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Adaptation of Industrial Revolution 4.0 in a Seaport System

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Abstract: As pillars of logistics, supply chains, and transport networks, seaports have led to a substantial demand for countless economic advantages. The sustainability and competitive advantage of seaport businesses depend on their ability to adapt to changing business requirements, while Industrial Revolution 4.0 (IR 4.0) is a current phenomenon that connects the global market through smart technologies involving cyber-physical systems to overcome global trade uncertainty. However, focusing only on growing economic benefits might lead to an ineffective sustainable implementation of IR 4.0 within a seaport system. Therefore, this paper compares the current status of IR 4.0 global implementation against the current Malaysian seaport system to ensure that the development of seaports in Malaysia is aligned with technological trends and global requirements. In addition, this paper investigates the critical sustainable factors (CSFs) for the implementation of IR 4.0 in Malaysian seaports. A Focus Group Discussion (FGD) is used to obtain the data from 13 domain experts, from various maritime stakeholders, which is further analysed by using Thematic Analysis. The result has shown that most seaports have started to initiate a fusion by focusing on IR 4.0 adaptation. In contrast, in Malaysia, the seaports in this country are still behind the global trend and are just starting to explore the concept of IR 4.0 instead of expanding to the next level (global benchmark). The current status and CSFs, for the implementation of IR 4.0 in Malaysian seaports, are presented in comparison to global requirements, and the marginal associations between them are shown. As a conclusion, by comparing a global seaport scenario with Malaysian seaports, the main considerations for sustaining the implementation of IR 4.0 in Malaysian seaports can be discovered.

Keywords: industrial revolution 4.0; Malaysian seaport; maritime industry; focus group discussion; thematic analysis

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1. Introduction

The IR 4.0 has been initiated in 2011 with the agenda to integrate the information and communication technology (ICT), as well as to encourage a more digitalization and information oriented industry. The IR 4.0 initiative was widely discussed and became a phenomenon that was believed to benefit many industry parties and stakeholders across all business sectors. In maritime sectors, several initiatives have been executed globally. For example, Hamburg Port has started an initiative to implement smart seaport logistics using cloud-based tools. This intelligent software extracts various data types (vessel positions, bridge heights and widths, planned routes, etc.) that can be viewed on mobile applications in real time. This increased access to such data streamlines the circulation of goods by allowing seaport workers to know exactly when ships are expected to dock and allowing truck drivers to know when cargo is expected to be discharged [1]. In addition, The Port of Cartagena in Columbia, has started using Internet of Things (IoT) analytics as a solution to predict equipment failures to guarantee that machinery is properly maintained [2].

Seaport terminal operators are often unable to organise the arrivals of vessels and other vehicles, which has a negative impact on accessibility and creates problems [3]. Furthermore, the decentralisation of seaport terminals occurs due to a lack of information exchange between those involved. Jacobsson et al. [3] stated that information exchange is critical for efficient operations. Consequently, information applications in IR 4.0 have been deployed to manage, monitor, and store massive amounts of data, such as information from the automatic identification system (AIS), maritime traffic data, and logistics data to provide large-scale computerised and paperless services [4]. The diversity of the gathered data and information enables smart seaport applications to adapt to the dynamic requirements of a complex system that handles diverse aspects, especially regarding the environment, energy, and traffic, and that consists of different technologies, including wireless communications and embedded systems, for sensing operations.

On the other hand, the seaport system in Malaysia has progressed and has been said to be a critical node in logistics, supply chains, and transport networks. Consequently, the performance of Malaysian trade (by volume in 2020) expanded by 4.3 percent compared to the 2019 level. The number of containers handled in Malaysian seaports increased from 18.14 million in 2010 to 24.96 million in 2018 [5]. In the era of Industrial Revolution 4.0 (IR 4.0), several challenging projects related to smart seaports from Europe to Asia, Australia, and North America are evident. Sensing technologies play a key role in all of these new architecture implementations [6]. As high-performing seaports, smart seaports utilise information and communication technology (ICT) to provide a wide range of smart applications, resulting in vastly improved vessels and seaport operations, which, in turn, improve the competitiveness and sustainability of the national economy [4]. The catastrophes faced determine the critical success factors (CSFs) and sustainable elements across most projects, and they are some of the reasons for complications in the Malaysian seaport sector [7,8].

Consequently, the extent to which IR 4.0 can be implemented, adopted and sustained need to be investigated in a Malaysian context. CSFs are necessary to ensure industry sustainability and success. However, the current status of and CSFs that determine the implementation of IR 4.0 in the Malaysian seaport system remain vague due to limited academic research in this area. Therefore, this paper aims to compare the current status of IR 4.0 global seaport implementation against the current Malaysian seaport system and to ensure that the development of seaports in Malaysia is aligned with technological trends and global requirements. As a result, this research will provide the overview of global and Malaysian points of view, which lead to the development of IR 4.0 implementation, in Malaysian seaports.

2. Materials and Methods

2.1. Research Design

We conducted this study to elucidate the current status of IR 4.0 implementation and to identify the most important CSFs that are required to enable IR 4.0 in the Malaysian seaport system. In the process of identifying CSFs, it is essential to realise the diverse opinions of the core value of sustainability across sectors [9]. According to Spangenberg [10], the pillars of sustainability must be considered equally when selecting appropriate strategies for enhancing sustainability. There is a lack of studies evaluating the current status of seaports and CSFs to enable IR 4.0 in the Malaysian seaport system compared to the global trend, while there is a need for qualitative research to be conducted through an FGD to grasp the current scenario in the Malaysian context. According to Stokes and Bergin [11], an FGD is an efficient tool for gaining a broad understanding of a new phenomenon. Our FGD facilitated an open and thorough discussion of the selected issues led by the researcher, and it explored the current status of CSFs for IR 4.0 implementation. According to Sekaran and Bougie [12], an FGD is a common tool for research and discovery with respect to new phenomena and for exploratory grounded studies. The FGD approach has been employed

to explore the phenomenon, especially the status of IR 4.0 in Malaysian seaports and the substantial CSFs that are required to meet the aim of IR 4.0 implementation.

Figure 1 illustrates the research methodology for examining the current status of IR 4.0 global implementation against the current Malaysian seaport system and investigates the critical sustainable factors (CSFs) for the implementation of IR 4.0 in Malaysian seaports.

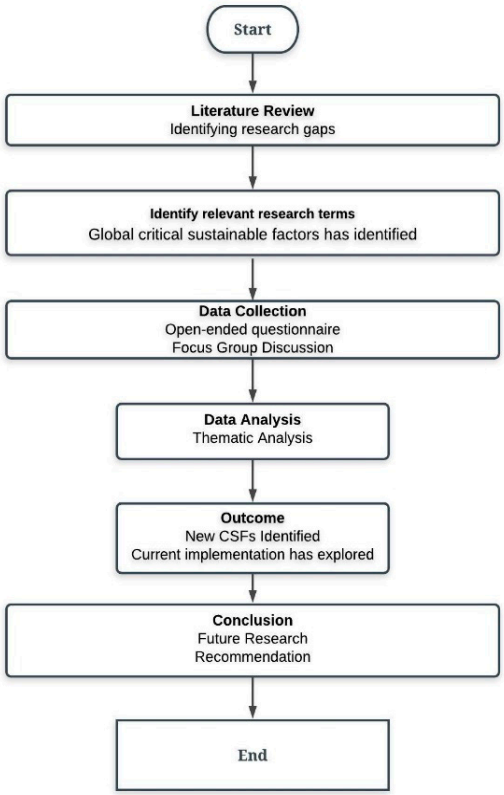

Figure 1. Research methodology. Source: Authors' work.

Prior to the FGD session, the question has been designed to ensure the session is guided within the context of discussion. The questions are listed as follows:

1. Based on your observation, what is the current status of IR4.0 implementation in Malaysian seaport sector?
2. How would Malaysian seaport sector benefit from the implementation of IR4.0 in the future?
3. What are the issues, challenges, and risk that would be expected during implementation of IR 4.0 in Malaysian seaport sector?
4. Do you have any opinion on mitigation plan to overcome these issues, challenges, and risk?
5. From your opinion, to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Economic Value needed?
6. From your opinion, to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Operational Value and Technical Quality needed?
7. From your opinion, to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Political and Legal needed?
8. From your opinion, to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Environment Protection needed?
9. From your opinion to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Social Equity and Culture needed?
10. From your opinion, to ensure the implementation of IR4.0 in seaport sector is sustained, what are the CSFs for Communication and Cooperation needed?

2.1.1. Data Collection

A group of thirteen experts (13) were involved in the FGD, which lasted three (3) hours. Adopting Thomas and Simerly's [13] approach, the experts were purposefully selected, based on their roles as decision-makers, and because they were recognised as experts in the field. The population was derived from the top-level managers of maritime-related organisations with sufficient years of industry experience (see Table 1). Experts with more working experience are expected to provide more precise information than those with less experience, ensuring the validity of the outcome [14]. To capture uncertainties related to the current status of IR 4.0 implementation, we conducted the FGD by asking questions about the experts' own current implementation status and that of the Malaysian scenario, as well as the CSFs that are required for a sustainable implementation of IR 4.0 in our seaport industry.

Table 1. The experts who participated in the FGD.

No. of Experts	Type of Organisation	Organisation	Years of Experience	Position in the Organisation	Educational Background
1.	Seaport authorities	Johor Port Authority	15–20	Associate manager	Bachelor's degree
2.	Seaport authorities	Port Klang Authority	15–20	Senior officer	Bachelor's degree
3.	Seaport authorities	Penang Port Commission	15–20	Associate manager	Bachelor's degree
4.	Government bodies	Ministry of Transport	15–20	Senior officer	Bachelor's degree
5.	Government bodies	Marine Department	>20	Head of department	Bachelor's degree
6.	Seaport operators	Kuantan Port Consortium	>20	Manager	Bachelor's degree
7.	Seaport operators	Kuantan Port Consortium	10–15	Manager	Bachelor's degree
8.	Seaport operators	Lumut Port	>20	Manager	Bachelor's degree
9.	Seaport operators	Port of Tanjung Pelepas	>20	Head of department	Bachelor's degree
10.	Seaport operators	Port of Tanjung Pelepas	>20	Head of department	Bachelor's degree
11.	Shipping operators	KA Petra	>20	Manager	Bachelor's degree
12.	Non-governmental organisations	Malaysia Shipowners' Association	>20	Secretary-General	Bachelor's degree
13.	Non-governmental organisations	Malaysia Shipowners' Association	>20	Manager	Bachelor's degree

Source: Authors' work.

Through convenience sampling, experts within the sampling frame, who were available and willing to be involved in the FGD, were identified [15]. Convenience sampling was carried out by locating potential experts who met the required criteria and were selected on a first come, first served basis until the sample size requirement was met [16]. Among the 13 samples, three experts were recruited from the seaport authorities, two experts from government bodies, six experts from private port operators, and two experts from non-governmental organisations. The session was conducted in two languages, English and the experts' native language, which mitigated any language barriers for the experts.

2.1.2. Data Analysis

The FGD data were collected by video and audio recording. The entirety of the audio and video recordings was transcribed, and the data were analysed to identify codes and themes. As the main tool, this research adopted 'thematic analysis'. Thematic analysis is a qualitative research method that has been widely used across the universe of knowledge and research questions. Based on Braun and Clarke's [17] recommendations, six phases

were implemented during the thematic analysis: (1) familiarising oneself with one's data, (2) generating initial codes, (3) searching for themes, (4) reviewing the themes, (5) defining and naming the themes, and (6) producing the report. Table 2 shows a summary of the procedure used by this research to conduct thematic analysis.

Table 2. The step-by-step procedure of the thematic analysis.

Phase	Description of the Process
1. Familiarising	Data transcription, reading and re-reading, preliminary ideas reported
2. Generating initial codes	Systematic coding, retrieval of data for each code
3. Searching for themes	Collecting codes for potential themes, collecting all information related to any possible theme
4. Reviewing themes	Checking whether the themes work in terms of the coded extracts and generating a thematic analysis map
5. Defining and naming themes	Continuous analysis to refine the specifics of each theme and the overall message the study tells, establishing simple meanings and names for each theme
6. Producing the report	Final analysis of the selected extracts, preparation of a scholarly analysis report

Source: Adapted from Braun and Clarke [17].

3. Results and Discussion

3.1. Implementation of IR 4.0 Is Malaysian Seaport System: Current Status

Based on all thirteen (13) experts who participated in this study, currently, the implementation of IR 4.0 in Malaysian seaports is at the stage of adoption known as the initial stage (Figure 2). Based on the views of experts 8, 9, 12, and 13, the implementation of IR 4.0 depends on the capacity of each seaport in Malaysia. Experts 2 and 10 claimed that some seaports have implemented, or started to implement, a vessel traffic service (VTS) control system for cargo tracing and handling efficiency, which has become an important performance indicator at seaports. In the views of others, experts 6, 7, 9, and 10 said that having high-quality infrastructure, facilities, and online systems enables shipping lines to be aligned with a seaport's requirements.

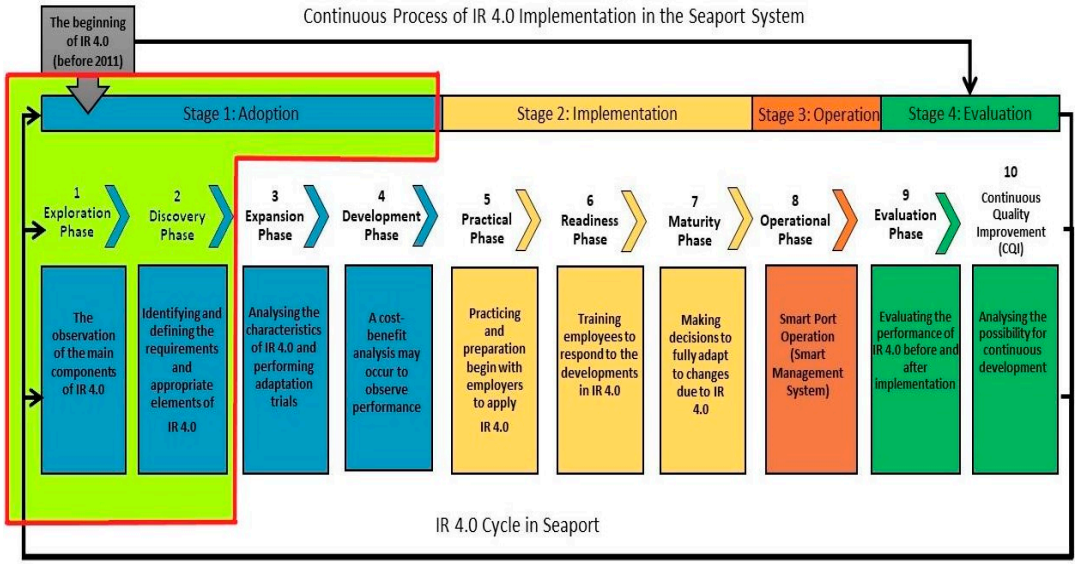

Figure 2. Stages in the implementation of IR 4.0 in the seaport system. Source: Adapted from Jeevan et al. [18] Notes: The shaded area indicates the current status of IR 4.0 in Malaysian seaports.

Based on current seaport operations, expert 4 claimed that 'the planning of aggregating volumes and the setting of cranes are done 3 months ahead, and if it could be done in

real time, things could be handled better'. However, experts 1, 4, 5, and 8 concluded that information sharing has been a substantial issue among clients along the supply chain. 'The current status of IR 4.0 has more to do with data integration, and the related maritime agencies should be identified for this purpose,' Expert 6 said, 'We are still lacking in awareness, educational level and leadership, and these components should be recognised before the implementation of IR 4.0 in the seaport system. Hence, the government itself has no goals, no roadmap regarding the policy for seaport operations. Compared to other industries, we have been left behind'.

Moreover, experts 2, 3, 4, 7, and 9 claimed that 'there are not many maritime players who are experts in the systems, and at present, it is also very expensive. From the ministry's perspective, there is no specific policy for maritime industries in terms of IR 4.0, and this is because every seaport is itself unique. Anyway, to implement IR 4.0, different aspects need to be clearly specified'. Currently, Malaysian seaports are in the process of adapting the concept of IR 4.0 in their daily operations. At this particular stage, they are exploring and discovering how IR 4.0 can be applied at seaports. On the other hand, the current status of Malaysian seaports in the process of implementing IR 4.0 is not aligned with the global trend. According to Jeevan et al. [18], the current status of IR 4.0 implementation, in the global seaport system, is in the stages of adoption and expansion. The reason is that the majority of seaports have begun to increase the application of IR 4.0 in their seaport operations, which is evident based on the emergence of the new concept of smart seaports. The most innovative technology and digital paradigms in developing countries have been embedded and adhered to proactively. Some Asian countries, especially China and the Republic of Korea, have already progressed rapidly in automating their industries [19]. This point is evident based on the expansion of the smart ports, logistics procedures, storage, seaport operations, and shipbuilding facilities in these countries. The complete advancement of the implementation and execution of IR 4.0 has become a trend in which most seaports are initiating, adapting, and accepting the IR 4.0 paradigm in their daily seaport operations.

Owing to continuing demand from global trade, most seaports have started to initiate a fusion by focusing on IR 4.0 adaptation. In contrast, in Malaysia, the seaports in this country are still behind the global trend and are just starting to explore the concept of IR 4.0 instead of expanding to the next level. This condition and the worldwide maritime culture, in the adaptation of IR 4.0, slightly diverge from the Malaysian seaport scenario. Some seaports have completed the exploration phase, and some are still struggling to understand the requirements, and to identify the prerequisites, to familiarise themselves with the IR 4.0 agenda. However, some seaports have already been in the discovery phase, where serious concerns, regarding the need to familiarise themselves with this new revolution to keep pace with other seaports and to remain attractive to their clients, have been expressed.

The majority of seaports in Malaysia are still trapped in the exploration phase because most of them are not sure how IR 4.0 works and how they could benefit from it. According to Chen et al. [20], most Malaysian maritime players are unable to realign themselves because container seaports are heavily reliant on road transport, even though traffic congestion is common.

The limitations of rail transport capacity, such as single-track systems, limited-service numbers, the lack of rail links at certain inland freight terminals, and poor transport circumstances, are additional factors that limit the transportation options in this country.

Jeevan et al. [21] suggested that, to cater to the additional volume of containers in this region, the utilisation of existing inland facilities has also substantially substituted for Malaysian seaports. Consequently, the hinterlands also play a key role in determining the productivity of the Malaysian seaport system. Moreover, human factors are becoming the leading factors that contribute to the inability of the Malaysian seaport system to realign itself with the IR 4.0 system. Thus, technological progress in e-navigation is needed to enable human players to accelerate the development of the maritime transportation network [22]. For these reasons, the seaport system in Malaysia has been unable to comply

with the global seaport system. In such a case, we found that appropriate knowledge of IR 4.0, in the seaport system, is essential to fully exploit the benefits of its implementation.

3.2. CSFs for IR 4.0 Implementation in the Malaysian Seaport System

According to Jeevan et al. [18], global seaports require thirty-one (31) CSFs, consisting of six (6) main clusters for the implementation of IR 4.0 in the seaport system. On the other hand, the CSF clusters that are required for Malaysian seaports are in parallel with the global requirements. However, from the Malaysian perspective, the components in each cluster are not in parallel with the global context. In terms of the CSFs that are significantly more capable, in the current Malaysian scenario, there are a few that need to be added or subtracted. Here, we show that the results of the focus group discussion (FGD) that we conducted consist of twenty-nine (29) CSFs that are crucial for, and adaptable to, the Malaysian seaport system that are in line with the global trend.

3.2.1. Environmental Protection Cluster

Experts 1, 5, 6, 7, and 8 emphasised that 'each seaport has its own respective policy on waste minimisation, and it is applied to the seaport. Similarly, some have also said that implementing the United Nations Sustainable Development Goals and having guidelines with the goals provided will lead to a better outcome. Nonetheless, there should be monitoring of the tracking of waste from vessels, the facilities possessed, the potential for disposal, where it is coming from, and the type of waste, whether chemical or non-chemical'. In another context, with or without the implementation of IR 4.0, most waste sorting is difficult to manually perform with manpower only. However, with technology, almost half of all waste can be reduced and converted into fuel, fertilisers, etc. Furthermore, the enforcement department needs to start a proper discussion on the importance of waste reception facilities in the seaport system. Such discussions have been held numerous times, but there is still uncertainty about whether or not a waste reception facility has been prepared. They also added that most Malaysian seaports have implemented a significant strategy for waste management services, seaport reception facilities, alternative energy services, and waste reception facilities, as well as proposing the usage of affordable and clean energy.

According to Jeevan et al. [18], the global seaport system is gravely concerned with energy consumption during seaport operation and renewable energy sources. Nevertheless, these particular strategies are not well established in the Malaysian seaport system. However, we clearly see that there are still many CSFs related to the environmental aspect that need to be considered in the global seaport system. Sustaining the quality of the environment is the critical component that we have concentrated on in the context of Malaysia, and thus, Malaysian seaports need to realign their strategy to embrace concerns about the environment in their daily operations.

3.2.2. Social Equity and Culture Cluster

Compared to other factors, the human element needs to be the prime focus (experts 2, 3, and 9). The experts argued that the topic of labour and unemployment is expected to arise during the implementation of full digitisation in the operation sectors. For this reason, for the handling or supervision of such highly technological systems, skills and skilled workers should not be neglected. The issue of unemployment will surely never arise if labourers are well equipped with sufficient and continuous training programmes. Otherwise, it has been the usual culture of use the VTS setup for location tracking and managing before, during, or after transloading activities. However, in the Marine Department, the presence of sensors that provide data on the real-time situation, the implementation of big data, and systems for ship monitoring are some of components required for IR 4.0 application. With these assets, efficiency is preserved, and spending on more unnecessary expenses is avoided. Therefore, the availability of training sessions conducted by the Marine Department is required to share information, knowledge, and technology with seaport operators and clients. We need

a strategy to change the culture by utilising local experts to spread knowledge of IR 4.0 rather than importing foreign experts.

There are diverse workplace cultures and working environments in different countries, and some global scenarios, that allow for adaptation in the Malaysian seaport system. For example, the global seaport system is more aware and concerned with top management decision making and its vision and mission, which are also concurrent with the current agenda of companies, i.e., IR 4.0. Possibly for this reason, global seaports are more advanced and sustainable than Malaysian seaports. Therefore, Malaysian seaports should take action to strengthen and restructure the vision, goal, and mission of organisations to be appropriate for the present trend. In addition, some global seaports are experiencing shortages of highly qualified human resources in terms of skills, professional knowledge, and specialised English proficiency. English is also needed to meet the requirements of IR 4.0 [23,24]. As a result, in Malaysia, we have granted and given proper attention to English as a second language, as provided for in National Article 152 [25], and we support the National Book Policy of 1985, in which Malaysians are highly interested in reading English-language literature. Here, we conclude that language is not an issue for Malaysia to adapt IR 4.0 in the seaport system. Comprehensive knowledge of languages and ICT skills can be easily developed among Malaysians to improve the quality of IR 4.0 implementation.

3.2.3. Economic Value Cluster

The implementation of IR 4.0 requires huge investment, and the costs are high (experts 2, 4, 7, 9, and 10). Industries need to better understand, and be more thoughtful regarding investment and cost-efficiency, during IR 4.0 implementation. For instance, one of the long-standing seaport operators in Port Klang required massive investments in infrastructure development, and such investments were the idea of the port owner. Undoubtedly, the actions taken also entirely depend on the owner's judgement and considerations of the need to import technologies and make reasonable investments. Furthermore, the experts agreed that cooperation from all parties and agencies, such as seaport operators and government and private sectors, is necessary for massive investments. Such cooperation is possible and depends on governmental intervention, that is, the contribution of certain portions of capital to all sectors to improve the industry. However, a huge investment is needed to become familiar with IR 4.0 in the Malaysian seaport system. In Malaysia, three (3) main components are parallel with the global trend, namely, research and development on IR 4.0, expert knowledge on the IoT, and quality education.

Unsurprisingly, Malaysian seaports do not wish to invest heavily in IR 4.0 because of the unpredictable information on what returns can be obtained in the given timeframe. Several variables, such as organisational size, strategic objectives, and the business segment, for identifying the cost itself, have become the key factors slowing down the seaport system and preventing it from keeping pace with other seaports around the globe. IR 4.0 requires a great deal of effort on the part of leaders and shareholders to guarantee that investments are aimed at establishing an IR 4.0 initiative. Despite a huge amount of investment, the seaports in this country need to plan a substantial approach to enhance the commitment of top management, have a clear vision and mission in human resource management, and have skilful and knowledgeable employees who are competent, trained, and ready for IR 4.0, have an adequate understanding of IR 4.0, can advance the working and social culture, and have comprehensive language, knowledge, and ICT skills.

3.2.4. Operational Value and Technical Quality Cluster

An efficient turnaround time is the utmost priority during seaport operations (experts 1, 2, 3, and 7). With the emergence of the need to upgrade cargo handling, with the advanced application of the IR 4.0 component, workers or company employees, themselves, should be simultaneously upgraded as well [26]. Furthermore, every seaport is different and is its own link in the seaport value chain. Another issue that will be seen is data sharing. Although various agencies and sectors own their respective systems, they are reluctant to

jeopardise their competitiveness by sharing their systems with the public. Networking among players should be thought of prior to the implementation of IR 4.0 in any section in seaports. In terms of data sharing, additional equipment, projecting tracks, and yard adjustments should be determined. On this basis, further strategies can also be framed for improvement and maintenance. Better efficiency can be tracked and will be relatively able to save on costs.

However, the application of operational values and technical quality in the Malaysian seaport system does not correspond to the global trend. The reason is that some major aspects, such as flexible services in the operational system, data and information sharing, just-in-time (JIT) capabilities, technical and technological integration, standardisation and validation of IR 4.0 applications, the role of ICTs, the quality of IR 4.0 services and applications, and technological dependence, are not being comprehensively implemented in the Malaysian seaport system. Basically, in the global seaport system, the operational value and technical quality cluster focuses on understanding how machines or instruments, integrated into IR 4.0 components, can be used. It calls for analytical thinking, effective interaction, and effective execution based on a high-end command of technology. In addition, the application of IR 4.0 in seaports, especially in Malaysia, has been focused on the internal operation of seaports, while at the global stage, it has been widely spread outside of seaports.

3.2.5. Communication and Cooperation Cluster

Some stakeholders are already working on the ground to explore and implement IR 4.0 in their organisation (experts 3 and 8). However, some top managers stated, *'IR 4.0 can only be achieved by both parties'*. Interruptions in the establishment of IR 4.0 will be averted by effective management, the creation of a regulatory framework, employee training, and ongoing career development [27]. The SDGs that were introduced by the United Nations, for sustainability and their implementation, as well as the targets aligned with the goals provided, need to be assimilated into this cluster to ensure that the application of IR 4.0 in a seaport system, especially in this country, can be achieved. For example, a partnership for achieving the goal, derived from SDG 17, was implemented in the Malaysian seaport system (see Table 3).

However, a lack of trust between parties has negatively impacted the development phase towards the application of IR 4.0. Furthermore, the slow growth of reliable suppliers along the supply chain has become another drawback, preventing Malaysian seaports from matching the same achievements as global seaports. In the meantime, trust between parties, and the development of reliable suppliers along the supply chain, have become a criterion for international seaports to adapt IR 4.0 in their current system. This is crucial to share in the information among the players, and this interoperability is crucial for determining its operational efficiency. As network communication technology evolves, there is a vision in which objects will be able to 'talk' to each other, integrating the virtual world with the global real world that has developed as the IoT [27]. We believe that these two components will become fundamental for applying the remaining components in this cluster.

Table 3. Comparison between global and Malaysian CSFs.

Clusters	Items
Environmental Protection *	Renewable energy sources Energy consumption *Waste management services ** *Port reception facilities ** *Alternative energy service ** *Waste reception facilities ** *Affordable and clean energy (SDG 7) **
Social Equity and Culture *	Employee job opportunities Top management commitment Vision and mission in management Employee skills and knowledge availability Human resource management Employee competences and readiness for IR 4.0 An adequate understanding of IR 4.0 Organisational working culture Demographic and social change Employee training and readiness for IR 4.0 Comprehensive language knowledge and ICT skills *R & D on IR 4.0 ** *Expert knowledge on the IoT ** *Quality education (SDG 4) **
Economic Value *	Maintenance and operational costs of IR 4.0 Financial resource management IR 4.0 payback period Cost of using modern technologies *Investment in IR 4.0 ** *Cost of IR 4.0 application **
Operational Value and Technical Quality *	Flexible services in the operating system Data and information sharing JIT capabilities Technical and technological integration Standardisation and validation of IR 4.0 applications Role of ICTs Quality of IR 4.0 services and applications Technological dependence *Efficient turnaround time ** *Port efficiency ** *Real-time monitoring ** *JIT practices ** *Port traffic management system ** *Predictive data application usage **
Communication and Cooperation *	Trust between parties Growth of reliable suppliers *Cooperation between all parties ** *Acceptance by shipping lines ** *Logistics service providers acceptance ** *Acceptance by vessel owners ** *Partnership to achieve the goal (SDG 17) ** *Socio-demographic pressure **
Political and Legal Parameters *	Security risks of IR 4.0 Government regulations on IR 4.0 Data protection and data security Security and safety of applications *Government legal policy ** *National security and defence with regard to data ** *Involvement of government agencies ** *Security of software and data privacy ** *The flexibility of IR 4.0 application ** *IP registration ** *Government incentives **

Source: Jeevan et al. [9]. Notes: * CSFs required in the Malaysian seaport system.

3.2.6. Politics and Legal Parameter Cluster

There is no specific policy for maritime industries, in terms of IR 4.0, because every seaport is, itself, unique (experts 4 and 5). Different aspects need to be specified before the implementation of any policy to support IR 4.0 in Malaysia. From the industry perspective, the rapid development of IR 4.0 can validate and clarify the economic benefits because someone will be the first person who is willing to take the risk. More incentives should be given by the government to encourage all maritime players to be more advanced and efficient in their operations. The government can intervene by providing grants for research and development (R & D), and the output can be mutually shared among seaports and their respective clients.

Clear guidelines, and a mutual understanding, are preferable for all parties to achieve better IR 4.0 implementation. Likewise, issues regarding cloud computing and security should be studied and investigated carefully before use is initiated. Currently, Malaysian policymakers who deal with the seaport system are aware of the government's legal policy, national security, and defence issues with regards to data. Government agencies involved in IR 4.0, the security of software and data privacy, the flexibility of IR 4.0 application, and intellectual property (IP) registration should offer sufficient government incentives for IR 4.0 implementation.

In the meantime, the security risks of IR 4.0, government regulations on IR 4.0, data protection, and the security and safety of applications have been neglected by seaport systems, especially in this region. Nonetheless, various nations have different legal systems and regulations, and these differences have become the main reason for disparities from the global perspective. The political and legal aspects are very fragile, and they fully depend on the national policy of each region. Therefore, policymakers in each country should understand the importance of IR 4.0 as the main agenda of global trade practices and educate the key players in the maritime sector for successful execution. Table 3 shows the summary of comparison between global CSFs and Malaysian CSFs.

3.3. Discussion

FGD is particularly useful to confirm the findings with a diverse range of port operator profiles. Within this paper, without a doubt, FGD is considered an effective method for facilitating the exchange of opinions and discussion of agreement and disagreement among maritime players [28]. A face-to-face interview is sometimes unable to capture the dynamics of this situation, which involves many parties at same session [29]. Aside from that, FGD may be less expensive in terms of both money and time if compared to interviews. As a conclusion, the author concludes that data gathered through FGD is credible and trustworthy.

According to Jeevan et al. [18] there are four stages that must be considered for implementing IR 4.0 in the seaport industry: adoption, implementation, operational, and evaluation and has proven that the current IR 4.0 implementation in the global scenario is currently at the stage of adoption at the expanding phase. Figure 2 shows a Malaysian situation where the findings indicate that the current status of IR 4.0 implementation, in this seaport system, is at the stage of adoption, after the exploration phase, and at the beginning of the discovery phase.

As a result, the extension of this research can be directed on those CSFs that could have a positive or negative impact on the implementation of IR 4.0 in the Malaysian maritime industry. Furthermore, the Analytical Hierarchy Process (AHP) method can be used to rank and prioritise the CSFs in this study. To explore and validate the relationship among the factors influencing the implementation of IR 4.0 in Malaysian seaports, compatibility analysis approaches can be used. On the targeted seaport, a strength, weakness, threat, and opportunity (SWOT) analysis can be performed to see their ability in implementing the IR 4.0. The SWOT analysis can be aided by using Nvivo software to identify common themes and patterns. The strategy of a seaport, in dealing with their internal and external environments in relation to IR 4.0, can be determined based on this analysis.

4. Conclusions

The aforementioned IR 4.0 initiative was widely debated and became a phenomenon that was supposed to benefit many sectors and stakeholders globally. Malaysian seaports, however, are still behind the global trend and are just starting to explore the concept of IR 4.0 instead of expanding to the next level (global benchmark). Environmental protection, social equity and culture, economic value, operational value and technical quality, communication and cooperation, and political and legal parameters are some dimensions that need to be considered by Malaysian seaports in implementing IR 4.0 sustainably. This research provides a significant basis for exploring the implementation of IR 4.0, in the seaport industry, in much detail. In addition, further research can be carried out to explore and validate the relationship between the factors influencing the implementation of IR 4.0 in Malaysian seaports. The contributions of this research provide a clear image of where Malaysian seaports are now with regard to the process of implementing IR 4.0. Basically, the path to the destination has been explored, and investment and clear policy-making strategies need to be made in advance to reach the destination.

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