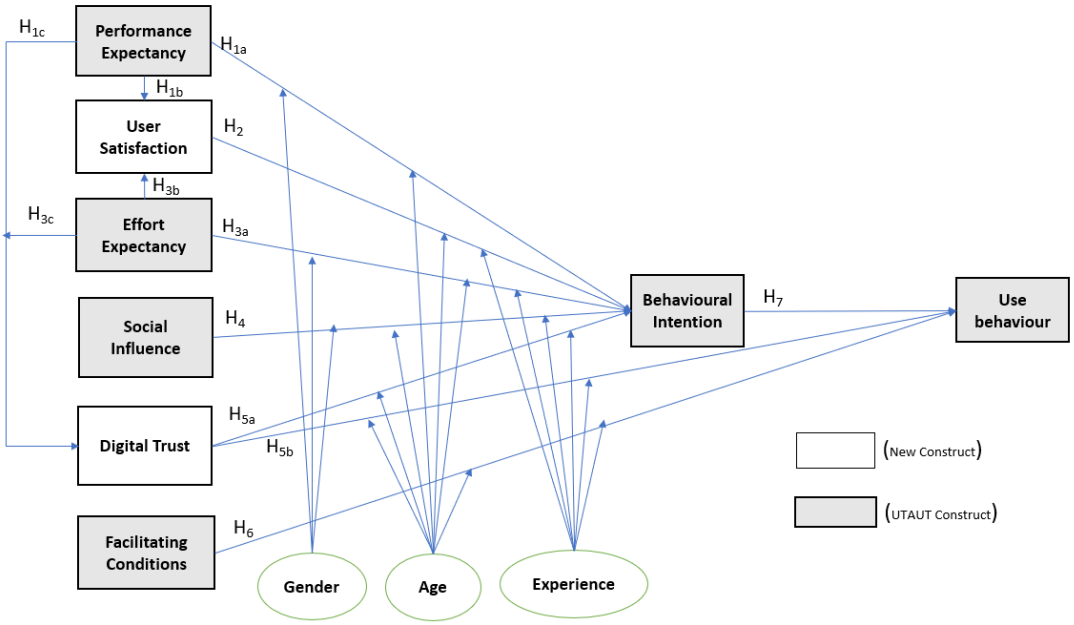


Figure 12 – Utaut S Proposed Model

4.3. Hypothesis Formulation

Beside the predictors coming from UTAUT S Proposed model, the Hypothesis from "Digital Trust" and "User Satisfaction" are the followings:

- Hypothesis 1a : Performance Expectancy has a significant influence on the Behavioural Intention (Venkatesh et al., 2003b)
- Hypothesis 1_b : Performance Expectancy has a significant influence on the Users Satisfaction (Chao, 2019; Mussa et al., 2022; Zha et al., 2022)
- Hypothesis 1_c : Performance Expectancy has a significant influence on Digital Trust (Adiratna & Wulansari, 2021; Chao, 2019)
- Hypothesis 2: User Satisfaction has a significant influence on the Behavioural Intention of using new technologies (Lee & Kim, 2022; Mussa et al., 2022; C. Y. Su & Chao, 2022)
- Hypothesis 3a : Effort Expectancy has a significant influence on the Behavioural Intention of using new technologies
- Hypothesis 3_b: Effort Expectancy has a significant influence on the Users Satisfaction (Chao, 2019; Mussa et al., 2022; Zha et al., 2022)
- Hypothesis 3c: Effort Expectancy has a significant influence on Digital Trust (Adiratna & Wulansari, 2021; Chao, 2019)
- Hypothesis 4: Social Influence has a significant influence on the Behavioural Intention of using new technologies (Venkatesh et al., 2003b)

- Hypothesis 5_a: Digital Trust has a significant influence on the Behavioural Intention of using new technologies (Adiratna & Wulansari, 2021; Mer & Virdi, 2021; Yu et al., 2021).
- Hypothesis 5b: Digital Trust has a significant influence on the Use Behaviour (Mer & Virdi, 2021)
- Hypothesis 6: Facilitating Conditions has a significant influence on the Use behavioral (Venkatesh et al., 2003b)
- Hypothesis 7: Behavioral Intention of using new technologies has a significant influence on the Use behavioral (Venkatesh et al., 2003)

4.4. Measurement instruments

This is descriptive research, since it seeks to investigate the existing relationships through the constructs of intention to use information technology.

Various kinds of rating scales have been developed to measure attitudes directly. The most widely used is the Likert Scale. Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them. Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions (Burns & Grove, 2005). These ordinal scales measure levels of agreement/disagreement. A Likert-type scale assumes that the strength/intensity of experience is linear, i.e. on a continuum from strongly agree to strongly disagree and makes the assumption that attitudes can be measured. Respondents may be offered a choice of five to seven or even nine pre-coded responses with the neutral point being neither agree nor disagree.

An instrument using a Likert scale usually consists of 15 to 30 items, each addressing an element of the concept being measured. Response-set bias tends to occur when participants anticipate that either the positive or the negative (agree or disagree) response is consistently provided either in the right- or left-hand columns of the scale. Participants might note a pattern that agreeing with scale items consistently falls to the right and disagreeing to the left. Thus, they might fail to read all questions carefully and just mark the right or left column based on whether they agree or disagree with scale items.

Testing control variables also allows to see whether these control variables are as important as independent constructs explaining behaviour and intention of use. This is particularly important as previous studies in similar subjects show that firm size, age and experience as well as the department of may have a significant impact on digitalization perception (Magsamen-Conrad, Upadhyaya, et al., 2015). Literature also indicates that age, experience, and firm size can have a significant impact on user satisfaction, perceived value, and loyalty in digital contexts (F. Xu & Du, 2018).

A questionnaire was created and divided into two parts: (1) the demographic/characterization information, (2) the constructs associated with the study.

A questionnaire was developed to unveil the willingness of the companies related with Shipping to adopt new technologies The questionnaire was developed on an online platform, aiming at data collection uniformity and speed and a more user- friendly environment.

The questionnaire was first pilot tested by a group of five (5) scholars and professionals involved in the shipping industry and IT without being included in the final research sample. Following a revision, a link to the online questionnaire's final version and a cover letter explaining the field research objectives were emailed to the target group.

4.5. Questionnaire

Based on the proposed research model and its constructs, a questionnaire was developed using the following table:

Construct	Description
Perceived Usefulness	Using technologies in my job would enable me to accomplish tasks mor quickly
	Using technologies would improve my job performance
	Using technologies in my job would increase my productivity
	Using technologies would enhance my effectiveness on the job
	Using technologies would make it easier to my job
	I would find technologies useful in my job
Perceived Ease of Use	Learning new technologies would be easy for me
	I would find it easy to get new technologies to do what I want it to do
	My interactions with new technologies would be clear and understandable
	I would find new technologies would be clear and understandable
	It would be easy for me to become skilful at using new technologies
	I would find new technologies easy to use
Social Influence	People who are important to me would think that I should use new technologies
	I would probably use new technologies if people who influence my behaviour think that I should use new technologies
	People whose opinions I value would like me to use new technologies
Facilitating Conditions	I have the resources necessary to use new technologies
	I have the knowledge necessary to use new technologies
	The system is not compatible with other systems I use
Digital Trust	My transactions via digital products are performed as expected
	My transactions via digital products are performed on time
	I do not need to make my transactions confirmed manually when I use digital products
Behavioural Intention	I am motivated to use new technologies
	I think we should use new technologies as much as possible
	I recommend using new technologies
Use Behaviour	The use of new technologies is independent of suppliers
	Using new technologies is a way to save money
	Using new technologies favours the development of business
User Satisfaction	Overall, our customers are satisfied with the digital services we provide
	The digital services offered exceed the customer expectations
	The digital services offered are close to my idea

Table 3 - Propose Model Constructs

In the Annexe B we present a Table (Table 29) with the relation between Constructs and sources.

4.6. Sample characterization

A survey was defined and after an experimental test and experts' validation, it will be sent for the major stakeholders of the Shipping Industry in Portugal and in Spain.

The questionnaire was sent previously to 5 experts, assisting the researcher in obtaining better findings (Almogren, 2022). A few small problems were expressed during the pre-test research (including the instructions and questions), as well as other minor observations. To ensure that the scales are meaningful, all ambiguities were eliminated.

The questionnaire had thirty (30) questions. The field research was conducted between March and April 2023. All parameters were measured by a 5-point Likert scale (strongly disagree – strongly agree.

Approximately 1200 surveys were sent to Portugal and Spain. It should be noted that the recipients were asked to forward the link to other members of their organisations, and it was therefore not possible to determine the exact number of recipients of the survey. Due to a greater knowledge of the Portuguese market, it was possible to obtain more recipient addresses and a much higher response rate when compared to Spain.

The survey was addressed to companies and entities that are part of the entire Shipping value chain, to obtain the most representative results possible of the industry.

The survey was sent in Portuguese to recipients in Portugal and in Spanish to recipients in Spain, always with an introductory email (Annexe A – Survey in Portuguese and Spanish). The aim of sending the survey in the local languages was to promote the widest possible adherence.

4.7. Statistical Methods

4.7.1. Descriptive Statistics

In terms of descriptive statistics for the characterization variables, the tables and graphs presented illustrate the frequency distribution of observed values. The quantitative and Likert scale variables were analyzed using the categories presented, calculating some relevant descriptive statistical data, addressed by Guimarães et al. (2010), as the mean (M) values (on a scale from 1 to 5, a value greater than 3 is higher than the scale middle point, on a scale from 1 to 7, a value greater than 4 is higher than the scale middle point), the standard deviation (SD) representing the absolute dispersion, the variation coefficient (VC) representing the relative dispersion and minimum (Min) and maximum (Max) values.

4.7.2. Scale Reliability

The internal consistency (reliability) analysis allows to study the properties of measurement scales and its items, according to DeVellis (1991). The Cronbach's Alpha (Cronbach, 1951) is the most widely used model of internal consistency in the social sciences, measuring how a set of variables represent a certain dimension Hill et al. (2002).

A coefficient of internal consistency of 0,80 or more is regarded as adequate for most applications and some studies admit internal consistency values from 0.60 to 0,80, which according to the literature is still acceptable. These values are referred, for example, by Nunnaly (1978).

4.7.3. Structural Equation Models

Confirmatory Factor Analysis uses Structural Equation Modeling (SEM), which began to be used in the late 1970s and 1980s, for example, with the work of Bentler (1980) and the use of statistical software such as LISREL Steenkampet al. (1991) .

Structural Equation Models integrate several related procedures (Kline, 1998) that use models of linear relationships between variables, either measured or latent (sometimes referred to as constructs). In SEMs the relationships between variables are previously determined from the research hypotheses, and the model is a confirmatory analysis technique.

The proper use of SEM requires large sample sizes, and the empirical rule is usually used that the sample size should be 5 to 10 times the number of estimated parameters Bentler et al. (1987).

For the development of SEM based on theoretical relationships between variables, it is necessary, according to Hair et al (1998):

i) build a theory-based model and a diagram illustrating the cause-effect relationships between variables or between constructs, where a direct causal relationship is represented by a straight arrow and a correlation by a curved arrow.

ii) build the Measurement and Structural models, the former to verify if the items are relevant, significant, as well as consistent, to measure the constructs, allowing us to conclude on the validity of each construct, and the latter to verify the research hypotheses. It is necessary to define if the model is formative (causality relationship from the indicators to the construct) or reflective (the causality relationship goes from the construct to the indicators: changes in the construct cause changes in the items). Usually the reflective models are used, since the constructs (latent variables) are considered the concept under study, which determine the variation observed in the measured items. Thus, the use of formative models is sometimes criticized: (Edwards, 2011) states that "formative measurement is based on conceptions (of constructs, measures, and causality) that are difficult to defend" and that "the goals of formative measures can be achieved by using alternative models with reflective

measures." Moreover, formative models often do not allow reaching a solution(Treiblmaier et al., 2011).

iii) definition of the estimation method used for the calculations, which are performed for the analysis of the pattern of relationships between responses rather than the individual responses (Hair et al., 1998), using the covariance matrix, being the most used calculation method the maximum likelihood (ML), which originates robust parameters, when the assumption of normality of the data is not violated. In case of violation of this assumption, other methods can be used such as the Least Squares (Gujarati, 2000) or Elliptical Reweighted Least Squares (ERLS).

iv) determine the SEM's quality of fit, three types of measures can be used: absolute measures, which measure the SEM's predictive quality of the covariance matrix; incremental measures, which compare the model to a null model by calculating the chi-square statistic (Hair et al, 1998); and parsimony measures, which analyze the SEM's fit as a function of the estimates made for its coefficients.

v) verify if the results prove the theoretical model proposed, as well as the hypotheses underlying it.

4.7.4. Inferential Analysis

The statistical tests are used to determine whether the differences observed in the sample are statistically significant, if the findings can be inferred for the population. The value of 5% is a reference used in social sciences to test hypotheses, meaning that the inference is made with a probability of error less than 5%.

In every test used, the result is the probative value (p-value), if less than 5% (0,05), the null hypothesis is rejected, if it exceeds the reference value of 5%, the null hypothesis cannot be rejected.

4.7.5. Chi-square test

As explained by Maroco, (2011), given two qualitative variables, a contingency table can be constructed to determine the relation between the variables using the Chi-square test, with the following hypothesis:

- H0: The two variables are independent.
- H1: The two variables have a relationship.

4.7.6. Parametric and non-parametric tests

When the sample groups compared are large, the distribution tends towards normality. According to Murteira et al. (2001), for samples with more than 30 elements in each of the groups, the violation of the assumption of normality does not affect the conclusions (Gravetter et al., 2000; Stevens, 1996). In

all the analysis conducted in this study, the sample size complies with these conditions, so it is not necessary to verify the assumption to apply the parametric tests.

4.7.7. Student's t test

To study the relationship between quantitative variables and a dichotomous variable, the use of the parametric Student's t test is addressed by Maroco, (2011). As the groups are large, the parametric Student's t test is used, with the following hypotheses:

- H0: There is no difference in the mean of the variables between the groups of the dichotomous variable.
- H1: There is a difference in the mean of the variables between the groups of the dichotomous variable.

4.7.8. ANOVA tests

To study the relationship between quantitative variables and a qualitative variable, the use of the ANOVA parametric test is addressed by Maroco, (2011) and the analysis of the assumptions that allow choosing between the use of parametric or non-parametric tests can to be found in Maroco, (2011).

When the groups in the sample are considered large or follow the normal distribution (analyzed with the Kolmogorov-Smirnov test), the parametric statistical test ANOVA is used, with the hypotheses:

- H0: The means of the variable are equal in the categories of the qualitative variable.
- H1: Variable means are different in the qualitative variable categories.

4.8. Conclusions

The methodological approach followed was presented in section 4.1 and the research model was presented in section 4.2. The research model is supported by the UTAUT model, already widely studied and applied in several studies and the new constructs (Digital TrusT and User Satisfaction) were added- that were identified in the literature as relevant for this sector. The proposed model should improve the predictive capacity compared with the UTAUT base model.

Based on the proposed model, the Hypothesis were formulated and presented in the Fig 12 and explained in section 4.3.

A questionnaire was developed based on the items described in Table 3. Interviews with specialists were done and the respective summary was presented in section 3.4.

Validation tests were carried out for the questionnaire, and the analysis techniques and models are detailed in section 4.7 and summarized in Table 4.

Objective	Research Questions	Data analysis technique used	Literature Review
Development of a model of acceptance and use of new technologies for the Shipping Industry	RQ1 -Is Shipping an Industry where the level of technological literacy is too low?	Reliability, Validity, Exploratory (using the SPSS 27), Confirmatory Analysis (using AMOS 27 software) and Content Analysis	Brouer et al., 2017; Conceição et al., 2018; Fonseca et al., 2021; Quitzau et al., 2018; Tijan et al., 2021
	RQ2- Could we improve the accuracy of a technological acceptance model specifically for Shipping?		Balci, 2021; DeLone & McLean, 2003; Venkatesh et al., 2003, 2012; Venkatesh & Bala, 2008

Table 4 - Analysis Technique Used

5. Presentation and discussion of results

5.1. Descriptive Analysis

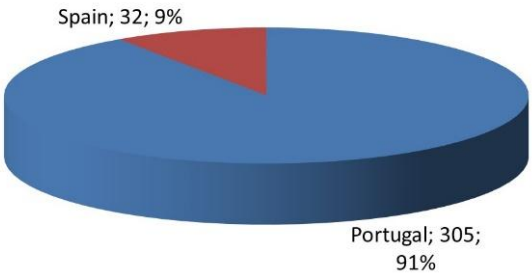
The sample contains 344 subjects that answered to an online questionnaire from March, 1 to April, 20, 2023. From this sample, 337 participants agree with the Informed Consent Form: “There are no right or wrong answers. It is important that you read carefully and answer all questions. Participation in this research is voluntary, so you may deny it or decide to stop filling out the questionnaire at any time if you wish. All data collected are anonymous and confidential.” and answered that “Having been made aware of the information about the study, I declare that I am over 18 years of age and that I agree to participate in this research.”, other 7 participants (all from Portugal) do not agree with the Informed Consent Form, answering that “I do not agree to participate in this research.” So, there are 337 valid participants.

The methodological approach was presented in section 4.1 and illustrated in Fig 11.

To verify the suitability of the measurement scales, we applied various forms of analysis: reliability, validity, exploratory (using the SPSS 27), and confirmatory (using AMOS 27 software).

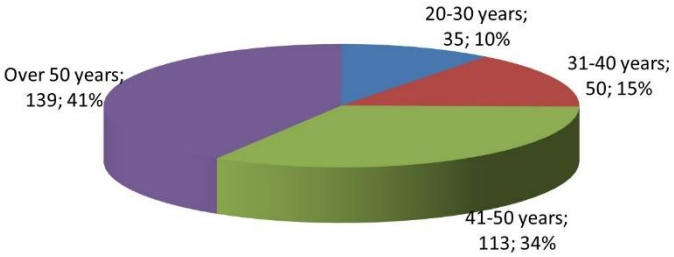
5.2. Sociodemographic and professional Characterization

In the sample, 90,5% are from Portugal and 9,5% are from Spain (Graphic 1).



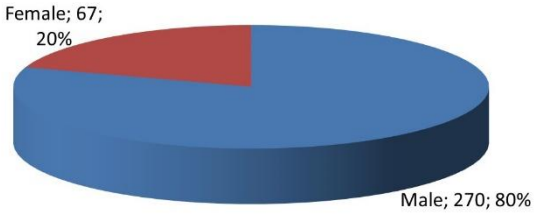
Graphic 1 : Frequencies Chart: Country

In the sample, 10,4% are 20-30 years old, 14,8% are 31-40 years old, 33,5% are 41-50 years old and 41,2% are over 50 years of age (Graphic 2).



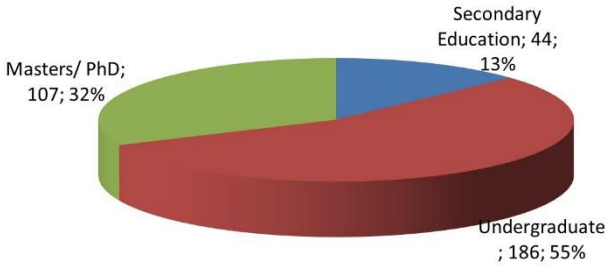
Graphic 2 - Frequencies Chart : Age

In the sample, regarding to gender, 80,1% are males and 19,9% are females (Graphic 3).



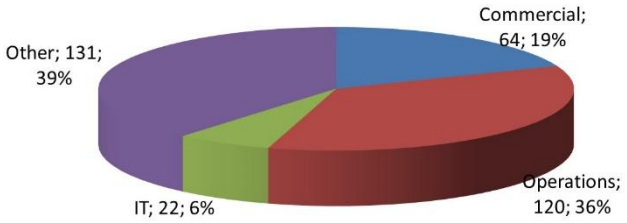
Graphic 3 - Frequencies Chart : Gender

In the sample, regarding the academic qualifications, 13,1% have Secondary Education, 55,2% have Undergraduate Degree and 31,8% have Masters/ PhD (Graphic 4).



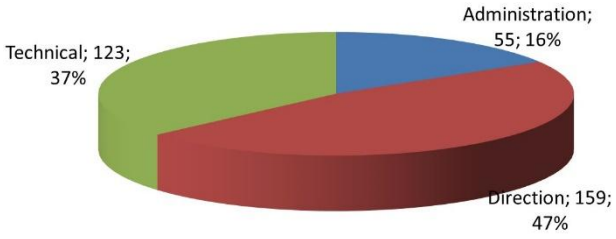
Graphic 4 - Frequencies Chart : Academic Qualifications

In the sample, regarding the Function, 19,0% have a Commercial function, 35,6% work in Operations, 6,5% work in IT and 38,9% work in other function (Graphic 5).



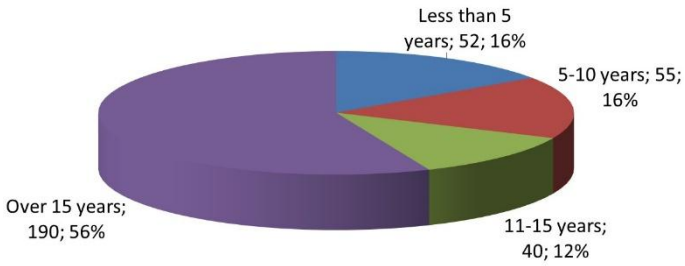
Graphic 5 - Frequencies Chart : Function

In the sample, regarding the Level, 16,3% are in Administration, 47,2% are in Direction and 36,5% are in a technical level (Graphic 6).



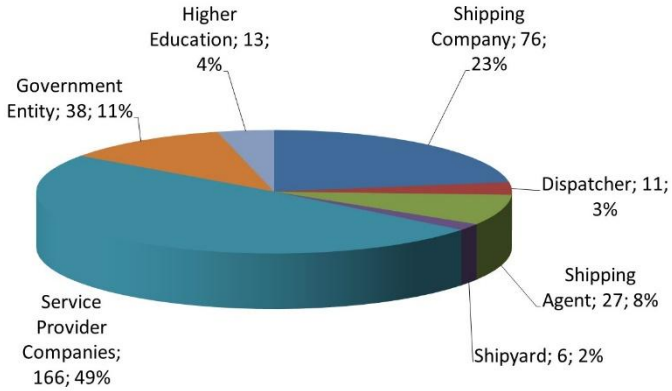
Graphic 6 - Frequencies Chart : Level

In the sample, regarding the Experience in the function, 15,4% have less than 5 years, 16,3% have 5-10 years, 11,9% have 11-15 years and 56,4% have over 15 years of experience (Graphic 7).



Graphic 7 - Frequencies Chart : Experience in the function

In the sample, regarding the Company Sector / Entity, 49,3% are in a Service Provider Companies, 22,6% are in a Shipping Company, 11,3% are in a Government Entity, 8,0% are in a Shipping Agent, 3,3% are a Dispatcher, 3,9% are in Higher Education and 1,8% are in a Shipyard (Graphic 8).



Graphic 8 - Frequencies Chart : Company Sector/Entity

		N	%
Country	Portugal	305	90,5
	Spain	32	9,5
Age	20-30 years	35	10,4
	31-40 years	50	14,8
	41-50 years	113	33,5
	Over 50 years	139	41,2
Gender	Male	270	80,1
	Female	67	19,9
Academic qualifications	Secondary Education	44	13,1
	Undergraduate	186	55,2
	Masters/PhD	107	31,8
Function	Commercial	64	19,0
	Operations	120	35,6
	IT	22	6,5
	Other	131	38,9
Level	Administration	55	16,3
	Direction	159	47,2
	Technical	123	36,5
Experience in the function	Less than 5 years	52	15,4
	5-10 years	55	16,3
	11-15 years	40	11,9
	Over 15 years	190	56,4
Company Sector / Entity	Shipping Company	76	22,6
	Dispatcher	11	3,3
	Shipping Agent	27	8,0
	Shipyard	6	1,8
	Service Provider Companies	166	49,3
	Government Entity	38	11,3
	Higher Education	13	3,9
Total	Total	337	100,0

Table 5 - Table of frequencies: Sociodemographic and professional characterization

5.3. General Characterization

In addition to the questions necessary to validate the research model, we took the opportunity to ask the participants about the perceived effort that their respective organizations make to adapt to new technologies and what is their perception in comparison with other industries.

	1		2		3		4		5
	%		%		%		%		%
1. My organization makes a relevant effort to acquire new technologies	2,1%	8	5,3%	5	7,4%	63	48,4%	24	36,8%
2. I think that the Shipping industry is more behind in the introduction of new technologies compared to the other industries	5,38	%	30,02	3%	19,4	0%	34,16	4%	11,7	0%

Measurement scale: 1- Totally Disagree; 2- Disagree; 3- Indifferent; 4- Agree; 5- Strongly Agree.

Table 6 - Table of frequencies: Items of the General Characterization

In the sample, the agreement answers are much more frequent for "1. My organization makes a relevant effort to acquire new technologies", the agreement and disagreement answers show similar frequency for "2. I think that the Shipping industry is more behind in the introduction of new technologies compared to the other industries", however slightly higher for agreement.

N=337	M	SD	VC
1. My organization makes a relevant effort to acquire new technologies	4,12	0,91	22%
2. I think that the Shipping industry is more behind in the introduction of new technologies compared to the other industries	3,15	1,13	36%

Measurement scale: 1- Totally Disagree; 2- Disagree; 3- Indifferent; 4- Agree; 5- Strongly Agree.

Table 7 - Statistics: Items of the General Characterization

In the sample, the mean for the concordance is higher for "1. My organization makes a relevant effort to acquire new technologies" (M=4,12), with mean value higher than the scale middle-point, meaning the agreement is high, the mean for the concordance is lower for "2. I think that the Shipping industry is more behind in the introduction of new technologies compared to the other industries" (M=3,15), with mean value close to the scale middle-point, meaning there is neither agreement or disagreement.

As a conclusion, we can say that despite recognizing an effort in technological modernization, there is a perception that this industry, when compared to others in general, has a great room for progression. This gap in technological adoption is linked to the conservatism of this industry as portrayed in Chapter 3.

5.4. Proposed Model- UTAUT S - Unified Theory of Acceptance and Use of Technology Model adapted to Shipping

In the sample, the agreement answers are more frequent than disagreement for all items, as presented in Table 8.

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
PE1 Using technologies in my job would enable me to accomplish tasks mor quickly	1	,3%	8	2,4%	9	2,7%	149	44,2%	170	50,4%
PE2 Using technologies would improve my job performance	1	,3%	5	1,5%	8	2,4%	157	46,6%	166	49,3%
PE3 Using technologies in my job would increase my productivity	1	,3%	4	1,2%	14	4,2%	148	43,9%	170	50,4%
PE4 Using technologies would enhance my effectiveness on the job	1	,3%	3	,9%	13	3,9%	156	46,3%	164	48,7%
PE5 Using technologies would make it easier to my job	1	,3%	3	,9%	10	3,0%	143	42,4%	180	53,4%
PE6 I would find technologies useful in my job	1	,3%	2	,6%	4	1,2%	144	42,7%	186	55,2%
EE1 Learning new technologies would be easy for me	1	,3%	13	3,9%	36	10,7%	189	56,1%	98	29,1%
EE2 I would find it easy to get new technologies to do what I want it to do	2	,6%	25	7,4%	59	17,5%	196	58,2%	55	16,3%
EE3 My interactions with new technologies would be clear and understandable	1	,3%	14	4,2%	35	10,4%	231	68,5%	56	16,6%
EE4 I would find new technologies would be clear and understandable	1	,3%	30	8,9%	76	22,6%	183	54,3%	47	13,9%
EE5 It would be easy for me to become skillful at using new technologies	2	,6%	14	4,2%	38	11,3%	218	64,7%	65	19,3%
EE6 I would find new technologies easy to use	2	,6%	21	6,2%	66	19,6%	191	56,7%	57	16,9%
SI1 People who are important to me would think that I should use new technologies	2	,6%	8	2,4%	85	25,2%	183	54,3%	59	17,5%
SI2 I would probably use new technologies if people who influence my behaviour think that I should use new technologies	20	5,9%	38	11,3%	102	30,3%	134	39,8%	43	12,8%
SI3 People whose opinions I value would like me to use new technologies	6	1,8%	18	5,3%	112	33,2%	161	47,8%	40	11,9%
FC1 I have the resources necessary to use new technologies	1	,3%	27	8,0%	43	12,8%	206	61,1%	60	17,8%
FC2 I have the knowledge necessary to use new technologies UTAUT	1	,3%	18	5,3%	32	9,5%	217	64,4%	69	20,5%
FC3 I can get help from other people when I have difficulties using new technologies	1	,3%	9	2,7%	35	10,4%	206	61,1%	86	25,5%
DT1 My transactions via digital products are performed as expected	1	,3%	15	4,5%	46	13,6%	215	63,8%	60	17,8%

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
DT2 My transactions via digital products are performed on time	1	,3%	14	4,2%	62	18,4%	210	62,3%	50	14,8%
DT3 I do not need to make my transactions confirmed manually when I use digital products	9	2,7%	42	12,5%	64	19,0%	163	48,4%	59	17,5%
BI1 I intend to continue using new technologies in the future	1	,3%			9	2,7%	146	43,3%	181	53,7%
BI2 I will always try to use new technologies in my daily life	1	,3%	4	1,2%	15	4,5%	163	48,4%	154	45,7%
BI3 I intend to continue to use new technologies often	1	,3%	1	,3%	12	3,6%	168	49,9%	155	46,0%
UB1 If I had the opportunity to use new technologies, I would do so	1	,3%	3	,9%	25	7,4%	151	44,8%	157	46,6%
UB2 If I can use new technologies in my job, I will do so	1	,3%			13	3,9%	156	46,3%	167	49,6%
UB3 I will use the new technologies in the future	1	,3%			9	2,7%	156	46,3%	171	50,7%
US1 Overall, our Users are satisfied with the digital services we provide	7	2,1%	36	10,7%	75	22,3%	177	52,5%	42	12,5%
US2 The digital services offered exceed the User expectations	6	1,8%	73	21,7%	112	33,2%	129	38,3%	17	5,0%
US3 The digital services offered are close to my idea	9	2,7%	62	18,4%	90	26,7%	154	45,7%	22	6,5%

Measurement scale: 1- Totally Disagree; 2- Disagree; 3- Indifferent; 4- Agree; 5- Strongly Agree.

Table 8 - Table of frequencies: Items of the Proposed Model UTAUT S - Unified Theory of Acceptance and Use of Technology Model adapted to Shipping

In the sample, as presented in Table 9, the mean for the concordance is higher for “PE6 I would find technologies useful in my job” (M=4,52), “BI1 I intend to continue using new technologies in the future] ” (M=4,50), “PE5 Using technologies would make it easier to my job” (M=4,48), “UB3 I will use the new technologies in the future” (M=4,47), “UB2 If I can use new technologies in my job, I will do so” (M=4,45), and lower for “DT3 I do not need to make my transactions confirmed manually when I use digital products” (M=3,66), “SI3 People whose opinions I value would like me to use new technologies” (M=3,63), “US1 Overall, our Users are satisfied with the digital services we provide” (M=3,63), “SI2 I would probably use new technologies if people who influence my behaviour think that I should use new technologies” (M=3,42), “US3 The digital services offered are close to my idea” (M=3,35), “US2 The digital services offered exceed the User expectations” (M=3,23), but all items have mean value higher than the scale middle-point, meaning the agreement is high.

N=337	M	SD	VC
PE1 Using technologies in my job would enable me to accomplish tasks mor quickly	4,42	0,69	16%
PE2 Using technologies would improve my job performance	4,43	0,65	15%
PE3 Using technologies in my job would increase my productivity	4,43	0,66	15%
PE4 Using technologies would enhance my effectiveness on the job	4,42	0,64	15%
PE5 Using technologies would make it easier to my job	4,48	0,63	14%
PE6 I would find technologies useful in my job	4,52	0,59	13%
EE1 Learning new technologies would be easy for me	4,10	0,76	18%
EE2 I would find it easy to get new technologies to do what I want it to do	3,82	0,81	21%
EE3 My interactions with new technologies would be clear and understandable	3,97	0,68	17%
EE4 I would find new technologies would be clear and understandable	3,73	0,82	22%
EE5 It would be easy for me to become skillful at using new technologies	3,98	0,73	18%
EE6 I would find new technologies easy to use	3,83	0,80	21%
SI1 People who are important to me would think that I should use new technologies	3,86	0,75	19%
SI2 I would probably use new technologies if people who influence my behaviour think that I should use new technologies	3,42	1,04	30%
SI3 People whose opinions I value would like me to use new technologies	3,63	0,83	23%
FC1 I have the resources necessary to use new technologies	3,88	0,80	21%
FC2 I have the knowledge necessary to use new technologies UTAUT	3,99	0,74	18%
FC3 I can get help from other people when I have difficulties using new technologies	4,09	0,70	17%
DT1 My transactions via digital products are performed as expected	3,94	0,72	18%
DT2 My transactions via digital products are performed on time	3,87	0,71	18%
DT3 I do not need to make my transactions confirmed manually when I use digital products	3,66	0,99	27%
BI1 I intend to continue using new technologies in the future	4,50	0,58	13%
BI2 I will always try to use new technologies in my daily life	4,38	0,66	15%
BI3 I intend to continue to use new technologies often	4,41	0,61	14%
UB1 If I had the opportunity to use new technologies, I would do so	4,36	0,69	16%
UB2 If I can use new technologies in my job, I will do so	4,45	0,60	14%
UB3 I will use the new technologies in the future	4,47	0,58	13%
US1 Overall, our Users are satisfied with the digital services we provide	3,63	0,91	25%
US2 The digital services offered exceed the User expectations	3,23	0,91	28%
US3 The digital services offered are close to my idea	3,35	0,94	28%

Measurement scale: 1- Totally Disagree; 2- Disagree; 3- Indifferent; 4- Agree; 5- Strongly Agree.

Table 9 - Statistics: Items of the Proposed Model UTAUT S - Unified Theory of Acceptance and Use of Technology Model adapted to Shipping

5.5. Model Scale Reliability

The scale is a Likert type scale, with five possible answers from "1- Totally Disagree" to "5- Strongly Agree", with 30 items, organized into eight dimensions.

DIMENSIONS	ITEMS
Performance Expectancy	PE1 Using technologies in my job would enable me to accomplish tasks more quickly
	PE2 Using technologies would improve my job performance
	PE3 Using technologies in my job would increase my productivity
	PE4 Using technologies would enhance my effectiveness on the job
	PE5 Using technologies would make it easier to my job
	PE6 I would find technologies useful in my job
Effort Expectancy	EE1 Learning new technologies would be easy for me
	EE2 I would find it easy to get new technologies to do what I want it to do
	EE3 My interactions with new technologies would be clear and understandable
	EE4 I would find new technologies would be clear and understandable
	EE5 It would be easy for me to become skillful at using new technologies
	EE6 I would find new technologies easy to use
Social Influence	SI1 People who are important to me would think that I should use new technologies
	SI2 I would probably use new technologies if people who influence my behavior think that I should use new technologies
	SI3 People whose opinions I value would like me to use new technologies
Facilitating Conditions	FC1 I have the resources necessary to use new technologies
	FC2 I have the knowledge necessary to use new technologies UTAUT
	FC3 I can get help from other people when I have difficulties using new technologies
Digital Trust	DT1 My transactions via digital products are performed as expected
	DT2 My transactions via digital products are performed on time
	DT3 I do not need to make my transactions confirmed manually when I use digital products
Behavioural Intention	BI1 I intend to continue using new technologies in the future
	BI2 I will always try to use new technologies in my daily life
	BI3 I intend to continue to use new technologies often
Use Behaviour	UB1 If I had the opportunity to use new technologies, I would do so
	UB2 If I can use new technologies in my job, I will do so
	UB3 I will use the new technologies in the future
User Satisfaction	US1 Overall, our Users are satisfied with the digital services we provide
	US2 The digital services offered exceed the User expectations
	US3 The digital services offered are close to my idea

Table 10 - Items belonging to each of the Model Scale Dimensions

The value of Cronbach's alpha is higher than the value of 0,80 for the dimensions Performance Expectancy, Effort Expectancy, Behavioral Intention, Use Behavior and User Satisfaction, so these dimensions are adequately measured; is higher than 0,60 for the dimensions Social Influence, Facilitating Conditions and Digital Trust, measured in an acceptable way (Table 11).

Dimension	Cronbach's Alpha	N of Items
Performance Expectancy	0,941	6
Effort Expectancy	0,912	6
Social Influence	0,748	3
Facilitating Conditions	0,725	3
Digital Trust	0,737	3
Behavioural Intention	0,919	3
Use Behaviour	0,896	3
User Satisfaction	0,852	3

Table 11 - Internal consistency statistics: Model Scale Dimensions

The additional tests in the table 12 indicate that there are no items correlated negatively with the dimensions, and all correlations are higher than the reference value of 0,30. Another relevant aspect is that the elimination of each item does not increase the value of Alpha in a significant way.

This scale is used to measure the dimensions adequately or acceptably in this sample.

		Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Performance Expectancy	PE1 Using technologies in my job would enable me to accomplish tasks mor quickly	,775	,937
	PE2 Using technologies would improve my job performance	,861	,926
	PE3 Using technologies in my job would increase my productivity	,864	,925
	PE4 Using technologies would enhance my effectiveness on the job	,835	,929
	PE5 Using technologies would make it easier to my job	,823	,931
	PE6 I would find technologies useful in my job	,791	,935
Effort Expectancy	EE1 Learning new technologies would be easy for me	,701	,903
	EE2 I would find it easy to get new technologies to do what I want it to do	,690	,906
	EE3 My interactions with new technologies would be clear and understandable	,808	,890
	EE4 I would find new technologies would be clear and understandable	,774	,893

	EE5 It would be easy for me to become skillful at using new technologies	,773	,894
	EE6 I would find new technologies easy to use	,795	,890
Social Influence	SI1 People who are important to me would think that I should use new technologies	,524	,727
	SI2 I would probably use new technologies if people who influence my behaviour think that I should use new technologies	,568	,706
	SI3 People whose opinions I value would like me to use new technologies	,678	,553
Facilitating Conditions	FC1 I have the resources necessary to use new technologies	,573	,607
	FC2 I have the knowledge necessary to use new technologies UTAUT	,606	,565
	FC3 I can get help from other people when I have difficulties using new technologies	,470	,724
Digital Trust	DT1 My transactions via digital products are performed as expected	,672	,545
	DT2 My transactions via digital products are performed on time	,663	,556
	DT3 I do not need to make my transactions confirmed manually when I use digital products	,424	,880
Behavioural Intention	BI1 I intend to continue using new technologies in the future	,796	,916
	BI2 I will always try to use new technologies in my daily life	,848	,877
	BI3 I intend to continue to use new technologies often	,872	,854
Use Behaviour	UB1 If I had the opportunity to use new technologies, I would do so	,800	,854
	UB2 If I can use new technologies in my job, I will do so	,861	,796
	UB3 I will use the new technologies in the future	,739	,898
User Satisfaction	US1 Overall, our Users are satisfied with the digital services we provide	,665	,846
	US2 The digital services offered exceed the User expectations	,773	,746
	US3 The digital services offered are close to my idea	,733	,784

Table 12 - Item-total correlation and effect of the elimination of each item: UTAUT Scale Dimensions

5.6. Measurement Model: Confirmatory Analysis of the Dimensions

The analyses presented in this section allow us to validate the dimensions used in the model. The Measurement model verifies if the items are significant and consistent to measure the constructs, allowing to conclude about the validity of each construct. A reflective model is used (the causality relationship goes from the construct to the indicators: changes in the construct cause changes in the items). The estimation method used for the calculations uses the covariance matrix and consists of the Maximum Likelihood (ML) method. (Fig 13 and Fig 14).

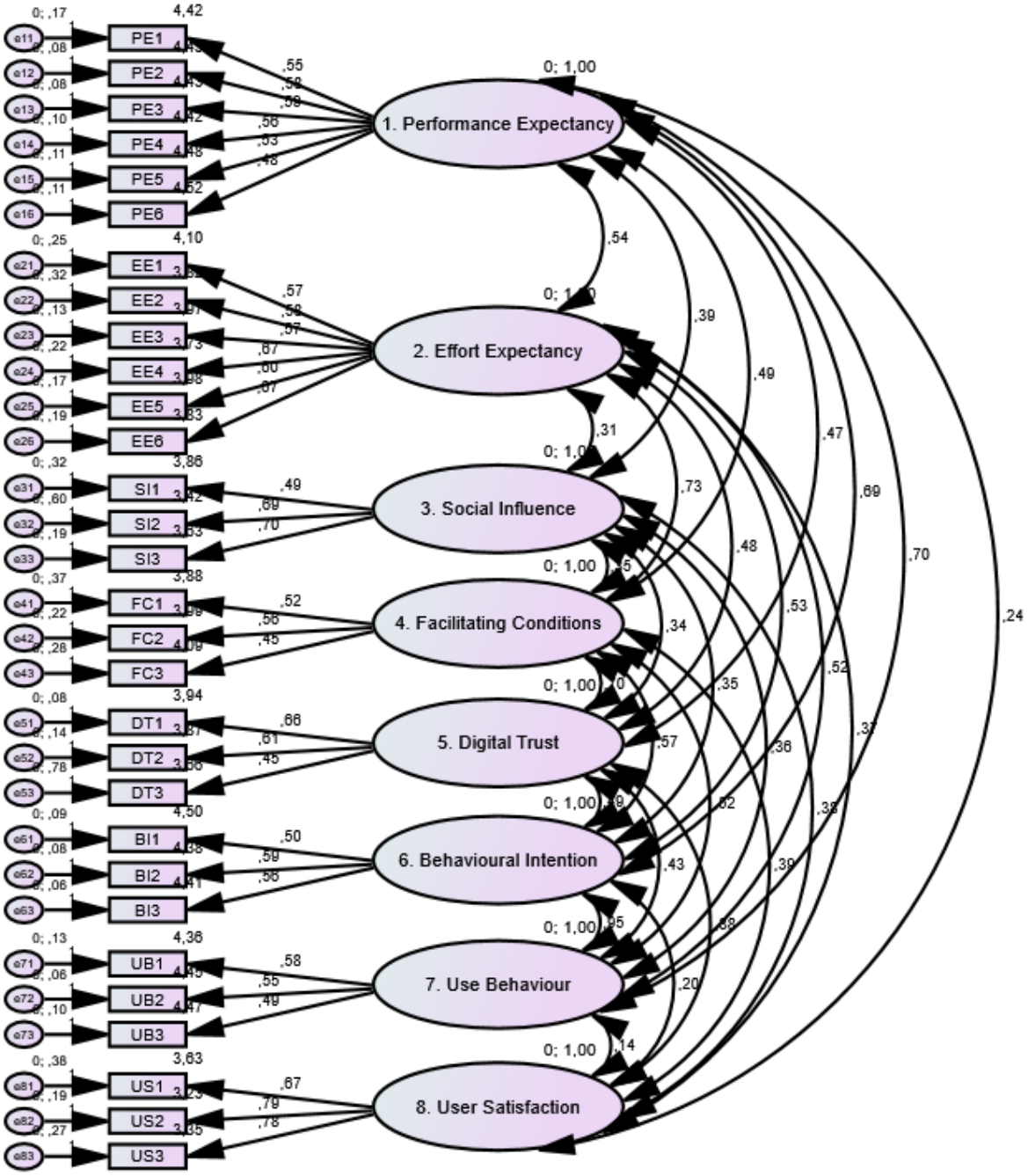


Figure 13 - Non-standardized Estimates of the Model Dimensions

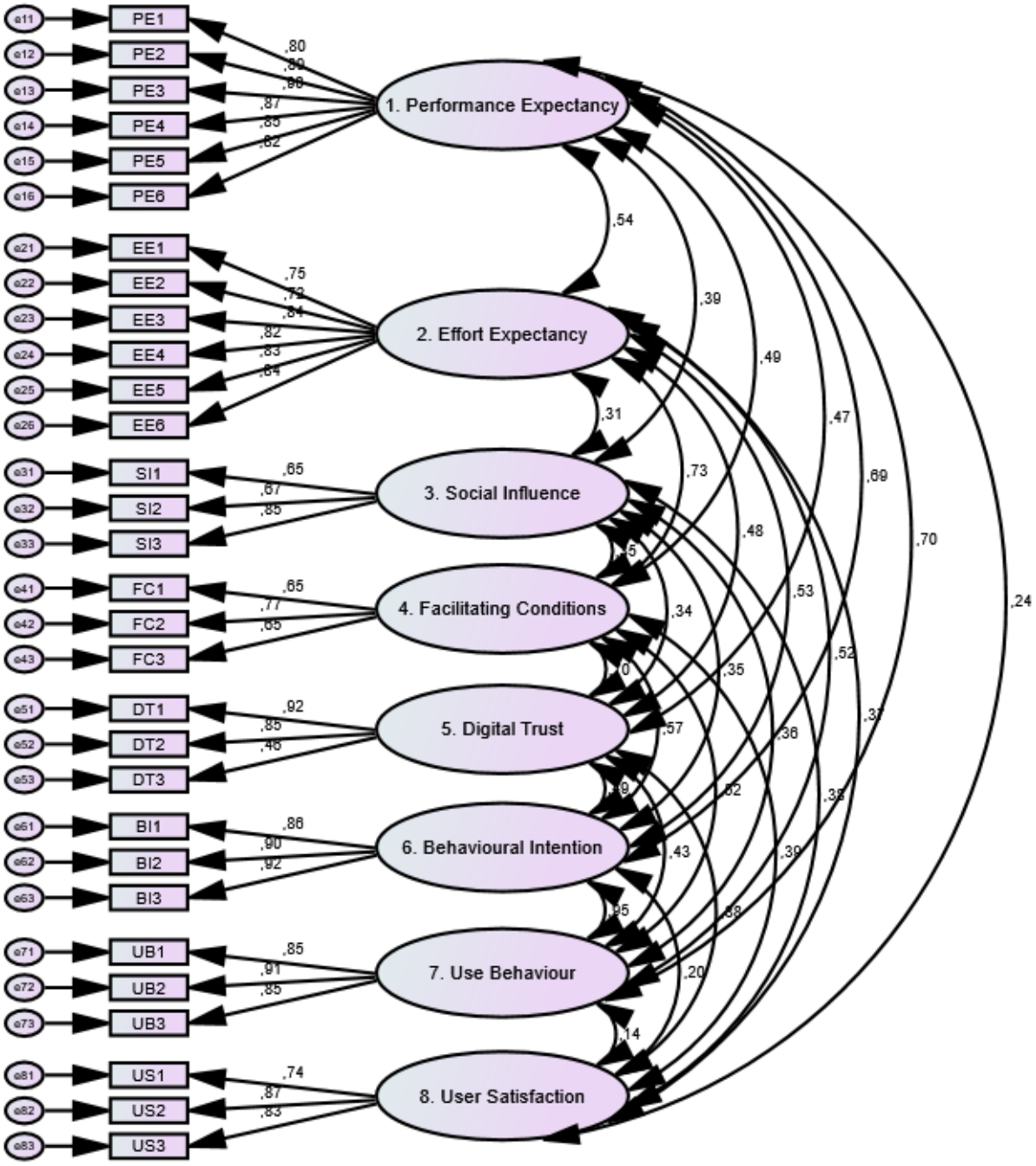


Figure 14 - Standardized Estimates of the Model Dimensions

Dimension	Item	Saturations		Standard error	t test	p
		Non Standardized	Standardized			
Performance Expectancy	PE1	,553	,802	,031	17,547	***<0,001
	PE2	,577	,893	,028	20,832	***<0,001
	PE3	,592	,897	,028	21,005	***<0,001
	PE4	,555	,867	,028	19,851	***<0,001
	PE5	,534	,847	,028	19,094	***<0,001
	PE6	,483	,822	,026	18,244	***<0,001
Effort Expectancy	EE1	,567	,751	,036	15,799	***<0,001
	EE2	,583	,720	,039	14,890	***<0,001
	EE3	,572	,842	,031	18,721	***<0,001
	EE4	,671	,818	,037	17,921	***<0,001
	EE5	,599	,827	,033	18,199	***<0,001
	EE6	,672	,841	,036	18,699	***<0,001
Social Influence	SI1	,486	,653	,041	11,951	***<0,001
	SI2	,694	,668	,057	12,258	***<0,001
	SI3	,704	,851	,044	15,994	***<0,001
Facilitating Conditions	FC1	,517	,647	,043	12,167	***<0,001
	FC2	,563	,766	,038	14,997	***<0,001
	FC3	,451	,648	,037	12,188	***<0,001
Digital Trust	DT1	,659	,918	,033	20,127	***<0,001
	DT2	,608	,853	,034	18,148	***<0,001
	DT3	,455	,458	,054	8,445	***<0,001
Behavioural Intention	BI1	,502	,863	,026	19,654	***<0,001
	BI2	,590	,898	,028	20,985	***<0,001
	BI3	,557	,920	,025	21,872	***<0,001
Use Behaviour	UB1	,580	,846	,031	19,007	***<0,001
	UB2	,547	,911	,026	21,434	***<0,001
	UB3	,492	,847	,026	19,013	***<0,001
User Satisfaction	US1	,667	,735	,045	14,836	***<0,001
	US2	,791	,874	,042	18,678	***<0,001
	US3	,783	,832	,045	17,456	***<0,001

*** p≤0,001

Table 13 - Table: Saturations of Model Dimensions, resulting from SEM and convergent validity

To determine the convergent validity of the measurement scale, it is important to verify if the items are statistically significant for the dimensions studied, if the factorial saturations are high, if there is reliability of the construct(Teodoro Luque Martínez, 2000) determined from the internal consistency and composite reliability (they should be higher than 0.7, according to Hair et al.1999) and the proportion of variance extracted it should be higher than 0.5, according to Bagozzi et al.(1988).

According to Claes et al.(1981), to calculate the composite reliability the quotient between the square of the sum of the standardized saturations and the difference between this same square and the sum of the measurement errors of the indicators is determined (complementary value for the unit of the square of the standardized saturation), while the extracted variance is determined by the quotient between the sum of the square of the standardized saturations and the difference between this same square and the sum of the measurement errors of the indicators.

In a first analysis, we found that all the saturations of the variables (items) measured in the respective dimensions were statistically significant ($p<0.001$) as illustraded in Table 13 . For each dimension, we calculated the mean of the factor saturations, the internal consistency and the composite reliability, as well as the proportion of the variance extracted, which are presented in the Table 14.

Dimension	Items	Factorial saturations mean	Internal reliability	Composite reliability	Proportion of variance extracted
Performance Expectancy	6	0,855	0,941	0,998	0,732
Effort Expectancy	6	0,800	0,912	0,996	0,642
Social Influence	3	0,724	0,748	0,941	0,532
Facilitating Conditions	3	0,687	0,725	0,920	0,475
Digital Trust	3	0,743	0,737	0,953	0,593
Behavioural Intention	3	0,894	0,919	0,988	0,799
Use Behavior	3	0,868	0,896	0,984	0,754
User Satisfaction	3	0,814	0,852	0,973	0,665

Table 14 - Criteria for validating the Model Dimensions through convergent validity

There is convergent validity of all dimensions, since the factorial saturations are high with mean values that are always higher than the minimum required value of 0,500, and the minimum value observed is 0,687; the factorial saturations are also significant (t values>1.96; $p<0.001$), as previously mentioned.

The reliability of the construct is verified since the values of internal consistency and composite reliability are always higher than the minimum required of 0,70, with most values higher than 0,80 for the internal reliability and even higher than 0,90 for the composite reliability.

And, finally, the variance extracted is higher than 0,50 for almost all the dimensions, with only one exception, that of dimension “Facilitating Conditions”, even so, with a value close to the reference (Table14). Therefore, the convergent validity comes to legitimize the possibility of creating the studied dimensions.

Dimension	Dimension	Saturations		Std. error	t test	p
		Non Standardized	Standardized			
Performance Expectancy	Effort Expectancy	,541	,541	,043	12,704	***<0,001
Performance Expectancy	Social Influence	,389	,389	,055	7,129	***<0,001
Performance Expectancy	Facilitating Conditions	,486	,486	,053	9,194	***<0,001
Performance Expectancy	Digital Trust	,465	,465	,048	9,746	***<0,001
Performance Expectancy	Behavioural Intention	,685	,685	,033	20,886	***<0,001
Performance Expectancy	Use Behaviour	,704	,704	,032	21,954	***<0,001
Performance Expectancy	User Satisfaction	,242	,242	,057	4,245	***<0,001
Effort Expectancy	Social Influence	,310	,310	,058	5,319	***<0,001
Effort Expectancy	Facilitating Conditions	,731	,731	,039	18,807	***<0,001
Effort Expectancy	Digital Trust	,478	,478	,048	9,957	***<0,001
Effort Expectancy	Behavioural Intention	,526	,526	,044	11,929	***<0,001
Effort Expectancy	Use Behaviour	,524	,524	,045	11,694	***<0,001
Effort Expectancy	User Satisfaction	,374	,374	,053	7,001	***<0,001
Social Influence	Facilitating Conditions	,355	,355	,064	5,525	***<0,001
Social Influence	Digital Trust	,342	,342	,058	5,859	***<0,001
Social Influence	Behavioural Intention	,350	,350	,057	6,172	***<0,001
Social Influence	Use Behaviour	,356	,356	,057	6,226	***<0,001
Social Influence	User Satisfaction	,384	,384	,058	6,667	***<0,001
Facilitating Conditions	Digital Trust	,703	,703	,042	16,629	***<0,001
Facilitating Conditions	Behavioural Intention	,565	,565	,049	11,466	***<0,001
Facilitating Conditions	Use Behaviour	,521	,521	,052	9,925	***<0,001
Facilitating Conditions	User Satisfaction	,386	,386	,060	6,404	***<0,001
Digital Trust	Behavioural Intention	,485	,485	,047	10,242	***<0,001
Digital Trust	Use Behaviour	,429	,429	,051	8,449	***<0,001
Digital Trust	User Satisfaction	,383	,383	,054	7,080	***<0,001
Behavioural Intention	Use Behaviour	,948	,948	,012	78,621	***<0,001
Behavioural Intention	User Satisfaction	,197	,197	,059	3,357	***<0,001
Use Behaviour	User Satisfaction	,144	,144	,060	2,393	* 0,017

* p≤0,05 *** p≤0,001

Table 15 - Saturations between the Dimensions of the Model, resulting from the SEM and convergent validity

The convergent validity of the measurement scale is further confirmed by the existence of positive and statistically significant saturations (t>1.96; p<0,001 or p<0,05 for one of the relations) among all dimensions of this construct.(table15).The model uses the Maximum Likelihood Estimator (MLE) method, which requires that the data meet the normality requirement.

Item	Min	Max	Skewness	Skewness Critical Ratio	Kurtosis	Kurtosis Critical Ratio
PE1	1,000	5,000	-1,428	-10,702	3,207	12,018
PE2	1,000	5,000	-1,292	-9,683	3,293	12,341
PE3	1,000	5,000	-1,232	-9,229	2,637	9,882
PE4	1,000	5,000	-1,129	-8,460	2,587	9,696
PE5	1,000	5,000	-1,300	-9,740	3,146	11,789
PE6	1,000	5,000	-1,307	-9,796	3,889	14,574
EE1	1,000	5,000	-,869	-6,510	1,226	4,594
EE2	1,000	5,000	-,769	-5,762	,683	2,561
EE3	1,000	5,000	-,984	-7,374	2,321	8,699
EE4	1,000	5,000	-,555	-4,160	,063	,235
EE5	1,000	5,000	-,999	-7,486	2,149	8,054
EE6	1,000	5,000	-,698	-5,228	,651	2,441
SI1	1,000	5,000	-,452	-3,388	,609	2,283
SI2	1,000	5,000	-,543	-4,069	-,134	-,502
SI3	1,000	5,000	-,531	-3,977	,629	2,358
FC1	1,000	5,000	-,865	-6,482	,834	3,124
FC2	1,000	5,000	-,978	-7,328	1,750	6,559
FC3	1,000	5,000	-,808	-6,054	1,686	6,317
DT1	1,000	5,000	-,828	-6,209	1,460	5,470
DT2	1,000	5,000	-,692	-5,185	1,089	4,082
DT3	1,000	5,000	-,690	-5,169	-,035	-,131
BI1	1,000	5,000	-1,043	-7,817	2,589	9,701
BI2	1,000	5,000	-1,090	-8,172	2,411	9,033
BI3	1,000	5,000	-,894	-6,702	2,299	8,614
UB1	1,000	5,000	-1,002	-7,509	1,544	5,786
UB2	1,000	5,000	-,912	-6,837	2,042	7,653
UB3	1,000	5,000	-,931	-6,979	2,410	9,030
US1	1,000	5,000	-,724	-5,429	,293	1,100
US2	1,000	5,000	-,207	-1,554	-,662	-2,481
US3	1,000	5,000	-,470	-3,524	-,460	-1,724
Multivariate					302,736	63,416

Table 16 - Analysis of normality for Dimensions of the Model

The values for many of the critical kurtosis ratios are outside the range between -3.0 and +3.0 for about two thirds of the items, indicating deviations from normality (Arbuckle, J., 2003). The critical asymmetry ratios also exceed the absolute value of 3,0 for most items, revealing that these variables do not have a symmetric distribution (Table 16). Therefore, overall, we cannot state that the assumption of normality is verified. Nevertheless, meeting this requirement ensures the validity of the model, although it is less relevant in large samples (Arbuckle, J., 2003), as is the case here, so the model can be applied.

Finally, to measure the quality of the adjustment, the benchmarks recommended by (Arbuckle, J., 2003), (Teodoro Luque Martínez, 2000), and (Heikki Karjaluoto, Minna Mattila, 2002) are used, according to the table 17.

Adjustment index	Description	Recommended values
Absolute index: Chi-square / d.f. $\chi 2$ /df.	Calculation of the difference between the observed and expected covariance matrices; adjusted for degrees of freedom	=1 very good fit < 2 good fit < 5 acceptable fit > 5 unacceptable fit
Discrepancy index: RMSEA (Root mean square error of approximation)	Indicates the overall fit of the model relative to the degrees of freedom	< 0,05 perfect fit; < 0,08 acceptable fit
Relative index: NFI (Normed of fit index)	Compares the proposed model to the null model; not adjusted for degrees of freedom	From 0 (no fit) to 1 (perfect fit); > 0,80 recommended fit
Relative index: CFI (Comparative fit index)	Index of overall model fit	From 0 (no fit) to 1 (perfect fit); 0,80 – 0,90 acceptable fit > 0,90 recommended fit

Table 17 - Benchmarks for assessing the fit of structural equation models; Arbuckle e Wothke, 1999; Luque, 2000; Karjaluoto, 2002

The adjustment indexes used are justified by (Kline, 1998) who suggests tests that include the RMSEA, CFI, and the model's chi-square, its degrees of freedom, and the p-value. Thompson, 2000 recommends the "comparative fit index (CFI)" and the "root mean square error of approximation (RMSEA)" as the most widely used for evaluating model fit. McDonald, R. P., & Ho, (2002), based on their review of the literature, consider that the most used models for measuring fit are CFI, GFI, NFI, and NNFI. suggest using the model's chi-square, its degrees of freedom and p-value, RMSEA, CFI and the NFI. This selection is based on the literature review and the fact that these indices are less sensitive to sample size, model misspecification, and parameter estimates.

χ2 /g.l.	CFI	RMSEA	NFI
1,946	0,951	0,053	0,905

CFI – Comparative fit index; RMSEA – Root mean square error of approximation; NFI – Normed of fit index.

Table 18 - Structural model adjustment

The measures indicate a good overall adjustment of the proposed model (Table 18) to the collected data if we consider the chi-square/df (<2), and a recommended adjustment if we take into account the remaining indices: RMSEA (RMSEA=0,053~0,05), CFI (CFI=0,951>0,90) and NFI (NFI=0,905>0,80).

Regarding the dimensions under study, the measurement model allows the conclusion that the items: i) are significant; ii) are consistent; iii) present convergent validity. In addition, the model presents a recommended quality of adjustment.

Therefore, in terms of the specific objective, we can conclude that the dimensions of the UTAUT Model can be used to create a structural model using this sample.

5.7. Descriptive and Inferential Analysis for the Proposed UTAUT S Model Dimensions

For the proposed Model Dimensions, its values were determined by calculating the mean of the answers to the items that constitute them.

The results presented in this section allow us to achieve the goal of analysing the adoption of new technologies in the Shipping Industry in Portugal and Spain and to understand the current status quo and the reason for the current level of use/utilization.

Table 19 - Statistics: Proposed UTAUTS Model Dimensions

		95% CI					
N=373	M	LL	UL	SD	VC	Min.	Max.
Performance Expectancy	4,45	4,39	4,51	0,57	13%	1,00	5,00
Effort Expectancy	3,90	3,84	3,97	0,64	16%	1,00	5,00
Social Influence	3,64	3,56	3,71	0,72	20%	1,00	5,00
Facilitating Conditions	3,99	3,92	4,05	0,60	15%	1,00	5,00
Digital Trust	3,82	3,75	3,90	0,66	17%	1,00	5,00
Behavioural Intention	4,43	4,37	4,49	0,57	13%	1,00	5,00
Use Behaviour	4,43	4,37	4,49	0,57	13%	1,00	5,00
User Satisfaction	3,40	3,32	3,49	0,81	24%	1,00	5,00

The mean value is higher for Performance Expectancy (M=4,45), Behavioral Intention (M=4,43) and Use Behaviour (M=4,43), followed by Facilitating Conditions (M=3,99), Effort Expectancy (M=3,90) and Digital Trust (M=3,82), then by Social Influence (M=3,64), and at last by User Satisfaction (M=3,40), all dimensions with mean value higher than the scale middle-point (Table 19).

Thus, the inference for the Model Dimensions in the population is that the most valued dimensions are Performance Expectancy [4,39; 4,51], Behavioral Intention [4,37; 4,49] and Use Behavior [4,37; 4,49], followed by Effort Expectancy [3,84; 3,97] and Facilitating Conditions [3,92; 4,05], then by Digital Trust [3,75; 3,90], followed by Social Influence [3,56; 3,71], and finally by User Satisfaction [3,32; 3,49].

5.8. Relation of the Proposed UTAUT S Model Dimensions with Age, Gender and Experience

The results presented in this section allow us to achieve the objective of studying the influence of gender, age and length of professional experience in Shipping on the UTAUT Model Dimensions constructs under study.

In the following analyses, because the groups under study are large, the parametric t-test and ANOVA are used.

5.8.1. Age

	20-30 years (N=35)		31-40 years (N=50)		41-50 years (N=113)		Over 50 years (N=139)			
	M	SD	M	SD	M	SD	M	SD	F(3,333)	p
Performance Expectancy	4,41	0,55	4,58	0,49	4,47	0,59	4,40	0,57	1,465	0,224
Effort Expectancy	3,94	0,65	4,15	0,47	4,02	0,58	3,71	0,69	8,495	*** 0,000
Social Influence	3,56	0,75	3,76	0,68	3,72	0,72	3,54	0,71	1,984	0,116
Facilitating Conditions	4,05	0,66	4,08	0,59	4,09	0,57	3,86	0,59	3,826	* 0,010
Digital Trust	3,62	0,63	3,87	0,58	3,87	0,69	3,82	0,67	1,369	0,252
Behavioural Intention	4,48	0,60	4,59	0,51	4,47	0,55	4,33	0,59	3,228	* 0,023
Use Behaviour	4,53	0,54	4,62	0,46	4,45	0,57	4,31	0,59	4,353	** 0,005
User Satisfaction	3,38	0,82	3,37	0,75	3,47	0,84	3,36	0,80	0,423	0,737
					* p<0,05		** p<0,01		*** p<0,001	

Table 20 - Statistics and ANOVA tests for the relation between the UTAUT S Model Dimensions and Age

The mean for the Effort Expectancy is higher for 31-40 years and lower for over 50 years, and the differences are significant ($F_{(3,333)}$=8,495; p<0,001); the mean for the Facilitating Conditions is lower for over 50 years, and the differences are significant ($F_{(3,333)}$=3,826; p=0,010); the mean for the Behavioural Intention is higher for 31-40 years and lower for over 50 years, and the differences are significant ($F_{(3,333)}$=3,228; p=0,023); the mean for the Use Behaviour is higher for 31-40 years and lower for over 50 years, and the differences are significant ($F_{(3,333)}$=4,353; p=0,005) as illustraded in Table 20.

In the sample, the mean for the Performance Expectancy is higher for 31-40 years; the mean for the Social Influence is higher for 31-40 years and 41-50 years; the mean for the Digital Trust is lower for 20-30 years; and the mean for the User Satisfaction is higher for 41-50 years; but the differences are not significant (p>0,050).

So, the Effort Expectancy, the Behavioural Intention and the Use Behaviour are significantly higher for 31-40 years and lower for over 50 years, the Facilitating Conditions are significantly lower for over 50 years, the Performance Expectancy, the Social Influence, the Digital Trust and the User Satisfaction are not significantly related to age.

5.8.2. Gender

In the sample, the mean for the Performance Expectancy, the Social Influence, the Behavioral Intention and the User Satisfaction are higher for male gender; the mean for the Effort Expectancy and the Digital Trust are higher for female gender; the mean for the Facilitating Conditions and the Use Behavior are similar for both genders; but the differences are not significant (p>0,050).

So, the Proposed UTAUT S Model Dimensions are not significantly related to gender (Table 21).

	Male (N=270)		Female (N=67)			
	M	SD	M	SD	t(335)	p
Performance Expectancy	4,45	0,57	4,44	0,54	0,237	0,812
Effort Expectancy	3,89	0,63	3,95	0,68	-0,688	0,492
Social Influence	3,67	0,68	3,49	0,84	1,884	0,060
Facilitating Conditions	3,99	0,59	3,99	0,65	0,047	0,963
Digital Trust	3,82	0,65	3,84	0,72	-0,164	0,870
Behavioural Intention	4,44	0,57	4,41	0,60	0,356	0,722
Use Behaviour	4,43	0,57	4,42	0,58	0,087	0,931
User Satisfaction	3,43	0,78	3,28	0,90	1,406	0,161

Table 21 - Statistics and t tests for the relation between the Proposed UTAUT -S Model Dimensions and Gender

5.8.3. Experience

The mean for the Behavioral Intention is higher for 5-10 years, followed by 11-15 years and lower for over 15 years, and the differences are significant ($F_{(3,333)}$=3,071; p=0,028); the mean for the Use Behavior is higher for 5-10 years, followed by 11-15 years and lower for over 15 years, and the differences are significant ($F_{(3,333)}$=3,100; p=0,027).

In the sample, the mean for the Performance Expectancy is higher for 5-10 years; the mean for the Effort Expectancy and the Social Influence are higher for 5-10 years and 11-15 years and lower for over 15 years; the mean for the Facilitating Conditions is higher for 5-10 years and lower for over 15 years; the mean for the Digital Trust is higher for 5-10 years and lower for less than 5 years; the mean for the User Satisfaction is higher for 5-10 years and lower for 5-10 years; but the differences are not significant (p>0,050).

So, the Behavioral Intention and the Use Behavior are significantly higher for 5-10 years, followed by 11-15 years and lower for over 15 years, the Performance Expectancy, the Effort Expectancy, the Social Influence, the Facilitating Conditions, the Digital Trust and the User Satisfaction are not significantly related to experience (Table 22).

	< 5 years (N=52)		5-10 years (N=55)		11-15 years (N=40)		Over 15 years (N=190)			
	M	SD	M	SD	M	SD	M	SD	F(3,333)	p
Performance Expectancy	4,44	0,49	4,51	0,55	4,41	0,58	4,44	0,59	0,295	0,829
Effort Expectancy	3,98	0,57	4,02	0,61	4,04	0,68	3,82	0,65	2,596	0,052
Social Influence	3,67	0,66	3,70	0,81	3,70	0,81	3,59	0,69	0,522	0,668
Facilitating Conditions	3,90	0,67	4,07	0,54	4,16	0,55	3,95	0,60	2,081	0,103
Digital Trust	3,67	0,63	3,88	0,68	3,93	0,65	3,83	0,67	1,389	0,246
Behavioural Intention	4,45	0,58	4,59	0,47	4,53	0,58	4,36	0,58	3,071	* 0,028
Use Behaviour	4,48	0,52	4,57	0,52	4,54	0,54	4,35	0,59	3,100	* 0,027
User Satisfaction	3,44	0,68	3,18	0,86	3,53	0,84	3,43	0,81	1,835	0,140

* p<0,05 ** p<0,01 *** p<0,001

Table 22 - Statistics and ANOVA tests for the relation between the Proposed UTAUT S Model Dimensions and Experience

5.9. Hypothesis Analysis with the Structural Equation Model

The structural model presented here allows the stated objective of determining the significant relationships between the different latent variables (dimensions) of the model to be achieved, according to the relationships established in the model, making it possible to verify the research hypotheses.

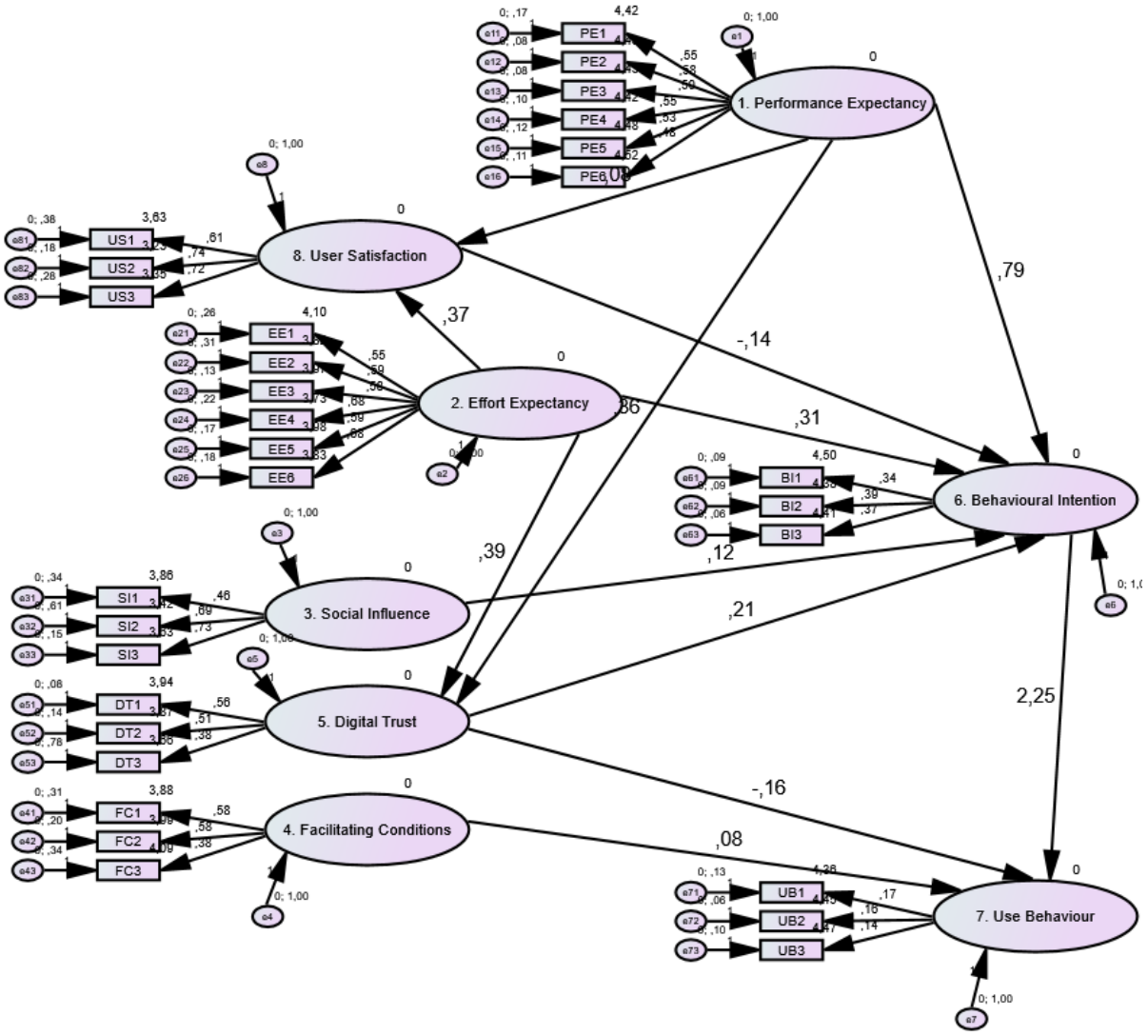


Figure 15 - Non-standardized Estimates of the Proposed Model Dimensions

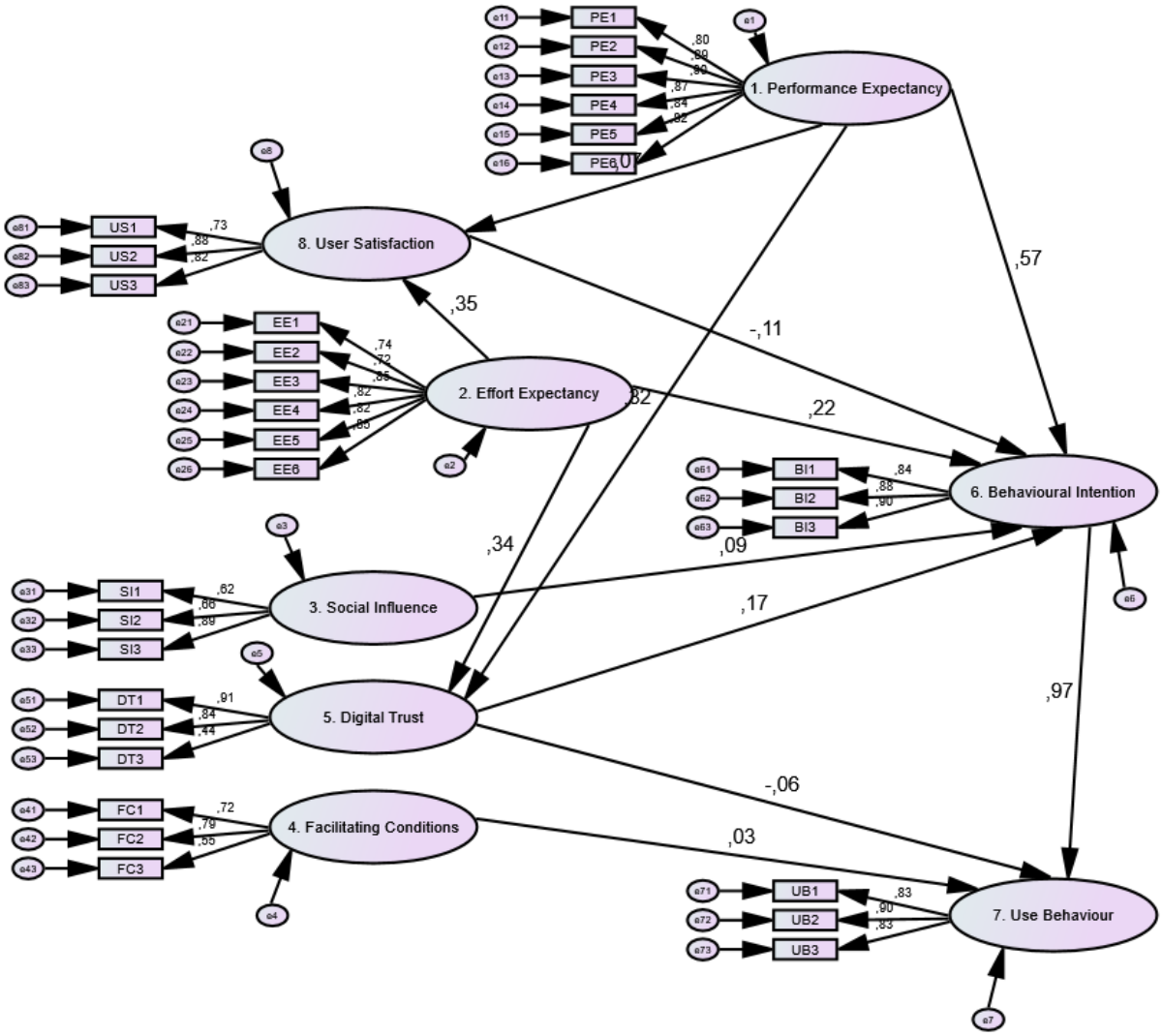


Figure 16 - Standardized Estimates of the Proposed Model Dimensions

The table 23 presents the results concerning the saturations and respective statistical significance for the dimensions of the model. These results have already been analysed in the validation of each dimension and are now presented for the overall structural model. The results now presented are very similar to the previous ones, thus reiterating the previously performed validation of each dimension, now for the conceptual model.

Dimension	Item	Saturations		Standard error	t test	p
		Non Standardized	Standardized			
Performance Expectancy	PE1	,555	,805	,031	17,649	***<0,001
	PE2	,578	,894	,028	20,869	***<0,001
	PE3	,593	,899	,028	21,073	***<0,001
	PE4	,555	,867	,028	19,813	***<0,001
	PE5	,532	,843	,028	18,956	***<0,001
	PE6	,481	,820	,027	18,135	***<0,001
Effort Expectancy	EE1	,555	,735	,036	15,295	***<0,001
	EE2	,585	,722	,039	14,926	***<0,001
	EE3	,576	,848	,030	18,892	***<0,001
	EE4	,677	,825	,037	18,099	***<0,001
	EE5	,593	,818	,033	17,886	***<0,001
	EE6	,676	,846	,036	18,824	***<0,001
Social Influence	SI1	,461	,619	,042	10,920	***<0,001
	SI2	,685	,659	,059	11,574	***<0,001
	SI3	,735	,887	,049	15,109	***<0,001
Facilitating Conditions	FC1	,577	,722	,049	11,770	***<0,001
	FC2	,580	,790	,046	12,618	***<0,001
	FC3	,383	,550	,041	9,386	***<0,001
Digital Trust	DT1	,557	,915	,032	17,319	***<0,001
	DT2	,510	,837	,031	16,418	***<0,001
	DT3	,383	,441	,048	7,985	***<0,001
Behavioural Intention	BI1	,335	,845	,019	17,639	***<0,001
	BI2	,391	,878	,021	18,604	***<0,001
	BI3	,369	,902	,019	19,294	***<0,001
Use Behaviour	UB1	,167	,827	,022	7,568	***<0,001
	UB2	,158	,897	,021	7,637	***<0,001
	UB3	,142	,828	,019	7,569	***<0,001
User Satisfaction	US1	,613	,728	,043	14,398	***<0,001
	US2	,738	,880	,041	18,125	***<0,001
	US3	,719	,823	,043	16,760	***<0,001

*** p≤0,001

Table 23 - Saturations of the Proposed Model Dimensions

In the table 24, the Squared Multiple Correlations are presented*, with a value of 90,2% for the Use Behaviour (this is much higher than the UTAUT model, of 70%)*.

Dimension	R2
Performance Expectancy	,000
Effort Expectancy	,000
Social Influence	,000
Facilitating Conditions	,000
Digital Trust	,219
Behavioural Intention	,478
Use Behaviour	,902
User Satisfaction	,125

Table 24 - Squared Multiple Correlations

Hypothesis	Dimension	Dimension	Saturations		Std. Error	t test	p
			Non Standardized	Standardized			
H1a	Performance Expectancy	Behavioural Intention	,787	,569	,082	9,595	***<0,001
H1b	Performance Expectancy	User Satisfaction	,079	,074	,061	1,292	0,196
H1c	Performance Expectancy	Digital Trust	,359	,317	,065	5,512	***<0,001
H2	User Satisfaction	Behavioural Intention	-,138	-,106	,065	-2,108	* 0,035
H3a	Effort Expectancy	Behavioural Intention	,308	,222	,075	4,098	***<0,001
H3b	Effort Expectancy	User Satisfaction	,370	,346	,066	5,599	***<0,001
H3c	Effort Expectancy	Digital Trust	,389	,344	,067	5,826	***<0,001
H4	Social Influence	Behavioural Intention	,120	,087	,065	1,830	0,067
H5a	Digital Trust	Behavioural Intention	,209	,171	,068	3,089	** 0,002
H5b	Digital Trust	Use Behaviour	-,164	-,058	,108	-1,526	0,127
H6	Facilitating Conditions	Use Behaviour	,082	,026	,109	,753	0,451
H7	Behavioural Intention	Use Behaviour	2,249	,972	,329	6,830	***<0,001
			* p<0,05		** p<0,01		*** p<0,001

Table 25 - Saturation Analysis to verify the Hypothesis with the Structural Model

Hypothesis Analysis as illustraded in Table 25:

- *Hypothesis 1a: Performance Expectancy has a significant influence on the Behavioral Intention*

The relationship between the Performance Expectancy and the Behavioral Intention shows a positive and statistically significant standardized coefficient (β=0,569, p<0,001), so that an increase in Performance Expectancy corresponds to a significant increase in Behavioral Intention, we can conclude that the Hypothesis H1a is verified.

- *Hypothesis 1b: Performance Expectancy has a significant influence on the Users Satisfaction*

The relationship between the Performance Expectancy and the User Satisfaction shows a positive but not significant standardized coefficient (β=0,074, p=0,196), so that a variation in Performance Expectancy does not correspond to a significant variation in User Satisfaction, we can conclude that the Hypothesis H1b is not verified.

- *Hypothesis 1c: Performance Expectancy has a significant influence on Digital Trust*

The relationship between the Performance Expectancy and the Digital Trust shows a positive and statistically significant standardized coefficient (β=0,317, p<0,001), so that an increase in Performance Expectancy corresponds to a significant increase in Digital Trust, we can conclude that the Hypothesis H1c is verified.

- *Hypothesis 2: User Satisfaction has a significant influence on the Behavioral Intention of using new technologies*

The relationship between the User Satisfaction and the Behavioral Intention shows a negative and statistically significant standardized coefficient (β=0,106, p=0,035), so that an increase in User Satisfaction corresponds to a significant decrease in Behavioral Intention, we can conclude that the Hypothesis H2 is verified.

- *Hypothesis 3a: Effort Expectancy has a significant influence on the Behavioral Intention of using new technologies*

The relationship between the Effort Expectancy and the Behavioral Intention shows a positive and statistically significant standardized coefficient (β=0,222, p<0,001), so that an increase in Effort Expectancy corresponds to a significant increase in Behavioral Intention, we can conclude that the Hypothesis H3a is verified.

- *Hypothesis 3b: Effort Expectancy has a significant influence on the Users Satisfaction*

The relationship between the Effort Expectancy and the User Satisfaction shows a positive and statistically significant standardized coefficient (β=0,346, p<0,001), so that an increase in Effort Expectancy corresponds to a significant increase in User Satisfaction, we can conclude that the Hypothesis H3b is verified.

- *Hypothesis 3c: Effort Expectancy has a significant influence on Digital Trust*

The relationship between the Effort Expectancy and the Digital Trust shows a positive and statistically significant standardized coefficient (β=0,344, p<0,001), so that an increase in Effort Expectancy corresponds to a significant increase in Digital Trust, we can conclude that the Hypothesis H3c is verified.

- *Hypothesis 4: Social Influence has a significant influence on the Behavioral Intention of using new technologies*

The relationship between the Social Influence and the Behavioral Intention shows a positive but not significant standardized coefficient (β=0,087, p=0,067), so that a variation in Social Influence does not correspond to a significant variation in Behavioral Intention, we can conclude that the Hypothesis H4 is not verified.

- *Hypothesis 5a: Digital Trust has a significant influence on the Behavioral Intention of using new technologies*

The relationship between the Digital Trust and the Behavioral Intention shows a positive and statistically significant standardized coefficient (β=0,171, p=0,002), so that an increase in Digital Trust corresponds to a significant increase in Behavioral Intention, we can conclude that the Hypothesis H5a is verified.

- *Hypothesis 5b: Digital Trust has a significant influence on the Use Behavior*

The relationship between the Digital Trust and the Use Behavior shows a negative but not significant standardized coefficient (β=-0,058, p=0,127), so that a variation in Digital Trust does not correspond to a significant variation in Use Behavior, we can conclude that the Hypothesis H5b is not verified.

- *Hypothesis 6: Facilitating Conditions has a significant influence on the Use behavioral*

The relationship between the Facilitating Conditions and the Use Behavior shows a positive but not significant standardized coefficient (β=0,026, p=0,451), so that a variation in Facilitating Conditions does not correspond to a significant variation in Use Behavior, we can conclude that the Hypothesis H6 is not verified.

- *Hypothesis 7: Behavioral Intention of using new technologies has a significant influence on the Use behavioral*

The relationship between the Behavioral Intention and the Use Behavior shows a positive and statistically significant standardized coefficient (β=0,972, p<0,001), so that an increase in Behavioral Intention corresponds to a significant increase in Use Behavior, we can conclude that the Hypothesis H7 is verified.

Note: the higher the value of the standardized coefficient, the stronger the relationship between the variables whose relationship is analyzed.

χ2 /g.l.	CFI	RMSEA	NFI
2,922	0,896	0,076	0,851

CFI – Comparative fit index; RMSEA – Root mean square error of approximation; NFI – Normed of fit index.

Table 26 - Structural model adjustment

The measures indicate an acceptable overall adjustment of the proposed model to the collected data (Tasble 26) if we consider the chi-square/df (<5), and also an acceptable adjustment if we take into account the remaining indices: RMSEA (RMSEA=0,076<0,08), CFI (CFI=0,896>0,80) and NFI (NFI=0,851>0,80).

5.10. Discussion of results

The purpose of this study was to identify the most accurate technological acceptance model for the Shipping Industry. The research model presented in this paper is unique in its integration of User Satisfaction and Trust into the UTAUT model to evaluate the determinants of users' BIs toward Use Behaviour in new technologies.

This study's findings showed several consequences. The study is based on responses obtained in the Portuguese and Spanish markets, mainly due to the greater ease of obtaining the appropriate level of participation. As expected, due to the researcher's greater knowledge of the Portuguese market, the level of responses was much higher in Portugal than in Spain. It was not intended in this study to carry out a comparative analysis between the two countries, but it is necessary to mention the great similarity of the results obtained.

The sample, with regard to the gender of the respondents, confirms the preponderance of the male sex in this Shipping Industry (sample results 80% male; 20% female) which, despite being different from the reality at a global level (only 6% in this Shipping Industry are female (UNCTAD, 2021)), demonstrates the preponderance of the male sex in this Industry.

The sample shows that 87% of the respondents have academic qualifications at the "Undergraduate" or "Master/PhD" level, which demonstrates that there is no problem of technological literacy, as we consider that these levels of academic qualifications meet the minimum necessary in terms of technological literacy that allows its users the minimum skills to be able to learn the introduction of new technologies. This result is also reinforced by the fact that there is strong

experience in the sector on the part of respondents (68% of respondents have an experience of 11 years or more in the sector). According to the McKinsey Global Institute (Madgavkar et al., 2022), experience in the role is decisive for performance and career progression. The same entity predicts that by 2030, about 375 million workers worldwide will need to change occupations or acquire new skills due to the automation and digitalization of processes. This means that the need for adaptation and constant learning will be increasingly essential for survival in the labour market. So, higher academic qualifications and long experience in the sector answers the first Research Question: "RQ1- Is Shipping an Industry where the level of technological literacy is too low?", as the theme of technological literacy is not a problem for the introduction and use of new technologies in Shipping (Table28).

The discussion of the results obtained will focus mainly on the new constructs (Digital Trust and User Satisfaction) added to the UTAUT base model. The UTAUT model is properly tested and proven, and it is intended to find a model more adjusted to the reality of Shipping. From the literature review and from the interviews with experts in the sector, this opportunity was identified, so the discussion and analysis of results will be around the new constructs and their relations proposed in the model.

The concept of trust has been addressed within many disciplines (philosophy, psychology, sociology, transaction economics, organization theory) and in technology as well (Kelton et al., 2008; Oliveira et al., 2017). According Balci (2021), “Digital trust (DT) in other words, as the belief of an individual towards a digital system regarding its reliability and punctuality in performing commercial and operational transactions”. This definition is similar to Akbari et al.(2020), who defines DT as “specific beliefs about the way that technology operates through a work environment”. Trust in information is required to provide adequate explanations of information use. Trust is the intervening variable that directly affects the use of technology (Balci, 2021; Kelton et al., 2008) and has an imperative impact on the adoption of technology (Akbari et al., 2020).

Regarding the hypotheses formulated in the study and the respective interpretation will be presented in the following paragraphs. The hypotheses formulated with the new constructs added to the UTAUT base model were given as preferential order.

According to Hypothesis 5a, it was projected that trust would affect the behavioural intention to use new technologies. The results from the study show that trust has a positive impact on the behavioural intention(β=0,171, p=0,002) in line with other studies showed and confirming the importance of this construct for a model of technological acceptance and use (Akbari et al., 2020; Bakri et al., 2023; Chan & Lee, 2021; Kapnissis et al., 2022; Korkmaz et al., 2021; Li et al., 2008; Mer & Virdi, 2021; Mubarak & Petraite, 2020) .

Surprisingly, Hypothesis 5b "Digital Trust has a significant influence on Use Behavior" was not confirmed, despite evidence suggesting that Digital Trust can positively influence technology use in certain contexts (Ghazizadeh et al., 2012; Shi et al., 2022; Yu et al., 2021; Zha et al., 2022). Mubarak & Petraite, 2020 noted that "trust embedded with digital technologies not only increases the reliability of communication channels but can significantly build trust among stakeholders." The lack of confirmation for this hypothesis may be attributed to the demographic composition of our sample, with 75% of respondents being over 41 years old. This age group typically exhibits greater resistance to digital tool adoption (Niehaves & Plattfaut, 2014). Recent research by Magsamen-Conrad, Dowd, et al., 2015 suggests that older adults' technology acceptance is more heavily influenced by factors such as perceived usefulness and ease of use, rather than trust alone.

Regarding the relations of other constructs with Digital Trust, namely Performance Expectancy and Effort Expectancy, the hypotheses identified are confirmed. Indeed “Hypothesis 1c: Performance Expectancy has a significant influence on Digital Trust” it’s confirmed - shows a positive and statistically significant standardized coefficient (β=0,317, p<0,001). This result was obtained in other studies (Adiratna & Wulansari, 2021; Akbari et al., 2020; Chan & Lee, 2021; Koufaris & Hampton-Sosa, 2004; Primanda et al., 2020) The “Hypothesis 3c: Effort Expectancy has a significant influence on Digital Trust” it’s also confirmed - shows a positive and statistically significant standardized coefficient (β=0,344, p<0,001) and this can be verified as well in other studies (Akbari et al., 2020; Chan & Lee, 2021; Koufaris & Hampton-Sosa, 2004; Primanda et al., 2020).

As a result of this study, it was discovered that the Performance Expectancy and Effort Expectancy had a beneficial influence on Trust, which in turn had a good impact on behavioral intention and actual usage of new technologies. Other research have found similar results (Akbari et al., 2020; Koufaris & Hampton-Sosa, 2004; Primanda et al., 2020).

DeLone & McLean (2003), emphasize “user satisfaction and usage are closely interrelated, and this relationship is rigorously researched in IS literature”. Increased user satisfaction will lead to increased intention to use, and thus use (DeLone & McLean, 2003). According Özecan & Arıkan (2022), “Satisfaction from using a service is vital as users decide on their future responses regarding their continuance intention to use it based on their experience”. Esawe (2022) posited that satisfaction is critical for explaining consumer adoption. This author says, “satisfaction and perceived enjoyment as antecedents of behavioral intention and adoption of e-wallets.”

According to “Hypothesis 3b: Effort Expectancy has a significant influence on the Users Satisfaction”, the relationship between the Effort Expectancy and the User Satisfaction shows a positive and statistically significant standardized coefficient (β=0,346, p<0,001), in line with other

studies. In fact we founded similar results in other studies(Chao, 2019; Esawe, 2022; Maillet et al., 2015; Mussa et al., 2022).

The "Hypothesis 1b - Performance Expectancy has a significant influence on the Users Satisfaction" shows a positive but not significant standardized coefficient (β=0.074, p=0.196), a finding consistent with some previous studies (Chao, 2019; Maillet et al., 2015). This result may be attributed to the age distribution of our sample. Research by (Czaja et al., 2006) suggests that older adults' satisfaction with technology is more closely linked to factors such as perceived ease of use and social influence rather than performance expectancy. Furthermore Oreg & Sverdlik (2011), found that in industries undergoing digital transformation, such as shipping, user satisfaction is often mediated by factors like change readiness and organizational support.

The "Hypothesis 2 - User Satisfaction has a significant influence on the Behavioral Intention of using new technologies" shows a negative and statistically significant standardized coefficient (β=-0.106, p=0.035). While this hypothesis is confirmed, the negative β value presents an intriguing result that warrants further investigation. This unexpected finding may be related to the unique characteristics of the shipping industry. The sector's inherent conservatism, coupled with the rapid pace of digital innovations, could lead to a paradoxical situation where increased satisfaction with current systems decreases the intention to adopt new technologies. This phenomenon, known as the "satisfaction-complacency paradox," has been observed in other traditional industries undergoing digital transformation (Ceaparu et al., 2004). Additionally, Laumer et al.(2017) work on technology adoption in high-stakes environments suggests that satisfaction with existing systems can sometimes create resistance to change, particularly when users perceive high risks associated with new technology implementation.

Regarding "Hypothesis 4: Social Influence has a significant influence on the Behavioral Intention of using new technologies," our study did not find support for this relationship. This finding can be explained by several factors. Firstly, as noted by DeLone & McLean (2003), the mandatory use of technologies in a corporate environment does not necessarily guarantee their adoption and effective use. Users may not feel compelled to adopt new technologies even under workplace pressure. Recent research by Bellet et al.(2023) and Venkatesh et al.(2016) in the context of digital transformation in traditional industries supports this view, suggesting that perceived organizational support and individual innovativeness play a more significant role than social influence in technology adoption intentions.

Regarding“Hypothesis 6: Facilitating Conditions has a significant influence on the Use behavioral”, the study did not support this relationship. Our major findings about this result are mainly attributed

to the age distribution of our sample and the sector's conservatism (Ceaparu et al., 2004; Niehaves & Plattfaut, 2014).

The other hypotheses of the proposed model, which were confirmed (Hypotheses 1a, 3a and 7 – hypotheses tested in the UTAUT model), confirm the hypotheses that served as the basis for the UTAUT base model (Venkatesh et al., 2003). As expected, these hypotheses are also confirmed in several studies that support their research, also based on the UTAUT model.

5.11. Conclusions – Analysis of results

Bearing in mind the proposed model and the hypotheses formulated, a summary of the respective results is presented in Table 27. Its interpretation has been set out in Section 5.10. We can as a synthesis say that, as expected, the relationship with the constructs of the UTAUT base model are aligned with the basic theoretical model. The new constructs helped to increase the predictive capacity of the model as we will see below.

Hypothesis Formulated		Verification
H1a	*Performance Expectancy has a significant influence on the Behavioral Intention*	**Verified**
H1b	*Performance Expectancy has a significant influence on the Users Satisfaction*	**Not verified**
H1c	*Performance Expectancy has a significant influence on Digital Trust*	**Verified**
H2	*: User Satisfaction has a significant influence on the Behavioral Intention of using new technologies*	**Verified**
H3a	*Effort Expectancy has a significant influence on the Behavioral Intention of using new technologies*	**Verified**
H3b	*Effort Expectancy has a significant influence on the Users Satisfaction*	**Verified**
H3c	*Effort Expectancy has a significant influence on Digital Trust*	**Verified**
H4	*Social Influence has a significant influence on the Behavioral Intention of using new technologies*	**Not verified**
H5a	*: Digital Trust has a significant influence on the Behavioral Intention of using new technologies*	**Verified**
H5b	*Digital Trust has a significant influence on the Use Behavior*	**Not verified**
H6	*Facilitating Conditions has a significant influence on the Use behavioral*	**Not verified**
H7	*Behavioral Intention of using new technologies has a significant influence on the Use behavioral*	**Verified**

Table 27- Hypothesis Verification

Regarding the Research Questions formulated, Table 28 presents the respective summarized analysis.

Research Questions (RQ)	Verification	Literature Review
RQ1 -Is Shipping an Industry where the level of technological literacy is too low?	No problem with technological literacy	Madgavkar et al., 2022; UNCTAD, 2021; Author Analysis
RQ2- Could we improve the accuracy of a technological acceptance model specifically for Shipping?	The proposed Model has a higher explanatory power compared with the technological acceptance Model UTAUT	Venkatesh et al., 2003

Table 28 - Research Questions Verification

Regarding the first Research Question: "RQ1- Is Shipping an Industry where the level of technological literacy is too low?", as presented in the previous section, the theme of technological literacy is not a problem for the introduction of new technologies.

The answer to “RQ2- Could we improve the accuracy of a technological acceptance model specifically for Shipping?” is affirmative. In fact, the UTAUT S model proposed for the Shipping Industry has a significantly higher capacity and accuracy than the UTAUT base model (Table 28).

This study contributes to an expanded model of UTAUT, in which the incorporation of the constructs Digital Trust and User Satisfaction reinforce and help to understand better the user’s intentions to use technologies.

Compared to empirical results of the UTAUT model, which explain about 70% of the variations (Venkatesh et al., 2003) the UTAUT S proposed model shows significant improvement in explanatory and predictive power of the model. The model has an R2 of 90%, thus presenting a much higher explanatory capacity than the UTAUT model(Venkatesh et al., 2003).

6. Conclusions

6.1. General Considerations

This study investigated a specific model for new technologies adoption for the Shipping Industry. The study was based on the UTAUT model, which offers the best explanatory capacity compared to any other model, but which needs to have the necessary adjustments for each specific framework. This study provides a holistic and comprehensive understanding of what triggers and inhibits new technologies adoption for the Shipping Industry by proposing an integrated model based on UTAUT model, contributing to filling a gap that currently exists (as we can explain in section 6.2).

Data were collected from 337 participants that works in several entities all of them belonging to the Shipping value chain. These participants in the study, all from the Shipping area, 90.5% from Portugal and 9.5% from Spain, have a socio-demographic characterization that is not far from each other and in some parameters (namely gender and age) very close to that reported by the report of the UNCTAD (2021). The sample of this study is mainly characterized by belonging to a high age group (87% over 41 years old) and with a high level of qualification (87% undergraduate or above).

Regarding the objective pursued by this thesis "develop a model of acceptance and use of new technologies specifically for the Shipping Industry", we can confidently state that this goal has been achieved. The proposed model demonstrated superior explanatory power compared to the base UTAUT model, with an R^2 value of 0.902 for Behavioral Intention, significantly higher than the 0.6-0.7 range reported by Venkatesh et al.,(2003). This improvement can be attributed to the incorporation of two additional predictor variables: digital trust and user satisfaction. These additions reflect the substantial developments in digital technologies since the original UTAUT model was developed in 2003. Recent meta-analyses of technology acceptance models in industry-specific contexts have highlighted the importance of contextualizing and extending established models to capture industry-specific nuances, which our study successfully accomplishes for the shipping industry(Dwivedi et al., 2019).

The results revealed positive influences of Performance Expectancy (PE), User Satisfaction (US), Digital Trust (DT) and Effort Expectancy (EE) on Behavior Intention (BI).

The results revealed that the model had high internal consistency and reliability, thereby indicating that the proposed model possesses substantial explanatory power. This study revealed that satisfaction and digital trust is a key factor that significantly influences user's BIs toward using new technologies.

This study is agnostic regarding any technology or any specific area of the value chain. It appears that while the UTAUT has been found to be a strong and versatile predictive model across contexts, it

is the power of the constructs in the model to predict users' intentions that can vary depending on the specific form of technology under study (Or & Chapman, 2021).

6.2. Theoretical Contributions

The study investigated the reasons for the new technologies' adoption across the Shipping value chain by analysing individual's propensity and resistance to technology adoption. We contribute to the literature by proposing an extension of the model based on UTAUT adding new constructs (Digital Trust and User Satisfaction) that aims to provide a better holistic and comprehensive understanding of what triggers and inhibits new technologies adoption.

This proved to be the case, as the R2 value of the proposed model, with regard to Use Behaviour was 0.921, distinctly higher than the value of the UTAUT base model presented, resulting in R^2 value of 0.7 (Venkatesh et al., 2003).

Shipping offers a wide range of opportunities for the introduction of new technologies (Aiello et al., 2020), UTAUT model delivers the highest explanatory power of all standard acceptance models (Venkatesh et al., 2003), the UTAUT model can be improved by the introduction of new factors (Chao, 2019; Khalilzadeh et al., 2017) and there is a lack of research in this area (Tijan et al., 2021). We contributed to close a gap in the literature by adding the constructs of Digital Trust and User Satisfaction to the base model of UTAUT obtaining a much more powerful model, to better understand the new technologies acceptance in the Shipping Industry.

Our results provide additional insights into the positive relationships among users' Performance Expectancy (PE) and Effort Expectancy(EE) with User Satisfaction(US) and Digital Trust (DT), and their intention to use new technologies. By a closer look at the discovered relationships and corroborating the existing literature, our findings show connections among PE, EE, US, DT and the intention to use new technologies. This provides empirical evidence concerning the intention to use new technologies in general.

The findings of this study support the utility of the UTAUT model with the additional variables in predicting the usage of new technologies. The strength of this study lies in the extension of the well-validated UTAUT theory with user satisfaction and digital trust. This is proved by the high explanatory power of our model.

6.3. Managerial Contributions

This proposed model provides a useful tool for managers in the Shipping Industry needing to assess the likelihood of success for new technology introductions and helps them understand the drivers of

acceptance to proactively design interventions including training, marketing and communication programs.

Respondents to the survey acknowledge that there is an effort on the part of companies/entities in the process of digitization or introduction of new technologies, although they recognize that from the point of view of adopting new technologies they are lagging when compared to other industries.

This industry is clearly conservative, and the adoption of new technologies is taking place at a slower pace and there is not, in general terms, a distinguishing factor in their use when compared to other industries.

Digital transformation is a determining factor for the development of the entire economy and consequently Shipping. It is therefore necessary that managers and decision-makers in this industry can design strategies to accelerate the digitalization of their main management, technical or administrative processes.

The existing positive relationships between Performance Expectancy (PE) and Effort Expectancy (EE) with Digital Trust (DT), and between DT and Behavioral Intention (BI), provide valuable insights for managers in the shipping industry. These relationships indicate favorable conditions for implementing new technologies to support business processes, both technical and managerial. Users recognize the importance of these tools for efficient task execution and increased confidence in their work. This aligns with recent findings by Alalwan et al. (2018), who observed that in industries undergoing digital transformation, the perceived usefulness and ease of use of new technologies significantly influence trust, which in turn drives adoption intentions.

In characterizing our sample, we found that while 87% of respondents have at least a bachelor's degree, indicating a baseline level of technological literacy, approximately 75% are over 41 years old. This age group, regardless of educational background, tends to show more resistance to new digital tools (Niehaves & Plattfaut, 2014). Research by Czaja et al. (2006), suggests that older professionals in traditional industries like shipping may require more targeted support and training to overcome initial resistance to new technologies. This finding highlights the need for age-sensitive approaches to technology implementation in the shipping industry.

The positive relationship between Effort Expectancy (EE) and User Satisfaction (US) suggests that increased ease of use of digital tools correlates with higher levels of user satisfaction. This finding aligns with recent work by Marangunić & Granić (2015), who found that in industries undergoing digital transformation, user-friendly technologies not only increase satisfaction but also drive productivity gains. Industry leaders should capitalize on this by prioritizing user experience in technology selection and implementation. Furthermore, as suggested by Venkatesh & Bala (2008), facilitating the execution of tasks through intuitive digital tools can create a positive feedback loop, where increased satisfaction leads to greater technology acceptance and, consequently, improved productivity

The relationship between Effort Expectancy and User Satisfaction also indicates that the greater the use of digital tools, the higher the level of user satisfaction. This factor should be taken advantage of by those responsible so that, facilitating the execution of tasks using digital tools, they increase the level of user satisfaction and consequently the level of productivity.

It is therefore essential, if not even mandatory, in this Industry that the introduction of new digital tools is preceded by an adequate process of information and training for all intervenient to ensure their easier adoption and use.

6.4. Limitations and suggestions for future investigations

Throughout this study several workstreams were identified concerning this subject that may justify further research effort. Almost 90.5% of the participants that answered the questionnaire were from one country (Portugal). Even though the remaining 9,5% (from Spain) show very similar results to those obtained by the Portuguese respondents, it would be good to have a broader multinational base. Future research can investigate their differences between countries. Researchers can also examine if our results can be generalized to countries with relatively mature Shipping Industry. This may provide richer insights on user adoption around the world. To increase the generalizability of the results the scope of respondents should be expanded for other countries.

The model presented in this study can be tested in various countries, especially those with different levels of Shipping Industry development (for example, in Europe, namely UK, Greece, Turkey or Danmark, where the Shipping Industry is very developed).

This study adopted a cross-sectional rather than a longitudinal approach as in the original UTAUT. Longitudinal research may provide more insights on how user adoption behaviour changes over time. Longitudinal research accounts for changes in consumers' User Behaviour to adopt a technology over time and is particularly useful for populations that are in an early stage of adoption. (Migliore et al., 2022). User behaviour is dynamic and constantly changing (Zhou et al., 2010).

Furthermore, the study employed quantitative research methods, whereas qualitative evaluation might offer more reasons for the hypothesized constructs' correlations.

This study looks at the Shipping value chain globally. Within each of the key areas in the value chain, would be needed to carry out a more detailed assessment.

Future research can also consider other theories such as perceived value theory and explore the effects of other factors such as cost.

Another axis of development would be to map in the value chain, the digital reference tools and the existing gaps for a desirable situation of global integration.

7. Bibliography

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8. Annexes

Annex A presents the surveys carried out in Spain and Portugal in their respective languages. Annex B presents a table with the relationship between the Model Constructs and the respective sources. Annex C presents graphs referred to in the text.

8.1. Annexe A – Questionnaire

- **Portuguese**

"Caro…..

Estou neste momento no ISCTE-Lisboa a desenvolver uma tese de doutoramento na área do "Shipping - adopção de novas tecnologias" e venho solicitar a sua participação no preenchimento deste inquérito (aproximadamente 10 minutos).

O futuro da indústria marítima depende do processo de transformação digital e requer sistemas adequados e devidamente integrados entre si. Espera-se que a rede digitalizada e inteligente de dados traga vantagens significativas para esta indústria. A tendência da digitalização dos processos no Shipping é evidente, mas ainda está numa fase preliminar sendo o nível actual considerado baixo quando comparado com outros sectores industriais.

A indústria marítima é, portanto, um dos setores-chave para a transformação digital. Com seu alto grau de complexidade e seu grande número de interfaces, a logística marítima oferece uma ampla gama de aplicações para tecnologias digitais.

O inquérito solicita para cada questão a opção de resposta de "Concordo Totalmente" a "Discordo Totalmente" para cada uma das afirmações.

O conceito de "Novas Tecnologias" deve ser entendido como ferramentas informáticas/digitais usadas na gestão dos diferentes processos (técnico, comerciais, administrativos).

As respostas são anónimas e serão usadas no âmbito do estudo em questão.

Agradecemos o tempo que irá dedicar e caso esteja interessado em receber o estudo deixe por favor mensagem para Rui Reis (rui_reis@iscte-iul.pt).

A – Identificação

- Idade : 20-30 __;31-40__;41-50__;>50__

- Genero: M__;F___;

- Habilitaçôes académicas : Ensino Secundario___;Licenciatura__;Mestrado/PhD___

- Função : Comercial___;Operações___; IT___; Outra__

- Nível : Administração __;Direcção__;Tecnico__

- Experiencia na função(anos) : <5__;5-10__;10-15__;>15__

- Sector Empresa/Entidade:

  Companhia de Navegação__

  Despachante__

  Agente de Navegação__

  Estaleiro__

  Empresas fornecedoras serviços __

  Entidade Governamental__

  Ensino Superior__

-Caracterização Geral

	Perguntas	Concordo totalmente	Concordo	Indiferente	Discordo	Discordo totalmente
1	A minha Organização faz um esforço relevante para adquirir novas tecnologias					
2	Acho que o sector do Shipping está mais atrasado na introdução das novas tecnologias comparado com as restantes industrias					

B - Questionário

Construct		Perguntas	Concordo totalmente	Concordo	Indiferente	Discordo	Discordo totalmente
Performance Expectancy	1	O uso de novas tecnologias no meu trabalho permite-me realizar as tarefas mais rapidamente					
	2	O uso de novas tecnologias melhora o meu desempenho no trabalho					
	3	Usar novas tecnologias no meu trabalho aumenta a minha produtividade					
	4	Usar novas tecnologias aumenta a minha eficácia no trabalho					
	5	Usar novas tecnologias facilita o meu trabalho					
	6	Eu acho as novas tecnologias úteis no meu trabalho					
Effort Expectancy	7	Aprender novas tecnologias é fácil para mim					
	8	Acho fácil fazer com que as novas tecnologias realizem o que eu pretendo					
	9	As minhas interações com novas tecnologias são claras e compreensíveis					
	10	Eu acho que as novas tecnologias são claras e compreensíveis					
	11	É fácil para mim tornar-me competente em usar novas tecnologias					
	12	Eu acho que as novas tecnologias são fáceis de usar					
Social Influence	13	Pessoas que são importantes para mim pensam que eu devo usar as novas tecnologias					
	14	Eu provavelmente usaria novas tecnologias se as pessoas que influenciam o meu comportamento acham que eu as deva usar					
	15	Pessoas cujas opiniões eu valorizo gostariam que eu usasse novas tecnologias					
Facilitating Conditions	16	Eu tenho os recursos necessários para usar novas tecnologias					
	17	Eu tenho o conhecimento necessário para usar novas tecnologias					
	18	Posso obter ajuda de outras pessoas quando tenho dificuldades em usar novas tecnologias					
Digital Trust	19	As minhas transações via produtos digitais são realizadas como esperado					
	20	As minhas transações via produtos digitais são realizadas no prazo esperado					
	21	Eu não preciso confirmar manualmente as minhas transações quando utilizo produtos digitais					
Behavioural Intention	22	Pretendo continuar a usar as novas tecnologias no futuro					
	23	Vou sempre tentar usar as novas tecnologias no meu dia-a-dia					
	24	Pretendo continuar a usar as novas tecnologias com frequência					
se Be	25	Se eu tivesse a oportunidade de usar novas tecnologias, fá-lo-ia					

	26	Se eu puder usar as novas tecnologias na minha função,fá-lo-ei					
	27	Vou usar as novas tecnologias no futuro					
User Satisfaction	28	Globalmente, os nossos utilizadores estão satisfeitos com os serviços digitais que dispomos					
	29	Os serviços digitais existentes excedem as expectativas dos utilizadores					
	30	Os serviços digitais existentes estão próximos da minha ideia					

- Spanish

“Caro….

El futuro de la industria marítima depende del proceso de transformación digital y requiere sistemas adecuados y adecuadamente integrados. Se espera que la red de datos digitalizada e inteligente aporte beneficios significativos a esta industria. La tendencia de digitalización de procesos en Shipping es evidente, pero todavía se encuentra en una etapa preliminar y el nivel actual se considera bajo en comparación con otros sectores industriales.

La industria marítima es, por tanto, uno de los sectores clave para la transformación digital. Con su alto grado de complejidad y su gran número de interfaces, la logística marítima ofrece una amplia gama de aplicaciones para las tecnologías digitales.

Solicitamos su participación en esta encuesta, como parte fundamental de una tesis doctoral en el área de Transporte Marítimo/Nuevas Tecnologías (Autor - Rui Reis; Institución - ISCTE Lisboa). El cuestionario tiene cómo opción de respuesta desde “Estoy totalmente de acuerdo” a “Totalmente en desacuerdo” para cada una de las preguntas.

El concepto de “Nuevas Tecnologías” debe entenderse como herramientas informáticas/digitales utilizadas en la gestión de diferentes procesos (técnicos, comerciales, administrativos).

El tiempo de respuesta estimado del cuestionario es inferior a 10 minutos. Agradecemos el tiempo que ha dedicado y si está interesado en recibir el estudio, envíe un correo a rui_reis@iscte-iul.pt.

Identificacion

- **Edad** :

  20-30 __;31-40__;41-50__;>50__

- **Género**:

  M__;F___;

- **Titulaciones académicas**:

  Enseñanza Secundaria___; Licenciado__; Máster/PhD___

- **Funcion**:

  Comercial___; Operaciones___; IT___; Otra__

- **Nível**:

  Administración __; Técnico __; Direcion __

- **Experiencia en el cargo (años):**

  <5__; 5-10__; 10-15__; >15__

- **Sector/Empresa/Entidad**:

  Compañía de Navegación (Shipping line)__

  Transitario (Freight Forwarder)__

  Agencia Marítima (Shipping Agency)__

  Astillero (Shipyard)__

  Empresas provedoras de servicios __

  Entidad gubernamental ___

  Enseñanza Superior__

Cuestionario:

Constructs		Preguntas	Totalmente de acuerdo	De acxuerdoo	Indiferente	En desacuerdo	Totalmente en desacuerdo
Performance Expectancy	1	El uso de nuevas tecnologías en mi trabajo me permite realizar tareas más rápido					
	2	El uso de nuevas tecnologías mejora mi rendimiento en el trabajo					
	3	Usar nuevas tecnologías en mi trabajo aumenta mi productividad					
	4	El uso de nuevas tecnologías aumenta mi eficacia en el trabajo					
	5	El uso de nuevas tecnologías facilita mi trabajo					
	6	Encuentro las nuevas tecnologías útiles en mi trabajo					
Effort Expectancy	7	Aprender nuevas tecnologías es fácil para mí					
	8	Me resulta fácil hacer que las nuevas tecnologías logren lo que pretendo					
	9	Mis interacciones con las nuevas tecnologías son claras y comprensibles					
	10	Creo que las nuevas tecnologías son claras y comprensibles					
	11	Es fácil para mí llegar a ser competente en el uso de nuevas tecnologías					
	12	Creo que las nuevas tecnologías son fáciles de usar					
Social Influence	13	Las personas que son importantes para mí piensan que debería usar nuevas tecnologías					
	14	Probablemente use nuevas tecnologías si las personas que influyen en mi comportamiento piensan que debería usar					
	15	Personas cuyas opiniones valoro le gustaría que usara nuevas tecnologías					
Facilitating Conditions	16	Tengo los recursos para usar nuevas tecnologías					
	17	Tengo los conocimientos necesarios para utilizar las nuevas tecnologías					
	18	Puedo obtener ayuda de otros cuando tengo dificultades para utilizar nuevas tecnologias					
Digital Trust	19	Mis transacciones a través de productos digitales se llevan a cabo según lo esperado					
	20	Mis transacciones a través de productos digitales se llevan a cabo en el tiempo esperado					
	21	No necesito confirmar manualmente mis transacciones cuando uso productos digitales					
Behavioural Intention	22	Tengo la intención de seguir usando nuevas tecnologías en el futuro					
	23	Siempre trataré de usar nuevas tecnologías en mi vida diaria					

	24	Planeo continuar usando nuevas tecnologías con frecuencia					
Use Behaviour	25						
	26	El uso de nuevas tecnologías es una forma de ahorrar dinero					
	27	El uso de las nuevas tecnologías favorece el desarrollo de las empresas					
User Satisfaction	28	Nuestros usuarios están satisfechos con los servicios digitales que tenemos					
	29	Los servicios digitales existentes superan las expectativas de los usuarios					
	30	Los servicios digitales existentes están cerca de mi idea					

8.2. Annexe B – Relation between Constructs and sources

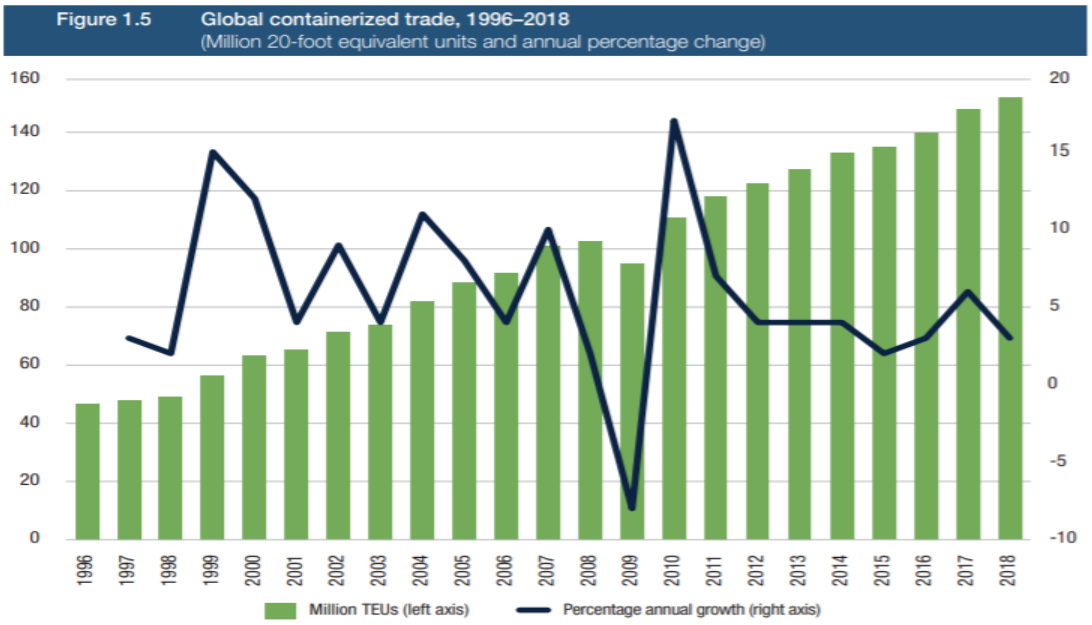
Table 29 - Relation between Constructs and sources

Construct	Code	Description	Source
Perceived Usefulness	PU1	Using technologies in my job would enable me to accomplish tasks mor quickly	TAM; UTAUT
	PU2	Using technologies would improve my job performance	
	PU3	Using technologies in my job would increase my productivity	
	PU4	Using technologies would enhance my effectiveness on the job	
	PU5	Using technologies would make it easier to my job	
	PU6	I would find technologies useful in my job	
Perceived Ease of Use	PE1	Learning new technologies would be easy for me	TAM; UTAUT
	PE2	I would find it easy to get new technologies to do what I want it to do	
	PE3	My interactions with new technologies would be clear and understandable	
	PE4	I would find new technologies would be clear and understandable	
	PE5	It would be easy for me to become skilful at using new technologies	
	PE6	I would find new technologies easy to use	
Social Influence	SI1	People who are important to me would think that I should use new technologies	UTAUT
	SI2	I would probably use new technologies if people who influence my behaviour think that I should use new technologies	
	SI3	People whose opinions I value would like me to use new technologies	
Facilitating Conditions	FC1	I have the resources necessary to use new technologies	UTAUT
	FC2	I have the knowledge necessary to use new technologies	
	FC3	The system is not compatible with other systems I use	
Digital Trust	DT1	My transactions via digital products are performed as expected	Balci, 2021
	DT2	My transactions via digital products are performed on time	
	DT3	I do not need to make my transactions confirmed manually when I use digital products	
Behavioural Intention	BI1	I am motivated to use new technologies	UTAUT
	BI2	I think we should use new technologies as much as possible	
	BI3	I recommend using new technologies	
Use Behaviour	UB1	The use of new technologies is independent of suppliers	UTAUT
	UB2	Using new technologies is a way to save money	
	UB3	Using new technologies favours the development of business	
User Satisfaction	US1	Overall, our users are satisfied with the digital services we provide	Shahid Iqbal et al., 2018
	US2	The digital services offered exceed the user expectations	
	US3	The digital services offered are close to my idea	

8.3. Annexe C - Graphics



Graphic C1 - Evolution of world merchandise trade (1950-2019)



Graphic C2 - Global containerized trade (1996-2018)