

A Study of Critical Sustainable Factors in the Malaysian Seaport Sector for the Implementation of Industrial Revolution (IR) 4.0

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ABSTRACT

The implementation of Industrial Revolution (IR) 4.0 is crucial in the maritime industry, and a global standardisation framework is necessary for its effective and long-term implementation in seaports. This study aims to identify the Critical Sustainable Factors (CSFs) for implementing IR 4.0 in Malaysian seaports. Six dimensions, namely environmental protection, social equity and culture, economic values, operational and technical qualities, communication and cooperation, and political and legal parameters, were identified through a literature review. The most significant CSFs were validated through a closed-ended questionnaire circulated to academics, practitioners, managers, and chief executives from port operators. According to the findings, 36 CSFs are compatible with IR 4.0 implementation in Malaysian seaports. This study contributes to developing a guideline for maritime stakeholders to be aware of the CSFs for implementing IR 4.0 in seaports. Future research should focus on developing a conceptual framework for implementing IR 4.0 in seaports.

Keywords: Industrial Revolution 4.0, Compatibility Analysis, Critical Sustainable Factors, Malaysian Seaport Sector, Maritime Industry.

Introduction

As the world accelerates its adoption of Industrial Revolution (IR) 4.0 and embraces the digital economy, players in the maritime industry must remain informed with technological trends in accordance with the change and thrive in the digital era. To accomplish this, a comprehensive approach is required to bring stakeholders up to pace with the globalist agenda shaped by IR 4.0.¹ The German government became acquainted with the latest Industrial Revolution mechanism in November 2011, which it believes will shake up the maritime industry. IR 4.0 has been demonstrated to have a positive impact on the global industrial sector.² The maritime industry plays an essential role in a nation's economic development.

Malaysia is a Southeast Asian country with a strategic location along the Strait of Malacca, which serves as a major sea route connecting the Far East to Asia, Europe, and the Middle East. Malaysia as a maritime nation has always relied on maritime trade. Malaysia will not be able to thrive in the maritime sector solely because of its location. As a result, a global standardisation framework must be established to ensure the efficacy and long-term implementation of IR 4.0 strategic and inventiveness in the Malaysian seaport

industry. Most stakeholders are still hesitant to spend a significant amount of money on IR 4.0 without knowing what benefits they will reap in the future.⁴ Most of the reasons for this are that organisations lack a proper organisational strategy for implementing IR 4.0.⁵ The most difficult challenge to implementing IR 4.0 is an absence of a coherent strategy for creating value, as well as a lack of leadership support. Malaysia highly depends on national ports to facilitate trade and economic development as the main ports to this maritime trade. Seaports are major players in the international supply chain.⁶

As a result, seaport competitiveness and profitability would be critical for ensuring the smooth operation of foreign trade. Nonetheless, the introduction of IR 4.0 in early 2010, at the beginning of the age of immersive digitization, demonstrated that the maritime industry, for example, the seaport sector, must be prepared to meet unexpected developments in dynamic maritime commerce.⁷ The subject of IR 4.0 is still understudied, even though research on it has grown tremendously in recent years.⁸ The goal of this research is to determine the most important Critical Sustainable Factors (CSFs) for implementing IR 4.0 in Malaysian seaports. CSFs must be considered as a critical component in the sustainable implementation of Malaysian seaports. Given that digitalization is a critical component of the maritime industry's future, not only in terms of operational and technical aspects, but also in terms of implementing the IR 4.0.⁹ Based on the literature, this study discusses several potential CSFs that may influence the implementation of IR 4.0. A conceptual model will be developed in future research to illustrate the CSFs outcomes in IR 4.0 implementation at the seaport industry, which will contribute to the eventual development of a decision-making guideline.

Industrial Revolution 4.0

The term "Industrial Revolution (IR) 4.0" refers to new technologies such as the Internet of Things (IoT), Big Data, and Cyber-Physical Systems (CPS) (CPS). Computers, automation, and robots have existed for decades, but the internet has revolutionised their use and opportunities.¹⁰ IR 4.0 is transforming corporate structures and practises, reshaping business strategies, and boosting customer satisfaction.¹¹ Furthermore, it is the same in the seaport industry, which starts with the arrival of the ship. Ships calling at the port will be received based on community circles. As soon as a ship is within range of a terminal, a harbour coordination centre, vessel traffic managers, tug masters, and pilots form a technology circle. All same principles are applicable on a shipment level, and it ends with the ship's departure.¹²

It accelerates communication developments by using a Cyber-Physical System (CPS). As a result, businesses will find it easier to establish global networks that integrate warehousing systems and run CPS seaports.¹³ Without a doubt, CPS in maritime aims for the tight integration of wireless communications, control, and computing technologies into the navigation transportation system, which possesses the typical CPS characteristics of revolutionising the navigation pattern to be safer and more efficient through real-time embedded systems for distributed sensing, computation, and control between cyber and physical systems.¹⁴

Internet of Things (IoT) can commonly provide advanced system, service, and physical object connectivity, allowing for object communication and data sharing. IoT can be achieved in a variety of industries by controlling and automating aspects such as remote control.¹⁵ The development of global trade and globalisation has resulted in a noticeable trend in traffic and cargo, obliging numerous seaport ports to accept changes and use the (IoT) in their seaports for more effective practises. Big Data has recently become a hot topic in IR 4.0. Importantly, big data refers to the use of digital technology to conduct analysis.¹⁶ In port terminals, we have very big amounts of data generated by the hour. Some examples of these data are ships that are being serviced, types of cargo stored within the terminal, current productivity of the equipment and workers, out-and inbound traffic, payment and billing information and details, cargo loading and unloading deadlines, ongoing contracts, etc. All this information can be stored in real-time in Data Warehouses, because it constitutes Big Data, that will ultimately help the Terminal grow.¹⁷

Critical Sustainable Factors

There is no clear consensus on the concept of sustainable development, but the most generally recognized interpretation is the following: “to provide for the needs of the present generation without compromising the abilities of future generations to meet their needs”.¹⁸ In contrast, most of the sustainable development taken into consideration and find a balance among economic, social, and environmental factors, which are also referred to as the triple bottom line.¹⁹ In this research, the identification of Critical Sustainable Factors (CSFs) for the implementation of IR 4.0 appears to focus on the additional narrow dimension such as political and legal, communication and cooperation, and operational and technical qualities. These dimensions are extended the “Triple Bottom Lines” strategy.²⁰ Additionally, there are many issues in maritime ports and related activities that are constantly emerging and becoming a competitive factor. CSFs has thus become a major research focus and continues to attract the attention of many scholars for sustainable implementation.²¹ In this study, researchers had identified the main dimension along with the CSFs which will influence the implementation of IR 4.0 in Malaysia seaports.

Environmental Protection

The environmental sustainability of the ports has been a matter of concern to the port users, policymakers, port authorities, and the local community. For ensuring sustainable development, environmental protection was promoted by international and national legislation. As well as that, the industrial businesses be required to realize that environmental responsibility should be included in the company policies.²² The port environment including the channels of entry, water management, dredging, beaches, soil, and other natural areas be required to be protected.²³ Owing to the appropriate use of the resources, a decrease in energy consumption, waste reduction, waste recycling, and a lower release of poisonous gases. This was possible when the technological innovations were related to the sustainability of a country wherein the environmental-based technological changes improve the environmental quality.²⁴

Waste minimization was described as a technique for removing wastes like the defects which needed reprocessing, transport of goods and people, excessive processing.²⁵ Some seaport operations use a lot of energy and hazardous materials or generate solid waste which can pollute the environment. Besides, Malaysia is facing a problem with marine derbies, for example, plastic pollution. Artificial Intelligence (AI) drones can help to identify the waste, for example, plastics, oil spills, and company waste. By using this, we can easily identify and measures the obstacles at the seaport, this shows the advantages of IR 4.0. AI in maritime technologies have undergone a significant change after the introduction of IR 4.0.²⁶

The consumption of natural resources is a matter of great concern to the port authorities. The ports have realized the importance of acquiring a green status by using novel technologies, redesigning their infrastructure, and preventing the massive consumption of energy.²⁷ Renewable energy was seen to a vital component in the maritime sector, since this sector aimed to reuse the electronic wastes to minimize their environmental effect.²⁸ Waste recycling refers to the processing of used materials or wastes to develop useful and novel products. IR 4.0 could help in reducing the use of raw materials for developing new products. It also requires lesser energy and was seen to be an effective technique for controlling water, air, and land pollution at the seaports.²⁹

Social Equity and Culture

The shipping companies focus primarily on balancing the main concerns of the employees such as their health and safety during work, their well-being, and job satisfaction, providing incentives for improving the skills of the workers while transferring the new knowledge related to IR 4.0.³⁰ The employees are seen to be more successful in their work and are more dedicated to the shipping business if all standards are successfully met.³¹ Internet of Things (IoT) is a novel concept that has revolutionized all lives and society. This concept was developed for connecting the objects to a network, which helped the people access all the global information. The employees must consider the trade-offs for promoting the “digital trust” amongst the working staff if they attempt to collect all data at their workplaces. This is necessary for understanding the actual benefits of the IoT and actual sharing of the information.³² The workers have to be more ready to adopt novel technologies of IR 4.0 which helps in preserving competitiveness and offers them a competitive advantage in the maritime industry.³³

Cloud Computing in IR 4.0 has helped in making the information more transparent by significantly increasing the number of objects and individuals who are interconnected. A virtual copy of the world could be generated by linking all sensor data and the digitized plant models. Hence, the results of the data analytics should be included in the support systems which can present all the IR 4.0 characteristics.³⁴ All the data related to the port operations are made transparent and then it is optimized for improving the usage of productive equipment, developing optimized energy schedules, and saving energy.³⁵ IR 4.0 could embrace the transition expertise, work-task rotation, make all work-related

adjustments (i.e., uncertainty tolerance), including the versatility of time and position, and the different leadership skills during the different seaport operations.³⁶ Developmental techniques could affect the tasks related to the engineering design behavior, research areas and development of cost-effective, Research and Development (R&D) project. Furthermore, the use of a digitization strategy provided a solution to the ports which helped them achieve a competitive advantage and increase their competitiveness.³⁷

Economical Values

IR 4.0 offered a near-real-time accuracy of the various port operations and improved their economic performance. Cyber-Physical System (CPS) can reduce the cost due to interconnection played a vital role, fed knowledge, and added value to the maritime industries so that they operated in a cost-effective manner.³⁸ Furthermore, the interconnection between objects, humans, and systems has led to the creation of a real-time optimized, dynamic, and self-organized inter-company value system, which is optimized and evaluated using criteria like resource efficiency, costs, and availability. IR 4.0 is a lean process that presented cost-effective logistics, which could be fulfilled by the managers who planned efficient operations for decreasing the stocks, decreasing the lead times, reducing the number of resources, hiring fewer employees, eliminating the non-value adding operations, decreasing redundant efforts and removing all wastes from the seaport operations.³⁹

Shipbuilding industries are a major activity carried out in the maritime ports. Shipbuilding 4.0 refers to a digitization process included in IR 4.0, which contributed significantly to the economy. It was stated that this technique would save 15% additional costs compared to the conventional shipbuilding techniques.⁴⁰ The company-level technology users of IR 4.0 ought to improve their capacity utilization and rapidly market their products, according to the changing needs of the market. Adaptability and the IT changes were seen to be important achievement variables affecting an assembly process, which can influence financial performance.⁴¹ Implementation of the IoT has offered many cost-reducing benefits to several organizations. IR 4.0 provides a real-time precision, enables a cross-sectional plant optimization of port services, and improves the economic output.⁴²

Operational Value and Technical Qualities

IoT was complemented by the Internet of Services (IoS) since the smart services offered their abilities as an intelligent service. The application of such technologies presents many technological improvements and advantages. IR 4.0 is giving a higher utilization rate of resources, and it can be considered as one of the lean principles which make, the seaport operations more convenient and fluently.⁴³ IR 4.0 helps in improving the efficiency of resource usage while also reducing while balancing the resource utilization in the environment which is affected by the destruction of the seaports or pollution. The

use of resources at the ports indicates the application of various equipment related to the vessel arrival times and rates during the seaport operations. The usage metrics estimate the rate of use of different port facilities, i.e., the occupancy rate of berths and the yard usage compared to the actual usage of the seaport services.⁴⁴

Just-in-Time (JIT) Practices, is an IR 4.0 activity which follows the lean approach and is mainly pull-oriented, indicating that the material was produced and supplied only in the case of real demand. JIT is a novel technique that increases productivity and decreases wastes by acquiring the products only when the inventory decreases, which reduces expenses.⁴⁵ The increasing use of Information Technology (IT) has made the system more efficient, faster, cost-effective, and allowed a reliable development of the information-related transport services in a maritime port sector. IR 4.0 implements the ICT processes, such as digitization and automation, for improving the seaport operations.⁴⁶ IR 4.0 has offered many administrative-efficiency processes, which help in decreasing administrative and documentation activities. Cloud data storage is one of the best examples from the IR 4.0, which makes the seaport operations more reality without any interruption. More, the smart machines which use as self-configuration, self-optimization, or man-made optimization for completing tasks are required to offer better services during the port operations.⁴⁷ IR 4.0 makes all services safer, flexible, and effective. Furthermore, IR 4.0 improved the efficiency and transparency of the management decisions and processes since the real-time data was made available for all the port operations.⁴⁸

Communication and Cooperation

Cooperation and communication were the major components that were involved in the knowledge and information sharing along with partnering with the main players. The research on the sustainability of the port operations stated that cooperation and involvement of the stakeholders was the main factor that helped the ports become more sustainable.⁴⁹ Early cooperation was needed between the stakeholders for implementing sustainable development activities. The successful implementation of the IR 4.0 activities was based on how the workers responded to the various IR 4.0 activities. Organizational readiness is based on communication, organization, and decision-making initiatives.⁵⁰ The vision, mission, and direction of a company must allow the implementation of novel technologies by the seaport operators, who are familiar with the IR 4.0 processes. The port authorities usually encourage the shipping companies to decrease waste and pollutant emissions at the ports. This was the major initiative undertaken by the port authorities for implementing the IR 4.0 activities at the seaports. They work with the shipping companies for eliminating their environmental issues by conducting business meetings and introducing relevant regulations/rules or campaigns.⁵¹

The implementation of the IR 4.0 principles in the organizations of the shipping lines can affect the deep structure of the organizations owing to their horizontal, vertical, and end-to-end integration. Furthermore, this changes the primary assumptions regarding the management processes since the existing business practices have started implementing the principles of digitization and automation.⁵² The culture of the organization and other

systems is also altered after the introduction of the IR 4.0 principles. Freight forwarders used digitization in their real-time activities for increasing the consistency of their planning, operation, management, control, and coordination activities for different tasks. One of the first factors which are considered in IR 4.0 is strategic management using an operational approach for maritime ports. The company strategy acts as a guide for various business decisions. The short and long-term success of the company is based on the performance of its operational strategies.⁵³

Political and Legal Parameters

The government ministries have formulated and implemented many industrial schemes and rules for developing novel business models which are based on the growth requirements or objectives of the countries. There is an increasing pressure to enhance the digital civilization of the seaport operators, along with different circumstances that encourage the financial growth of the company and society. For preventing risks to the workers after the implementation of the digital transformation process, the company management needs to involve them in the early planning processes. IR 4.0 allows for a flexible replica of the working time.⁵⁴ The workers, management, and the representative groups need to define arrangements which make the work hours more flexible while taking into consideration issues like the time enforcement and the restrictions on the overtime policies in the shipping and maritime sector.⁵⁵

Furthermore, the skills of the existing workforce need to be assessed for understanding the emerging digital technology era. Many changes implemented in the intellectual property laws have altered the market strategies and made them more liberal and global. This also led to the initiation of new activities which encouraged the maritime organizations to develop their Intellectual Property Rights. IR 4.0 significantly affected intellectual property protection laws. The IR 4.0 encourages organizations to make several efforts for mastering the legal reforms related to IT security, data privacy, labor laws, and liability after the digital conversions. Company should be responsible for the accidents and damages resulting due to the use of the autonomous vehicles.⁵⁶

From the outcome of the comprehensive literature review, in total, 6 main dimensions and 36 critical sustainable factors are identified as critical to IR 4.0 implementation. Based on the sub section 2.2.1 - 2.2.6, Table 1 summarizes the 36 CSFs for the implementation of IR 4.0 in Malaysian seaports.

Table 1. Summary of literature review on critical sustainable factors

Critical Sustainable Factors	References
Environmental Protection	
Waste Minimisation	Mrugalska & Wyrwickah, 2017; Rasidi <i>et al.</i> , 2019; Roh <i>et al.</i> , 2016
The efficiency of Natural Resource Consumption	Chiu <i>et al.</i> , 2014
Renewable Energy Initiatives	Kuhl <i>et al.</i> , 2016
Environmental Impact Minimisation	Kuhl <i>et al.</i> , 2016; Bonilla <i>et al.</i> , 2018;

Waste Reuse	Kuhl <i>et al.</i> , 2016; Rasidi <i>et al.</i> , 2019
Waste Recycling	Chiu <i>et al.</i> , 2014; Barquet <i>et al.</i> , 2016; Kuhl <i>et al.</i> , 2016
Social Equity and Culture	
Employees' Trust on the Internet of Things	Schuh <i>et al.</i> , 2014; Jayashree <i>et al.</i> , 2019
Employee's Acceptance of IR 4.0 Technologies	Schuh <i>et al.</i> , 2014; Jayashree <i>et al.</i> , 2019
Employee's Expertise for the IR 4.0 Technologies	Hareide <i>et al.</i> , 2018
Data Transparency owing to the IR 4.0 Implementation	Hermann <i>et al.</i> , 2016; Vaidya <i>et al.</i> , 2018
Demographic Transition and Social Changes with the adoption of IR 4.0	Singh, 2018
Research and Development Culture Required for the implementation of IR 4.0	Singh, 2018; Oh <i>et al.</i> , 2018
Economical Value	
Cost Reduction through the Interconnection	Bahrin <i>et al.</i> , 2016
Non-value-adding Effort Reduction	Waters, 2007
Maintenance and Operational Costs of the IR 4.0 Technologies	Stanić <i>et al.</i> , 2018
IR 4.0 Technologies Replacement Costs	Bonilla <i>et al.</i> , 2018; Mrugalska & Wyrwicka, 2017
Cost and Benefits of IR 4.0 Implementation on the Seaports	Haddud <i>et al.</i> , 2017
Economic effectiveness of the IoT	Singh 2018
Operational Value and Technical Qualities	
Higher Utilisation Rate of Resources	Zhou <i>et al.</i> , 2016; Rasidi <i>et al.</i> , 2019; Salleh <i>et al.</i> , 2017
Shorter Lead-Time	Rasidi <i>et al.</i> , 2019; Ha <i>et al.</i> , 2017
Just-in-Time (JIT) Practices	Singh & Ahuja, 2012; Rasidi <i>et al.</i> , 2019
Information Spreading through the Network	Rasidi <i>et al.</i> , 2019; Bahrin <i>et al.</i> , 2016
Documentation and Administration Reduction	Müller <i>et al.</i> , 2018
Service Flexibility Enhancement	Bahrin <i>et al.</i> , 2016; Roblek <i>et al.</i> , 2016); Müller <i>et al.</i> , 2018
Communication and Cooperation	
Readiness of the Seaport Operators for the implementation of IR 4.0	Sony & Naik, 2019; Schuh <i>et al.</i> , 2014; Jayashree <i>et al.</i> , 2019
Readiness of the Seaports Authorities to Implement the IR 4.0 principles	Roh <i>et al.</i> , 2016
Cargo-owners' Acceptance Related to the IR 4.0 Implementation by the Seaports	Sony & Naik 2019
Shipping Lines Acceptance of the IR 4.0 Implementation by the Seaports	Ancarani <i>et al.</i> , 2019; Manavalan & Jayakrishna, 2019; Sony & Naik, 2019
Freight forwarders' Acceptance of the IR 4.0 Implementation by Seaports	Sony & Naik, 2019
Align the Implementation of the IR 4.0 principles with the maritime port organisational strategy	Sony & Naik, 2019

Political and Legal	
Government enhancement in the shipping industries	Schroeder & Bigdeli, 2018; Singh, 2018; Oh <i>et al.</i> , 2018
The role of Maritime Administration and the Ministry of Transport	Singh, 2018; Yunus & Yang, 2012 Sony & Naik, 2019
Social-democratic pressure on the digital culture	Singh, 2018; Schroeder & Bigdeli, 2018
Onboard working policies and labour laws	Bhattacharjea, 2006; Singh, 2018
Intellectual property rights in the Shipping and Maritime Industries	Basant, 2004; Singh, 2018
Liability and Regulations for the autonomous devices and machines used by the seaport operators	Singh, 2018

Source: Compiled by Author

The finding in Table 1 above can conclude that, the literature had shown there can be further investigate on the “Triple Bottom Line” sustainability. Operational Value and Technical Qualities, Communication and Cooperation, Political and Legal Parameters are the main dimension which is an extension for the normal sustainability concept. There are 6 major dimension which indicates the sustainable implementation of IR 4.0 in Malaysian seaports. Moreover, these findings addressing the research questions on: What are the most critical sustainable factors for the implementation of Industrial Revolution 4.0 in Malaysian Seaports.

Methodology

To identify the most Critical Sustainable Factors by using the Compatibility Analysis, there are six steps needed to be followed:

Step 1: Identifying Critical Sustainable Factors by using literature review.

Step 2: CSFs were validated by expert consultation.

Step 3: The CSFs that relevant to the implementation of IR 4.0 were finalized.

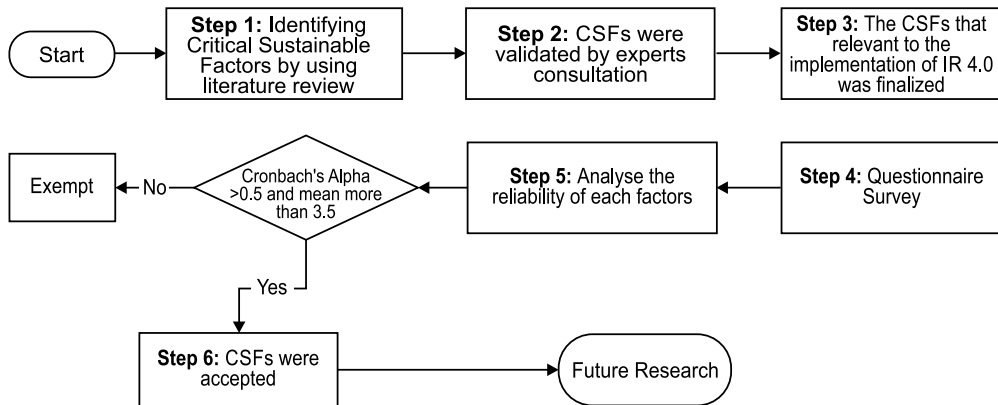
Step 4: Paper-based questionnaire surveys were distributed again to the experts.

Step 5: The reliability of each CSFs was tested.

Step 6: Cronbach’s Alpha more than 0.5 and the mean value of more than 3 were accepted for future study.

Figure 1 below illustrates the steps that need to be followed during the Compatibility Analysis for IR 4.0 implementation.

Figure 1 identifies the most Critical Sustainable Factors for IR 4.0 implementation, the methods (i.e., Compatibility Analysis) were used. The CSFs are first identified from the secondary data (literature review). Then, factors validation through an expert’s consultation. After the expert’s validation, the CSFs that relevant to the implementation

Figure 1. Compatibility Analysis of IR 4.0 Implementation

Source: Author

of IR 4.0 were finalized. In this study, the data was collected by a structured questionnaire. “Questionnaire is a popular method of collecting data because researchers can gather information fairly easily and the questionnaire responses are easily coded”.⁵⁷ A paper-based survey comprising a closed-ended questionnaire was used to collect the data. The quantitative data are gathered from 38 maritime domain experts-i.e., academic researchers, strategy managers, and senior executives of the port operators from Malaysian seaports with over 10 years of experience in managing seaport operations. The experts were given equal chances to answer the designed questionnaire by evaluating and rating the compatibility of CSF for the implementation of IR 4.0. After that, the reliability of each CSFs was tested, and the mean value had been calculated. Cronbach’s Alpha more than 0.5 and the mean value of more than 3.5 were accepted for future study.⁵⁸

Analysis of findings and discussion

In designing the questionnaire, the outcomes from the comprehensive literature review were used. The paper-based questionnaires contain five-point scale Likert-type questions. Likert scale starts from 1 (strongly disagree) to 5 (strongly agree). The main reason for choosing a Likert scale is because it reflects the level of agreement on the importance of certain constructs and dimensions which is important for the implementation of IR4.0 in Malaysian seaports. Secondly, it provides the optimal length of rating to maximize the reliability and validity of the results. In total, 41 questions were generated for the questionnaire, grouped into two different sections- i.e., Section A: Respondent’s background and Section B: Critical Sustainable Factors for IR 4.0 implementation. All the questions were generated precisely to answer the research question and only consume approximately 15–20 minutes of the respondent’s time. This strategy reduces the length of the survey, reduces the amount of time needed for respondents to answer the questions, and increases the response rate.

The CSFs are filtered by choosing them with a 3.5 mean value and above. The CSFs which are lower score than 3.5 will be exempted. The results had been shown below in Table 3. Generally accepted rule is that 0.6-0.7 alpha value indicates an acceptable level of reliability, and 0.8 or greater a very good level. However, values higher than 0.95 are not necessarily good, since they might be an indication of redundancy. It cannot be denied 0.5 alpha value can be considered to be moderately reliable.⁵⁹ This section disclosed the findings of the paper-based survey with 38 experts. Apart from that, this section will also give the analysis of the demographic information of 38 experts, followed by results of compatibility analysis and discusses the findings. Table 3 summarize the CSF with average value for each criterion.

Table 3. Summary of CSFs with average value for each criterion

Factors	Cronbach's Alpha	Mean	Standard Deviation
Environmental Protection	0.506		
Waste Minimisation		4.08	0.487
Efficiency of Natural Resource Consumption		4.08	0.632
Renewable Energy Initiatives		4.03	0.592
Environmental Impact Minimisation		3.92	0.587
Waste Reuse		3.76	0.820
Waste Recycling		3.68	0.842
Social Equity and Culture	0.551		
Employees' Trust on the Internet of Things		3.71	0.732
Employee's Acceptance of IR 4.0 Technologies		3.87	0.665
Employee's Expertise for the IR 4.0 Technologies		4.08	0.632
Data Transparency owing to the IR 4.0 Implementation		3.84	0.823
Demographic Transition and Social Changes with the adoption of IR 4.0		3.87	0.623
Research and Development Culture Required for the implementation of IR 4.0		4.29	0.611
Economical Value	0.805		
Cost Reduction through the Interconnection		3.76	0.943
Non-value-adding Effort Reduction		3.63	0.714
Maintenance and Operational Costs of the IR 4.0 Technologies		3.55	0.891
IR 4.0 Technologies Replacement Costs		3.95	0.804
Cost and Benefits of IR 4.0 Implementation on the Seaports		3.97	0.592
Economic effectiveness of the IoT		4.03	0.716
Operational Value and Technical Qualities	0.795		
Higher Utilisation Rate of Resources		3.63	0.786
Shorter Lead-Time		3.82	1.010
Just-in-Time (JIT) Practices		3.92	0.941

Information Spreading through the Network		4.03	0.822
Documentation and Administration Reduction		3.95	0.655
Service Flexibility Enhancement		4.05	0.733
Communication and Cooperation	0.786		
Readiness of the Seaport Operators for the implementation of IR 4.0		4.16	0.679
Readiness of the Seaports Authorities to Implement the IR 4.0 principles		4.24	0.714
Cargo-owners' Acceptance Related to the IR 4.0 Implementation by the Seaports		3.95	0.567
Shipping Lines Acceptance of the IR 4.0 Implementation by the Seaports		4.13	0.529
Freight forwarders' Acceptance of the IR 4.0 Implementation by Seaports		3.87	0.623
Align the Implementation of the IR 4.0 principles with the maritime port organisational strategy		4.18	0.692
Political and Legal Parameters	0.775		
Government enhancement in the shipping industries		4.24	0.675
The role of Maritime Administration and the Ministry of Transport		4.45	0.795
Social-democratic pressure on the digital culture		3.87	0.529
Onboard working policies and labour laws		3.79	0.704
Intellectual property rights in the Shipping and Maritime Industries		4.05	0.695
Liability and Regulations for the autonomous devices and machines used by the seaport operators		4.16	0.638

Source: Author

The following formula used to calculate the mean value.

$$\bar{x} = \frac{\sum fx}{\sum f}$$

\bar{x} is the average value,

f is the number of occurrences,

$\sum fx$ is the sum of the product fx ,

$\sum f$ is the total number of occurrences.

Cronbach's Alpha reliability analysis was conducted to measure the internal consistency of the two constructs (see Table 3). This Cronbach's Alpha value were calculated from Statistical Package for Social Sciences (SPSS). SPSS is a statistical program that is developed by the IBM company and commonly used by researchers or academics around the world. This statistical program is very user-friendly and numerous statistical tests could be carried out using this programme. In the form of univariate, bivariate and multivariate analyses, both parametrical and non-parametric statistical techniques are performed for comparison and correlation statistical examination.

The demographic information from the survey was used to review the characteristics of experts. Table 4 presents a summary of the experts' work positions and the years of experience that they had in their respective fields. Out of the 38 experts, 9 (23.7%) were senior lecturers, 20 (52.6%) were executives and another 9 (23.7%) were companies' manager. The responses from these groups are expected to produce significant findings for this research. In respect to the experts' working experience, almost (50%) of them possessed 15 to 20 years of experience in their respective fields, while experts having work experience between 10 to 14 years are 39.5% of them. In total, 10.5% of the experts had more than 20 years of work experience in the maritime sectors. None of them who have a working experience of less than 10 years were chosen. Experts with more working experiences are expected to provide more precise information than those with fewer experiences, which ensures the quality of the research. Apart from that, the education background had considered for this research. More than 50% experts having a bachelor's degree, while another half of them had their master's and Doctoral Degree. A paper-based questionnaire survey is effective only when experts have knowledge of the topic and they are competent to answer the questions.

Table 4. Summary of expert demography

No.	Position	Response	Percentage (%)
1.	Senior Lecturer	9	23.7
2.	Manager	9	23.7
3.	Executive	20	52.6
No.	Experience	Response	Percentage (%)
1.	0-9 years	0	0
2.	10- 14 years	15	39.5
3.	15- 20 years	19	50.0
4.	than 20 years	4	10.5
No.	Education	Response	Percentage (%)
1.	Bachelor's Degree	20	52.6
2.	Master's Degree	9	23.7
3.	Doctoral Degree	9	23.7

Source: Author

Based on the results above, economic value dimension is becoming a driving force in the globalization of sustainable development. This is because, it has the greater value of Cronbach's Alpha with 0.805. The assessment of the economic value dimension of a seaport is an important subject for both the political and the public debate. Seaport is considered a determinant of economic growth; it contributes to private sector development

and economic gain. By implementing IR 4.0, it enhances the service quality of the seaport business and the operation sector. It has been noted that port sector investment can sustain the implementation of IR while it helps to economic growth of a nation. The Internet of Things (IoT) adoption has the potential to enhance operating processes, to reduce costs and risks due to its adaptability and versatility. IR 4.0 helps to boost economically and cutting down the operational costs.

Conclusion

This study concludes that, six main dimension and 36 critical sustainable factors are identified as critical for the implementation of IR 4.0 in Malaysian seaports. This paper has conducted an extensive literature review in the field of maritime sectors to identify the CSFs affecting the IR 4.0 implementation. Therefore, future research can significantly investigate those CSFs that could give a positive or negative impact on the implementation of IR 4.0 in the Malaysian maritime industry. A Focus Group Discussion (FGD) can conduct to enhance the quality of the CSFs with the more stakeholders, port operators and government agencies. Moreover, Analytical Hierarchy Process (AHP) method can be applied in this study to rank and prioritize the CSFs. Exploratory Factor Analysis (EFA) approaches can be conducted to explore and validate the relationship among the factors influencing the implementation of IR 4.0 in Malaysian seaports.

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