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Quality, Safety, and Security Systems in the Greek Port Industry: Over Twenty Years of Research, Empirical Evidence, and Future Perspectives

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Abstract: *Background*: Quality, Safety and Security are embedded in all aspects of port operations and are crucial for port industry stakeholders. Over the past decades, numerous assurance systems, codes, and regulations for quality, safety, and security have been developed and implemented in ports world-wide. This paper examines key insights for the implementation those systems in ports, reviewing over 20 years of empirical research on the impact and outcomes of such systems in Greek ports and internationally. *Methods*: It compares and discusses evidence from two empirical surveys spanning the first two decades of the 21rst century. The first survey was conducted in 2011 (with evidence from 2000 to 2011) including 12 major Greek ports (SAs) and the second one was conducted up to 2022–2023, including 23 over 25 Greek ports (the same SAs and other ones from the Greek TEN-T network). *Results*: The higher-level scope of this paper is to investigate critical perspectives on and trends in quality, safety, and security systems in the port industry. *Conclusions*: This investigation aims to strengthen the assumption that quality, safety, and security play a pivotal role in shaping the image, performance, and growth of ports.

Keywords: port industry; quality; safety; security; Greece; ISPS code; ISO 9001; ISO 14001; EMAS; PERS

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1. Introduction

The implementation of quality, safety, and security systems in the port domain is a marvel of integration [1]. A holistic approach serves the purposes of a port by supporting strategic planning and operational targets, facilitating efficient decision-making processes, delineating responsibilities, encouraging collaboration and synergies, and promoting better implementation of decisions. This fosters internal alignment on port processes, operations, services, and development, while also projecting a strong ethical stance outward into the highly competitive environment [2]. At the same time, it cultivates a management environment conducive to learning and development. Ports consistently strive for quality, safety, and security, driven by their dynamic for advancement, the nature and complexity of the services they provide, the increasing requirements and pressures from stakeholders—especially regulators—and the necessity to mitigate the external impacts stemming from their existence and operations [3]. Quality, safety, and security help ports build a strong foundation for business growth and development, strengthen their market position, enhance reliability and reputation, optimize efforts and resource allocation, and promote better relations with the surrounding city. Moreover, these elements are now considered indispensable features of a modern smart port, a topic that has sparked active discussion among scholars in recent years [4–9], often in conjunction with the subject of port performance [10–12].

Over the past decades, a wide array of voluntary and/or compulsory quality, safety, and security systems have been made available for ports around the world [13,14]. Indeed, a vast number of successful implementations are presented in the literature in respect of quality, safety, and security across maritime transport and the port industry. While numerous successful implementations are documented in the literature across maritime transport and the port industry, the introduction and implementation of these systems occur non-uniformly across different regions and over time [15,16]. Moreover, each port is unique and the experience to date demonstrates that each case is different when it comes to quality, safety, and security systems implementation. The literature highlights the need for additional empirical research to gain a comprehensive understanding of the application of quality, safety, and security systems [17].

The higher-level scope of this paper is to investigate critical perspectives and trends on quality, safety, and security systems in the port industry. This investigation aims to strengthen the assumption that quality, safety, and security play a pivotal role in shaping the image, performance, and growth of ports. At a granular level, we first study the relevant literature and thereafter we present evidence on the implementation of quality, safety, and security systems within the port industry in Greece over a period of over two decades, from 2000 to 2011, as reported in [17], up to 2022–2023. The recent empirical research conducted between 2022 and 2023 is based on a specially designed structured interview format distributed to representatives of all major Greek ports, comprising twenty-five Greek Trans-European Transport Network (TEN-T) ports, of which five belong to the "Core TEN-T Corridor" and the remaining twenty to the "Comprehensive TEN-T Corridor" (see Section 2.1 and 2.2 below). Greek ports hold significant strategic importance, not only due to their geographical location at the crossroads of major international trade routes but also as vital hubs within the TEN-T. The focus on major Greek ports, therefore, allows for a detailed examination of street-level implementation while drawing conclusions on a wider scale, offering valuable insights into European and global transport trends.

This investigation offers a picture of the current situation in 23 ports, providing valuable empirical evidence and insights. Furthermore, the earlier empirical research results of Chlomoudis et al. [17] is compared to the recent results, encompassing twenty years of research, empirical evidence, and perspectives on the port industry in Greece. Drawing from this comparative qualitative analysis, several notable challenges in quality, safety, and security management are identified and discussed. These include internal dependencies and port maturity, as well as external and situational influences shaped by, for instance, the legislative framework of the EU, particularly for major European ports.

2. Background

2.1. The TEN-T Network

With the Maastricht Treaty, EU member states committed in the early 1990s to establishing robust and efficient European networks encompassing transport, energy, and telecommunications (Trans-European Networks—TENs). In 1996, the Council and the European Parliament adopted the first guidelines for the establishment of a TEN-T policy under Decision No 1692/96/EU [18]. The TEN-T policy focused on developing a network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports, railway terminals, transport systems, and transport services across Europe. Its aim was to organize policy efforts to enhance transport infrastructure and systems, promote their efficient management and use, and enable the establishment and operation of sustainable and efficient transport services. The 2013 revision provided TEN-T guidelines for the following decade, setting out objectives, priorities, and modalities [19,20]. The latest revision of the TEN-T framework was introduced through Regulation (EU) 2024/1679, which established updated guidelines for the development of the Trans-European Transport Network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010, and repealing Regulation (EU) No 1315/2013 [21,22], alongside Regulation (EU) 2021/1153, which established the Connecting

Europe Facility and repealed Regulations (EU) No 1315/2013, (EU) No 283/2014, and (EU) No 913/2010 [23].

The TEN-T is designed to connect all Member States and regions of the Union, promoting European territorial cohesion, and facilitating transport needs within the EU, as well as connections with neighboring countries and regions. It also seeks to promote intermodal transport development, ensuring its benefits for various stakeholders, namely transport service providers and users, producers and consumers, economic entities operating in the Union, and European citizens. According to the new Regulation, the TEN-T consists of three layers: the Core Network, the Extended Core Network, and the Comprehensive Network, with the Core and Extended Core Networks built upon the Comprehensive Network. The Core Network includes the most important connections between major cities and nodes and must be completed by 2030. The Extended Core Network has a completion deadline of 2040, ten years later. The Comprehensive Network, which connects all regions of the EU to the Core Network, is set to be completed by 2050. The TEN-T also includes European Transport Corridors of the highest strategic importance, based on priority sections of the Trans-European Transport Network and projects of common interest. Furthermore, the Regulation sets out priorities for the development of the network and provides measures for its implementation [23].

Seaports serve as crucial nodes in the development of the TEN-T, promoting maritime transport and facilitating intermodal connections within the EU. They also play a key role in shifting cargo flows from land to maritime or intermodal transport with a significant maritime component. The inclusion of seaports in the TEN-T is essential for creating a balanced intermodal transportation network, offering greater opportunities for greener, more environmentally friendly modes of transport. This, in turn, would significantly enhance environmental benefits, reduce negative externalities, and promote greater sustainability within the transport system [24]. Strengthening seaports and integrating them into intermodal corridors and logistics chains is a major challenge. The TEN-T framework guides efforts in the port industry across short, medium, and long-term horizons, presenting both challenges and opportunities for ports to enhance their quantitative and qualitative characteristics. Ensuring quality services, safety, and security is increasingly vital within this context.

2.2. The Greek Port System

The Greek port system is an essential part of the country's transportation infrastructure and a key contributor to its economy. Acting as crucial nodes, Greek ports serve multiple functions simultaneously within both the Greek and European system. They facilitate inland and international trade, as well as passenger traffic, fostering connectivity and territorial cohesion within Greece and across Europe. Comprising various facilities such as major container and cargo terminals, ferry terminals, cruise ports, and smaller regional ports, the port system caters to diverse needs. Greek ports are continuously advancing through public and private investments in infrastructure, technology, and logistics to bolster their competitiveness and efficiency in the global maritime industry. Moreover, the rigorous implementation of quality, safety, and security systems ensures that Greek ports adhere to international standards, providing reliable and secure services to vessels, cargo, and passengers.

As shown in Figure 1, Greece had a total of twenty-five seaports within the TEN-T network until the adoption of Regulation (EU) 2024/1679. Among these, five were designated as "Core TEN-T" ports, with the remainder classified as "Comprehensive TEN-T" ports. With the new Regulation, the number of "Comprehensive TEN-T" ports increased to thirty-five, incorporating additional ports that meet the set requirements, thus bringing these ports into a stronger policy focus for further improvements in quality, safety, and security. The implementation of quality, safety, and security management systems among seaports within TEN-T in Greece ensures adoption of broader international and European management principles and policies. In the new framework, the former Orient/East-Med Core TEN-T corridor (see Figure 2) was replaced by the Baltic Sea–Black Sea–Aegean Sea

and Western Balkans–Eastern Mediterranean corridors (see Figure 3), encompassing the Greek Core TEN-T ports [25].

Figure 1. Trans-European Transport Network ports in Greece. Source: TENtec Public Portal and authors, 2024.

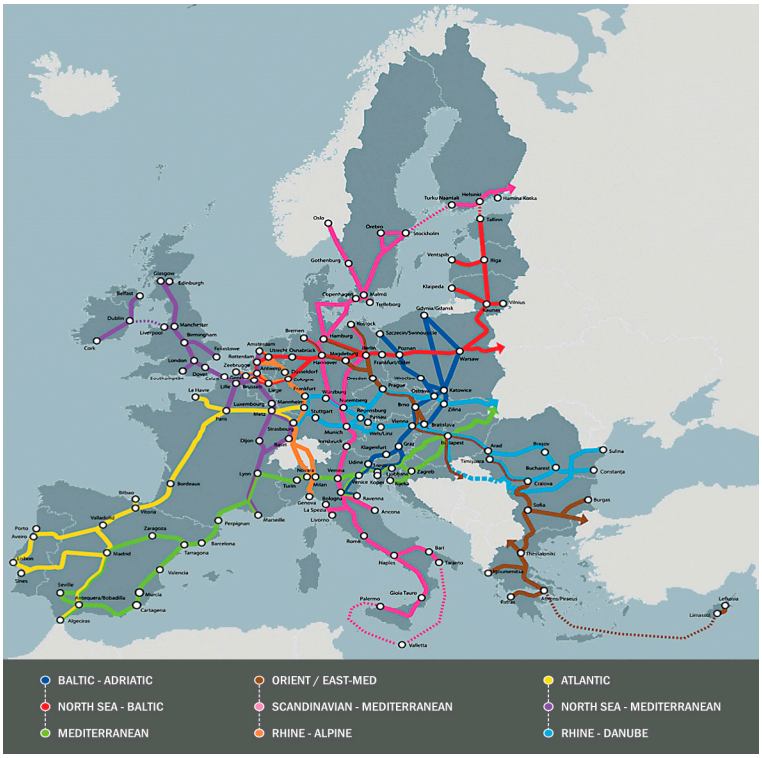

Figure 2. Trans-European Transport Network corridors, Regulation (EU) 1153/2021. Source: TENtec Public Portal and authors, 2024.

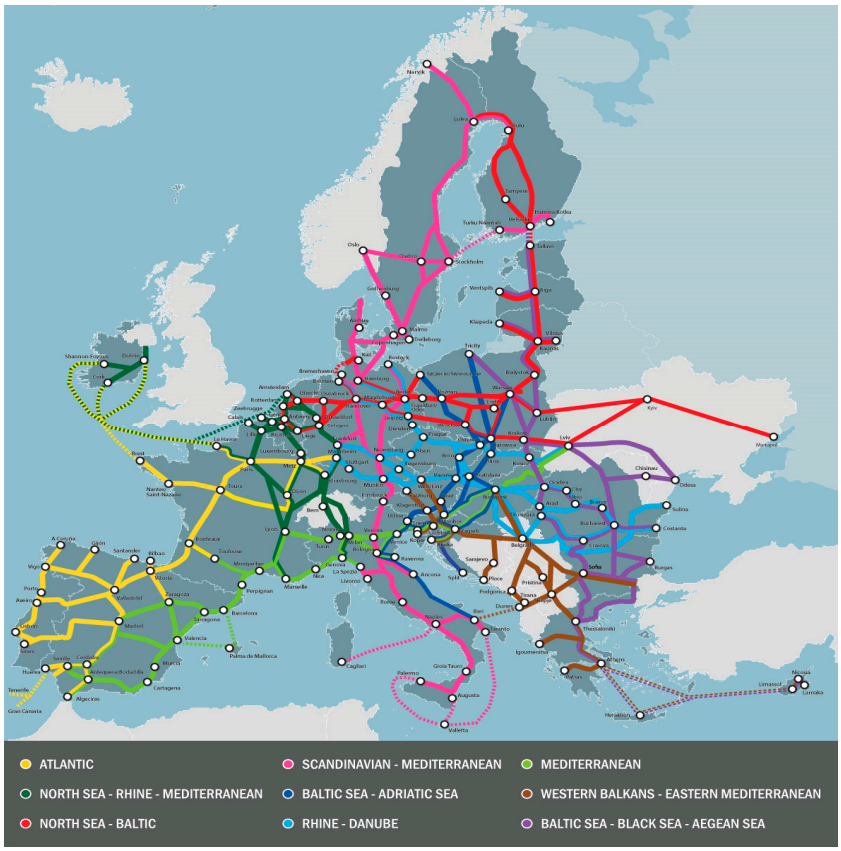

Figure 3. Trans-European Transport Network corridors, Regulation (EU) 2024/1679. Source: TENtec Public Portal and authors, 2024.

3. Literature Review

Research spanning over two decades on port management has clearly illustrated the initiatives undertaken by port authorities in implementing various approaches and processes related to quality, safety, and security management systems. These initiatives encompass assurance standards, accreditation models, codes, legislation, and conventions. Currently, there is a growing recognition of the need for an integrated approach to systems implementation tailored to the specific circumstances of ports. This approach must consider factors such as port organization, management, legal status, and services offered [26].

Since the early 2000s, the European Committee has been advocating for conventions and regulations aimed at integrating safety into maritime transport [17]. Moreover, regarding environmental concerns, significant momentum has been generated by the sustainability paradigm in the European Union (EU) [27]. Environment adjustments, as a cross-cutting issue, encompass a wide range of EU policies [26,28]. For instance, in terms of alternative fuels, the EU has committed to establishing a sufficient number of liquefied natural gas (LNG) refueling points at ports across the EU by the end of 2025, enabling LNG-powered ships to circulate throughout the Core Trans-European Transport Network (TEN-T) [29]. This commitment gains renewed significance in light of legislative initiatives proposed under the Fit for 55 Package [30]. Another example within the Fit for 55 Package is the FuelEU maritime regulation, according to which vessels have the obligation to use alternative fuels on voyages between EU ports and on voyages departing from or arriving at an EU port [31]. Moreover, air quality has remained a top priority of European ports since 2009 [32].

This emphasis can be attributed to various legislation targeting emissions, such as the Sulphur Directive [33], the National Emission Ceiling Directive [34], the introduction of the global 0.5% sulfur cap on marine fuels in 2020 [35], and the IMO NOx Tier III requirements for vessels built from 1 January 2021 onwards, operating in the North and Baltic seas (NECAs) [36]. Furthermore, the growing political interest in aligning growth with green

development is a prominent item on the agenda of many countries [37,38], as recently epitomized by initiatives like the European Green Deal.

Table 1 provides a summary of quality, safety, and security systems in the port domain, indicating whether their implementation is mandatory or not. ISO 9000 denotes a well-established series of standards that serve as a framework for ports to certify a quality management system [15]. In recent decades, safety and security have gained increasing importance, to the extent that they are often considered synonymous with "quality" [39,40]. More recently, the authors of [41] conducted a study on environmental awareness in ports, assessing the extent to which port authorities are implementing procedures and processes necessary to operate an effective Environmental Management System.

Table 1. Quality, safety, and security systems in the port sector.

Quality Safety and Security Systems	Standard Category					
	Implementation		Quality	Safety		Security
	Mandatory	Voluntary		Environment	Human	
ISPS code	√					√
OHSAS 18001		√			√	
ISO 9001		√	√	√	√	√
ISO 14001		√		√		
ELOT 1429		√	√			
ISO 28000		√				√
EMAS		√		√		
PERS		√		√		
Internal Q/S MS		√	√	√	√	√

Source: Authors, 2024.

They also tracked progress over time [41,42], and discussed the challenges posed by the evolution of the last decades' legislation aimed specifically at safety issues for environmental protection. Styliadis et al. [43] advocate for sustainability and environmental issues through assessment and measurement of port externalities. Özispa and Arabelen [13] investigated port sustainability through content analysis. On the other hand, Poulsen et al. [44] suggest that ports have considerable potential for promoting environmental upgrading in maritime transport and along global value chains. Similarly, Davarzani et al. [45] and Noteboom et al. [46] focus on the attitudes and perceptions of port-related actors towards the greening of port-related supply chains. In comparison with the relatively small amount of legislation developed, during this period (as shown in Table 2), an increasing number of international standards and guidelines have been made available [2].

Table 2. International general standards and guidelines across industries.

Organizations	Industrial Sector	Name/Year	Aim for
ISO	General	ISO 45001/Under development	Occupational health and safety management systems
	General	ISO 9000 Series/1987, 2008, 2015	Quality management systems
	General	ISO 14001/1992, 1996, 2004, 2015	Environmental management systems
	General	ISO 31000/209	Risk management
EU (European Union)	Chemical industry (also other industries)	Seveso Directive (Directive 82/501/EEC)/1982	Control of major accident hazards involving dangerous substances
		Seveso II (Directive/96/82/BC)/1996	
		Seveso III (Directive 2012/18/EU)/2012	
	General	(Directive 89/391/EEC)/1996	Guidance on risk assessment at work

Table 2. *Cont.*

Organizations	Industrial Sector	Name/Year	Aim for
BS (BSI Group, British Standard)	General	BS 5750/1979	Quality management systems
	General	BS 7750/1994	Specifications for environmental management systems
	General	BS 8800/1996, 2004	Occupational health and safety management systems
	General	BS OHSAS 18001/2007	Occupational health and safety management systems
OHSA (United States)	General	PART 1910 (Standards–29CFR)/2001	Occupational safety and health standards

Source: [2].

In the same vein, escalating safety/environmental management concerns have increased the need for port practitioners to invest in and implement environmental management systems and tools, such as ISO 14001, SDM, PERS, and EMAS, as integral components of a port's corporate strategy [47–49] and continual improvement management program [50].

As far as security is concerned, the International Ship and Port Facility Security (ISPS) Code presents a comprehensive set of measures aimed at enhancing the security of ships and port facilities [51]. Among its objectives, the Code establishes a framework for detecting security threats and implementing preventive measures to mitigate security incidents affecting ships and port facilities [17].

4. Research on Quality, Safety, and Security Systems Implementation in Greek Ports

4.1. Survey Methodology

The survey was conducted during the first months of 2022 and concluded by September of the next year. It focused on Greece's 23 over 25 aforementioned TEN-T seaports (sample size: 92% response rate). The selection criteria of our methodology for including the appropriate Greek ports were the Greek TEN-T ports. According to Article 20(2) of No. 1315/2013 EU Regulation, seaports are part of the TEN-T network when they meet at least one of the following conditions [19]:

- "The total annual passenger traffic volume exceeds 0.1% of the total annual passenger traffic volume of all EU seaports.
- The total annual volume of goods–cargo handling exceeds 0.1% of the corresponding total annual volume of goods handled in all EU seaports.
- They are located on an island and are the only access point to a NUTS 3 region.
- They are located in an outermost or peripheral area, at a distance of more than 200 Km from the nearest TEN-T seaport."

For this survey, a specially designed structured interview form was created and distributed to the top management (president/administrator/legal representative) of each port/port authority in Greece. The survey instrument included a mix of closed- and open-ended questions, as provided in Appendix A. Prior to implementation, the structured interview form underwent qualitative pilot testing with a group of port management experts. It consists of the following sections:

Section A: Provides information regarding the respondent (port representative) and the port environment.

Section B: Comprises four sets of questions. The first pertains to whether a port authority has implemented and certified a quality, safety, and security system during the last 5 years. The second gathers information on any improvement in image and/or operations attributed to the implementation of a quality, safety, and security system. The third set collects data on the motives behind a port's preference for implementing a particular quality,

safety, and security system. The fourth set highlights barriers to a port authority's decision to apply any of the aforementioned quality, safety, and security systems.

The final version of the structured interview form received ethics approval from the Director of the Research Ethics Committee of the Laboratory of Integrated Port Economics and Management at Piraeus University. After several rounds of communication by phone/email with the port representatives themselves (one representative—President or Administrator/Legal Representative—from each Port Authority), 23 of the 25 ports agreed to participate, and completed and returned the interview form. The two ports that did not participate (Port of Santorini and Port of Syros) claimed a "lack of time". Descriptive statistics have been used for the survey outcomes. The participating ports are listed in Table 3.

Table 3. Greek Trans-European Transport Network ports.

			Legal Entity		TEN-T		Geographical Orientation	
Port Authority	**Acronym**	**Respondent/ Management Position ***	**Société Anonyme (SA) ****	**Municipal Port Authorities (MPA) ****	**Core ****	**Comprehensive ****	**Mainland ****	**Island ****
Chalkida	PAChal	√/P	√			√		√
Chania	PAChan	√/A –L.R		√		√		√
Chios	PAChi	√/A –L.R		√		√		√
Corfu	PACo	√/P	√			√		√
Elefsina	PAE	√/P	√			√	√	
Heraklion	PAHe	√/P	√		√	√		√
Igoumenitsa	PAI	√/P	√		√		√	
Kalamata	PAKal	√/A –L.R		√		√	√	
Katakolo	PAKat	√/A –L.R		√		√	√	
Kavala	PAKav	√/P	√			√	√	
Kyllini	PAKy	√/A –L.R		√		√	√	
Lavrio	PAL	√/P	√			√	√	
Mykonos	PAMyk	√/A –L.R		√		√		√
Mytilini	PAMyt	√/A –L.R		√		√		√
Naxos	PAN	√/A –L.R		√		√		√
Paros	PAPar	√/A –L.R		√		√		√
Patras	PAPa	√/P	√		√		√	
Piraeus	PAP	√/P	√		√		√	
Rafina	PARa	√/P	√			√	√	
Rhodes	PARh	√/A –L.R		√		√		√
Santorini	PASa			√		√		√
Skiathos	PASk	√/A –L.R		√		√		√
Syros	PASy			√		√		√
Thessaloniki	PAT	√/P	√		√		√	
Volos	PAV	√/P	√			√	√	

Source: Authors, 2024. *: P: president; A: administrator; L.R: legal representative; **: Société Anonyme (SA): ports governed by boards and controlled by the state; Municipal Port Authorities (MPAs): ports governed by municipalities; Core: ports included in the Greek Core TEN-T Network; Comprehensive: ports included in the Greek Comprehensive TEN-T Network; Mainland: ports that are based on Greek mainland territory; Island: ports that are based on a Greek Island.

4.2. Results

Most of the Greek TEN-T ports that participated in the survey (83%) have at least one accredited/certified management system for each of the assurance dimensions, i.e., quality, safety, and security. This indicates that for Sociétés Anonymes (SAs) and Core TEN-T ports, quality, safety, and security are indeed a priority, with management allocating time and resources towards systems implementation.

Table 4 illustrates a clear distinction between Core and Comprehensive TEN-T ports, as well as between Municipal Ports (MPAs) and Sociétés Anonymes (SAs). Specifically, all twelve (12) SAs and five (5) Core TEN-T ports (100%) have currently accredited quality, safety, and security systems, compared with fourteen (14) out of eighteen (18) Comprehensive TEN-T ports (78%) and seven (7) out of eleven (11) Municipal Ports (64%). This discrepancy highlights the maturity of SAs and Core ports compared to MPAs and Comprehensive TENT-T ports. While there is a consistent pattern of ISPS accreditation across all port categories, recognized as a prevailing security approach, regardless of their legal entity (SAs: 75%, MPAs: 100%), their TEN-T status (Core: 80%, Comprehensive: 85.71%), and even their geographical orientation (Mainland: 90.90%, Island: 75%), substantial differences

exist in quality, safety, and other security systems. It is evident that the ISO series (ISO 9001, ISO 14001, and ELOT 1429) is indeed the primary focus of port authorities, with a notable preference for ISO 9001 implementation and certification, particularly among SAs (68%), Core (100%), and Mainland ports (91%), and to a lesser extent among MPAs (29%), Comprehensive (57%), and Island ports (37%). Conversely, significant discrepancies exist regarding environmental management systems (EMSs), with ISO 14001 and PERS implemented by 66.66% and 25% of SAs, 80% and 40% of Core TEN-T ports, and by 54.54% and 18.18% of Mainland ports, respectively. EMS accreditations are not integrated into the operational or commercial strategy of MPAs or Comprehensive TEN-T ports. A total of 28.57% and 75% of certified ports hold an EMS certification, with half of them certified with ISO 14001 (49.28%) and the remainder with an EcoPorts PERS (18.84%).

Table 4. Greek TEN-T ports' currently accredited quality, safety, and security systems—aggregated for 2023.

Selected Options	2023						
		Legal Entity		TEN-T		Geographical Orientation	
	Total	Société Anonyme (SA)	Municipal Port Authorities (MPA)	Core	Comprehensive	Mainland	Island
Yes	19	12	7	5	14	11	8
No	4	0	4	0	4	2	2
If yes, which of the following:							
ISO 9001	13	11	2	5	8	10	3
ISO 14001	8	8	0	4	4	6	2
PERS	3	3	0	2	1	2	1
ISO 28000	1	1	0	0	1	0	1
OHSAS 18001	1	1	0	1	0	1	0
EMAS	1	1	0	1	0	1	0
Internal Q/S MS	2	0	2	0	2	0	2
ISPS Code	16	9	7	4	12	10	6
ELOT 1429	7	6	1	1	6	4	3

Source: Authors, 2024.

Table 5 presents the perceptions of port representatives (presidents/directors of port authorities) regarding the impact of quality, safety, and security system implementation on the image of the port (to users/customers) and on the operation of the port's internal procedures. The mean score for each of the research questions indicates the extent to which a particular quality, safety, and security system implementation is perceived to have an impact on the corresponding aspect, measured on a scale from 1 ("not at all") to 5 ("very much"). In terms of the port's image to users/customers, the highest impact scores were assigned to the ISPS Code and to the ISO 28000 system for security, as well as to OHSAS 18001 and EMAS for safety. Similarly, for the impact on the operation of ports' internal procedures, the higher values were attributed to ELOT 1429 for port management, the ISPS Code for security (smuggling, cyber threats, etc.), as well as to OHSAS 18001 and EMAS for safety. There is a blend of regulatory duties and responsibilities involved in ensuring safety and security operations within the port, including compliance with international (ISPS Code) or national (ELOT 1429) laws and regulations in these fields. Key focus areas encompass health and safety emergency preparedness and response, port area security, and cyber-security. With the increasing threats of global terrorism, cross-border criminality and digitalization, security issues have gained significant importance. Cyber-security, in particular, is crucial for port communities, emphasizing the need for a unified approach towards establishing resilient port community policies on cyber-security [52].

Table 5. Research results of the closed-ended research questions expressing the view that implementing quality, safety, and security standards had improved the port image among users/customers and improved the operation use of the port's internal procedures.

Impact of Systems Implementation on	Port Image to Users/Customers			Operation Use Port Internal Procedures	
	(Measurement Scale from 1 = "not at all" to 5 = "very much")				
	n	**Mean Score**	**Stdev**	**Mean Score**	**Stdev**
ISO 9001	13	3.69	0.48	3.85	0.38
ISO 14001	8	3.88	0.64	4.00	-
PERS	3	3.00	-	2.75	0.58
ISO 28000	1	4.00	-	3.00	-
OHSAS 18001	1	4.00	-	4.00	-
EMAS	1	4.00	-	4.00	-
Internal Q/S MS	2	3.50	2.12	4.00	1.41
ISPS Code	16	4.38	0.62	4.00	1.10
ELOT 1429	7	3.38	0.69	4.14	0.38

Source: Authors, 2024.

In the subsequent section of the questionnaire, perceptions of experts (presidents/directors of port authorities) regarding motives for quality, safety, and security systems implementation were collected, as presented in Table 6. Mean scores indicate the extent to which a particular option (first column) serves as a motive for implementation. Notably, motives with mean scores above four (4.0) include:

- Improved port operations;
- Improved port image;
- Market requirements;
- Cost reduction;
- Certification of competitors.

Table 6. Research results of the closed-ended research questions expressing the motives for implementing quality, safety, and security systems.

Motives	2023									
		Legal Entity		TEN-T		Geographical Orientation				
	Total	**Société Anonyme (SA)**	**Municipal Port Authorities (MPA)**	**Core**	**Comprehensive**	**Mainland**	**Island**	**n**	**Mean Score**	**Stdev**
	(Measurement Scale from 1 = "not at all" to 5 = "very much")									
Port services improvement	16	8	8	3	13	8	8	16	3.63	0.72
Port operations improvement	14	7	7	3	11	8	6	14	4.14	0.77
Port image improvement	11	5	6	2	9	5	6	11	4.18	0.75
Required by the market	2	1	1	0	2	1	1	2	4.00	1.41
Future demand	2	1	1	1	1	1	1	2	3.50	0.71
Competitive advantage	6	2	4	1	5	4	2	6	3.50	0.84
Marketing tool	7	2	5	2	5	4	3	7	3.86	0.90
Expansion tendency	2	1	1	1	1	1	1	2	3.50	0.71
Entrance to new markets	3	2	1	1	2	2	1	3	3.33	0.58
Required by current users/current demand	2	1	1	0	2	1	1	2	3.00	-
Reduction in cost	1	1	0	0	1	0	1	1	4.00	-
Certification of competitors	7	7	0	0	7	5	2	7	4.00	0.82

Source: Authors, 2024.

Experts participating in our survey assigned the highest scores to motives relating to market demands and competition (e.g., port image, market requirement, certification of others, and competition), reflecting an increased awareness of the competitive pressures

faced by Greek ports. Furthermore, the emphasis on quality, safety, and security systems for enhancing organizational processes, particularly in a cost-effective manner, highlights a strategic investment decision beyond mere marketing efforts. Moreover, our survey reveals a consensus among SAs and MPAs regarding the significance of motives such as improved port services, operations, and image. Similar trends were observed among Core and Comprehensive ports in the TEN-T, as well as among Mainland and Island ports. An unexpected finding pertains to the motive of "Certification of competitors", since it is selected by SAs and Comprehensive TEN-T ports but not by all MPs and Core TEN-T ports. This divergence suggests that Core ports prioritize improving operational efficiency and service provision, while Comprehensive ports place greater importance on certification for increasing commercial value and revenues. The findings still suggest that transparency and the relationship with the local community and other stakeholders remains a high priority not only for SAs and Comprehensive ports, but also for European ports, especially for EMS certifications [32]. Additionally, consistent with Pantouvakis and Dimas [53], our research investigates the impact of ISO 9000 certification on port authorities' financial performance, revealing that ISO certified ports demonstrate greater financial efficiency compared to their non-certified counterparts.

The last section of the survey examines the perceptions of the experts (presidents/directors of port authorities) regarding deficiencies associated with the implementation of international standards for quality, safety, and security. Table 7 presents mean scores indicating the extent to which port representatives perceive each statement/shortcoming included in the questionnaire as likely. Port experts attributed higher scores to shortcomings related to staff involvement ("personnel involvement in system development" and "personnel involvement in system maintenance") due to the understaffing of port authorities. On the contrary, low scores were assigned to the cost of quality, safety, and security system accreditation and maintenance, suggesting that the cost of quality/cost of conformity is not a significant drawback.

Table 7. Research results of the closed-ended research questions regarding the barriers to the implementation of quality, safety, and security systems.

Barriers	2023									
		Legal Entity		TEN-T		Geographical Orientation				
	Total	Société Anonyme (SA)	Municipal Port Authorities (MPA)	Core	Comprehensive	Mainland Ports	Island Ports	n	Mean Score	Stdev
	(Measurement Scale from 1 = "not at all" to 5 = "very much")									
Cost of system development and certification	17	8	9	4	13	8	9	17	3.00	0.71
Cost of system maintenance	17	8	9	4	13	8	9	17	3.00	0.71
Personnel involvement for system development	17	8	9	4	13	8	9	17	3.71	0.69
Personnel involvement for system maintenance	17	8	9	4	13	8	9	17	3.71	0.69
Problematic implementation with port operations	17	8	9	4	13	8	9	17	3.18	0.73
Reduced flexibility	17	8	9	4	13	8	9	17	3.24	0.83

Source: Authors, 2024.

5. Discussion

5.1. Heterogeneity of Quality, Safety, and Security Systems Implementation in the Greek Port System

The survey encompassed 23 out of the 25 Core and Comprehensive TEN-T seaports of Greece, examining the implementation of quality, safety, and security systems. Detailed

distinctions based on legal entity, TEN-T network, and geographical orientation are presented in Tables 4–7. As shown in the survey results, all twelve (12) SAs and five (5) Core TEN-T ports (100%) currently possess accredited systems, predominantly in the ISO series and the ISPS Code. In contrast, fourteen (14) out of eighteen (18) Comprehensive TEN-T ports (78%) and a further seven (7) out of eleven (11) Municipal Ports (64%) have accredited systems, showcasing a strong quality, safety, and security awareness among larger ports (e.g., SAs and/or Core TEN-T ports). The changing market environment and competitive pressures emphasize the need for internal procedures adjustments and standardized services to users/customers through certified procedures in a cost-effective manner. A major shortcoming involves understaffing within port authorities particularly evident in smaller ports (Municipal Ports and Comprehensive TEN-T ports).

The survey further highlights a correlation between port size and quality, safety, and security maturity. Major ports (SAs and Core TEN-T ports) demonstrate greater maturity compared to smaller ones (MPAs and Comprehensive TEN-T ports), indicating a need for the further integration of quality, safety, and security measures in smaller ports. Larger, more established ports are better positioned to address these challenges due to their organizational awareness and potential funding. Moreover, there is little difference observed between Mainland and Island ports (85% and 80%, respectively) in terms of their accreditation/certification and reported perceptions regarding motives and barriers to implementation of quality, safety, and security systems.

5.2. The Need for the Integration of Quality, Safety, and Security Systems in Greek Ports

Greek ports are effectively responding to EU policy demands, particularly in environmental compliance [24]. However, our survey reveals concern among port representatives (ports' presidents and administrators—legal representatives) regarding the simultaneous implementation of quality, safety, and security systems. Existing literature underscores the necessity of discussing the need for a holistic and integrated implementation of quality, safety, and security management systems based on the assimilation of various management systems standards, such as ISO 9001, ISO 14001, and OHSAS 18001 [54]. Specific operation practices and implementation insights on integrating these management systems within the port industry should be further explored.

The concurrent implementation of different systems poses significant challenges for port quality management in different types of Greek ports (e.g., SAs and/or Core TEN-T ports). These challenges include reconciling conflicting requirements between the distinct systems, converging processes, exchanging data and information interchange, maintaining extensive documentation, and navigating complex external audit processes for certification/accreditation, personnel training, etc. To address these challenges, major ports in Greece are compelled to develop integrated management systems. This integration primarily ensures that quality, safety, and security concerns are addressed cohesively, rather than in isolation. By consolidating documentation and processes into a unified framework, ports, in a more macro approach, which is indicative of industry trends, can enhance regulatory compliance and prioritize quality, safety, and security in decision-making processes.

5.3. Following a Decade of Quality, Safety, and Security Systems Implementation in Greek SA Ports

Table 8 presents an overview of Greek SA port certifications. The first part of the table provides certifications reported by Chlomoudis et al. [17], while the subsequent part details system implementations for the same SA ports after a decade (as reported at 2023).

It is clearly suggested that there is a noticeable and significant increase in the implementation of quality, safety, and security systems at SA ports in Greece over the specified period. Particularly noteworthy is the port of Igoumenitsa, which attained four (4) quality, safety, and security certifications during the previous decade, with the Volos, Piraeus, and Thessaloniki ports achieving three (3) certifications each, highlighting the advancements made in these areas of port operations.

Table 9 provides insights into experts' views on motives, both presently and a decade ago. Directors/presidents of SA ports in Greece indicate that ports exhibit significant attention to market factors (e.g., image, market requirements, and certifications of others), as well as to the anticipated enhancements in port operations throughout our study period. Conversely, comparatively less emphasis has been placed on forecasting future demand and reducing costs, potentially due to these factors being perceived as relatively inflexible and resistant to change. Notably, the ports of Lavrio, Kavala, and Corfu exhibited the highest level of responsiveness, indicating a maximum score of "5."

Table 8. Greek SA ports' accredited quality, safety, and security systems– 2011 vs. 2023.

Q/S MS	PAV	PAT	PAL	PAPa	PAHe	PARa	PAP	PAE	PAKav	PACo	PAI	PAChal	Total
						2011							
ISO 9001	1							1	1		1		**4**
ISO 14001													**0**
PERS		1					1						**2**
OHSAS 18001													**0**
EMAS													**0**
Total 2011	**1**	**1**	**n/a**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**n/a**	
						2023							
ISO 9001	1	1		1	1	1	1	1	1	1	1	1	**11**
ISO 14001	1	1		1		1	1			1	1	1	**8**
PERS	1						1				1		**3**
OHSAS 18001		1											**1**
EMAS											1		**0**
Total 2023	**3**	**3**	**0**	**2**	**1**	**2**	**3**	**1**	**1**	**2**	**4**	**2**	

Source: Authors, 2024.

Table 9. Research results from 2011 to 2023 on the motives for quality, safety, and security standards implementation.

Selected Options for SAs	2011			2023		
	n	Mean Score	Stdev	n	Mean Score	Stdev
(Measurement Scale from 1 = "not at all" to 5 = "very much")						
Port services improvement	10	4.40	0.52	8	3.63	0.52
Port operations improvement	10	4.30	0.67	7	4.00	0.82
Port image improvement	10	4.50	0.53	5	3.80	0.45
Required by the market	10	4.30	0.67	1	3.00	-
Future demand	10	2.30	1.34	1	4.00	-
Competitive advantage	10	4.20	0.63	2	3.50	0.71
Marketing tool	10	4.60	0.70	2	4.00	0.00
Expansion tendency	10	3.80	0.79	1	4.00	-
Entrance to new markets	10	3.70	0.82	2	3.50	0.71
Required by current users/current demand	8	3.50	0.76	1	3.00	-
Reduction in cost	10	2.70	1.06	1	4.00	-
Certification of competitors	9	4.22	0.97	7	4.00	0.82

Source: Authors, 2024.

Table 10 presents the perspectives of experts regarding the barriers to the performance of a quality, safety, and security system now and ten years ago. In 2023, SA port experts assigned higher scores to shortcomings related to staff involvement, specifically in system development and maintenance. This trend mirrors the findings of the 2011 research, highlighting the issue of understaffing within port authorities. Notably, the port of Corfu received the highest possible score ("5"), while the ports of Heraklion, Igoumenitsa, and Chalkida received the lowest scores ("2"), indicating variations in perceptions across different ports.

Table 10. Research results from 2011 to 2023 regarding non-implementation of a quality, safety and security system.

Selected Options for SAs	2011			2023		
	n	Mean Score	Stdev	n	Mean Score	Stdev
(Measurement Scale from 1 = "not at all" to 5 = "very much")						
Cost of system development and certification	8	2.50	0.76	8	3.00	0.93
Cost of system maintenance	8	2.00	0.76	8	3.00	0.93
Personnel involvement for system development	10	3.50	0.71	8	3.75	0.89
Personnel involvement for system maintenance	10	3.50	0.85	8	3.75	0.89
Problematic implementation with port operations	9	2.33	1.22	8	2.88	0.83
Reduced flexibility	9	2.67	1.22	8	3.00	1.07

Source: Authors, 2024.

5.4. Environmental Management Systems Certificates: Greek TEN-T Ports Compared to ESPO Ports

An examination was conducted to compare the environmental performance of the Greek TEN-T ports' respondents with the findings of the questionnaire administered by ESPO in 2023 [31]. This analysis aims to draw conclusions that extend beyond the domestic level.

Table 11 demonstrates conclusively that ISO and PERS are the most popular standards in the sector. It is noteworthy that some ports hold certifications for multiple standards, with percentages of 16.6% for SAs and 60% for Core TEN-T ports, respectively. The environmental certifications of surveyed Greek TEN-T ports are primarily driven by Core TEN-T ports, Sas, and Comprehensive TEN-T ports, while MPAs significantly trail behind, both domestically and in comparison to ESPO ports at a European level. Exceptional scores were obtained by responding SAs and Core TEN-T ports for ISO 9001, ISO 14001, and EcoPorts PERS, often surpassing ESPO's corresponding figures. The simultaneous adoption of all three certification schemes by ports is observed solely in the ESPO Environmental Report—EcoPortsinSights.

Table 11. Greek TEN-T ports and ESPO 2023 EMS certificates.

		Legal Entity		TEN-T		
	Total (%)	Société Anonyme (SA) (%)	Municipal Port Authorities (MPA) (%)	Core (%)	Comprehensive (%)	ESPO 2023 (%)
ISO *	78.9	100.0	42.9	100.00	71.4	49.0
ECOPorts PERS	15.8	16.6	0.0	60.0	7.1	23.0
ISO * and ECOPorts PERS	15.8	16.6	0.0	60.0	7.1	16.0
ISO *, ECOPorts PERS and EMAS	5.3	8.3	0.0	20.0	0.0	10.0
ISO * and EMAS	5.3	8.3	0.0	20.0	0.0	2.0
EMAS	5.3	8.3	0.0	20.0	0.0	2.0

(*): ISO 14001. Sources: Authors, 2024 and [31].

5.5. Further Research Directions and Limitations

The authors hope for this paper to inspire additional research in this field. Directions for further investigation might include, among others, the following:

- Recording best practices for the implementation and integration of management systems;
- The role of information governance and/or artificial intelligence advances when it comes to implementing quality, safety, and security management systems in ports;
- The interrelation of quality, safety, and security management systems with port sustainability goals;
- In-depth investigation of port operational activities that are integrated with ports' quality, safety, and security systems and corresponding certificates.

Gathering more field data and conducting detailed case studies would yield additional insights and provide a more comprehensive and nuanced understanding of the subject matter. Furthermore, conducting in-depth and/or comparative analyses could yield deeper insights into various intriguing aspects related to implementation, such as cultural advancements within port authorities or the broader sector, the role of stakeholders, integration dynamics, and individual factors influencing implementation decisions and outcomes. Exploring these avenues could pave the way for a follow-up study on the implementation of these systems in practice, thus contributing to the ongoing discourse and advancement of knowledge in this area.

Although the survey results that our analysis provided on systems implementation in the port industry shed light on this interesting research field, they are subject to limitations. Some of the profound limitations, among others, include the following:

- The survey provides evidence from the first months of 2022 and last months of 2023;
- The survey could have related valuable insights and outcomes with port performance indicators;
- The survey focuses only on Greece's 23 of the 25 aforementioned TEN-T seaports. It could have embodied paradigms from European and International ports (Middle and Far East regions) with respect to benchmark certifications awarded to and operations implemented at different ports;
- The survey provides a macro-level approach. Therefore, a micro-level investigation could shed light on practical operations issues that are involved in the implementation of quality, safety, and security systems in ports.

6. Conclusions and Future Research

The modern port industry recognizes quality, safety, and security systems as indispensable components, with their added value and multiple benefits extending to the entire port community, as well as to society, the economy, and the environment. The implementation of these systems transcends mere compliance with existing legislation; rather, they form part of a port's strategic choices to address challenges comprehensively and systematically, leveraging accumulated knowledge and sector experience. Moreover, they serve to establish standardized procedures and operational methods, promote effective solutions to specific issues, follow clear and predictable patterns, and foster reliable relationships among stakeholders. Concurrently, these systems undergo significant improvements, better aligning with sector realities and needs.

It is anticipated that a growing number of ports will increasingly adopt and implement such systems, with intensified efforts towards this goal. Peer review pressure and sector dynamics will persistently drive and shape a continuous trend towards system implementation. Greek ports are anticipated to follow this overarching trend, especially considering the positive outcomes achieved by numerous major ports and the widespread dissemination of these achievements throughout the entire port network.

This research appears to support the hypothesis that the developmental stage of a port correlates to some extent with the implementation of quality, safety, and security systems. These elements play a crucial role in contributing to the maturity of a port, leading to not only tangible improvements but also cultural advancements that influence decisions and outcomes. While acknowledging obstacles and constraints, it is apparent that decisions in favor of such systems, as well as the quality of their implementation and outcomes, largely depend on the initial requirements and characteristics of the ports. Nevertheless, significant potential exists for both individual ports and the port sector in general.

On a governance level, it is vital to encourage and support ports in implementing quality, safety, and security systems to ensure the overall effectiveness and resilience of port operations. While imposing mandatory requirements through a regulatory approach may face resistance from the industry and not be the most appropriate method or even necessary, softer measures and tools can still drive significant progress. Soft measures, such as providing incentives, offering guidance and assistance, fostering collaboration among

stakeholders, and promoting best practices, can create a supportive environment. These approaches motivate ports to voluntarily adopt and implement these systems, resulting in improved performance, enhanced safety and security, and better outcomes for the port community and the broader sector.

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Appendix A

Which of the following management system standards has been certified in your port?
ISO 9001 ISO 14001 PERS ISO 28000 OHSAS 18001 EMAS
Internal Q/S MS ISPS Code ELOT 1429 NONE

To what extent might the following quality, safety, and security standards improve the image of a port to users/customers?

Q/S MS	**(Measurement Scale from 1 = "not at all" to 5 = "very much")**				
ISO 9001	1	2	3	4	5
ISO 14001	1	2	3	4	5
ISO 28000	1	2	3	4	5
OHSAS 18001	1	2	3	4	5
PERS	1	2	3	4	5
EMAS	1	2	3	4	5
Internal Q/S MS	1	2	3	4	5
ISPS Code	1	2	3	4	5
ELOT 1429	1	2	3	4	5

To what extent might the following quality, safety, and security standards improve the internal procedures of a port?

Q/S MS	**(Measurement Scale from 1 = "not at all" to 5 = "very much")**				
ISO 9001	1	2	3	4	5
ISO 14001	1	2	3	4	5
ISO 28000	1	2	3	4	5
OHSAS 18001	1	2	3	4	5
PERS	1	2	3	4	5
EMAS	1	2	3	4	5
Internal Q/S MS	1	2	3	4	5
ISPS Code	1	2	3	4	5
ELOT 1429	1	2	3	4	5

To what extent do the following factors motivate management to implement the following quality, safety, and security management systems?

(Measurement Scale from 1 = "not at all" to 5 = "very much")				
1	2	3	4	5

Motives for Implementation of	**ISO 9001**	**ISO 14000**	**ISO 28000**	**OHAS 18001**	**PERS**	**EMAS**	**INTERNAL Q/S MS**	**ISPS CODE**	**ELOT 1429**
Port services improvement									
Port operations improvement									
Port image improvement									
Required by the market									
Future demand									
Competitive advantage									
Marketing tool									
Expansion tendency									
Entrance to new markets									
Required by current users/current demand									
Reduction in cost									
Certification of competitors									

To what extent are the following issues barriers to implementing a quality, safety, and security management system?

Barriers for Implementation	**(Measurement Scale from 1 = "not at all" to 5 = "very much")**				
Cost of system development and certification	1	2	3	4	5
Cost of system maintenance	1	2	3	4	5
Personnel involvement for system development	1	2	3	4	5
Personnel involvement for system maintenance	1	2	3	4	5
Problematic implementation with port operations	1	2	3	4	5
Reduced flexibility	1	2	3	4	5

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