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Developing a Holistic Oil Port Sustainability Framework: A Case of China

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Developing a Holistic Oil Port Sustainability Framework: A Case of China

A thesis submitted to the University of Plymouth in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

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Abstract

The global trading environment is changing dramatically, especially in the recent years. Driven by the increasing frequency and scale of trading, as well as the desire to meet the handling demand and to sustain development, the competition between port's productivity and the pursuits of regional and international influences is becoming significantly severe. This fact has brought, and is still bring consequences to the balance between different sections at port. For instance, the conflicts between environmental and social section issues, which are led by the increasing pressure from multiple perspectives (e.g. environmental pollution, lack of maintenance, interest parties' disputes). Under these circumstances, the disputes between economic development, social benefits, as well as the environmental protection at port have attracted many people's attention. However, no holistic framework is forwarded as a 'guidance', or 'measurement', to cover most crucial matters from every section to help evaluate the sustainability performance at ports. In the previous literature, each section has only been individually researched in terms of the current performance at port. The lack of a 'holistic framework' is a potential hinder to maintain and develop ports in a sustainable way.

Among all the port types, oil port has been relatively neglected due to its relatively late attraction to people while previous studies mostly concerned about the container port for the significant economic contribution to both regional and national economy. Nevertheless, due to oil port's higher sensitivity to negative environmental impact and safety issues in comparison to other port types, as well as the incompletely fitted cargo handling capacity to the increasing trading quantity, many incidents and inefficiencies do happen in the oil port on a relatively frequent basis. Thus, it is not only needed to have a general port framework as the guidance, but it is also

crucial to develop a holistic oil port framework for port operators to have a systematic and structural overview of the important factors, as well as the connections between the factors to enhance overall performance. As sustainability is the most suitable concept covering all-important aspects, this research focuses on the development of a holistic oil port sustainability framework.

This research adopts a mixed methods[1] methodology[2] - a mixture of semi-structured interviews (qualitative stage), Analytic Hierarchy Process (AHP) survey, Total Interpretative Structural Model (TISM) panel group meeting, and Matrice d' Impacts Croises-Multiplication Appliqúe an Classment (cross-impact matrix multiplication applied to classification) (MicMac) analysis (quantitative stage) to first obtain the experts' opinion to build a practical, holistic oil port sustainability framework, then prioritise the importance of the sustainability groups and indicators for oil ports, and discover the connections[3] (both interrelationships and contain powers) between sustainability groups (structural interrelationships of, and the contain powers between each groups).

A theoretical holistic sustainability oil port framework is formed first via Systematic Literature Network Analysis (SLNA). Then, in the qualitative stage, semi-structured interviews are conducted to examine the theoretical framework and develop it into a practical holistic oil port sustainability framework. The practical framework will act as the foundation in this research for further value adding analysis. Followed by the qualitative stage (interview), quantitative methods are used to expand the new knowledge range to be added to the newly developed practical framework to further ease the

[1] In this research, 'Method' refers to the approaches obtaining empirical data. e.g. Interview, Survey, and Observation.

[2] In this research, 'methodology' implies a systematic 'methods set' to achieve the final research goal.

[3] In this research, 'Connection' means both the interrelationships between sustainability groups and their individual contain powers to the system.

application of this framework to ports.

In the quantitative stages, from the value adding perspective, Analytic hierarchy Process (AHP) method is first adapted to prioritise the identified sustainability groups and indicators to show a general ranking of the importance of the sustainability groups and indicators, which provide the port manager with convenience to choose the ones to accomplish when there are limited resources (e.g. capital, time, and funds). Then, connections between the sustainability groups are identified with the most crucial sustainability groups highlighted via Total Interpretative Structural Model (TISM) and Matrice d' Impacts Croises-Multiplication Appliqúe an Classment (cross-impact matrix multiplication applied to classification) (MicMac). In other words, TISM and MicMac are adopted to provide support to identify the most commonly recognised 'impacting' oil port sustainability groups in the system. Moreover, by the comparison of the empirical results from the three methods (Interview, AHP, and MicMac), a 'must have set' of sustainability groups have been identified that deserve the most attention regardless of external condition, to act as the 'central' of the framework. As a result, the empirical evidences do not only build a holistic oil port sustainability framework, but also maximise the framework's application by providing importance rankings, discovering the connections among sustainability groups, and conclude the most crucial sustainability groups via results comparison between different methods.

Lastly, it is worth mentioning that this research uses China as the case study due to its representative feature of facing complicated situations after having tremendous oil relevant cargo trading quantity and the desire to conduct further development on oil ports. Thus, the theme of this study is determined as 'developing a holistic oil port sustainability framework: a case study of China', which uses Chinese oil ports as the starting case to explore the sustainability field at oil ports. Thus, the framework built in this study and its application is based on the Chinese demand.

Keywords: Oil Port, Port Sustainability, Prioritized Sustainability Framework, Indicator Interrelationships

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List of Abbreviations

4P & 5P	4 Pillars & 5 Pillars
AHP	Analytic Hierarchy Process
ANP	Analytical Network Process
C.I.	Consistency Index
C.R	Consistency Ratio
CSR	Corporate Social Responsibility
EC	Expert Choice
FRM	Final Reachability Matrix
IMO	International Maritime Organisation
IR	Inconsistency Ratio
IRM	Initial Reachability Matrix
ISM	Interpretative Structural Model
MCDA	Multi Criteria Decision Analysis
MicMac	Matrice d' Impacts Croises-Multiplication Appliqúe an Classment (cross-impact matrix multiplication applied to classification)
R.I.	Random Index
SC(M)	Supply Chain (Management)
SLNA	Systematic Literature Network Analysis
SSIM	Structural Self Interaction Matrix
TISM	Total Interpretative Structural Model

List of Notable Terms

Method:	Approaches obtaining Empirical Data
Methodology:	A Systematic 'Methods Set' to achieve the final Research Goal
Connection:	Interrelationships between Sustainability Groups and their individual Contain Power to the System
Limited Resources:	e.g. Capital, Time, and Funds
Shipping relevant Industries:	Including port industry
Port Sustainability relevant Literature / relevant Sustainability Field:	Refers to multiple fields such as 'green port', 'low carbon port', 'port sustainability', 'port economic', 'port corporate social responsibility (CSR)', and 'port environment' relevant literature
Researching field Features Analysis:	Keywords, abstract, citation, publication year, and authors relevant trends analysis

Chapter 1 Introduction

1.1 Research background

Mirroring the increased interest in sustainability among governments and NGOs in recent years, ports have also started to focus on sustainability management, and are likely to pay increasing attention to port sustainability issues in the future (Port of Rotterdam, 2017[a]; Puig, M. et al., 2015; Puig, M. et al., 2017; Puig, M. et al., 2014). Currently, the chief interest of port entities lies in cost reductions and achieving profit maximisation, while minimising their negative environmental impact and potentially negative social impacts (Port of Gothenburg, 2012). In this way, sustainability management has become the latest but most urgent goal for ports, following decades in which they pursued a balanced development approach between economic developments and avoiding environmental damage.

The term 'sustainability' is often accompanied by other terms focusing on similar matters such as 'green' and 'low carbon,' with which it significantly overlaps. However, there are notable differences between these concepts, and this study will limit its scope to 'sustainability.' In the 1960s, the concept of green movements started to enter many industries, especially ones that were growing quickly such as manufacturing and transportation. The notion of 'green activity' was developed to lower the environmental opportunity cost for fast-growing sectors of the economy, and the shipping industry (including ports) showed a positive attitude in response to this new trend (Silveira, 2004). The concept of 'sustainability' developed in the 1980s, which was a period in which people increasingly realised that economic growth not only had an effect on environmental issues, but was also relevant to social concerns (Giovannoni and Fabietti, 2013). However, in the shipping industry, sustainability issues were not well studied until about 2010, and in the last four years in particular, sustainability has received ever more attention, given the imposition of increasingly strict environmental regulations, in combination with frequent environmentally focused appeals from governments and NGOs (such as the UN's 2030 Sustainable Goals) (Sustainable Development Knowledge Plateform, 2015).

Since the introduction of the concept of sustainability in the late 1980s, along with the uptick in research on economic and environment matters as they relate to the green movement, experts now agree that the most urgent environmental concern is air emission. This has significantly worsened due to the industrial activities that took place in the mid-20th century, which have not only continued until now, but have actually sharply increased. In this way, after the notion of sustainability became solidified, the concept of a low-carbon economic approach attracted particular attention, especially in the shipping industry, which as a whole contributes to over 90% of worldwide CO_2 emissions (Vidal, 2007). To improve this, the industry has embraced low-carbon ideas into daily operations, and as a result, despite the fact that low-carbon ideas were introduced later than sustainability, both green and low-carbon issues have been studied more than sustainability in the shipping industry.

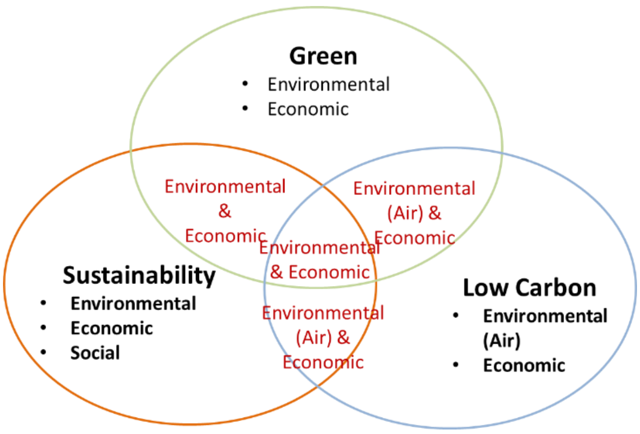


Figure 1 The concepts 'green,' 'sustainability,' and 'low carbon.' Source: Jiang and Mao (2012); Chang and Wang (2012); Chen et al. (2013); Cheng et al. (2013); Chiu et al. (2014);

Cheng et al. (2015); Shiau and Chuang, 2015; Sislian et al. (2016)

As can be seen in Figure 1, sustainability focuses on environmental, economic, and social issues; green emphasises the balance between environmental and economic factors; while low carbon is most relevant to air emission reduction (which is an environmental factor) and economic matters (Jiang and Mao, 2012; Chang and Wang, 2012; Chen et al., 2013; Cheng et al., 2013; Ciu et al., 2014; Cheng et al., 2015; Shiau and Chuang, 2015; Sislian et al., 2016; Port of Rotterdam, 2017[b]). As outlined in the Figure, the sustainability and green factors overlap with regards to the economy and the environment; green and low carbon both relate to air emission and economic conditions; while sustainability and low carbon share a focus on the air and economy.

It can be summarised that all three concepts have the environment and the economy in common, which might lead to confusion about which is more important. It is worth noting that economic issues have a strong focus in all three areas, and result from the belief that contemporary industrialised economic activity is the source of most environmental damage (OECD, 2015; Sahu and Choudhury, 2005; Hiranandani, 2012). Following this logic, given that the demand for economic activity is increasing, to solve urgent environmental issues (especially air quality), it is necessary to strike a balance between economic activity and the environment.

To cater the pursuit of balancing environmental protection and continuous economic activities, the concept of ‘Green’ and ‘Low Carbon’ are developed on the basis of sustainability. Green, which has started from the 60s during the ‘green movement’, tends to seek for solutions promote a balance between economic activity and the environment. Until the late 80s, the concept ‘Green’ is firmly defined and with a focus of environmental protection. After a few years, while researches’ and practices’ focus have increasingly focused on the most urgent environmental damage: air pollution, the term ‘low carbon’ is invented in the early 90s to emphases on significantly reduce air pollution. However, as the latter two concepts are based on the ‘sustainability’ idea and developed therefrom, they share the same theories as ‘sustainability’.

Despite the popular belief that sustainability follows the same logic as the previous concepts, it is mainly concerned with economic, environmental, and social factors, and it is this focus that forms the standard definition of the concept. Social factors, which were the most ignorant factors, refer to all indicators that show the living condition of citizen. For instance, employment (new working positions brought by port), safety issues (potential harm to citizen’s health), and knowledge delivery (knowledge required to fit to port positions, especially that are relevant to new technologies handling). The most concerned social factors are going to be identified in this study. The reason social factors were not included is mainly because the economic and environmental impacts on human were not the focus of the study, especially in the port industry (Zhang, 2016). Led by the increasingly closed correlation between environmental damage and the economic activities (Di Vaio, 2017), their impacts are more and more infused into people’s daily life. Therefore, social factors are increasingly worthy to be concerned.

However, as sustainability theory has developed, new theories have been suggested, such as the four (4Ps) and the five pillars (5Ps), which add new items of interest to the initial definition. According to the new theories, the most fundamental and unchanging aspect of sustainability is based on the dichotomy between the environment and economy; however, some scholars have criticised this approach, asserting that environmental protection is nothing but a product of capitalistic marketing strategies (Bakari, 2017; Hart et al, 2013). Despite this modern approach to sustainability, this research will adopt the original definition of the term, which is limited to the environmental, the economy, and social factors, because it remains the mainstream understanding of the concept, while the new theories have not yet received widespread recognition. The reason why the new approach has not yet been commonly accepted is that it has not been scientifically proven that industry is ready to deal with all the aspects covered by the new theories, or for the new theories to be adopted as industry standards. Most importantly, due to the variation in demand and acceptance among different industries, it is more difficult to achieve agreement on the same aspects that should be added to the current sustainability model. Conclusively, the sustainability concept of sustainability used in this study is: 'to maximise the economic development while minimise the harm brought to the environment, and eventually to the social welfare.'

From the perspective of the port industry, it is likely that there will be an increase in the emphasis placed on sustainable development in the foreseeable future. Being a crucial link in the shipping chain, as well as in the continually developing supply chain (SC), the port is one of the most commonly recognised complicating areas that gives rise to many issues such as environmental concerns (e.g. CO_2, SO_x, and NO_x emissions); economic issues like overproduction, conflicts of interest, and competitiveness; and social problems such as employment, living conditions, and career development opportunities. For this reason, the port industry has become increasingly interested in sustainability research in recent years.

However, in the existing research into port sustainability management (which includes green and low carbon issues because they are used interchangeably to a certain extent), the three elements of sustainability are often examined separately, with separate research being conducted into the evaluation of the green performance of a certain port, low carbon assessments, and the evolution of port-city relationships (Jiang et al., 2012; Denktas-Sakar and Karatas-Cetin, 2012; Shiau and Chuang, 2015; Venus Lun et al., 2015; Sislian et al., 2016; Lu, 2016). This absence of a holistic sustainability framework for ports has created a research gap that this research aims to fill.

Another phenomenon that merits attention is the fact that most research in this field is conducted on one type of port – the container port. As mentioned previously, this has come about due to the large economic contribution container ports make to the national and regional economy, as a result of the tremendous growth in trading volume. Furthermore, before the trend of developing oil ports into hub ports, container ports acted as such, making an outsize economic contribution. Due to the multiple positive impacts and development opportunities that hub ports bring to a country and surrounding region, a significant amount of research has been done into the current situation and potential development of and potential threats to container ports. In this way, while container ports are central to port research, oil ports have been relatively neglected. To fill the gap, this research aims to develop a holistic sustainability framework, with a focus on oil ports.

Oil port could refer to varied meanings, such as an oil and relevant products handling terminal (only onshore areas), a general port with one or several oil and relevant products handling terminal(s) along with terminals for other products, a specific port dealing with only oil and relevant products, or terminals (with both onshore and onshore areas) only dealing with oil and relevant products (Barnes, 2015; Port of Amsterdam, 2018; Globalenergyobservatory, 2018). Among all those meanings, the two concepts that are mostly common accepted are: 1) a general port with (but not limited to) large oil and oil relevant product handling ability, with an inclusion of both onshore and offshore areas (Barnes, 2015); 2) a simply mean of specific terminals that handles oil and oil relevant products, with an inclusion of both onshore and offshore areas (Globalenergyobservatory, 2018). It can also be seen, the main confusion lies upon the term ‘port’ or ‘terminal’, which is a concern of the oil and relevant product handling coverage area. In the existing studies, the terms are interchangeably used, and no specific commonly acknowledged definition has been given. Thus, it is worth to mention that this study adopts the second commonly acknowledged meaning to give an exact context to the researching target.

China, one of the world's largest oil-trading countries (Paraskova, 2018; Crooks, 2017), is representative of countries seeking to deal with the complex nature of oil port sustainability issues. For strategic purposes, China has for many decades been a prominent importer of oil products, and since the price of crude oil dropped at the end of 2014, China has increased its trading in this area, officially becoming the largest crude oil-importing country in the world (Chen and Meng, 2017; Marex, 2018; Export.gov, 2017). In this period, the increasing size of trade has indirectly led to an expansion in the country's extant oil ports and the construction of new such ports, in addition to the development of oil ports into hubs. This situation has given rise to a number of complex problems including citizen health issues and the creation of potentially dangerous areas, while foreign investment has resulted in unbalanced relationships between port companies. Based on the number and complexity of oil port-related sustainability issues it is facing, China has been taken as the case study for this research project.

1.2 Research Aim, Objectives, and Question

Based on understandings gained from the research background, this section defines the research aim, objectives, and questions of this study. The overall aim of this research is to develop a practical holistic sustainably framework for the Chinese oil port. This aim is expected to provide structural guidance for the oil port sustainability management under today's constantly changing environment, fill the knowledge gap of not having much sustainability research on oil port, and discover connections between the sustainability objects. However, as each country has a different focus, and each port has its own situations (e.g. geographical, resource, and functional situations), this research takes Chinese oil port as a case study to develop the holistic sustainability framework as China is representative on dealing with oil port sustainability issues across the world.

To reach the research aim and add value to it, it is crucial to address interdisciplinary matters within the oil port sustainability management field. Therefore, the following *research objectives* are expected to be achieved:

1) To identify factors to a practical sustainably framework for Chinese oil ports;
2) To prioritise the practical oil port sustainably framework groups and indicators;
3) To discover the interrelationships between the oil port sustainability groups, and to structure the sustainability groups;
4) To determine the containing powers (the degree of interdependence) of the oil port sustainability groups;
5) To identify the most important oil port sustainability groups to form a 'must have set'.

The *research question* is:

'What sustainability objects should be included and what relationships among them in a holistic oil port sustainably framework?'.

To find answers to the research question, this thesis illustrates in detail how each research objective has been answered through a rigours methodology. The following section justifies the reason for conducting this research.

1.3 The structure of the thesis

This section briefly introduces the thesis structure to clearly outline the nature of the aim, objectives, and results of this research. As can be seen in Figure 2, the thesis consists of seven chapters, organised as follows:

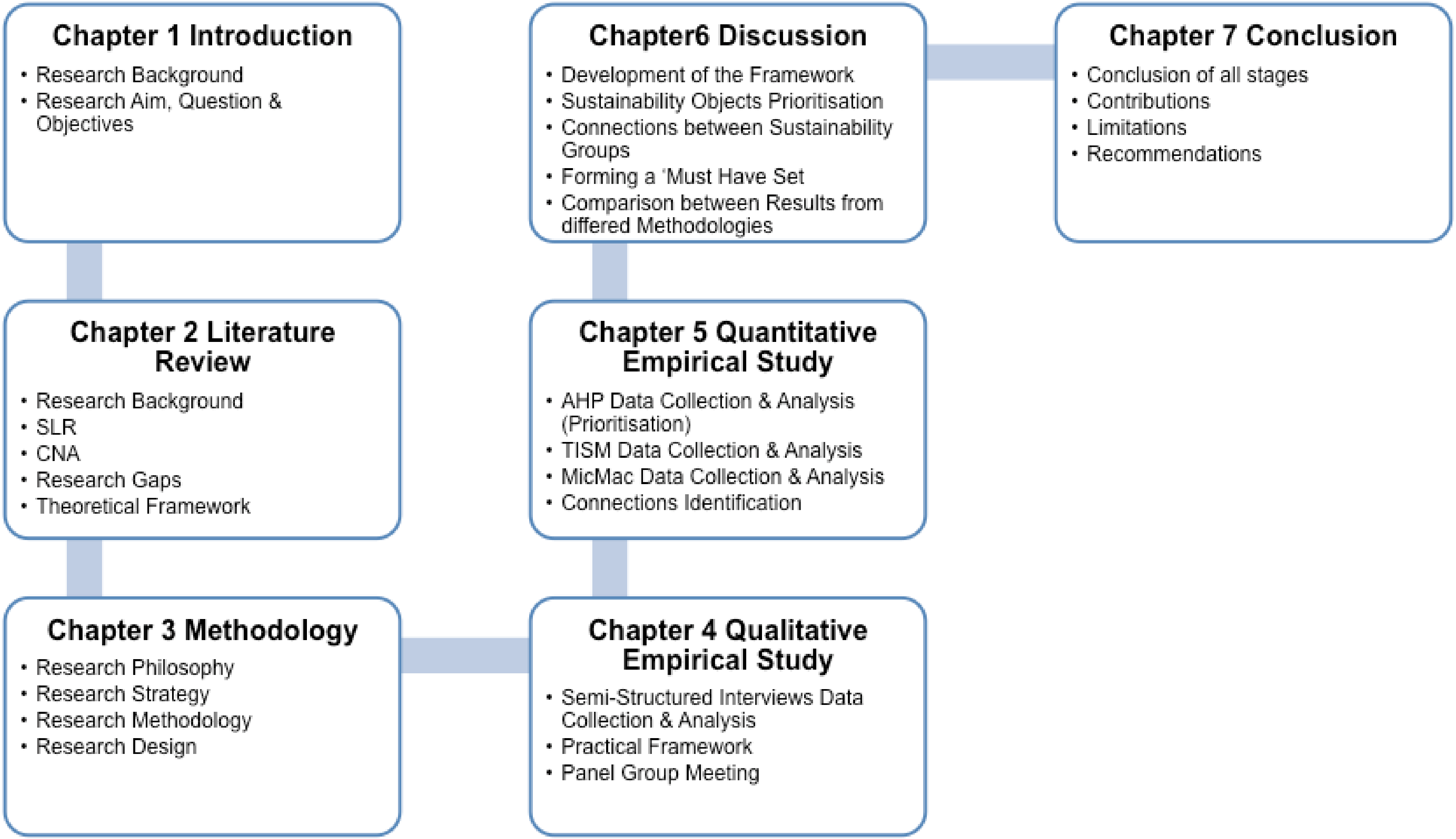

Chapter 1 Introduction
• Research Background
• Research Aim, Question & Objectives
Chapter 2 Literature Review
• Research Background
• SLR
• CNA
• Research Gaps
• Theoretical Framework
Chapter 3 Methodology
• Research Philosophy
• Research Strategy
• Research Methodology
• Research Design
Chapter 4 Qualitative Empirical Study
• Semi-Structured Interviews Data Collection & Analysis
• Practical Framework
• Panel Group Meeting
Chapter 5 Quantitative Empirical Study
• AHP Data Collection & Analysis (Prioritisation)
• TISM Data Collection & Analysis
• MicMac Data Collection & Analysis
• Connections Identification
Chapter6 Discussion
• Development of the Framework
• Sustainability Objects Prioritisation
• Connections between Sustainability Groups
• Forming a 'Must Have Set
• Comparison between Results from differed Methodologies
Chapter 7 Conclusion
• Conclusion of all stages
• Contributions
• Limitations
• Recommendations

Figure 2 Thesis structure

Chapter 1 presents an overall description of this research project, introducing the research background, aim, objectives, question, and the contribution this research will make to the field.

Chapter 2 discusses the foundation of this research. Firstly, this chapter discusses in detail the existing research trends (SLR), and the connections between the key literature (CNA). This is done to provide a basic understanding of the knowledge in the field, and to confirm the gaps in the literature gaps. Then, by combining these aspects, this research can outline the reason why no research has yet been conducted into holistic sustainability. Lastly, the various aspects of sustainability are outlined to construct a theoretical holistic oil port sustainability framework.

Chapter 3 illustrates the philosophy, approach, design, strategy, methods, and sampling techniques in this study has adopted to achieve the research objectives. In detail, this chapter first outlines the research philosophy, overall design, and the strategy to clarify why this particular research methodology has been chosen over other potential choices. Then, it will explain why each method in each research stage was chosen, and finally present an overall research methodology including both qualitative and quantitative stages, along with an explanation of the 'what,' 'where,' and 'why' of the various research techniques that have been adopted at each stage.

Chapters 4 show the processes and results of the study, and present the qualitative stage research, made up of the data collection, analysis, and results. This chapter demonstrates the use of appropriate and rigorous processes, using semi-structured interviews and thematic analysis to complete the data analysis. In this way, this chapter will suggest a practical sustainability framework for Chinese oil ports, establishing the foundation of this research, and enabling a further value-added analysis.

Chapter 5 will consist of quantitative data collection, analysis, and results, as generated by three research methods (AHP, TISM, MicMac, and 'Must have

Set') from the multi-criteria decision analysis (MCDA), while Expert Choice has been used to facilitate the AHP survey analysis. By doing so, the following value can be added: ranking the importance of sustainability groups and indicators via AHP; identifying connections between sustainability groups (the relationships between and powers of the various factors) via TISM and MicMac; and, this research offers a 'must-have' list of sustainability groups needed for a sustainable operation, as obtained via a comparison between the interviews, AHP, and MicMac.

Chapter 6 discusses the findings of Chapters 4 and 5 and the knowledge that has been created in the course of the development of a holistic sustainability framework, and the connections (the relationships and power) between each aspect of sustainability. In addition, this chapter emphasises the differences between the empirically developed and theoretical frameworks, illustrating the 'why' and 'what' of the connections between each aspect of sustainability.

Chapter 7 draws a conclusion of all stages of the study, and highlights the contributions of the research. Moreover, this chapter identifies the study's limitations, and offers suggestions for potential future research in the area of port sustainability management.

1.4 Summary

This chapter has presented an overview of this research project, including research aim, objectives, and the question. Besides, issues such as the nature of oil port sustainability, why it is important, and the benefits of researching this topic were also illustrated. Furthermore, this chapter has also provided a justification for the development of an oil port sustainability framework and has highlighted how the research findings will enrich the knowledge in the field of port management. Finally, this chapter has outlined the structure of the entire thesis.

Chapter 2 Literature review

2.1 Research Background

This section explains why specific research aim, objectives, and questions have been chosen. Port sustainability is playing an increasingly important role in port management (Cheng et al., 2015; Asgari, 2015; Gilman, 2003; Lu et al., 2012) and shipping areas (Lirn et al., 2013; Mansouri, 2015; Lam and Lee, 2015; Wong et al., 2015; Kim and Chiang, 2014) due to the significant environmental and social impact of economic growth, especially during the trade expanding periods. For instance, South Africa has the plan of investing $3.2 billion for general commercial ports (e.g. Durban, Cape Town, Port Elizabeth and the Port of Ngqura) expansion (Mooney, 2016); led by the significant blooming in the U.S oil market, Wood Mackenzie forecasted that Corpus Christi Port are expecting over 200 barrels/day and thus requires reasonable expansion (Mooney, 2016); In China, Da Lian Port also uses over 60% of the new investment of 43.32 billion Hong Kong Dollar on port expansion activities, such as service integration, new network establishments, and new logistics facilities building (ZGSYB, 2016) to enhance port service and further business growth.

As trade has expanded, ports are playing an increasingly important role in value-added activities and sustainability development (UN, 2002; PWC and Panteia, 2014). Therefore, port sustainability management ability needs to be enhanced accordingly as many accidents harming a sustainable growth have happened. For example, between the year 1999 – 2011, when the port industry was in an positively increasing trend, there are 42 times of contacts, 60 times of hall and machinery, 10 missing accidents, 44 times of collisions, 267 times of fire and explosion, 298 times of wreck, 1032 times of foundered. Since 2017, shipping industry has started recovering. The past experience proves that in the industry increasing and blooming periods when developments are needed, it is crucial to focus on sustainability management at the meantime (PWC and Panteia, 2014).

Moreover, from the increasingly varied value-added activities' perspective, Okorie et al. (2015) mentioned that the value-added activities conducted in port include cargo loading and discharge, industrial services, labelling, weighing, and repackaging, etc. Having an efficient operational system (e.g. not engaging in over-production) and an active approach to innovation cannot only ensure port to enjoy a healthier life cycle, but can also enhance their competitiveness, which is extremely important in today's business environment. In addition, Jung (2011), Jouili and Allouche (2016), and Wildenboer (2015) have claimed that ports are one of the most important assets in national economies because they provide trading gateways, and thereby attract commercial infrastructure (such as banks, stevedores, and logistics agencies). Port can be said to be crucial strategic business locations, and this is likely to remain true in the future.

However, economic prosperity typically causes damage to other facets of life, especially to the environment. Zhang (2016), Norton (2004), and Higgins (2013) note that it is always difficult to strike a balance between environmental protection and economic development. Many people believe that priority needs to be given to either environmental protection or economic development, while He and Ou (2017) and Sloman (2012) have asserted that environmental protection and economic development are symbiotic processes, and a balance is needed between the marginal pollution profit (the size of the profit that enterprises can expect to make if they engage in pollution elimination) and the marginal pollution cost, which can be calculated using a pollution cost model. Information concerning land rights, pollution emission charges, and emission taxes can enrich these models and help enterprises to achieve a balance between environmental protection and economic development, and provide effective guidance for relevant policies

(Jonathan and Harris, 2013). Nevertheless, environment, economic, and social factors are normally researched separately, rather than as a whole (Di Vairo and Varriale, 2018; Roh, 2016). Therefore, new holistic guidance is required to promote the development of sustainable ports (IMO, 2018; Port of Los Angeles, 2013; Port of Gothenburg, 2012).

Given the complex nature of port management, it is commonly accepted that systematic management is required, with a pre-condition that the approach adopted extends beyond the interests of individual companies' (Denktas-Sakar and Karatas-Cetin, 2012). In other words, simultaneous cooperation and action is required by all relevant parties (e.g. managers and other stakeholders) to ensure a common understanding can be reached, thereby solving the challenges the industry faces (Wu and Pagell 2011; Gunasekaran et al., 2004; Beamon, 1999; New and Ramsay, 1997). Once a common understanding has been established, or the various port entities are considered as a whole, it will become possible to balance environmental protection and economic development (Handfield et al., 2005), as well as guarantee holistic port sustainability, including social concerns.

Port sustainability is not a well-developed area of research, and has only started to attract attention in the last ten years. However, there has been abundant interest in similar topics, such as how green and low-carbon issues affect ports (Cheng et al., 2013; Lu et al., 2016[a]; Lu et al., 2012; Lam and Van Voorde, 2012; Wen et al., 2015; Li et al., 2011). Nevertheless, as can be seen from the definitions of 'green' and 'low carbon' (see Section 1.1), the issue of green ports is concentrated on environmental and economic concerns, while low-carbon research focuses on air quality control (rather than the general environment) and economic issues. Sustainability sections have typically been researched independently of each other in existing studies, and no research has considered them as a whole to investigate holistic sustainability management at ports. It is this knowledge gap that this study aims to investigate.

The definition of ‘port’ is extremely multi-varied, and given that each port type has a different focus and features, this research will be limited to oil ports. In comparison to other port types such as container ports, oil ports suffer from a greater risk of accidents (such as collisions, leaking, and facility damages), especially those that cause explosions and fire. These accidents not only risk greatly harming citizens’ and employees’ health and daily lives, but can also cause tremendous economic loss to the government and local authorities. Given the fact that accidents are a relatively frequent occurrence, there is an urgent need for research into oil port sustainability.

Due to the significant economic contribution container ports make to a country, many scholars have researched the effects of green and low-carbon policies at such ports. In recent years, as a response to the increasing appeal of sustainability, some experts have started to investigate container port sustainability management, but there is a dearth of research into sustainability in oil ports. This gives rise to the opportunity for this research to fill this gap by not only researching holistic port sustainability management approaches, but also outlining a holistic oil port sustainability framework by using the existing literature examining container ports as a reference.

Moreover, given the fact that most of the existing research has researched only one aspect of sustainability, with much more attention having been paid to economic rather than social issues, there has been no research into the connection between the various elements of sustainability. This study is therefore the first study to investigate the connection between the various facets of oil port sustainability, in addition to providing a holistic framework of oil port sustainability management.

As mentioned previously, this study will use Chinese oil ports as a case study. The advantage of examining only one nation is that each country might have different conditions and priorities. China is one of the world’s largest importers and handlers of crude oil, petroleum, and chemical products, and the issues it is facing can be seen as representative of the industry as a whole. Moreover, because Chinese oil ports follow a general common goal (Wang et al., 2017[a]; Wang et al., 2017[b]) of achieving an enhanced sustainability performance, it is hoped that this research can aid in the formation of a holistic sustainability framework, from the perspective of the Chinese oil port industry.

2.2 Introduction

This chapter introduces the procedure and results of using a systematic literature network analysis (SLNA) to conduct a systematic literature review of the topic of port sustainability.

Literature reviews are performed to gather informative knowledge in a certain field to contribute to the current study being conducted, and can include guiding theories, common methodologies, and existing findings (Gimenez and Tachizawa, 2012; Whittemore and Knafl, 2005). The literature review is a crucial stage in a research project, outlining fundamental knowledge in the field. Of the various literature review methods, SLNA has the advantage of showing visualised and systematic results of the extant research to minimise the chance of missing information, while presenting general trends of the research such as the most popular topics and research gaps (Webster and Watson, 2002).

SLNA was first used by Colicchia and Strozzi (2012) in their study of supply chain management, and then adopted in other studies such as Colicchia and Strozzi (2012. SLNA enables rigorous research to identify research trends and gaps in a given field, and is therefore a suitable method of conducting a literature review. In this study, using the SLNA method, extant research into port sustainability can be filtered for potentially useful aspects in the creation of an oil port sustainability framework. Moreover, common methodologies (research methods/approaches and data analysis techniques) can be identified to analyse the current state of research in the field. For these reasons, SLNA has been chosen as the most suitable method of literature review for this study.

SLNA is a combination of systematic literature review (SLR) (Tranfield et al., 2003) and citation network analysis (CNA) (Calero-Medina and Noyons, 2008; Kajikawa et al., 2007; Batagelj, 2003). From this combination, one can see that the SLNA approach is based on a thoroughly assessed review of the literature within the relevant field. It first analyses the descriptive features of the existing literature (SLA), and then looks at its content, finally identifying interrelationships (CNA). This combination entails a systematic system that can also highlight the current gaps in the research. Furthermore, the fact that SLNA has not been used in any previous studies concerning shipping and ports means that this study is the first use of this method to analyse the port sustainability literature. In the following section, the application of SLNA in the relevant literature will be illustrated. Due to the interchangeable usage of the concepts of 'sustainability,' 'green,' and 'low carbon,' and the fact that each of these factors has been separately studied, 'port sustainability literature' can be said to cover multiple fields such as green ports, low-carbon ports, port sustainability, port economics, port corporate social responsibility (CSR), and port environmental effects.

Because SLNA is a combination of SLR and CNA, studies that use SLR will be considered first to obtain an objective overview derived from the popular keywords and significant authors and journals, in addition to the quantity of published materials (Colicchia and Strozzi, 2012). Then, using CNA, this research identifies the connections between the most important/influential (most cited) articles to uncover central point(s)/origin(s) of port sustainability, and the relationships between them and other studies in the field. A visual graphical network is provided to showcase the current achievements, gaps, and structural in the field by showing the connections between the various themes that appear in the literature.

A general view of the SLNA approach adopted in this study can be seen in Figure 3. As mentioned previously, SLNA can be divided into two parts: SLR and CNA. For both parts, there five preparation steps, given that the materials to be analysed is similar. They are both decided on in the second step (the literature adoption criteria) depending on their features (e.g. if they are relevant to the study, the publishing date is valid, and the publishing source is reliable).

However, the software changes, based on whether one is using SLR and CNA data, given that the data varies in type, and because different results are expected. This means that the results of SLR and CNA must be analysed with software that matches their nature. After the first stage, the literature search can be conducted, according to the correct article selection criteria. Lastly, the data is input into the chosen software, through which the SLR and CNA results are obtained. After completing this analysis, the research trend, gaps, and relationships between the existing studies can be generated, along with the holistic sustainability framework (see Section 2.4).

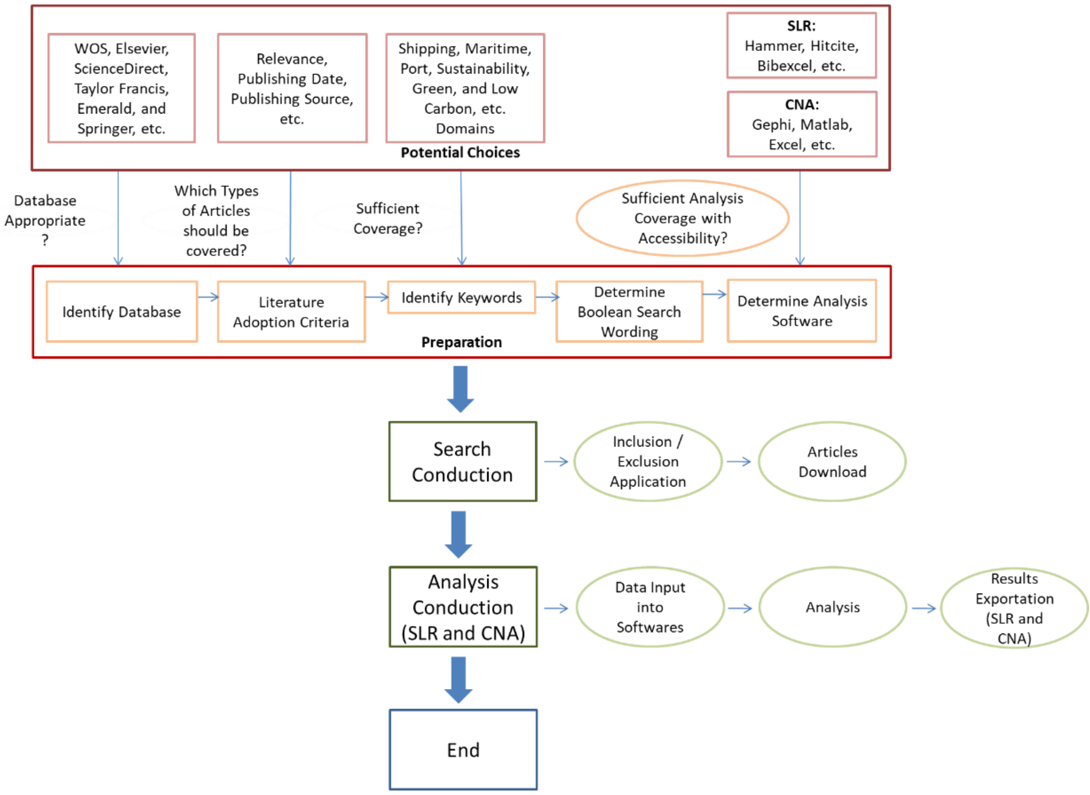


Figure 3 Overview of the SLNA application procedure

2.2 Systematic Literature Review (SLR)

2.2.1 The background of SLR

It is expected that this stage will yield a holistic overview of the existing literature in the field, thereby revealing research trends, focuses, and keywords. In other words, this stage aims to explore what has been done in the previous studies via a systematic literature review to ensure no relevant information is missed. To do so, information about the extent of discussions of port sustainability, the most productive and influential authors, the most relevant journals, and keywords should be extracted.

Reading the literature, one can see that in addition to journals that focus on marine biology, environment, and engineering, there are several that are concerned with maritime, shipping, and transportation matters from the commercial angle. And, by reviewing studies into port sustainability, it is apparent that there is a causal relationship between journal type and the studies published, as well as the methodologies they follow. For instance, most journals in the field prefer quantitative methods, especially the analytic hierarchy process (AHP) and other multi-criteria decision-making analysis (MCDA) methods (Galva et al., 2014; Feng et al., 2012; Lisboa, 2012). Besides, experts are often collected with unified occupation (e.g. port stakeholders), as well as unified country of origin (Lu et al, 2012; Lirn et al, 2013; Roh et al, 2016). Due to number of journals that publish articles on port sustainability-related topics from different angles such as society, economy, and environment, a variety of methodologies have been adopted, and much research has been conducted from many angles.

Given the large number of journals, it becomes necessary to carefully select information. However, the quality and suitability of a journal is not only abstract but hard to quantify, and there are limited guidelines by which researchers and academics can evaluate journals (Colepicolo, 2015; Theoharakis et al., 2007; Zsidisin et al., 2005). In this study, criteria have been followed that define to what extent a journal and its studies are reliable, and thereby ensure the reliability and suitability of the literature studied.

The most commonly used criteria are peer review, impact factors, and the journal reputation (Boston College Library, 2017). Nevertheless, it is worth mentioning that the above-mentioned criteria are mostly based on citation numbers. In the UK, one of the most influential and accepted criteria is the Association of Business Schools' (ABS) ranking. However, even though the researcher has tried to gather prestigious studies (that have been cited times from journals with a high impact factor), the absence of journals ranked with three or more stars in the field of transportation (e.g. shipping, logistics, and maritime transportation) has forced the researcher to accept studies from one- and two-star journals, or those with low citation rates. As a result, all the studies and journals used in the course of this research can be said to be reliable because they are from journals with at least one star. This study is mainly restricted to transportation and maritime journals, especially those relevant to the issue of port sustainability.

2.2.2 SLR implementation

This section illustrates the way in which SLR is conducted. After determining the journals to be considered, this section will discuss the steps and software involved. To obtain accurate SLR results, the three most crucial factors are the database, the search keywords, and the resulting analysis software. This study will use a range of databases to analyse the features of the research field and to extract individual port sustainability factors (Bergmann et al, 2014). Further details regarding the databases used are provided in Section 2.2.2.1.

2.2.2.1 Databases

The databases chosen for this study are critical because both the coverage and the standard of the studies included will affect the quality of the results obtained (Kendall, 2017). For instance, Google Scholar, Web of Science (WoS), and PrimoCentral are among the most commonly used databases. Databases in general can be divided into two kinds: non-human-curated (e.g. Google Scholar) and human-curated (e.g. WoS, Elsevier, ScienceDirect, Taylor Francis, Emerald, and Springer). The main difference between non- and human-curated databases is that the latter are formed by literature review committees, taking into account scholarly and quality criteria (Michigan State University, 2017), while the former can be considered a search engine of the entire Internet, and possess less relevance, quality, and recently published documents.

In the initial search, non-human curated database ‘Google Scholar’ was used to maximise the searching scope and inclusion coverage. ‘Google Scholar’ has been chosen is because it is a search engine that covers almost the entire Internet. Plus, the specific criteria could be set to assist filtration (e.g. publication year, language, and relevance). In this study, to extend the scope of potential literature, and also to ensure that the most relevant articles that is not ABS listed is included are also taken into consideration, the only criteria in Google scholar has been modified is ‘language’. The language has been set in ‘English’ and ‘Chinese’. English is chosen is because as most of the publications are published in English. Chinese is chosen is because even though not many Chinese mainland publications are listed in Google Scholar, many publications from Taiwan area are listed and are in Chinese. Taiwan, as an area that has numerous valuable researches done regarding ‘port sustainability’ and ‘green port’, is very much worth to take their publications into consideration.

As a result, it is noticed that most of the relevant articles are sourced from human-curated databases, such as WoS and Elsevier. Thus, humand-curated databases will be the dominating source of the literature in this study. Details are explained in the below paragraph.

However, it is worth mentioning that a few journals and conference proceedings (such as ‘The Asian Journal of Shipping and Logistics’, ‘Proceedings of the 2015 International Conference on Management Science and Management Innovation’ and ‘case studies on transport policy’) are not in the ABS list, but are either included in human-curated databases (e.g. ‘The Asian Journal of Shipping and Logistics’) or having numbers of quality articles within ‘port sustainability’ field (popular authors such as Roh. S, Wang. H also published relevant articles in the proceeding and journals). Thus, even though human-curated databases are considered as the main source of literature (especially ABS journals), few of the additional studies outside the ABS journal sourced from the conference proceeding and journals obtained from Google Scholar are still included in the stage of forming theoretical sustainability framework. However, they are not included in the analysis of systematic literature review analysis for research trends, popular authors, etc.

To further improve accuracy and ensure that the literature review does not miss any up-to-date articles, this study has chosen human-curated databases as its literature review source. Furthermore, keywords will be used, which narrows the field down to the most popular human-curated databases: WoS, Elsevier, ScienceDirect, Taylor Francis, Emerald, and Springer. These six databases are all reliable, offer broad publication year coverage, and the literature contained is mostly from journals of at least one star. Nevertheless, even though they can all be included as literature sources, further attention is needed when selecting the main studies to conduct further analyses to find out about the trends and popular topics in the field.

Further attention is needed because not all databases provide the ability to generate and download article details such as keywords, abstract, citation, publication year, and authors. In order to analyse research trends and popular topics to improve accuracy, covering a large number of studies, it is necessary to filter the articles contained in the databases. The studies from these databases are the main area of interest in this study, while other studies from four databases in particular (Elsevier, Taylor Francis, Emerald and Springer) will be used to collect information to build up the framework, without engaging in further analysis of the field in question.

As can be seen in Table 1, all the databases mentioned offer broad coverage and relatively high-quality studies, and also meet the criterion of cost-efficiency, being obtainable from the University of Plymouth library service. The remaining problem is to establish whether they provide citation information to reveal the most influential studies in the field and the contents of the studies such as the authors, journal name, publication year to enable an analysis of the research trend. The databases listed in Table 1 with the most ticks (√) are marked in red, and are considered the most suitable one for this study, both for analysing further features of the field and detailing the indicators of port sustainability. In summary, Table 1 shows the differences between databases to enable the selection of the most appropriate ones for this study.

Table 1 A comparison between the databases

	Paper Coverage	Paper Quality Control	Cost Effectiveness	Further Analysis Friendly (authors, journal name, publication year, etc.)	Citation Track
WoS	√	√	√	√	√
Elsevier	√	√	√		√
ScienceDirect	√	√	√	√	√
Taylor Francis	√	√	√		
Emerald	√	√	√		√
Springer	√	√	√		

Table 1 presents to what extent each database meets the criteria for selection, with WoS and ScienceDirect receive the most ticks. This study will therefore use WoS and ScienceDirect to conduct further analysis on the research trends and focuses due to the fiction they offer of downloading the main publication content of studies (such as keywords, abstracts, citations, publication year, and authors). After conducting a general overview of the studies contained in WoS and ScienceDirect, it was observed that these databases cover almost all of the literature in the field of port sustainability, and there is no big difference between databases is terms of the studies with the most citations. For this reason, there is no reason not to use only these two databases to conduct the literature review (in the form of a general information analysis and to build up a theoretical framework, as well as the CNA analysis conducted in Section 2.3).

However, all six databases have been used as literature review sources to collect items for the theoretical framework (including four that were not further analysed via the specific features of the research field). The four databases can be understood as complementary sources to WoS and ScienceDirect, and even though the WoS and ScienceDirect cover the most studies, other databases should be included when forming the theoretical framework to maximise the range of indicators taken into consideration.

It is worth mentioning that even though the other four databases have not been used for further analysis due to their limitations, a number of duplicated articles emerged, after the appropriate studies were downloaded from WoS and ScienceDirect. These duplicated studies have been eliminated manually.

2.2.2.2 Keywords

In addition to the databases, the keywords used to search for information are also important because their accuracy has a direct influence on the search results, and therefore the keywords must be carefully chosen to ensure their accuracy before gathering the studies. In this study, Boolean search phrases were identified after reading roughly 40 studies in a pilot literature review. This not only helped the researcher to confirm the search phrases to be used such as 'port sustainability' and 'terminal sustainability,' but also further widened the keyword options by going through the topics of studies relevant to this field (such as 'green port,' 'port environment,' 'port competition,' and 'low carbon port'). After the appropriate search phrases have been identified, further search criteria need to be developed. Even though the choice of databases has already significantly filtered out studies with the least influence (those published in journals that are not in the ABS list), studies from irrelevant fields need to be weeded out (those address topics such as 'port engineering,' 'marine biology,' and 'oil spill reaction evaluation system') and the studies' date of publication (some studies were too old to provide any meaningful contribution to the research, given today's constantly changing market environment and national policies).

When determining the keywords, it was noted that there were relatively few studies that touched on all three aspects of port sustainability mentioned previously, with most studies tending to focus on one aspect alone. Furthermore, only studies that looked at the concepts of green and low carbon could be found during the pilot literature review. For this reason, this study will divide the keywords into two broad areas: Firstly, relevant concepts (such as 'port,' 'terminal,' 'sustainability,' 'green,' and 'low carbon'), and secondly, the three elements that make up sustainability (environmental, economic, and social factors). Table 2 presents in detail the keywords used in the literature review.

Table 2 Keywords used in the SLNA search

Port Sustainability Keywords	Environmental Keywords	Economic Keywords	Social Keywords
Sustainable Port	Port Pollution	Port Development	CSR
Sustainable Terminals	Port Sustainability	Port Operator	Workplace Ethic
Green Port	Terminal CSR Sustainab*	Port Stakeholders	Social Management
Green Terminals	Green Port	Port Coordination	
Low Carbon Port	Green Terminal	Port Competition	
Low Carbon Terminals	Environmental* Management	Port Economics	
Port Policy		Terminal Coordination	
Terminal Policy		Terminal Competition	
Port Operation		Terminal Economics	
Terminal Operations		Maritime Connection	
Port Management		Hinterland Connection	
Terminal Management		Product*	
Port Development			
Terminal Development			
Port Governance Oil Port			
Oil Terminal			

As can be seen in Table 2, the keywords have been classified into four specific port-related areas: those relevant to sustainability, environment, economy, and social factors.

Sustainability is the first area to be searched because it is directly relevant to this study, and it is expected that this literature will provide the foundation for this research; the area can be further divided into general coverage of port sustainability, themes that indicate sustainability, and the general coverage of port sustainability in the literature, based on port types. This search also covered the green and low carbon aspects of port sustainability (see Table 2). However, due to the overlap between these topics (due to the general desire to ensure environmental protection in the port areas while minimising economic sacrifices), many studies cover the entire field, and they are also interrelated in terms of their definitions and common focus on the environment (see Figure 1). They are therefore categorised in the first research group, 'port sustainability,' and have been searched first.

After reviewing the literature in the light of the definitions of sustainability, green, and low carbon, it can be seen that their general coverage is limited to the areas of environmental, economic, and social factors. However, insufficient data for this research was found in the literature when searching for the port sustainability category keywords, so to obtain more information in each area, the environmental, economic, and social factors were determined as the second, third, and fourth categories of keywords.

As can been seen in Table 2, a number of keywords coincide (for example, 'green ports' can be found under both 'port sustainability' and 'port environment'). However, in order to obtain a variety of views of the relevant literature, maximise the searching coverage, and emphasise the area being searched, the researcher chose to input both the keywords (e.g. 'green port') and the category keywords (e.g. 'sustainability,' 'green,' and 'economic').

After identifying the keyword categories, keywords were then used based on a string of Boolean logic operators to extract the largest amount of relevant studies. The keywords used to generate Boolean phrases were put into the WoS and ScienceDirect system, which was identified as the most suitable database for this purpose, as mentioned in the previous section. The data generation includes citation and references to enable further analysis.

2.2.2.3 Software

After determining the databases and keywords, it is necessary to choose which software to use to conduct an analysis of the trends and popular topics. There are several options in this regard such as Bibexcel, Hammer, and Histcite. Of these, Bibexcel has been employed in many studies (Fahimnia et al., 2015; Movahedipour, 2016) because it offers many advantages. For instance, it is freely accessible, can be used to conduct multiple analysis (into e.g. the authors, publication year, and research areas), and most importantly, it can analyse data from multiple sources (Fahimnia et al., 2015). However, one limitation of Bibexcel is that conducting the analysis is a complicated procedure. To simplify the procedure and be more time-efficient, but ensure the accuracy of the results, other software has also been considered.

Histcite and Hammer have similar functions. As shown in Table 3, not only can almost the same results be obtained from Hammer and Histcite in comparison to Bibexcel, Hammer even offer more analysis options. As a result, this study will use Hammer to conduct the systematic literature review because it offers the most options for analysis.

Table 3 A comparison between systematic literature review analysis software

	Critical Authors	Popular Topics	Publish Year	Publication Volume	Critical Journal	Keywords
Hammer	√	√	√	√	√	√
Histcite	√	√	√			√
Bibexcel	√	√	√	√		

2.2.3 SLR results

This section will discuss various features of the existing literature in the field including research trends, prominent authors, and frequent keywords. These features have been obtained from relevant studies listed in the WoS and ScienceDirect databases.

The results of the analysis conducted using the Hammer software are presented as follows. These results identify common research trends and popular topics, thereby providing a foundation for the following CNA analysis through the creation of a more detailed literature development map. The results are based on studies with the most direct relevance to the field under study in this thesis (316 studies), rather than including indirectly related articles such as those that look at port planning and calculations of ports' chemical emissions.

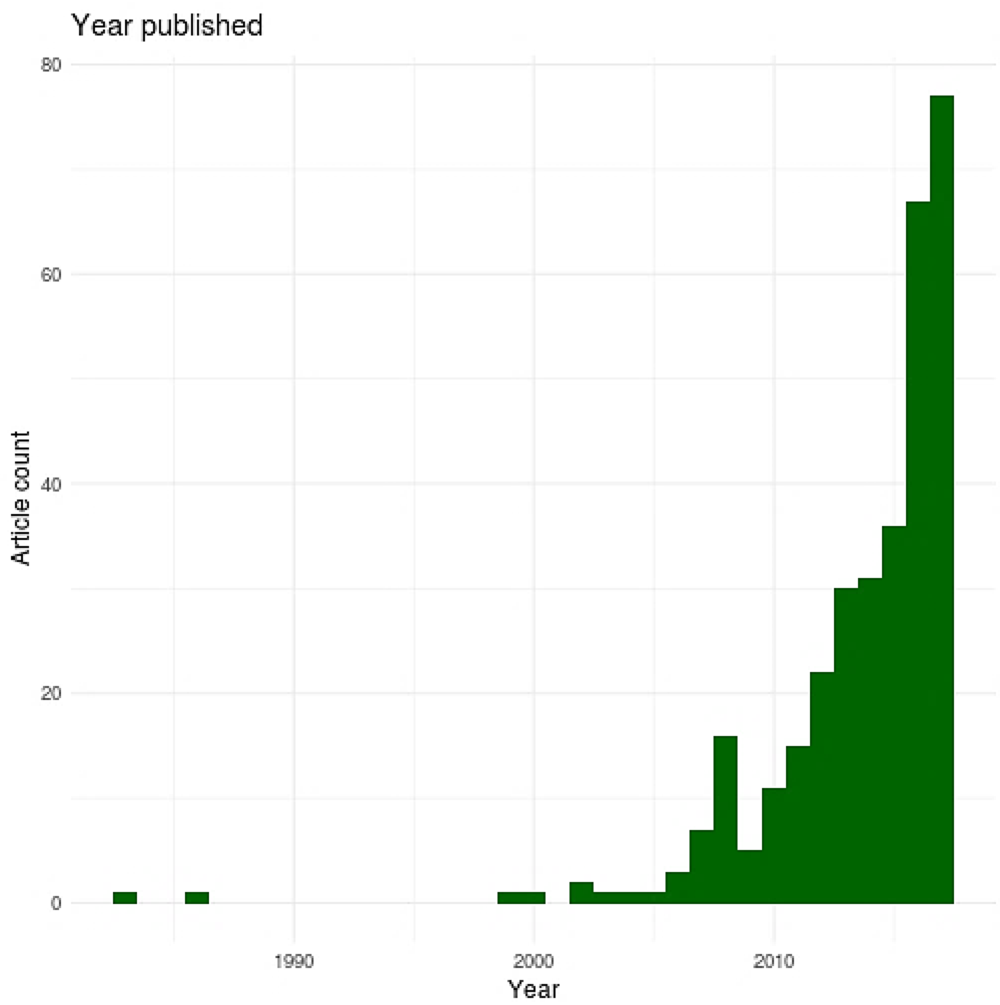


Figure 4 Year Published

From Figure 4, it can be seen that 'port sustainability' has been a topic of research not only in the recent years but since the mid-80s. This trend is very likely to be led by the trend of building ports in developing countries and the rapid development of ports worldwide (Slack, 1980). However, as the 'sustainability' concept at ports was first officially developed in 1992 by the UN Conference on Environment and Development (Di Vai and Varriale, 2017), many studies may not be directly linked to 'port sustainability' in itself, but rather concern areas around this concept (e.g. port development, port-city relationships, and especially the third-generation port's logistics hub concept). Moreover, it can also be noticed that there is a gap in research on port sustainability from the late 80s until the late 90s. This might be because the continuous development in ports and connected areas was considered as the most important issue given the need to compete for more market share and more economic growth.

Even though, since the year 2000, there has always been a steady amount of studies on port sustainability – which has become relevant as the topic starts to be felt in people's daily lives, and led by the environmental protection concept – studies remain relatively few. The reason might be that sustainability and environmental protection are still considered as less important in comparison to economic development. Since the 'logistics hub' concept was introduced during the 80s and 90s (Lin and Tan, 2013), its outcomes only began to become clear in the late 90s and the early 2000s. Moreover, because of the 1997 Asian economic crises, the shipping industry and ports were directly influenced by the poor trading situation (Manning, 1998). Given that environmental protection and social disputes were not popular topics back then, it is natural that researchers choose to focus on re-boosting economies rather than port sustainability. Popular sustainability-relevant topics were more economic than environmental and social. Nevertheless, since around 2005, it can be seen from Figure 4 that research in these areas starts to show an increase. This can be understood on the background of the economic recession gradually passing, with people starting to reconsider the increasingly severe environmental issues.

However, there is a short, sharp downturn around 2008 to 2009 during the world economic crisis. It can be understood that economic recession attracts researchers' attention more than sustainability issues (Schulz, 2008). However, the number of port sustainability articles remains relatively high proves that sustainability has become a serious concern and a hot topic: this time research is still being produced on both economic and environmental matters, while in the 90s only a few were researching in these areas.

Since 2010, there has been a sharp increase in port sustainability research because this year marks the beginning of the increasingly severe approach that has been taken to environmental issues. In this way, government policies, warnings and reports by NGOs, and environment and economic developments have become ever more important. Moreover, since 2015, there has been a significant growth in research in this area. This is due to the fact that the International Maritime Organisation (IMO) passed a number of additional environmental policies (e.g. on ballast water control, and imposing a 0.5% sulphur limit) (IMO, 2018), and the UN released its 2050 sustainable development goals (Gatto, 1995; Goodland and Bank, 2002; Levett, 1998), which meant that economic, environmental, and social factors have become an area of concern for the port industry, rather than just profit-maximisation. Furthermore, the changes that took place during this period were not restricted to economy and environment, even though they were the chief areas of interest; social concerns such as cooperate social responsibility also attracted attention. However, social issues still form only a small part of port-related research, are one of the gaps in the field of port sustainability that awaits further research. To summarise, Figure 5 shows trends in studies on port sustainability that have published in the past three decades.

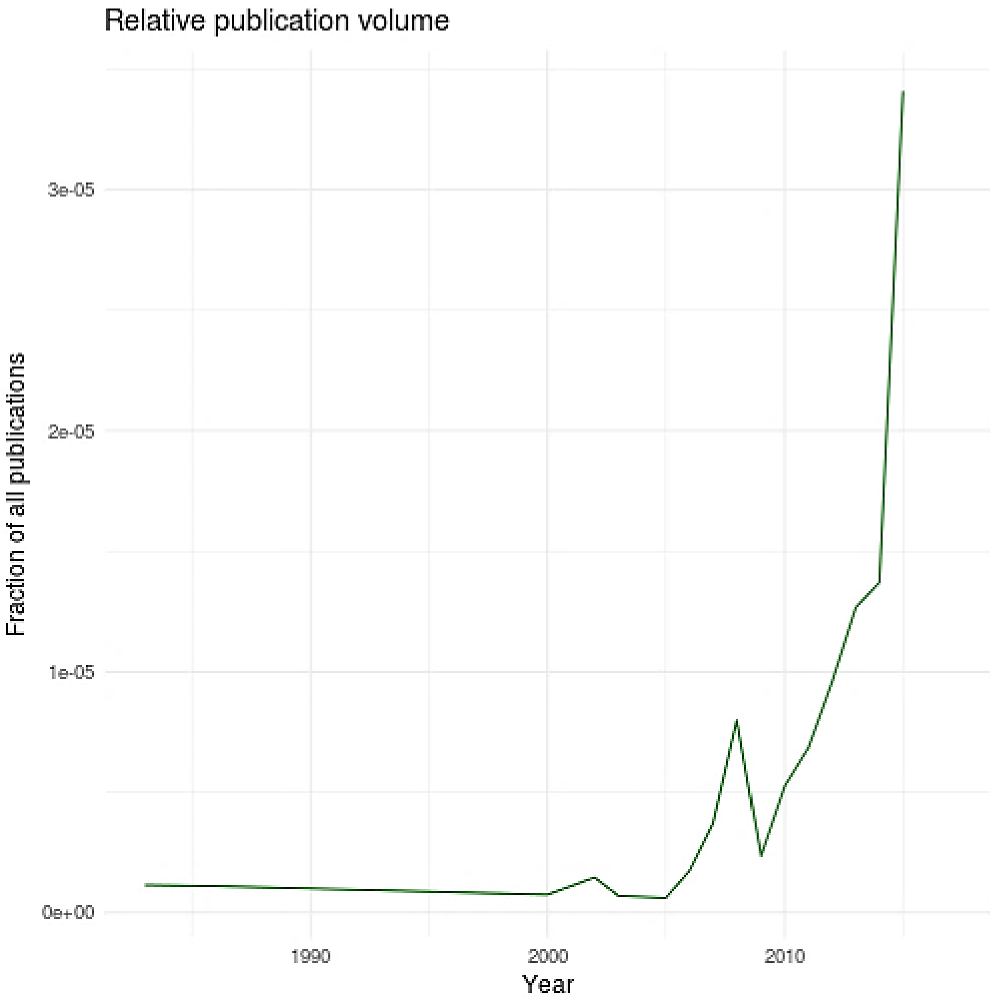


Figure 5 General trends in the publication of articles on port sustainability

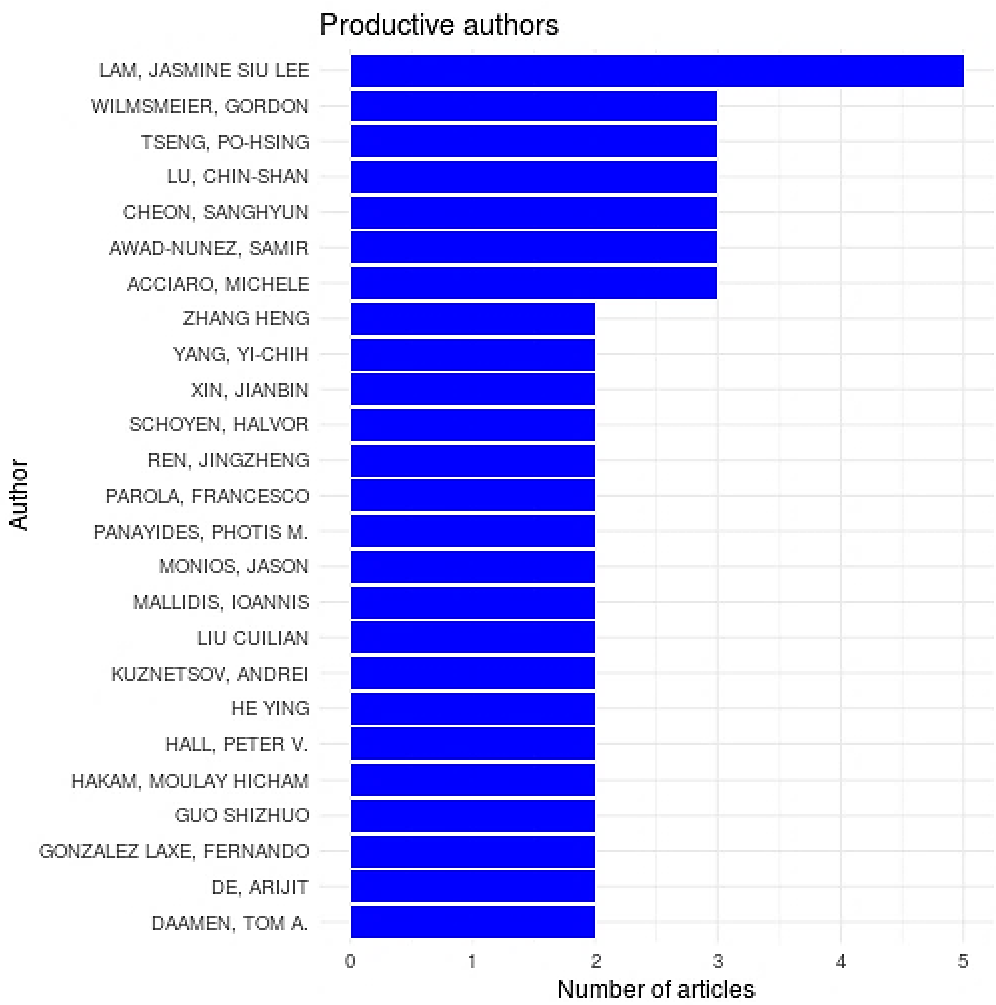


Figure 6 Most prolific authors

As can be seen in Figure 6, the four authors who have published the most articles on port sustainability or similar topics are Lam, Jasmine, Siu, Lee, Wilmsmeier, Gordon, Tseeng, Ph-Hsing, Lu, Chin-Shan (Lu et al, 2012; Lu et al[a], 2016; Sánchez and Wilmsmeier, 2006), who have all published at least two high-quality studies in the field. However, the authors listed above have only written between two and five studies, which indirectly proves that even though port sustainability is an area of research interest, it is still a relatively underdeveloped academic area.

It is also worth noting that Asian authors are heavily overrepresented among the most productive authors. This might be because Asian counties are more demanding of sustainability in the port sectors, compared to their European counterparts, given that many Asian ports have been built relatively recently.

Another reason for this could be the huge amount of port-based trade that takes place in Asian countries, which means that port sustainability issues cannot be ignored. The huge demand for port services requires that they be efficient, conducive to good employee and living conditions, help to develop the regional economy, and be environmentally friendly to maintain their potential future growth and development (Fancello et al, 2014; Flitsch et al, 2014; Heggie, 1974; Kim and Chiang, 2014; Carbone and De Martino, 2003; Goulielmos, 2000). Moreover, port sustainability is a relatively popular topic in Asia, compared to other regions. The authors mentioned here have contributed the most to the field of 'port sustainability' by creating new knowledge.

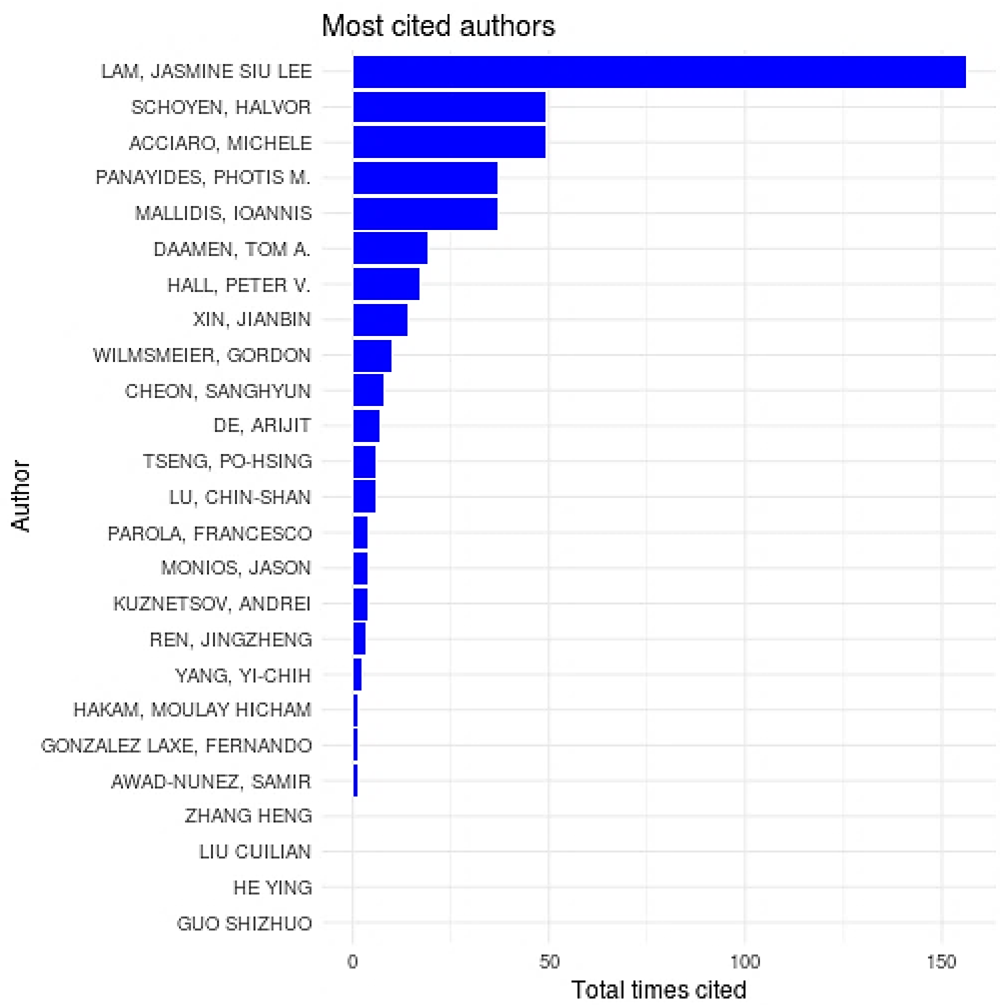


Figure 7 Most cited authors

As can be seen in Figure 7, this list of authors who have been cited the most is very similar to that of the top-publishing authors. However, there is a change in the ranking, with non-Asian authors being cited more on average than Asian authors, which indicates that this topic is still new to Asia, and that most new knowledge is built on previous theories established by Western scholars. However, the figure establishes that beyond doubt, Lam, Jasmine, Siu, and Lee are still the most important author in the field. And, even though the field still has a relatively low citation rate, in comparison to other similar research areas (such as supply chain, logistics, and operational management), the citation numbers are still big (up to 150), showing that there is increasing interest in conducting port sustainability research, and that this area is attracting ever more attention.

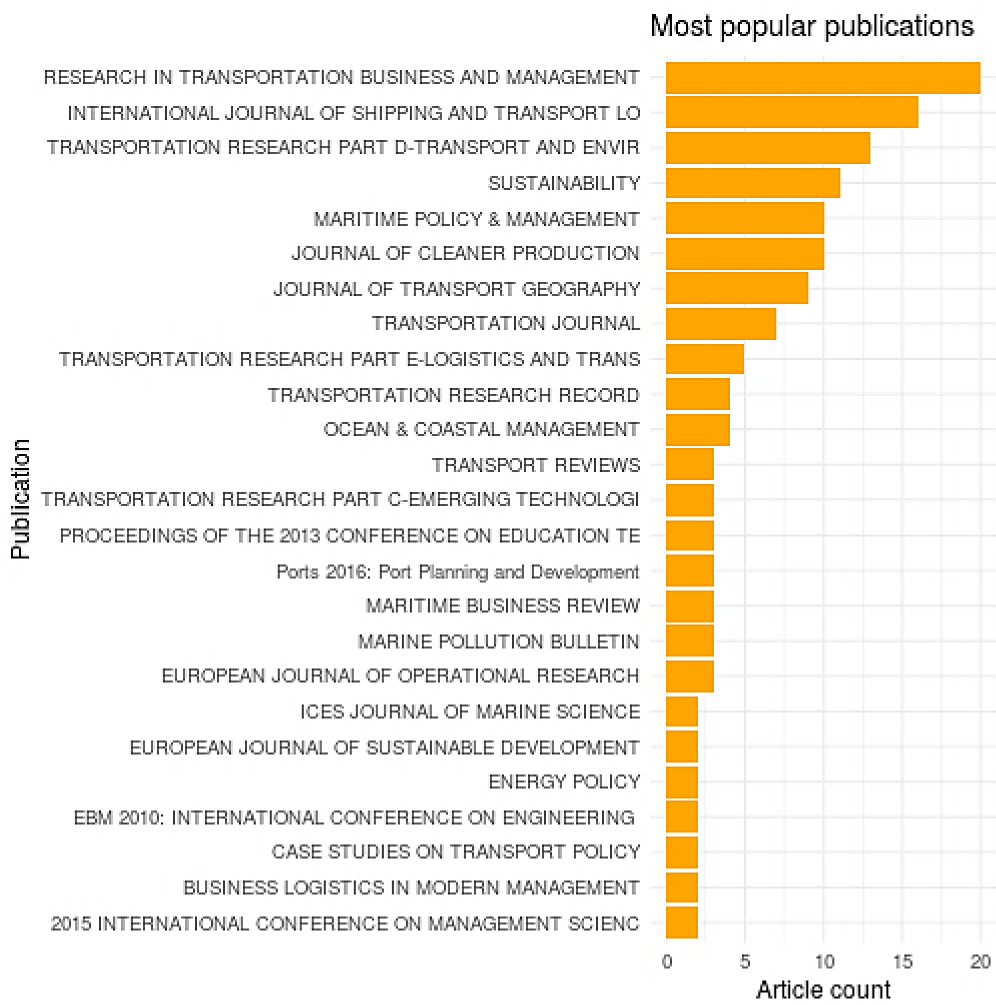


Figure 8 Most popular publications

Figure 8 shows that the journals that have published the most port sustainability-related studies are *Research in Transportation Business and Management*, *International Journal of Shipping and Transportation Logistics*, *Transportation Research Part D: Transport and Environment*, *Sustainability*, *Maritime Policy and Management*, and *Journal of Cleaner Production*, having published ten or more such articles (Carlan et al, 2016; Ghashat and Cullinane, 2013; Schøyen and Bråthen, 2015; Sislian et al, 2016; Van Hassel et al, 2016; Cariou, 2011; Chang and Wang, 2012; Davarzani et al, 2016; Ducruet et al, 2010). *Research in Transportation Business and Management* has published the most (20 studies) (Ghashat and Cullinane, 2013; Schøyen and Bråthen, 2015; Sislian et al, 2016; Van Hassel et al, 2016). Of these journals, few have a ranking of three stars or above, according to the ABS, and most have two stars or fewer. This indicates that few articles related to port sustainability have been published in the most influential journals, there are relatively few journals ranked as having three or more stars or in the general research area of transportation, and shipping in particular.

Figure 9 The journals with the most citations

Figure 9 shows that the journals with the most citations are relatively similar to those that have published the largest amount of studies related to port sustainability. However, the order of the ranking has changed, the top five being *Journal of Transport Geography*, *International Journal of Shipping and Transportation Logistics*, *Transportation Research Part D: Transport and Environment*, *Journal of Cleaner Production*, and *European Journal of Operational Research* (all with at least 60 citations). Of particular note is the *Journal of Transport Geography*, which has a total of 90 citations. We can thereby conclude that the *International Journal of Shipping and Transportation Logistics*, *Transportation Research Part D: Transport and Environment*, and *Journal of Cleaner Production* are the prominent journals in the field, having published the most relevant articles and having been cited the most. These criteria prove that they can be considered the most influential journals in the field.

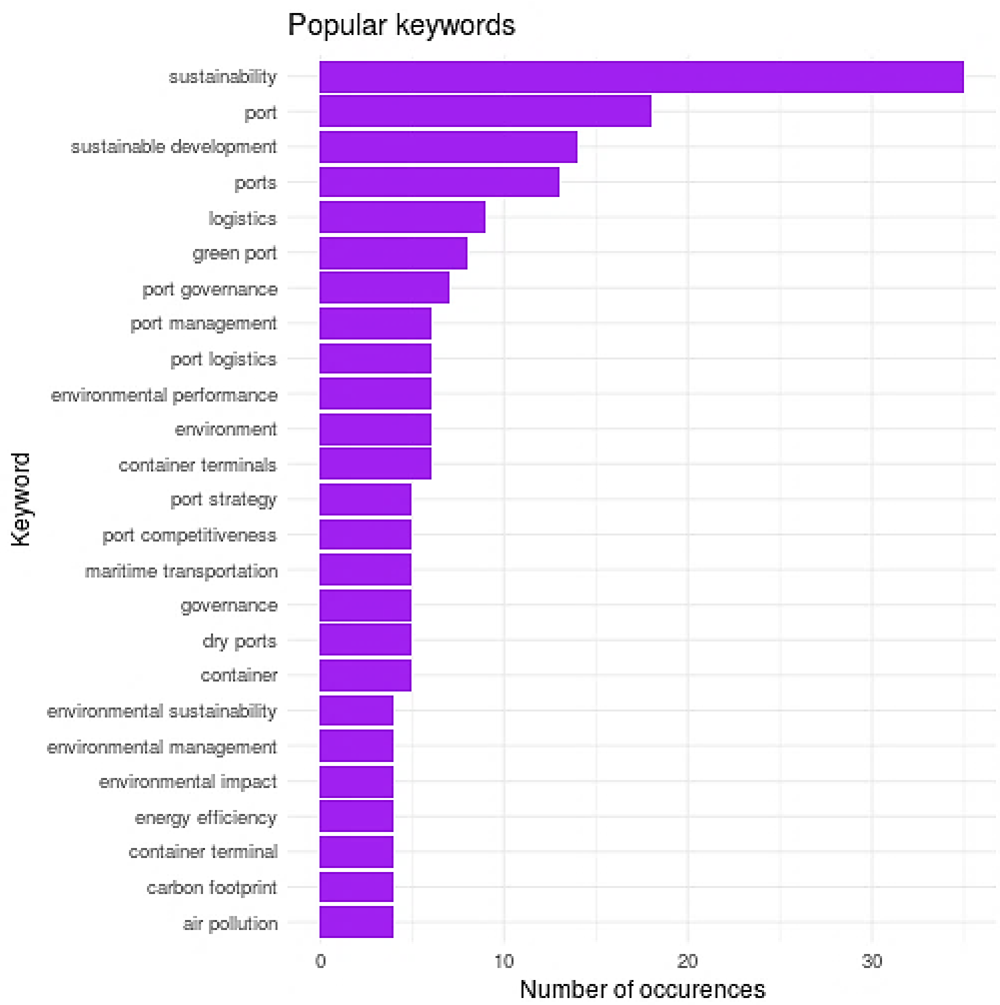


Figure 10 The most popular keywords

As illustrated in Figure 10, the most popular keywords are ‘sustainability,’ ‘port,’ ‘sustainable development,’ and ‘ports,’ each having more than ten occurrences. By examining the entire list of popular keywords, one can see that it can be divided into three parts: general port conditions (including sustainability, governance, and container ports) (Gritsenko, 2015; Meersman et al, 2006; Ng and Pallis, 2010; Notteboom, 2006[b]); environmental factors (e.g. carbon footprint, air emission, and environmental management) (Hörisch et al, 2014; Hoshino, 2010; Jung, 2011; Kim and Chang, 2014; Sislian et al, 2016; Wang et al, 2017[a]; Pallis, 2007; Notteboom, 2006[a]); and economic development (such as port strategies, logistics, and competitiveness) (Sheng et al, 2017; Van Hassel, 2016; Wan et al, 2016; Yip et al, 2016). It can therefore be concluded that most port sustainability research concerns dry and container ports, with special focus on their environmental and economic conditions. This result indicates that not only is there little interest in holistic sustainability research, including social factors, in the field, but there is a total lack of research into holistic sustainability framework with regard to ports, despite the need for such research due to safety and environmental issues.

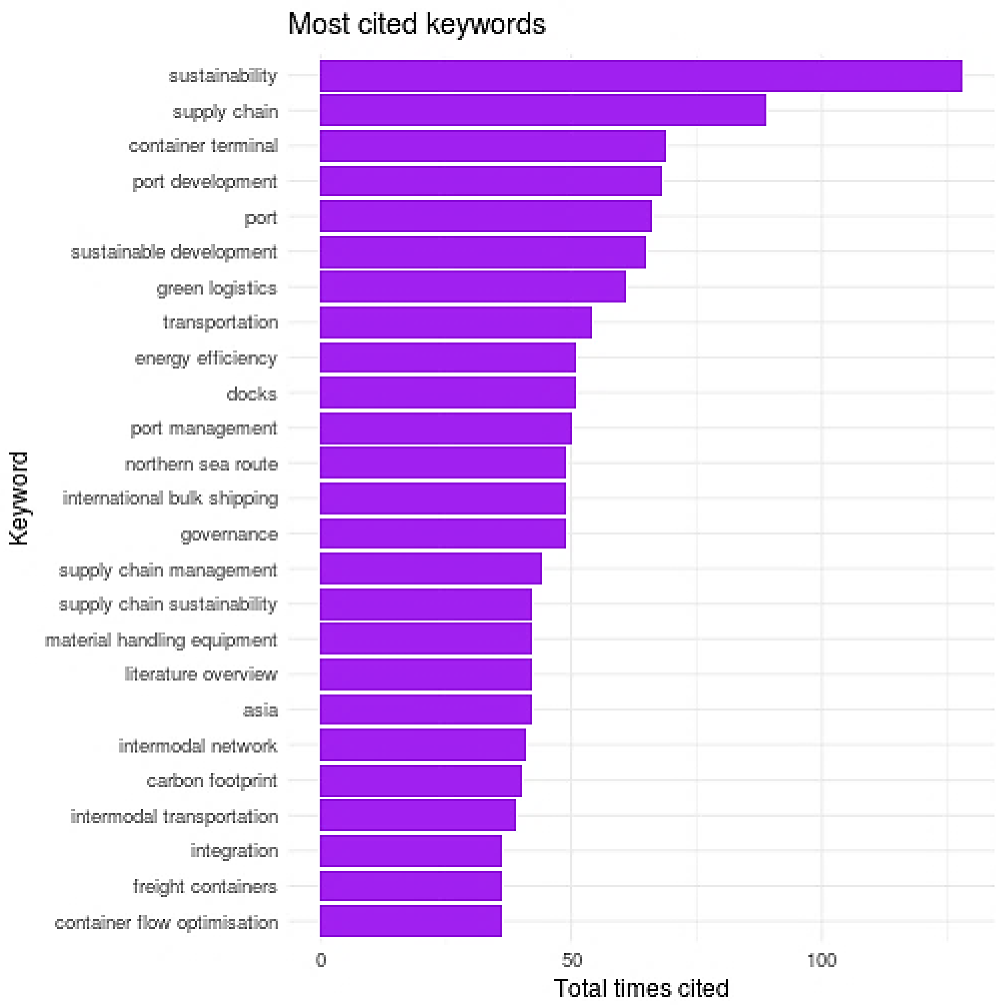


Figure 11 Most cited keywords

Comparing Figure 11 to Figure 10, we can see some similarities between the most cited and the most popular keywords. For instance, the most cited keywords can also be divided into the three same categories: general port conditions (such as sustainability, supply chains, and port management)

(Gritsenko, 2015; Meersman et al, 2006; Ng and Pallis, 2010; Notteboom[b], 2006), economic development (international bulk shipping, port networks, and container flow optimisation) (Sheng et al, 2017; Van Hassel, 2016; Wan et al, 2016; Yip et al, 2016), and a smaller number of environmental issues (such as carbon footprints, supply chain sustainability, and green ports) (Hörisch et al, 2014; Hoshino, 2010; Jung, 2011; Kim and Chang, 2014; Sislian et al, 2016). This reveals a further gap in research into holistic oil port sustainability management. However, Figure 11 shows that research in this area has emphasised ports' economic development, especially in the context of holistic supply chains and logistics, which matches with the definition of third-generation ports. It can therefore be concluded that current research into port still utilises a 'third generation' understanding of ports.

2.2.4 SLR summary

The following main findings can be extracted from the above findings:

1) Port sustainability has gradually become a popular topic since the late 1990s and has experienced a sharp increase after the year of 2010. The process is firstly economic-focused, and then emphasised on environmental protection since the late 2000s, and has reached the high peak after 2014 due to the IMO and UN regulations. However, the global economic situation is identified as one of the most influential impacts of the port sustainability research amounts;

2) Lam, Jasmine, Siu and Lee can be said to be the most influential author in the field of port sustainability, based on her contribution to knowledge in the domain. However, the authors in this field show relatively limited productivity, in comparison to authors in other comparable fields, which indirectly proves that there is a considerable need for further research into port sustainability.

3) There are relatively few journals ranked as having three or more stars in the field of transportation, and especially shipping. *International Journal of*

Shipping and Transportation Logistics, *Transportation Research Part D: Transport and Environment*, and *Journal of Cleaner Production* are the prominent journals in the field, having published the most directly relevant articles with the largest number of total citations.

4) There is a gap in the field with regard to holistic oil port sustainability management. The current research emphasis is port economic development, especially in the context of holistic supply chains and logistics, which matches with the third-generation understanding of ports, and current research in the field still follows this model.

2.3 Content Network Analysis (CNA)

2.3.1 The CNA review

At this stage, the CNA analysis needs to be conducted, based on the same literature obtained in the course of the systematic literature review. It is expected that the CNA will reveal the most frequently cited works in the field, along with the relationships between the studies. In this study, citation times are considered one of the most crucial criteria to measure studies' importance, given that they show the impact a study has had on its field; the more a study has been cited, the more it can be assumed to have made a critical contribution to the field. To show the relationships between the most important studies, this study has extracted 111 studies with cited at least once, from all 316 studies reviewed that are relevant to the research topic. After filtering them, the previous notes of each of chosen study that detail its main idea, methodology, and outcome have been re-read to link them together, based on their impact direction.

To complete the above process, the results are input into the graphical modelling software for the CNA analysis. There are several potential choices of software, of which the most common are Mathematica, Gephi, Graphstream, NetMiner 4, and Network X. In order to select the most suitable and convenient software, the functions of each have been summarised in Table 4. The categories have been marked with a tick (√) if the software in question is able to perform the stated function. The software with the most ticks has been marked in red, and deemed the software most for the CNA analysis. Lastly, it is worth mentioning that the features listed in the table have been chosen based on the understanding of the aim behind performing a CNA, as per its definition and relevant literature.

Table 4 A comparison of the various software options

Software	Large Information Handling Capacity	Convenient Graphical User Interface (GUI)	Fast Responsiveness	Ability to build Network basing on Analysis	Ability to show Empathized factors (e.g. citation times, level of the Journal, etc.)
Gephi	√	√	√	√	√
Graphstream		√			
Mathematica	√			√	√
NetMiner 4					
Network X				√	

As can be seen in Table 4, the evaluation of the potential software shows that Gephi offers the most functions. It is also able to handle a large amount of information with fast responsiveness in a GUI-friendly approach to build a network basing on a rigorous analysis, which makes it the most suitable software to conduct the CNA analysis. In the following section, the visualised data analysis has been shown using Gephi to enable an easier and clearer understanding of the relationship between the most crucial studies in the field.

2.3.2 CNA results

Through the visualised Gephi analysis, four objectives have been achieved, as shown in Figure 12:

1) What has been researched in previous studies in the field;

2) The research gaps in the field;

3) The most important studies;

4) How the most important studies are connected.

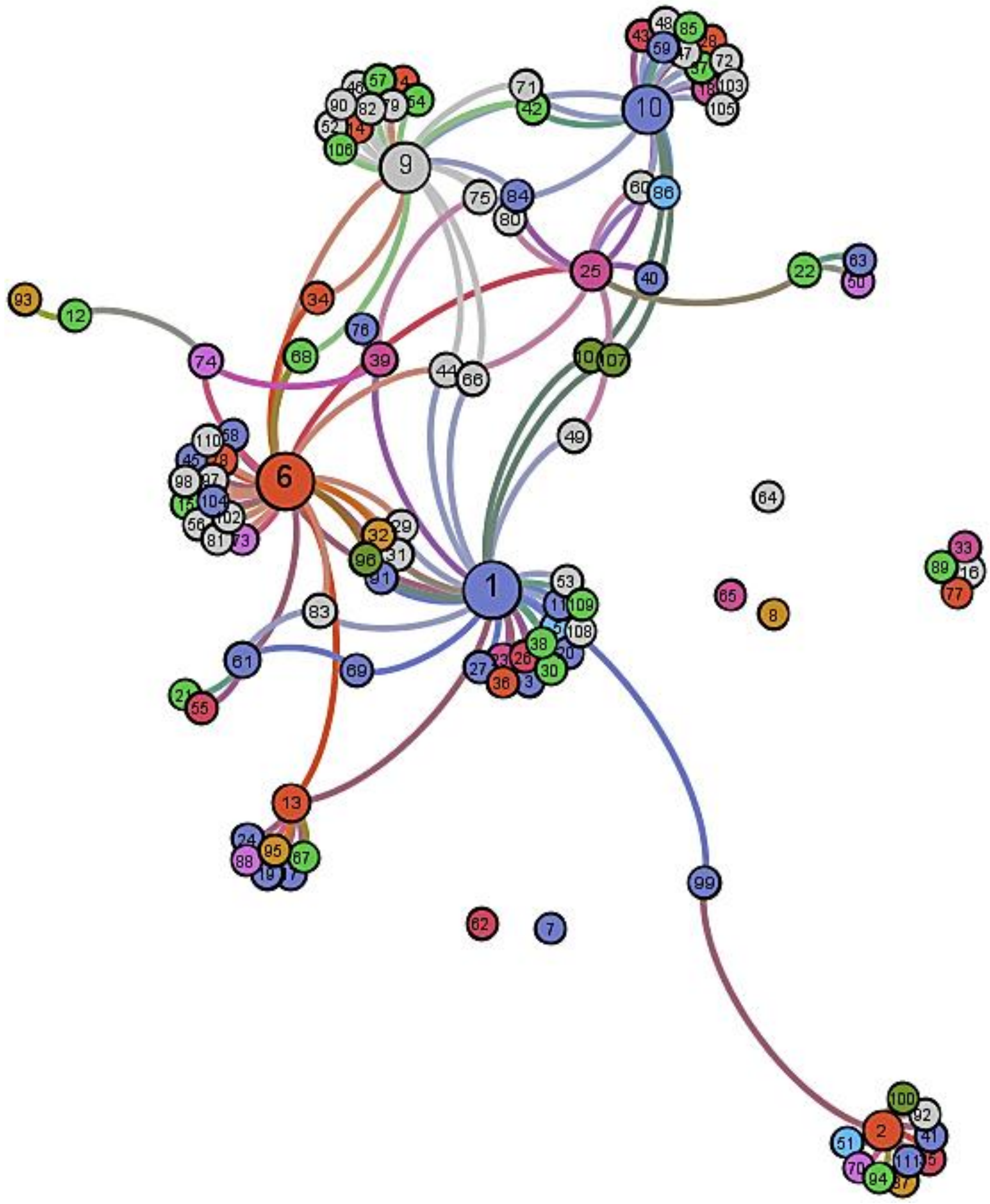


Figure 12 A citation network of the most influential studies in the field

The size of nodes in Figure 12 presents the amount of connection each of them has. The bigger the nodes are the more connection to other studies they have. The numbers in the nodes present the symbols of each analysed study. Please find the lists of articles in accordance to the symbols in Appendix 18.

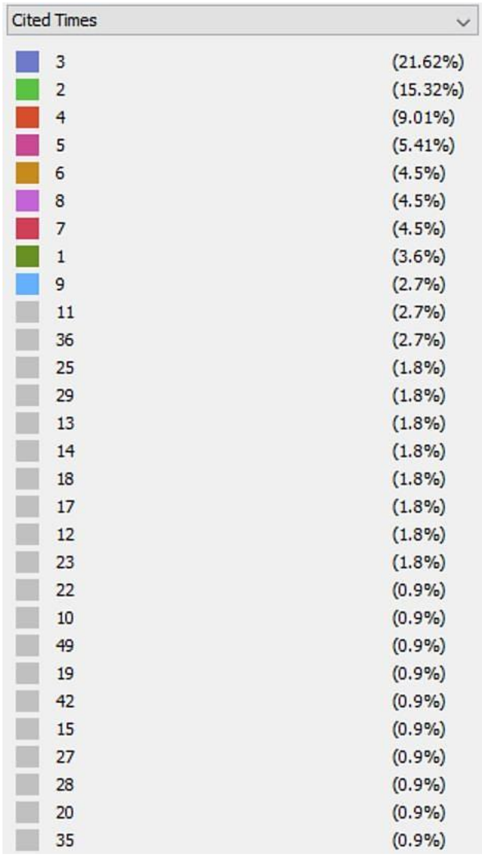


Figure 13 The citation rates of the influential studies

As can be seen in Figures 12 and 13, the citation rates for each study has been marked in different colours. Figure 12 shows that the studies with the most connections (with the biggest node size) focus on general sustainability indicators for ports (Acciaro et al, 2014; Cerret and De Toro, 2012; Dinwoodie et al, 2012); evaluations of green ports (Lam and Nottemboom, 2014; Guo et al, 2010); and ports' economic development plans (Hoshino, 2010; Higgins, 2015). These form the centre of the research field and together with the smaller nodes, combine to make up a research cluster. However, reflecting the colours of the nodes in Figures 13 and 12, the most-cited studies (the ones considered the most influential) are relatively small (grey-coloured) having limited connections with other studies, rather than those with the most citations. The most cited studies are mostly detailed studies that look at sustainability indicators at container ports (Iannone, 2012; Jiang and Mao, 2012; Lu et al., 2016[b]; Lun, 2011); the establishment of green port performance evaluation mechanisms (Ha et al, 2017; Liao et al, 2016; Lirn et al., 2013; Lun, 2011; Chiu et al., 2014); environmental evaluations in the context of the contemporary market (Cheng et al., 2013; Antão et al., 2016; Bailey and Solomon, 2004; Darbra et al., 2004; Darbra et al., 2005; Darbra et al., 2009; Challinor et al, 2014); and port development in specific logistics development plans (César, 2006; Chen and Kumagai, 2006; Chan and Yip, 2010; Choi, 2013; Dai, 2016; Ferrari and Claudio Ferrari, 2011).

This shows that the topics analysed in previous studies mostly only look at container ports, and not dry bulk or oil ports. Furthermore, no holistic sustainability framework has been developed because most works focus on the environmental and economic aspects of ports. Other issues at the centre of port sustainability include sustainability development (Pavlic et al., 2014; Lirn et al., 2013; Schenone et al., 2017; Monteiro, 2013; Yap and Lam, 2012); the balance between economic issues and sustainability (Burskyte et al., 2011; Dinwoodie et al., 2012); green port logistics (Song and Panayides, 2002; Yang et al, 2016; Chang and Wang, 2012); and whether ports achieve high efficiency in the intermodal context. Because these topics mainly concern economic development and the environment (given that most are centred on green and environmental issues), this outcome further proves that the important studies that lay the foundation for other studies focus on the balance between the environment and economic development.

Furthermore, it can also be concluded that the previous studies that look at a relatively general topic such as sustainability evaluation (Hakam and Solvang, 2009; Sislian et al., 2016; Lu et al., 2016[b]); green port measurement (Yang et al, 2016; Lun, 2013); and port economic development (Yuen and Cheung, 2013; Smith, 1999; Brooks et al., 2014; Brooks, and Pallis, 2008) were written in the light of the most influential studies in the field, absorbing the data provided in the most cited studies, such as those outlining sustainability indicators in a specific context (like container ports), environmental and economic development from a logistics perspective, and those in a particular market environment. Moreover, of the studies that look at ports, ‘sustainable and ‘green’ issues are mostly connected to ‘environmental’ and ‘economic’ matters. A small portion consider the matter as they affect port stakeholder, and are partially relevant to the relationship between stakeholders’ engagement and economic development, and the remaining ones examine CSR performances among port operators, from the stakeholders’ perspective. Structurally, it can be concluded that the studies that connect most studies together are those with large node size. The small nodes are the clusters with a detailed focus, and which branch off under the general themes of sustainability or green ports.

Figure 12 includes the most cited studies in the field, and together with the links that bring the studies together, Figure 12 in this way establishes the research gaps: the absence of interest in either oil port sustainability or the formation of a holistic sustainability framework that takes social factors into account.

2.3.3 CNA summary

In the previous, the following results have been generated:

1) The extant research in the field are concentrated on two kinds of studies: those look at general sustainability/green/low carbon systems in the port domain (Acciaro et al, 2014; Asgari et al, 2015; Cheng et al, 2013; Cheng et al, 2015; Denktas-Sakar and Karatas-Cetin, 2012), and studies of one aspect of sustainability such as environmental approaches at container ports, the relationship between ports and cities, and measurements of air emissions (Álvarez-SanJaime et al, 2015; Ascencio et al, 2014; Bailey and Solomon, 2004; Ball, 1999; Brooks et al, 2014[a]; Brooks et al, 2014[b]; Budd, 1999; Brooks and Cullinane, 2006[a]; Brooks and Cullinane, 2006[b]).

2) In terms of port types, container and dry ports have attracted the most scholarly attention (Cariou, 2011; Brooks et al, 2014 [b]; Chen et al, 2013; Fan

et al, 2015; Ghashat and Cullinane, 2013; Hakam, 2015; Hoshino, 2010; Iannone, 2012; Jiang et al, 2012; Lu et al, 2016; Lun, 2011; Notteboom, 2006[a]; Schøyen and Bråthen, 2015; Van Hassel, 2016), while oil port has mainly been researched in the context of chemical and technical developments (such as assessments, reactions, and solutions to oil spills) (Benedict, 2011); and from the perspective of sustainability, environmental and economic matters are the main concerns (Wen et al, 2015; Yang et al, 2013; Zhu et al, 2014; Acciaro et al, 2014; Antão et al, 2016; Bailey and Solomon, 2014; Burskyte et al, 2014; Dinwoodie et al, 2012; Chan et al, 2010). However, there is increasing interest in social issues in the form of CSR and safety (Group, 2004; IMO, 2003; International Organization for Standardization, 2015).

3) The main centres of the port sustainability network are sustainable development, economic issues and sustainable balancing, green port logistics, and whether ports achieve high efficiency in the intermodal context (Jiang et al, 2016; Zhu et al, 2014; Antão et al, 2016; Bailey and Solomon, 2014; Coronado Mondragon et al, 2012; Dinwoodie et al, 2012; Chan et al, 2010; Acciaro et al, 2014;). Because the most frequent topics are economic development and the environment (given that the greenest and sustainability studies are limited to environmental issues) (Yang et al, 2013; Zhu et al, 2014; Acciaro et al, 2014; Antão et al, 2016; Hakam, 2015; Hoshino, 2010; Iannone, 2012; Jiang et al, 2012; Lu et al, 2016; Lun, 2011; Notteboom, 2006; Schøyen and Bråthen, 2015; Van Hassel, 2016), this further proves that the important studies that lay the foundation for others are those focusing on the balance between the environment and economic development.

4) The most cited studies, which should be considered the most important in the field, are not those with the most connections or central points.

2.4 SLNA results

In this section, two SLNA results will be discussed:

1) Gaps in the research

2) The creation of a holistic theoretical sustainability framework.

<u>Gaps in the research</u>

Following the SLNA, the following gaps (and the reasons for their existence) can be generated:

Table 5 Gaps in the research, why they exist

	Gap	Reason
1	Sustainability in few port types discussed	Most of the current focus lies on container port
2	No holistic sustainability framework developed	Most dicussion lie sololy on envionmnet, CSR, or the relationship between economic and environment, but not all together
3	No prioritisation on each of the sustainability section provided	Led by the above gap, no importance analysis in specifically each of the sustainability se3ction is done
4	No interrelatipnships between sustainability objectives identified	In the port sustainability literature, main focus is still on the stage of identifying sustainability objects, as no standard have been made at ports before
5	No suggestions to the most inignorable sustainability objectives	Methods conducting port sustainability research are relatively unitary (e.g. Interview, AHP, and FAHP)

Table 5 reveals five gaps in the research, based on the port sustainability studies that have been reviewed. Research into port sustainability is still at the initial stage, resulting in many gaps. For instance, one of the most significant gaps is that even though oil ports have a higher sensitivity to unsustainable incidents, there are few relevant studies that have examined oil port sustainability (such as evaluations of ports' reactions to oil spills). Given that container ports make a significant contribution to regional and national economies, the field has begun to embrace new concepts in recent years such as big data and automation, port sustainability mainly focuses on this type of port.

Look at the studies into port sustainability, it can be seen that the research is mostly limited to environment and economic factors of sustainability. While there are some that investigate CSR, they are still very few in number. This could be because environmental issues, and especially air pollution, is a traditional concern in this field. Furthermore, no studies have systematically looked at the various aspects that make up sustainability, because port sustainability is still under-researched, the sustainability objects are still a matter of contention; it is difficult to propose a single formula due to the different features and pursuits of each port, and no research into the interrelationships has been conducted.

Finally, due to the limited nature of the research into port sustainability, there have been no suggestions as to the most crucial indicators in the field. This would merit further investigation, given that there are no standard global guidelines that outline how ports can achieve sustainability; however, because it would take too long to develop a specifically port-oriented sustainability framework, the establishment of a set of fundamental indicators could help port stakeholders to achieve temporary sustainability, especially if they have limited resources.

<u>A holistic sustainability framework</u>

Through the systematic literature review of the concept of port sustainability, a number of indicators related to oil ports have been identified and categorised, based on common sense and the researcher's subjective opinions (see Table 6 and Figure 14). Because the indicators and the reasons for their adoption can be seen in the conclusion or discussion section, there is no need to conduct a further analysis (such as a thematic analysis) to obtain an accurate answer at this stage. However, the researcher has decided on the reasons behind this selection based on their own knowledge and common sense, in cases when there are no or conflicting explanations across different studies (the results in the 'Reason of Selection' in Table 6 are also confirmed during the pre-interview panel meeting to minimise the biases; for this, see Section 2.5).

A thematic analysis will be used to conduct the following qualitative empirical study (the semi-structured interviews). This is because the interview transcripts involve content that might be irrelevant to sustainability, and that the mentions of sustainability can be spread over the entire transcript, without a standard location as in the existing literature. The fact that the researcher used their own subjective opinions to identify the various items that make up sustainability should not be a cause for concern; to enhance the accuracy, the theoretical framework finally developed will be discussed with a panel of three experts with deep understanding of the field (see Section 2.5).

In this way, the indicators of all three aspects of sustainability can be extracted for potential use in the formation of an oil port-oriented sustainability framework, as outlined in Table 6. A total of 64 theoretical indicators have been derived from the literature review, which have been divided into six environmental groups, three economic groups, and four social groups. The key terms of sustainability have then been divided in the following way. The first layer is formed of the three areas of sustainability (Port of Los Angeles, 2013; Hörisch et al, 2014; Hoshino, 2010; Schenone et al, 2017; Shiau and Chuang, 2015; Shiau and Chuen, 2016; Sislian et al, 2016; Wong et al, 2015; Acciaro, 2014); the second is made up of number of groups to which they belong (such as air, stakeholder involvement, and HR) (Ferrari and Claudio, 2011; Flitsch et al, 2014; Heggie, 1974; Hörisch et al, 2014; Hoshino, 2010; Jung, 2011; Kim and Chang, 2014; Meersman et al, 2006; Notteboom, 2006; Ontwerp, 2015; Pallis, 2007), while the third layer consists of detailed sustainability indicators (such as CO2, cost-effectiveness, and noise) (Shiau and Chuang, 2015; Meersman et al, 2006; Shiau and Chuen, 2016; Sislian et al, 2016; Pallis, 2007). This will be taken as the default structure for the whole research project. The sustainability indicators that have been taken from the existing literature that are relevant to oil ports have been listed as follows, along with their respective groups and sectors:

Table 6 Port sustainability indicators

Sustainability Sector	Group	Indicators & Source	Reason for Selection
Environment	**Air** (Lam & Van Voorde, 2012; Badurina et al, 2017; Levett, 1999; Chiu et al, 2014; Pavlic et al, 2014; Mansouri et al, 2015)	**CO2** (Lun et al, 2013; Antoni et al, 2015; OECD, 2011)	Ports CO2 are mainly generated from: 1) Fuel burning (for offshore trucks and onshore usages); 2) Onshore and offshore coal burning for electricity, etc.
		VOC (OECD, 2011; Portofrotterdam, 2011; Lam & Van Voorde, 2012)	1) Onshore and offshore coal and natural gas burning (e.g. cooking stoves, ship engine operation, etc.); 2) Onshore and offshore waste water treatment; 3) Smelling products (e.g. Crude oil, Gasoline, Naphtha) loading, unloading, and storage.
		CH4 (Greenport, 2018; Merk et al 2014)	1) Onshore and offshore domestic sewage emission (into water); 2) Petroleum load and unload
		SO Category (Lam & Van Voorde, 2012; Badurina et al, 2017; Chiu et al, 2014; Pavlic et al, 2014)	1) Crude oil and petroleum products itself (containing sulphur); 2) Liquid Fuel consumption: - corrosion on facilities including pipelines, pumps, etc., - burning of the fuels
		NO Category (Lam & Van Voorde, 2012; Chiu et al, 2014)	1) Onshore and offshore fuel consumption 2) Soil and marine organic matter decomposition (Natural nitrogen circulation)
		Hydrocarbon (Borriello et al, 2013; IMO, 2015)	1) Burning coal and natural gases onshore and offshore (e.g. ship engine, truck, etc.); 2) Accidents (e.g. Petroleum products spill/explosion)
		Dust (Greenport, 2012)	Construction Projets (port expansion, etc.)
		Suspend Solides (Morgan et al, 2011; Yang, 2017)	Construction Projets (port expansion, etc.)
	Water (Ng and Pallis, 2010; Levett, 1999; Chiu et al, 2014; Notteboom, 2006; OECD; 2011)	**Ballast Water** (Thomas, 2016; EBRD, 2014)	Set loading and discharging
		BOD (Akgul et al, 2017)	Water Pollution (e.g. dead aquatic animals and plants, sewage emission, etc.)
		COD (Akgul et al, 2017)	Water Pollution (e.g. oil spill, sewage emission, etc.)
		Contaminated Sludge from Dredging (HFW, 2013)	port construction projects (e.g. port expansion, new port development, etc.)
		Washing Water (HFW, 2013)	Oily water, etc.
		Ship Operational Disposal (HFW, 2013)	Remaining pain from the painting can
	Solid Wastes (Notteboom, 2006; OECD, 2011; OECD; 2011)	\	Onshore and offshore daily wastes (e.g. waste food, medical disposal, etc.)
		\	1) Garbage; 2) Medical disposal, etc.
	Noise (Bucak and Kuleyin; 2016; Beškovnik et al, 2014)	**Sound Pollution** (Bucak and Kuleyin; 2016; Beškovnik et al, 2014)	Construction, engine, etc. affecting ecosystem.
	Ecosystem (Lam & Van Voorde, 2012)	**Biodiversity Issue** (Lam & Van Voorde, 2012; OECD, 2011; OECD, 2015)	1. Ballast water; 2. oil spill, etc.
		Vegetation Coverage (OECD, 2011; OECD, 2015)	Sewage Emission, oil spill, etc.
		Distance from Ecological Sensitive Area (OECD, 2011; OECD, 2015)	Important for the ecosystem to maintain healthy.
	Energy Consumption (EUCC, 2013; OECD, 2011; OECD, 2015)	**Electricity Consumption** (Lam & Van Voorde, 2012)	Onshore and offshore lightening.
		Fuel (Lam & Van Voorde, 2012; OECD, 2011; OECD, 2015)	Truck, ship engine, etc.
		Renewable Energy Utilisation (EUCC, 2013)	There is an increasing demand of using renewable energy instead of traditional coal and fuel.
		Energy Saving Facility Utilisation (Port Authority of New South Wales, 2016)	Under the big context of requiring less energy consumption, energy saving facilities should be used when renewable energy is in-substitutable.

Social	**Port's Working Environment** (Kusi et al, 2015; Port of Gothenburg, 2012)	**Security** (Kusi et al, 2015; IMO, 2003; Port of Gothenburg, 2012)	ISPS (The International Ship and Port Facility Security) Code, which is an amendment to the Safety of Life at Sea (SOLAS) Convention (1974/1988)
		Safety (Kusi et al, 2015; IMO, 2003; Port of Los Angeles, 2013)	Occupationnel Diseasse;
			Accidents (explosion, etc.)
		Accidents (Jalonen and Salmi, 2009)	Oil spill, collision, etc.
	Citizen Lively Condition (OECD, 2011; OECD, 2015; Schenone et al, 2017)	**Port city relationships** (Pigna, 2014; Ducruet, 2006)	The frequent port activity brings economic prosperity to port areas, eventually improves citizen living condition.
		Knowledge Development (OECD, 2011; OECD, 2015; Port of Los Angeles, 2013)	Professional training and relevant knowledge broadening.
		Population Growth (OECD, 2011; OECD, 2015; Schenone et al, 2017)	Mainly refers to the port city and the region. However, the frequent port activity also brings economic prosperity to port areas, which attracts more people coming to the port areas (e.g. new port company, etc.).
		Safety (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	As there are citizen and employee living and working in port areas, safety issue would be crucial for citizen lively condition.
		Resources (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	Resources (both tangible and intangible resources) at port enhances the citizen lively condition.
		Community (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	As there are citizen and employee living and working in port areas, communities (both private and public sectors) should be focused to avoid conflicts.
		Accidents (OECD, 2015; Port of Gothenburg, 2012; Port of Los Angeles, 2013)	As there are citizen and employee living and working in port areas, accidents may harm citizen's health and lively condition.
		Social Justice (Beškovnik et al, 2014)	Whether the development have caused local citizen concerns and whether their pursuits can be taken seriously and properly solved.
	Port HR (OECD, 2011)	**Human Capital Development** (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	Human is a kind of important resources in port
		Knowledge Development (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	Knowledge expansion is significant for career development and task allocation.
	Noise (Bucak and Kuleyin; 2016; OECD, 2015; Port of Gothenburg, 2012)	**Sound Pollution** (Bucak and Kuleyin; 2016; OECD, 2015; Port of Gothenburg, 2012)	Construction, engine, etc. affecting citizen lively condition.

Economic	**Port's Operational Ability** (Schenone et al, 2017; Song and Parola, 2015; Soszynska, 2010; Li and Yang, 2010)	**Employment** (Soszynska, 2010)	Whether tasks are being assigned to the right person affects the port's operational ability
		Cost Effectiveness (Carlan and Vanelslander, 2016; Chan and Yip, 2010; Iannone, 2012)	As there is no case there can be unlimited budget, money should be spent effectively to maximise its utilisation.
		Investment Quantity (Iannone, 2012)	As there is no case there can be unlimited budget, money should be spent effectively to maximise its utilisation.
		Damage Frequency (Schenone et al, 2017)	Damage would cause further cost.
		Transit Time (Lun, 2011; Schøyen, H. & Bråthen, 2015)	Transit time would cause further cost.
		Financial Performance (Port of Gothenburg, 2012; Port of Los Angeles, 2013)	Financial performance leads to financial situation.
		Capacity (Song and Parola, 2015)	Capacity leads to financial situation.
		Increased Productivity (Soszynska, 2010)	Productivity leads to the potential for further development.
		Political Influence (Stuart and Hart, 2013)	Political influence causes handling amount of the port.
		Value Added Growth (Soszynska, 2010; Li and Yang, 2010)	Value adding service provides competitiveness to port.
		Diverse Service (Iannone, 2012)	Diverse service reflects a port's operational ability.
		Optimised Land Use (Kusi et al, 2015)	No land should be wasted.
	Port Competitiveness	**Connection to other ports** (Weigend, 2011; Lu et al, 2016; Mansouri et al, 2015)	Conveniences to go to other ports enhances the port competitiveness.
		Connection to Hinterland (Hou and Geerlings, 2016; Iannone, 2012; Lättilä et al, 2013)	Under the third-generation port, advanced hinterland connection provides potential value adding opportunities in terms of supply chain and logistics management and eventually maximises the profit.
		Resources (OECD, 2011)	Appropriate usage of resources (both tangible and intangible) leads to profit maximisation.
		Service Quality (Marex, 2018; Ng et al, 2010)	Service quality leads to preference of shipping and transportation companies (e.g. whether there is too long queuing time, etc.).
		Cost Effectiveness (Lättilä et al, 2013; Iannone, 2012)	Cost effectiveness is one of the most criteria hipping and transportation companies to choose ports.
		Active Shipping Activities (OECD, 2011)	It reflects the prosperity of a port.
		Economic Catalyst (Port of Los Angeles, 2013; Jonathan, 2013; Jung, 2011)	Port's functional change.
		Economic Strategies (Jonathan, 2013; Jung, 2011; Jung, 2011; Kim and Chiang, 2014; Meersman et al, 2006)	It determines the port's development strategy.
		Market-Share Growth (Meersman et al, 2006)	Market-share leads to profitability.
		Regional Contribution (Meersman et al, 2006; Iannone, 2012; Lättilä et al, 2013)	Regional contribution may lead to profitability and more funding, as well as more development potentiality.
		Diverse Service (Iannone, 2012)	Diverse service provides competitiveness to port.
		Enhancement of Offshore Environment (Matsushima and Takauchi, 2014)	This may lead to more funding after achieving a certain level and better reputation.
		Increasing Quality of Information Flow (Jung, 2011; Kim and Chiang, 2014)	This will lead to a more effective daily operation.
		Benefits to Port Users (OECD, 2011)	This brings ports good reputation.
	Interest Parties' Involvement (Arat, 2011)	**Stakeholder's Corporation** (Arat, 2011)	Stakeholder's engagement leads to operational ability and competitiveness.

Following the categorisation of each group and indicator in Table 6, a theoretical oil port sustainability framework has been developed, and is shown in Figure 14.

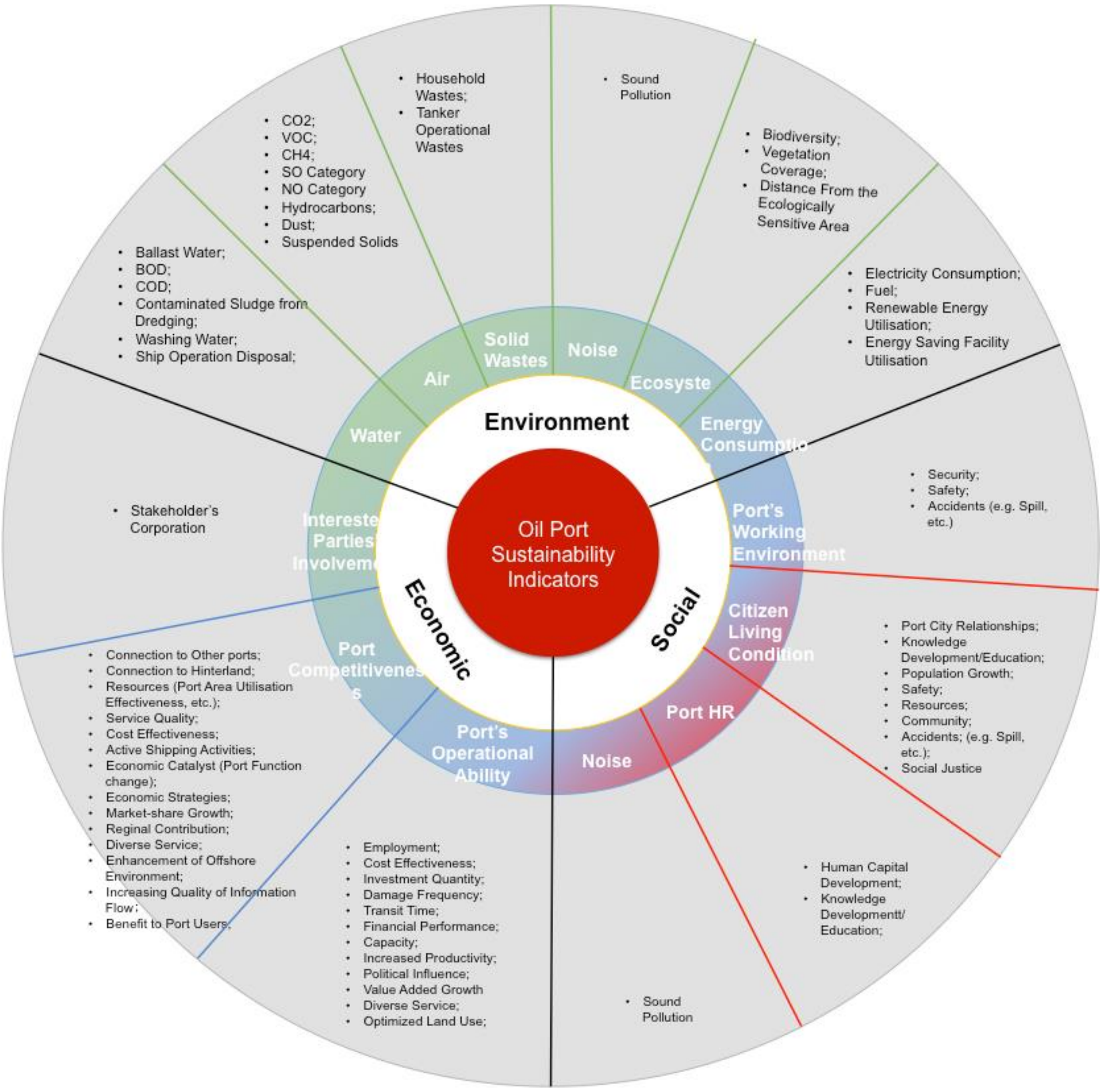


Figure 14 Theoretical oil port sustainability framework

What worth mentioning is that both environment and social have 'noise'. Even though they have similar meaning, in this study they are slightly differentiated. Both noise refer to the sounds produced by e.g. vessels and port facilities during operation. However, their impacted groups are different. In the environment section, these noises impact the wildlife living condition, such as seabirds and fishes, and eventually the ecosystem. On the other hand, 'noise' in the social section is because the sounds impact citizen's daily live (e.g. sound of trucks and construction areas), and eventually citizen's welfare. Thus, to differentiate these two groups, this study defines the sounds effecting ecosystem as environmental noise, and ones impacting social welfare as social noise. From another perspective, both 'noise' have similar source. However, ‘noise’ as a wider coverage. For example, it also includes the sound of port construction areas and truck noises. Besides, the two ‘noise’ have a different impacting group. During the whole empirical study (interview, AHP, and TISM/MicMac), both of their meanings and differences are explained to participants either orally or written during the email communication.

2.5 Pre-Interview panel group meeting

This section will outline why it is necessary for this study to conduct a pre-interview panel meeting. Because not every indicator has been allocated to a group or sustainability aspect (such as noise and stakeholder cooperation), in combination with the absence of selection criteria in the existing literature, a pre-interview panel meeting with three experts in the field has been conducted to initially confirm whether the subordinate is appropriate. Details of the specific nature of the panel meeting, in addition to the criteria used to select the panel members, will be explained in the following methodology section.

The pre-interview panel meeting with three experts was held after the completion of the SLNA so as to limit the formation of subjective and biased opinions by the researcher. This was done because it is impossible to quantify the categorisation of the sustainability groups, indicators, and reasons for their inclusion, and there is no numerical standard. This meeting helped to provide a general view of the framework and the researchers’ intentions. The members of the panel group are the same as those who make up the panel group meeting that follows the interviews (for more details, see Section 4.7).

The post-interview panel group meeting was held for the same reasons as the pre-interview meeting: to ensure the sustainability groups and indicators were categorised effectively, as well as to avoid biased opinions. Furthermore, because the theoretical framework is likely to change after the interviews, a further check of the appropriateness of the criteria is needed to increase the rigour. The reason why the group members do not change is because panel group meetings should consist of people with a strong understanding of the matter being researched, because such discussions are conducted based on the results of empirical studies conducted by experts. For this reason, the panel members need to be able to view the empirical results from an expert angle. Furthermore, because both the SLNA and interview analysis are causally related, it would be better to retain the same members for both panels to avoid a major difference in the results, and to ensure that the theoretical and empirical frameworks are comparable.

Because the panel members have a deep understanding of the topic in question, and the categorisation issue is not very problematic, given that it is obvious how most should be divided (such as water, air, and soil), the panel does not require many members, and this study deems that three is sufficient. The members were selected from potential interviewees who agreed to participate in the empirical studies throughout this project. The reason why the panel members were selected from the potential interviewees, rather than the survey participants, is that the interviews establish the foundation for this research, while the panel participants must have a deeper understanding of the field. Generally speaking, the members of the panel members are required to have extensive knowledge of the field of port sustainability, and the selection criteria used to choose them are shown in Table 7.

The selection criteria are work experience, position, direct relevance, and the number of ports at which they have worked. These criteria should be sufficient because the panel members have been selected from the interviewees, who were already selected from a wide range of relatively well-experienced experts (see the interview selection criteria outlined in Section 3.4). The four criteria are the most directly relevant to discover which are the most experienced experts. Each of the potential members will be scored, but due to the qualitative nature of some criteria, a simplified score system has been determined, as follows:

Work experience: typically, the more work experiences a person has, the deeper their understanding of their field will be. The scoring system for this criterion is divided into up to 10 years (resulting in 1 point); 11-15 years (2 points); 16-20 years (3 points); 21-25 years (4 points); and more than 30 years (5 points);

Position: the higher their workplace position, the more likely it is that a person will have relevant experiences and a deeper understanding of the field. The following scoring system has been adopted: basic employee (1 point); low managerial level (2 points); mid-managerial level (3 points); and top managerial level (4 points).

Direct relevance: the more directly relevant a person's work is to the topic, the more likely it is that they will have a deeper understanding of and more insights into the field. The following scoring system has been used: experience with only one of the three aspects of sustainability (1 point); two of the three (2 points); and three (3 points).

Number of ports at which staff have worked: the more ports at which a person has worked, the more they are likely to have a deep and diversified understanding of the field. The following scoring system has been used: one port (1 point); two ports (2 points); and three or more ports (3 points).

The scores received according to each criterion are then added together to calculate a total score. After filling in the details in the table, the three people with the most experience can be distinguished. The three experts with the highest scores will be chosen as the panel members.

Table 7 Panel selection criteria

	Member 1	Member 2	Member 3	Member 4	Member ….
Work experience					
Current position					
Direct relevance					
Number of ports					
Total score					

No changes have been made after consulting with the panel group members during the pre-interview panel meeting, and the theoretical conceptual framework illustrated in Figure 14 is confirmed. The formation of the theoretical framework follows the default structure outlined at the beginning of this section, and the structure will remain the same in the following section.

2.6 Summary

This chapter has introduced the process by which the systematic literature view was conducted in this research, regarding the research topic and general features of the most relevant studies, and delineates the relationships between each study. More importantly, a theoretical holistic oil port sustainability framework has been developed as the basis for further empirical research and analysis. In summary, this chapter has two main functions: outlining the features of and relationships between previous studies, and forming the aforementioned framework. These steps have been completed to establish the situation of the current research in the field, and the reasons why research gaps exist.

The development of a theoretical framework will be the foundation for the forthcoming practical framework, as well as further value-adding analysis. The next chapter (Chapter 3) introduces the methodology achieving this goal. How the theoretical framework is developed into a practical framework, along with the value-adding analysis, is outlined in Chapters 4 and 5.

Chapter 3 Research Methodology

3.1 Introduction

This chapter introduces the methodology set to obtain empirical information to answer the research question and achieve research objectives. This chapter consists of relevant content of research philosophy, approach, strategy, methods, and design that have been adopted in this research. Besides, this chapter also provides justification for each adopted concept and method. The highlight of this chapter is the interpretation of qualitative and quantitative data collection methods' and analysis techniques' usage at different stages. However, this chapter only acts as an overview of the methodology used in this research without details of how specific data were collected nor analysed. The detailed explanations will be presented in Chapters four and five together with each of their results. The content of this chapter can be summarised using Saunders (2009)' research onion figure.

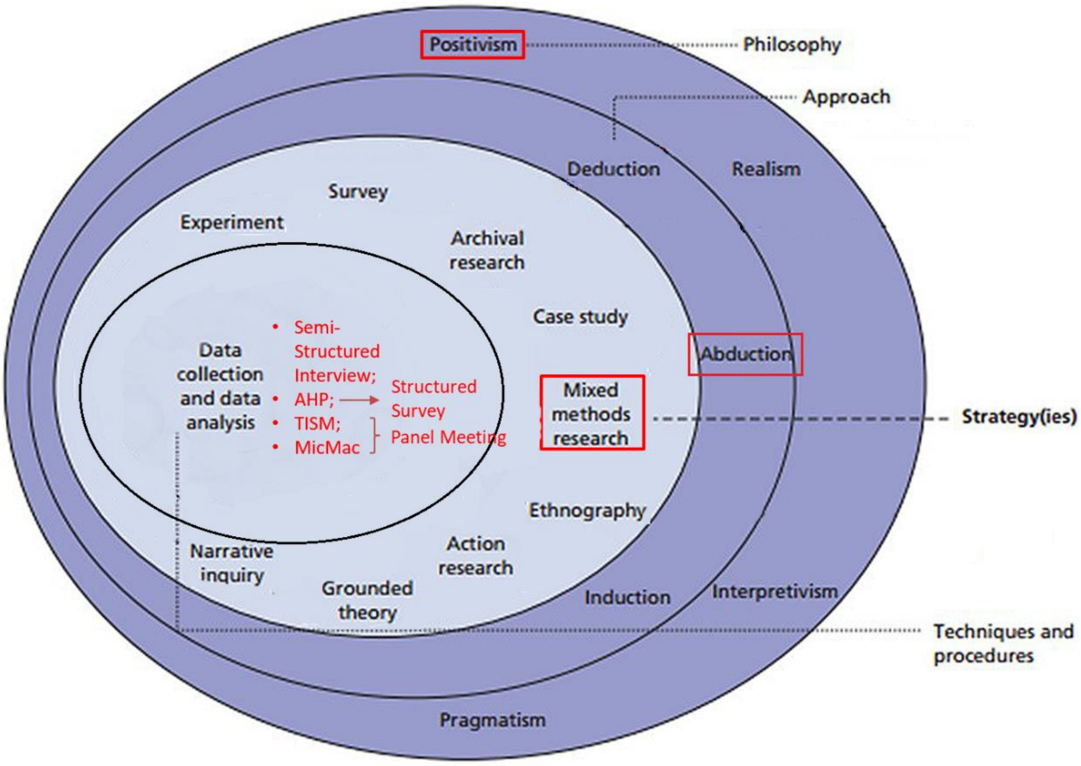


Figure 15 Research Methodologies, Source: Saunders et al (2009)

In this research, pragmatism is adopted as the research philosophy, and the research approach is abductive reasoning. As for research methods, this research uses semi-structured interview, AHP survey, and panel meeting for TISM and MicMac analysis. The sampling approach used is purposive sampling. Details of why the methodology in this research has been determined will be introduced following the sequence of philosophy and abduction reasoning, strategies, methods, research design, and sampling techniques. Lastly, the ethical implication of research methodology in this research will also be presented.

3.2 Research Philosophy and Approach

This section illustrates what research philosophy and approach are available, and which one has been chosen in this study. Research philosophy describes different kinds of believers of how data are collected and analysed during the research. It is realised via a specific methodology formed by set(s) of the method. Research philosophy can also be understood as a way of knowledge development in a specific domain (Saunders et al., 2009). Research philosophy first categorises how the world is being viewed and shows from which perspective the researcher considers the problem and how the issue is going to be solved. Research philosophy has always been considered as an important part forming a rigorous research via careful choices of the right research philosophy in accordance with the research topic. The research will then be able to go through the most accurate direction with appropriate research design and strategies (Bajpai, 2011). According to Saunders et al (2012), it is essential to determine how far the research is philosophically informed. However, it is also crucial to reflect the philosophical based methodological choices with the defence of potential alternative methodologies that could have been applied in the research.

The four most commonly used research philosophies, especially in the realm of business and management, are positivism, realism, interpretivism, and pragmatism. They can be achieved via the most popular research directions of ontology, epistemology, axiology, and data collection techniques. The research directions can be understood as the way of the researcher sees the world. Mkansi (2012) argues the way a researcher sees the world, shall differ from the research philosophies they follow to develop knowledge in a particular field. Following these concepts, this research follows the philosophy of pragmatism because other philosophies are beyond the scope of the research focus in this research. The understanding and comparison of research philosophies have been summarised in Table 8 by taking research directions into account.

Table 8 Comparison of the Research Philosophies

	Positivism	Realism	Interpretivism	Pragmatism
Ontology: researcher's view of the reality	Objective; thinking externally, and act independently from social actors	Objective; Facts exist independently from human thoughts, beliefs, and concepts (realism); Being interpreted via social conditioning (critical realist)	Subjective; Socially Constructed; May change	Thinking externally
Epistemology: researcher's view of constitution	Observable phenomena can provide relatively credible data; Focus on causality and law like generalisations; Phenomena to simplest elements	Observable phenomena can provide relatively credible data; Insufficient data means inaccuracies in sensations (direct realism); Phenomena can also create sensations which are open to misinterpretation (critical realism); Focus on explaining within a context or contexts	Subjective meanings and social phenomena; Focus upon the details of situation and a reality behind the details	Either or both observable phenomena and subjective meanings can provide relatively more accurate knowledge dependent upon the research question; Focus on practical applied research, integrating different perspectives to help interpret the data
Axiology: researcher's view of the role of value	Research will be undertaken in a value-free way, the researcher is independent of the data and maintains an objective stance	Research is value laden; The researcher is subjective by the world views, cultural experiences, and upbringing	The researcher is part of what is being researched, cannot be separated and would be subjective	Values play a large role in interpreting results; The researcher adopting both objective and subjective views
Data Collection Methods (most popular ones)	Highly structured, large samples, measurement, quantitative, but can use qualitative	Methods chosen must fit the subject matter, quantitative or qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs; Quantitative and qualitative

In comparison to other kinds of research philosophies, pragmatism, which has been adopted in this research, is in the ‘neutral’ position and has the provision to work as both interpretive and positivist (Saunders et al., 2003). Pragmatism believes in the function of getting to know a particular knowledge is not solely interpreting the objective nature of the world, but also to understand the impact of actions to provide motivation to the actions. Furthermore, one of its highlights is to be able to integrate several methods and interpretations practically (Giacobbi Jr et al, 2005). This provides the researcher opportunities to gain a deeper insight of an issue which is hard to be understood with only quantitative or qualitative method (Venkatesh et al., 2013).

In summary, pragmatism is an effective philosophy to use qualitative and quantitative research methods at the same time to gain new knowledge. In this research, pragmatism has the advantage of building frameworks from not only theoretical facts but also includes experts' experiences obtained from both qualitative and quantitative approaches. Thus, this is the research philosophy which was used in this study.

As per research approaches, they could be divided into two types: the deductive reasoning and the inductive reasoning. Deductive reasoning means to deduct facts from existing knowledge. On the other hand, inductive reasoning means to deduct knowledge from known facts (Creswell, 2009). In this study, the oil port sustainability framework and other value-adding knowledge are developed based on existing sustainability knowledge regarding container ports. Besides, explanations to the phenomenon shown by the collected data also need to be explained. Thus, it can be said that this study is adopting abductive reasoning as a research approach.

As mentioned above, this research uses pragmatism as the philosophy and the abductive reasoning as the approach. Following this concept, the research methods can be divided into two parts, the qualitative stage and quantitative stage.

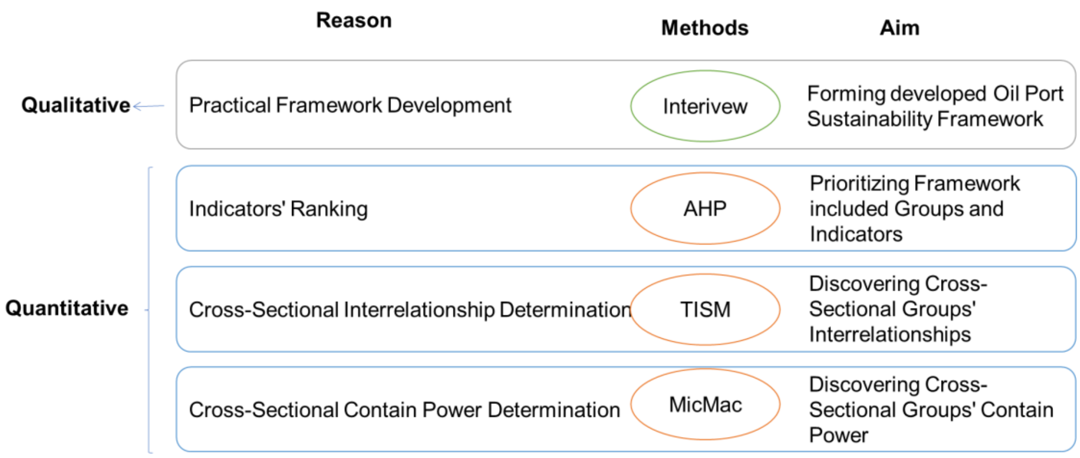


Figure 16 Abduction Reasoning of Pragmatism

As can be seen from Figure 16, the qualitative stage used the interview as the method. As literature review provides not enough indicators to form the prospective sustainability framework, the current identifiable theoretical indicators literature should be further assessed for its suitability in the new field while allowing new practical indicators to be added to the framework via interview. For instance, whether all identified indicators belonging to air emission group have impacts on oil port and why should be further evaluated; as well as what exactly stakeholder relevant factors should be considered should also be added to form new knowledge and why. The interview fulfils the demand of the first objective of this research of forming a holistic sustainability framework.

Secondly, AHP, TISM, and MicMac are quantitatively based. The quantitative stage is being used in this research is because the qualitative result is required to be ranked for their importance and finding out the connections (interrelationships, driving and contain powers) between cross-sectional sustainability groups. To be more specific, the indicators' ranking via AHP meets the need of the second objective of this study (giving priority); finding out interrelationships through TISM meets the requirement of the third objective (interrelationships discovery); obtaining containing power via MicMac fulfils the fourth objective (containing power determination); lastly, the comparison of these empirical results matches the need of the fifth objective (‘must have set’ formation).

With these procedures, more meaning could be added to the qualitative results and expands the range of qualitative outcomes along with explanations to why some indicators are identified as the most crucial sustainability indicators. For example, more solid and accurate result could be generated from a greater number of participants; the ranking could provide an improved structure of the framework; the interrelationships could be identified; and the most crucial indicators are identified via multi-methods comparison.

A rigorous research could be completed through a suitable research philosophy. In this research, the adoption of mixed methods can be justified by the paradigm of pragmatism the best. Therefore, this research adopts pragmatism as the research philosophy and follows the mix methods.

3.3 Research Strategy

This section illustrates what research strategy has been adopted in this study. The research strategy is methodologies that help the researcher to investigate determined research issues. It can be understood as a general plan which assists the researcher in answering the research question in a systematic way (Saunders, 2003).

This research adopts mixed methods as the research strategy. Using mixed methods have many advantages. According to Bryman (2003) and Brannen (2005), mixed methods provide the opportunity of obtaining different aspects of answers to the research question. As Venkatesh et al (2013) have mentioned, there are three main benefits of adopting mixed methods in the research: first, mixed methods provide stronger evidence to the deductions in comparison to single method; second, mixed methods enable confirmatory and exploratory research questions by using both qualitative and quantitative methods; lastly, mixed methods provide a greater variety of opinions and comparisons.

Saunders et al (2012), Tashakkori and Teddlie (2003), and Creswell (2009) also share the common opinion that mixed methods reach cross-validation of adopted methods to neutralise and minimise the bias of adopting a single method. As it has been proven by Molina-Azorin (2012), 11.4% (152) of 1330 strategic management and organisational behaviour relevant articles in his sample have adopted mixed methods. Not only that, 80.9% of the 152 studies have used the combination of quantitative and qualitative methods as mixed methods. Table 9 generates seven main purposes of using mixed-methods:

Table 9 Purpose of using Mixed-Methods, Source: Venkatech et al. (2013)

Purpose	Explanation
Complementarity	Mixed methods are used in order to gain complementary views about the same phenomena or relationships.
Completeness	Mixed methods designs are used to make sure a complete picture of a phenomenon is obtained.
Developmental	Questions for one strand emerge from the inferences of a previous one (sequential mixed methods), or one strand provides hypotheses to be tested in the next one.
Expansion	Mixed methods are used in order to explain or expand upon the understanding obtained in a previous strand of a study.
Corroboration/ Confirmation	Mixed methods are used in order to assess the credibility of inferences obtained from one approach (strand).
Compensation	Mixed methods enable to compensate for the weaknesses of one approach by using the other.
Diversity	Mixed methods are used with the hope of obtaining divergent views of the same phenomenon.

Based on the above discussion, mixed-methods help to enrich and develop knowledge that cannot easily be tested by single method meeting both subjective and objective needs. In this research, the subjective need is achieved via qualitative method (semi-structured interview analysed by thematic analysis). It gains deeper understanding of relevant theories to set the guideline of this research to validate and enrich the initial oil port sustainability framework. The objective needs are achieved via quantitative methods (AHP analysed via Expert Choice, and TISM and MicMac analysed manually). They fulfil the need of prioritising identified sustainability factors, and to select the most unneglectable factors to form the ‘must have set’, and to find out interrelationships between cross-sectional factors.

Led by the advantages of mixed methods, there are numerous port and logistics relevant studies that have adopted mixed-methods (Roh et al, 2016; Cooper, 2012; Kim and Chiang, 2014; Kim, 2016; Dawson, 2002). For instance, Feng et al (2012) used the combination of questionnaires and semi-structured interviews to address a gap in the performance comparison between western European and Eastern Asian ports. Wilding and Juriado (2004) adopted open-ended questions in the integrated method to complete empirical study in the customer’s perceptions of outsourcing in the European customer goods industry.

To be more detailed, as Creswell (2009) have summarised, the main four types of mixed methods strategies are:

1. Triangulation: triangulate research combines qualitative and quantitative data together to answer the research question;

2. Embedded: embedded research uses qualitative, or quantitative data to gain understanding of the research issue within a largely quantitative, or qualitative study;

3. Explanatory: explanatory research uses qualitative data to illustrate quantitative results;

4. Exploratory: exploratory research uses quantitative data to add value and widening qualitative data results.

Taking the above discussion into consideration, it is obvious this research belongs to triangulation mixed methods strategy.

To sum up, this research uses triangulation mixed methods to obtain theoretical acceptable answers to the research question and meets the research objectives through overcoming challenges of minimising subjective biased opinions. The main purpose of adopting mixed methods in this research is to link theoretical understanding into practical demand, to provide factor's ranking for the convenience of selection, and to expand knowledge by forming a holistic framework and identifying interpretations between cross-sectional factors.

3.4 Research Methods

This section illustrates what data collection methods and data analysis methods have been adopted in this research, as well as why they are chosen over other potential choices. According to Saunders (2012), Gonzalez and Trujillo, 2007, and Chapman and McNeill (2005), it is vital for a study to select the most suitable data collection methods and analysis methods to enable an efficient, rigorous, and accurate research.

In this study, the achievement of each research objectives requires different research methods across qualitative and quantitative stages. Figure 17 shows an overview of what data collection methods and analysis methods have been adopted in this research at different stages. Further details of why the chosen data collection methods and analysis methods are adopted will be illustrated in the following context following their implication sequences.

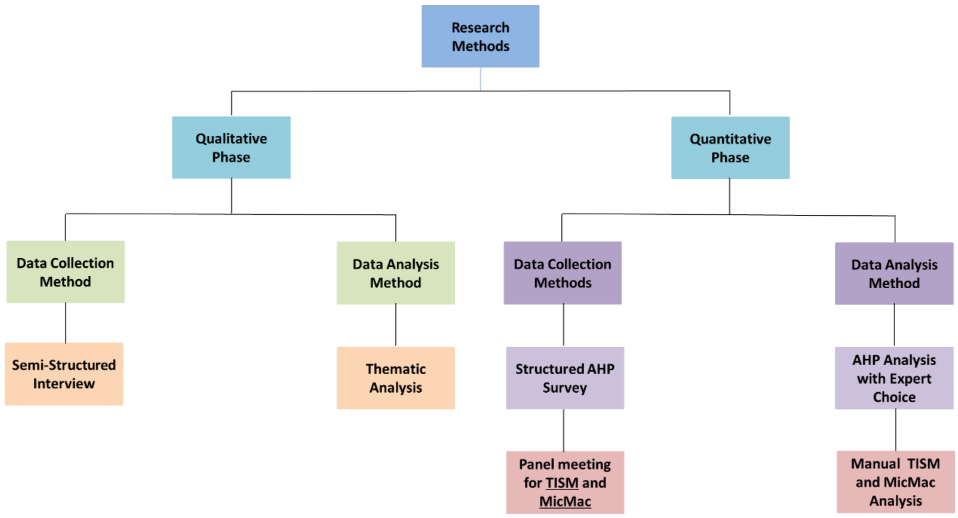


Figure 17 Research Methodologies in this Research

Semi-Structured Interview and Thematic Analysis

Why choosing Semi-Structured Interview

In the qualitative phase, the semi-structured interview is chosen as the most suitable research method over other potential choices of Delphi, observations, and action research, etc. This is mainly led by the research purpose during this stage: linking theoretical results into practice (the validation of obtained theoretical framework). Validation is required at this research as the first empirical step is because the literature results only provide general port sustainability indicators, which oil ports oriented factors might be neglected or paid with less attention. Thus, the validation process is needed to form a practical oil port focused sustainability framework. Following this logic, the interview has the following advantages in comparison to other methods:

1) Interviews are an effective approach to examine and confirm the theoretical results as the participants are more likely to share their opinions freely with face to face conversation (Flick, 2009). The type of semi-structured interview further extends the flexibility of receiving more information as the predetermined interview questions and question order is only a guideline, which can be changed in accordance to the real situation and enables mutual conversation (e.g. add more questions, change the sequences, omit unneeded questions) (Jamshed, 2014).

2) Interviewee tends not to share their opinion freely in front of other peers and experts, and this phenomenon will more or less impact on the research result (Longhurst, 2003; Guest et al, 2006; Folkestad, 2008; Edwards and Holland, 2013; Alshenqeeti, 2014). Semi-structured interviews that have been conducted individually minimises the possibility of this situation to happen.

3) In comparison to other forms of qualitative methods, especially the type of semi-structured interview maximises the opportunity for interviewees to share their experiences on the matter. As literature review does not provide the full

amount of required information to form the prospective holistic oil port sustainability framework, the semi-structured interview became extremely crucial for this research to gain needed information from interviewees' practice and opinions.

4) Interview, especially semi-structured interview, can obtain different perspectives of answers on the proposed question by asking what, how, and why (Saunders et al, 2009).

For these reasons, interview is adopted at this stage. On the other hand, there are multiple approaches to obtain interview data, such as telephone interview and face-to-face interview. In this research, a face-to-face interview is adopted over the other methods. This is because many scholars have mentioned the benefits of having the conversation face-to-face, especially when collecting important information. Face-to-face conversation is not only capable of enclosing people to enable more detailed information, it is also more convenient to question unclear points until fully understand the other party's intention. Moreover, face-to-face approach overcomes the disadvantage of technology limitations, e.g. application utilisation, application accessibility, and unstable signal.

<u>Interview Analysis with Thematic Analysis</u>

Thematic analysis has been used to analyse the data collected from the semi-structured interview with port experts. Thematic analysis has been used here to analyse the interview transcripts and extract the most commonly mentioned sustainability indicators for oil ports. For this research, thematic analysis is beneficial when used for within-case analysis by receiving the results via a systematic process and categories or identifying new themes from coded data while confirming the existing themes to form knowledge determinants and components (Braun and Clark, 2008). After the interview data analysis, an empirical sustainability framework resulted from the qualitative stage has been determined as the oil port focused holistic sustainability framework. Further detailed participants' selection, data collection implementation and analysis of qualitative stage using thematic analysis will be presented in Chapter 4.

AHP Survey and Analysis with Expert Choice

Why choosing AHP

In the quantitative phase, AHP has been adopted to provide prioritised rank of identified sustainability factors after interviews to form a prioritised practical framework. AHP method is a widely used decision-making method invented by Thomas L. Saaty. The characteristics of AHP are its pairwise comparison between criteria or factors to identify a commonly accepted recognition of the most important factors (Saaty and Vagas, 2012). In this research, the result of multi-criteria decision making is not only expected to identify the ranking of each factor in its category, but also use the comparison between the multi-criteria decision-making result and the interview result to select the most important indicator from each category to form a 'must have set' to show which sustainability factors that are most important for the daily oil port sustainability operation (see Section 6.5).

Within the field of multi-criteria decision making, several similar methods are also available other than AHP, such as Goal Programming, Scoring Models, Analytic Network Process (ANP) (Ulukan and Kop, 2009) and Fuzzy Analytic Hierarchy Process (FAHP).

This research has identified more than 70 sustainability indicators after the interview, and thus has 167 times of pairwise comparisons. There are 3 comparisons at the sustainability sectional level (among environment, economic, and social); in sustainability groups level, there are 3 times of comparison among economic groups (among interested parties' involvement, port's competitiveness, and port's operational ability), 21 times among environmental groups (among air, water, soil, noise, energy consumption, ecosystem, and NMHC), and 6 times among social groups (among noise, port human resource, citizen living condition, and port's working environment); in sustainability indicators level, there are 10 times among interested parties' involvement indicators, 21 times among port competitiveness indicators, 10 times between port operational ability groups, 21 times between air indicators, 10 times between water indicators, 3 times between soil indicators, 4 times between noise (environment) indicators, 6 times between energy consumption indicators, 3 times between ecosystem indicators, 6 times between noise (social) indicators, 10 times between port human resources indicators, 15 times between citizen living condition indicators, and 15 times among port's working environment. Thus, in total, there are 167 times of AHP comparisons.

Due to the large amount of comparisons, rigorousness and feasibility thus is the main concern of this stage in this research. For that reason, Goal Programming and Scoring Models were not being used in this research as they cannot provide the level of rigorousness in terms of ranking each identified theme and their belonging sub-indicators.

In comparison to the prior two methods, AHP, FAHP, and ANP methods have a relatively rigorous calculation process which ensures the obtained results of each expert's opinion is valid and logic. In comparison to AHP, ANP enables not only ranking of the factors but also adjusting the weights of indicators by participants' feedbacks to form a network. According to Saaty (2006)[a], ANP is good at showing which of the two alternatives influences more on the given criterion and how much more. However, even though this method meets the demand of this research to first rank factors and then identify interrelationships between indicators, the participants will be asked to answer a much larger number of questions which makes this research not feasible in an effective way due to a large number of pair comparisons that need to be done. Furthermore, ANP only provides interrelationships between sectional-indicators rather than cross sectional indicators. Thus, ANP was eventually not adopted in this research, but AHP or FAHP.

AHP and FAHP have almost same functions and process, the only difference is that FAHP vague the AHP scoring system by using 'triangular fuzzy function' to fix AHP's problem of being 'subjective' (as the participants may have difference definition of each score and their opinion are unquantifiable). However, according to Saaty (2006)[b], FAHP does not make big difference to the traditional AHP as the concept and data obtaining mechanism are still the same. Not only that, even though the result of FAHP and AHP could be different, it is proven that fuzzy AHP approach produces the weight for each pair of criteria with the same tendency as classic AHP approach (Zhang, 2010; Chen, 2011; Sehra et al, 2013). Thus, considering the concept of triangular fuzzy function complicates the calculation process, and the ranking is more focused in this research rather than a specific number of how many time factor A is more important that factors B, this study chooses AHP which provides more detailed scores than FAHP, and fixes the issue of being 'subjective' by providing a guiding scoring standard (see Table 18, Page 139).

AHP has one limitation of not showing interrelationships between cross-sectional factors. This issue will be solved by the research method TISM, which is illustrated later in this section.

To collect AHP data, structured AHP survey in Excel tables have been created to send out AHP surveys to experts as it is the most efficient ways to contact port sustainability experts and gather quantitative data from them. Online questionnaire websites and software (such as Survey Monkey) have not been used because most accessible websites and software have a limitation of the questions' and answers' format and design. In the case of this research, AHP survey lets participants choose the importance level of 1-9. However, most of the accessible websites and software do not provide more than 5 choices in the answer's section, thus, do not meet the AHP criteria. Plus, the survey in the Excel has a clearer look and is convenient for the participants to answer and look through (As can be seen from Appendix 6). Other applications' format is mostly defaulted and is hard to do logic checks. As a result, Excel has been chosen to obtain AHP survey data. Further details on participants' selection, data collection implementation and analysis of quantitative stage will be presented in Section 5.2.2.

AHP Analysis with Expert Choice

The AHP data analysis software 'Expert Choice' is used in this study to analyse data obtained from AHP survey. This study chooses to use software to analyse data rather than manually is because AHP has a complicated mathematical process to ensure that the participants logic is valid (the C.I value calculation). To do the analysis process manually would take too much time. Thus, in order to save time, this study uses analysis software after understanding the analysis mechanism and process.

There are not many AHP analysis software available, the most commonly used ones are Excel, a Chinese software called 'YAAHP', and Expert Choice. Excel is not used because Excel can only analyse one AHP survey at one time, and cannot generate multiple survey results together. As this study is not a survey with only one participant, Excel cannot be used in this study. As for the Chinese software 'YAAHP', even though it is used by many Chinese researchers, it is not internationally recognised and is developed by a private party. Thus, its analysis can only be used as advisory. On the other hand, Expert Choice is not only developed by the founder of AHP, Saaty himself, but also meets every criterion of this study (C.I obtain with ease, able to combine multiple survey results together, easily accessible, and internationally recognised). Thus, it is chosen as the data analysis method for AHP survey in this study.

TISM (Total Interpretative Structural Modelling) and MicMac Panel Meeting

and Manual Analysis

TISM

The limitation of the AHP not being able to identify interrelationships between cross-sectional factors can be fulfilled by Interpretative Structural Modelling (ISM) or Total Interpretative Structural Modelling (TISM) via panel meeting. Both of them are able to show the logical connection and hierarchy of identified factors via rigorous calculation process ensuring the structural and connection accuracy. However, while ISM only provides how the indicators are connected, TISM also provides the reason they are connected. Therefore, TISM has been adopted in this research as the second quantitative data collection method following AHP. Further details on participants' selection, data collection implementation and with TISM analysis of qualitative stage will be presented in Section 5.2.1.

The main target for TISM data collection is to ensure that panel members are familiar with the content, easy to read, and logic of provided answers can be easily traced. After comparing with other software and applications such as survey monkey, Excel tables are used to collect answers. Excels were sent out with TISM surveys to experts before the panel meeting for them to get familiar with the question and prepare their opinion. Then, during the meeting, Excel is easily readable and writing notes for discussion, and easily amendable in the end for both participants and the researcher. After the meeting, the Excel table is also convenient for the researcher to organise collected answers. Thus, Excel is used at this stage as data collection technique.

As there was no accessible software to analyse TISM data, the result is manually analysed. Even though it is manually analysed, it was not too time consuming as the analysis process amount is affordable. Thus, TISM data is manually analysed in this study. Further details can be found in Section 5.2.2.

MicMac

MicMac is an additional analysis conducted based on the results of TISM analysis. In addition to the TISM diagram showing the connections between sustainability groups, MicMac provides another diagram showing the contain power of each sustainability group to the system. The result enhanced the understanding of which group has the most impact on the group and also explored more nature of each identified sustainability group. Lastly, the results of MicMac will also be used as one of the references to form the 'Must Have Set'. Thus, in this research, MicMac analysis is not only helpful to understand each group better, but also adds more value to the practical sustainability framework.

No new data is collected at this stage. No software or additional applications were needed at this stage due to all this stage needed is simple counting. Thus, it is conducted manually as no further empirical data has been obtained, and the result is analysed based on the TISM method manually. Further details on MicMac analysis will be presented in Section 5.2.3.

3.5 Research Design

This section illustrates from a general view of how this research is designed and conducted. As it has been mentioned in the research philosophy section, the chosen research philosophy has great influence on how the research question is going to be answered and objectives to be achieved. Not only that, it also indirectly impacts on the further process of determining research strategy, data collection methods, and the data analysis methods adopted in this research (Saunders et al, 2009). To receive a rigorous research result, a structured research design following the determined philosophy and approach was planned.

Figure 18 Research Design

This research has been divided into four stages: conceptual stage, qualitative stage, quantitative stage, and conclusion stage (Figure 18). In Figure 18, the conceptual stage is considered as the first stage and marked in yellow, which accumulates the theoretical data from the literature to form the initial framework (theoretical framework). Before entering to the next stage, a pre-interview panel meeting is held to ensure the accuracy of theoretical data generation. Then, in the qualitative stage, the second phase, which is coloured in purple, gathers the first stage empirical research that develops and enriches the content of the initial framework. By the end of this stage, a panel group meeting is held again to ensure the appropriateness of practical framework. The quantitative stage is considered as the third stage and marked in blue. The third stage ranks the sustainability indicators in the practical framework. The next stage marked in black is the conclusion stage, which first selects the most crucial groups to form the 'must have sets', and then identifies not only the contributions and limitations of this research, but also the potential further research directions.

To be more specific, the aim of the conceptual stage is to first determine the scope of this research via choosing the adoption of theories, and deepens the understanding on the research topic; then, a focused literature review is conducted to select the crucial sustainability factors and to form the initial theoretical framework. The second stage is accomplished through semi-structured interviews, which provides the room to validate and enrich the initial sustainability framework content based on thematic analysis of the interview result. Also, semi-structured interview enables the possibility of linking theory into practice, which adds further practical value to the framework. After determining the sustainability framework, the consisted factors have been prioritised based on their importance via the AHP method at the beginning of the quantitative stage. At the other part of the quantitative stage, TISM has been used to analyse the interrelationships between each identified factor in the determined sustainability framework. Based on the TISM result, the MicMac analysis has also been conducted to analyse the contain power of each sustainability group. Furthermore, via the comparison between interview, AHP, TISM, and MicMac results, a 'must have set' of sustainability indicators have been established. The most crucial factors are made visible and emphasised for the convenience of giving the most important sustainability factors priority in daily operation. Lastly, the findings, contributions, and limitations of this research have been summarised to be used as the potential reference to further research.

3.6 Sampling Techniques

This section concerns the popular sampling categories and techniques, and which one is appropriate for this study.

3.6.1 Sampling Categories

This section first explains what sampling categories are available, and then justifies the one suits the best to this study. In order to study the general phenomenon, or a fact, selecting the appropriate representative samples from the overwhelming data source is crucial for a research. There are two main sampling categories, probability sampling and non-probability sampling. Probability sampling is mainly used to answer research questions that aim to reflect a phenomenon from a general, or average view, while non-probability tries to explain the result from specific sections, or the researcher already has in mind what sample groups are involved in causing the phenomenon / should be targeted to obtain result (Saunders et al, 2012). To be more detailed, probability sampling could be further divided into four techniques: simple random sampling (SRS); systematic sampling; stratified sampling; and cluster sampling. Non-probability sampling techniques include convenience sampling, purposive sampling; and quota sampling.

Probability sampling is a quantitative sampling method, which is more likely to select random samples that would allow general information to obtain (Miles and Huberman, 1994). Non-probability sampling tends to show qualitative features to a specific issue that enables in-depth information (Oates, 2006). In other words, the research questions influence the sampling technique, aim, objectives, the selection of research strategies, and can be understood as the tool enabling the researcher to gain deeper insights of the research topic (Saunders, 2012). According to this concept, non-probability sampling is more suitable for all three empirical stages of this study as the nature of this research does not allow random sampling. This is because this study concerns professional knowledge. The participants cannot be anyone who works relevant to port but must be people who deal directly with research topic relevant matters and have knowledge in all three sections of sustainability applied in oil ports. To enable probability sampling, a large population should be accessible. Then, the result from large population could partially fulfil the gap of not being able to gain needed information directly from people meeting the participants' selection criteria by increasing reliability. However, limited participants are accessible in this study. Thus, non-probability sampling would be more appropriate. Besides, the adoption of non-probability sampling allowed this study to have a 'case study' like result targeting on people from specific occupations. This enabled clarification of how these group of people think on the researching matter.

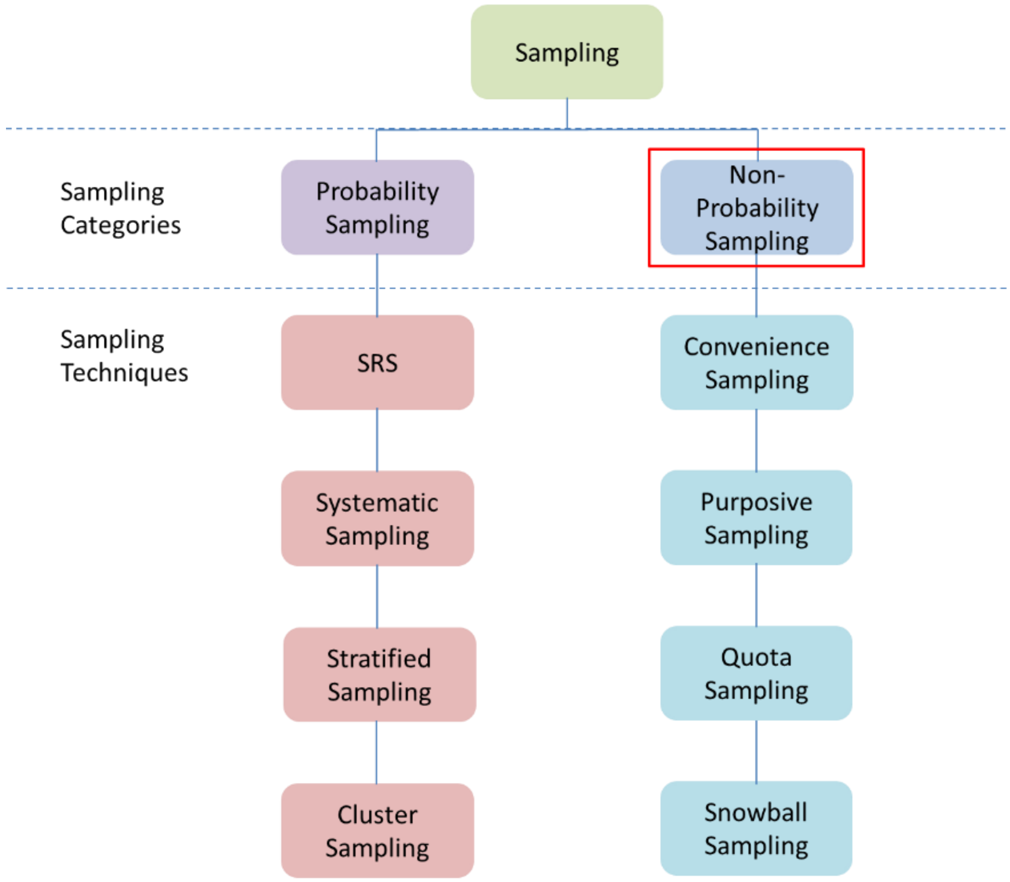


Figure 19 Sampling Techniques

Using non-probability sampling, the 'misleading' information provided by participants who cannot contribute to this study can be avoided. For instance, information provided by employees who have only driven trucks at the port, accounting people, and IT people. However, it also has its disadvantages. Non-probability sampling size is normally not specified and can be determined by the researcher's subjective judgement. Thus, it is important to keep in mind that the sample size should be fitting in accordance with the research question and objectives (Saunders et al., 2009).

There are three stages of this research needing sample size determination, semi-structured interview, structured AHP survey, and TISM and MicMac panel meeting. As there is no rule stating how big the sampling number should be by non-probability sampling itself, this study adopts the opinion from Yin (2014), Guest et al. (2006), Saunders and Rojon (2014), and Luborsky and Rubinstein (1995) that after not receiving any new information from the interview, the interview could be stopped and the research could move to next stage as it has reached the saturation (e.g. in their studies they state a research can likely reach saturation after interviewing 8, 12, or 15 experts).

However, due to the large coverage of this study topic as all three aspects of sustainability are being covered, it is determined by the researcher that in the interview stage, no matter until how many interviewees no information shows up, the least sample size cannot be less than 30 to ensure the coverage and breadth of the research. In summary, it is possible to determine the exact sample size during conducting the interviews to wait for the saturation point to come. In this study, each interview has taken averagely c.a. 50 - 70 minutes due to a large number of sustainability indicators needing to be questioned about.

As per AHP, since the saturation cannot be reached due to AHP's nature and the large coverage of sustainability indicators, the sample size should be maximised. In the end, interviewing 34 interviewees were completed at the interview stage and obtaining 70 valid feedbacks were achieved at the AHP stage.

3.6.2 Sampling Techniques

This section deepens on the knowledge in prior section by explaining under the chosen sampling category, which sampling techniques are available and adopted.

<u>Convenience Sampling</u>

Convenience sampling is a technique often used when the initially targeted samples become not reachable due to limited funding and time, potential samples with easier accessibility are contacted instead after receiving their consent to be the object of the empirical study. This technique is also called accidental sampling (Alshenqeeti, 2014; Brannen, 2005; Mkansi and Acheampong, 2012).

Purposive Sampling

Purposive sampling refers to the occasions when the researcher should select specific cases and groups that the researcher is expecting to gain particular information from, which can also be referred to expert sampling and judgement sampling. Purposive sampling is also a sampling technique that allows the researcher to find individuals with specific features to form specialised sample groups following his/her own judgment and intention, to achieve certain research purpose, objectives, and answer the research question (Saunders et al, 2012). As Saunders et al (2009) have stated, the purposive sampling technique is commonly used and suitable to research stages that require focusing on one, or several particular groups which all the participants within each of the group are expected to share the same feature.

As per sampling target, the sampling group can be formed by contacting the potential participants individually for their consent to the conduction of the research method; or it can also be done by posting the need for cases on the appropriate media (e.g. topic relevant platforms) and collecting data from whom approach the researcher. The appropriate media platforms include many places, such as professional / official websites, magazines, discussion groups, where the targeted groups may likely read.

Quota Sampling

Quota sampling means when conducting the empirical study, different featured samples are required to be obtained with a certain pre-set amount of percentage. This is mainly used to ensure the results have ‘comparability’

(Luborsky and Rubinstein, 1995; Pan, 2008; Sekaran & Bougie, 2013).

Snowball Sampling

As per snowball sampling, it obtains feedback from respondents that are referred by the initially chosen participants (Oates, 2006). This sampling technique is often being adopted in cases, which are difficult to select potential participants from desired population pools. Under this case, not only the sample size could be maximised, the quality of the empirical study could also be ensured.

3.6.3 Sampling in this Study

In this study, there are in total three stages needing sampling, which are respectively semi-structured interview, structured AHP survey, and TISM and MicMac panel meeting stages. At the interview and AHP stage, the combination of purposive sampling and snowball sampling were considered the most suitable techniques and used. In the TISM stage, only purposive sampling is used.

The reason the combination of purposive sampling and snowball sampling are used in the interview and AHP stages is because of the following two reasons:

1) Professional responses required;
2) Hard accessibility to experts having knowledge in all three sustainability sections.

As the research is focusing on Chinese oil ports, experts are also expected to have knowledge of Chinese oil port features and can validate the theoretical data to provide opinion on a series of relevant matters. Thus, the requirement on port sustainability relevant knowledge is high. Under this circumstance, only experts with relevant knowledge could be considered suitable people to participate in the empirical study. On the other hand, people meeting these features are not easy to be found. Thus, initially reached experts are encouraged to refer other experts within the field to maximise the sample size.

To obtain the interviewees and AHP participants, initially targeted experts are first screened via web searching (e.g. company, government department, and university websites), professional social media (e.g. LinkedIn), and industrial contacts. Then, they are further filtered via criteria listed in Section 4.3 'interviewee selection', page 100, and Section 5.2.1.4 'participants selection' (AHP), page 151. Lastly, by emailing and phoning to contact targeted interviewee and AHP participants, the research topic background, question, objectives, and goal to be achieved in each stage have been illustrated for the potential interviewees' and AHP participants' consent to carry out empirical studies. What worth mentioning is all of the interviews have been recorded (audio) with the consent of interviewees for later transcribing purpose

After receiving initial by contacted experts' consent, the researcher asked to refer other experts within the field. Thereby, experts participate in the empirical study could assist in identifying more qualified experts within the field and forward the interview and AHP survey request.

The targeting samples are the port sustainability experts who had more than five years working experience with port sustainability knowledge. As the occupation that has the most connection to the researching field are seafarers (mostly second navigation officer), university scholars researching on relevant topics (e.g. port competition, port environment, maritime law), research institute researchers (e.g. port city environment research institutions), government officers (e.g. relevant to port investment and governance), and port company employees (mostly at managerial level), experts within these field are taken as the samples as they have the most representative opinions in this field led by their obsession with port sustainability knowledge in both general and detailed views.

As a result, five groups of interviewees were chosen to conduct the interview and AHP. They are people all having good knowledge or working experience with the oil port sustainability relevant matters in China. This action allows a deeper understanding of the topic by receiving different aspect of the information on the same topic provided by each of the interested groups.

TISM only required purposive sampling is because this study only targeted three experts to form the panel group. Besides, TISM is conducted in the third stage. Experts pool accumulated from the prior stages could be used when conducting TISM data collection.

In summary, purposive and snowball purposive and snowball sampling techniques have helped researcher to identify appropriate participants who are able to provide accurate, reliable, and rich port sustainability relevant knowledge and maximize the sample size (Fossey et al., 2002; Sekaran and Bougie, 2009). This paragraph is written in accordance with the previous Section 4.3 to illustrate the justification of the applicability and appropriateness of the self-selection and snowball sampling techniques in this study.

3.7 Ethical Implications

This section assures that the study conducted meets ethical requirements. Interview, AHP, TISM, and MicMac are considered and taken as the most suitable research methods in this study. Data obtained from these methods are valuable and essential for the conduction of this research. Thus, the procedures of collection data should be rigorous to ensure not only the rigour but also meeting the ethical requirement.

Before starting the empirical research, the researcher applied for ethical approval to ensure the study does not violate any ethical restrictions. The ethical approval was reviewed and granted by University of Plymouth's Faculty Research Ethical Approval Committee (FREAC) (Ref. No: PBS.UPC/FREAC/FREAC1112.40/clc). The conduction of interviews, AHP survey, TISM panel group, and pre- and post-panel groups are reasonably ensured being ethical and facilitates 'fairness' to the experts' representation of their views. The basic standards are 'every participant should have the equal right and opportunity to have their opinion being taken into account with no bias made based on any reason, such as gender, nationality, disability, and age; participants must understand the background and aim of this research and the research procedures; confidentiality; and their rights during the participation (Guillemin and Gillam, 2004)'.

This research was not biased when selecting potential participants and filtering feedbacks based on their gender, nationality, disability, and age. Participants at every empirical stage in this research have been informed about the purpose of this research, the interview and survey procedures needing to be followed, and the expected participating duration (for interviews, survey, and panel groups) should be maintained (with an acceptable potential extension of 15 min.). Lastly, participants were informed that they have the right to withdraw from the empirical research at any time. Under these circumstances, potential harm, inconveniences, and bothers to the participants are being reduced to the lowest possible level.

Moreover, the most crucial issue for the empirical stage of this research is confidentiality. This research is carried out by one person (the researcher) only. Therefore, individual names, contact details, gender, age, and working company, would be held safely confidential throughout the empirical study, as no second person would be able to gain access to these data. No break of confidentiality has been done. The commitments have been made regarding keeping their details and answers confidential until the files, to be destroyed (six months after the research completion). Author's personal contact details have been left to the participants in case they wish to discuss any relevant matter about this research itself: interview, or the survey including queries and comments that were informed to them before they gave their consent to join the empirical studies.

Participants have been assured that for the purpose of anonymity and achieving the research goal, only their working position (title), nationality, and working experience would be shown in the analysis figures in an aggregated manner in the thesis. Working position (title) is needed to be kept. It is because this research does not only require experts with a certain amount of knowledge in oil port, port management, and sustainability to participate to obtain reliable answers but also needs to show the results of whether there will be different opinion between Chinese domestic and foreign experts. Thus, working position (title), nationality, and working experience would need to be included in the research to prove research results reliability and accuracy while other personal information is held confidential. As a result, the majority of the participants gave their consent and provided required details while others wished their position to be kept anonymous. For the purpose of maximising the responses, some of the experts were contacted and reminded to complete the AHP survey within a certain period of time.

3.8 Summary

Saunders et al (2009) define research methodology as the theoretical foundation of how a research shall be carried out and how the research direction shall be guided to discover new knowledge. This study adopts the pragmatism philosophy along with abductive reasoning to answer the research question and fulfil the research objectives. This study further adopts triangulation mixed methods as the research strategy. The qualitative stage semi-structured interview and thematic data analysis determine the practice linked holistic oil port sustainability framework. AHP, TISM, and MicMac have been used to meet quantitative stage demand in this study. Thus, it can be concluded that the qualitative stage informs the quantitative stage and the quantitative stage is formed based on the qualitative stage results. What is also worth mentioning is that the time horizon of this study is cross-sectional. It is because of this study researches on a specific topic at a particular time.

The first empirical stage in this study, qualitative stage, is mainly used to link theories to practice forming a practical holistic oil port focused sustainability framework based on the initial theoretical framework from existing literature. The second empirical stage, quantitative stage, first adds value to the practical framework by ranking the factors to show their importance priorities and to form a 'must have set' to extract the most significant sustainability indicators from each category, and then identifies the interrelationships between cross-sectional factors. This chapter provides the general view of what and why different data collection methods (semi-structured interview, AHP survey, TISM and MicMac panel meeting) and data analysis methods (Thematic analysis, AHP analysis, TISM and MicMac analysis), have been used in this study. The detailed implementation of the data collection methods and data analysis techniques shall be further explained in following chapters, Chapter 4 and Chapter.

In the qualitative stage, interviews are adopted to gain further confirmed indicators for its suitability and daily life usage in the Chinese oil ports, as well as finding out what factors were, or should be included in the prospective sustainability framework. After gaining and validating obtained data from the literature, a theoretical sustainability framework has been formed. However, due to a large number of identified indicators and the need to know each of their importance, AHP is used to rank the sustainability indicators so that interested parties could see clearly which factors are the most important and urgent to be put into practice.

After explaining the data collection methods, the data analysis methods are explained as the second part of this chapter. Thematic analysis is used to summarise the most useful information from the interview manuscripts. Moreover, after a careful comparison, Expert Choice has been chosen as the most suitable application to analyse the AHP Survey obtained data. As for TISM and MicMac, the results have been calculated manually.

Lastly, the ethical implication of the empirical research is discussed. The methods and techniques used in this study are summarised in Table 10, which includes three main oil port sustainability framework development steps with according data obtaining approaches and application purpose.

Table 10 An Overview of the Research Methods and Data Analysis Techniques

Steps	Data Collection Methods	Data Analysis Methods	Purpose
1) Popular and Valid Sustainability Indicators Extraction	Semi-structured Interview	Thematic Analysis	To Collect the Data of Oil Port Sustainability in Practice
	Interview with Panel Group	/	To Validate the Grouping Appropriateness and the Chosen Indicators to Chinese Oil Port
2) Forming Sustainability Framework	Structured AHP Survey	Expert Choice	To Prioritise the Sustainability Factores
	Structured AHP Survey	Expert Choice	To Form the Holistic Sustainability Framework Hierarchy
3) Interrelationships Identification	TISM (Panel Meeting)	Manual	To identify Cross-Sectional Interrelationships between Sustainability Groups
5) Contain Power Identification	MicMac (Panel Meeting)	Manual	To recognise Driving and Dependency Power of each Sustainability Groups

Chapter 4 Qualitative stage: qualitative data collection and analysis

4.1 Introduction

This section provides an overview of the qualitative stage of this study, introducing the methods of data collection and analysis that have been used. The qualitative stage helps to validate and develop the research objective, linking theory and practice. Following on from Chapter 3, this chapter further illustrates how the chosen method of data collection and analysis techniques are used in this study in more depth, and introduces semi-structured interviews to collect data, and the thematic analysis of the data obtained. As a result, this section identifies practical oil port sustainability indicators that have been omitted from the theoretical framework. The qualitative practical framework is the foundation of the quantitative phase and further prioritises the factors that make up the framework, according to the generally accepted ranking. In addition, these interviews enable the future development of the 'must-have set' of highly recommended factors generated by the further comparison between the interviews, the AHP, and the MicMac results.

4.2 Semi-structured interviews

This section explains how semi-structured interview has been implemented as the qualitative method for this study. The results of these interviews are crucial; they are the foundation of this study, providing a base for the practical sustainability framework, and enabling a future ranking of all factors and a comparison between the relative similarities the various results obtained. Even though many types of interviews are used in research, this study adopts the semi-structured method to gather the first round of empirical data.

The reasons for adopting this method have been illustrated in Chapter 3. It is mainly due to its time efficiency, the fact that it enhances the closeness between interviewees and interviewer, and its flexibility to obtain more necessary data. Face-to-face interviews on a one-to-one basis have been conducted with the help of an interview question template. And, with the interviewees' consent, most interviews were recorded, while manual transcripts were made and kept, regardless of whether audio recordings were made. Both recordings and transcripts will be destroyed six months after of the completion of this study to ensure adherence to ethical guidelines.

Each interview question template has the same contents: descriptive questions; brief information regarding the topic; predetermined interview questions; and the space for potential added questions. This helps to guide the interviews and keep them focused on the matter at hand (Saunders et al., 2009). For which organisations do the interviewees work for is one of the descriptive questions. It is stated for so as to allow for a future analysis of how the experts' opinions vary according to their occupation. If some of the interviewees happen to work at the same company, the section in which they work is noted on the question template sheet via the words 'XXX organisation; number; position' (e.g. research institution, 1, fifth-year researcher). During the interviews, in addition to recording the interview content, the answers to each question are written down in the order of the question template sheet to enable a further data analysis. After completing the interviews, each interviewee is given a folder that contains the question template, answers, and the recordings. The recordings are taken to ensure that no information is missed, and they will be played a number of times when checking the manual transcripts until the researcher is certain that nothing important has been omitted.

In the question template, the interview questions can be divided into the aspects of sustainability that are being considered in practice; what has not been included, but the interviewees think should have been; and the validation of the identified indicators.

This study has divided sustainability into three aspects, environmental, economic, and social factors, and the questions follow this segmentation. Due to limited interest in the economic and social aspects of port sustainability in the literature, the validation part of the economic and social aspects is relatively short, ensuring that greater importance should be attached to the questions concerning economic and social factors. All aspects are designed to validate the identified indicators and discover new factors from the semi-structured interviews, and particular attention needs to be paid to the questions that relate to the economic and social aspects.

Following the semi-structured interview approach, the interviews begin with general questions about the participants such as their experience if and knowledge of issues relevant to oil port sustainability. This design has the advantage of enabling the researcher to ask open-ended questions, change the question sequence, and add or eliminate questions, based on the situation (Tharenou et al., 2007).

For this reason, the semi-structured interview method suits this study because it explores the 'what,' 'why,' and 'how' of the sustainability indicators pertaining to oil ports. This approach is suitable for the purpose of this research stage, and maximises the scope of the useful data collection. The researcher then adopts abductive reasoning to understand the interviewees' meanings and their interpretation of the various phenomena and facts.

4.3 Interview data collection

This section illustrates in detail how the interview data were collected and how the interview preparation procedures (such as deciding on the interview selection and contact method) are conducted.

Data collection via interviews

The qualitative phase of this study consists of interviews, and has been conducted to come to gain the practical experiences of experts who have knowledge or direct experiences in matters that relate to oil port sustainability. Direct contact with experts is one of the most effective ways to gleaning information that is relevant to this research (to both validate the theoretical outcome and add new practical knowledge), and this stage is crucial to establish a foundation for this and further analysis. The researcher contacted the experts directly because people play a crucial role in sustainability development and monitoring, given that social and economic perspectives are abstract and hard to quantify and measure automatically. In addition, because only humans can decide which indicators to include in the sustainability framework, especially with regard to economic and social matters; being the decision-makers, people exert a strong influence on sustainability performance.

Furthermore, as discussed in Chapter 2, being a relatively new area, the social perspective is quite 'underdeveloped' in the context of port sustainability management. The theoretical framework that has been introduced in Chapter 2 is based on all three aspects of sustainability – economy, environment, and social matters – which has not been adequately researched in the port context, especially for oil ports. However, some of the aspects of sustainability have been researched, especially those that concern the environment, and therefore most of the empirically obtained data can be divided based on the existing categories. According to Davenport and Prusak (2000) and Pan et al. (2001), it is important to gain a deep understanding of the source of any research issue, and build a prospective theory based on the data collected. Even though a theoretical model has been developed in light of the literature review, its suitability to oil ports could be questioned, given today's business environment. For this reason, there is a provision for introducing new elements and eliminating irrelevant ones, as well as to validate the previously identified theoretical elements in the course of the interviews.

However, given that the decisions are made by people, it is possible that subjective biases or personal preferences may affect what is included in the practical framework. To minimise this subjective influence and obtain a relatively 'objective' practical framework, it is necessary to achieve a common agreement on which sustainability factors should be included, which means that the interviews should be conducted contentiously until 'saturation point' (Saunders, 2009). Moreover, due to this stage of qualitative data collection, a quantitative stage is required to increase objectiveness by ranking the factors with a relatively large number of participants. More details regarding the quantitative stage of this research will be presented in Chapter 5.

At this stage, the qualitative approach is considered more useful that the quantitative because this stage tries to obtain experts' opinion on how, why, and what sustainability factors should be included to form the prospective framework. Because neither the questions nor answers to these questions can be quantified, the most suitable approach to conducting the data collection is the qualitative method, which consists of the semi-structured interviews with port sustainability experts. This method deepens and widens the coverage of interview content, thereby providing the researcher with deeper insights into what, how, and why particular sustainability factors should be added to or removed from the theoretical framework, enriching each category. In this way, through this qualitative approach, each of the components needed to build up a practical oil port sustainability framework is identified.

Interviewee selection

In order to ensure the quality and accuracy of the information obtained from the interviewees, there are many criteria that act as a standard to select the most appropriate interviewees. For instance, Jones (2011), Sargeant (2012), and Alshenqeeti (2014) state that the following basic rules should be observed, when selecting interviewees for academic research:

1) The selected participants must have been directly involved in matters related to port sustainability such as environmental studies, the development of strategic plans, and conducting port projects. There are a limited number of experts who meet this criterion for oil ports, so for this research, the criterion is extended to people with experience with other types of ports who are also familiar with oil ports and sustainability.
2) The chosen participants should have at least five years of experience in their field.

These criteria have been adopted for this study for the following two reasons:

1) Direct engagement with the relevant subject matter is essential because the experts to be interviewed require a relatively solid background to be able to contribute to the formation of the foundation of this study. Port sustainability is a specialised area, and requires interpretation by experts in the field.
2) People who have worked in the relevant field for a short space of time might not have gained a relatively deep understanding of the area. In this study, interviewees have to not only point out phenomena or mention the various aspects of sustainability, but also to give their own opinions on the background behind the phenomenon to give the researcher deeper insight. For this reason, a minimum of five years working experience engaging in relevant projects is a prerequisite for participation in this study.

However, it is worth mentioning that in the interview stage, the participants do not necessarily have to be Chinese or especially having experience at

Chinese oil ports as long as they have relevant knowledge in general port/port sustainability. Even though the first preferences are Chinese experts with relevant knowledge, other nationals meeting the above two requirements were also taken into account. The reason the interview stage does not have to be linked with Chinese ports is because the interview stage is considered as the fundamental port sustainability knowledge accumulation stage. In other words, mixed opinions with international representatives are acceptable to avoid biased results. Led by globalisation, international standards and commonly accepted opinions should be considered as sustainability issues impact worldwide social welfare (e.g. environmental damages). Therefore, foreign experts with foreign oil ports and sustainability knowledge are also included. Nevertheless, Chinese experts with direct knowledge to oil port sustainability are still the first choice. As a result, most of the interview participants were Chinese experts or experts with Chinese oil port knowledge.

As shown in Table 11, interviewees have been chosen from five occupations, and have work experience for at least five years. Each interview lasted for approximately 50-70 minutes to allow participants to express their opinions in full. Most of the interviewees are advanced in their careers, being at least second navigation officers or team leaders (or equivalent). This assists the researcher to gather information from a general perspective, while also providing details of daily operations.

Apart from occupation, the final list of interviewees consists interviewee from China, Korea, and Philippine. In the existing literature, most of the empirical participants are mainly from a single nationality. In this study, diverse internationality of participants allowed this study to obtain opinions from different perspectives. Chinese interviewees provided opinion from the perspective of Chinese external environment (e.g. political, economical and strategic developmental). However, if all interviewees were Chinese national, no knowledge exchange could be achieved. Moreover, foreign interviewees matching with this study's demand contributes international representative opinions.

As this study is a Chinese port focused study, Chinese interviewees have been targeted at the first place. As the Chinese experts understand the most about the Chinese ports, they are interviewed because they provides basic sustainability concepts applied in Chinese oil port and their opinion on further sustainable development. In this study, most of the Chinese interviewees tend to focus on strategic sustainability development plans, and they all hold positive attitudes to the future sustainability situation in Chinese oil port.

Korean and Pilipino are chosen because Qingdao oil port had a Korean port company GS participating daily oil port operations. Not only that, before 2015, there were a time that Korean ships stayed at Qingdao for a few months (most of them also had experiences to come to other oil ports in China for multiple times). The Korean and Pilipino working on that ship are thus chosen as they are not only foreigners with opinions other than Chinese, but they also happened to stay in Qingdao oil port for several times to have the chance to learn more about Chinese port. In the end, the conclusion is found that foreign interviewees tend to feel that even though Chinese oil ports had difficulties meeting international standard in environment and port workers welfare, the sustainability development in Chinese port has been applied increasingly effectively. However, the employee welfare part could be further enhanced. As a conclusion, both of Chinese and foreign experts do think Chinese oil port sustainability are effectively managed. Chinese experts focus more on environment and economic issues; foreign experts think China should focus more on environment and social issues.

Table 11 Interviewees' occupations

	Interested Parties' Invovlement	Port's Competitiveness	Port's Operational Ability	Air
Indicator Mentioning	55	70	98	150
Seafarer	6	12	19	17
Port Company	19	19	30	41
Research Institution	15	15	19	65
Scholar	9	11	21	19
Government	6	13	9	8

Contacting the interviewees

The potential interviewees who met the requirements to participate in this research were contacted directly via email to enable convenient and effective communication (Appendix 1), with consent form attached (Appendix 2) to obtain their consent for the interview. A total of 34 out of the 60 people contacted agreed to participate. One reason for this relatively high rate of acceptance could be because roughly half of the finalised interviewees were referred by personal contacts of the researcher in the field, and interviewees who had previously agreed to participate.

At the end of the interview, each interviewee was asked for their oral consent to participate in the subsequent quantitative empirical section (AHP and TISM). After obtaining their consent, they were sent a consent form (Appendix 2) to sign. All interviewees agreed to this further participation, and most (32 of them, 94%) went on to participate in the AHP survey. Only two experts did not do so, due to their busy schedule. Three of the experts were then chosen to take part in the TISM (for the selection criteria, see Section 5.2.2.4), and sent a consent form (Appendix 2), and all attended the subsequent TISM panel meeting.

Summary

The potential interviewees for this study were selected and filtered via the two criteria outlined above. Every expert interviewed has been directly involved in projects related to port sustainability for more than five years, and possesses relevant knowledge of oil ports. The interviewees' long years of experience ensure that they have a high level of knowledge, deep understanding of sustainability with regard to port management, and practical experience in the daily operations of ports. However, it should be noted that even though the interviewees have knowledge of both oil ports and port sustainability, few have direct knowledge of the sustainability performance, management, and development of oil ports. For this reason, it must be accepted that the majority of the interviewees' answers derive from a combination of their work in other ports in general, and their knowledge or experience at oil ports in particular, which makes their opinion to a certain level theoretical. This makes it crucial to conduct a quantitative stage to ensure a common understanding of the practical oil port sustainability framework, and to test the results of the oil port sustainability performance evaluation, based on this practical framework.

The interview template focuses on how, why, and what sustainability indicators are included in the practical framework, which gives the interviewees the freedom and right to express their opinion on the oil port sustainability matters, given that none of the questions are quantified. Even though the interview results are partially the result of a combination of the interviews' theory and practice, their opinions are still considered valid and helpful for the prospective framework because the participants possess enough knowledge and experience with regard to both sustainability and oil port operations.

The following section will explain how the interviews were conducted after the preparation.

4.3.1 Developing the interview questions

This section explains in detail how the interview questions were developed. The literature review provided a theoretical foundation for the prospective sustainability framework for oil ports, constructing the basis of the potential sustainability indicators to be included in the framework. In this way, a set of questions have been created to use as guidelines for the main discussion points of the interview. In order to ensure there is enough flexibility to obtain in-depth information, the interview format followed this study is semi-structured, which allows for the questions to be modified, added, or eliminated, if necessary. In this way, the interview makes it possible to collect information concerning all three aspects of sustainability and the categories to which they belong, thereby identifying suitable sustainability indicators for oil port. The interview questions have been designed to answer the first research objective, that of forming a practical holistic sustainability framework by linking theories with practice, and answering the pre-condition to achieve the fifth research objective: forming a 'must-have' set of sustainability indicators by comparing the results from the interview results, the AHP, and the MicMac.

The interview template consists of 36 questions categorised into environmental, economic, and social sections (see Appendix 3). In each section, the questions are divided into different areas, based on the categories of the aspects of sustainability. In total, there are 32 questions (six environmental, three economic, and four social, plus one additional question for each group) to cover the suitability of the aspects of sustainability in deciding on a theoretical oil port framework, and uncover anything else that should be included in the prospective framework. Moreover, each of the questions aims to find out why and how these indicators should be taken into consideration. For instance, the first question in the environmental section is: 'What do you think of the suitability of including water-related issues (with listed indicators) in the prospective framework for oil ports, and if so, what indicators should be included?' The other questions all follow this concept. This part is intended to validate and, if necessary, eliminate the theoretical indicators. Each interviewee was given a copy of the interview template before starting the interview so they could prepare, and have an overview of the indicators included in each section/group, which not only gives them more information, but also saves time when asking the questions. In this case, only two questions are required, e.g. 1) is it appropriate to include this question in the category; and 2) what has not been included.

Lastly, for each section, the researcher put a summarising question to each interviewee: 'What other factors that have not been mentioned do you think should be included in the prospective holistic framework; please state why and how.' If the answer is positive, the interviewee is asked further questions about where and how this opinion occurred to them, and about the feasibility of measuring it in practice. This part enables sustainability indicators to be added if necessary, and showcases the benefits of using semi-structured interviews by giving extra space to allow the interviewees to provide more relevant information. These two parts link the practical to the theoretical elements to enable the formation pf a practical holistic sustainability framework.

In order to obtain accurate information, the interview questions were put as a pilot test to three shipping experts with knowledge and experience in the area of both sustainability and oil ports. These experts did not make any significant corrections to the questions, and provided useful information, following the guidance of the question template. The interview questions were therefore not modified, other than by making changes to the wording so that they could be better understood by the interviewees. However, there were several times during the interviews when the interviewees had to ask for more details and background about the indicators because they found it hard to answer, without knowing more about the perspective of the indicator. In this way, to avoid confusion and ensure more accurate results, the background behind each indicator (how it is relevant to this study, and why its suitability is being questioned) is explained during each interview.

4.3.2 Conducting the interviews

This section provides details of how the interviews were conducted. The interviews were carried over three months, from February to April, 2017. Throughout the entire process, the researcher abided by ethical principles such as requiring consent forms, ensuring privacy, confidentiality, and anonymity, and recording the interviewees' preferences, as suggested by Longhurst (2003) and Boeije (2010).

After receiving their consent, the researcher decided on a fixed number of interviewees based on their eligibility, experience, knowledge on the topic, and consent to the interview. Even though interviewees were able to choose how the interview would take place, most agreed to meet face to face, with only five asking to be interviewed via Skype due to time and personal issues. In total, 29 interviewees were interviewed face to face, and five via Skype. Most of the interviews were recorded for analysis, with each interview lasting until the researcher had collected sufficient material and information (all were under 70 minutes), and ensured that all information obtained reflected the interviewees' genuine thoughts. Before finishing each interview, the researcher expressed appreciation and thanks to the interviewees for their support and valuable time, and asked them whether they could be contacted later if any clarification was needed, to which all interviewees kindly agreed.

The recordings were useful in checking whether any information was missing from the manual transcript, and a word-by-word check also reduced any bias or errors that may have occurred while producing the manual transcript. This ensured the accuracy and reliability of the results. The privacy and confidentiality of the interviewees was guaranteed at all times.

4.4 Interview data analysis using Thematic Analysis

This section will explain how the interview data was analysed. Qualitative data were collected using semi-structured interviews regarding the interviewees' opinion on the aspects of sustainability with regard to oil ports. In order to obtain accurate and meaningful results, the matching qualitative data analysis technique was adopted, specifically by performing a thematic analysis. Even though several major groups had been identified from the literature for use during the empirical stage (such as water, air, and noise), newly identified indicators in this stage were categorised into either existing or new groups, depending on whether the existing groups covered the content of the new indicators. If new categories emerged during the interviews, they were noted and eventually added to the theoretical framework via coded data, and categorised as appropriate.

Thematic analysis is generally done by describing each overarching theme in turn, giving examples from the data and using quotations to facilitate characterisation of the various themes. However, Braun and Clarke (2006) state thematic analysis is done not only to provide a descriptive summary of the analysis but also to interpret how the research findings have cast light on the issue in hand. Furthermore, according to Jiao et al (2016), quotations from participants should be directly included when transcribing to enable a better understanding of the interviewees' thoughts and because the original wording could give readers more precise information. Further details of this technique are presented in the following section.

The thematic analysis can be divided into five main stages (see Figure 20): transcribing, editing, coding, categorising, and modelling. In this research, to ensure the accuracy of the interview results and prevent any omissions, the audio files were transcribed word for word, and transcripts were carefully edited to remove irrelevant terms and duplicated words. The thematic analysis was then done on the updated version of the transcripts after the audio file check, and the coding process can begin.

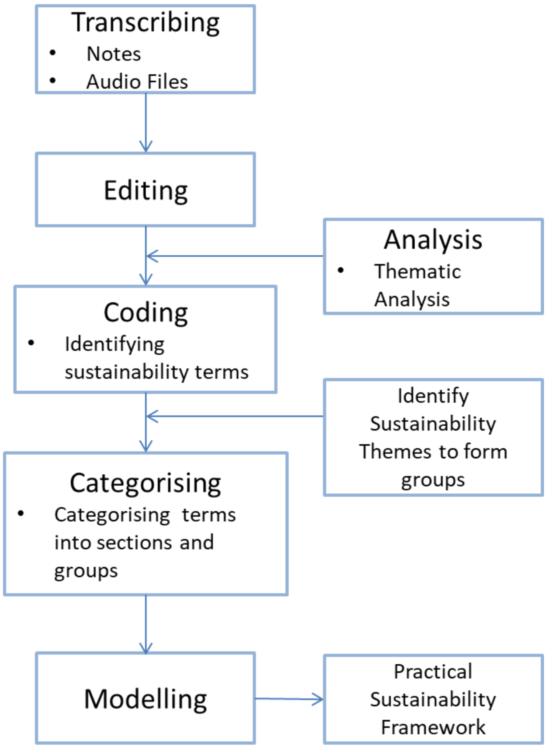


Figure 20 Thematic analysis

The main step during the coding process is to identify and validate the terms that are relevant to aspects of sustainability at oil ports. In other words, the coding extracts what, how, and why a certain indicator should be included in the framework. The coding enables a thematic analysis of the themes, subjects, and terms that emphasise, pinpoint, validate, or confirm the patterns within the data (Braun and Clarke, 2006). Throughout the analysis in this research, the researcher not only validated the components and groups of the framework, but also enriched the theoretical framework with new indicators and categories. When all the important terms have been extracted, it is crucial to categorise them into the most suitable group, based on their nature. This was relatively straightforward for this study because many of the indicators have already mentioned, along with their description, and are sometimes categorised in the extant literature.

The main outcome of thematic analysis in this research can be divided into three sections: first-order (sustainability indicators), second-order (sustainability groups), and third order codes (aspects of sustainability) (see Figure 21).

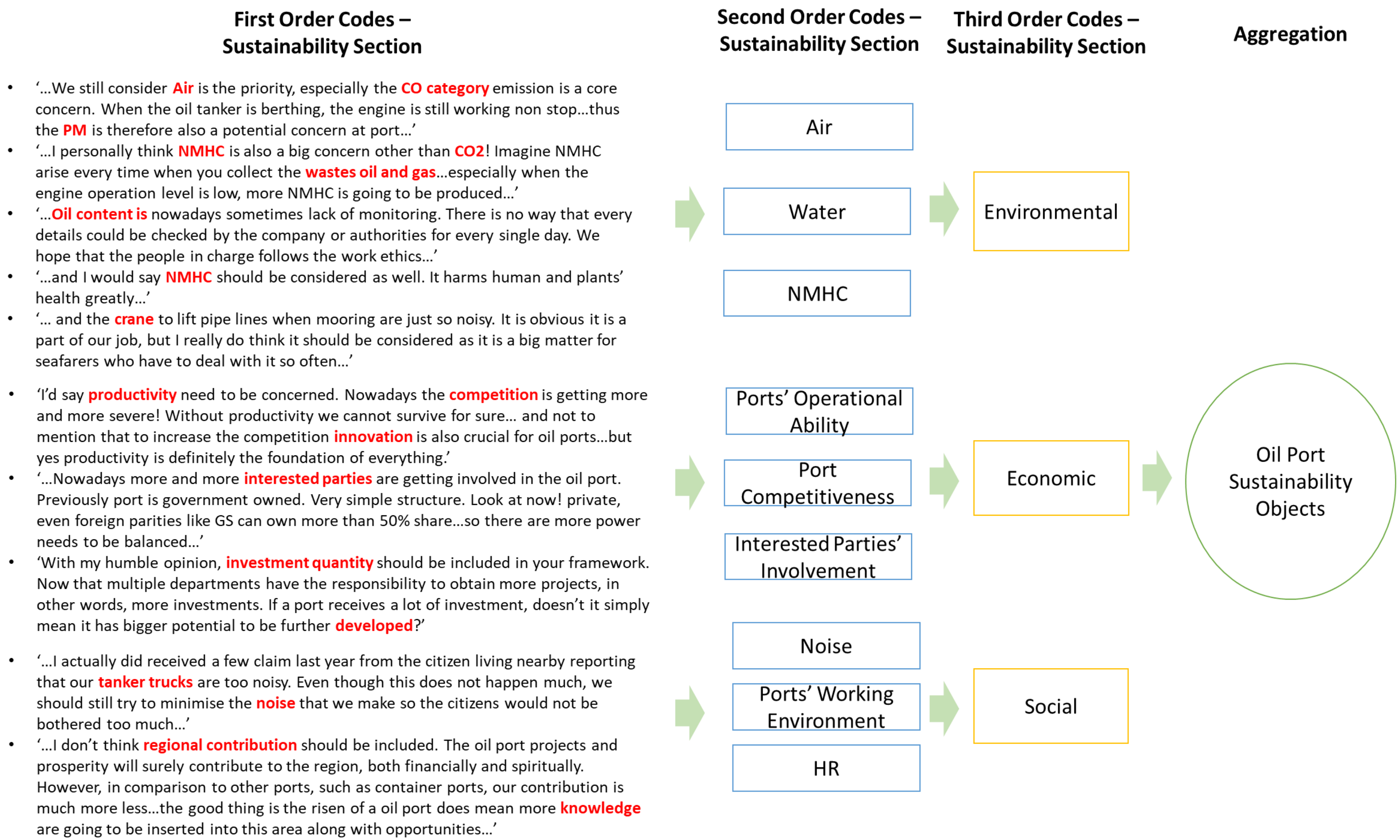


Figure 21 Interview data analysis via thematic analysis (partial)

In the first stage, detailed indicators are filtered from the interview transcripts, and then, the indicators with broader meanings (such as water, air, and HR) are extracted, and the remainder of the detailed indicators categorised into each group; lastly, the groups - along with their indicators - are categorised into the three general aspects of sustainability. Tables 12 and 13 show how the groups and indicators were identified after the thematic analysis (for further detail, please see Appendices 4 and 5).

Table 12 Interview Record of Sustainability Groups Identification (Layer 2)

Participants	Interested Parties' Invovlement	Port Competitiveness	Port's Operational Ability	Air	Water	Soil	Noise (Envir.)	Energy Consumption	Ecosystem	NMHC	Noise (Soc.)	HR	Citizen Lively Condition	Port's Working Environment
Seafarer 1	2	3	3	4	4	3	1	0	0	1	2	0	3	4
2	0	5	2	3	5	0	0	2	0	0	0	0	0	4
3	4	4	5	3	3	2	3	3	0	1	1	0	3	3
4	0	0	4	3	3	0	0	2	1	1	0	2	0	5
5	0	0	5	4	2	3	0	0	0	0	0	0	0	3
SUM	6	12	19	17	17	8	4	7	1	3	3	2	6	19
Port Company 1	2	0	0	5	4	0	0	1	1	1	0	0	0	4
2	3	2	3	6	3	0	1	2	1	1	2	0	3	5
3	0	3	4	4	3	2	0	1	0	0	0	2	2	3
4	2	4	4	5	4	1	0	0	0	0	2	0	0	0
5	3	3	3	3	3	0	1	0	0	1	0	0	0	3
6	1	2	4	5	4	0	0	0	0	0	0	0	3	0
7	0	2	4	5	4	3	0	3	0	0	0	0	3	3
8	3	0	3	3	3	0	1	0	3	1	3	0	4	2
9	5	3	5	5	4	1	0	3	0	1	0	0	0	4
SUM	19	19	30	41	32	7	3	10	5	5	7	2	15	24
Research Institution 1	3	1	3	7	5	0	2	3	2	0	0	0	1	0
2	1	1	3	4	4	0	0	0	3	0	0	0	1	0
3	0	0	2	5	5	3	0	2	2	0	2	0	0	0
4	0	2	1	6	4	0	0	3	3	0	0	0	2	0
5	4	1	3	7	4	0	1	2	1	0	0	4	0	0
6	2	2	1	5	4	3	0	0	2	0	0	0	3	0
7	1	1	1	6	5	0	0	0	0	0	0	0	0	0
8	0	3	1	6	3	0	0	0	2	0	0	0	2	0
9	0	0	1	4	4	0	0	1	2	0	1	0	1	0
10	3	2	2	5	5	1	0	0	2	0	0	2	2	0
11	0	1	1	6	3	3	0	0	1	0	0	0	0	2
12	1	1	0	4	4	2	0	0	2	0	2	0	1	0
SUM	15	15	19	65	50	12	3	11	22	0	5	6	13	2
Scholar 1	0	5	5	4	3	0	0	0	0	0	0	0	0	0
2	4	0	4	3	3	0	3	0	1	1	1	0	0	3
3	2	3	5	4	4	2	0	3	1	0	0	0	2	2
4	3	2	3	5	2	0	4	0	0	0	3	3	0	4
5	0	1	4	3	4	0	2	0	2	0	2	0	0	0
SUM	9	11	21	19	16	2	9	3	4	1	6	3	2	9
Government 1	0	4	3	3	3	2	0	2	1	0	0	0	3	2
2	5	5	3	3	2	3	0	0	1	0	0	1	0	0
3	1	4	3	2	3	0	3	4	1	0	3	3	1	3
SUM	6	13	9	8	8	5	3	6	3	0	3	4	4	5
TOTAL	55	70	98	150	123	34	22	37	35	9	24	17	40	59

Table 13 Interview Record of Sustainability Indicators Identification (Layer 3)

Participants	Sharing Common Goal	No Privilige	Regularly Develop Strategic Development Plan	Sharing Same Responsibility	Balanced Relationship	Maritime Connectivity	Effective Terminal Operation	Connection to Hinterland	Effective Resources Utilisation	Terminal's Utlisation Cost	Performance under the whole SC	Regional Cooperation Performance	Ports' Function Diversity	Cost Effectiveness	FDI	Productivity	Service Quality	CO Category	VOC	NO Category	CH4	PM Category	SO Category	Hydrocarbon	NMHC
Seafare 1		Y		Y			Y			Y		Y		Y		Y	Y	Y	Y	Y		Y			
2						Y	Y	Y		Y		Y	Y		Y			Y		Y		Y			Y
3	Y		Y	Y	Y			Y	Y	Y	Y		Y	Y	Y	Y	Y	Y		Y		Y			
4													Y	Y		Y	Y	Y		Y			Y		
5													Y	Y	Y	Y	Y	Y		Y			Y	Y	
SUM	1	1	1	2	1	1	2	2	1	3	1	2	4	4	3	4	4	5	1	5	0	3	2	1	1
Port Company 1			Y		Y													Y	Y	Y	Y	Y			
2	Y		Y		Y				Y	Y			Y	Y			Y	Y	Y	Y	Y	Y	Y		
3			Y	Y	Y	Y	Y	Y						Y		Y	Y	Y			Y		Y	Y	Y
4			Y		Y	Y		Y		Y	Y		Y	Y		Y	Y	Y	Y	Y			Y	Y	
5			Y	Y	Y				Y		Y	Y		Y		Y	Y	Y		Y			Y		Y
6					Y		Y		Y				Y	Y		Y	Y	Y	Y	Y		Y	Y		
7							Y					Y	Y	Y		Y	Y	Y	Y	Y		Y	Y		
8		Y	Y		Y									Y	Y		Y	Y		Y			Y		
9	Y	Y	Y	Y	Y			Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		
SUM	2	2	7	3	8	2	3	3	4	2	2	3	5	8	2	6	8	9	6	8	3	5	8	2	2
Research Institution 1	Y			Y	Y				Y				Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	
2	Y										Y		Y		Y	Y		Y	Y	Y			Y		
3													Y	Y				Y	Y	Y			Y	Y	Y
4											Y	Y			Y			Y	Y	Y		Y	Y	Y	Y
5	Y		Y	Y	Y							Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	
6			Y	Y					Y	Y						Y		Y	Y	Y	Y		Y		Y
7		Y				Y				Y	Y						Y	Y	Y	Y	Y	Y	Y		Y
8						Y	Y		Y				Y					Y	Y	Y		Y	Y	Y	
9																	Y	Y	Y	Y			Y		Y
10		Y	Y		Y						Y	Y		Y	Y			Y	Y	Y			Y	Y	
11										Y							Y	Y	Y	Y	Y	Y	Y		
12			Y							Y								Y	Y	Y			Y		
SUM	3	2	4	3	3	2	1	0	3	4	4	3	5	3	4	3	4	12	12	12	4	5	12	6	5
Scholar 1						Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y			Y		
2	Y		Y	Y	Y								Y	Y		Y	Y	Y		Y			Y		
3		Y	Y				Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y		
4	Y	Y	Y				Y				Y		Y		Y	Y		Y	Y	Y		Y	Y		
5									Y				Y	Y	Y	Y		Y		Y			Y		
SUM	2	2	3	1	1	1	3	1	2	1	2	1	5	4	4	5	3	5	3	5	0	1	5	0	0
Government 1							Y	Y		Y		Y	Y		Y	Y		Y		Y			Y		
2	Y					Y	Y	Y	Y	Y		Y		Y		Y	Y	Y		Y			Y		
3			Y			Y			Y	Y	Y		Y	Y		Y				Y	Y				
SUM	1	0	1	0	0	2	2	2	2	3	1	2	2	2	1	3	1	2	0	3	1	0	2	0	0
TOTAL	9/34	7/34	16/34	9/34	13/34	8/34	11/34	8/34	12/34	13/34	10/34	11/34	21/34	21/34	14/34	21/34	20/34	33/34	22/34	33/34	9/34	15/34	29/34	9/34	8/34

Because the basic categorisations were done by the researcher, it was decided to hold a panel group meeting for all experts to finally decide on the categorisation; this took around 28 minutes. This was done because during the analysis, the interview data were coded based on the nature of the information, and the experience and knowledge of the researcher to increase the reliability of the coding. The reliability and accuracy were further enhanced by the three experts in the panel group. During the post-interview panel meeting, no big changes were made to the researcher's categorisation, and the experts merely tightened what the researcher had already done. More detail regarding the panel group can be found in Section 4.5.

In the end, a practical sustainability framework can be formed after the thematic analysis, which gives rise to new sustainability themes (categories) and indicators by coding and categorising every important term from the transcript. This process also helped to validate the existent themes and indicators to link the practice and the theory. Moreover, this thematic analysis helped to find the data saturation point to determine when to stop the interviews.

4.5 Post-interview panel group meeting

After the interviews, the researcher decided to hold a panel group meeting to evaluate the results of the interview because the information collected during interviews meant that changes were made to the theoretical conceptual framework formed based on the literature review. The changes include added and eliminated sustainability indicators, such as the new section 'soil conditions,' the change in content in 'stakeholder involvement,' and the eliminated indicators from 'operational ability.' The panel group meeting was therefore held to ensure that these new factors were placed in the right category,

This group meeting involved the same three experts who had participated in the pre-interview panel. It was not difficult to conduct the panel group meeting because these experts had been informed at the pre-interview panel meeting that they would be invited to take part in a second one after the interview stage to evaluate the appropriateness of the interview results.

Due to the experts' varying schedules and locations, the meeting was conducted via Skype for their convenience, and the interview results were sent to each panel member beforehand. At the beginning of the meeting, the experts were encouraged to share their opinions regarding the framework, such as the allocation of the indicators of sustainability, the category titles, and the structure of the framework; the researcher took notes of their opinions, and adjusted the framework accordingly. The meeting came to an end when the experts had reached a shared understanding about the practical framework.

At the end of the meeting, a summarised version of the adjusted practical framework, based on what they had suggested, was shown to the experts for their final confirmation, and they all agreed with the new version. The meeting lasted for 37 minutes, and confirmed the result of the interviews and a revised version of the practical sustainability framework for Chinese oil ports. The next stage is the quantitative stage, which will determine the prioritisation of and interrelationships among the indicators included in the practical framework. The methods by which these goals will be achieved will be introduced in Chapter 5.

4.6 Interview data analysis results

4.6.1 Descriptive analysis results

As mentioned in Section 4.4, descriptive data such as interviewees' position/occupation, work experience, and field of employment were collected from the interview template. In this section, a descriptive analysis is conducted to analyse the results not only as a whole but also based on occupation, to see whether different preferences of this type exist. Furthermore, descriptive analysis provides valuable information to the research because it is the main criterion to evaluate the reliability of the feedback and classify the answers for further analysis. From the summary of the descriptive data, there are diverse occupations, managerial levels, and professional experience among the participants. Given that the targeted participants of interview are academics, governmental/port authority officials, NGO members, seafarers, and research institution researchers, the data at this stage were analysed as a whole based on groups to see whether different occupational groups hold different opinions on the same issues (see the texts in blue in the descriptive section of Appendix 3). The following template questions were used to create profiles.

Participants' occupations:

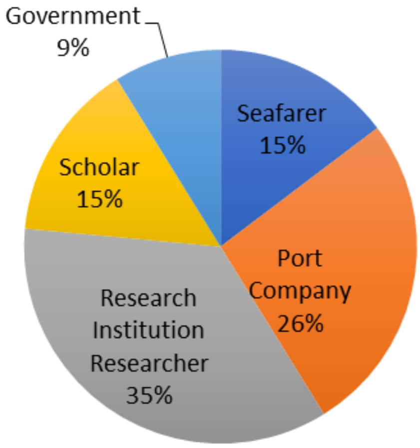


Figure 22 Participants' occupations

As shown in Figure 22, 15% of the participants are academics, 35% researchers at research institution, 15% are seafarers, 9% are government officials, and 26% working in port companies. Around 41% of the interviews were with people who work with sustainability-related issues in daily port operations, and 9% have positions that involve a general and planning perspective. Of the participants, 29.41% are non-Chinese people who have work experience in Chinese ports and knowledge of Chinese oil ports in particular (such as international ship workers who regularly visit oil ports in China), and 70.59% are Chinese citizens working at Chinese oil ports. The non-Chinese participants will be able to enrich the knowledge produced in this study by presenting a different perspective to that of domestic experts. Moreover, a total of 41% of the participants work in jobs that bring them into contact with the Chinese oil port sector, while 9% work in the general port sector. This also not only brings different perspectives to bear (such as whether the participants working directly with oil ports have different priorities to those working with general port matters), but also ensures the reliability of the results because most participants work in sectors that are directly connected to Chinese oil ports.

<u>**Experience (in years)**</u>

Figure 23 shows that 14% of participants have more than 20 years of experience, and all have at least five. This indicates that the data obtained are reliable and have solid practical support.

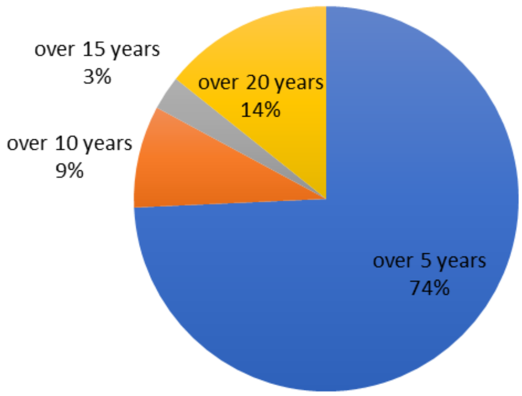


Figure 23 Participants' work experience

<u>Participants' policy roles</u>

Figure 24 shows that 70% of the participants are policy followers, while the remainder 30% evaluate sustainability performance at ports. This result indicates that the study offers a broad view because it is not limited to only one type of opinion on port sustainability (such as that of policy followers), but also takes into account policymakers' opinions on the matter.

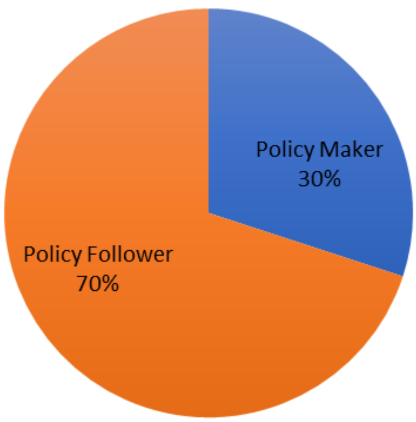


Figure 24 Participants' policy roles

4.6.2 The thematic analysis results

This section outlines the qualitative results obtained in the interview stage through a thematic analysis. Table 14 summarises the results of the analysis of the interview transcripts, after categorisation.

Table 14 Thematic analysis result

	Indicator	Adding/Eliminating
Water	Contaminated Sludge from Dredging	Eliminating
	Washing Water	Eliminating
	Ship Operation Disposal	Eliminating
	Oil Content	Adding
	Suspend Solids	Adding
Air	CO2	Eliminating
	Suspended Solids	Eliminating
	CO Categories	Adding
	PM	Adding
NMHC	NMHC	Adding
Noise (Env.)	Pump House	Adding
	Oil Tanker	Adding
	Tanker Truck	Adding
	Crane (Oil Loading Arm)	Adding
Soil	Oil Leak/Discharge	Adding
	Heavy Metal	Adding
	NO Categories	Adding
Port's Working Environment	Occupational Disease (Lung Cancer, Casrbio Vascular Disease, Asthana, etc.	Adding
	Periodic Check on Equipment	Adding
	Oil and Gas Poisoning	Adding
	Security	Eliminating
	Safety	Eliminating
	Accidents (e.g. Spill, etc.)	Eliminating
Citizen Lively Condition	Environmental Effect to Citizen	Adding
	Effect of Living in Port on Citizens' Health	Adding
	Population Growth	Eliminated
	Resources	Eliminated
	Community	Eliminated
	Accidents; (e.g. Spill, etc.)	Eliminated
Port HR	Employment Increase Rate	Adding
	Employee Welfare	Adding
	Employee Turnover Rate	Adding
	Training (Education/Knowledge Development)	Adding
	Employee Career development	Adding
	Human Capital Development	Eliminating
Noise (Soc.)	Pump House	Adding
	Oil Tanker	Adding
	Tanker Truck	Adding
	Crane (Oil Loading Arm)	Adding
Port's Operational Ability	Ports' Function Diversity (e.g. Value adding Service, Linkage with Hinterland, etc.)	Adding
	Productivity	Adding
	Foreign Direct Investments (FDI)	Adding
	Investment Quantity	Eliminating
	Damage Frequency	Eliminating
	Transit Time	Eliminating
	Financial Performance	Eliminating
	Capacity	Eliminating
	Increased Productivity	Eliminating
	Political Influence	Eliminating
	Value Added Growth	Eliminating
	Optimized Land Use	Eliminating
Port Competitiveness	Performance in the Supply Chain Context	Adding
	Regional Cooperation Performance	Adding
	Port utilization Cost	Adding
	Service Quality	Eliminating
	Economic Efficiency/Cost Effectiveness	Eliminating
	Active Shipping Activities	Eliminating
	Economic Catalyst (Port Function change)	Eliminating
	Economic Strategies	Eliminating
	Market-share Growth	Eliminating
	Reginal Contribution	Eliminating
	Diverse Service	Eliminating
	Enhancement of Offshore Environment	Eliminating
	Increasing Quality of Information Flow	Eliminating
	Benefit to Port Users	Eliminating
Interested Parties' Involvement	Developing Strategic Development Plans every certain Period of Time	Adding
	Balanced Relationship between Interested Partied	Adding
	Interested Parties Sharing the Same Goal on Sustainability	Adding
	Sharing Responsibilities on Sustainability Matter on Port	Adding
	No Party has Privileges when not following the Rules	Adding
	Stakeholders' Cooperation	Eliminating

Based on the groups and indicators of sustainability factors that have been identified and categorised in Table 14, a practical oil port sustainability framework has been suggested in Figure 25. Figure 25 (the practical framework) and Figure 14 (the theoretical framework, which can be found on page 63) show that there are differences between the theoretical and practical frameworks (the aspects of sustainability marked in red in Figure 25, and the indicators in Table 14). The reasons why certain indicators were eliminated or added will be discussed in Section 6.2, and can also be found in Appendix 17.

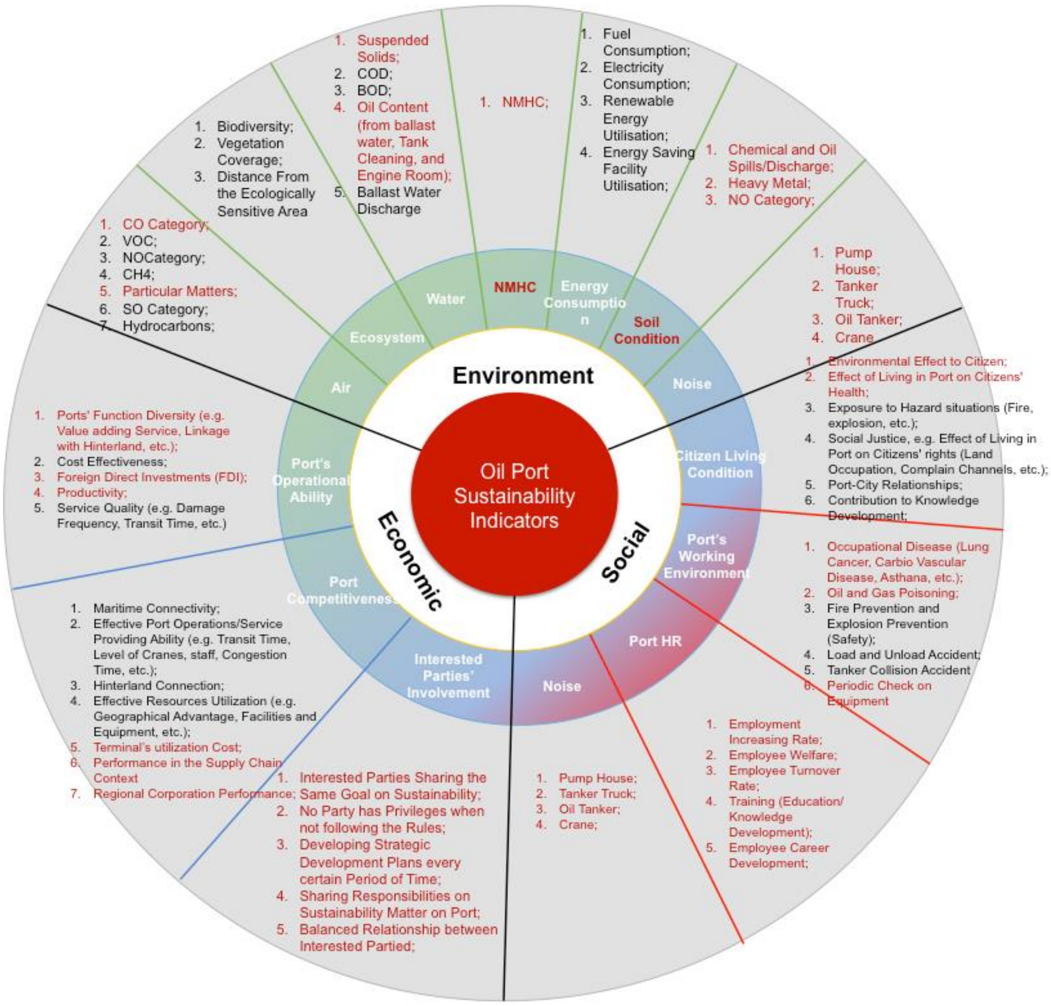


Figure 25 Practical oil port sustainability framework

The number before the sustainability indicators represents the interview ranking. Figure 25 shows that there are differences in all three aspects of sustainability, compared to the theoretical framework. Despite the fact that there is little change to the sustainability groups, the indicators of sustainability have changed a great deal. We can see that even though the general points of interest remain the same, compared to container ports, the coverage of the detailed indicators has been broadened (such as by adding soil and noise indicators) and changed based on the particular features of oil ports (such as being exposed to hazards and a higher incidence of explosions and fire).

Of the three aspects of sustainability, the economic and social factors have changed the most; from the seven economic and social groups, three have changed completely, with new indicators, while the other four have eliminated most of the theoretical indicators, which have been replaced with new ones. This further strengthens the focus on port sustainability, and the chief points of focus have changed and become more detailed. Further discussion of this matter can be found in Section 6.2.1.

4.6.3 Results based on interviewees' occupations

This section deepens the result of the qualitative stage of the semi-structured interviews by presenting the difference in results based on occupation. This stage is necessary to yield practical results in the oil port sustainability framework. To this end, each of the identified components in the literature review are evaluated, and the sustainability groups or indicators that should be added to the framework will be discussed. After the interviews, a practical sustainability framework for Chinese oil ports is formed with a holistic view, one that takes practical accessibility into consideration. The empirical findings from this stage will then be analysed in terms of the sustainability groups (second layer) and the sustainability indicators (third layer).

Because the interviews were conducted to determine the factors that should be included in the framework, the interviewees were mainly selected from official departments (port associations and governmental department (3/34), environmental research institutions (12/34), and universities (5/34) to ensure expert answers. In addition, five seafarers were included to outline details of the examinations/activities they have completed in the course of their working life in oil ports that concern sustainability. The selected interviewees all possess relevant knowledge and experience in oil port sustainability management, having either determined which factors should be used to decide on policies related to oil port sustainability, or having evaluated the successful implementation of such policies. A summary of the interviewees' occupations is provided in Table 15:

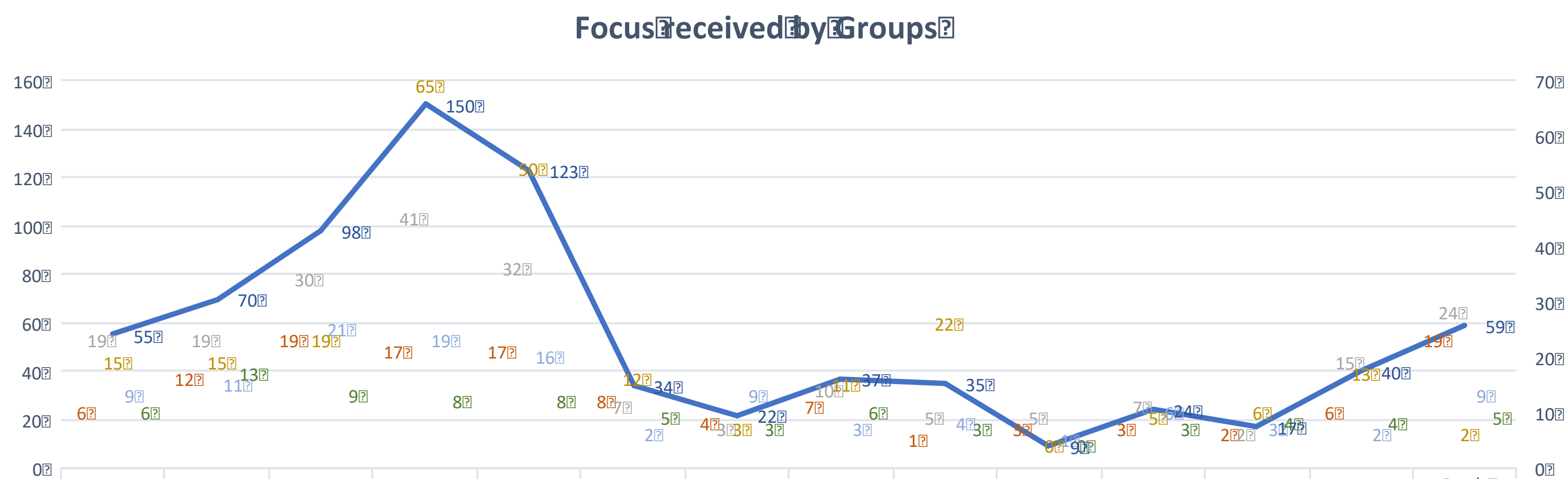
Table 15 Interviewee occupation and country of origin

Interviewee Occupations	Occupation	Interviewee Number	Percentage
1	Seafarer	5/34	14.71%
2	Port Company	9/34	26.47%
3	Research Institution	12/34	35.29%
4	University Scholar	5/34	14.71%
5	Governmental	3/34	8.82%
Interviewee Origins	**Origin**	**Interviewee Number**	**Percentage**
1	Chinese Expert	24/34	70.59%
2	Foreign Expert	10/34	29.41%

After interviews with 28 experts, no new factors had appeared, and the final six interviews were done to ensure no other sustainability-related factors had been omitted. The final six interviewees provided no new information. The mix of interviewees of different occupations and origins ensured that the practical sustainability framework embraced a variety of opinions on sustainability management in Chinese oil ports.

Figure 25 shows that in total, 14 sustainability groups have been outlined under the three aspects of sustainability, and the number of times they were mentioned has been recorded. Due to their conclusive nature, they have been categorised as 'sustainability groups,' which together form the second level of the practical framework. A total of 66 sustainability indicators have been identified for oil ports, and are defined as 'indicators,' which are factors of sustainability that belong to certain sustainability groups' because they are detailed indicators that cannot be further reduced. A list of the identified indicators can be found in Appendices 4 and 5, along with a record of the numbers of times they were mentioned by the experts. Together, these indicators form the third level of the practical sustainability framework. A further analysis based the number of mentions is presented in Section 4.6.2.1 and Section 4.6.2.2 to show the focus of each occupation in the field oil port sustainability, to a certain extent.

4.6.3.1 Sustainability groups (Layer 2)



	Interested Parties' Invovlement	Port's Competitiveness	Port's Operational Ability	Air	Water	Soil	Noise (Envir.)	Energy Consumption	Ecosystem	NMHC	Noise (Soc.)	HR	Citizen Lively Condition	Port's Working Environment
Seafarer	6	12	19	17	17	8	4	7	1	3	3	2	6	19
Port Company	19	19	30	41	32	7	3	10	5	5	7	2	15	24
Research Institution	15	15	19	65	50	12	3	11	22	0	5	6	13	2
Scholar	9	11	21	19	16	2	9	3	4	1	6	3	2	9
Government	6	13	9	8	8	5	3	6	3	0	3	4	4	5
Indicator Mentioning Times	55	70	98	150	123	34	22	37	35	9	24	17	40	59

Figure 26 Differences in focus, by group

Figure 26 reveals how often the sustainability groups are mentioned, among the various occupations represented. The seafarers mentioned most frequently ports' operational abilities (19), port working environment (19), air (17), and water (17), while they barely spoke about 'ecosystem' (1), HR (2), NMHC (3), and noise (3). This indicates that the seafarers are mainly interested in the economic and environmental aspects of sustainability.

The port company workers mentioned air (41), water (32), and ports' operational abilities (30) the most, and only mentioned HR (2), noise (environmental) (3), ecosystem (5), NMHC (5), and noise (social) (7) a few times, also revealing their focus on the economic and environmental aspects of sustainability.

The research institutions researchers mention most air (41) and water (32), barely touch on NMHC (0), noise (environmental) (3), port working environment (2), noise (social) (5), or HR (6). This shows that they are mainly concerned about the environmental aspect of sustainability.

For the academics, the main concerns are ports' operational abilities (21), air (19), and water (16), and they have much less interest in soil' (2), citizens' living conditions (2), energy consumption (3), HR (3), and ecosystem (4). These experts were somewhat interested in environmental matters, but much more so in air and water pollution.

Lastly, the experts working in government departments frequently mentioned port' operational abilities (13), but apart from that issue, show no especial interest in the other factors, and did not mention anything about NMHC (0). This indicates that government officials are concern with both the environmental and economic aspects of sustainability.

In general, air is the most frequently cited group, being mentioned 150 times, much more often than the others. This implies that air is a core concern in oil port sustainability management. 'Water,' mentioned 123 times, followed by

‘Port operational abilities’ (98), ‘Port competitiveness’ (70), ‘Port working environment’ (59), and ‘Involvement of interested parties’ (55). It can be concluded that the interviewees were most interested in these six groups, given that sustainability indicators from these groups came to their minds much more frequently than those of other groups. Differently, ‘Noise (Environment)’ (9), ‘NMHC’ (9), and ‘HR’ (17) are the least important factors in the eyes of the experts. In summary, most of the experts, regardless of their occupation, unconsciously focused more on the environmental and economic aspects of sustainability, and relatively neglected the social aspect, speaking most about ‘Air,’ ‘Water,’ and ‘Port operational abilities.’ The changes in sustainability groups between the interview and the theoretical framework will be discussed in Section 6.2.

4.6.3.2 Sustainability indicators (Layer 3)

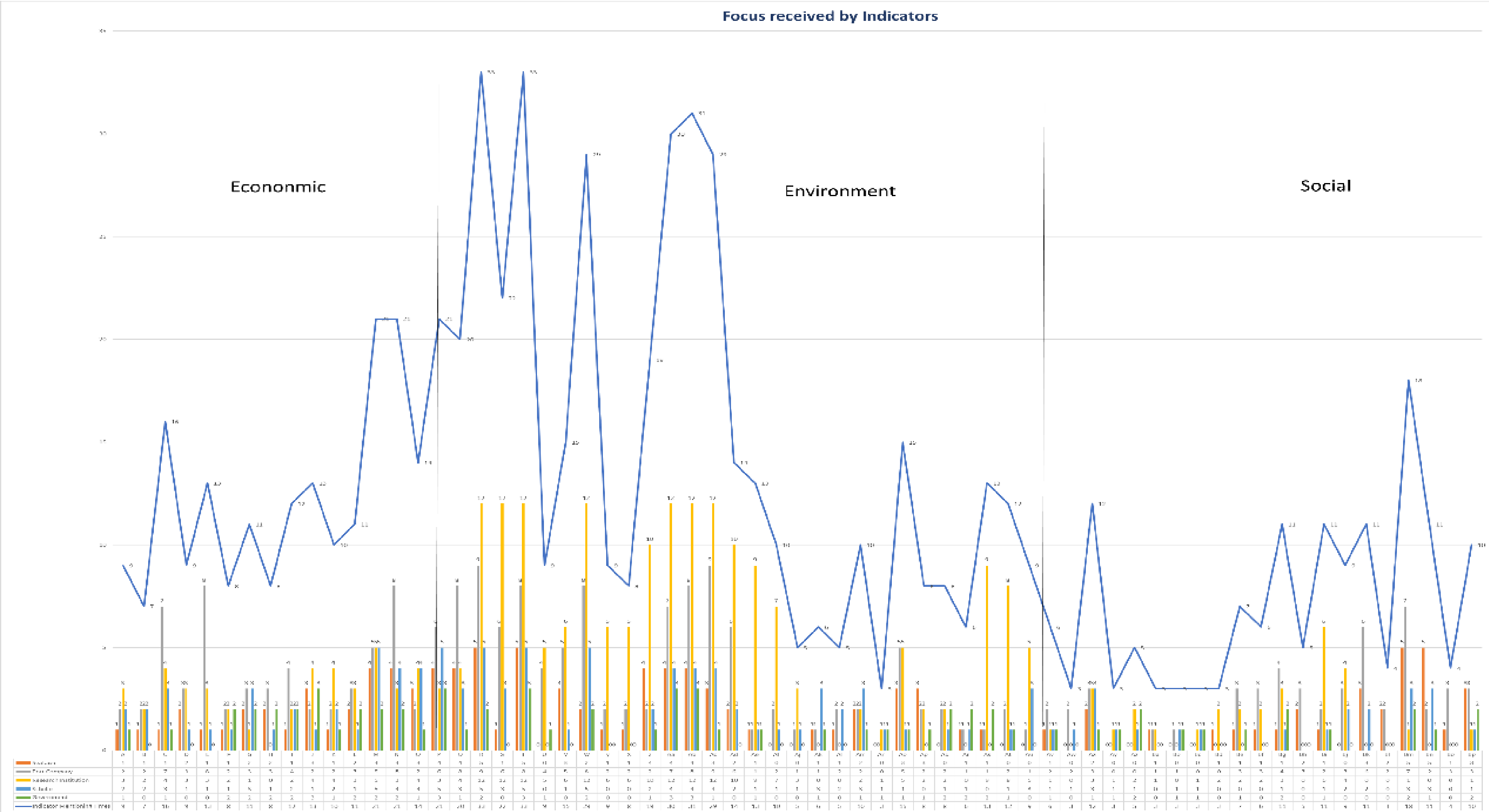


Figure 27 The variance in interest in the indicators

As shown in Figure 27, the indicators mentioned most frequently are those connected to the environment, especially 'Air' and 'Water.' The economic indicators are mentioned less frequently, but more than for social indictors. As a whole, indicators that pertain to the 'HR' group are mentioned the least, which is generally consistent with the analysis of the sustainability groups (second layer), that experts' focus is unconsciously placed on economic and environment aspects, with a strong emphasis on economic issues (especially with regards to 'Air' and 'Water'), to a certain extent neglecting social indicators. It is surprising that the economic indicators are brought up relatively evenly, while the environmental focus is mainly restricted to 'Air' and 'Water,' and that of the social aspect is 'Port working environment' ('Fire and explosion prevention').

An examination of the differences in interest between the experts based on their occupations indicates that researchers emphasise the environment, are especially concerned about air and water. Also, the experts from port companies are relatively more interested in economic and environmental factors in addition to citizens' living conditions and port working environments. None of the other occupation groups differ in their interests so markedly, chiefly focusing on 'Air' and 'Water,' followed by economic aspects such as 'Port operational abilities.' The changes made to the theoretical sustainability framework based on the interviews will be discussed in Section 6.2.

4.7 Summary

This chapter discusses the qualitative empirical aspect of the study with semi-structured interviews. In order to ensure the results were accurate, the researcher then conducted pre- and post-interview panel meetings with experts. Then, this chapter suggests a post-interview holistic sustainability framework as a foundation for further analysis, after having ensured of the sustainability groups and indicators' accuracy that were included.

Chapter 5 Quantitative stage: quantitative data collection and analysis

Following the sustainability framework that was established in the light of the interviews, this study will now embark on the multi-criteria decision-making stage to take a deeper look at into the factors that form the framework to discover the interrelationships between the indicators. Due to the large number of confirmed indicators of sustainability, this stage is needed to prioritise the factors and emphasise the most crucial ones, given that the relevant authorities and employees may have limited power to achieve every single indicator as a result of limited funds, operational ability, and time. The goal of this chapter is to extend and add value to the findings from the qualitative stage, and this chapter discusses the methods used to prioritise the indicators and outline the interrelationships.

5.1 Introduction

This section provides an overview of the features and expectations of the quantitative stage, and includes an introduction of the methods of multi-criteria decision-making (MCDA) that have been used, and how these methods were selected to enable prioritisation of the sustainability indicators and outline the interrelationships. The methods that have been used are AHP, TISM, and MicMac (the Matrice d' Impacts Croises-Multiplication Applique an Classment, or the 'cross-impact matrix multiplication applied to classification').

This chapter starts with an introduction to the MCDA and its commonly used methods, and then explains why AHP, TISM, and MicMac methods were chosen, along with their implications and results. The outcomes of the AHP method will influence the second and third layers (the sustainability groups and indicators) of the practical framework. The TISM and MicMac approaches will be used to discuss the second layers only.

The AHP stage seeks to achieve the following purpose:

1) To visualise an AHP hierarchy of oil port sustainability.

2) To prioritise the sustainability indicators.

TISM is used based on the results of the interviews and is aimed to add further value to the interview results, identifying the interrelationships between cross-sectional sustainability groups. Another benefit of TISM is that AHP only provides rankings of the importance of the aspects of sustainability, but no analysis of interrelationships, and TISM is therefore used:

1) To identify the cross-sectional relationships between indicators

2) To form a model of flow of the influence of the indicators

3) To recognise the main reason why one factor affects another.

Lastly, this chapter introduces how MicMac has been adopted to identify the nature of the sustainability groups. This is then compared to the interview and AHP results to extract the most crucial groups that should be prioritised during oil port daily operations, as discussed in Section 6.5. The main issue that has been addressed is:

- Which aspects of sustainability have the most driving power (Section 5.2.3.2).

To extend and add value to the qualitative research findings, this chapter seeks to fulfil the research objectives of identifying the most crucial sustainability indicators, and discovering the interrelationships between the cross-sectional factors.

5.2 Multi Criteria Decision Analysis (MCDA)

This section introduces the MCDA and justifies the use of the MCDA methods. MCDA is a general term for a number of methods including AHP, Keeney's value-focused thinking (VFT), and the technique for order preference by similarity to ideal solution (FTOPSIS), the fuzzy analytical hierarchical process (FAHP), TISM, and MicMac, among others. MCDA is designed to solve issues by outlining suitable decisions in complicated situations, and also supports the structure and organisation of complicated issues (Wątróbski, 2016; Eikelboom et al., 2018; Kelvyn, 2011). It could be considered a way of facilitating the decision-making process by providing decision-makers with a particular set of alternatives. In recent years, MCDA has been often adopted in business and management settings, and in studies that are relevant to shipping and maritime, such as how to evaluate green port systems through AHP.

Table 16 Various MCDA methods

Method	Sources	Description
AHP	Saaty (1980)	AHP aims to generate different perspectives of expert opinions systematically and accompanied with scored evaluations to form a hierarchy system.
Fuzzy AHP	Van Laarhoven & Pedrycz (1983)	Fuzzy AHP aims to achieve the same goal as AHP, but with a scoring system of more generated marks.
ANP	Saaty (1996)	Through the clusteration of the criterions, and decisions are influenced and based on the AHP concept.
ISM	Cartwright et al (1965)	It aims to identify and organise the contextual relationship and interactions across the whole system, and then transforming the data into a comprehensive and visibly well-defined model.
TISM	Nasim (2011)	TISM aims to achieve the same goal as ISM, only wth one more function of illustrating how the interrelationships exist.
Fuzzy Set Theory	Zadeh	Fuzzy set theory examines the elements in binary terms per a bivalent condition to see whether it belongs to the set or not while allowing gradual assessment of data.

As can be seen in Table 16, MCDA offers a number of different methods. In this study, AHP, TISM, and MicMac have been chosen because they fit the particular needs of this research. There are two goals for this stage of the study: To extract the most crucial sustainability indicators, and to identify the interrelationships between the factors of sustainability.

AHP is a commonly used tool in the shipping and maritime field, and ranks the indicators based on their importance to show the relative significance of each factor. However, because AHP is unable to show the interrelationships between the factors, and especially cross-sectional factors, TISM has been used to do so, and thereby enrich the outcomes of this study. Finally, the MicMac tool is used to extract the most crucial indicators.

The reasons why AHP, TISM, and MicMac will be used in this study can also be explained by looking at all the MCDA methods mentioned. In Figure 28, the left-hand methods coloured in orange have regularly been in the literature in the field; those marked in red on the right-hand side match the two goals of this stage; and those at the bottom are neither often regularly in the field, nor do they match the goal of this stage of the project. The intersecting methods (marked in blue) are AHP, TISM, and MicMac, and they are therefore considered the most suitable methods for this stage of the study, due to their proven effectiveness and appropriateness.

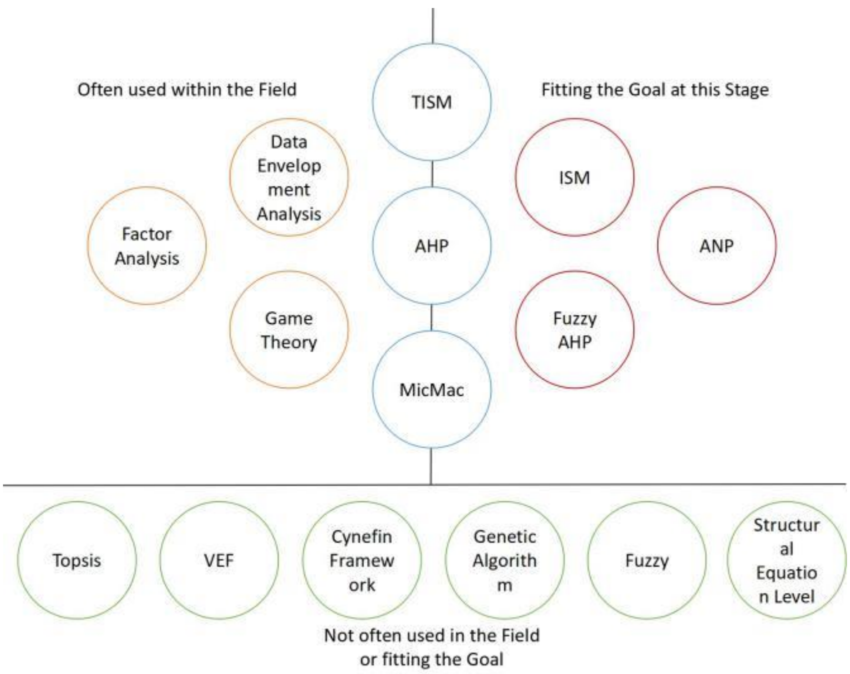


Figure 28 The MCDM methods’ appropriateness for this study

In the following sections, the applications of each chosen method will be outlined.

5.2.1 The application of the AHP method

5.2.1.1 Introduction to the AHP method

This section will discuss AHP in detail. The AHP method was first developed by Thomas L. Saaty in 1971 (Saaty and Vargas, 2006[b]) to assist in the solution of multi-criteria issues that contain a large amount of information. In recent decades, AHP has been proven to be an effective approach to analyse issues that contain complex data. It has also been widely used in the field of shipping, such as green port evaluation studies.

AHP has been frequently used as and is considered an appropriate tool to solve complicated data-based issues. AHP requires survey participants to make judgements about the relative importance of each criterion (in this case, the various facets of sustainability). As a result, AHP will produce a ranking of the criteria, based on the overall preferences of the decision-makers.

This method has been used to broaden existing knowledge in multiple fields since the 1970s, such as business management (e.g. determining HR strategies) (Saaty et al., 2007), engineering (e.g. selecting a bridge design) (Pan, 2008), economics (e.g. policy evaluations) (Basak and Saaty, 1993; Qureshi and Harrison, 2003), education (e.g. modelling the admission process for graduate business schools) (Saaty, 2007), shipping (Tseng and Cullinane, 2018; Guo et al., 2010; Jiao et al., 2016; Wan et al., 2010), and port performance evaluation (Chiu et al., 2014; Zhu, 2014; Liao et all., 2016; Li and Yang, 2010; Lirn et al., 2013; Jiang et al., 2017).

An example of a typical AHP model is presented in Figure 29 below.

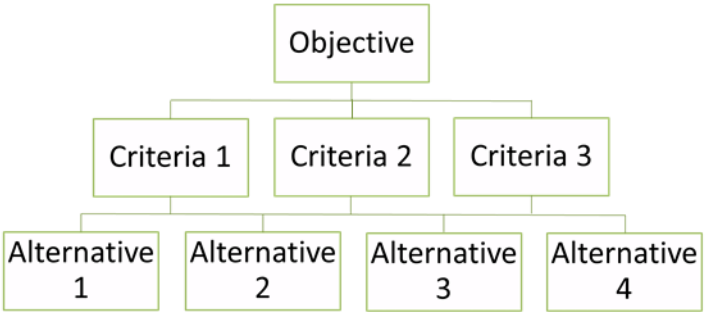


Figure 29 An example of an AHP model (Saaty, 1971)

As can be noticed from the above example, AHP is a hierarchical structure led by an objective, which is supported by the criteria and alternatives. The combination of different 'sets' of criteria would be considered as the evaluation process of selecting the 'best choice (alternative)' to achieve the goal (Objectives). The 'best choice' for the decision maker is made through the pairwise comparison between criteria. In other words, AHP is formed by 'classes' and 'components' to obtain a structured system. In addition, factors in each of the levels are independent of other layers (not comparable).

There are several points that need to be noted when applying the AHP method. Firstly, it is crucial to understand the terminological concepts: 'Objective' refers to the goal for conducting this research; a 'decision criterion' is a variable used to prioritise one choice over others; and a 'decision alternative' represents proposals that are available for choice. When using the AHP method, the decision-maker is required to compare items in pairs in accordance with the criteria, using a score of 1-9 (Wind and Saaty, 1980). However, due to the large number of items and comparisons needed, it is possible for inconsistencies to arise in these comparisons. For instance, if the criteria A is n times more important than B, and B is m times more important than C, then theoretically, A should be n*m times more important than C. Nevertheless, it is likely that the participants may give other responses, such as 'C is z times more important than A.' To ensure that the survey result is logical, inconsistency ratios should be calculated for each matrix to avoid such errors. To ensure the accuracy of the results, the ratio values should be kept within an acceptable range (<0.1). More details regarding the AHP analysis/calculation process used in this study are presented in Section 5.2.1.3.

In this study, the decision criteria are the three aspects of sustainability (the environment, the economy, and social factors), while the first sub-criteria level is the sustainability groups (such as air, HR, and citizens' living conditions) that pertain to each aspect. Lastly, the indicators of sustainability (such as CO2, the NO category, and knowledge development) are the second sub-criteria level. This research does not make use of alternatives to the AHP hierarchy because the main purpose of this stage is to highlight the most important sustainability indicators for daily port operations, rather than choosing the best performing port. In future research, alternatives may be added when evaluating the sustainability performance of multiple oil ports. In summary, this model involves three criteria, 14 first level sub-criteria, and 64 second-level sub-criteria, as outlined in Figure 30. The facets of sustainability for each criteria level are compared in pairs to find out the relative importance of each factor within its group.

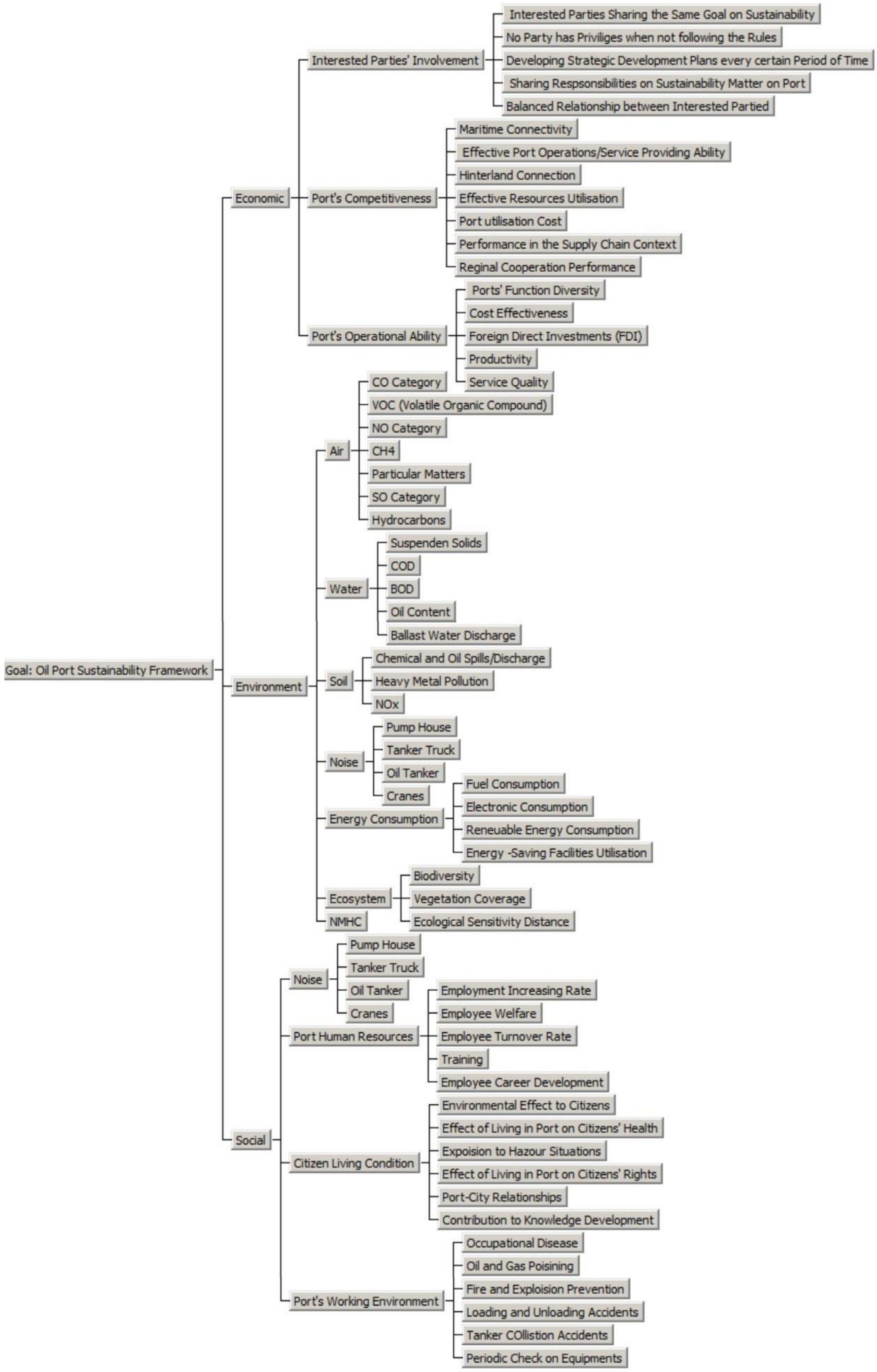


Figure 30 The AHP hierarchy

AHP is a rigorous quantitative method because the results are generated after a series of complex mathematical calculations. The scholars who have contributed to the development of AHP have simplified the calculation process to ease and expand its utilisation by reducing the calculations to a few simple but organised steps that ensure accurate and reliable results, but requiring less complicated mathematics. For this reason, AHP is not only available to all scholars, even those with less professional mathematical knowledge, but remains a reliable quantitative research method.

These advantages have significantly increased the popularity of AHP. However, one limitation is that the results are subjective because the data-gathering process is based on the subjective comparisons made by experts, without quantifiable standards and metrics. AHP is therefore not considered a ‘pure mathematical method,’ but rather relatively precise, reliable, and quantifiable. To overcome this issue, this study provides the participants with a basic guideline to quantify their scores and in this way, AHP not only enables more detailed results than the fuzzy AHP method, but also minimises the problems created by the absence of a scoring standard.

Furthermore, the AHP results of this study can be compared to the results in the existing literature because they are based on the same research method. This being so, the contribution to knowledge made by this research to the field of port sustainability, and the differences between sustainability in oil ports and other types of ports, can be compared to results obtained by other methods.

5.2.1.2 Analysing the AHP data with software

This section determines the most suitable AHP data analysis software.

<u>Potential software choices</u>

Due to the complicated mathematical calculations required by AHP to calculate the weight and consistency ratio (C.R) of the various facets of sustainability, it is very hard and inefficient to analyse the data manually, especially when a large number of criteria and participants are involved. This study will use the data analysis software that was specially developed for AHP: Expert Choice (Ishizaka and Labib, 2009; Russo and Camanho, 2015).

This study has considered a number of online applications such as Survey Monkey to input AHP questions, but most such applications do not support more than 9 scoring criteria (in the case of this stage of the study, there are a total of 17 scores required, as shown in Table 19), making regular survey and questionnaire applications unsuitable for AHP surveys. AHP analysis friendly software have been developed, such as Expert Choice, Criterium, HIPEW 3, REBRANDT, and tools for Excel. According to Olson (2004), computer-based software can be easier and more efficient to use than manual versions, and this is especially true for AHP surveys that involve large amounts of data. For these reasons, computer-based analysis software has been used in this study.

Several applications have been designed specifically for the analysis of AHP surveys, of which Expert Choice is one of the most commonly used. Its features include easy accessibility, application, utilisation, and placement into the AHP survey process conduction, as well as to build up the complete AHP hierarchy.

Criterium is worth considering, being a new product that allows researchers to efficiently analyse AHP data in a spreadsheet.

HIPRE 3 is another such software package for AHP data analysis, and software enables comparisons between pairs, thereby providing different perspectives. In this way, decision-makers do not have to provide a precise ratio of the relative value of one element over another, but rather a range of relative advantages. HIPRE 3 has the advantage of providing an accurate preference range, rather than precise values, in comparison to other applications (Olson, 2004). However, this software does not meet the demands of this study.

REMBRANDT is a software package for AHP data analysis that uses geometric means rather than eigenvalues to calculate weights, adopting a logarithmic scale instead of the traditional 1-9 system. Olson (2004) states that REMBRANDT offers technical support to researchers who have issues and queries regarding the approaches incorporated into the AHP method.

In addition to software specially designed for AHP data analyses, other general packages such as Excel can also be used for the same purpose. Unlike the above-mentioned software, Excel has the advantage of costless accessibility and easy utilisation, and also makes clear the logic that is used to provide answers. However, the disadvantage of Excel is the calculation summary of the eigenvalue λ_{max} and the consistency ratio of all participants, which need to be calculated individually.

A comparison between each software package is presented in Table 17, in terms of how they meet the requirements and demands of this study.

Table 17 A comparison of the various AHP data analysis applications

	Cost Efficiency	Automatic Calculation	Easy Application
Expert Choice	✓	✓	✓
Criterium		✓	✓
HIPEW 3		✓	✓
REBRANDT		✓	✓
Microsoft Office Excel	✓		

Table 17 indicates that Expert Choice is the most suitable software because it bests meets the most requirements of this study. Expert Choice and Excel are the only two that meet the criterion of cost efficiency. Excel is cost-effective because it is freely accessible from the researcher’s computer and laptop, while Expert Choice is freely available from the researcher's university. Differently, other software is not as cost efficient as Expert Choice.

Secondly, Expert Choice, Criterium, HIPEW 3, and REBRANDT all provide an automatic calculation function. This study requires the automatic calculation function for the C.I. because unlike smaller AHP surveys, this study involves a large number of pair comparisons, between over 60 indicators. For that reason, manually calculating the data would take a lot of time. Even though simple equations can be inserted into Excel sheets, it is complicated to calculate C.I, values and summarise results from multiple participants using Excel, so this software is also not an option.

All the software surveyed entails easy applicable, except for Excel. It is not only hard to establish a complex survey to distribute to participants in Excel, but another serious issue is that it would not be possible to summarise all the results from the various participants, given that there are 70 such responses to consider. For these reasons, Excel is not a potential tool for use in this study.

Because Expert Choice obtained the most 'ticks' in Table 17, it has been determined as the most suitable AHP data analysis tool for this study. Thomas L. Saaty, who is considered the father of AHP, has developed expert Choice. To make Expert Choice, he automated the manual AHP process to make it user-friendlier, running the complicated mathematics in the backend of the software (Ishizaka and Labib, 2009). Saaty also ensured that the software follows the same process as outlined in his publications (Saaty and Vargas, 2012).

Apart from the generic criteria listed in Table 17, Expert Choice has been chosen over other potential software packages due to the following features:

- It was created by the developer of AHP, making it likely that it has higher reliability and accuracy than other potential software.

- Export Choice can be used both online and on Windows, both of which follow the AHP analysis method in their calculations. However, given that not every expert participating in this study successfully opened the online questionnaire link to Expert Choice, the researcher used the Windows version in this study. The researcher first developed a questionnaire about oil port sustainability indicators in Excel (please see the finalised survey template, made following the receipt of pilot suggestions, in Appendix 6), which had a clearer structure than the web questionnaire, and then sent it to every participant via email (see Appendix 7). All participants were then invited to write down their answers in the Excel sheet, and return them to the researcher via email. After receiving the feedback, the results were manually input into Expert Choice on Windows.

- Expert Choice allows a larger number of criteria, sub-criteria, and participants than other software. Due to the large number (>60) of both criteria and participants, Expert Choice is the only accessible tool that meets the requirements of this study.

- When entering the comparative survey responses, the inconsistency ratio is calculated automatically and shown immediately on the next screen. This feature provides the researcher with an easy way to uncover invalid answers. If an inconsistency ratio was found to be higher than the acceptable range, the survey was returned to the participant for him/her to re-evaluate the answers. This feature was not available in most of the other AHP data analysis software.

5.2.1.3 The AHP data analysis method

This section illustrates the main stages of the AHP process. According to Saaty (1988), this can be illustrated as follows:

1. The problem is formed;

2. Relevant data are collected and measured;

3. The normalised weights are computed;

4. A synthesis-finding solution to the problem is established.

In the first phase, the survey goal is identified, and an AHP hierarchy is formed (Pun and Hui, 2001). Then, a more accurate set of criteria and sub-criteria can be determined to enable precise measurement.

In the second phase, the relative priorities of the criteria and sub-criteria are measured. This is done via the mutual comparisons between each of the indicators at the same level. After receiving feedback, the C.R examined to ensure the validity of the feedback that has been received. After the feedback has been validated, the weights can be calculated and as a result, the relative priorities of the sustainability indicators can be determined.

In summary, the AHP survey is formed by multiple sets of paired comparisons; this procedure 'lifts one and then lifts another and then back to the first and then again, the second and so on until each pair of decision elements have been formulated to the relative weight' (Saaty, 1980). In the second phase, it is crucial that participants can quantify their ideas into scores (1-9) based on a shared standard, and to provide answer that are logically valid. Participants were given a standard scoring system to avoid confusion and different definitions in the scoring system. This was done in the Excel question sheet, as shown in Table 18).

Table 18 The AHP survey measurement standard, Source: Saaty, 1988

Measure scale	Definition	Description
1	Equal importance	Two factors contribute equally to the objective
3	Weak importance of one over another	Experience and judgement slightly favour one over another.
5	Essential or strong importance	Experience and judgement strongly favour one over another.
7	Very strong or demonstrated importance	A decision element is favoured very strongly over another. Its dominance demonstrated in practice.
9	Absolutely importance	The evidence favouring one decision element over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values	When compromise is needed.
Reciprocals of above nonzero	If decision element i has one of the above nonzero numbers assigned to it when compared with decision element j, then j has the reciprocal value when compared with i	A reasonable assumption
Rational	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

After they had been sent the survey, the participants were asked to make judgements about the two-way comparisons to determine the importance of each object. Table 19 provides an example of the AHP survey, consisting of the AHP scores.

Table 19 An example of the AHP survey question, Source: Hassan, 2013

Row	Factor I	Evaluation																	Factor II
1	Man	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Material
2	Man	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environment
3	Man	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machine
4	Man	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Method
5	Material	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environment
6	Material	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machine
7	Material	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Method
8	Environment	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Machine
9	Environment	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Method
10	Machine	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Method

AHP is a logical method of ensuring answers' validity by calculating the C.R. Although many scholars have followed this format (Hassan, 2013), it has the disadvantage of being hard for participants to understand the logic behind it. As Excel matrix provides a clearer structure and eases the participants to trace comparisons they have made before. This study adopts Excel to list the questions (see Table 20) as the AHP survey format for the convenience of tracing logic and the ease to read.

Table 20 The AHP survey format in Excel

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
空气 Air	水 Water		
	土壤 Soil		
	噪音 Noise		
	能源消耗 Energy Consumption		
	生态环境 Ecosystem		
	非甲烷总烃 NMHC (Non-methane hydrocarbon)		
水 Water	土壤 Soil		
	噪音 Noise		
	能源消耗 Energy Consumption		
	生态环境 Ecosystem		
	非甲烷总烃 NMHC		

In the third phase, several steps are taken to quantify and compute the weights of each object, and examine the C.R of the results. Even though the calculation is done using the 'Expert Choice' software, it is still worth coming to understand how the weight and C.R calculation process is done.

In order to do so, the first step is to calculate the set of weights (W_1, W_2,…, W_n) after comparing all the pair comparisons, based on decisions between C_1, C_2,…, C_n. Then, the data are organised as a reciprocal matrix A, composed of numbers a_{ij}, a value that indicates the strength of decision element c_i, when compared with decision element c_j (Saaty, 1980). If there are more than two survey participants, the a_{ij} should use the geometric mean approach to combine the two-way comparison. The following set of equations makes up the matrix:

$$A = [a_{ij}] = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ 1/\left(w_1/w_2\right) & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ 1/\left(w_1/w_n\right) & 1/\left(w_2/w_n\right) & \cdots & w_n/w_n \end{bmatrix}$$

Where:

$$w_i/w_j = a_{ij} \text{ (for i, j = 1, 2, …n);}$$

This can then be transformed into:

$$w_i = a_{ij}w_j \text{ (for i,j = 1, 2, …, n)}$$

As suggested by Saaty (1988), an alternative, more realistic version can be outlined as follows:

$$w_i = \frac{1}{n}\sum_{j=1}^{n} a_{ij}w_j \quad (for\ i,j = 1,2,\dots,n)$$

This can be transformed into:

$$\sum_{j=1}^{n} a_{ij}w_j = nw_i \quad (for\ i,j = 1,2,\dots,n)$$

;

Which is also equivalent to:

A ∙ w = n ∙ w,

Where w represents the w_j column vector. Conclusively, the above equation and matrix can be presented as:

$$A \cdot w = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = n \cdot \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}$$

In this study, c_i and c_j represent each sustainability object, and a_{ij} is the weight pair-comparison between indicator categories c_i and c_j. Taking one response regarding the economic category result as an example, here, one of the experts stated that the 'Involvement of interested parties' (c_i) is twice as important as 'Port competitiveness' (c_j). Thus, a_{12} equals 2.

Nevertheless, W remains an unknown vector and cannot accurately produce the weights in matrix A. To resolve this issue, the eigenvector methodology is formulated as A * W = λ_{max} * W, where W is the eigenvector and λ_{max} is the maximum eigenvalue of matrix A.

According to Saaty (1988), 'the λ_{max} is being considered as the tool to estimate the consistency value as reflected in the proportionality of preferences. The closer λ_{max} is to n, where n represents the total amount of decision elements in the matrix, the more consistent is the result.' In a perfectly consistent matrix, the maximum eigenvalue λ_{max} is equal to n, and for a positive reciprocal matrix, λ_{max} is always greater than n. The maximum eigenvalue λ_{max} can be derived from above equation as follows:

$$\lambda_{max} = (\sum_{j=1}^{n} a_{ij} w_j)/w_i$$

After obtaining the maximum eigenvalue λ_{max}, the consistency index (C.I.) is calculated for the purpose of examining if the participant has followed the consistent scaling system, when completing the AHP survey. C.I. is defined as:

$$C.I. = \frac{\lambda_{max} - n}{n - 1}$$

It is common that after calculating the survey result, the C.I. emerges as higher than 0.1, especially when there is an increase in the amount of decision elements (ranks). For this reason, Saaty (1980) proposed a concept of 'random index' (R.I.), as shown in Table 21, to adjust the C.I. value under different ranks and produce a new value, termed the 'consistency ratio' (C.R.) to examine the consistency value of the holistic survey. The C.R. is taken from the ratio of C.I. to divide R.I. for the same order matrix, and it is acceptable for the degree of consistency of the hierarchy structure when C.R. is smaller than 0.1. The C.R. equation is C.R = C.I/R.I. In this study, a survey considered only acceptable when the C.R number is below 0.1.

Table 21 Random index table. Source: Saaty (1980)

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

The fourth phase involves 'the determination of a synthesis-finding solution to the problem' (Saaty, 1980). In this study, because port sustainability performances are not evaluated through the developed framework and obtained weighting, no calculation of alternatives is required, but only on the levels of the criteria. If the hierarchy structure fits the requirements of the consistency test, the evaluator can then calculate the weight of each decision element and rank its priority. The calculated priorities are then organised together via the hierarchical composition principle, and the resulting priorities of each level represent the intensity of the respondents' judgements as to the relative importance of the element represented in the hierarchy, considering the importance of and trade-offs among criteria.

In more detail, the four phases together can be further divided into eleven steps according to Saaty (1980), as follows:

1) Proposing the issue;
2) Putting the issue into a broad context, embedding it if necessary into a larger system including other factors, their objectives, and outcomes;
3) Identifying the criteria that impact on the problematic behaviour;
4) Structuring the criteria and sub-criteria to form a hierarchy;
5) In a multi-party problem, different levels derive a composite outcome;
6) Eliminating ambiguity to define every element in the system;
7) Prioritising the primary criteria by taking their impact on the system into consideration;
8) Clearly stating the question for two-way comparisons above each matrix;
9) Prioritising the sub-criteria, with respect to their criteria;
10) Entering two-way comparison judgments and their reciprocals;
11) Calculating priorities by adding the elements of each column, and dividing each entry by the total of the column. Averaging the rows of the resulting matrix, and obtaining the priority vector.

5.2.1.4 The AHP survey Design

This section outlines the most important aspects of designing an AHP survey.

Survey structure

A survey design consists of either quantitative or numerical metrics to describe the trend, attitudes, and opinions of a field of research (Creswell and Clark, 2007). Based on this, Tashakkori and Teddlie (2002) have outlined several advantages to using a survey:

1) It is an effective way of quantifying attitudes, opinions and extract other needed knowledge form the research participants;

2) It guarantees anonymity for respondents, is inexpensive, has a moderately high measurement validity, a well-constructed and validated questionnaire is very reliable, and facilitates data analysis;

3) In comparison to interviews and panel groups, surveys are more efficient at obtaining a lot of data from a large-scaled question set.

4) Because the results are quantitative and numerical, analytical software can be used to enhance efficiency and accuracy, while analysing the data (Saunders et al., 2009).

However, the disadvantage of the survey method is that it can only obtain limited information. This information is mostly limited to closed questions such as ‘how much,’ ‘which one,’ and ‘does or does not,’ rather than opened questions such as ‘how,’ ‘what,’ and ‘when.’ However, in this study, the only kind of answer required for the large-scaled questions in the two-way comparisons is to the question, ‘which one is more important.’ For this reason, surveys are the most appropriate and efficient method to use to gather the data needed for this study.

To obtain accurate and reliable answers, the researcher needs to be clear about the research goal, what data need to be collected, and who the targeted participants will be, before conducting the survey (Dawson, 2002). Furthermore, to ensure a sufficient response rate and sample size, the survey should be designed simply and effectively with a clear logical structure, a well-designed format, and clear presentation (Morse, 2003; Creswell, 2009).

Designing a questionnaire requires a set of clear and logical steps, which may vary according to the particular demands and nature of each research project. However, the main concept and the purpose of each step should generally remain the same. This study follows the steps outlined in Figure 31 to form and implement a survey design. The following content provides details of the survey design and development process used in this study.

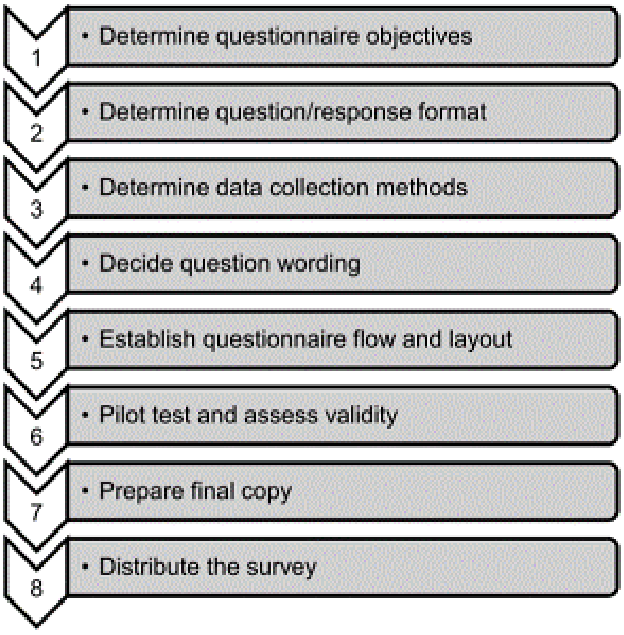


Figure 31 Survey design steps. Source: McDaniel and Fates (2006)

1) Determining the survey objectives

At this stage, the goal of the survey is to prioritise the importance of oil port sustainability objectives to establish a holistic Chinese oil port sustainability framework. To do this, quantitative numerical data are collected to rank the content based on the AHP method.

2) Determining the survey format

In this survey, nominal scales are adopted in the questions that are related to the descriptive data collection (such as the participants' eligibility to take the survey, their experience with and knowledge of ports and oil port sustainability, and their opinions). The remaining questions concern the participants' opinions of the importance and preference of the paired comparisons to rank the sustainability groups and indicators.

This design fulfils the need to obtain a ranked sustainability framework system (object) with the inclusion of the aspects of sustainability (criteria), sustainability groups (the first level of sub-criteria), and the sustainability indicators (the second level of sub-criteria) (see Figure 32). However, it should be noted that in this study, the criteria, first-level sub-criteria, and second-level sub-criteria are not linked together, which means that they have not been cross-examined. A cross-sectional paired comparison is not necessary for this study because in the practical holistic sustainability framework, each of section and group is expected to be covered to become 'holistic,' while the connections between each group are identified to emphasise the core groups (see Sections 5.2.2 and 5.2.3). Based on this background, each of the indicators is ranked in accordance with their relative importance to provide port managers and stakeholders with an overview of the prioritised framework. The results could allow them to choose which aspects of sustainability and indicators to use, according to their particular situations and demands.

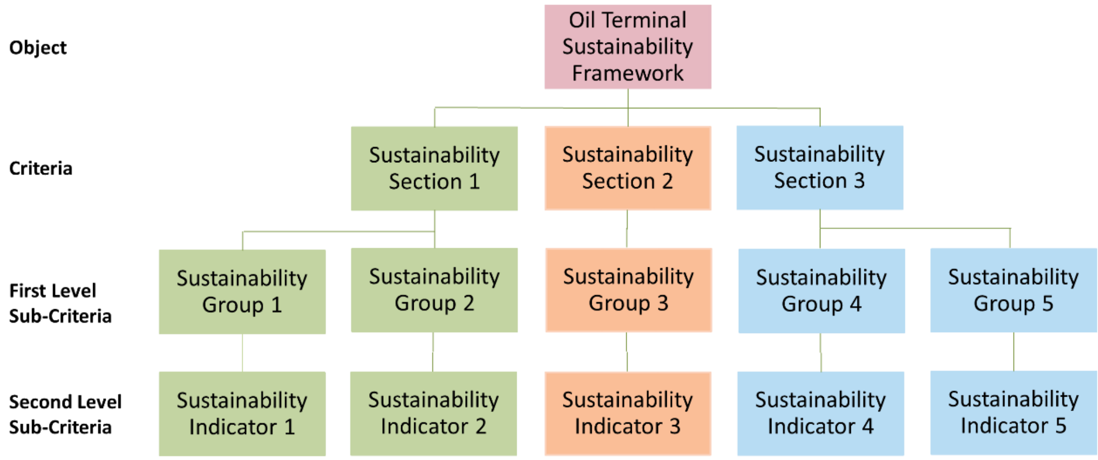
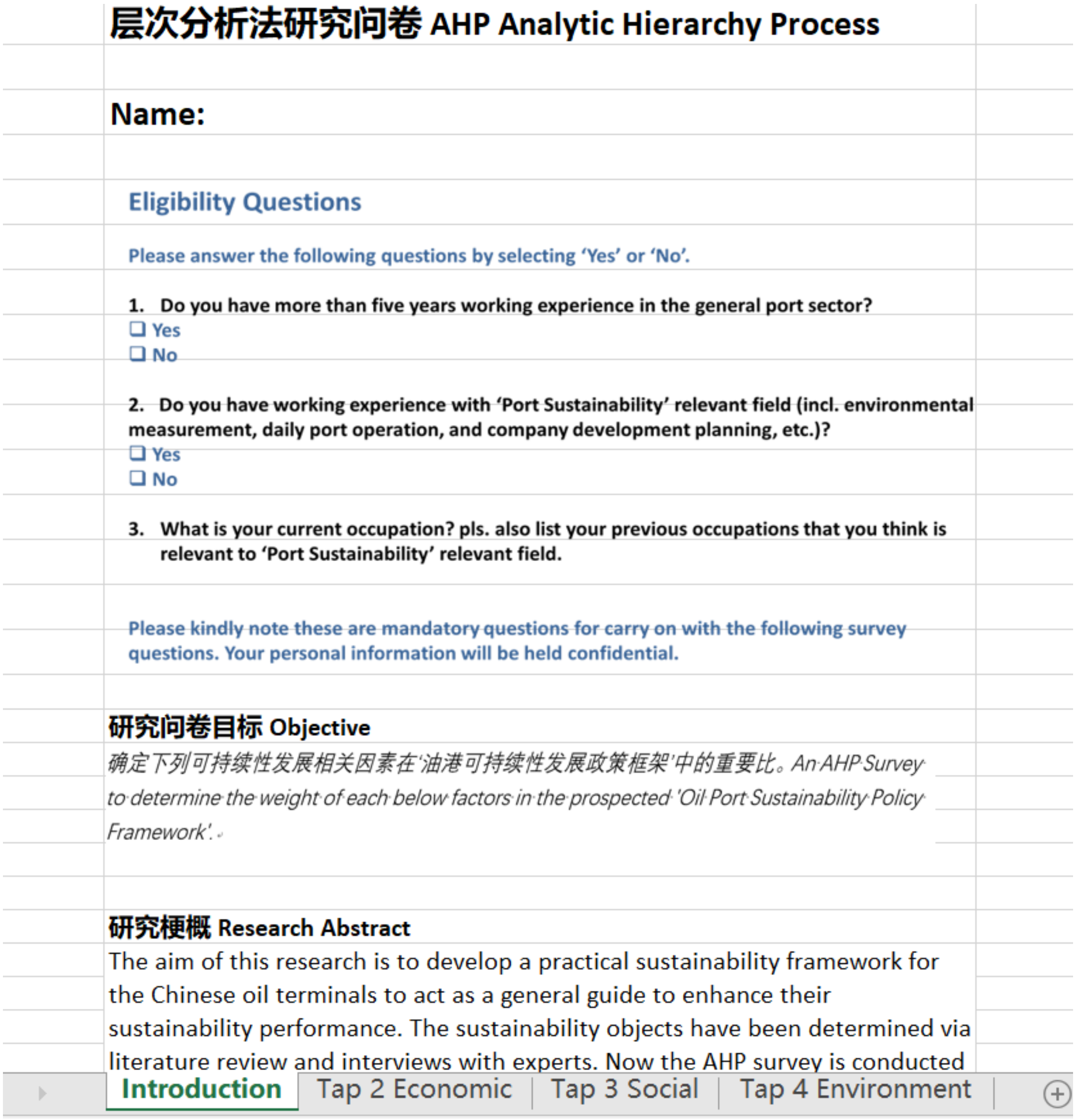


Figure 32 Overview of the AHP survey structure

To provide a clearer structure, this study divides the survey into four tabs, according to each aspect of sustainability. Each section is presented in a different tab in Excel, as shown in Figure 33 (Tab 1: Introduction; Tab 2: Economic; Tab 3: Social; Tab 4: Environment).



层次分析法研究问卷 AHP Analytic Hierarchy Process

Name:

Eligibility Questions

Please answer the following questions by selecting 'Yes' or 'No'.

1. Do you have more than five years working experience in the general port sector?
❑ Yes
❑ No

2. Do you have working experience with 'Port Sustainability' relevant field (incl. environmental measurement, daily port operation, and company development planning, etc.)?
❑ Yes
❑ No

3. What is your current occupation? pls. also list your previous occupations that you think is relevant to 'Port Sustainability' relevant field.

Please kindly note these are mandatory questions for carry on with the following survey questions. Your personal information will be held confidential.

研究问卷目标 Objective

确定下列可持续性发展相关因素在'油港可持续性发展政策框架'中的重要比。An AHP Survey to determine the weight of each below factors in the prospected 'Oil Port Sustainability Policy Framework'.

研究梗概 Research Abstract

The aim of this research is to develop a practical sustainability framework for the Chinese oil terminals to act as a general guide to enhance their sustainability performance. The sustainability objects have been determined via literature review and interviews with experts. Now the AHP survey is conducted

Introduction | Tap 2 Economic | Tap 3 Social | Tap 4 Environment

Figure 33 Overview of the AHP survey layout

The first tab includes descriptive questions regarding the participants' eligibility (see Appendix 8), objectives, and guidance. The reason for conducting this survey is introduced here, along with the research background, to present the participants with a brief background of the study (the research abstract). In this way, they will be better prepared to make more accurate judgements because they understand the focus of the study. Furthermore, participants are provided with guidance on how to complete the survey and express their opinions via the Excel matrices, while avoiding confusion and inaccuracies. This includes a description of the scoring system). Lastly, this section included the first-layer question: the comparison between the three aspects of sustainability (the criteria level). This comparison is done here, rather than in a new tab, because this is a general comparison of the sustainability groups and indicators. Moreover, because there are only three aspects of sustainability, only three mutual comparisons are required (see Table 22).

Table 22 Mutual comparisons between the aspects of sustainability

1. 综合 General			
对比表 Table			
因素Criteria		**重要比More Important**	**测评值Scale**
A	B	A或B A or B	(1-9)
经济 Economic	环境 Environment		
	社会 Social		
环境 Environment	社会 Social		

In the second tab, the detailed sustainability indicators will be mutually compared, based on the groups to which they belong. In addition, the questions are divided into three parts according to their essence, using a logical and a user-friendly approach for convenience. These three parts are the three aspects of sustainability, the sustainability groups (such as water, the involvement of interested parties, and noise), and the indicators of sustainability (such as CO2, pump house, and training). The Excel sheet structure of the survey allowed the participants to navigate either forward and backward with ease, adjusting answers if necessary.

In summary, the survey (see Appendix 6) is divided into the following parts, as shown in Table 23:

Table 23 The structure of the survey

Sections	Name	Content	Tab No.
1	General Guideline	Topic Background & AHP Implementation Guideline	1
	Descriptive Questions	Participants' Eligibility	1
2	Sustainability Sections (X 3)	Economy, Environment, and Social	1
	Sustainability Groups (X 14)	e.g. Water, Interest Parties Participation, and Sound, etc.	2 - 4
	Sustainability Indicators (X 69)	E.g CO2, Pump House, and Training, etc.	2 - 4

The first part of the survey briefly introduces the background and current situation of oil port sustainability to show the participants the focus of the study, and the perspective from which this study is carried out. Doing so can help the participants make more accurate judgements. In the second part, three questions are raised to ensure the participants' eligibility for participation in the survey: that their work is relevant to the topic at hand (given that the subject of oil port sustainability is too narrow, the criteria have been broadened professionals with experience of all aspects of port sustainability); the extent of their work experience (they must have at least five years of experience to ensure a solid understanding of the field, as well as the constantly changing nature of shipping and ports); and the institutions they have worked for (such as small-sized private companies, universities, or large government-owned institutions).

The AHP stage of this study is an extension to the qualitative phase by which the most important sustainability indicators are identified. For that reason, participants need to understand both the daily operations of oil tankers that berth at ports (offshore), and general port managerial issues (onshore). There are relatively few experts who have knowledge of all three aspects of sustainability, and relevant knowledge in both onshore and offshore matters. In total, five types of participants were contacted for this study: seafarers, government officials who deal with port investment management, university academics, port company employees, and research institution researchers who have at least some knowledge of all the areas in question. The results will be analysed in Section 5.2.1.6.

In the second part, the survey conducts more than 160 mutual comparisons to rank the aspects, groups, and indicators of sustainability on a scale of 1-9. Three mutual comparisons are made in the AHP section of this study:

1) The first-level comparison (the three aspects of sustainability) is done to show a general view of which aspect is considered the most important;

2) Two-way comparisons are made between the sustainability groups to find out which groups are considered more attention;

3) Two-way pairwise comparisons are made between the sustainability indicators to illustrate which indicators within each group is the most important.

As can be seen in Appendix 6, these segments have been structured logically to ensure quick and easy data collection. General instructions about the survey's purpose were explained in the cover emails, and a copy of the survey in Excel was sent as an attachment.

<u>Participant selection</u>

The background of the potential participants was researched on the Internet through sites such as LinkedIn, Facebook, and individual company websites. After choosing potential participants, the researcher sent them an email asking if they would agree to participate in the AHP survey. To ensure that they met the standards for eligibility, they were asked about their length of experience in the industry, whether they had worked in field relevant to the study, and their job title (this can be seen in more detail in Figure 34, which is written in blue text in 'Appendix 6, Tab 1'). The first two questions required answers of 'Yes' or 'No,' while the third was an open question that could be answered depending on the individual situation. All questions were obligatory, and surveys that did not complete all sections as required were considered invalid.

Eligibility Questions

Please answer the following questions by selecting 'Yes' or 'No'.

1. Do you have more than five years working experience in the general port sector?
❑ Yes
❑ No

2. Do you have working experience with 'Port Sustainability' relevant field (incl. environmental measurement, daily port operation, and company development planning, etc.)?
❑ Yes
❑ No

3. What is your current occupation? pls. also list your previous occupations that you think is relevant to 'Port Sustainability' relevant field.

Please kindly note these are mandatory questions for carry on with the following survey questions. Your personal information will be held confidential.

Figure 34 Eligibility questions for AHP survey participation

3) Survey instruments with emails

As mentioned previously, this study uses Excel to collect the AHP data and Expert Choice to conduct the data analysis, being the most efficient and appropriate choices for this study to gather information from busy port sustainability professionals.

There are several other primary data collection techniques that use surveys, such as by posting messages on professional websites, via telephone, and face-to-face or Internet-mediated approaches (Frazer and Lawley, 2000; Saunders et al., 2009; Dawson, 2002; Cooper and Schindler, 2003). The Excel survey method that has been used in this study does not fall into any of the above groups. Although Internet-mediated approaches can lead to more opportunities to obtain feedback from participants with diverse backgrounds, the probability of obtaining invalid answers also increases, and the researcher can only filter these out afterwards. Moreover, given that this is a passive approach, it might be more time-consuming than simply sending out the survey via email. Face-to-face or phone approaches are also likely to be inefficient because the AHP method does not only require logical responses, but also a great many two-way comparisons, which would be too time-consuming via these methods. In summary, emailed survey were deemed the best option for this study.

4) Deciding on the wording

The wording of the questions requires careful consideration to ensure they accurately express the intentions of the researcher, and to enable the respondents to accurately evaluate what they have been asked to measure (Saunders et al., 2009; Sekaran and Bougie, 2009). In this study, the importance of the wording mainly concerns whether the scoring guidelines are clear, and this information is included in the survey guidance. To avoid any misunderstanding or ambiguity, the chosen wording is kept as simple as possible, while to avoid bias from participants when they answer the questions, explanations of each 'proper noun' are included, especially for the groups and indicators belonging to economic and social aspects of sustainability (such as the meaning of 'stakeholder involvement'). Lastly, participants were encouraged to ask the researcher at any time if there is any confusion regarding the survey questions.

5) Establishing the survey flow and layout

The layout of the AHP survey requires careful consideration because logical responses are needed to ensure that the answers are valid (C.R. number < 0.1). Because there is no available software that calculates the C.R. number immediately after the data is input, it is crucial to design a format that allows participants to easily check and adjust their answers while completing the survey.

As mentioned previously, the survey background and guidelines about how to correctly complete the survey are located in the first tab of the Excel sheet (Section 1, Part 1) along with an example of how to complete the survey. The first part of the comparison (the aspects of sustainability) is in tab 2, followed by the second and third comparisons (for the sustainability groups and indicators) in tab 3 and tab 4, respectively. Tab 4 requires the most attention and patience because it contains the most two-way comparisons (> 70).

By this stage, however, it is expected that the participants will be accustomed to the format, and that this will minimise the chance that they will input illogical or invalid data. After completing the entire survey, the participants will send the survey back to the researcher for validity check. As mentioned previously, if the C.R. is above the threshold, the survey will be returned to the participants for modification, along with guidance concerning how to minimise invalid answers. Since Excel is used to fill in the survey, the participants – who are busy participants – will have the chance to save their progress, if they are unable to complete it in one go; after saving and exiting the Excel file, they will be able to carry on at the point where they previously stopped.

6) Pilot test and validity assessment

After making the required adjustments to the AHP draft survey, a pilot study was conducted to test its validity, accuracy, wording, and feasibility to eliminate potential issues before sending it to the participating experts. The pilot survey was sent via email to seven participants, who were asked for their opinions as to whether it met the above criteria. These participants were also asked to note the time it took them to complete the survey so the researcher could provide guidance to the experts who would complete the actual survey about the length of time it would take them (the average result for the pilot was 43 minutes). Finally, the pilot survey participants were encouraged to write down their opinions of the survey and anything they found confusing (such as unclear wording and illogical structuring) to enable potential improvements (please see Appendix 9).

The seven participants were randomly selected from the participants who had agreed to participate in the survey. If the C.R. number were to indicate that the main content is adequate, the answers would be considered valid unless any changes to the same content are suggested by more than three pilot participants. The pilot survey participants only mentioned confusion about the wording, and did not say anything about the structure or questions, so no questions were added or eliminated. The entire survey was therefore deemed valid, and the proper nouns that had caused confusion were modified.

The pilot study took about three weeks, from April 25 to May 15, 2017. Some participants took up to two weeks to complete the survey, but all responded and completed it. The survey consisted of all the two-way comparisons that needed to be evaluated to enable a hierarchy ranking of the aspects of sustainability, along with the groups and indicators.

7) Preparing the final copy

Given that the participants completing the pilot survey showed some confusion about the sustainability indicators, the researcher adjusted these before finalising the survey. Then, a cover letter was prepared that would accompany the survey in each email and LinkedIn message. These messages contained basic information such as brief background to the research project, an assurance that anonymity and confidentiality would be maintained, and the expected survey completion time (which was, according to the pilot study, 43 minutes on average). Despite its length, the researcher deemed it impossible to cut down the time because nothing in the AHP hierarchy can be removed. Finally, the email also outlined a brief structure of the survey to give the participants a general idea of what they could expect.

Finding potential survey participants

The survey participants were selected from multiple sources. They were chosen from lists of employees and managers at port authorities, companies, and association, research institutions, universities, Google Scholar, and social media such as LinkedIn to ensure they were all closely linked to the research field; in total, 223 potential participants were identified. After establishing the initial list, the participants were further filtered according to the selection criteria, as stated previously in the ‘participant selection’ part of this section (in total, 187 met the criteria). All 223 potential participants were sent the survey and cover letter; the 36 who has worked within the field but less than five years were nevertheless contacted because they were deemed potential backup participants in case the reply rate of the 187 was lower than 60% (112 feedbacks). A total of 125 of the 187 agreed to participate in the survey, so the 125 participants’ answers were taken (the 36 backup experts’ answer were thus not included in the result). In the end, 70 of the 125 responses were valid, and since 70 is enough for a reliable analysis, the 36 backup answers were not taken into consideration.

Not all the 223 potential participants were directly found via websites and social media; some were referred by the potential participants who the researcher contacted. This was acceptable because this study has a large topic coverage and requires expertise knowledge, which decreased the amount of potential qualified experts. To ensure the size and quality of the survey feedback, such referrals were considered an acceptable approach in this stage of data collection, and this method was adopted as one of the sampling techniques, as discussed in Section 3.6.2.

8) Distributing the survey

The survey participants returned their completed surveys over a period of 15 weeks (from April to August 2017). Participants who had not returned the feedback after one week were sent reminders via email and LinkedIn (Appendix 10), and another round of reminders was sent out if the participants had not responded seven days after the first (Appendix 11). The final reminder was then sent seven days after the second (Appendix 12). Respondents were removed from consideration if no reply was received after the third reminder.

Summary on the survey design

The survey was composed with appropriate wording and a logical structure for the convenience and efficiency of the participants, and the research design strictly followed the research question and the results of the qualitative interviews to ensure its accuracy and validity. Finally, the recommendations and comments provided by the participants in the pilot study, which mainly took the form of suggested further clarifications of the wording and proper nouns, especially for the economic and social aspects of sustainability, were taken into account to improve the quality of the survey to ensure that port sustainability professionals would provide sufficient and accurate responses.

5.2.1.5 The AHP data analysis

This section will analyse the AHP data results.

Response rate

Because the port sustainability experts who agreed to participate in the study were often busy, and that the research topic requires a large amount of professional knowledge, it was hard to obtain complete feedback from all professionals, or even find many experts in the field. After the initial contact with the 125 experts who agreed to participate the survey, three rounds of reminders were sent out during the data collection process. Excluding uncompleted and invalid answers, 70 responses were kept and used for further analysis, meaning a valid and satisfactory response rate of 37% (70/187).

The C.R. analysis

Figure 35 An example of the C.R. validity process

As mentioned previously, in AHP research, it is crucial to calculate the C.R. number after obtaining the results because the C.R. number indicates whether the answer is sufficiently logical to be taken into consideration. AHP is a logic-based method that requires answers that are mathematically valid. In this study, the C.R. ratios of every two-way comparison were calculated, and none was found to be over the limit (>0.1), meaning that all the answers obtained were valid and amenable for further analysis. Figure 35 provides an example of the C.R. ratio result of one two-pair comparison (<0.1), while the full C.R ratio validity calculation can be found in Appendix 13. In summary, the final results of the ranking of the sustainability aspects, groups, and indicators are all sufficiently logical to be considered valid answers for further analysis. The results are obtained using mathematical software, which ensures their accuracy and reliability.

In order to show the C.R calculation procedures, formulas mentioned in the previous section are used. What worth mentioning is that the following calculations are only presented for the purpose of show how the AHP data analysis software Expert Choice calculated the C.R results. The calculations in this study are all completed via the AHP data analysis software Expert Choice.

Taking the No. 5th seafarer participant's answers regarding the priorities of the groups under economic section were taken as an example. He indicates:

Interested parties involvement (factor j_1) has the same importance as port's competitiveness (factor i_2), and port's competitiveness (j_2) has the same importance as port's operational ability (i_3), which means:

$$A = [a_{ij}] = \begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 1 \\ ½ & 1 & 1 \end{bmatrix}$$

where:

$w_i/w_j = a_{ij}$ (for i, j = 1,2,..n);

which can also be presented as $w_i = a_{ij}/w_j$ (for i, j = 1,2,..n);

To apply the formula into the given priorities, the matrix becomes:

$$\underset{5/2 \quad 1 \quad 8/2}{\begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 1 \\ ½ & 1 & 1 \end{bmatrix}} = \begin{bmatrix} 1/_{5/2} & 1/1 & 2/_{8/2} \\ 1/_{5/2} & 1/1 & 1/_{8/2} \\ ½/_{5/2} & 1/1 & 1/_{8/2} \end{bmatrix} = \begin{bmatrix} 2/5 & 1 & 1/2 \\ 2/5 & 1 & 1/2 \\ 1/5 & 1 & 1/4 \end{bmatrix}$$

which allows further calculation of each line's average value:

$$\begin{bmatrix} (1/_{5/2} & 1/1 & 2/_{8/2}) / 3 \\ (1/_{5/2} & 1/1 & 1/_{8/2}) / 3 \\ (½/_{5/2} & 1/1 & 1/_{8/2}) /3 \end{bmatrix} = \begin{bmatrix} 0.63 \\ 0.63 \\ 0.48 \end{bmatrix}$$

followed by that, the initial matrix will need to times each line's average value to obtain the Eigenvector:

$$\begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 1 \\ ½ & 1 & 1 \end{bmatrix} \text{X} \begin{bmatrix} 0.63 \\ 0.63 \\ 0.48 \end{bmatrix} = \begin{bmatrix} 2.22 \\ 1.74 \\ 1.425 \end{bmatrix}$$

then, the Eigenvector will divide the average value:

2.22 / 0.63 = 3.52

1.74 / 0.63 = 2.73

1.425 / 0.48 = 2.97

Lastly, the λ_{max} will be calculated:

λ_{max} = (3.52 +2.73 + 2.97) / 3 = 3.07

followed by this result, the C.R number could be obtained via (R.I index see table 21):

C.R = CI / RI = {(3.07 – 3) / 3 – 1} / 0.58 = 0.03/0.58 = 0.05

As can be seen that the above C.R result is < 0.1, which means the feedback from this participant is valid.

Expert Choice data analysis results

After manually inputting the data into Expert Choice, the following holistic prioritised sustainability indicators were obtained:

Figure 36 Prioritised sustainability indicators

In Figure 36, the importance of the sustainability indicators has been prioritised, with the numbers representing the relative importance of each indicators. To organise the results into a more readable layout, a prioritised practical sustainability framework has been constructed, as shown in Figure 37:

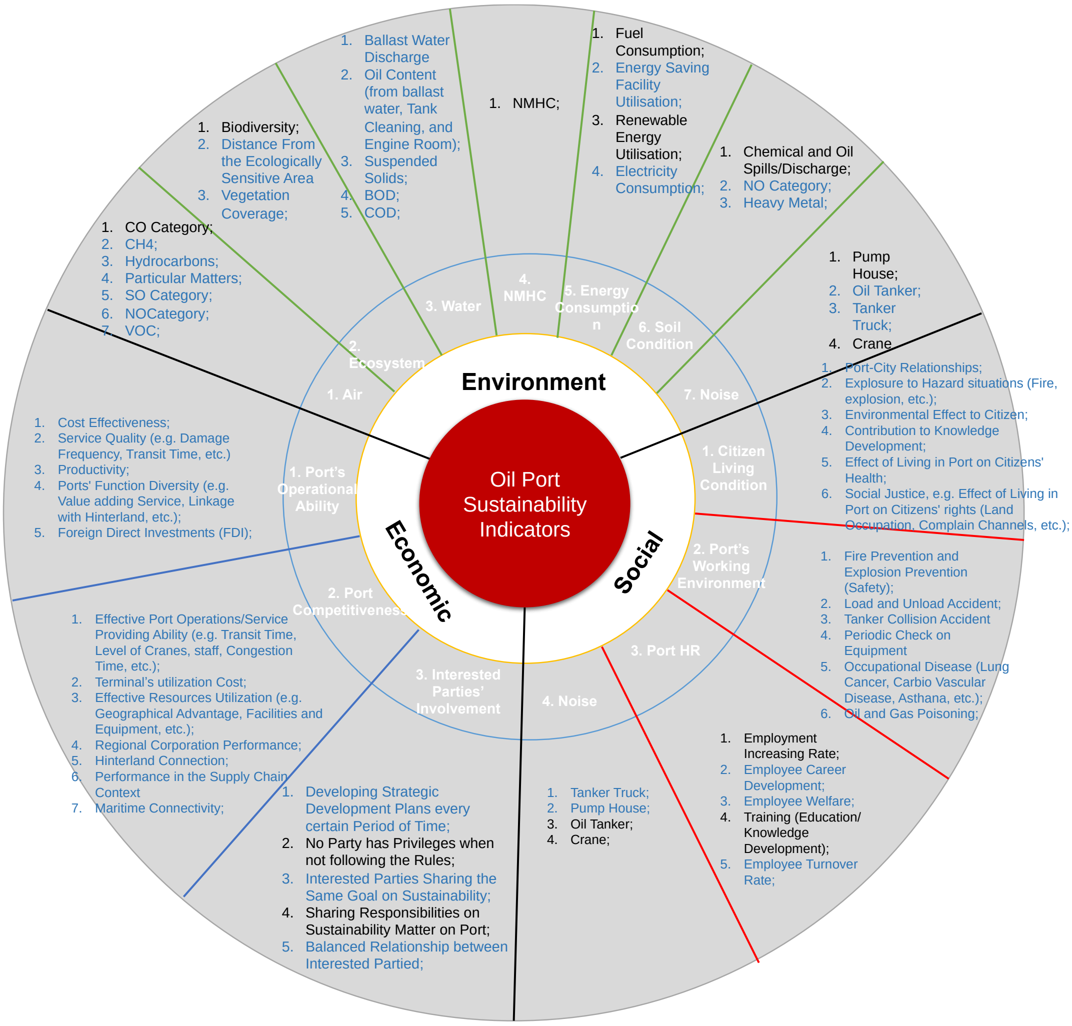


Figure 37 Prioritised oil port sustainability framework

The number before the indicators represent the ranking. Figure 37 shows that most of the rankings (marked in blue) have changed in comparison to the practical framework (Figure 25). However, it should be noted that the AHP ranking are not directly comparable with the interview rankings because interviews were only conducted with 34 interviewees, and therefore the interview rankings are only used as a confirmation. For instance, if the interview ranking happens to match with the AHP result, this double-confirms the importance of the matching sustainability indicators.

In the AHP ranking, the most important economic group is the port's operational ability (39.6%). Within this group, the most crucial indicators are cost effectiveness (26.4%), service quality (22.3%), and productivity (20.5%). This indicates that for the participants, maintaining a healthy operational system is the economic priority, rather than development. In the second most important economic group port competitiveness (35.2%), effective port operations (39.6%), port utilisation cost (18.9%), and effective resource utilisation (16.7%) are the top important ones. This confirms that competitiveness mainly requires maintaining a healthy operational system, not adding value adding or functional diversity. In the least crucial economic group, the involvement of interested parties (25.2%), the least important factor is maintaining a balanced relationship between interested parties (15.3%). This proves that even though a balanced relationship is a worthy pursuit, it is not necessary or possible to ensure completely balanced relationships.

Of the environmental groups, air is the most important (18.3%), and noise the least (7.8%). This indicates that currently, experts in the field believe that air pollution emissions are the most severe issue in oil ports. If accident occurs at an oil port, there is a great risk of explosions or fire. Noise is the least important factor noise pollution is not severe enough to harm the ecological system.

Of the social groups, citizens' living conditions (31.8%) are considered more important than the working environment at ports (31.3%), followed by HR (20.9%) and then noise (16%). The most important indicators in the working environment at ports group are port-city relationships (25.9%), exposure to hazardous situations (18.5%), and the environmental effect on citizens (15.3%), indicating that social welfare mainly come from economic development and aspects of daily life. The least important indicators are the from noise group: tanker trucks (28.4%), pump houses (26.3%), oil tankers (24.2%), and crane (oil loading arm) (21.1%). This is understandable, given that the noise usually occurs at locations that are far away from citizens' daily lives. More detailed explanations are illustrated in Section 6.3.

5.2.2 The application of the TISM method

5.2.2.1 Introduction to the TISM method

As mentioned previously, AHP does not allow a cross-sectional analysis of the priority and importance of the sustainability groups to be conducted, and therefore, this study requires an additional data analysis method to find out the cross-dimensional interrelationships among the groups. Of the various methodologies available, TISM has been chosen for this purpose.

TISM is a group-learning process that identifies and organises contextual interrelationships and interactions. The results allow the researcher to identify the relationships between various indicators under complicated circumstances by transforming data into a comprehensive and well-defined model (Attri et al., 2013; Sushil, 2012; Thirupathi and Vinodh, 2016; Ambikadevi et al., 2012; Poduval et al., 2015). This method interprets a small group decision to see the mutual relationship between factors and objects. It first specifies the relationships and overall structure, and then provides a graph for better understanding. In this way, TISM helps to impose order and direction on the complicated relationships between the various elements that make up a system.

There are several advantages to TISM that prompt researchers to choose this method instead of alternatives. The TISM method produces a graph that can help to solve complicated problems, and helps later scholars to understand the results obtained in the course of any one study (Mclean and Shepherd, 1976; Lendaris, 1981; Shibin et al., 2016; Dubey et al., 2015; Liu, 2016; Jena et al., 2016). Furthermore, TISM is based on a systematic process, which means that it is not only mathematically programmed, but also minimises subjectivity. It also has no requirement that participants understand the underlying process, before getting involved; all the instructions are straightforward, and can be easily understood in the introduction. In this way, participants are only required to understand the basic system and provide their answers.

Although there are many advantages to TISM, it also has some drawbacks. The most crucial issue for this research is that it becomes more difficult to use when the number of variables is increased. This means that researchers using TISM are best advised to limit the number of variables they employ. It is therefore important that for this study, less important factors are eliminated.

In summary, TISM is a suitable method for use in conjunction with AHP, and has therefore been chosen to add value to the research analysis (Attri et al., 2013).

5.2.2.2 How the TISM was used in this study

This section illustrates the most important issues that need to be borne in mind when using TISM. The nature of TISM requires the researcher to ask a small number of experts to form a panel group to achieve the research objective: to identify the relationships between the sustainability groups.

In order to obtain accurate responses, three matters need to be considered:

1) Why only the second layer (sustainability groups) will be investigated;

2) How many experts are to be included;

3) How to obtain responses.

The reason why only the second layer interrelationships are examined is because it is the most representative layer in this study. The second layer is connected to both the third layer, and therefore the results of this analysis can be used to explain phenomena in other layers by showing how the environmental, economic, and social aspects of sustainability are connected to each other. Furthermore, a first-layer TISM analysis would not provide much valuable information because it contains only three broad aspects of sustainability, making the second-layer analysis the most useful one to do.

To determine the number of participating experts, it is crucial to ensure that the experts have a solid understanding of each of the aspects of sustainability, with regard to oil port. Given that most of the participants from the interview stage have at least general knowledge of each area, potential panel members were sought from among the interviewed experts with relatively deeper knowledge of the research field. The potential panel members were then filtered for occupation, career length, work experience, and current field of expertise (see Table 24), and ranked based on the number of ticks generated in Table 24; the more ticks they obtain, the more likely they are to be considered for membership in the panel.

Table 24 TISM panel selection criteria

	Member 1	Member 2	Member 3	Member 4
Working Lengths				
Current Position				
Direct Relevance				
Served Ports (No.)				
Current Field				
Total Score				

As can be seen in Table 24, the criteria for selecting TISM panel members are similar to those of the previous two panels, the pre- and post-interview panels. The only change is that the ‘current field’ criterion has been added to ensure the chosen TISM experts have the most up-to-date knowledge in the field. These criteria are crucial for discovering the connections between the sustainability groups. Unlike the commonly accepted sustainability categories, which barely change over decades due to their nature, connections are easily changed as a result of the external environment (such as political impacts, new developments in technology, and changes to the business environment). For this reason, 'current field' has been added to ensure that the experts are making judgements based on contemporary oil port factors.

Another element that differentiates the TISM panel selection from the previous examples is the sample requirements. Previous panel members are expected to outline which knowledge is most fundamental to the study, being the people with the most knowledge and understanding in the field. However, at this stage, even though most potential panel members were derived from among the interviewees, the selection pool can be expanded to AHP survey participants with relatively deeper knowledge than others (those chosen ones have at least general knowledge of the research field). Because there are few experts who meet these criteria, the sample size is expected to be small in comparison to the methods (e.g. surveys, questionnaires, or interviews), which derive outcomes based on quantity. Even though this study only has three eligible participants in the end, there are previous literature also successfully produced reliable and convincing results with less than five experts. For instance, Geng et al (2018) and Mohany and Shankar (2017) all used less than five experts to participate the panel meeting. Even though the more experts participating the more reliable and representative the results will be, there are many limitations to gather a large quantity of experts (for instance, time limitation and schedule arrangements). In this research, the scale of accessible experts within the field is already restricted. Moreover, eligible experts with experience are even more limited. However, as previous literature also obtained reliable data from few experts, it proves that having few experts is generally acceptable for this method.

The experts were contacted via email (see Appendix 14) to gauge their willingness to join the panel, after assessing their suitability. In the end, three suitable participants were found who agreed to join the panel. The panel was designed to focus more on discussion of quality, which is mostly enabled by ensuring the participants possess sufficient knowledge of the field. For this reason, after rigorously assessing the potential participants, as outlined in Table 24, there was no need to increase the number of participants.

The TISM method requires the participants to reach a common understanding of the survey answers, and it was therefore important to find a convenient way for participants to share their ideas. The most common way to obtain unified answers are panel meetings and by using Delphi survey, and the researcher chose the former to obtain the required information.

Even though panel meetings can be held via Skype regardless of experts' different location and time zones, and it saves on travel costs, it has the disadvantage that it is harder to communicate than face to face, and it is not so easy to reach common understandings. Delphi is more useful when the sampling size is large (e.g. more than 15), for which a panel is not feasible. However, given that the sample size of this study is only three, it is more convenient to form a panel to enable smooth communication and unanimous responses. The only issue in this process is gathering the experts at the same location at the same time. Due to the geographical distance between the researcher and the experts, it would be costly and inefficient to oblige all participants to physically attend.

This issue was solved by using Skype; participants were sent an email (Appendix 14) to assess their availability to conduct the panel meeting on Skype. After receiving the replies, several potential meeting dates were proposed, based on their commonly available day. After confirming one date that worked for everyone, a specific time was suggested. When this was agreed, it was decided that the meeting would last for roughly 90 minutes to enable the experts to reach a common understanding.

5.2.2.3 The TISM method implementation

This section illustrates how the TISM data were obtained. To conduct this stage precisely and efficiently, the potential limitations and difficulties need to be identified.

Although TISM enriches the research analysis, it has the unavoidable limitation of interpretive bias, due to its subjective nature (Dubey et al., 2015; Ambikadevi et al., 2012; Poduval et al., 2015; Sushil, 2012; Kannan et al., 2007). This limitation should therefore be minimised, or at least maintained at an acceptable level (Dubey et al., 2015). However, many researchers have successfully adopted TISM into their studies, and it is still considered an effective and accurate method to obtain interrelationships. To minimise the limitation, the participants are asked to provide a justification for the interrelationships they suggest. When all the participants have come to an agreement, TISM is deemed to have been successfully applied.

In order to develop the TISM model, the following steps were accomplished:

1. Listing the elements

In the TISM model, two types of 'symbol' are normally used: letters representing the factors on the column and row sides (respectively, 'i' and 'j'), and letters marking the relationship direction between the two-way comparisons (V, A, 1, and 0).

Table 25 An example of the allocation of TISM indicators

	1 Interested	2 Port Com	3 Port Oper	4 Air	5 Water	6 Soil	7 Noise (En	8 Energy Co	9 Ecosysten	10 NMHC	11 Noise (S	12 HR	13 Citizen L	14 Port's W
1 Interested Parties' Invovlement														
2 Port Competitiveness														
3 Port Operational Ability														
4 Air														
5 Water														
6 Soil														
7 Noise (Envir.)														
8 Energy Consumption														
9 Ecosystem														
10 NMHC														
11 Noise (Social)														
12 HR														
13 Citizen Livelyhood														
14 Port's Working Environment														

In this study, ‘L’ is defined as the items in the columns of the survey matrix, and ‘R’ represents the items in rows. In order to show the relationships, four symbols normally chosen in TISM models: ‘V,’ ‘A,’ ‘1,’ and ‘0.’ In the two-way comparisons, V means that the impact has gone from factor ‘L’ to ‘R’; A means the influence has gone from R to L; 1 means the impact is mutual ; and 0 means that the factors are not related. Table 26 presents the relationships between the variables:

Table 26 The symbols and relationships between the factors. Source: Sandbhor and Botre (2014)

Symbol	Relationship Direction	Meaning
V	L to R	Denoting relationship from L to R
A	R to L	Denoting relationship from R to L
1	Mutually Impacting Each Other	Denoting relationship in both directions
0	No Relationships	Denoting relationship not existing

2. Developing the reachability structural (self-interaction) matrix

After identifying the relationships between the sustainability indicators, the values representing the relationships are converted into a structural self-interaction matrix to enable prospective calculations for the model (Dubey et al., 2015). To do so, the four symbols ‘V,’ ‘A,’ ‘1,’ and ‘0,’ which mean respectively ‘positive,’ ‘negative,’ ‘equal,’ and ‘none,’ are converted into quantified numerical values of 1 and 0, as shown in Table 27:

Table 27 Symbols showing the relationships between the factors. Source: Sandbhor and Botre (2014)

Symbol	Relationship Direction	Meaning
V	L to R	1
A	R to L	0
1	Mutually Impacting Each Other	1
0	No Relationships	0

In summary, if the value in the structural self-interaction matrix is V, then ‘i’ and ‘j’ have a positive correlation, and thus the i -> j value is 1, and the j -> i value is 0. This also shows that the ‘i’ indicator has a stronger influence than the ‘j’ factor; However, if the symbol is ‘A,’ then i -> j is negatively correlated, where the value is 0 and the j -> i value is 1. This means that the ‘j’ factor has a stronger impact. If the symbol is 1, it means the value for both i -> j and j -> i is 1, which implies that both factors are of equal strength. And lastly, if the value is ‘0,’ then both i -> j and j -> i have a value of 0, meaning that no relationship exists. In this way, the first such matrix is prepared and adjusted.

3. Reachability matrix and transitivity test

To finalise the reachability matrix, any transitivity that emerges, based on the opinions accumulated, is given a value of 1, using the colour red. In this way, any gaps in the matrix are filled, and the final reachability matrix is obtained.

4. Using the reachability matrix to regroup the variables

After the final reachability matrix has been outlined, the reachability and antecedent sets for each sustainability group are derived. The former identifies the set of sustainability groups that affect other such groups, while the latter identifies the set of sustainability groups affected by others. Subsequently, the intersection points between the various sustainability groups are identified and assessed, and those that have same reachability and intersection set values are given the highest hierarchical level within the interpretive structural matrix hierarchy. After identifying each high-level sustainability group, they are removed from consideration to identify the next level of groups until all groups have been located within the hierarchy (Attri et al., 2013).

5. Canonical matrix

After the hierarchical modelling of the indicators, the indicators at the same levels across the rows and columns are clustered together, and the drive and dependence power of each indicator is calculated. The drive power for each indicator is calculated by adding the number of 1s in the rows, while the dependence power is calculated by adding the number of 1s in the columns. In this way, the indicators can be ranked according to the strength of their dependence and drive powers.

6. Structuring the graphs between the variables

After generating links from the reachability matrices, the relationships can be visualised. The graph is organised in a hierarchy such that the top-level indicators are positioned at the highest position, followed by each of the subsequent-level indicators. The lowest level of indicators can be found at the lowest point of the diagram.

7. Conceptual inconsistencies

The final step to complete the TISM model is to ensure that no conceptual inconsistencies emerge. In case of any inconsistencies, the model must be modified to guarantee accuracy.

5.2.2.4 The TISM Template Design

This section illustrates how the TISM template is designed. The design of the TISM template differs from that of the interview and the AHP model. The main difference is the reason why each stage is conducted. During the face-to-face interviews, the aim is to form a practical sustainability framework, and this is done by examining the appropriateness of the theoretical sustainability indicators, and finding any new and unnecessary such indicators. To this end, the interview design was divided into three parts; a descriptive section (consisting of factors such as participants' experience, occupation, and position, to ensure their eligibility); close-ended questions ('yes' or 'no' questions that analyse the suitability of the existing sustainability indicators); and open-ended questions (to add new or eliminate unnecessary sustainability indicators).

The aim of the AHP stage is to conduct the two-way comparisons to find out the relative importance of each sustainability object and to this end, the template design has two sections: descriptive section (involving factors such as participants' experience, occupation, and position, to ensure their eligibility), and the two-way comparisons (to compare the relative importance of the sustainability indicators).

At this stage, the TISM model is constructed to discover the relationships between the sustainability groups. Similar to the AHP method, the TISM template is also presented in the form of a matrix in an Excel sheet (see Table 28). However, the difference between AHP and TISM is that the latter is in lack of a descriptive section, in that there is no analysis based on the different occupations or positions of the panel members. Furthermore, only one matrix is required for the TISM template to cover all questions (the AHP has multiple matrices because three layers of sustainability indicators needed to be mutually compared). In the TISM template, there are in total four types of answers (L -> R, R -> L, R $\neq$ L, and L = R), while AHP only has three types of answers (A > B, A < B, A = B). The TISM template document (see Appendix 15) was distributed via email to the three participants, initially to familiarise them with the questions. Then, the researcher collected the answers during the Skype group meeting after the experts had reached a common understanding about each question.

Table 28 TISM survey design

	1 Interested	2 Port Com	3 Port Oper	4 Air	5 Water	6 Soil	7 Noise (En	8 Energy Co	9 Ecosysten	10 NMHC	11 Noise (S	12 HR	13 Citizen L	14 Port's W
1 Interested Parties' Invovlement														
2 Port Competitiveness														
3 Port Operational Ability														
4 Air														
5 Water														
6 Soil														
7 Noise (Envir.)														
8 Energy Consumption														
9 Ecosystem														
10 NMHC														
11 Noise (Social)														
12 HR														
13 Citizen Livelyhood														
14 Port's Working Environment														

5.2.2.5 The TISM data analysis

This section outlines the results obtained from the TISM data analysis. Following the TISM, a structural self-interaction matrix (SSIM) is developed from the two-way comparisons (Table 29). The SSIM was then transferred into the initial reachability matrix (IRM), based on the following rule:

- Transforming the SSIM into an IRM made up of only 1 and 0 (Table 30).

However, since the IRM does not present transitive links, it was further developed into a final reachability matrix (FRM) to build up a holistic TISM diagram, following the Boolean calculation method. The FRM is shown in Table 31.

Lastly, it is not enough to see the relationships between the identified sustainability groups, and the level are categorised based on the FRM results. The columns with a value of 1 were recorded for both the reachability and antecedent set, and once the intersection of the reachability and antecedent sets are identical, the groups are noted in levels as per the sequencing level (from top to bottom). In the following iterations, the top-level groups are eliminated from the set, and this is continued until all levels have been determined. The division of the levels is shown in Table 32.

In this study, after five rounds of iterations and combining them with the FRM results, a TISM diagram has been developed, as presented in Figure 38.

Table 29 The structural self-interaction matrix

Initial Reachability Matrix	1 Interested	2 Terminal's	3 Terminal's	4 Air	5 Water	6 Soil	7 Noise (En	8 Energy Co	9 Ecosyster	10 NMHC	11 Noise (S	12 HR	13 Citizen L	14 Termina
1 Interested Parties' Invovlement		1	1	0	0	0	0	0	0	0	0	A	0	0
2 Terminal's Competitiveness			A	0	0	0	0	0	0	0	0	A	0	0
3 Terminal's Operational Ability				A	V	V	V	V	V	V	V	A	V	V
4 Air					A	0	0	A	0	A	0	0	V	V
5 Water						V	0	0	V	0	0	0	V	0
6 Soil							0	0	0	0	0	0	V	0
7 Noise (Envir.)								0	V	0	1	0	V	V
8 Energy Consumption									V	V	0	0	0	0
9 Ecosystem										0	0	0	A	0
10 NMHC											0	0	V	V
11 Noise (Social)												0	V	V
12 HR													V	V
13 Citizen Livelyhood														0
14 Terminal's Working Environment														

Table 30 The initial reachability matrix

Initial Reachability Matrix	1 Interested	2 Terminal's	3 Terminal's	4 Air	5 Water	6 Soil	7 Noise (En	8 Energy Co	9 Ecosyster	10 NMHC	11 Noise (S	12 HR	13 Citizen L	14 Termina
1 Interested Parties' Invovlement	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2 Terminal's Competitiveness	1	1	0	0	0	0	0	0	0	0	0	0	0	0
3 Terminal'st Operational Ability	1	1	1	0	1	1	1	1	1	1	1	0	1	1
4 Air	0	0	1	1	0	0	0	0	0	0	0	0	1	1
5 Water	0	0	0	1	1	1	0	0	1	0	0	0	1	0
6 Soil	0	0	0	0	0	1	0	0	0	0	0	0	1	0
7 Noise (Envir.)	0	0	0	0	0	0	1	0	1	0	1	0	1	1
8 Energy Consumption	0	0	0	1	0	0	0	1	1	1	0	0	0	0
9 Ecosystem	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10 NMHC	0	0	0	1	0	0	0	0	0	1	0	0	1	1
11 Noise (Social)	0	0	0	0	0	0	1	0	0	0	1	0	1	1
12 HR	1	1	1	0	0	0	0	0	0	0	0	1	1	1
13 Citizen Livelyhood	0	0	0	0	0	0	0	0	1	0	0	0	1	0
14 Terminal's Working Environm	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 31 The final reachability matrix

FinalReach	1 Interested	2 Terminal'	3 Terminal'	4 Air	5 Water	6 Soil	7 Noise (En	8 Energy C	9 Ecosystem	10 NMHC	11 Noise (S	12 HR	13 Citizen I	14 Termina	Driving Pow
1 Interested	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
2 Terminal'	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
3 Terminal'	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
4 Air	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
5 Water	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
6 Soil	0	0	0	0	0	1	0	0	1	0	0	0	1	0	3
7 Noise (En	0	0	0	0	0	0	1	0	1	0	1	0	1	1	5
8 Energy C	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
9 Ecosystem	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
10 NMHC	1	1	1	1	1	1	1	1	1	1	1	0	1	1	13
11 Noise (S	0	0	0	0	0	0	1	0	1	0	1	0	1	1	5
12 HR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
13 Citizen's	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
14 Termina	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Dependen	8	8	8	8	8	9	10	8	13	8	10	1	12	11	

Table 32 The division of the levels of the sustainability groups

Iteration 1	RS	AS	AS & RS	
1	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,6,10	
2	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,6,10	
3	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,6,10	
4	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,6,10	
5	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,6,10	
6	6,9,13	1,2,3,4,5,6,8,10,12	6	
7	7,9,11,13,14	1,2,3,4,5,7,8,10,11,12	7,11	
8	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
9	9	1,2,3,4,5,6,7,8,9,10,11,12,13	9	Level1
10	1,2,3,4,5,6,7,8,9,10,11,13,14	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
11	7,9,11,13,14	1,2,3,4,5,7,8,10,11,12	7,11	
12	1,2,3,4,5,6,7,8,9,10,11,12,13,14	12	12	
13	9,13,14	1,2,3,4,5,6,7,8,10,11,12,13	13	
14	14	1,2,3,4,5,7,8,10,11,12,14	14	Level1
Iteration 2	RS	AS	AS & RS	
1	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
2	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
3	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
4	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
5	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
6	6,13	1,2,3,4,5,6,8,10,12	6	
7	7,11,13	1,2,3,4,5,7,8,10,11,12	7,11	
8	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
9				
10	1,2,3,4,5,6,7,8,10,11,13	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
11	7,11,13	1,2,3,4,5,7,8,10,11,12	7,11	
12	1,2,3,4,5,6,7,8,10,11,12,13	12	12	
13	13	1,2,3,4,5,6,7,8,10,11,12,13	13	Level2
14				
Iteration 3	RS	AS	AS & RS	
1	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
2	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
3	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
4	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
5	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
6	6	1,2,3,4,5,6,8,10,12	6	Level3
7	7,11	1,2,3,4,5,7,8,10,11,12	7,11	Level3
8	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
9				
10	1,2,3,4,5,6,7,8,10,11	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	
11	7,11	1,2,3,4,5,7,8,10,11,12	7,11	Level3
12	1,2,3,4,5,6,7,8,10,11,12	12	12	
13				
14				
Iteration 4	RS	AS	AS & RS	
1	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
2	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
3	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
4	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
5	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
6				
7				
8	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
9				
10	1,2,3,4,5,8,10	1,2,3,4,5,8,10,12	1,2,3,4,5,8,10	Level4
11				
12	1,2,3,4,5,8,10,12	12		
13				
14				
Iteration 5	RS	AS	AS & RS	
1		12		
2		12		
3		12		
4		12		
5		12		
6				
7				
8		12		
9				
10		12		
11				
12	12	12		Level5
13				
14				

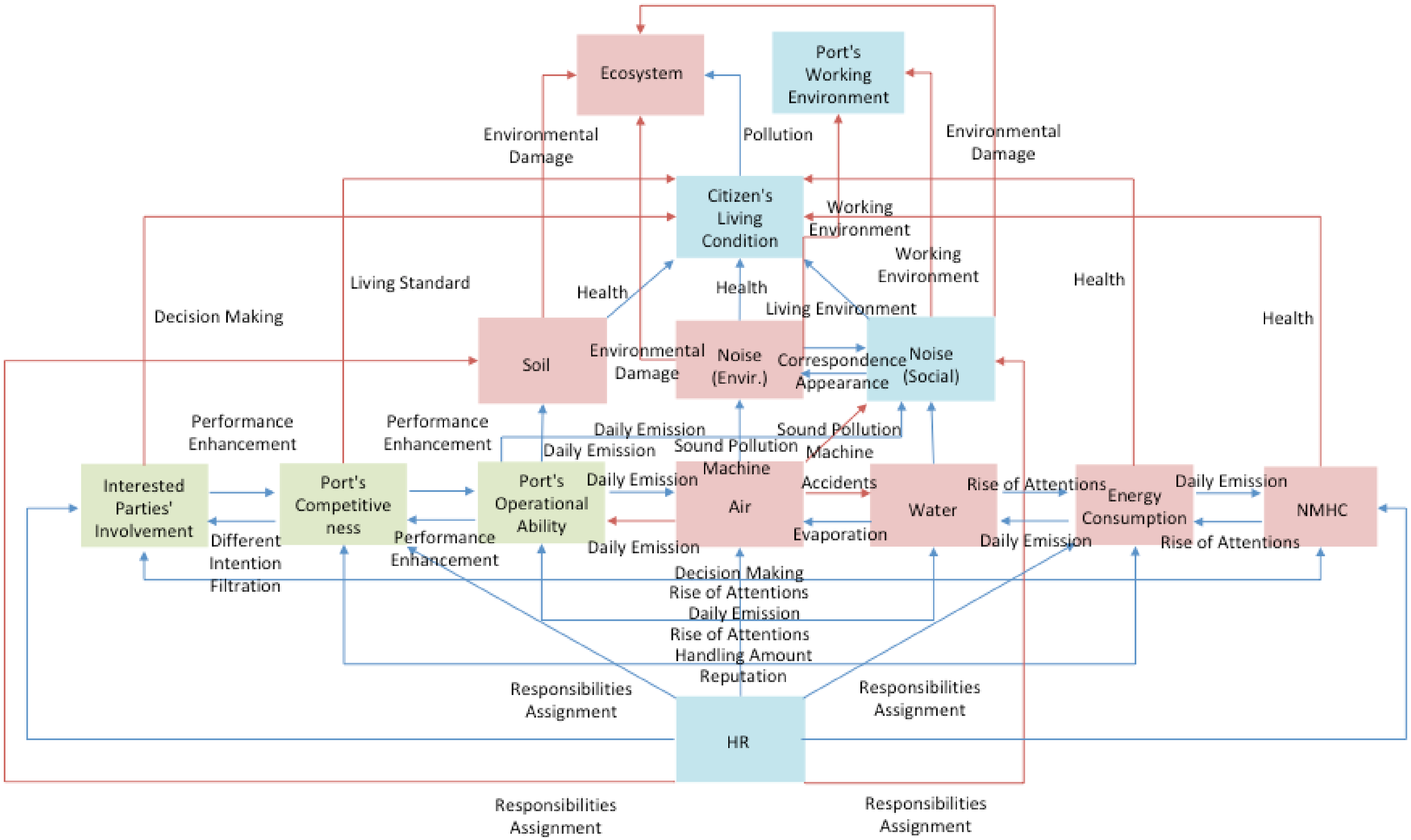


Figure 38 The TISM Diagram of Sustainability Groups

Rather than saying Figure 38 shows the strength of the connection (impact) between groups, it is more appropriate to say that Figure 38 shows the hierarchy of the sustainability framework. For instance, in this framework, HR is identified as the input of the system, which is directly or indirectly impacting the rest of the system. On the other hand, ecosystem and port's operational ability are the output of the system, which indicates that they can only be impacted by other groups but not impacting other groups. In a certain perspective, it can be said that HR has the broadest impact within the system while ecosystem and port's operational ability have the least impacts. However, this system does not show how much exactly one group is dependent to other groups via driving and dependency powers. Thus, MicMac method is used to show to what extend one group is connected to another.

To be more detailed, as presented in Figure 38, linkages and the relationships between sustainability groups are illustrated. The links can be categorised into two kinds: the direct and indirect links. Direct links are the ones that have been obtained during the panel meeting. Indirect links are the ones achieved after 'transitivity' calculation (Dubey et al, 2015). In this study, the blue links represents direct links, and the red links shows indirect links within the system. From the linkages we can see, that the sustainability groups are not only connected to their own section, but also cross-sectional. The words on the blue/red links are the reasons of why the groups are linked together. For instance, energy consumption is indirectly connected to citizen's living condition is because energy consumption indirectly damages citizen's health; terminal's operational ability is directly impacting air is because the more the port throughout increases, the more emission the port produces.

The economic groups, are interconnected, and also influence all the groups in the system (except for HR). Furthermore, they are impacted by approximately half of the groups, mainly by those within its own section, and environmental groups. This proves that the experts consulted believe that economic activity is the source of all environmental and most social consequences.

The environmental groups are also interconnected, and most (4 out of 7) influence all the groups in the system (except for HR), and all are affected by NMHC. In addition, they are all impacted by over half of the groups in the system, mainly by those from the economic-aspect groups other than environmental groups. These two share the common feature of being impacted by all economic groups, and at least a majority of their own group (4 out of 7, and are all affected by NMHC). Besides, economic activity is the source of all environmental consequences, showing that the 'air,' 'water,' and 'NMHC' groups are the source of damaging for the other environmental groups.

In the social aspect of sustainability, except for HR, none of the groups impacts more than five others in the system, while they are all impacted by almost every other group in the system, again except for HR. This indicates that in the experts' opinion, being the ultimate goal of any economic development or environmental protection, the social groups do not impact other sections much, but are only themselves impacted.

Lastly, a unique group, 'HR,' impacts every group in the system, and is not affected by others at all. This is surprising but also understandable, given that human decisions drive all economic, environmental, and social consequences. HR is the place where human decisions are made by choosing the leaders and determining the organisational culture (Kosiorek, 2016).

In summary, a clear structure has been extracted from the 'messy' sustainability groups. The outlined relationships between the cross-sectional groups will give port managers and stakeholders a clearer understanding of what can be changed, once the improvement goals are determined. These results offer any interested parties straight-forward guidance concerning which groups merit the most focus, during daily operations.

5.2.3 The MicMac analysis

5.2.3.1 Introduction

This section provides an overview of the MicMac method. After the TISM analysis, the MicMac test is conducted to further analyse the driving and dependency powers among the examined groups. Driving power refers to the power of how much a group in the system can directly/indirectly impact other groups. Dependent power refers to the power of to what extend a group will be impacted either directly or indirectly by another group. Then, depends on the dependency and driving power of each group, the groups will be located in a coordinate to see which section they belong to (linkage, autonomous, dependent, and independent) to further define their nature. However, all of the quantified numbers of dependent and driving power are relative as they are obtained from subjective panel members. In many studies, and especially those in the field of shipping, neither TISM nor MicMac are used. However, these methods can be extremely useful in providing extra information to enrich the practical framework by showcasing the relationships between sustainability groups, and further illustrating the most important groups by revealing their drivers and dependency power. MicMac adds value to this study by providing more evidence to form the 'must-have set.'

The MicMac method is based on the multiplication properties of matrices. After conducting the systematic analysis, the factors examined can be divided into four parts: autonomous, linkage, dependent, and independent factors. This division is based on their dependence and driving powers. The autonomous factors are those with weak driving and dependence powers, which means that they are relatively isolated from the whole framework, and probably have either few or no strong links. Differently, the linkage factors are those that have strong driving and dependence power, and are unstable because they can easily influence other factors or be affected. The dependent factors have weak driving power but strong dependence power, while the independent factors have strong driving power but weak dependence power. Against this background, a factor that has strong driving power is considered a 'key factor,' and pertains to either the independent or the linkage factors.

Given that the MicMac analysis is based on the results of the TISM analysis, the research design and steps do not differ, so the following section will present its analysis directly based on the TISM results.

5.2.3.2 Results from the MicMac data analysis

This section provides the results of the MicMac data analysis. After calculating the dependency and driving powers from Table 31 (page 188), the sustainability groups are categorised into four sections with different features.

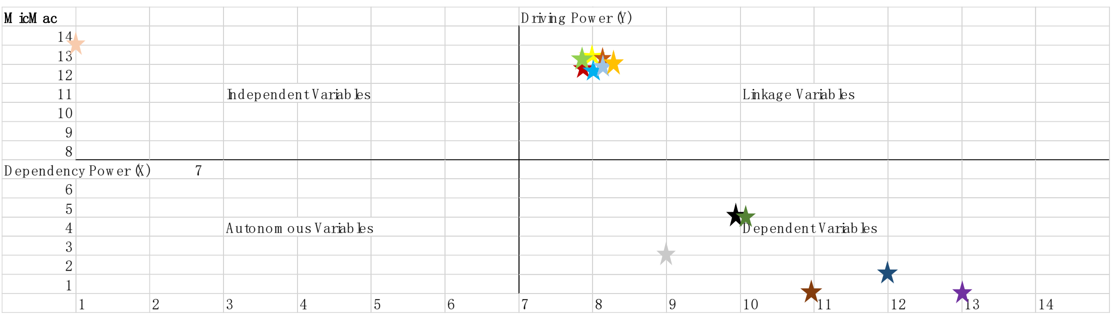


Figure 39 The powers of the sustainability groups

As shown in Figure 39, none of the sustainability groups are in the autonomous category, which means none of them is independent of the any others; the eight key groups are allocated to the independent and linkage groups. This reveals that most of the identified groups are connected with either high driving or dependency power. HR is in the independent group: The involvement of interested parties, port competitiveness, port operational abilities, air, water, energy consumption, and NMHC are in linkage group. Oil, noise (environmental), ecosystem, noise (social), citizens' living conditions, and port working environment are in the independent group). Further discussion regarding this will be illustrated in Chapter 6.

5.3 The 'must-have' set of indicators

In this section, the results of the three empirical methods employed in this study – the interviews and the AHP and MicMac tests – are compared to form a 'must-have' set of indicators for ports to ensure they develop sustainably. As can be seen in Figures 39, Figure 40 and Figure 41, the most crucial groups have been generated from the empirical results outlined in detail in this study.

The number of times the various factors are mentioned in the interviews can be used to contribute to this set because this indirectly reveals what the participating experts think of the relative value of the sustainability groups; the more often the groups are mentioned, the more value the experts consider them to have. Furthermore, the results of the AHP test are relevant because they directly reveal the experts' opinions of the relative importance of the sustainability group, while the MicMac results are included because they show which groups have impacted the system the most. On the other hand, the TISM result is not included because the power of each sustainability group that is obtained via MicMac is based on the TISM results, which means that the TISM and MicMac results partially overlap. However, not all the groups with the most connections in the TISM diagram are included because they are not necessarily the most important ones, given that some of the connections might be indicating the impacts on them, not the impact that they have.

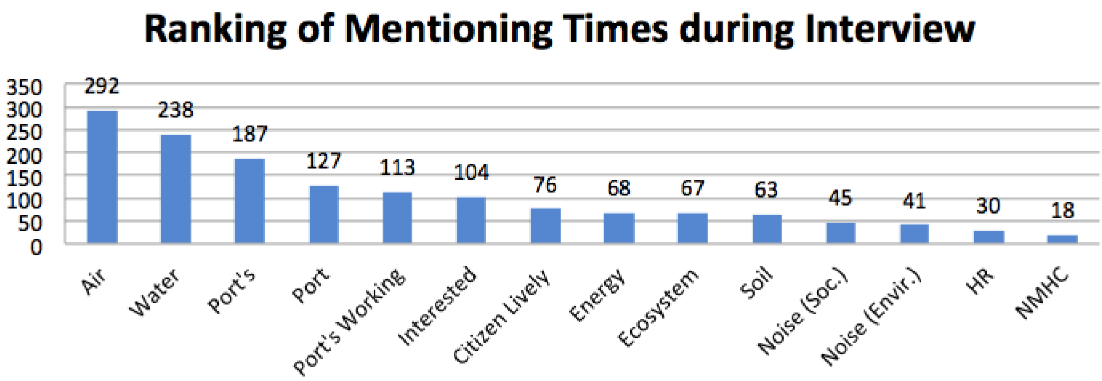


Figure 40 How often the indicators were mentioned during the interviews

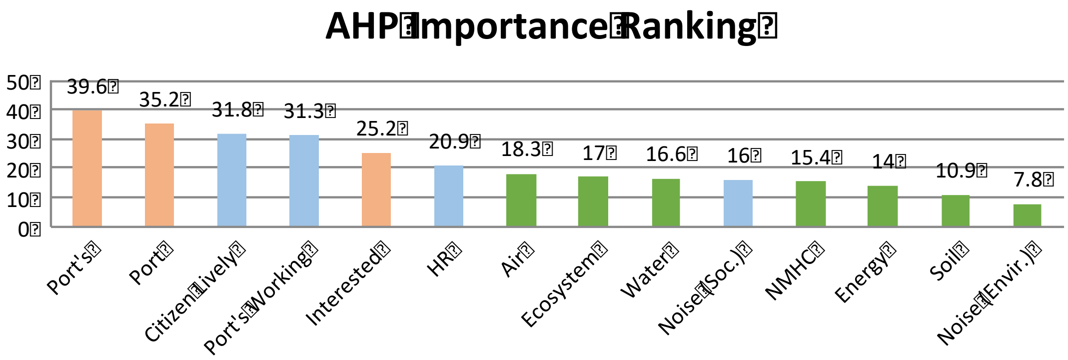


Figure 41 The AHP ranking, by importance

The results of these three methods have been summarised in Table 33. Four groups have been included for two reasons: the top four groups make up the top 30% of the 14 total groups, and because these groups are considered the most important in the MicMac analysis.

Table 33 A comparison between the AHP and MicMac results

	Interview	AHP	MicMac
Sustainability group 1	Air	Ports' operational abilities	HR
Sustainability group 2	Water	Air	Involvement of interested parties; ports' operational abilities; competitiveness; air, water; energy consumption
Sustainability group 3	Ports' operational abilities	Working environment	
Sustainability group 4	Port Competitiveness		

Table 33 shows that the results of the number of times the indicators were mentioned during the interviews, the AHP ranking, and the MicMac results do not completely match. What worth mentioning is that interview and MicMac were cross-sectional compared, while AHP was not able to do so. Therefore, the AHP ranking have been marked in figure 41 (environmental groups in green, social groups in blue, and economic groups in red). Besides, as no cross-sectional comparisons could be conducted, only the first prioritised groups in each sustainability sector are listed in table 33 (respectively port's operational ability from economic, air from environment, and working environment from social).

Lastly, the term 'sustainability group' in table 33 do not have any specific definition, nor related to any earlier classification. They only refer to the first, second, third, and fourth listed sustainability group based on interview, AHP, and MicMac ranking. The factors that emerged as most important during the interviews were air, water, ports' operational abilities, and competitiveness, while according to the AHP ranking, ports' operational abilities, air, and ports' working environment are significantly more important than the other groups. And, as per the MicMac results, the involvement of interested parties, port competitiveness, ports' operational abilities, air, water, energy consumption, and HR are the key groups in the practical oil port sustainability system because they have the highest driving power. However, it is worth paying attention to the fact that even though above groups also have similar level of driving power as the HR, HR is the only one with the lowest dependency power (only 1). Thus, it shows that the biggest difference between HR and other high driving power groups is other groups are still dependent to groups within the system, while HR is the only one does not impacted by, nor interacting with any other groups. For that reason, HR becomes level 1 (input level) in the sustainability hierarchy, and it is located in the independent variable section in the MicMac coordinate.

After the comparison, it can be seen that air and ports' operational abilities (marked in red) are the only ones that match. This reveals that these two groups and their indicators are the key sustainability indicators that require the most attention from port managers. And, even though HR is not identified in the other two groups, it nevertheless emerged as the 'input' group in the TISM test, and is therefore included in the list of the most important groups. Moreover, the groups that emerged from the interviews (water and port competitiveness), the AHP ranking (port working environment), and the MicMac results (the involvement of interested parties, port competitiveness, ports' operational abilities, air, water, and energy consumption) should also be considered important. In this way, a new ranking of sustainability groups (termed here a 'must-have' set of indicators) has been generated by a combination between the interviews, AHP ranking and MicMac results (Figure 42).

In this new ranking, the most crucial groups have been found to be ports' operational abilities, air, and HR, followed by the second layer second: the involvement of interested parties, port competitiveness, ports' operational abilities, air, water, and energy consumption. The last layer, which is not shown, includes the factors that of relatively less importance.

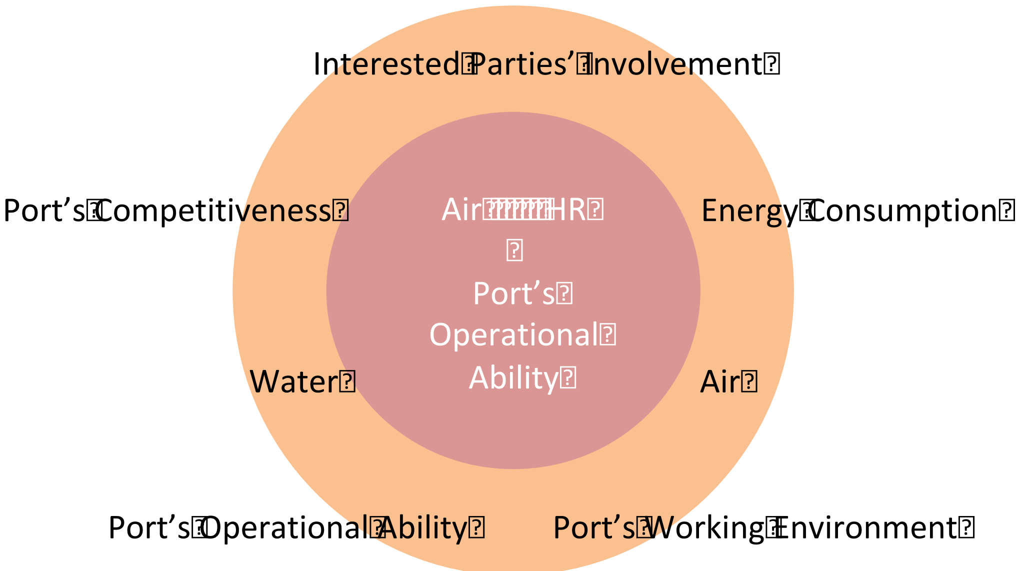


Figure 42 The 'must-have' set of indicators

In extreme situations with limited resources, the priority for port managers who seek to achievve sustainability should be the ‘must-have’ set of factors. However, during daily operations, it is suggested that port managers follow the AHP ranking (Figure 41), also paying extra attention to the key groups suggested by MicMac: HR, the involvement of interested parties, port competitiveness, port operational abilities, air, water, and energy consumption due to their high driving power and impact on other groups.

5.4 Summary

This chapter presents the quantitative empirical study based on the AHP, TISM, and MicMac methods. Through these results, this study adds value to the practical sustainability framework by prioritising the sustainability indicators, finding out the connections between each group, and have be compared to form a ‘must-have set’ of the most important groups. These results make it possible to observe the differences and the reasons why they appear in the theoretical framework and existing knowledge.

Chapter 6 Discussion

6.1 Introduction

This chapter discusses the results generated from the qualitative and quantitative stages of this study. Some of the findings reflect those in the extant literature, while others offer new conclusions. This study has been able to identify the development of a sustainability framework suitable for Chinese oil ports, highlighting the most crucial sustainability groups, and pointing out the relationships between each group.

The combination of qualitative and quantitative empirical tests not only validates the framework, which is to some extent based on the literature, but also contributes new knowledge to the field. Furthermore, the factors that make up sustainability have been prioritised and the relationships between the groups discovered. In total, this study can be said to offer six main achievements:

Table 34 The achievements of this study

Number	Achievement	Method
1)	Theoretical oil port sustainability objects identification	via SLNA
2)	Practical oil port sustainability objects validation	via interview
3)	Practical oil port sustainability objects prioritisation	via AHP
4)	Interrelationships among practical oil port sustainability groups discovery	TISM
5)	Dependency and driving power recognition among practical oil port sustainability groups	MicMac
6)	‘Must have Set’ of practical oil port sustainability objects formation	Interview + AHP + MicMac

As shown in Table 34, achievements, 1) and 2) are the foundation of this research, and make possible the formation of the practical holistic oil port sustainability framework. and enable the possibility of further analysis. This stage is essential because it fills the research gap left by previous studies in the field.

The third achievement is the result of further analysis based on 1) and 2), and ranks the importance of all sustainability indicators to show which areas of sustainability should be prioritised at oil port with limited resources available such as limited funds, limited resource, and many requirements.

The fourth achievement makes use of a graph to show the key relationships between the sustainability groups, not only showing how they are related (on the level of the indicators as well), but also shows that one action or change can influence the whole system through a direct or indirect relationship.

Achievement 5) is based on 4). It confirms the result of 5), that each sustainability group in the framework is interrelated, and then presents in detail the nature of each group, such as high driving power with high dependency power, high driving power with low dependency power, low driving power with high dependency power, and low driving power with low dependency power).

Lastly, 6) offers a conclusion about the sustainability indicators to form a 'must-have set,' which is generated from a comparison of the three empirical tests to highlight the most important, which need to be emphasised in any port situation. Of the achievements, 1), 2), and 3) differ from previous studies due to the change in port type, while 4), 5), and 6) are new contributions that do not reflect the findings of previous studies.

The qualitative element of this study is the foundation for construction of the sustainability framework to fill the research gap. Furthermore, the quantitative test contributes further knowledge to the field of by ranking sustainability indicators, generating a 'must-have set' of sustainability indicators, identifying the key relationships between them, and further determining the nature of each group to add value to the framework. This will be explained in more detail in the following section. Section 6.2 illustrates the changes to and emphasis of the framework; Section 6.3 explains the prioritisation of the sustainability indicators; Section 6.4 discusses the connections between the groups; and in Section 6.5, the 'must-have set is formulated'

6.2 Sustainability framework

This section discusses the outcomes that are relevant to the sustainability framework, including the transformation of the theoretical into a practical framework, and the differences between the two (achievements 1) and 2), as shown in Table 34). Before the development of the practical framework, a theoretical framework was developed, using the literature to identify the existing sustainability indicators. Based on this finding, the practical framework was modelled in the qualitative stage to improve the feasibility and appropriateness of the theoretical framework. The practical framework then prioritised the indicators. To show the differences between the three frameworks, the changes in both content and rankings are highlighted in colour (see Appendix 16).

Hakam and Hicham (2016) have researched all three aspects of sustainability, looking at in ports, while Lu et al (2016) examined the relationships between supply chains and the sustainability performance of container ports. Parllis (2008) proposed a port performance framework with an emphasis on the economic angle, while scholars such as Zhang (2016), Wolf et al. (2015), Wen et al. (2015), Vrije and Brussel (2012), Venus Lun et al. (2015), and Seguí et al. (2016) have identified relevant sustainability indicators at other types of ports, chiefly container ports. Generally, they can all be said to have contributed a part to the port sustainability puzzle. Based on their findings, this study has developed an oil port-oriented framework that addresses all three aspects of sustainability, while also broadening the focus to the groups and indicators of the social aspect.

Based on the theoretical framework, the results of the qualitative empirical stage of this study – the interviews – illustrates what, how, and why the sustainability indicators have changed. As a result, it becomes possible to not only see the difference between the theoretical and practical frameworks, but also see how they have changed. The theoretical framework was mainly developed based on other types of ports such as container ports, and the results also serve to show the changes between the different periods and port types.

6.2.1 Changes to the theoretical sustainability framework

This section illustrates the changes made to the theoretical sustainability framework.

<u>What</u>

As can be seen in Figure 25, in the second layer (the sustainability groups), two more environmental groups were added after the qualitative study: Soil and NMHC. Even though 'soil' has been discussed a number of times in the literature (Acciaro, 2014; Bailey and Solomon, 2014; Burskyte et al., 2011; Chang and Wang, 2012; Davarzani et al., 2016), the relatively low number of mentions has eliminated it from the theoretical framework. This shows that in previous studies of port sustainability, soil was not a matter of great interest, compared to other factors such as air (Bailey and Solomon, 2014; Burskyte et al., 2011; Kim and Chiang, 2014; Lam and Van Voorde, 2012) and water (Kim and Chiang, 2014; Seguí et al., 2016). However, during the interviews, soil conditions were mentioned frequently, revealing that experts are interested in the issue of soil pollution. Furthermore, the experts gave the following reasons why they included soil pollution in the practical sustainability framework:

1) Leaked petroleum products can directly damage soil;

2) Leaked petroleum products can contaminate water, and the damaged

water can in turn damage the soil;

3) There is little remaining farming land around the port area, and damaged soil can further damage these lands and thereby damage people's health.

NMHC is another group that was added, despite not being found in any of the port sustainability literature, because the experts were concerned about how it can damage both plants and humans. Considering the potentially far-reaching effects, once such an accident occurs, it has been included in the practical framework.

The group 'Solid waste' was eliminated. It had been identified and included in the practical framework because it is often mentioned in the literature (Davarzani et al., 2016; Kim and Chiang, 2014; Lam and Van Voorde, 2012; Sislian and Cariou, 2016; Nappi and Rozenfel, 2015). However, some experts believe that the indicators from this group can be divided into other groups to avoid duplication. For this reason, in the second layer, the group 'solid wastes' was deleted and its indicators placed into different groups that they may affect (for example, the indicator 'sludge' was placed in the 'water' group).

In the third layer (sustainability indicators), multiple indicators have been changed in almost every group (except for the 'ecosystem' and 'energy consumption' groups under the environmental aspect). This may be due to the fact that they are similar in terms of energy consumption (for example, energy-saving facilities to evaluate sustainability performance and the main energy saving approach are always a central criterion) and the criteria to evaluate the ecosystem. Other differences occur, as explained in Appendix 17.

In the environmental aspect of sustainability, two groups (soil and NMHC) and their indicators (there are four and one of each) have been added. The majority of the indicators from the other four environmental groups, air, water, ecosystem, and energy consumption, have barely changed (and the final two did not change at all). In summary, in the environmental aspect of sustainability, some theoretical indicators obtained from scholars such as Vrije and Brussel (2012), Wooldridge et al. (1999), Yang et al. (2013), Zhu et al. (2014) and Firestone et al. (2005) have been eliminated due to the rearrangement in the categorisation (for instance, CO2 and CO were combined into the CO category). Indicators were added mainly due to the environmental issues caused by specific oil port operation processes, which are not relevant to other types of port (such as pump houses, and oil content from vessel operations).

No groups have been added to the economic aspect of sustainability. However, the indicators in the group involvement of interested parties have changed completely, as have most of the indicators for port operational abilities and port competitiveness, due to either adding or eliminating them. Many of the theoretical indicators, obtained from scholars such as Hoshino (2010), Hou and Geerlings (2016) Ishii et al. (2013), Jeon et al. (2016), Kim (2016), and Notteboom (2006)[a], are eliminated mainly due to the unique features of oil port, such as the fact that they see less investment than container ports, the definitions of oil ports are insufficiently accurate (e.g. transit time does not necessarily lead to financial development), duplication, and because they are not mentioned by the experts in the interview. Indicators are added mainly due to the changes in oil ports such as regional cooperation and performance in the supply chain. Further details regarding the changes made to the theoretical framework can be found in Appendix 17.

No groups have been added to the social aspect of sustainability. Nevertheless, most groups have changed due to either additions or eliminations. In the groups noise and HR groups, the indicators have changed completely. Usually, they were eliminated after being obtained from sources such as Port of Los Angeles (2013), Shiau and Chuang (2015), Wu and Jeng, 2012, and Sislian et al. (2016), mainly because they were division up (e.g. safety being divided into fire and poisoning), and they were not mentioned by most of the experts during interviews. Indicators are added mainly because providing further detailed matters relevant to safety issues. This is understandable as oil port has a higher sensitivity to accidents.

How

This section is divided into three parts and will explain how the changes were made to the practical oil port sustainability framework.

1) For the aspects of sustainability (the first layer): the theoretical sustainability framework focused on the environmental aspect, comparatively neglecting the economic and social aspects. Due to the relatively large amount of literature reviewed, and the long publication timespan, the current focus of port susceptibility management is still the environment (Badurina et al., 2017; Bailey and Solomon, 2004; Chang and Wang, 2012; Sislian and Cariou, 2016; Wu and Goh, 2010). Few changes were made to the environmental aspect (the sustainability groups remained almost identical), only becoming more detailed. The biggest trend is that the main focus in the existing literature was air (Bailey and Solomon, 2014; Burskyte et al., 2011; Kim and Chiang, 2014; Lam and Van Voorde, 2012; Sislian et al., 2016), while the practical framework considers other environmental groups and indicators to be crucial to achieve sustainability in oil ports.

However, in the practical framework, while the chief focus is the environment, there has been a significant increase in the number of economic and social indicators added. This shows that from the perspective of port management experts, there has been a significant rise in awareness of economic and social factors in recent years, given that the experts provided details of the impact of economic and social factors on port sustainability, in addition to the environmental concerns.

2) For the group level of sustainability (the second layer): as can be seen in the two frameworks, changes were only made to a few groups (two were added and one eliminated). This implies that regardless of the type of port (e.g. container or oil port), the main sustainability groups do not vary. This can be explained by the fact that the standard framework is developed based on one initial perspective, in this case container ports, given that they have attracted the most attention in China due to the economic contribution they make to the nation (Chen et al., 2013; Cariou, 2011; Brooks et al., 2014; Fan et al., 2015; Ghashat and Cullinane, 2013; Matsushima and Takauchi, 2014; Mangan et al., 2008; Lee et al., 2008; Lättilä et al., 2013; Lagoudis et al., 2014).

3) For the sustainability indicators (the third layer): the indicator level received the most changes during the process of constructing the frameworks. Details of these changes can be found in the previous section ('what') and Appendix 17.

Why

As outlined in the two frameworks and the above explanations of 'what' and 'how' was changed, all three sustainability sections have been modified. This section summarises why these changes were made:

1) Differences in port type: as mentioned previously, container ports are the main type that has been studied in China, due to the large economic contribution they have made to the country (Brooks et al., 2014; Fan et al., 2015; Hakam, 2015; Lagoudis et al., 2014; Klopott, 2013; Gilbert and Bows, 2012; Cullinane, 2002). Compared to container ports, oils ports have created little wealth, and have therefore received little scholarly attention. The few studies that have been made on oil ports that are relevant to sustainability focus on safety issues, which is a central concern of oil ports, but only a small aspect of oil port sustainability. Because container ports and oil ports have different features, the sustainability indicators of the former that can be

generated from previous studies cannot be directly used for the latter.

One of the main differences between oil and container ports is their commodities; the latter handle cargo in containers only, while the former can handle crude oil as well as chemical and petroleum products. This difference in commodities results in four main differences:

- Information management: container cargo can be labelled, which makes it trackable, and therefore locations, loading and unloading times, and recipient information can all be input into database (e.g. clouds or company systems). However, because oil cannot be labelled, the definition of 'tracing' a commodity is also different, and the process done at container ports is hard to achieve at contemporary oil ports. Instead of location, information management at oil ports focus more on the condition of the commodities such as temperature, tank level, pressure, and crude oil characteristics.

- Cargo flow process and layout: because the commodities in oil ports cannot be labelled, oil ports have a lower level of automation; all the main processes need to be checked manually to prevent explosions and fire, given that tank sensors can often be wrong and valves can always leak, and the facilities required are also different, such as the storage tank, loading arm, and refineries. Due to these reasons, oil ports have different cargo flow processes to container ports.

- Cargo: due to the different types of cargo, the features of each port also differ. At container ports, the main concern is security, given that the cargo can be stolen (Jiang and Mao, 2012). Differently, oil ports emphasis safety issues because even though small amounts of oil and petroleum products are stolen via oil tankers, it is not worth taking such rare cases into consideration. However, accidents often happen at oil ports due to a lack of monitoring (Benedict, 2012), which causes more harm to people and the environment than any other products. For this reason, the high sensibility and flexibility of the cargo in oil ports requires a large amount of safety monitoring to avoid explosions and fire.

2) The rise in awareness of the social and economic aspects of sustainability: Awareness is increasing of the importance of both the social and the economic aspects of sustainability (Tahar, 2016; Theys, 2010; Tian et al., 2013; Verhoeven and Vanoutrive, 2010; Verhoeven and Vanoutrive, 2012; Wu et al., 2012; Wu et al., 2013), and especially for social factors (Edoho, 2008; Iannone, 2012; Shiau, 2015; Lee et al., 2008; Lättilä et al., 2013). As outlined in the literature review, most studies in the literature have focused on the environment (Chen et al., 2013; Jiang et al., 2012; Acciaro et al., 2014; Bailey and Solomon, 2014; Burskyte et al., 2011; Cariou, 2011; Chang and Wang, 2012; Klopott, 2013). while economic development is mentioned infrequently. However, social issues are barely mentioned, which could be due to the following two reasons:

- The development of sustainability: one reason why there is little interest in social issues in port studies might be the development of the concept of sustainability. As mentioned in Section 1.1, sustainability has developed from 'green' and 'low carbon' theories, and even though sustainability was first suggested in the 1980s, its application in shipping – and especially the port sector – has only been discussed since about 2013 (see Figures 4 and 5). Given this focus, and the fact that social concerns are not included in the definition of either 'green' or 'low carbon,' social issues have been neglected in the literature, compared to the environmental and economic facets of sustainability.

- Increased awareness of social issues: According to Maslow (1943), when an economy reaches a certain level of prosperity, people tend to pay more attention to spiritual matters. After decades of development in the maritime and port industry in China, developments in the field are generally meeting and even exceeding people's expectations, while the general national development, means that people have started to become more interested in matters concerning social welfare such as job-related illnesses, regional/local employment rates, and living condition. Social concerns are also becoming a matter of general interest following actions and campaigns conducted by governments and NGOs.

Compared to the extant studies that focus on social issues at ports, the practical sustainability framework has deepened the concept by taking account of more details. For instance, in the literature, most authors only mention corporation social responsibility (CSR) (Edoho, 2008; Iannone, 2012; Arat, 2011), without going into more detail. However, the empirical study conducted in this study has enriched the content of CSR and has contributed to knowledge development, HR, and issues surrounding citizens' living conditions.

With regard to economic matters, the practical framework has also provided more detail in issues relevant to port stakeholders. Previous studies that have looked at economic matters for ports have focused on port-city relationships and stakeholder involvement (Denktas-Sakar and Karatas-Cetin, 2012; Ghashat and Cullinane, 2013; Ha et al., 2017), while in this study, not only has the content of stakeholder involvement been enriched by providing detailed indicators (such as on the interested parties that share the same goals for sustainability; how to share responsibility for sustainability issues at ports; and the rule that no party has privileges if they do not follow the rules), new indicators have also been included that pertain to the diversification of port functions and the operations under new policies.

6.2.2 Changes in emphasis for different periods and port types

This section explains the changes in focus, depending on the era and port type. Combining the information gathered in the literature review and the interviews, two issues could be summarised as the main reason for the changes that have been made to the theoretical sustainability framework. It is worth noting these points for potential further analysis and to gain a better understanding of the formation of the practical sustainability framework.

According to the literature analysis (see Section 2.2.2.1), the literature results have been generated from a relatively long timeframe (mainly from the period 1998 - 2018), and period has a different focus. The trend in focus in the research mainly follows the development of the concepts of ‘green’ (Lam and Van Voorde, 2012; Badurina, 2017; Chang and Wang, 2012; Cheng et al., 2013; Chiu et al., 2014; Davarzani et al., 2014; Ha et al., 2012), ‘low carbon’ (Chen et al/, 2013; Jiang and Mao, 2012; Bailey and Solomon, 2004; Vidal, 2007), and ‘sustainability’ (Lu et al., 2012; Acciaro et al., 2014; Wang et al., 2017). For instance, the ‘green’ studies focus on environmental and economic development; the ‘low carbon’ studies concentrate on improving air conditions; and the contemporary focus is economic development (for container ports), environmental protection, and social matters. Figures 4 and 5 reveal different amounts of studies are published in each era on the various aspects of sustainability. The production volume started to increase significantly around 2008, showing that sustainability has only started to attract scholarly attention in the last ten years. This is especially true in the last three years (after 2014), when production volume suddenly reached the highest historical point.

As mentioned previously, different port types are suitable for different types of sustainability framework. Container ports have been frequently researched because they make a large contribution to the economy. Given the large amount of such studies, the theoretical framework was mainly based on container ports, while the intention of this study was to suggest an oil port-oriented framework. For this reason, during the interviews, numerous changes were made to the theoretical framework, and eventually a practical sustainability framework for oil ports was formed. The differences between these frameworks is mainly due to the fact that different ports handle different types of cargo, which require different port layouts, processing flows, and handling facilities. The liquidity of the cargo and the possibility of fires and explosions makes oil port very different to dry bulk and container ports, which mean that the theoretical framework needed to be considered no more than a foundation or initial framework from which the final framework could be developed.

This being so, it can be concluded that no holistic sustainability research has been studied with regard to oil ports. The changes made to the theoretical framework are due to the varying features of each port. As a result, the practical framework is holistic, taking account of many sustainability indicators directly relevant to oil ports, without making large-scale changes to the sustainability groups. The few changes to the sustainability framework can be understood as the practical framework making use of the theoretical framework as a foundation, following the logic of segmenting and grouping the sustainability indicators. The results also prove that the sustainability groups have high similarity, regardless the port type.

6.3 Prioritising the sustainability indicators

This section discusses the prioritisation of the sustainability indicators (achievement 3 in Table 34) to highlight the most crucial of hundreds of indicators and more than ten groups. This section is needed because a large number of sustainability indicators were identified, and the most important ones need to be highlighted so port manager can focus on the most urgent and crucial ones, given that they have access to limited resources, funds, and time. The prioritisation will be discussed following the order in which they layers appear in the frameworks.

In previous studies, AHP is often used for two purposes: to evaluate ports' performances, and to prioritise the identified factors. Because no holistic oil port sustainability framework has been developed in the literature, the sustainability groups and indicators have never been ranked by importance. However, comparisons can be made from a general perspective: ports' natural amenities (such as berth and water depth) are more important than operational abilities (such as he ports' capacities and handling volume); operational ability is more important than further development; water and air are the most important groups, with water being more important than air; and investment is more important than port operation (Chiu et al., 2014). However, this study found that air is more important than water for oil ports, and port operations are more important than investment.

What worth mentioning is that the relative importance of factors in AHP from the samples are collected from the participants. The concept of AHP method is to obtain subjective importance ranking from the participants, while ensuring their feedbacks are logically correct and can be taken as reliable results. To ensure the results are logical, it is the participants have to pass the C.R (<0.1) check. In the end, more than 70 participants'' result passed the C.R check and are considered valid. As per reliability, the eligibility of participants are ensured, and the participants'' number is relatively big (>70). Thus, it is considered that the collected results are reliable and relatively accurate. To conclude, the importance of factors in AHP from the samples are collected from the reliable participants who have provided validate results.

The use of average score is adopted in this study. It is generally accepted as most of the existing literature has also done so (Li and Jiang, 2010; Elzarka et al, 2014; Guo and Cai, 2010; Ruso and Camanho, 2015). Even though deviation could happen, but the amount will be too small to affect the result. During the conduction of AHP, it is noticed that most of the valid feedback are in the similar range (e.g. environment is 2 time more important than social). Extreme cases (e.g. Air is 9 times more important than soil) barely happened.

Thus, it can be concluded that even though extreme cases do exists, but they are too small to be considered as representative results. Most importantly, because of the small number of existence, the generalization and average of results do not impact on the final result. Conclusively, the standard deviation is too small and thus can be omitted.

6.3.1 The aspects of sustainability

This section discusses the newly developed prioritisation of the aspects of sustainability, in comparison to the existing literature. Figure 43 – 59 (the newly developed prioritisation of this study) are the division of the completed AHP model (as shown in Figure 36) based on the sustainability sections, groups, and individual indicators in the sustainability framework. The explanation follows the order of sustainability section comparison (section 6.3.1, Figure 43), sustainability groups (section 6.3.2, Figure 44 - 46), and individual sustainability indicators (section 6.3.3, Figure 47 - 59).

Figure 43 The prioritisation of the aspects of sustainability

The result outlined in Figure 43 is the same as that of the previous studies. As mentioned before, environmental issues have typically attracted more attention in the field, while social matters have received the least concern (Di Vai and Varriale, 2017; Darbra et al, 2014; Darbra et al, 2009; Lu et al (2016), Sislian et al (2015), Darbra (2009), Lam and Notteboom (2012); Roh, 2016; Dinwoodie et al, 2012). Most of the experts questioned in this study hold the opinion that ‘environment’ is the most important issue, agreeing that due to the special characteristics of the cargo handled at oil ports, if accidents occur (typically due to collisions, leaking, or fire), the damage to the environment, capital, and human health is tremendous, so most experts assigned a relatively higher score to the environment.

The economic aspect is the second most important, according to the experts. Even though container ports have contributed more to Chinese economic prosperity than the other two types of port, oil port managers are still seeking ways to develop. For instance, many are seeking to expand to be able to accommodate larger vessels, and such development can also bring about improvements to different local employment rates (Merk, 2013; Manginas et al, 2017; Ghashat and Cullinane, 2013; Lee et al, 2008; Kim, 2016; Lagoudis et al, 2014; Carbone and De Martino, 2003).

There are several reasons why the environmental aspect is considered more important that the economic, of which the top three can be said to be:

1) Campaigns and policies by the government, NGOs, and other entities (IMO,2003; IMO, 2018; IOS, 2015; Pot of Gothenbutg, 2012; Port of Los Angeles, 2013; Puig et al, 2017);

2) The tremendous harm to health and the environment resulting from accidents (Mansouri et al, 2015; Lam et al, 2012; Vrije AND Brussel, 2012; Zhang, 2016);

3) Oil ports make less direct economic contributions and have less interest in expansion than container ports (Jung, 2011; Meersman et al, 2006).

In other words, people tend to believe in the environment and economic dichotomy that holds the opinion that economic development definitely brings harm to the environment, and that economic development and environmental protection cannot be pursued at the same time other than finding a balance. Also driven by limited resources theory, people tend to choose environment protection over economic development in the ideal case. All these reasons made economic not the priority.

Due to the scarcity of resources, many international bodies agree that the contemporary world has a responsibility to leave future generations with at least the same level of resources for their development and living demands as we currently enjoy. As mentioned in the introduction to this study, such bodies are increasingly demanding that national governments ensure environmental protection. For instance, the IMO is implementing a strict 0.5% sulphur limit on fuels by 2020; governments are rewarding port companies that meet port environmental performance standards; and research institutions are seeking to constantly improve their methods of environmental evaluation. All these reasons combine to entrench the concept of environmental protection in relevant stakeholders. This could be why the experts who participated in this study focus more on environmental than economic issues: because they feel responsible to maintain or improve the environment, and leave adequate resources for the next generation.

Moreover, due to the danger represented by oil port cargos, accidents harm the environment and citizens' health far more than they do at container and bulk ports. If accidents happen, such as oil leaking to the sea or soil, the resulting harm to the environment is harder to fix than accidents at other types of ports, and the recovery period is much longer, so it is reasonable for scholars to focus more on the environmental aspect of sustainability than economic growth.

Furthermore, a practical reason why the economy attracted less attention than the environment could be the relatively smaller economic impact of oil ports. For instance, any growth in container ports can directly lead to port expansion and a higher employment rate, and indirectly bring about growth in other industries such logistics, packaging, and automation. In oil ports, however, the main effects will be on knowledge development. Compared to container port cargos, oil ports do not require many logistics company to transport the cargo, which generally comes through a pipeline, while the employment is relatively small because only high-skilled staff can be hired, due to the characteristics of the cargo. The refinement industry could see improvements, but this is not easy to do because it is technology- and capital-intensive, and cannot easily be expanded without huge funding and technology injections. Therefore, one of the main contributions made by oil ports to is to knowledge development, which can encourage people to gain relevant qualifications to obtain employment at the port. To conclude, oil ports do not make a direct economic contribution in the way that container ports do, so it is logical that citizens in general and experts in particular see no reason to oppose increases in environmental protection.

The social aspect of sustainability is considered the least important. This could lead to the following reasons:

1) A general lack of awareness.

2) A lack of certainty concerning which factors should be included in this area.

The lack of awareness is likely to be due to the recent development of this area in the literature, and the limited number of studies that have looked at social factors at ports. In recent years, there has been an uptick in the research into CSR-related matters, but it is likely to take some time before citizens and port managers come to consider social issues to be a serious concern that is closely linked to social welfare, economic developments, and port reputations.

One reason for this lack of attention could be the broad definition of the social aspect of sustainability, and the fact no clear framework or definition has been suggested as to which social issues ports should emphasise, making it hard to measure success. In this study, the main groups that were identified in the theoretical stage remained in this aspect of the framework, and during the first stage empirical research, no new group was added.

In summary, even though no official ranking was conducted of the three aspects of port sustainability, it can be seen that the main focus on the environment and the economy has not changed.

6.3.2 The sustainability groups

This section discusses the prioritisation of the sustainability groups in this study, in comparison to the literature.

Environment

Figure 44 Ranking the environmental groups

Figure 44 shows that there is no significant difference between the environmental groups. The biggest gap can be found between the soil and the 'noise' groups.

In the previous literature, the groups that have attracted the most concern are air and water, with the latter being mentioned much more frequently than the former (Chiu et al., 2014; Lirn et al., 2013; Manginas et al, 2017). In this study, air was found to be the most crucial group within the environmental aspect (18.3%). This represents a change compared to the literature, but air can still be said to be of central interest to ports. This result is no unexpected, given that oil ports contribute a huge amount of CO2 and gas, due to the amount of fuel and coal that they burn; in comparison to other ports, oil ports burn more fuel, and in this study, air pollution is considered the most important environmental group (with a 1.3% lead over the second-ranked group).

The ecosystem is ranked as the second important group, with 17.1%. This is a surprise, given that the literature shows more interest in water. This difference could be because if an accident occurs at an oil port, not only are the local air and water damaged, but so is the ecosystem as a whole, given that oil, petroleum products, and chemical products have a far-reaching impact on the ecosystem, much more than other types of cargo. However, despite this ranking, the difference between the relative importance of the ecosystem and water was only 0.4%.

Water is almost as important as the ecosystem, and it has always been a chief focus in port environment management because the products handled at oil ports can significantly harm water conditions, especially in case of an explosion.

NMHC has been separated from air because it is considered to represent a kind of environmental harm.

Similarly, to the other two groups, soil (10.9%) and noise (7.8%) have the least impact on ports' performance. Soil could be considered less important because:

1) The scale of oil port expansion is relatively small, compared to container ports, so little damage occurs to soil during construction, which plays a big role in soil harm;

2) For oil ports, soil can only be damaged when accidents take place or there are monitoring mistakes. Given that this happens quite infrequently, soil is considered less important than the other environmental factors, but it is still worth including in the practical sustainability framework because many accidents (such as collisions, leaking, and explosion) have taken place in recent years due to the increased trade in crude oil, chemical products, and petroleum. Furthermore, if an accident happens, soil is the area is greatly damaged, so most experts take it into consideration in oil port sustainability management.

Finally, it is not surprising that noise remains at the least importance factor, showing no change in its ranking.

<u>Economic</u>

Figure 45 Ranking the economic groups

In previous studies, the natural conditions of ports are considered more important than their operational abilities (Chiu et al., 2014), while the latter has received more attention than port development (Chiu et al., 2014; Asgari et al, 2013). However, in this research, these factors are not comparable because the groups have changed.

In this study, of the three economic groups, the factors ports' operational abilities and competitiveness have received a similar score (39.6% and 35.2%, respectively), while the involvement of interested parties was found to be less important (25.2%). This relative importance of port operational abilities could be because it is the foundation by which a port can survive in today's business environment, while other two factors can only be achieved when an oil port has already reached a certain standard.

Competitiveness was the second most important factor (35.2%), due to the high competition between ports. There is a trend towards overproduction in the industry, especially for oil ports, so they can gain a larger market share to maximise profits, showing the importance of competition for oil ports.

Lastly, the involvement of interested parties stands at the lowest level of importance. This does not mean that this group is unimportant, but implies that the current situation of this factor is relatively healthy, and not severe enough to impact on economic performance or the competitiveness. However, because more entities are interested in entering the sector, there is a potential need to pay attention to this issue.

<u>Social</u>

Figure 46 Ranking the social groups

In this section, the result is not comparable because the groups are again different. In this study, of the four social groups, citizens' living conditions and ports' working environment receive similar scores, and are relatively more important (both over 31%) than the remaining two groups (HR and noise). HR received only 20.9%, and noise only 16%.

The reason for the strong focus on citizens' living conditions (31.8%) is because even though the social factor with regard to ports is not well defined, it is widely accepted that the ultimate goal of solving social issues is to improve citizen' lives, and therefore citizens' living condition re considered the most crucial facet of oil port sustainability management.

The social group that comes next in importance is ports' working environment, because it has strong impacts on working performance. Working performance directly affects companies' profitability and effectiveness, and therefore most experts believe that the working environment at a port is crucial.

HR and noise are not considered as important as the previously mentioned factors, having less of an impact on port performance and profitability. Noise is concluded to have the least impact on a port's performance because at the noise that occurs at oil ports is generally bearable to both local residents and employees. Even though port HR departments are essential because they attract talented employees and allocate the port's human capital, of the four social groups, it is deemed to have a very small effect as it looks like to have limited importance contributing directly to sustainability. Nevertheless, in the TISM and MicMac results, HR shows a contradictory result of being considered the most important one, as it is the input of sustainability system which impacts the rest of the groups. This is because the experts' opinion shows that the selection of leaders and the allocation of employee lead to company culture and sustainability performance. For example, if the leaders emphasis on sustainability, the company culture will tend to focus on sustainability as well. Also, the quality of employee and their working attitudes determines the sustainability activities executive ability. Therefore, the TISM and MicMac result finds HR is one of the most important sustainability groups within the system.

The main reason of AHP and TISM/MicMac show different result is because AHP reflects concrete feelings directly. For instance, people tend to feel environment is more important than economic without thinking. On the other hand, TISM/MicMac results are obtained after calculation of connections (e.g. A is impacting B, B is impacted by C, and D is impacting B and A). They show the connection between groups, as well as the hidden connections (e.g. indirect links) in participants' logic rather than only presenting the subjective thinking conducted within the same level (e.g. A is 3 time more important than B, C is 3 times more important than D). Conclusively, both AHP and TISM/MicMac can show the priorities, but they show in different ways. AHP presents from the subjective importance level of groups, TISM/MicMAc shows from impacts and links between groups.

6.3.3 Sustainability indicators

This section discusses the new prioritisation of sustainability indicators, compared to the literature.

Economic/ports' operational abilities

Figure 47 Ranking the sustainability indicators

In the literature, investment is considered more important than port operations (Chiu et al., 2014), while in this study, port operations and productivity has been found to be more important than investment.

In this section, there is a huge gap between the most crucial economic indicator, cost-effectiveness (c.a. 26%), and least important, FDI (12%). It is understandable that cost-effectiveness is ranked first because funds are always limited, and all available money has to be spent effectively. Even though FDI reflects a port's economic potential, the amount of FDI a port has received, if any, does not necessarily indicate its financial status, nor the regional/local economic conditions. Cost-effectiveness, or resource-allocation, has a direct impact on ports' operational abilities, but not FDI.

The other three factors have similar scores, which shows that they do impact on operational abilities. However, their influence is less important than cost-effectiveness, and more than FDI.

<u>Economic/port competitiveness</u>

Figure 48 Ranking the sustainability indicators

These results cannot be compared to those of the literature because the nature of the indicators has changed. In the group port competitiveness, the facets effective service provision abilities and port utilisation costs receive similar scores of 20% and 19%, respectively). A port's service provision ability affects the costs and performance of sellers, ship owners, customers, and other third parties in the trading chain, while port utilisation costs are also crucial because every party would like to achieve cost minimisation. These two indicators are the two most crucial reasons of why people choose a certain port, and it is not surprising that the experts ranked them at the top.

Regional cooperation, hinterland connections, SC performance, and maritime connectivity receive similar scores (20%, 19%, 17%, 13%, 12%, 11%, and 10%, respectively), and are ranked in as less important. They are considered not to have a direct influence on competitiveness, and certainly less than service provision abilities and costs.

<u>Economic/involvement of interested parties</u>

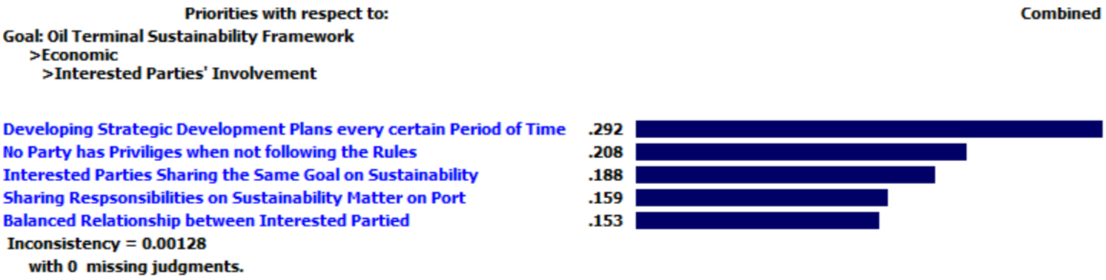


Figure 49 Ranking the sustainability indicators

These results are again not comparable to the literature because indicators have been completely changed, all of them having been added after consulting with the experts. In this group, the indicator periodically developing strategic development plans (19%) is much more important than the other four (below c21%). Particular unimportant are sharing findings of port-related sustainability matters (16%)' and balancing the relationships between interested parties (15%), due to low contribution they have on the performance of the interested parties. Furthermore, there are laws and regulations ensuring that they share the same responsibility at ports. However, they are still included in the framework because if they meet the basic legal standard, there could be some conflict between interested parties due to their individual preferences, which may eventually indirectly harm a port's sustainability performance.

The most important facet in this group is periodically developing strategic plans because it is necessary to ensure that interested parties share the same general goals and enjoy a common understanding of a port's sustainability performance. For this reason, this indicator is considered the basis of port sustainability. The other factors take into account smaller potential conflicts, but these are deemed much less important.

Social/citizens' living conditions

Figure 50 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. Figure 50 shows that port-city relationships are considered significantly more important than the other five indicators because the ultimate goal of any development improve citizens' living standards; this is mostly achieved by port-city relationships because ports can create prosperity in its region. Even though oil ports contribute less directly to the local economy than container ports, it is nevertheless worth considering how to maximise their positive impact on the surrounding areas.

'Citizens' rights' was the least important indicator. The interviews found that even though some citizens are opposed to ports being located near them because they are scared of the risk of exposure to chemical products, this is not a common complaint, and there are ways of recompensing citizens with this concern. For this reason, this is the least important indicator in the group. However, given that this is a genuine risk to citizens' quality of life, it is still very much worth including in the practical sustainability framework.

Social/port working environment

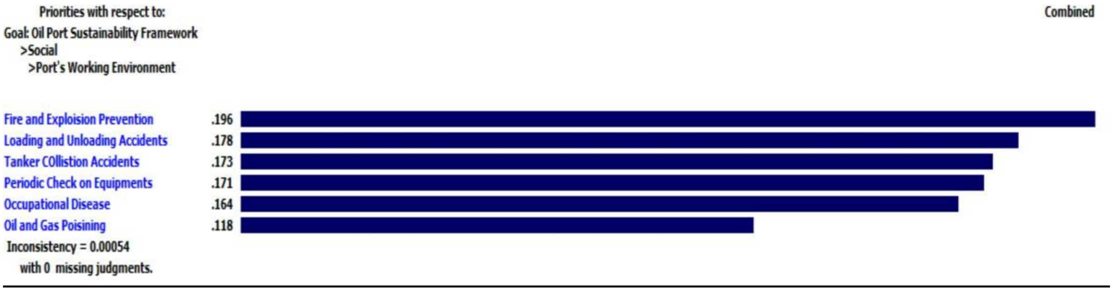


Figure 51 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. As shown in Figure 51, the most important indicator is fire and explosion prevention because safety issues have always been a central concern at oil ports, due to the cargo they handle. The next factors are fire and explosion prevention, leaking issues, including loading and unloading, tanker collision, and failure due to equipment monitoring accidents, which have almost the same level of importance. This is because the harm that results from leaking is more extensive than that of explosions. Oil and poisoning are considered the least important because there is a much smaller possibility of this type of accident occurring.

<u>Social/port HR systems</u>

Figure 52 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. The most important factors, which receive an equal score, are increases in the employment rate and career development, because these indicators can be said to motivate employees the most. Compared to these indicators, training and employee turnover rate are less important ones (also receiving similar scores), with no gap of any significance occurring between other indicators (within roughly 3%). In general, the indicators in this group are of almost the same importance.

Social/noise

Figure 53 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. Oil trucks are considered to be the most important factor here, given the ever-present need for transportation, and its importance to the industry. Pumphouses and oil tankers are the second- and the third-most important factors because they both deal with only tankers, and therefore have a limited effect. Cranes (oil loading/unloading arms) are the least important because the noise they emit is relatively limited and infrequent.

Environment/air

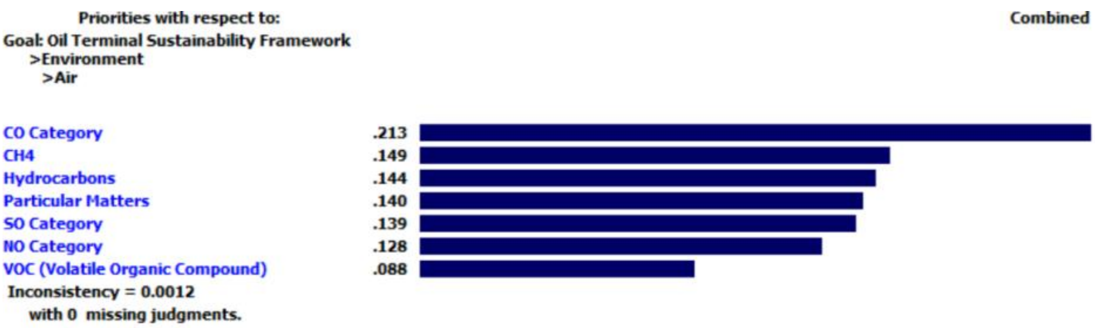


Figure 54 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. In this group, the CO category is significantly more important than the other indicators (receiving roughly 21%) because CO is the main cause of the greenhouse effect (GHE). Because

GHE is currently the main focus of environmental interest, it is no surprise that this category attracted the most attention, while VOC is the least important (at 9%). Even though oil ports deal with a lot of VOC, there is not normally enough present to damage citizens' and employees' health. However, since it ca be a serious issue in case of explosions or fire, it is included in the framework. Of the other two indicators, CH4, hydrocarbons, PMs, SO, and NO all have similar importance (15%, 14%, 14%, 14%, and 13%, respectively) because these factors all derive from burning fuel, which damaging the air quality.

Environment/water

Figure 55 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. In the water category, ballast water attracts the most attraction due to the campaigns that have been conducted by NGOs, and especially the IMO and in response, local governments are now seeking to solve this issue. Secondly, crude oil, petroleum products, and chemical products are now traded much more than in previous decades, a trend that has increased after the oil price drop in 2015. Non-standardised ballast water discharge may result in severe ecosystem damage and to prevent this and indeed improve the situation, ballast water has begun to be considered of to be of importance. Oil content is the second most important factor, given the need for deck-washing and other types of sewage disposal. The least crucial facets are BOD and COD (both receiving around 14%). This could be because given the current situation at oil ports, they both meet regulations, because if ports break the law in this matter, they could have to face severe legal consequences. BOD and COD are therefore considered the least urgent issues, and are deemed to be relatively less important.

Environment/noise

Figure 56 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. From the environmental perspective, pump houses and oil tankers are very significant ones because the noise they emit is loud enough to potentially scare away fishes and sea birds, thereby damaging the ecosystem. Tanker trucks and cranes are less significant because they are offshore, and are therefore responsible for less noise pollution. However, even though the noise indicators should be taken into consideration for the sake of a healthy ecosystem, currently only Australia has enacted measures to minimise such noise. For this reason, it would be beneficial to pay more attention to the noise group in the environment section.

Environment/soil

Figure 57 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. Chemical and oil spills and discharges is the most crucial factor for oil conditions because they destroy the quality of the land for a long period. The next most important issue is NOx because it can also damage air quality; it NOx is categorised in this group, rather than for air, because in addition to fuel and coal burning, much of this pollution comes from chemical reactions with elements in the soil. Lastly, heavy metal pollution is considered least important because not enough of it occurs to harm the soil. However, because oil ports are likely to be expanded in the future, this factor is still worth taking into consideration in the practical sustainability framework.

Environment/energy consumption

Figure 58 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. Fuel consumption (36%) is significantly more important than the other indicators in this group. This is understandable because oil ports have numerous sources of fuel that cannot be replaced by energy-saving resources due to either the price or efficiency. According to these results, it is also crucial for managers at oil ports to make use of energy-saving facilities and adopt renewable energy (23% and 24%, respectively) to reduce fuel consumption. Electricity consumption is the least important factor because based on current technology, coal and fuel (and in some countries, nuclear power) are still the main resources to produce electricity, without other options to replace the main fuel. However, it should be borne in mind that electricity usage should be minimised for the environmental good.

Environment/ecosystem

Figure 59 Ranking the sustainability indicators

The results of this section are not comparable to the literature because the indicators have been significantly changed. Figure 59 shows that the experts deem it important to maintain biodiversity. Also important is ecological sensitivity because it is important to minimise the damage to the surrounding ecosystem; oil and chemical and petroleum products can be fatal and harmful to wildlife. Lastly, vegetation coverage is the least important indicator in this group because at oil ports, it is not considered worthwhile to pay attention to the amount of vegetation in place in the nearby seaside because such ports are located in industrial areas that typically did not have vegetation even before becoming a port. However, this factor still needs to be considered because a vegetation can absorb a certain level of CO_2, which helps to improve the ecosystem, given the large amount of CO_2 that oil ports produce.

6.4 Connections between the sustainability groups

This section discusses the relationships between sustainability groups. The results obtained using the TISM and MicMac methods are novel contributions to the field, and are therefore not comparable to previous studies.

6.4.1 TISM model relationships

This section discusses the relationship and connections established through the TISM. These results are not comparable to those of previous studies because this matter has not yet received scholarly attention. As discussed previously, the TISM model shoed how various groups are directly and indirectly connected (the red marked groups in the TISM diagram belong to the environmental section; the green to the economic section; while the blue is social). In this way, theoretically, changes to one factor can have an impact on the whole system, both directly and indirectly. This section why such connections exist.

There are several features that merit discussion:

1) Several groups from the three aspects of sustainability have connections to all other groups, except for HR;

2) Being the group that is not impacted by all other groups but impacts all the others, HR is the 'input' point of the TISM graph;

3) Ecosystem and citizens' living condition are impacted by almost every group (13 and 12 groups, respectively), but do not impact any other groups, and are therefore 'output' point of the TISM.

In the following section, each feature is explained, followed by a discussion of the surprising results that HR is the input point, and how each group connects to others.

With regard to 1) above, the groups with the most connections to other groups are the involvement of interested parties, port competitiveness, ports' operational abilities, air, water, energy consumption, and NMHC. They are located at the bottom of the graph as a result of their influence. Most of the groups that have the most connections are not surprising, especially air, water, and energy consumption because they are mentioned frequently in the literature (Chiu et al., 2014; Lirn et al., 2013; Chen et al., 2013; Jiang et al., 2012; Acciaro et al., 2014; Bailey and Solomon, 2014; Burskyte et al., 2011; Cariou, 2011; Chang and Wang, 2012), which emphasises their impact on other sustainability groups and relationships with other environmental and social groups. Another reason these groups have the most connection is because they are to a certain extent the focuses of studies into green, low carbon, and sustainability, in the area of ports.

However, it is surprising that these groups exert an influence on all the listed groups except for HR. According to the TISM panel, this could be because these groups impact the port environment, given that in general, all human and economic activities can be said to influence environmental and social conditions.

As for why they do not impact HR, this could be because HR often refers to the working hierarchy at an organisation (Kosiorek, 2016), so external condition do not affect it, even facets such as citizens' living conditions, noise, and a port's working environment).

With regard to 2), HR is the input in the TISM graph. During the TISM panel meeting, experts said that they thought that HR could greatly influence employee performance. In this way, HR not only has an economic impact (due to the daily performance of oil ports and companies) and a social effect (enhanced citizens' living standard due to the increase in knowledge and employment opportunities), but also indirectly impact environmental groups due to the monitoring of environmental conditions (such as recording emissions) during daily operations. As a result, HR has either a directly or an indirect influence on the rest of the groups in the sustainability system in this study.

As for 3), because the output points in the TISM diagram are ecosystem and citizens' living conditions, they are only impacted by almost all the groups, and do not have an impact themselves. This is because the ultimate goal of sustainability is to promote human development while harming the environment as little as possible (Bakari, 2014; Gatto, 1995). In other words, development can be thought of a method of improve human living conditions, while environmental protection is designed to bring about a balanced ecosystem. Following this logic, the remainder of the groups in the sustainability system are support these goals, while supporters' behaviour impact on the performance of the goals. For this reason, ecosystem and citizen' living conditions are positioned at the end of the TISM graph, and do not impact other groups.

The surprising outcome of the TISM analysis was that HR was revealed as the input, which was not previously mentioned in other studies, nor expected in this one. Even though TISM has not been used in the shipping domain in previous studies, one can still find terms such as coal and fuel burning in studies related to port sustainability; in other words, human or trading activities are always considered the leading elements of sustainability, in that the environment was and to a certain extent still is the main focus of sustainability). The outcome that HR is the input of the sustainability system could entail that:

1) Over time, experts are beginning to think of other matters, rather than just the environment;
2) This new result has emerged because this study has looked at all three aspects of sustainability, rather than only focusing on individual aspects;
3) In the contemporary port industry, employees' motivation enhances their performance (Kosiorek, 2016). In this study, HR has been found to be the biggest motivation for port employees to work towards sustainability.

<u>The economic aspect of sustainability</u>

<u>The involvement of interested parties</u>

The involvement of interested parties directly and indirectly impacts on almost all the groups across all three aspects of sustainability, with the exception of HR. It directly impacts on the groups in its own section (competitiveness and operational ability), and indirectly influences all environmental and social groups except for HR. This shows that it has a relatively high driving power in the sustainability system, and can therefore be said to play a fundamental role.

The reason it directly influences competitiveness and operational ability is because a strong organisation will enhance the competitiveness and operational performance of any company. In summary, the decisions made by relevant parties could have an impact on most of the other groups, given that such parties are decision- and policy-makers, while the other parties are mostly employees. It does not impact HR because HR is only controllable and manageable by its direct supervisory entity (such as the port company or local authority, and relevant governmental authorities). Besides, HR mainly refers to matters relevant with employees. Interested parties involvement mainly focus on the collaboration among different parties, such as developing strategic goals and each of the party bearing specific responsibilities. Thus, it is only possible for HR to impact interested parties as several interested parties could be selected via the HR system, but not the opposite.

The involvement of interested parties group is impacted by roughly half of the groups in the system, meaning that it has a medium dependency power. It is only directly impacted by its own groups and HR, and only the environmental groups – air, water, energy consumption, and NMHC impacted it indirectly. This is because being the place where decisions are made regarding other groups, decisions and strategic plans are made based on the performance and conditions of an individual company's current operational and competitiveness status, while external factors such as ethical pressure from the public could also force the interested parties to make certain decisions.

<u>Port competitiveness</u>

Port competitiveness directly and indirectly impacts on most of the groups across all three sustainability sections, except for HR. It directly impacts on the groups in its own section (the involvement of interested parties and operational abilities), and indirectly influences all the environmental and social groups (except for HR). This shows that it has a relatively high driving power, and plays a fundamental role in the sustainability system as a whole.

Port competitiveness directly impact on the involvement of interested parties because of filters the interested parties who do not share the same development goals; a higher level of competitiveness encourages more motivation for interested parties to get involved. Port competitiveness impacts on operational abilities because there is likely to be a periodic gap between the amount of cargo a port is handling amount and its real capacity. For instance, its strong competitiveness can bring more cargo to a port, even when it does not have the official capacity to handle, which is likely to affects its operational abilities.

However, competitiveness is affected by some other groups, which gives competitiveness a medium dependency power in the system. It is directly impacted by its own groups and HR, and indirectly influenced by some environmental groups (air, water, energy consumption, and NMHC). It is also impacted by the involvement of interested parties because the decisions made by interested parties influence a port's operational abilities, which in turn impacts on its competitiveness. It is impacted by operational abilities because the higher these abilities, the more attractive it is to port users, which directly increases its competitiveness. A port's operational abilities refers to its cargo-handling capacity, and value-adding service range. Once the capacity increases and more value-adding services are offered, it is likely that competitiveness will increase.

Operational abilities

This group directly impacts almost all the others (except for its indirect influence on air), and has no impact on HR at all. This proves that this group plays a fundamental role in the system, and has high driving power.

This is because while human and trading activities result in both better living conditions and environmental damage, a company's operational abilities is the main factor that impacts on its results, and this factor is therefore positioned as the cause for the changes in the performance of the other groups. The reason it does not influence HR might be because operational abilities do affect employees' motivation and in oil ports, this factor is not something that attracts talented or skilled employees. Lastly, another reason could be that the strong operational abilities do not necessarily have a positive correlation with promotions or salary increases.

On the other hand, this group is directly impacted by the involvement of interested parties, air, and HR, and indirectly impacted by some environmental groups (competitiveness, water, energy consumption, and HR). The number of groups that are impacted shows that operational abilities has a medium dependency power. Oil ports' operational abilities are directly impacted by the involvement of interested parties because the latter factor directly reflects ports' operational abilities and capacity, while operational abilities are directly affected by air is because air pollution policies restrict the what facilities can be used and for how long. These restrictions directly influence ports' operational abilities, while operational abilities are directly impacted by HR because the HR hierarchy decides the composition of the decision-maker in the main interested parties.

The environmental aspect of sustainability

Air

Air either directly or indirectly impacts groups across the system, with the only exception of HR, which means it has high driving power. Air has a direct impact on operational abilities, citizens' living condition, and ports' working environment, and an indirect impact on all the other groups. As mentioned previously, air directly impacts on operational abilities because of the effect of working restrictions. Furthermore, it impacts on citizens' living conditions because it is relevant to the issue of citizens' health (especially to children and elders). It will be a long-term harm as many citizens' are living there for decades, even a lifetime long. Moreover, it also impacts on ports' working environment because port workers working condition could be worsened if the port air quality is poor.

However, air is not impacting the HR. Even though one expert did mention the bad air condition might impact the working motivation, more expert do hold the opinion that the air condition is not bad enough to impact on employee's motivation to work at port, nor to influence their option of working places. Especially, the currently air quality in most of the ports are in a similar level. Moreover, as HR system focuses on the management of human to achieve higher operating efficiency, air quality is not impacting the conduction of activities to achieve the goal. All experts agree that even though there might be a very slight difference of the air quality in different ports or positions, higher salary or better welfare would act as an effective compensation to attract potential employees. Thus, the goal of HR – a higher operating efficiency, will eventually not be affected by air.

Air has a medium dependency power, being directly impacted by water, energy consumption, and NMHC, and indirectly impacted by all the economic groups and HR. Air is directly impacted by water because polluted water evaporates into the air, and is impacted by energy consumption because the latter is one of the most important sources of polluted air. The same is true for NMHC, given that these emissions directly lead to worsened air quality.

<u>Water</u>

Water either directly or indirectly impacts groups across the system, except for HR, which means it has high driving power in the system. However, water only has a direct impact on air, soil, ecosystem, and citizens' living condition. It has a direct impact on air is because polluted water evaporates into the air; it influences soil because some polluted water enters the land in surrounding areas; and it directly influences the ecosystem is not only because polluted water harms the soil and air, but also impacts on wildlife in the water such as fish. Polluted water contributes to the growth of water-based weed, which consume oxygen in the water needed by other creatures. If any of the above-mentioned issues take place, the living conditions of citizens residing close to port will be influenced, in the form of negative health developments, while damage to the surrounding environment also decreases regional living condition.

Water is impacted by a majority of the other groups, and can be said to have a medium dependency power. It is only directly impacted by operational abilities because the higher the handling demand, there greater the chance of producing more water emissions.

Soil

Soil has low driving power because it is only directly connected to citizens' living condition, and indirectly connected to the ecosystem. It has a direct link to citizens' living conditions because people residing close to oil ports often own land on which they plant crops, and once their soil is damaged, their living quality is decreased.

Furthermore, soil is affected by several groups across the system; it is directly impacted by operational abilities and water, and indirectly impacted by the involvement of interested parties, operational abilities, air, energy consumption, NMHC, and HR, and therefore has medium dependency power. It is impacted by operational abilities because the higher the handling demand, the greater chance of harmful emissions entering the soil. Furthermore, any enhancement to ports' operational abilities, such as through expansion or new project, can also harms soil condition; soil is impacted by water is because polluted water can penetrate into the soil.

Noise (environment)

Noise has low driving power because it only impacts on ecosystem, noise (social), citizen's living condition, and working environment. It impacts the ecosystem because the noise of, for example, tanker engines and pumps could affect seabirds and fish; it also directly impacts on other noise from a social perspective because such noise has both an environment and social impact. Furthermore, it impacts on living conditions and the working environment is because even though there is a distance from port to residential areas, the noise that happens during ports operation can annoy employees.

Noise has a relatively high dependency power, in that 10 groups across the system have an impact on it. It is indirectly impacted by ports' operational abilities and noise of the social group, and indirectly impacted by competitiveness, air, water, energy consumption, NHMC, and HR. It is impacted by ports' operational abilities because the more the handling a port has to do, the more noise is necessary. Furthermore, noise is impacted by the noise from a social perspective because once a noise appears, it has both an environmental and social impact.

<u>Energy consumption</u>

Energy consumption has a high driving power because it has either a direct or an indirect impact on most of the groups. It directly impacts air, ecosystem, and NMHC, and indirectly impacts the rest of the groups, apart from HR. It has an impact on air is because the forms of energy such as coal that are often used in oil ports directly pollutes the air. For the same reason, ecosystems are harmed by the fuels ports consume, and the more energy a port consumes, especially in the form of coal and fuel, the more NMHC is produced.

Energy consumption has a medium dependency power. It is directly impacted by ports' operational abilities and indirectly impacted by the involvement of interested parties, port competitiveness, air, water, NMHC, and HR. The reason it is directly impacted by ports' operational abilities is because the higher the amount of handling, the more energy needs to be consumed.

Ecosystem

Ecosystem has a low driving power. It has no connection with any of the groups in the system, except for HR. As explained previously, the ecosystem is a consequence of other actions, and therefore has a high dependency power, due to its connected to almost all the other groups. Of these connections, ecosystem is directly impacted by ports' operational abilities, water, noise, and energy consumption. It is impacted by ports' operational abilities because the higher the amount of cargo handling, the greater the impact on nature, and in this way impacts the ecosystem. It is impacted by water because polluted water can harm the ecosystem, and ecosystems are also impacted by noise because it may scare away fishes and seabirds and thereby lead to a natural imbalance. Lastly, this factor is impacted by energy consumption because the higher the amount of energy consumption, the more likely it is that the an imbalance in the ecosystem will appear.

NMHC

NMHC has high driving power, with a connection to all group except for HR. It directly impacts air, citizens' living conditions, and the ports' working environment. It directly impacts air because after NMHC is released, it comes into direct contact with the air, while it impacts citizens' living conditions and ports' working environment because it is harmful to people's health system.

NMHC has medium dependency power. It is directly impacted by ports' operational abilities and energy consumption, and indirectly impacted by the involvement of interested parties, port competitiveness, air, water, and HR. NMHC is directly impacted by ports' operational abilities because the higher the amount of cargo being handled, the more NMHC is likely to be produced and released, and it is directly impacted by energy consumption because the more energy that is consumed, the more likely it is that NMHC will be produced.

The social aspect of sustainability

Noise (social)

Noise (social) has low driving power because it only directly influences noise (environmental), citizens' living conditions, and ports' working environment, and indirectly influences ecosystem. It impacts 'noise (environmental) because as mentioned previously, noise has both an environmental and social impact, and this impacts citizens' living conditions and the port working environment because employee and residents can be annoyed by such noise.

Noise (social) has a relatively high dependency power because many actions can lead to noise. It is directly impacted by ports' operational abilities and noise (environmental), and indirectly influenced by the involvement of interested parties, port competitiveness, air, water, energy consumption, and NMHC. It is directly impacted by ports' operational abilities because the higher the amount of cargo a pot handles, the higher the possibility that both employees and local residents could be annoyed, and it is impacted by noise (environment) because such noise has both an environmental and social impact.

HR

HR has the highest driving power in the system, having a direct or indirect influence on every group in the system. However, it only has a direct influence on the economic and social aspects of sustainability. It influences the economic aspect because HR is the fundamental cause of any economic impact because the HR managers make the most important decisions. It influences the social section because the HR hierarchy and the decisions they make both enhance the quality of life of port employees and local residents (e.g. employability increase), but also leads to a positive working environment (e.g. knowledge sharing, providing training, and good welfare) that motivates staff. Conclusively, ‘social issues’ not only covers local residencies, but also port employees. As both citizen’s and port employee’s benefits could be enhanced by providing a better working environment and more opportunities, HR impacts on social groups are reasonable.

Differently, HR is not influenced by any other group in the system, and it is therefore considered to constitute the input of the TISM system as a whole.

Citizens’ living conditions

This group has low driving power because it only directly impacts ecosystem. This because improving citizens’ living condition can usually only be done by harming the ecosystem, such as by developing land in the port area, expanding ports, and emitting more pollution.

On the other hand, citizens’ living conditions has high dependency power because it is impacted by 12 of the groups. It is directly impacted by ports’ operational abilities, air, water, soil, noise (environment), NMHC, noise (social), and HR. It is impacted by ports’ operational abilities is because higher operational abilities bring more economic contribution to the region, which eventually brings more benefits to citizens (more convenience of life, higher tax from companies brings better welfare to local residency, etc.). Moreover, citizen’s living condition is impacted by HR is because citizens could benefit from HR knowledge development, better welfare, and higher motivation to work, etc. Therefore, it is reasonable to say that citizens’ living conditions is depending on the condition of operational abilities and HR. Lastly, citizens’ living conditions are also impacted by air, water, soil, noise (environment), NMHC, and noise (social) because they are groups that can harm the health of both port employees and residents living nearby.

Port working environment

This group does not have any driving power because as has been mentioned previously, it is one of the goals for achieving sustainability and for that reason, it has high dependency power. It is directly impacted by ports' operational abilities, air, noise (environment), NMHC, noise (social), and HR. It is impacted by ports' operational abilities because the higher the amount of cargo being handled at a port, the more pressure employees have to face; it is impacted by air and NMHC because they are relevant to employees' health; it is impacted by noise (both environmental and social) because noise can distract and annoy employees; and lastly, it is impacted by HR because the HR system determines employees' motivation and satisfaction.

6.4.2 MicMac diagram

This section discusses the connections between the groups from the perspective of the containing powers. The TISM result is not comparable to those of previous studies because this is not an issue that has been discussed in the literature. By transferring the driving and dependency powers from the final reachability matrix into the MicMac diagram, the groups can be divided into four types of variable: the independent, linkage, autonomous, and the dependent variables.

As shown in Figure 39, there is one independent variable, seven linkage variables, zero autonomous variables, and six dependent variables. Because the key groups with high driving power fall into either the independence or linkage variables, eight of the 14 groups examined in this study are considered important.

The independent variables have strong driving power but low dependency power, and as can be seen in the MicMac diagram, HR falls into this section.

The linkage variables have both strong driving and dependency power, which implies their instability, due to the fact that when any action affects the groups in this section, they not only impact the other groups, but are also impacted themselves. The groups in this section connect the dependent and driving groups such as the involvement of interest parties, port competitiveness, ports' operational abilities, air, water, energy consumption, and NMHC. None of the social groups is included here but all economic groups are.

The autonomous variables have both low driving and dependency power. They are relatively disconnected from the rest of the system, but have few but strong links. In this study, none of the groups falls into this section.

The dependent variables have low driving power but strong dependency power, and thus do not impact the other groups, but are rather influenced by any change to the other groups. They are located at the top of the TISM diagram, and do not affect the factors above their own level, even while they are greatly influenced by the others. Soil, noise (environmental), ecosystem, noise (social), citizens' living conditions, and port working environment belong to this section, as do two of the three social groups.

It is surprising to discover as a result that the involvement of interested parties and HR are the key groups in the practical oil port sustainability system. For interested parties' involvement, it can be concluded that it is required to reach a common understanding and participate in sustainable development, ensuring a more balanced relationship. Potential solutions for the government or local authorities are to monitor or develop policies to ensure that each party involved suffers the same consequences when breaking the law, and to evaluate the appropriateness of the periodically developed plans. As for the HR, it is important as an effective HR system of selecting the right people to make the decisions that have an economic effect and also motivate employees, and also provide prompt training to employees to ensure they remain effective, motivated, and safe could also adds value to port's sustainability development.

Moreover, because most of the environmental groups are relatively independent of the system, this to a certain extent shows why the extant literature has only rarely researched the issue of holistic sustainability in ports, and the paucity of attempts to combine the environmental, economic, and social aspects of sustainability: the environment is considered a separate group, and not part of the operational system of oil ports. For this reason, it is crucial for both port managers and general citizens to take environmental performance into account as a feature of port performance, and not only as a consequence of operational actions. This is especially relevant, given the few but strong links they have to other groups, which impacts on other sectors.

Last but not least, most of the social groups fall into the dependent groups, which are mainly affected by others. This shows that currently, it is not easy to monitor or manage social factors because they are mainly the 'result' of other actions. However, this requires the government and local authorities to further improve their monitoring of and control over the other influencing groups to ensure a balance is maintained between economic development and social demands.

6.5 Summary

Combining the results of this study as a whole, the following discoveries have been identified that contribute to the field:

1. Groups from the same aspect of sustainability do not necessarily have the same connections to the same group, nor to the groups from the same section. For this reason, it is crucial for port managers to manage each incident and group separately because, as this study shows, there have no common features;
2. Many groups share the one feature – that of being impacted by the pressure of public criticism;
3. Several groups only reveal an impact when significant incidents occur, such as oil leaks, tanker collisions, or explosions at the port, which are relatively rare events;
4. Surprisingly, HR has been found to be the most crucial group in the system due to the extent of its impact on other indicators;

5. The environmental issues are a separate area of interest, or only a consequence of the actions of other groups. However, it is increasingly crucial to consider the environment as a part of the oil port operational chain because it has few but strong links to other groups in the system;

6. Because there are too many sustainability groups, and these issues cannot be achieved simultaneously due to the limited resources available to ports, the must-have groups are deemed to be ports' operational abilities and air, followed by five groups obtained from the interviews (water and port competitiveness), the AHP ranking (port working environment), and the MicMac result (the involvement of interested parties and HR).

Chapter 7 Conclusions

7.1 Introduction

This chapter presents conclusions across all stages of this study, which also illustrates how the five main research objectives have been achieved via each stage of empirical studies (both qualitative and quantitative). Moreover, this chapter also shows how the knowledge gaps in existing literature were filled by this study, which was supported by the adoption of an appropriate methodology. Lastly, this chapter highlights the contributions while outlining the limitations of this study and suggestions for future research.

7.2 Findings from all stages

This section summarises the findings from different stages. As can be seen from Figure 60, the conclusions across all stages have been visualised by showing key research activities.

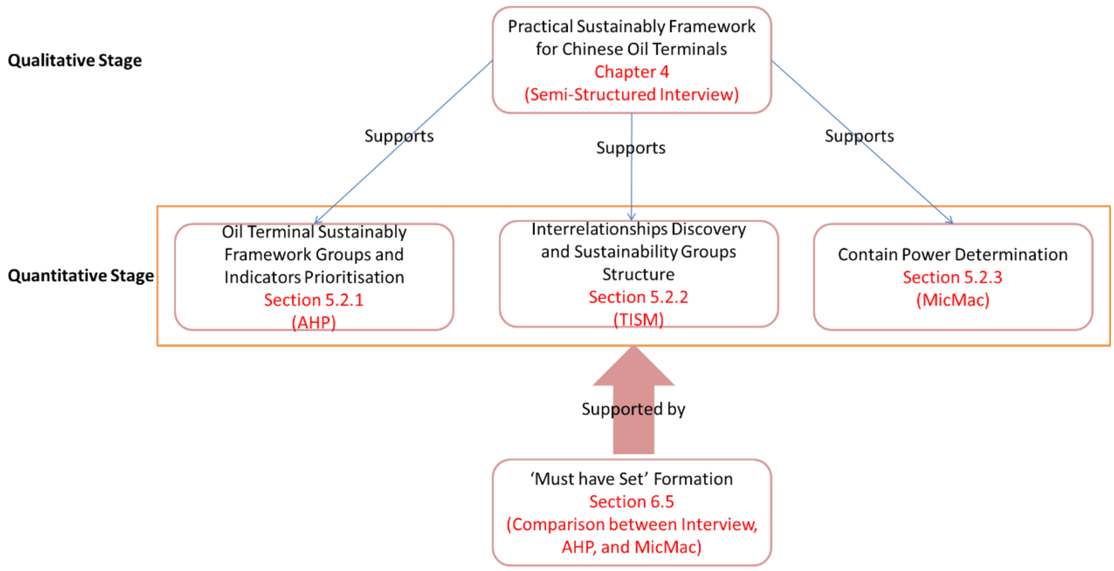


Figure 60 Visualisation of all Stages

As mentioned in the introduction chapter, the main research objectives of this study are:

1) To develop a practical sustainably framework for Chinese oil ports;
2) To prioritise the practical oil port sustainably framework groups and indicators;
3) To discover the interrelationships between the oil port sustainability groups, and to structure the sustainability groups;
4) To determine the contain powers of the oil port sustainability groups;
5) To identify the most important oil port sustainability groups to form a ‘must have set’.

By the end of the research, all the research objectives have been achieved. The first objective has been achieved via interview; the second objective has been fulfilled via AHP survey; the third objective has been achieved by TISM; the fourth objective has been met through MicMac; and the last objective has been achieved via the comparison between all the four empirical study results.

The foundation knowledge gap in existing port sustainability management literature is that there is no oil port oriented holistic sustainability framework developed within the field. To fill this gap, it is required to forward a practical Chinese oil port sustainability framework (Research Objective 1). Thus, a theoretical sustainability framework was developed first based on existing literature at the beginning of this study. To further answer the research objective 1, qualitative method (semi-structured interview) has been used to gain up-to-date practical knowledge with relevance. In the end, a practical Chinese oil port sustainability framework has been developed as shown in Figure 25 (see page 117).

However, due to a large number of identified oil port sustainability groups and indicators, it is crucial to highlight the most important ones while ranking them in accordance to their importance for the ease of implication when there are limited resources. Thus, multiple quantitative stages have been further conducted to extract the ‘must have set’ while prioritising identified sustainability indicators.

First, based on the confirmed practical Chinese oil port sustainability framework, AHP surveys have been conducted to obtain experts’ opinion on the relative importance of identified sustainability indicators. This not only answers the Research Objective 2, but also fills the knowledge gap of not pointing out the relative importance of crucial oil port sustainability groups. As a result, a prioritised oil port sustainability framework has been forwarded (Figure 37, Page 160).

Second, to fill the further knowledge gap of no interrelationships have ever been detected in port sustainability management’s field, this study used TISM to discover the interrelationships between the sustainability groups and to visualise the connections between the sustainability groups (Figure 38, Page 177). This action answers the Research Objective 3, and highlights ‘Air’, ‘water’, and ‘Port’s Operational Ability’ as the most connected groups. In order words, they are the most impacting ones in the system which thus deserve extra attention from the port managers.

To support the TISM results generated from the previous stage, this study deepens the connection discovery part by continuously looking at the contain powers of each sustainability groups. This action answers the Research Objective 4, and fills the knowledge gap of no contain powers of sustainability groups have ever been detected in port sustainability management’s field. This research discovers the groups having high driving power to the system (‘Interested Parties’ Involvement’, ‘Air’, ‘Port’s Operational Ability’, and ‘HR’), and most of the environmental groups are relatively independent from the system, which implies that they are considered only as a consequence of the human activities at ports.

Lastly, it is crucial to highlight the most crucial sustainability groups out of varied results as the ‘common understanding’ on oil port sustainability prioritises. To fill the research gap of no groups have been selected and no results have been compared which have gathered from different methods, this research has compared the outcome of both qualitative and quantitative methods (interview, AHP, and MicMac method), and concludes that 'Air' and 'Port's Operational Ability' are the commonly recognised most crucial sustainability groups for Chinese oil ports.

To conclude, via the adoption of mixed-methods (both qualitative and quantitative methods), this research develops a holistic practical sustainability framework for the Chinese oil ports with groups and indicators' prioritisation, and discovers the interrelationships between the sustainability groups with the support of analysing containing powers.

7.3 Contributions of this Study

This section summarised the contributions made by this study. This research contributes to the knowledge of providing a holistic prioritised sustainability framework for oil ports in China. The contributions could be divided into two parts: the practical and theoretical contributions.

Key Contributions

Theoretical

- Oil port sustainability groups and indicators' coverage extension as a foundation to the future research;
- Oil port sustainability groups and indicators classification;
- Oil port sustainability groups' interrelationships identification;
- Oil port sustainability groups' containing powers identification;
- Oil port sustainability groups and indicators identification, prioritization, and interrelationships determination from multi-national port relevant experts;
- Obtaining empirical data from multi-occupational port relevant experts;
- The sustainability framework, indicators prioritisation, and the 'must have set' results might be able to be applicable to oil ports in other countries;
- 'HR' is defined as an important factor in the oil port sustainability system.

Practical

- Oil port sustainability groups and indicators' coverage extension as a guide to port managers;
- Oil port sustainability groups and indicators prioritization;
- 'Must Have Set' formation.

Figure 61 Contributions of this Study

<u>Theoretical contributions:</u>

1) *Oil port sustainability groups and indicators' coverage extension*: This study adds new and eliminates several inappropriate sustainability groups and indicators to the theoretical framework based on empirical evidence (see Appendix 17). This action makes the practical sustainability framework more appropriate for the Chinese oil ports and provides the researchers and practitioners with the opportunity to have a broad overview of sustainability groups and indicators needing to be included. In this research, even though only two sustainability groups have been added, 37 out of 70 indicators are newly added to the theoretical framework.

This is considered a theoretical contribution. It is because as it has been mentioned before, barely any studies have covered all three sustainability sections. Di Vaio and Varriale (2012) have conducted a view on the port environmental indicators. However, they did not reveal any sustainability groups or indicators from economic and social perspectives. Same as Di Vaio and Varriale (2012), Wolf et al (2015), Lu et al (2016), Puig et al (2016) and Hakam (2015) also focused port sustainability management from the environmental perspective only. On the other hand, Bucak and Kuleyin (2016), Beskovnik et al (2014) only concerned about social issues at the port. Thus, this research fulfilled the gap of existing literature lacking a holistic sustainability system.

Besides, previous studies mostly focus on container port's sustainability management, and thus not many oil port oriented indicators are identified (Pavlic et al, 2014; Vujicic et al, 2013; Lirn et al, 2013). Since oil port has different features, especially higher sensibility to accidents, oil port awaits deepened studies based on sustainability indicators' identifications. At the meantime, container port oriented sustainability systems and indicators do not perfectly fulfil the needs of oil port managers when making strategic plans, nor provide conveniences during daily operation. Therefore, the development of a holistic sustainability framework consisting specific oil port oriented groups and indicators not only provides a clearer view and guidance to oil port managers to see the coverage of oil port sustainability, but also proposes a foundation for future oil port sustainability studies (e.g. on sustainability objects' prioritisation, port performance evaluation, and performance comparisons between different ports).

2) *Oil Port Sustainability Groups and Indicators Classification*: This research classifies oil port sustainability groups and indicators under each sustainability section based on empirical evidence. This provides researcher and practitioner information of where the sustainability groups

and indicators belong to and thereby forms a systematic sustainability system.

It is considered as a theoretical contribution. This is because, in the existing literature, identified sustainability groups and indicators are not well classified in accordance with their nature. As it has been mentioned before, studies not only tend to list all sustainability indicators without grouping (Pinder, 2003; Mansouri et al, 2015; Asgari et al, 2015), but also not cover all three sustainability sections (Lam and Gu, 2013; Davarzani et al, 2016; Cerreta and De Toro, 2012). This phenomenon results in inconveniences when port managers choosing sustainability indicators to achieve strategic sustainability improvement plans. Thus, the results of this study are crucial to the academic field by contributing an organised system allowing future port sustainability research to be conducted with ease (e.g. on sustainability groups' interrelationships, port performance evaluation, and evaluation mechanism establishments).

3) *Oil Port Sustainability Groups' Interrelationships Identification*: This research for the first time uses TISM method in port sustainability field to discover the interrelationships between oil port sustainability groups. This action contributes the knowledge of recognising the connections among oil port sustainability groups and provides a structured structure of the groups. Besides, it also leaves future research a reliable basis to make further comparison between results obtained from different methods.

This part is considered as a theoretical contribution is because for the first time the interrelationships between sustainability groups have been proposed. In the previous literature, only sustainability indicators have been listed (De et al, 2017; Lu et al, 2016; Dinwoodie et al, 2012) and prioritised (Chiu et al, 2014; Manginas et al, 2017; Asgari et al, 2013; Lirn et al, 2013), but no connections between each other have been analysed. The interrelationship analysis in this study provides explanations to the importance of the sustainability groups and their positions in the system, and allows researchers to compare the results with other methods.

4) *Oil Port Sustainability Groups' Containing Powers Identification*: This study contributes to the knowledge of categorising oil port sustainability groups into four sections in accordance with the contain powers (driving and dependency powers) between each other in the port sustainability system. This provides supporting material to the TISM result to deepen understandings regarding the connections among oil port sustainability groups.

   This is also considered a theoretical contribution is because, in the previous studies, no analysis regarding the sustainability indicators contain power has been down. The containing power analysis helps researches and practitioners to understand the how the sustainability system works. Thus, it is needed to know the contain power of each sustainability groups to enhance the sustainability performance and making strategic plans.

5) *Oil port sustainability groups and indicators identification, prioritization, and interrelationships determination from multi-national port relevant experts*: As it has been mentioned earlier, previous port sustainability studies tend to use unified research methods and take one country as a case study each time. These facts resulted in the issue that the previous literature many obtain port sustainability system formation data from experts from one single country. For instance, Roh et al (2016) conducted the semi-structured interview with experts from only Vietnam. Lirn et al (2013) only obtained data from experts from China mainland. Lu (2012) also only used experts from Taiwan as samples. Moreover, Kim and Chiang (2014) interviewed with only Korean experts to research on the Busan port sustainability achievement. Nevertheless, at todays globalised and port privatised environment, it is crucial to gain more insights from

experts with different backgrounds. This study included both Chinese and foreign experts meeting the sample selection criteria. The results are thus considered reliable, and helps researchers to understand what is important to match with the demand of ports having an increasing amount of new foreign entities getting involved.

6) *Obtaining empirical data from multi-occupational port relevant experts*: Similar to the previous contribution, previous port sustainability studies tend to collect port sustainability system formation data from experts with a unified occupation. For instance, Roh et al (2016), Lu (2012), and Park and Yeo (2012) all just focused on port stakeholders, while Dinwoodie et al (2015) collected interview data only with port authority officials. Nevertheless, at today's globalised and port privatised environment, it is crucial to gain more insights from experts with different occupations. This study included port stakeholders, research institution researchers, and governmental officials, etc. who meet the sample selection criteria. The results are thus considered reliable, and helps researchers to understand focuses of different occupational fields to allow the potential formation of a 'generalised sustainability framework' to be set as the basic 'standard'.

7) *The sustainability framework, indicators prioritisation, and the 'must have set' results might be applicable to oil ports in other countries*: in the existing research, except for the port performance comparisons, no sustainability mechanism has been compared between different ports. As a big 'port area' is formed by multiple small ports and ports, gaining understandings regarding the sustainability and its mechanism focuses' differences could mean a lot to the 'big port areas' sustainability performance'. Thus, the sustainability framework, indicators prioritisation, and the 'must have set' results in this study builds a foundation for researchers' future investigation.

8) *'HR' is defined as an important factor in the oil port sustainability system*:

As it has been mentioned earlier, port sustainability field is 'environmental' dominated. The prioritisations normally happen under environmental indicators (Chiu et al, 2014; Lirn et al., 2013; Manginas et al, 2017). Thus, the finding of 'HR' showing to be the source impacting the whole sustainability system could mean that people's perspective started to change, which leaves researchers more possibility to conduct future research regarding the centre of port sustainability shifting from 'human activities' or 'Air' to 'HR'.

Practical contributions:

1) *Oil port sustainability groups and indicators' coverage extension*: As it has been mentioned in the theoretical contribution part, the development of a holistic sustainability framework consisting specific oil port oriented groups and indicators not only supports future studies but eases the port managers' work by providing a structured view of a relative full coverage of oil port sustainability management system.

2) *Oil port sustainability groups and indicators prioritization*: This research advises the most crucial and attention attracted oil port sustainability sections, groups, and indicators based on a relatively large-scale quantitative empirical research. The prioritisation enables the practitioners the opportunity to see and select the most crucial sustainably groups to achieve when there are limited resources (e.g. capital, funding, geographical limitations). Besides, based on available resources, port managers could decide with more ease which indicators should be achieved first

   A prioritised sustainability framework is considered a practical contribution is because previous literature did not provide any prioritised holistic sustainability system, nor oil port focused sustainability system (Chiu et al, 2014; Elzarka et al, 2014; Asgari et al, 2013). This brings port managers both inconveniences and inefficiencies when making strategic plans or monitoring daily works, as the number of sustainability indicators are huge and sometimes not categorised. Thus, the highlight of oil port sustainability groups and indicators helps port managers identifying the most important indicators to enhance sustainability management efficiency.

3) *'Must Have Set' Formation*: This research provides a guidance of the sustainability 'Must Have Set' for Chinese oil ports via the comparison between the adopted methods in this study. This provides the practitioners with the opportunity to recognise the most crucial oil port sustainability groups and leaves future research a reliable basis to make the further comparison between results obtained from different methods.

   Same as the third practical contribution, forming the 'Must Have Set' also reveals to the port managers which indicators are important. The difference is the holistic sustainability indicators' prioritisation acts as a supportive guidance to allow port managers choosing indicators to achieve based on suggested importance. In this case, the sustainability performance could be maximised based on the capability of the port (e.g. available fund). On the other hand, when a port has extremely limited resources, the 'Must Have Set' shows the most crucial groups which are suggested to be achieved regardless what. Since the 'Must Have Set' is the result of comparing multiple empirical methods, the outcome is considered relatively accurate than the indicators' prioritisation (which were obtained only from AHP). What worth mentioning is no result comparison have been made by any previous literature.

4) *Generalisation of the sustainability framework:* This study shows a generalisation of the sustainability framework, which provides the different angles of views from different methods. For instance, it is obviously seen that the AHP method tends to provide subjective answers directly regarding priorities. On the other hand, TISM provides and hierarchy

system formed by the impact level and connections between groups. As AHP and TISM obtained different answers, it is proven that the combinations of methods with different logics are needed in one research to enrich the research results and to show the multiple sites of the researching issue(s).

Besides, the generalisation of the sustainability framework provided an increasingly practical framework for Chinese oil port. At the beginning, existing literature mostly focused on environmental groups and indicators exploration. Besides, most of identified factors were not given prioritisation. Thus, the theoretical framework only formed a foundation of the sustainability framework. Then, interview is conducted and formed a practical framework. As shown in the framework, changes have been made to all three sections, and especially to the economic and social factors. This proves that the economic, and especially social sections are attracting more and more attention. Lastly, after the application of AHP, a prioritised framework is formed with factors prioritisation. AHP has changed most of the rankings showed in practical framework, and the results are backed up with a relatively large number of participants to increase reliability. Thus, it can be said that the generalisation of frameworks presented an increasingly practical and reliable framework to future Chinese oil port sustainability management.

Summary

In summary, an increasingly reliable and practical sustainability framework is suggested to future Chinese oil port sustainability management. The empirical results advice the oil port sustainably practitioners to use the developed sustainability framework as a guideline to evaluate the oil port's sustainability performance. When needed, the sustainability groups and indicators importance ranking, the connections, and contain powers between the sustainability groups can also be used as supporting information when decisions are required.

7.4 Limitations of this Study

Although the empirical studies are not only reliable and relatively accurate, a few limitations have been identified that provide some insights for future research. The limitations have been listed below along with reasons of existence and why they are meaningful to be extended in future research:

Interview Part

- The experts participated in the empirical research in this study are mainly Chinese (more than half). Thus, it could be concluded that the practical sustainability framework is mainly based on the perspectives and demands of the Chinese oil ports. However, it would be worthwhile to embrace more internationally recognised oil port sustainability groups and indicators to gradually forming an international sustainability framework as a guideline for the oil ports worldwide.
- This research only accessed opinions from a limited number of both foreign and domestic experts within the field. Thus, the results were not able to provide enough insights regarding oil port sustainability frameworks to make the comparison between emphases of experts from different national background. However, if there were more accessible experts, it would be interesting to discover whether there are any differences of foci on oil port sustainability framework inclusion by experts from different countries.
- Due to the limited number of experts and the uneven numbers of experts with different occupations, this research could not make a comparison of different focuses on sustainability framework by experts from different occupational groups. If there were more accessible

experts from different occupations, this research could have provided more knowledge by comparing the different foci on sustainability framework by experts from different occupational groups.

AHP part

- Even though this research has included 70 AHP responses from experts regarding the practical sustainability groups and indicators' importance ranking, following the nature of the AHP method, it is always better to have respondents as much as possible.
- In the future, it would be worthwhile to use the practical oil port to evaluate more than one oil port with different features (e.g. different nationality, different geographical location, and different ownership) to compare their sustainability performance, and then analyse whether there are certain trends.

TISM and MicMac Part

- As the TISM and MicMac panel group meeting participants were only selected from within the experts agreed to participate in this research (from both interview and the AHP participants), have selected them following a well organised and rigour selection process, opinions from the chosen three experts cannot be ensured to be able to represent the general opinion of the whole industry. Thus, if there were the chance to access more experts in the future and select the most authorised ones to form TISM and MicMac panel group, it would be interesting to see the most representative opinion of the industry in terms of the interrelationships between oil port sustainability groups.

Even though the above points could be considered as limitations of this research, nevertheless, there are great chances to include them as future research opportunities for further exploration within the field.

7.5 Recommendations for Future Research

In this research, there are several research ideas that were not included in the research question and the research objectives. However, it is still worthy to pay them with attention in the future studies as they might contribute to the future sustainability oil port development. The research ideas are:

- As there are always limited resources at ports (e.g. capital, funding, geographical limitations), it is crucial to develop a widely recognised 'must have sets' for oil port sustainability development across different regions and countries by taking varied features in each port into consideration.
- As there are several methods to generate the sustainability groups out of all possible groups (or at least the most often brought up ones), it is meaningful to compare the 'most crucial oil port sustainability groups' set in different methods for the purpose of extracting the commonly recognised most crucial oil port sustainability groups.
- As this research aims to fill the gap of oil ports not having enough attention on sustainability nor having a holistic sustainability framework, it will be meaningful to compare the sustainability framework inclusion differences between different types of ports.
- In this research, the concept follows the most commonly accepted sustainability definition of 'our generation need to at least leave the similar level of the living environment as us to provide the same development opportunity for our progenies'. Thus, the current framework is mainly formed based on the idea of mainly maintaining the current living situation. However, it would be interesting to find whether there will be any differences on the sustainability framework inclusion when changing the framework forming the perspective of maintaining the current situation to sustainability development.

- As this research follows the most commonly accepted and traditional definition on ‘sustainability’ (dichotomy), it will be interesting to use the latest sustainability theories against dichotomy in oil ports sustainability framework development to see whether there are differences between the two frameworks.
- As this research follows the most commonly accepted and traditional definition on ‘sustainability’ (3Ps), it would also be interesting when taking the ‘Cultural’ section into consideration to form a 4P sustainability framework for oil ports and to see whether there are differences between the two frameworks.
- This research only focused on the oil port sustainability to fill the knowledge gap of new relevant research that has been conducted regarding oil ports. However, it could be meaningful to investigate the general relationships between oil port sustainability to the other types of port’s sustainability performances at ports, which could be helpful to help manage ‘port sustainability’ as a whole in the future.
- Lastly, the ‘must have set’ could be validated by industrial experts from different port and areas to test whether it has a suitability limitation on port with different features.

To summarise, this research not only begins to open the shed of oil port oriented port sustainability management study, but also sets the foundation for the potential of future research within the field.

7.6 Summary

This study developed a practical holistic sustainability framework for the Chinese oil port. In addition, this study adds value to the practical sustainability framework by the prioritization of oil port sustainability indicators and their connections identification to ease the port manager to locate urgent ones to achieve at port based on their own situation. It is first achieved by the examination of theoretical sustainability indicators via 34 semi-structured interviews; prioritization via AHP with 70 experts; the discovery of the interrelationships between Chinese oil port sustainability groups by TISM with 3 experts; and the use of MicMac method to determine driving and dependency power of each group. This study discovers that there are no absolute positive correlations between the most prioritized groups and the groups with the highest driving power. However, 'Air' and 'Port's Operational Ability' are the most crucial ones as shown in every method used in this study. Besides, 'HR' is considered one of the core groups as well as it has the highest driving power. As a result, this study contributes to the existing literature a prioritized oil port sustainability framework, and the interrelationships between sustainability groups highlighting the groups with the high driving power to identify the most unignorably sustainability groups. Lastly, the core sustainability groups have been determined to form a 'Must Have Set' acting as the 'basic sustainability achievements' base on the result comparison between above mentioned four methods. Due to the common understanding on the importance of 'Must Have Set' included sustainability groups, it is recommended that 'Air' and 'Port's Operational Ability', and 'HR' should be taken as the priority when achieving sustainability performance at Chinese oil ports regardless any situation. Moreover, in the future research, 'must have set' could be validated by experts in different ports to see whether it has a limitation when encountering different situations / port features.

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Appendix

Appendix 1: Interview Invitation via Email

Title: Participation on an Oil Terminal Sustainability Interview for a PhD Research

Dear ,

My name is Xuemuge WANG, a PHD student researching on the Chinese oil terminal sustainability framework formation. I am writing to ask for your willingness to be interviewed for this research.

This research aims to develop a practical holistic oil terminal sustainability framework. Based on the general port governance (with focuses mainly on environment, economic, and social) relevant studies, I have forwarded a theoretical oil terminal sustainability framework and wishing to develop it into a practical one via interviewing experts (pls. find more research background at 'Research Abstract' by the very end of this email). By knowing you are the expert within the field, I would appreciate a lot if you could kindly spare me c.a. one hour at your best convenience to share some opinion with me in regards to the theoretical framework development. Your knowledge sharing action would mean a lot to both me and my study.

If you agree with the interview request, please kindly reply me back with your preferred time and the consent form (as attached) signed. Please do note your personal information, contact details, and interview content would all be held confidential (will only be accessed by me: the researcher) until they get destroyed six months after the study completion (c.a. end of 2018). Please also kindly be aware you have the right to withdraw from this research at any time you wish.

Thank you in advance!

Sincerely yours,

Xuemuge

Research Abstract

Due to the current studies' main focus on the container terminal, and the fact that sustainability is a quite new topic, oil terminal sustainability has been to a certain level ignored with barely any instructions provided even though oil terminal has a high sensitivity to accidents. With the increasing appeal from NGOs and governments on the sustainability achievement, a development of a holistic sustainability framework would be beneficial to act as a general guidance for the oil terminals to have better sustainability performance and to respond to the sustainability appeals.

Please do not hesitate to ask the researcher at any time when you have any queries regarding the interview procedure or content.

Appendix 2: Consent Form

Consent Form

I, _________________, hereby agree the request from Miss Xuemuge WANG, on the empirical stage ☐ interview / ☐ AHP / ☐ TISM (please tick) participation regarding the *Practical Holistic Oil Terminal Sustainability Framework Development* for the purpose of her PhD research completion. I understand that my personal information, contact details, and interview content would all be held confidential until they get destroyed six months after the study completion (c.a. end of 2018). I am also aware that I have the right to withdraw from this research at any time I wish.

Interviewee only:

Please tick whether you mind the interview content to be recorded. ☐ yes ☐ No

Sign:

Date:

Appendix 3: Interview Question Template

Interview Question Template

Developing a Holistic Sustainability Framework: A Case Study of China

Researcher: Xuemuge WANG

Descriptive Section:

(Name:)

Occupation:

Experience (of years):

Party (Policy Follower/Maker):

Managerial level:

Professional coverage focus:

Research Question Section:

Part 1. General Sustainability:

1. For Chinese oil terminals, what do you think of the appropriateness of *Interested Parties' Involvement, Port Competitiveness, and Port's Operational Ability* being included in the economic section?
2. For Chinese oil terminals, *what else* do you think should be included in the economic section?
3. For Chinese oil terminals, what do you think of the appropriateness of *Water, Noise, Air, Ecosystem, Energy Consumption, and Solid Wastes* being included in the environment section?
4. For Chinese oil terminals, *what else* what do you think should be included in the environment section?
5. For Chinese oil terminals, what do you think of the appropriateness of *Noise, Port HR, Citizen Living Condition, and Port's Working Environment* being included in the social section?
6. For Chinese oil terminals, *what else* what do you think should be included in the social section?

Note:

Economic refers to any matter that contributes to the port company, port authority, regional, and national development;

Environment includes to any matter that impacts on the port area ecological environment (e.g. Air condition, Water condition, etc.);

Social implies to any matter that shows influence on the port area citizen and employee livelihood.

Part 2. Economic Section:

1. For Chinese oil terminals, what do you think of the appropriateness of Employment; Cost Effectiveness; Investment Quantity; Damage Frequency; Transit Time; Financial Performance; Capacity; Increased Productivity; Political Influence; Value Added Growth; Diverse Service; and Optimised Land Use being included in the Port Operational Ability group? Please illustrate why.
2. For Chinese oil terminals, *what else* do you think should be included in the Port's Operational Ability group? Please illustrate why.
3. For Chinese oil terminals, what do you think of the appropriateness of Connection to Hinterland; Connection to other Ports; Resources; Service Quality; Cost Effectiveness; Active Shipping Activities; Economic Catalyst; Economic Strategies; Market-Share Growth; Regional Contribution; Diverse Service; Enhancement of Offshore Environment; Increasing Quality of Information Flow; and Benefits to Port Users being included in the Port Competitiveness group? Please illustrate why.
4. For Chinese oil terminals, *what else* do you think should be included in the Port Competitiveness group? Please illustrate why.
5. For Chinese oil terminals, what do you think of the appropriateness of Stakeholder's Cooperation being included in the Interested Parties' Involvement group? Please illustrate why.
6. For Chinese oil terminals, *what else* do you think should be included in the Interested Parties' Involvement group? Please illustrate why.

Part 3. Environnent Section:

1. For Chinese oil terminals, what do you think of the appropriateness of CO_2, VOC, CH_4, SO Category, NO Category, Hydrocarbons, Dust, and Suspended Solids being included in the Air group? Please illustrate why.
2. For Chinese oil terminals, *what else* do you think should be included in the Air group?
3. For Chinese oil terminals, what do you think of the appropriateness of Ballast Water; BOD; COD; Contaminated Sludge from Dredging; Washing Water; and Ship Operation Disposal being included in the Water group? Please illustrate why.

4. For Chinese oil terminals, *what else* do you think should be included in the Water group? Please illustrate why.
5. For Chinese oil terminals, what do you think of the appropriateness of Household Wastes and Tanker Operational Wastes being included in the Solid Wastes group? Please illustrate why.
6. For Chinese oil terminals, *what else* do you think should be included in the Solid Wastes group? Please illustrate why.
7. For Chinese oil terminals, what do you think of the appropriateness of Noise being included in the Noise group? Please illustrate why.
8. For Chinese oil terminals, *what else* do you think should be included in the Noise group? Please illustrate why.
9. For Chinese oil terminals, what do you think of the appropriateness of Biodiversity; Vegetation Coverage; and Distance from Ecological Sensitive Area being included in the Ecosystem group? Please illustrate why.
10. For Chinese oil terminals, *what else* do you think should be included in the Ecosystem group? Please illustrate why.
11. For Chinese oil terminals, what do you think of the appropriateness of Electricity Consumption; Fuel; Renewable energy utilisation; and Energy saving facility utilisation being included in the Energy Consumption group? Please illustrate why.
12. For Chinese oil terminals, *what else* do you think should be included in the Energy Consumption group? Please illustrate why.

Part 4. Social Section:

1. For Chinese oil terminals, what do you think of the appropriateness of Security; Safety; and Accidents (e.g. Spill, etc.) being included in the Port's Working Environment group? Please illustrate why.
2. For Chinese oil terminals, *what else* do you think should be included in the Port's Working Environment group? Please illustrate why.
3. For Chinese oil terminals, what do you think of the appropriateness of Port City Relationships; Knowledge Development/Education; Population Growth; Safety; Resources; Community; Accidents; (e.g. Spill, etc.), and Social Justice being included in the Citizen Living Condition group? Please illustrate why.
4. For Chinese oil terminals, *what else* do you think should be included in the Citizen Living Condition group? Please illustrate why.
5. For Chinese oil terminals, what do you think of the appropriateness of Noise being included in the Noise group? Please illustrate why.
6. For Chinese oil terminals, *what else* do you think should be included in the Noise group? Please illustrate why.

7. For Chinese oil terminals, what do you think of the appropriateness of Human Capital Development and Knowledge Development being included in the Port HR group? Please illustrate why.
8. For Chinese oil terminals, *what else* do you think should be included in the Port HR group? Please illustrate why.

Please do not hesitate to ask the researcher at any time when you have any queries regarding the interview procedure or content.

END

Appendix 4: Interview Record of Sustainability Groups Identification

Participants	Interested Parties' Invovlement	Port Competitiveness	Port's Operational Ability	Air	Water	Soil	Noise (Envir.)	Energy Consumption	Ecosystem	NMHC	Noise (Soc.)	HR	Citizen Lively Condition	Port's Working Environment
Seafarer 1	2	3	3	4	4	3	1	0	0	1	2	0	3	4
2	0	5	2	3	5	0	0	2	0	0	0	0	0	4
3	4	4	5	3	3	2	3	3	0	1	1	0	3	3
4	0	0	4	3	3	0	0	2	1	1	0	2	0	5
5	0	0	5	4	2	3	0	0	0	0	0	0	0	3
SUM	6	12	19	17	17	8	4	7	1	3	3	2	6	19
Port Company 1	2	0	0	5	4	0	0	1	1	1	0	0	0	4
2	3	2	3	6	3	0	1	2	1	1	2	0	3	5
3	0	3	4	4	3	2	0	1	0	0	0	2	2	3
4	2	4	4	5	4	1	0	0	0	0	2	0	0	0
5	3	3	3	3	3	0	1	0	0	1	0	0	0	3
6	1	2	4	5	4	0	0	0	0	0	0	0	3	0
7	0	2	4	5	4	3	0	3	0	0	0	0	3	3
8	3	0	3	3	3	0	1	0	3	1	3	0	4	2
9	5	3	5	5	4	1	0	3	0	1	0	0	0	4
SUM	19	19	30	41	32	7	3	10	5	5	7	2	15	24
Research Institution 1	3	1	3	7	5	0	2	3	2	0	0	0	1	0
2	1	1	3	4	4	0	0	0	3	0	0	0	1	0
3	0	0	2	5	5	3	0	2	2	0	2	0	0	0
4	0	2	1	6	4	0	0	3	3	0	0	0	2	0
5	4	1	3	7	4	0	1	2	1	0	0	4	0	0
6	2	2	1	5	4	3	0	0	2	0	0	0	3	0
7	1	1	1	6	5	0	0	0	0	0	0	0	0	0
8	0	3	1	6	3	0	0	0	2	0	0	0	2	0
9	0	0	1	4	4	0	0	1	2	0	1	0	1	0
10	3	2	2	5	5	1	0	0	2	0	0	2	2	0
11	0	1	1	6	3	3	0	0	1	0	0	0	0	2
12	1	1	0	4	4	2	0	0	2	0	2	0	1	0
SUM	15	15	19	65	50	12	3	11	22	0	5	6	13	2
Scholar 1	0	5	5	4	3	0	0	0	0	0	0	0	0	0
2	4	0	4	3	3	0	3	0	1	1	1	0	0	3
3	2	3	5	4	4	2	0	3	1	0	0	0	2	2
4	3	2	3	5	2	0	4	0	0	0	3	3	0	4
5	0	1	4	3	4	0	2	0	2	0	2	0	0	0
SUM	9	11	21	19	16	2	9	3	4	1	6	3	2	9
Government 1	0	4	3	3	3	2	0	2	1	0	0	0	3	2
2	5	5	3	3	2	3	0	0	1	0	0	1	0	0
3	1	4	3	2	3	0	3	4	1	0	3	3	1	3
SUM	6	13	9	8	8	5	3	6	3	0	3	4	4	5
TOTAL	55	70	98	150	123	34	22	37	35	9	24	17	40	59
SUM	104	127	187	292	238	63	41	68	67	18	45	30	76	113

<u>Appendix 5:</u> Interview Record of Sustainability Indicators Identification

Participants	Sharing Common Goal	No Privilige	Regularly Develop Strategic Development Plan	Sharing Same Responsibility	Balanced Relationship	Maritime Connectivity	Effective Terminal Operation	Connection to Hinterland	Effective Resources Utilisation	Terminal's Utlisation Cost	Performance under the whole SC	Regional Cooperation Performance	Ports' Function Diversity	Cost Effectiveness	FDI	Productivity	Service Quality	CO Category	VOC	NO Category	CH4	PM Category	SO Category	Hydrocarbon	NMHC
Seafare 1		Y		Y			Y			Y		Y		Y		Y	Y	Y	Y	Y		Y			
2						Y	Y	Y		Y		Y	Y		Y			Y		Y		Y			Y
3	Y		Y	Y	Y			Y	Y	Y	Y		Y	Y	Y	Y	Y	Y		Y		Y			
4													Y	Y		Y	Y	Y		Y			Y		
5													Y	Y	Y	Y	Y	Y		Y			Y	Y	
SUM	1	1	1	2	1	1	2	2	1	3	1	2	4	4	3	4	4	5	1	5	0	3	2	1	1
Port Company 1			Y		Y													Y	Y	Y	Y	Y			
2	Y		Y		Y				Y	Y			Y	Y			Y	Y	Y	Y	Y	Y	Y		
3			Y	Y	Y	Y	Y	Y						Y		Y	Y	Y			Y		Y	Y	Y
4			Y		Y	Y		Y		Y	Y		Y	Y		Y	Y	Y	Y	Y			Y	Y	
5			Y	Y	Y				Y		Y	Y		Y		Y	Y	Y		Y			Y		Y
6					Y		Y		Y				Y	Y		Y	Y	Y	Y	Y		Y	Y		
7							Y					Y	Y	Y		Y	Y	Y	Y	Y		Y	Y		
8		Y	Y		Y									Y	Y		Y	Y		Y			Y		
9	Y	Y	Y	Y	Y			Y	Y			Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		
SUM	2	2	7	3	8	2	3	3	4	2	2	3	5	8	2	6	8	9	6	8	3	5	8	2	2
Research Institution 1	Y			Y	Y				Y				Y			Y	Y	Y	Y	Y	Y	Y	Y	Y	
2	Y										Y		Y		Y	Y		Y	Y	Y			Y		
3													Y	Y				Y	Y	Y			Y	Y	Y
4											Y	Y			Y			Y	Y	Y		Y	Y	Y	Y
5	Y		Y	Y	Y							Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	
6			Y	Y					Y	Y						Y		Y	Y	Y	Y		Y		Y
7		Y				Y				Y	Y						Y	Y	Y	Y	Y	Y	Y		Y
8						Y	Y		Y				Y					Y	Y	Y		Y	Y	Y	
9																	Y	Y	Y	Y			Y		Y
10		Y	Y		Y						Y	Y		Y	Y			Y	Y	Y			Y	Y	
11										Y							Y	Y	Y	Y	Y	Y	Y		
12			Y							Y								Y	Y	Y			Y		
SUM	3	2	4	3	3	2	1	0	3	4	4	3	5	3	4	3	4	12	12	12	4	5	12	6	5
Scholar 1						Y	Y	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y			Y		
2	Y		Y	Y	Y								Y	Y		Y	Y	Y		Y			Y		
3		Y	Y				Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y		
4	Y	Y	Y				Y				Y		Y		Y	Y		Y	Y	Y		Y	Y		
5									Y				Y	Y	Y	Y		Y		Y			Y		
SUM	2	2	3	1	1	1	3	1	2	1	2	1	5	4	4	5	3	5	3	5	0	1	5	0	0
Government 1							Y	Y		Y		Y	Y		Y	Y		Y		Y			Y		
2	Y					Y	Y	Y	Y	Y		Y		Y		Y	Y	Y		Y			Y		
3			Y			Y			Y	Y	Y		Y	Y		Y				Y	Y				
SUM	1	0	1	0	0	2	2	2	2	3	1	2	2	2	1	3	1	2	0	3	1	0	2	0	0
TOTAL	9/34	7/34	16/34	9/34	13/34	8/34	11/34	8/34	12/34	13/34	10/34	11/34	21/34	21/34	14/34	21/34	20/34	33/34	22/34	33/34	9/34	15/34	29/34	9/34	8/34

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Continued:

Suspend Solids	COD	BOD	Oil Content	Ballast Water	Oil Spill/Leak	Heavy Metal	NO Category	Pump House	Tanker Truck	Oil Tanker	Crane (Oil Loading Arm)	Fuel Consumption	Electric Consumption	Renueable Energy Utilisation	Energy Saving Facility Utilisation	Biodiversity	Vegetation Coverage	Distance from the Ecologically Sensitive Area	Pump House	Tanker Truck	Oil Tanker	Crane (Oil Loading Arm)	Regional Employmetn Increasing Rate	Employee Welfare	Employee Turnover Rate	Training	Career Developmetn Opportunity
Y	Y		Y	Y						Y									Y		Y						
Y	Y	Y	Y	Y								Y	Y														
Y	Y	Y			Y			Y	Y	Y		Y	Y		Y						Y						
Y		Y	Y									Y	Y			Y								Y			Y
	Y	Y																									
4	4	4	3	2	1	0	0	1	1	2	0	3	3	0	1	1	0	0	1	0	2	0	0	1	0	0	1
Y	Y	Y	Y									Y															
		Y	Y	Y					Y			Y	Y				Y			Y	Y						
	Y	Y	Y			Y						Y												Y	Y		
	Y	Y	Y	Y						Y									Y		Y						
Y			Y	Y																							
	Y	Y	Y	Y		Y	Y																				
	Y	Y	Y	Y								Y	Y	Y													
	Y	Y	Y		Y			Y	Y	Y						Y	Y	Y	Y	Y	Y						
	Y	Y	Y	Y								Y		Y	Y												
2	7	8	9	6	1	2	1	1	2	2	0	5	2	2	1	1	2	1	2	2	3	0	0	1	1	0	0
Y	Y	Y	Y	Y	Y	Y				Y	Y	Y		Y	Y	Y	Y										
Y	Y	Y	Y		Y	Y										Y	Y	Y									
Y	Y	Y	Y	Y	Y	Y						Y		Y		Y	Y				Y	Y					
Y	Y	Y	Y		Y							Y	Y	Y		Y	Y	Y									
Y	Y	Y	Y		Y	Y	Y			Y		Y	Y			Y							Y	Y		Y	Y
Y	Y	Y	Y		Y	Y	Y									Y	Y										
Y	Y	Y	Y	Y																							
	Y	Y	Y		Y	Y	Y										Y	Y									
Y	Y	Y	Y									Y				Y	Y				Y						
Y	Y	Y	Y	Y												Y		Y					Y				Y
	Y	Y	Y		Y	Y												Y									
Y	Y	Y	Y		Y											Y	Y		Y		Y						
10	12	12	12	4	9	7	3	0	0	2	1	5	2	3	1	9	8	5	1	0	3	1	2	1	0	1	2
	Y		Y	Y																							
Y		Y	Y					Y	Y	Y								Y			Y						
Y	Y	Y	Y		Y	Y	Y					Y		Y	Y			Y									
	Y	Y						Y	Y	Y	Y								Y	Y	Y		Y		Y	Y	
	Y	Y	Y	Y				Y		Y							Y	Y			Y	Y					
2	4	4	4	2	1	1	1	3	2	3	1	1	0	1	1	0	1	3	1	1	3	1	1	0	1	1	0
	Y	Y	Y		Y									Y	Y	Y											
	Y	Y														Y							Y				
Y	Y	Y						Y		Y	Y	Y	Y	Y	Y		Y		Y		Y	Y	Y		Y	Y	
1	3	3	1	0	1	0	0	1	0	1	1	1	1	2	2	2	1	0	1	0	1	1	2	0	1	1	0
19/34	30/34	31/34	29/34	14/34	13/34	10/34	5/34	6/34	5/34	10/34	3/34	15/34	8/34	8/34	6/34	13/34	12/34	9/34	6/34	3/34	12/34	3/34	5/34	3/34	3/34	3/34	3/34

Continuous next page

Continued:

Environmental Effect to Citizens	Health Affection to Citizens	Expose to Hazour	Social Justice	Port City Relationship	Contribution to Knowledge	Occupational Disease	Poinsoning	Fire and Explosion Prevention	Loading and Unloading Accident	Collision Accident	Periodic Check on Facilities and Equipments
	Y	Y	Y			Y	Y	Y	Y		
								Y	Y	Y	Y
Y			Y	Y		Y		Y	Y		
						Y	Y	Y	Y		Y
								Y	Y		Y
1	1	1	2	1	0	3	2	5	5	1	3
								Y	Y	Y	Y
Y	Y		Y			Y	Y	Y			Y
		Y		Y		Y	Y	Y			
					Y						
					Y	Y		Y	Y		
	Y	Y	Y		Y						
Y		Y	Y			Y		Y		Y	
Y	Y	Y		Y		Y		Y			
						Y		Y		Y	Y
3	3	4	3	2	3	6	2	7	2	3	3
				Y							
				Y							
					Y						
	Y			Y	Y						
					Y						
	Y	Y		Y							
		Y		Y	Y						
Y											
Y		Y									
								Y			Y
				Y							
2	2	3	0	6	4	0	0	1	0	0	1
						Y		Y	Y		
		Y		Y	Y			Y	Y		
					Y	Y		Y	Y		Y
0	0	1	0	1	2	2	0	3	3	0	1
Y		Y		Y				Y			Y
		Y						Y	Y		Y
1	0	2	0	1	0	0	0	2	1	0	2
7/34	6/34	11/34	5/34	11/34	9/34	11/34	4/34	18/34	11/34	4/34	10/34

END

Appendix 6: AHP Survey in Excel (Tab 1 Introduction)

层次分析法研究问卷 AHP Analytic Hierarchy Process

Name:

Eligibility Questions

Please answer the following questions by selecting 'Yes' or 'No'.

1. Do you have more than five years working experience in the general port sector?
- ❑ Yes
- ❑ No

2. Do you have working experience with 'Port Sustainability' relevant field (incl. environmental measurement, daily port operation, and company development planning, etc.)?
- ❑ Yes
- ❑ No

3. What is your current occupation? pls. also list your previous occupations that you think is relevant to 'Port Sustainability' relevant field.

Please kindly note these are mandatory questions for carry on with the following survey questions. Your personal information will be held confidential.

研究问卷目标 Objective

确定下列可持续性发展相关因素在'油港可持续性发展政策框架'中的重要比。An AHP Survey to determine the weight of each below factors in the prospected 'Oil Port Sustainability Policy Framework'.

研究梗概 Reseafch Abstract

The aim of this research is to develop a practical sustainability framework for the Chinese oil terminals to act as a general guide to enhance their sustainability performance. The sustainability objects have been determined via literature review and interviews with experts. Now the AHP survey is conducted to obtain the relative importance of each sustainability objects. 此研究的研究目的是发展出一个可以作为导引来帮助中国油港提高可持续性发展表现的油港可持续性发展框架。可持续性发展指标已通过文献综述和专家采访获得。现在则需要通过AHP研究法来确定各可持续性发展指标的重要性。

填写指导 Guidance

确定下列可持续性发展相关因素在'油港可持续性发展政策框架'中的重要比。An AHP Survey to determine the weight of each below factors in the prospected 'Oil Port Sustainability Policy Framework'.

范例 Example

因素Criteria		重要比 More Important	测评值Scale
A	B	A或B A or B	(1-9)
经济 Economic	环境 Environment	B	2
	社会 Social	A	1

意味着：环境因素是经济因素的两倍重要，且社会因素和经济因素同等重要。

Means: Environment is 2 times more important than Economic, and Social and Economic are equally important.

1. 综合 General

对比表 Table

因素Criteria		重要比More Important	测评值Scale
A	B	A或B A or B	(1-9)
经济 Economic	环境 Environment		
	社会 Social		
环境 Environment	社会 Social		

Continuous next page

Continued (Tab 2 Economic):

Layer 2	*2.0 经济 Economic*			
	对比表 Table			
	因素 Criteria		**重要比 More Important**	**测评值 Scale**
	A	B	A或B A or B	(1-9)
	利益相关者 Involvement of Interested Parties	港口竞争力 Port's Competitiveness		
		港口运营能力 Port's Operational Ability		
	港口竞争力 Port's Competitiveness	港口运营能力 Port's Operational Ability		
Layer 3	*2.1 经济 Economic 利益相关者参与Involvement of Interested Parties*			
	对比表 Table			
	因素 Criteria		**重要比 More Important**	**测评值 Scale**
	A	B	A或B A or B	(1-9)
	利益相关者在可持续性发展上有共同目标 Interested Parties Sharing the Same Goal on Sustainability	任何一方在为遵循法律和规则时都无特权 No Party has Priviliges when not following the Rules		
		定期发展策略性地发展计划 Developing Strategic Development Plans every certain Period of Time		
		共同承担港口可持续性发展相关的责任 Sharing Respsonsibilities on Sustainability Matter on Port		
		利益相关者之间的良好关系 Balanced Relationship between Interested Partied		
	任何一方在为遵循法律和规则时都无特权 No Party has Priviliges when not following the Rules	定期发展策略性地发展计划 Developing Strategic Development Plans every certain Period of Time		
		共同承担港口可持续性发展相关的责任Sharing Respsonsibilities on Sustainability Matter on Port		
		利益相关者之间的良好关系 Balanced Relationship between Interested Partied		
	定期发展策略性地发展计划 Developing Strategic Development Plans every certain Period of Time	共同承担港口可持续性发展相关的责任Sharing Respsonsibilities on Sustainability Matter on Port		
		利益相关者之间的良好关系 Balanced Relationship between Interested Partied		
	共同承担港口可持续性发展相关的责任Sharing Respsonsibilities on Sustainability Matter on Port	利益相关者之间的良好关系 Balanced Relationship between Interested Partied		
	2.2 经济 Economic 港口运营能力Ports' Operational Ability			
	对比表 Table			
	因素 Criteria		**重要比 More Important**	**测评值 Scale**
	A	B	A或B A or B	(1-9)
	港口功能多元化(例:增值服务,和内陆链接等) Ports' Function Diversity (e.g. Value adding Service, Linkage with Hinterland, etc.)	客观的利润(投资产出) Cost Effectiveness		
		外商直接投资 Foreign Direct Investments (FDI)		
		生产力 Productivity		
		服务质量 Service Quality		
	客观的利润(投资产出) Cost Effectiveness	外商直接投资 Foreign Direct Investments (FDI)		
		生产力 Productivity		
		服务质量 Service Quality		
	外商直接投资 Foreign Direct Investments (FDI)	生产力 Productivity		
		服务质量 Service Quality		
	生产力 Productivity	服务质量 Service Quality		
	2.3 经济 Economic 港口竞争Ports' Competition			
	对比表 Table			
	因素 Criteria		**重要比 More Important**	**测评值 Scale**
	A	B	A或B A or B	(1-9)
	和其他港口链接 Maritime Connectivity	有效的港口运营/服务能力 Effective Port Operations/Service Providing Ability (e.g. Transit Time, Level of Cranes, staff, Congestion Time, etc.)		
		和内陆链接 Hinterland Connection		
		资源的有效利用 (例:地理优势,基础设施等) Resources (e.g. Geographical Advantage, Facilities and Equipments, etc.)		
		港口使用成本 Port utilisation Cost		
		在整条供应链下的表现 Performance in the Supply Chain Context		
	有效的港口运营/服务能力 Effective Port Operations/Service Providing Ability (e.g. Level of Cranes, staff, Congestion Time, etc.)	和内陆链接 Hinterland Connection		
		资源的有效利用 (例:地理优势,基础设施等) Resources (e.g. Geographical Advantage, Facilities and Equipments, etc.)		
		港口使用成本 Port utilisation Cost		
		在整条供应链下的表现 Performance in the Supply Chain Context		
	和内陆链接 Hinterland Connection	资源的有效利用 (例:地理优势,基础设施等) Resources (e.g. Geographical Advantage, Facilities and Equipments, etc.)		
		港口使用成本 Port utilisation Cost		
		在整条供应链下的表现 Performance in the Supply Chain Context		
	资源的有效利用 (例:地理优势,基础设施等) Effective Resources Usage (e.g. Geographical Advantage, Facilities and Equipments, etc.)	港口使用成本 Port utilisation Cost		
		在整条供应链下的表现 Performance in the Supply Chain Context		
	港口使用成本 Port utilisation Cost	在整条供应链下的表现 Performance in the Supply Chain Context		

Continuous next page

Continued (Tab 3 Social):

Layer 2 *3.0 社会 Social*

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A or B	(1-9)
噪音 Noise	港口人力资源 Port Human Resource		
	居民生活状况 Citizen Lively Condition		
	港口工作环境 Port's Working Environment		
港口人力资源 Port Human Resources	居民生活环境 Citizen Lively Condition		
	港口工作环境 Port's Working Environment		
居民生活环境 Citizen Lively Condition	港口工作环境 Port's Working Environment		

Layer 3 *3.1 社会 Social 噪音影响 Noise Effect*

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
泵房 Pump House	油罐车 Tanke Truck		
	油船 Oil Tanker		
	吊机 Cranes		
油罐车 Tanke Truck	油船 Oil Tanker		
	吊机 Cranes		
油船 Oil Tanker	吊机 Cranes		

3.2 社会 Social 工作环境 Working Environment

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
职业病（肺癌，心血管疾病，哮喘等）Occupational Disease (Lung Cancer, Casrbi	油气中毒 Oil and Gas Poisoning		
	防火防爆 Fire Prevention and Explosion Prevention		
	装卸事故 Load and Unload Accident		
	入港时船体榷撞 Tanker Collision Accident		
	器械定期检查 Periodic Check on Equipments		
油气中毒 Oil and Gas Poisoning	防火防爆 Fire Prevention and Explosion Prevenrion		
	装卸事故 Load and Unload Accident		
	入港时船体榷撞 Tanker Collision Accident		
	器械定期检查 Periodic Check on Equipments		
防火防爆 Fire Prevention and Explosion Prevenrion	装卸事故 Load and Unload Accident		
	入港时船体榷撞 Tanker Collision Accident		
	器械定期检查 Periodic Check on Equipments		
装卸事故 Load and Unload Accident	入港时船体榷撞 Tanker Collision Accident		
	器械定期检查 Periodic Check on Equipments		
入港时船体榷撞 Tanker Collision Accident	器械定期检查 Periodic Check on Equipments		

3.3 社会 Social 人力资源 Human Resource

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
当地就业率增长 Employment Increasing Rate	员工福利 Employee Welfare		
	员工跳槽率 Employee Turnover Rate		
	培训 Training		
	员工职业发展 Employee Career development		
员工福利 Employee Welfare	员工跳槽率 Employee Turnover Rate		
	培训 Training		
	员工职业发展 Employee Career development		
员工跳槽率 Employee Turnover Rate	培训 Training		
	员工职业发展 Employee Career development		
培训 Training	员工职业发展 Employee Career development		

3.4 社会 Social 居民生活状态 Citizen Livelyhood

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
环境对居民影响 Environmental Effect to Citizen	在港口生活对居民健康影响 Effect of Living in Port on Citizens' Health		
	曝光在危险中（火灾，爆炸等）Expoision to Hazour situations (Fire, explosion, etc.)		
	在港口生活对居民人身权力影响（占地，申诉渠道等）Effect of Living in Port on Citizens' rights (Land Occupation, Complain Channels,		
	港口和城市关系 Port-City Relationships		
在港口生活对居民健康影响 Effect of Living in Port on Citizens' Health	曝光在危险中（火灾，爆炸等）Expoision to Hazour situations (Fire, explosion, etc.)		
	在港口生活对居民人身权力影响（占地，申诉渠道等）Effect of Living in Port on Citizens' rights (Land Occupation, Complain Channels,		
	港口和城市关系 Port-City Relationships		
	对知识拓展和教育的贡献 Contribution to Knowledge Development and Education		
曝光在危险中（火灾，爆炸等）Expoision to Hazour situations (Fire, explosion, et	在港口生活对居民人身权力影响（占地，申诉渠道等）Effect of Living in Port on Citizens' rights (Land Occupation, Complain Channels,		
	港口和城市关系 Port-City Relationships		
	对知识拓展和教育的贡献 Contribution to Knowledge Development and Education		
在港口生活对居民人身权力影响（占地，申诉渠道等）Effect of Living in Port on C	港口和城市关系 Port-City Relationships		
	对知识拓展和教育的贡献 Contribution to Knowledge Development and Education		
港口和城市关系 Port-City Relationships	对知识拓展和教育的贡献 Contribution to Knowledge Development and Education		

Continuous next page

Continued (Tab 4 Environment):

Layer 2 *4.0 环境 Environment*

对比表 Table

因素 Criteria		重要比 More Importan	测评值 Scale
A	B	A或B A or B	(1-9)
空气 Air	水 Water		
	土壤 Soil		
	噪音 Noise		
	能源消耗 Energy Consumption		
	生态环境 Ecosystem		
	非甲烷总烃 NMHC (Non-methane hydrocarbon)		
水 Water	土壤 Soil		
	噪音 Noise		
	能源消耗 Energy Consumption		
	生态环境 Ecosystem		
	非甲烷总烃 NMHC		
土壤 Soil	噪音 Noise		
	能源消耗 Energy Consumption		
	生态环境 Ecosytem		
	非甲烷总烃 NMHC		
噪音 Noise	能源消耗 Energy Consumption		
	生态环境 Ecosystem		
	非甲烷总烃 NMHC		
能源消耗 Energy Consumption	生态环境 Ecosystem		
	非甲烷总烃 NMHC		
生态环境 Ecosystem	非甲烷总烃 NMHC		
油罐车 Tanke Truck	油船 Oil Tanker		
	吊机 Cranes		
油船 Oil Tanker	吊机 Cranes		

Layer 3 *4.1 环境Environment Sound 噪音环境*

对比表 Table

因素 Criteria		重要比 More Importan	测评值 Scale
A	B	A或B A or B	(1-9)
泵房 Pump House	油罐车 Tanke Truck		
	油船 Oil Tanker		
	吊机 Cranes		
油罐车 Tanke Truck	油船 Oil Tanker		
	吊机 Cranes		
油船 Oil Tanker	吊机 Cranes		

4.2 环境Environment 生态环境 Ecological System

对比表 Table

因素 Criteria		重要比 More Importan	测评值 Scale
A	B	A或B A or B	(1-9)
生物多样性 Biodiversity	植被覆盖率 Vegetation coverage		
	与生态敏感距离 Biological Sentivitity Distance		
植被覆盖率 Vegetation coverage	与生态敏感距离 Biological Sentivitity Distance		

4.3 环境Environment 水环境 Water Condition

对比表 Table

因素 Criteria		重要比 More Importan	测评值 Scale
A	B	A或B A or B	(1-9)
悬浮物 Suspended Solids	化学需氧量 Chemical Oxygen Demand (COD)		
	生化需氧量 Biochemical Oxygen Demand (BOD)		
	含油量 (压舱，洗舱，机舱) Oil Content (from ballast water, Tank Cleaning, and Engine Room)		
	压舱水排放 Ballast Water Discharge		
化学需氧量 COD	生化需氧量 BOD		
	含油量 Oil Content		
	压舱水排放 Ballast Water Discharge		
生化需氧量 BOD	含油量 Oil Content		
	压舱水排放 Ballast Water Discharge		
含油量 Oil Content	压舱水排放 Ballast Water Discharge		

Continuous next page

Continued:

4.4 环境Environment 能源消耗 Energy Consumption

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
燃油消耗 Fuel Consumption	电消耗 Electronic Consumption		
	可再生能源使用 Renuewable Energy Consumption Utilisation		
	能源节省型器械使用 Enrgy-saving Facilities Utilisatoin		
电消耗 Electronic Consumption	可再生能源使用 Renuewable Energy Consumption Utilisation		
	能源节省型器械使用 Enrgy-saving Facilities Utilisatoin		
可再生能源使用 Renuewable Energy Consumption U	能源节省型器械使用 Enrgy-saving Facilities Utilisatoin		

4.5 环境Environment 土壤环境 Soil Condition

对比表 Table

因素 Criteria		重要比 More Important	测评值 Scale
A	B	A或B A or B	(1-9)
油化泄露/排放 Chemical and Oil Spills/Discharge	重金属污染 Heavy Metal Pollution		
	氮氧化物 NOx		
重金属污染 Heavy Metal Pollution	氮氧化物 NOx		

4.6 环境 Environment 空气 Air

对比表 Table

Criteria		More Important	Scale
A	B	A or B	(1-9)
CO类 (CO, CO2) CO Category (CO, CO2)	挥发性有机物 VOC (Volatile Organic Compound)		
	NO类 (NOx, N2O, NO2) NO Category (NOx, N2O, NO2)		
	CH4		
	悬浮粒子类 (PM2.5, PM10) Particulat Matters Category (PM2.5, PM10)		
	SO类 (SOx, SOx) SO Category (SOx, SOx)		
	碳氢化合物 Hydrocaebons		
挥发性有机物 VOC (Volatile Organic Compound)	NO类 (NOx, N2O, NO2) NO Category (NOx, N2O, NO2)		
	CH4		
	悬浮粒子类 (PM2.5, PM10) Particulat Matters Category (PM2.5, PM10)		
	SO类 (SOx, SOx) SO Category (SOx, SOx)		
	碳氢化合物 Hydrocaebons		
NO类 (NOx, N2O, NO2) NO Category (NOx, N2O, N	CH4		
	悬浮粒子类 (PM2.5, PM10) Particulat Matters Category (PM2.5, PM10)		
	SO类 (SOx, SOx) SO Category (SOx, SOx)		
	碳氢化合物 Hydrocaebons		
CH4	悬浮粒子类 (PM2.5, PM10) Particulat Matters Category (PM2.5, PM10)		
	SO类 (SOx, SOx) SO Category (SOx, SOx)		
	碳氢化合物 Hydrocaebons		
悬浮粒子类 (PM2.5, PM10) Particulat Matters Catego	SO类 (SOx, SOx) SO Category (SOx, SOx)		
	碳氢化合物 Hydrocaebons		
SO类 (SOx, SOx) SO Category (SOx, SOx)	碳氢化合物 Hydrocaebons		

END

Appendix 7: AHP Survey Invitation via Email

Title: Participation on an Oil Terminal Sustainability AHP Survey for a PhD Research

Dear ,

My name is Xuemuge WANG, a PHD student researching on the Chinese oil terminal sustainability framework formation. I am writing to ask for your willingness to participate a survey for this research.

This research aims to develop a practical holistic oil terminal sustainability framework. Based on the previous interview conduction with experts, I have forwarded a practical oil terminal sustainability framework and wishing to develop it into a prioritised one via sending AHP survey to experts (pls. find more research background at 'Research Abstract' by the very end of this email and more survey guidance in the attached Survey file). By knowing you are the expert within the field, I would appreciate a lot if you could kindly spare me c.a. 30 minutes at your best convenience to share some opinion with me in regards to the oil terminal sustainability objectives prioritisation. Your knowledge sharing action would mean a lot to both me and my study.

If you agree with the survey request, please kindly reply me back with your filled survey and the consent form (as attached) signed. Please do note your personal information, contact details, and survey content would all be held confidential (will only be accessed by me: the researcher) until they get destroyed six months after the study completion (c.a. end of 2018). Please also kindly be aware you have the right to withdraw from this research at any time you wish.

Thank you in advance!

Sincerely yours,

Xuemuge

Research Abstract

Due to the current studies' main focus on the container terminal, and the fact that sustainability is a quite new topic, oil terminal sustainability has been to a certain level ignored with barely any instructions provided even though oil terminal has a high sensitivity to accidents. With the increasing appeal from NGOs and governments on the sustainability achievement, a development of a holistic sustainability framework would be beneficial to act as a general guidance for the oil terminals to have better sustainability performance and to respond to the sustainability appeals.

Please do not hesitate to ask the researcher at any time when you have any queries regarding the interview procedure or content.

Please see 'AHP participants Eligibility' continued in the next page

Appendix 8: AHP Participants Eligibility

Eligibility Questions

Please answer the following questions by selecting 'Yes' or 'No'.

1. Do you have more than five years working experience in the general port sector?

❑ Yes
❑ No

2. Do you have working experience with 'Port Sustainability' relevant field (incl. environmental measurement, daily port operation, and company development planning, etc.)?

❑ Yes
❑ No

3. What is your current occupation? pls. also list your previous occupations that you think is relevant to 'Port Sustainability' relevant field.

Please kindly note these are mandatory questions for carry on with the following survey questions. Your personal information will be held confidential.

Appendix 9: Pilot AHP Survey Template

层次分析法研究问卷 AHP Analytic Hierarchy Process (Pilot)

Name:

Completion Time:

Suggestions on this Survey:

Eligibility Questions

Please answer the following questions by selecting 'Yes' or 'No'.

1. **Do you have more than five years working experience in the general port sector?**
   - ❑ Yes
   - ❑ No

2. **Do you have working experience with 'Port Sustainability' relevant field (incl. environmental measurement, daily port operation, and company development planning, etc.)?**
   - ❑ Yes
   - ❑ No

3. **What is your current occupation? pls. also list your previous occupations that you think is relevant to 'Port Sustainability' relevant field.**

Please kindly note these are mandatory questions for carry on with the following survey questions. Your personal information will be held confidential.

研究问卷目标 Objective

确定下列可持续性发展相关因素在'油港可持续性发展政策框架'中的重要比。An AHP Survey to determine the weight of each below factors in the prospected 'Oil Port Sustainability Policy Framework'.

研究梗概 Reseafch Abstract

The aim of this research is to develop a practical sustainability framework for Chinese oil terminals to act as general guidance for the increasingly crucial port sustainability development.

这篇文章的研究目的是发展出一个实际的中国油港可持续性发展框架已作为帮助港口可持续性发展进步的基本指导框架。

填写指导 Guidance

确定下列可持续性发展相关因素在'油港可持续性发展政策框架'中的重要比。An AHP Survey to determine the weight of each below factors in the prospected 'Oil Port Sustainability Policy Framework'.

范例 Example

因素Criteria		重要比 More Important	测评值Scale
A	B	A或B A or B	(1-9)
经济 Economic	环境 Environment	B	2
	社会 Social	A	1

意味着：环境因素是经济因素的两倍重要，且社会因素和经济因素同等重要。

Means: Environment is 2 times more important than Economic, and Social and Economic are equally important.

Appendix 10: AHP Feedback Initial Reminder (Email)

Title: Reminder of the Oil Terminal Sustainability AHP Survey Completion

Dear ,

I am the PHD student researching on the Chinese oil terminal sustainability framework formation, whom has sent you the AHP survey in Excel a week ago. I am writing to ask whether you have encountered any trouble when completing this survey.

If you find any difficulties or any queries regarding this research or this survey, please feel free to contact me at any time. Your kind support and help are greatly appreciated.

Thank you.

Sincerely yours,

Xuemuge

Appendix 11: AHP Feedback Second Reminder (Email)

Title: Reminder of the Oil Terminal Sustainability AHP Survey Completion

Dear ,

I am the PHD student researching on the Chinese oil terminal sustainability framework formation, whom has sent you the AHP survey in Excel two weeks ago. I am writing to ask whether you have encountered any trouble when completing this survey.

If you find any difficulties or any queries regarding this research or this survey, please feel free to contact me at any time. Also, it will be very insightful if you could kindly complete the survey as soon as you can.

Your kind support and help are greatly appreciated.

Thank you.

Sincerely yours,

Xuemuge

<u>Appendix 12:</u> AHP Feedback Third Reminder (Email)

Title: Reminder of the Oil Terminal Sustainability AHP Survey Completion

Dear ,

I am the PHD student researching on the Chinese oil terminal sustainability framework formation, whom has sent you the AHP survey in Excel previously. I am writing to ask whether you have encountered any trouble when completing this survey.

If you find any difficulties or any queries regarding this research or this survey, please feel free to contact me at any time. Also, it will be very insightful if you could kindly complete the survey as soon as you can.

Alternatively, if you wish to withdrawn from this research due to any reason, please kindly reply me briefly stating you wish to withdrawn.

Your kind support and help are greatly appreciated.

Thank you.

Sincerely yours,

Xuemuge

Appendix 13: Full List of C.I Consistency

PID	Name	Overall	Goal: Oil Terminal Sustainability Framework
		#Factors	3
0	Facilitator	.0642	.0000
2	P2	.0354	.0511
3	P3	.0253	.0000
4	P4	.0527	.0511
5	P5	.0267	.0000
6	P6	.0349	.0088
7	P7	.0477	.0511
8	P8	.0113	.0000
9	P9	.0587	.0511
10	P10	.0625	.0000
11	P11	.0373	.0511
12	P12	.0188	.0174
13	P13	.0472	.0511
14	P14	.0180	.0088
15	P15	.0271	.0000
16	P16	.0381	.0511
17	P17	.0190	.0000
18	P18	.0272	.0088
19	P19	.0090	.0000
20	P20	.0306	.0511
21	P21	.0395	.0511
22	P22	.0384	.0000
23	P23	.0093	.0088
24	P24	.0126	.0000
25	P25	.0319	.0511
26	P26	.0408	.0511
27	P27	.0131	.0000
28	P28	.0135	.0088
29	P29	.0197	.0000
30	P30	.0299	.0000
31	P31	.0170	.0000
32	P32	.0275	.0174
33	P33	.0489	.0174
34	P34	.0236	.0000
35	P35	.0390	.0000
36	P36	.0436	.0511
37	P37	.0464	.0088
38	P38	.0257	.0000

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Continued:

39	P39	.0312	.0000
40	P40	.0363	.0174
41	P41	.0390	.0174
42	P42	.0450	.0511
43	P43	.0503	.0511
44	P44	.0579	.0511
45	P45	.0334	.0511
46	P46	.0403	.0174
47	P47	.0320	.0174
48	P48	.0234	.0000
49	P49	.0237	.0000
50	P50	.0359	.0000
51	P51	.0622	.0277
52	P52	.0431	.0511
53	P53	.0621	.0511
54	P54	.0319	.0000
55	P55	.0234	.0000
56	P56	.0472	.0511
57	P57	.0273	.0000
58	P58	.0329	.0511
59	P59	.0423	.0511
60	P60	.0326	.0511
61	P61	.0509	.0511
62	P62	.0312	.0000
63	P63	.0177	.0000
64	P64	.0556	.0420
65	P65	.0428	.0511
66	P66	.0426	.0511
67	P67	.0251	.0174
68	P68	.0356	.0511
69	P69	.0274	.0511
70	P70	.0352	.0511

END

Appendix 14: TISM Invitation via Email

Dear ,

I am the PHD student researching on the Chinese oil terminal sustainability framework formation whom had an interview with you. During our last interview, you have kindly agreed to participate the TISM panel meeting for this research.

This TISM panel group is formed by three experts (including you). As I have explained after the interview, the aim of gathering this panel meeting is to obtain a common understanding on the relationships determination between the previously identified sustainability groups (generated from the interview result). During the prospective meeting, the sustainability groups will be pairwise compared to determine their relationships from only the following four types of answer:

V: related, and the factor i is impacting j;

A: related, and factor j is impacting I;

1: mutually impacted;

0: no relation at all.

Based on the small number of sustainably groups and the few options, this meeting is not expected to exceed 60 minutes. I am hereby to ask you to kindly advise when will at your best convenience to have the panel meeting. Please select from the following date with the specific time you **CANNOT** attend the meeting in the following date:

- 25th, Sep, 2017
- 26th, Sep, 2017
- 27th, Sep, 2017
- 28th, Sep, 2017
- 29th, Sep, 2017

Please also kindly adivise your preferred meeting method:

- WeChat video call;
- Skype

Please find more information about this meeting in the TISM survey file attached. I shall also explain in detail when we hold the meeting. Thank you and look forwarding hearing from you.

Sincerely yours,

Xuemuge

Appendix 15: TISM Survey in Excel

TISM 问卷

研究问卷目标 Objective
确定下列可持续性发展相关因素在 油港可持续性发展框架'中的相互相关关系。

研究梗概 Reseafch Abstract
本研究项目的目标是针对中国油港在私有化的大环境下发展出一个可持续性发展的政策框架，并用该框架来测评公有油港和私有油港在可持续性发展的表现上是否有区别，区别在哪里。油港可持续性发展政策框架的相关因素已通过文献综述和专家采访确定，此层次分析法研究问卷是为了确定各可持续性发展相关因素（大类）所应在政策框架中所占的重要比。The aim of this research is to develop a policy framework for the Chinese oil ports' sustainability development in port privitisation and use the framework to examine the impact of whether ownership has an impact on the ports' sustainability performance. Factors to build the framework has been generated from previous literature and interviews with experts in the field. This survey is designed to fulfil the aim of determining the weight of each factor in the prospective sustainability framework.

填写指导 Guidance
确定下列可持续性发展相关因素在 油港可持续性发展框架'中的相互相关关系。

范例 Example

因素A	因素B	因素B	因素B
	Involvement of Interested Parties 利益	Competitiveness 港口竞	perational Ability 港口运营能力
Involvement of Interested Parties 利益相关者参与		1	0
Port's Competitiveness	A		B

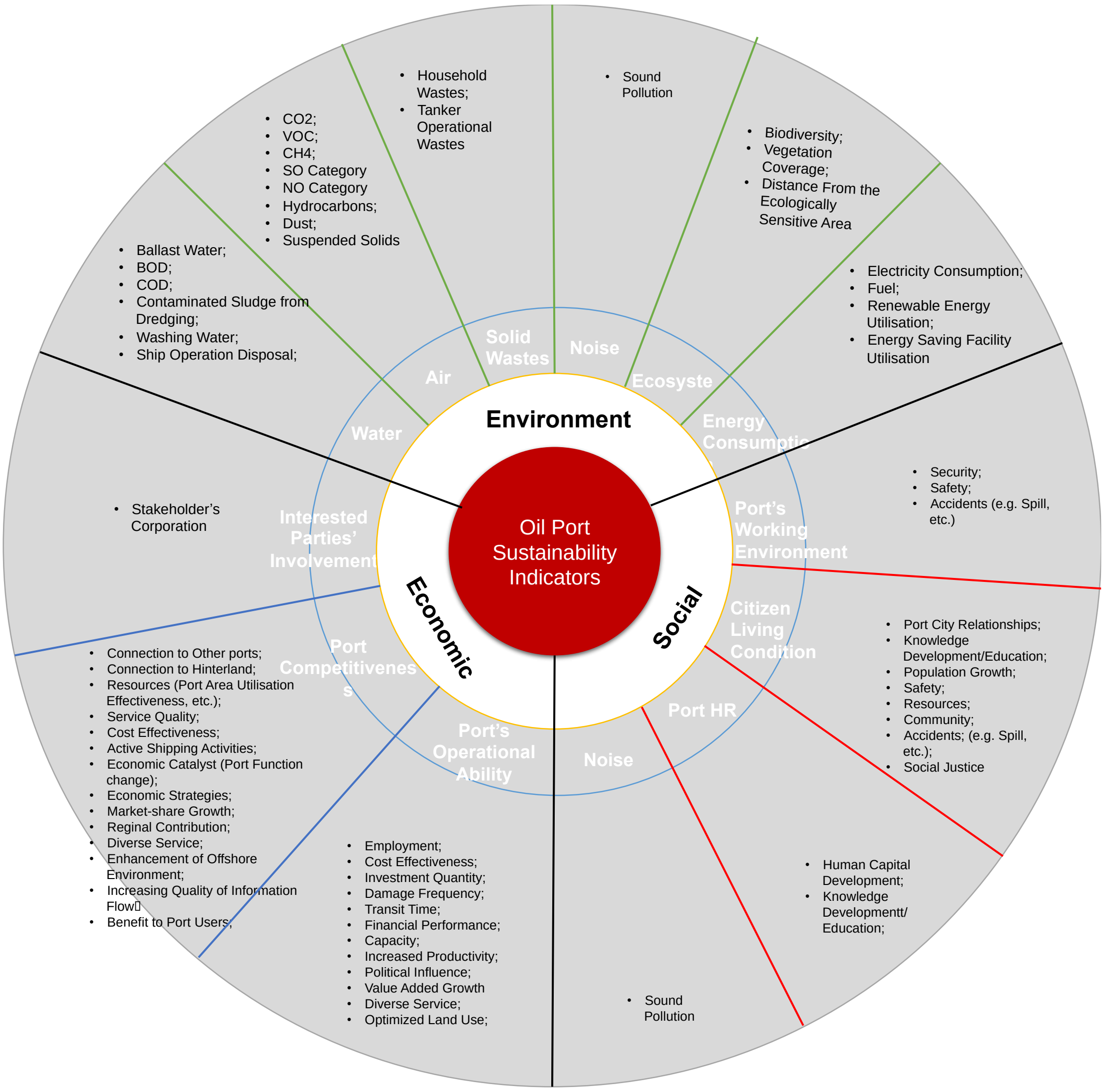
A：因素A与因素B相关，且A的结果影响着B（因素A与因素B呈正相关关系）
B：因素A与因素B相关，且B的结果影响着A（因素A与因素B呈负相关关系）
1：因素A与因素B相关，且起相同等比例的相互影响
0：因素A与因素B不相关
灰色块部分：不用填

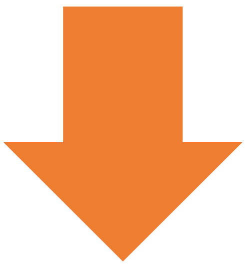
意味着 Means
Involvement of Interested Parties和Port's Competitiveness相关且互相起同等比例的影响
Involvement of Interested Parties和Port's Operational Ability不相关
Port's Competitiveness和Involvement of Interested Parties相关，且Port's Competitiveness的结果影响着Involvement of Interested Parties（两者呈正相关关系）
Port's Competitiveness和Port's Operational Ability相关，且Port's Operational Ability的结果影响着Involvement of Interested Parties（两者呈负相关关系）

因素A	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B	因素B
	1 Interested Parties' Invov	2 Port Competitiveness 港	3 Port Operational Ability	4 Air 空气	5 Water 水	6 Soil 土壤	7 Noise (Envir.) 噪音 (环境	8 Energy Consumption	9 Ecosystem 生态系统	10 NMHC 非甲烷总烃	11 Noise (Social) 噪音 (社	12 HR 港口人力资源	13 Citizen Livelyhood 居民	14 Port's Working Environment 港口工作环境
1 Interested Parties' Involvement 利益相关者参与														
2 Port Competitiveness 港口竞争力														
3 Port Operational Ability 港口运营能力														
4 Air 空气														
5 Water 水														
6 Soil 土壤														
7 Noise (Envir.) 噪音 (环境层面)														
8 Energy Consumption 能源消耗														
9 Ecosystem 生态系统														
10 NMHC 非甲烷总烃														
11 Noise (Social) 噪音 (社会层面)														
12 HR 港口人力资源														
13 Citizen Livelyhood 居民生活状况														
14 Port's Working Environment 港口工作环境														

Appendix 16: Transformation of the Sustainability Framework

Theoretical Framework





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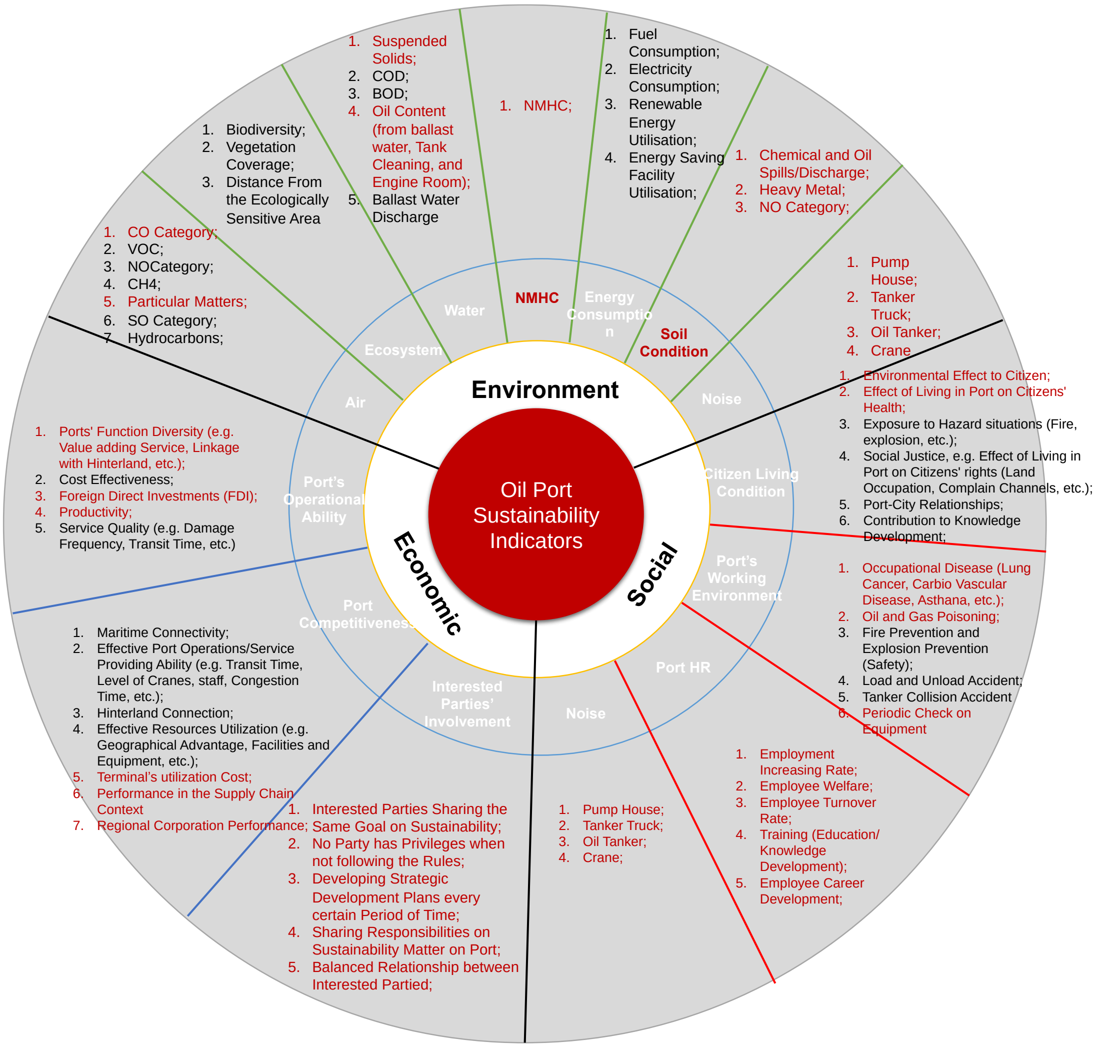
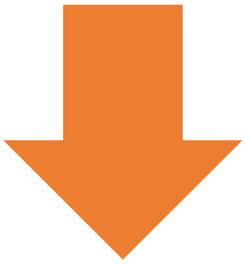
Practical Framework





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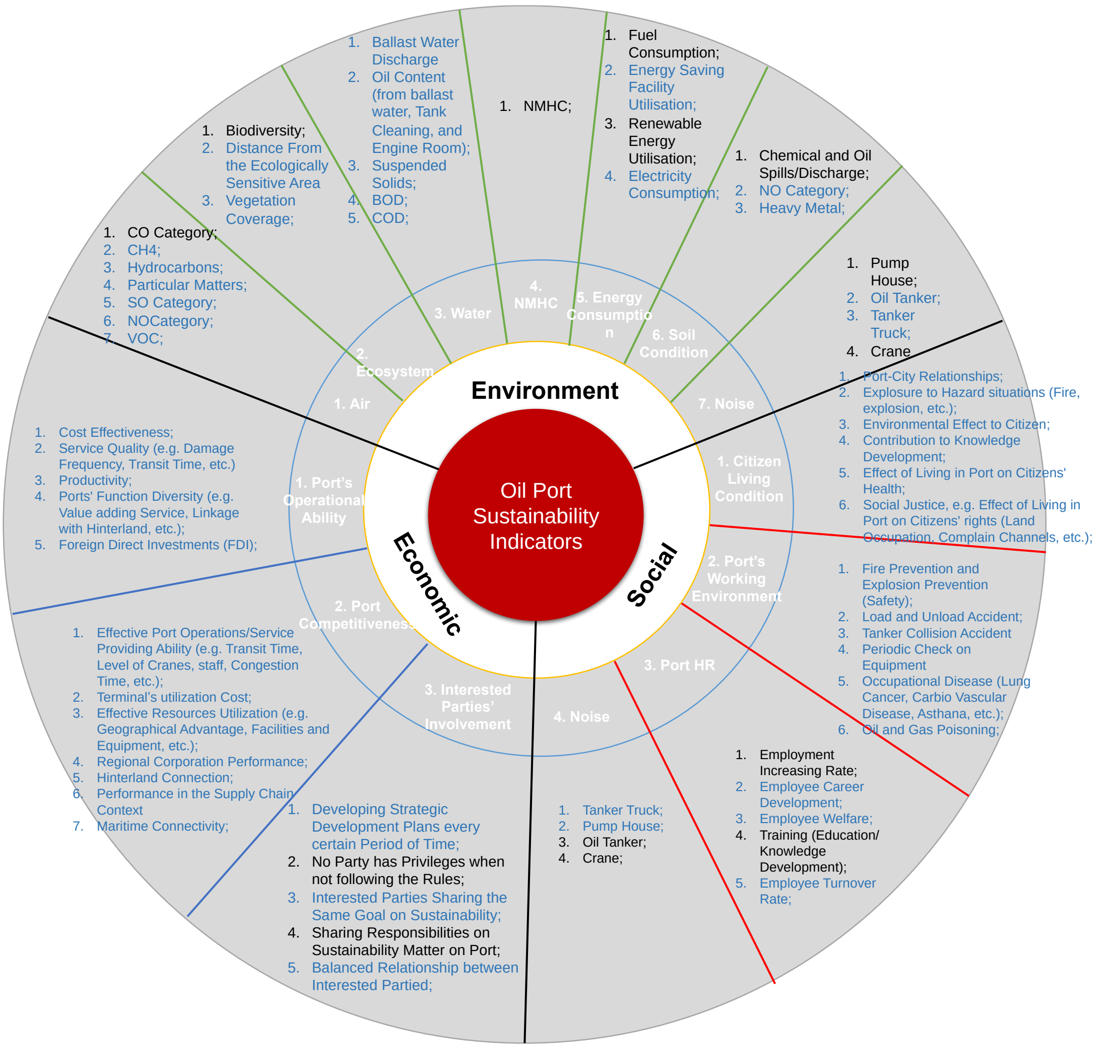
Prioritised Framework



END

Appendix 17: Change to the Theoretical Sustainability Indicators

Section	Group	Indicator	Adding/Eliminating	Reason of Change
Environment	Water	Contaminated Sludge from Dredging	Eliminating	Normally happen in the Construction period (e.g. port expansion). However, it did not occur to most of the experts (95% out of 100%) until the researcher brought it up.
		Washing Water	Eliminating	Rearranged into 'Oil Contents'.
		Ship Operation Disposal	Eliminating	Rearranged into 'Oil Contents'.
		Oil Content	Adding	The main concern in the case of oil port is the residual of petroleum products being remained in any form of disposal (both solid and liquid disposal), which has a big form coverage and harms the water quality a lot.
		Suspend Solids	Adding	A kind of particulars. It could be found in oil ports e.g. when the port is under construction, after burning coal, from daily disposal. Due to the multiple source of arisen and its harms the water quality, most of the experts (97% out of 100%) think it should be included in the practical framework.
	Air	CO2	Eliminating	Being embraced by CO category.
		Suspended Solids	Eliminating	in container ports, suspended solids is a serious issue. But in the case of oil ports, except for construction period, the suspended solids mostly refer to oil residuals and mainly harm the water rather than air.
		CO Categories	Adding	In oil ports, not only CO_2 is the main concern for air quality, C_2O, CO, and other CO category indicators also exists and harms the port area air quality.
		PM	Adding	Often arise from coal burning, waste water disposal, and fuel burning, etc. which happens a lot in oil ports.
	NMHC	NMHC	Adding	Under the most cases, NMHC is categorised under the 'Air' groups. It is because NMHC happens every time when the collecting wastes gas and oil, as well as truck use. Especially when the tanker is berthing, due to the low engine operation level, the NMHC are being produced at a relatively high level. Thus, it is now a serious concern affecting the air condition. In this study, the reason this study separates NMHC from the air group, is because multiple experts mentioned the impact of NMHC to both plants (decreasing the ability to against insects) and human health, especially the damage to eyes, skin, and breathing system through the rise of PAN (Peroxyacetyl Nitrate) and Ozone when exposed to strong light. However, due to the fact it can only be captured from the air, it is categorised under the 'Environmental' section.

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Environment	Noise	Pump House	Adding	Pump house is needed on the oil tanker to load and unload petroleum products to/from the tanker to the storage tank/tanker. During pumping, the loud sound could make seafarers and relevant employees. Another pump house is existing onshore for fire & explosion control. In this case the sound may also affect fishes and birds within the port area. However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.
		Oil Tanker	Adding	Even though the tanker is berthing, the engine is still under operation at all times. The engine sound is loud enough to make employees and seafarers uncomfortable. However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.
		Tanker Truck	Adding	Pipelines, chemical oil and petroleum products normally transport even though crude oil are often being transported via tanker truck. Thus, during the transportation period, the noise of tanker truck could be a source to make residences and employees uncomfortable.
		Crane	Adding	Even though in comparison to pump house, the crane is relatively less noisy when loading and unloading petroleum products. However, the sound of crane is still laud enough to affect fishes and birds within the port area.However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.
	Soil	Oil Leak/Discharge	Adding	Onshore oil leaking (fuel and petroleum products) to land could lead to soil damage.
		Heavy Metal	Adding	Onshore heavy metal inappropriate disposal and exposure to land could lead to soil damage. (e.g. during construction)
		NO Categories	Adding	Coal and fuel burning onshore and offshore

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Economic	Port's Operational Ability	Ports' Function Diversity (e.g. Value adding Service, Linkage with Hinterland)	Adding	This indicator is added as the ports can no longer be profitable and useful by only having the basic functions (e.g. loading and unloading cargos). To meet the contemporary criterion of an advanced and leading oil port, the oil port should be able to have multi-functions at the same time, which may include petroleum products storage, loading and unloading service, transit, value adding, and a complete logistics net towards hinterland.
		Productivity	Adding	The productivity has been rarely mentioned in oil port relevant studies. This might because the productivity is mostly focused, and more presentative in container ports. However, oil ports do have productivity issues and face the same other issues including lead time, queuing time, etc. Thus, it is worthwhile to take 'productivity' into consideration.
		Foreign Direct Investments (FDI)	Adding	Previously, only container port has the right to be 'privatised'. Nowadays (since April 2003), followed by the new policies, oil port can not only be privatised, but also is now allowed to have foreign stakeholders at port companies. Thus, the FDI could become new criteria of measuring how the examined port is economically doing, and how big its future development potentials are.
		Investment Quantity	Eliminating	Investment quantity has been eliminated as there are only 1 experts out of 34 have mentioned it.
		Damage Frequency	Eliminating	This indicator has been mentioned in the previous literature as the facility damages could lead to longer time and more repair cost, which eventually would cause lower profitability and efficiency. However, given the fact that oil ports do not tend to have a high damage rate (very rare in comparison to container ports), this indicator has eliminated as most of the experts (85% out of 100%) find it unnecessary for the practical sustainability framework.
		Transit Time	Eliminating	The new added indicator 'productivity' do include 'transit time', and has a broader meaning than 'transit time', this indicator is thus eliminated.
		Financial Performance	Eliminating	Duplicated from the three new added indicators 'FDI', 'productivity', and 'Ports' Function Diversity'.
		Capacity	Eliminating	Even though from some perspective, capacity could partially present the financial status of the port, it is not being mentioned by any of the experts during interview.
		Increased Productivity	Eliminating	Even though from some perspective, increased productivity could partially present the financial status and the development potential of the port, it is not being mentioned by any of the experts during interview.
		Political Influence	Eliminating	The political influence could affect a ports financial status in many ways, such as trading quantity, FDI amount, and development limitation. However, it is not being mentioned by any of the experts during interview.
		Value Added Growth	Eliminating	In comparison to container ports, oil ports have less opportunity to be value added at the port. Thus, this indicator is being eliminated.
		Optimized Land Use	Eliminating	It is not being mentioned by any of the experts during interview.

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Economic	Port Competitiveness	Performance in the Supply Chain Context	Adding	As it has been mentioned before, it is required for the contemporary ports to have multiple functions. Due to the demand to link the port with hinterlands and other ports for the convenience of transporting the commodities to other locations. Therefore, this indicator is increasingly crucial to be more competitive to other ports.
		Regional Cooperation Performance	Adding	Engaging more with the general SC linkages bring ports a higher effeciency.
		Port utilization Cost	Adding	The utilisation cost is a crucial criterion for vessels to determine where to berth. Thus, for better financial condition, development, and be more competitive to other ports, ‘Port utilization Cost’ should be included in the system.
		Service Quality	Eliminating	Service quality is a crucial criterion for vessels to determine where to berth, and the port reputation is. Thus, for better development and, and be more competitive to other ports, ‘Service Quality’ should be included in the system. However, it is duplicated by the above-mentioned indicators such as ‘Port utilization Cost’, ‘performance in the SC’.
		Economic Efficiency/Cost Effectiveness	Eliminating	Even though expenses are considered as one of the main focuses leading to a profitable situation, it is not being mentioned by any of the experts during interview.
		Active Shipping Activities	Eliminating	Even though active shipping activities are considered as one of the main focuses leading to a profitable situation and long-term development, it is not being mentioned by any of the experts during interview.
		Economic Catalyst (Port Function change)	Eliminating	Even though the port’s function is becoming increasingly diversified, the changes of functions at current oil ports remain to be not much.
		Economic Strategies	Eliminating	Even though from a certain perspective, economic development strategies can be used as a crucial point to evaluate a port’s development potential, it is not being mentioned by any of the experts during interview.
		Market-share Growth	Eliminating	Even though from a certain perspective, market share growth can be used as a crucial point to evaluate a port’s development potential, it is not being mentioned by any of the experts during interview.
		Reginal Contribution	Eliminating	The main contribution made to a nation’s prosperity (from the shipping sector) are often made by the container ports, which is probably why this indicator was mentioned in existing literature (considering the current trend is still container port study). However, even though the regional contribution made by oil ports cannot be ignored (e.g. employment rate increase, relevant industries development, or education level enhancement), in comparison to container ports, the scale is much smaller.
		Diverse Service	Eliminating	Duplicated with above mentioned indicators.

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Economic	Port Competitiveness	Enhancement of Offshore Environment	Eliminating	Duplicated with the groups belonging to the 'environmental' section.
		Increasing Quality of Information Flow	Eliminating	Even though information management level at container ports is high (e.g. RFID, data management system), its level is relatively lower at oil ports as the crude oil, chemical products, and petroleum products cannot be either labelled or tracked. The information management at oil ports will mainly be for safety reasons (e.g. Temperature) to prevent fire and explosion. However, due to the relatively low level of information management, this indicator is being eliminated by the experts.
		Benefit to Port Users	Eliminating	This in indicator mainly refers to welfare to the employees that may motivate better performance which will eventually turn to profitability to the company, which is duplicated with the previous indicators.
	Interested Parties' Involvement	Developing Strategic Development Plans every certain Period of Time	Adding	One of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. Therefore, commonly recognised development plans will be crucial between stakeholders to ensure a balanced development in the future. Furthermore, the plans should be made periodically as the market trend changes on a frequent basis.
		Balanced Relationship between Interested Partied	Adding	As it has been mentioned in the above indicator (Developing Strategic Development Plans every certain Period of Time), one of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. Therefore, it is crucial for stakeholders to maintain healthy and close relationships for a sustainable and maximised development of oil ports.
		Interested Parties Sharing the Same Goal on Sustainability	Adding	As it has been mentioned in the above indicator (Developing Strategic Development Plans every certain Period of Time), one of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. However, each entity/party may have differed preference on achievement (e.g. profit, market influence, market share, or environmental protection). Thus, it is important that the stakeholders sharing common goals to maintain healthy and close relationships for a sustainable and maximised development of oil ports.
		Sharing Responsibilities on Sustainability Matter on Port	Adding	As it has been mentioned in the above indicator (Developing Strategic Development Plans every certain Period of Time), one of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. However, each entity/party may have differed power and responsibility on the sustainability matters. Considering they may have different priorities on goals, it is crucial to ensure they have common understanding on the oil port sustainability significance and are sharing sustainability responsibilities.
		No Party has Privileges when not following the Rules	Adding	As it has been mentioned in the above indicator (Developing Strategic Development Plans every certain Period of Time), one of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. However, each entity/party may have differed power and responsibility on the oil ports. Therefore, it is needed to ensure that no party/entity is having privileged on sustainability matters. The policies and laws should be equal to each of the stakeholder.
		Stakeholders' Cooperation	Eliminating	As it has been mentioned in the above indicator (Developing Strategic Development Plans every certain Period of Time), one of the expectations to oil ports is to enable oil port multiple diverse functions as the container ports do. In order to achieve that, more parties and entities may be included during the process. However, it is eliminated as the details are being divided into the above indicators.

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Social	Port's Working Environment	Occupational Disease (Lung Cancer, Casrbio Vascular Disease, Asthana, etc.	Adding	Exposure to petroleum products, especially the chemical relevant ones, causes damage to employee's health.
		Periodic Check on Equipment	Adding	Period check on equipment could ensure the safety level onshore and thus ensures the employee's safety.
		Oil and Gas Poisoning	Adding	Exposure to petroleum products, especially the chemical relevant ones, causes damage to employee's health.
		Security	Eliminating	Nowadays petroleum products are not easily stolen due to improved transportation and storage methods. Thus, even though there are still security issue on small oil ports, the security issue on oil ports are greatly decreased in general.
		Safety	Eliminating	Divided into detailed factors (see above)
		Accidents (e.g. Spill)	Eliminating	Divided into detailed factors (see above)
	Citizen Lively Condition	Environmental Effect to Citizen	Adding	The potential explosion and fire caused environmental damage (e.g. damaged soil, water, and Sewage treatment plant) greatly harms citizen's living standard (as there will be citizens living within the oil port area).
		Effect of Living in Port on Citizens' Health	Adding	This indicator is also relevant to potential explosion. Once explosion or fire happens, citizen's health could be greatly harmed (e.g. exposure to Xylene, fire, and explosion).
		Population Growth	Eliminated	Population growth was included because the prosperity of ports could lead to economic growth in the surrounding area, and thus attracts many people to work here. However, it is not being mentioned by none of the experts (100% out of 100%) during empirical study. One cause might be the prosperity is mainly brought by the container shipping.
		Resources	Eliminated	Resources were considered as human capital, money, and port's natural condition as resources and eventually going to turn into profits and opportunities benefiting citizens. However, it is not being mentioned by most of the experts (95% out of 199%) during empirical study.
		Community	Eliminated	The existence of community is relatively small. It is thus not worthwhile to be mentioned separately. However, there are still many small and medium sized communities within or near the port area which could be affected by potential explosion and fire. Thus, the welfare of citizen is being considered in separately (e.g. 'Effect of Living in Port on Citizens' Health' and 'Environmental Effect to Citizen').
		Accidents; (e.g. Spill)	Eliminated	Being divided into 'Effect of Living in Port on Citizens' Health' (Health) and 'Environmental Effect to Citizen' (inconvenience and uncomfortableness to citizen's daily life).

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Social	Port HR	Employment Increase Rate	Adding	Prosperity or developing port would require a big amount of employee. At the meantime, there are still many opinions regarding the fact that the contemporary port's goal is smoothly getting automated. However, given this expectation will not be applied to every port across the country in a short time, most experts (91% out of 100%) holds the opinion of this indicator is still important, and the port's employment increase rate would rise the general regional employment rate.
		Employee Welfare	Adding	Nowadays the employee welfare is being greatly considered for both attracting new talented people to work here and to remain the existing staffs.
		Employee Turnover Rate	Adding	Port operation, especially oil port operation, requires highly skilled employees to prevent any potential operation risks (e.g. explosion and fire). It takes a long time to train a skilled employee. Thus, for a port company, it is crucial to have low staff turnover rate to maintain the most effective operation.
		Training (Education/Knowledge Development)	Adding	By having high skill intensive positions, and especially under the condition that the current society is constantly developing and applying new technologies and new approaches, it is critical to train the employees regularly to maintain their best condition and access to knowledge at all times.
		Employee Career development	Adding	To hold employees, especially the talented and critical ones, it is important to let them see a clear career development path and opportunities to realise their self-ambitions. Thus, it is important to provide enough career development opportunities for the employees for them to stay in the company.
		Human Capital Development	Eliminating	The reason this indicator is being eliminated, and it differed from the newly added indicator 'Employment Increase Rate', is because this indicator considers the employee as a capital rather than just an employee. However, surprisingly, it is not being mentioned by most of the experts (95% out of 100%) during empirical study.
Social	Noise	Pump House	Adding	Pump house is needed on the oil tanker to load and unload petroleum products to/from the tanker to the storage tank/tanker. During pumping, the loud sound could make seafarers and relevant employees. Another Pump house is existing onshore for fire & explosion control. In this case the sound may also affect seafarers and relevant employees when pumping foam to put out a fire. However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.
		Oil Tanker	Adding	Even though the tanker is berthing, the engine is still under operation at all times. The engine sound is loud enough to make employees and seafarers uncomfortable. However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.
		Tanker Truck	Adding	Even though crude oil is normally transported by pipelines, chemical oil and petroleum products are often being transported via tanker truck. Thus, during the transportation period, the noise of tanker truck could be a source to make residences and employees uncomfortable.
		Crane	Adding	Even though in comparison to pump house, the crane is relatively less noisy when loading and unloading petroleum products. However, the sound of crane is still laud enough to make seafarers and employees uncomfortable. However, as relevant staffs will not stay around for a long time, the noise issue could be considered not too serious in comparison to the air condition at port.

END

Appendix 18: List of CNA Articles

ID	Label
1	Selection of sustainable alternative energy source for shipping: Multi criteria decision making under incomplete information
2	Green port performance index for sustainable ports in egypt: a fuzzy AHP approach.
3	Coastal and port environments: International legal and policy responses to reduce Ballast Water introductions of potentially invasive species
4	North-South container port competition in Europe: The effect of changing environmental policy
5	A collaborative supply chain management system for a maritime port logistics chain
6	80 million-twenty-foot-equivalent-unit container port? Sustainability issues in port and coastal development
7	Sustainability ranking of the UK major ports: Methodology and case study
8	Port waste reception facilities in UK ports Iwan Ball
9	Strategic environmental assessment of port plans in italy: experiences, approaches, tools
10	An evaluation of green logistics within the Shanghai shipping hub based on AHP Fuzzy Comprehensive Evaluation
11	A game theoretical analysis of port competition
12	Social construction of port sustainability indicators: a case study of Keelung Port
13	Economic growth and sustainability : systems thinking for a complex world
14	Sustainability and national poicy in UK port development
15	Identifying crucial sustainability assessment criteria for container seaports
16	SNA approach for analyzing the research trend of International port competition
17	Revisiting port performance measurement: a hybrid multi-stakeholder framework for the modelling of port performance indicators
18	Comparing port performance: western european versus eastern Asian ports
19	Hub port competition and welfare effects of strategic privatization
20	Contribution to the implementation of “green port” concept in Croatian seaports
21	European policy on port environment protection
22	Maritime policy in the north sea region: application of the cluster approach
23	Sustainable development in the maritime industry: a multi-case study of seaports
24	Green management practices and firm performance: a case of container terminal operations
25	Competition and collaboration among container ports
26	Economic contribution of ports to the local economies in Korea
27	Analysis of the potential contribution of value-adding services to the competitive logistics strategy of ports
28	Container ports multimodal transport in China from the view of low carbon
29	Identifying crucial sustainability assessment criteria for international ports
30	The self diagnosis method: a new methodology to assess environmental management in sea ports
31	Maritime policy in the north sea region: application of the cluster approach
32	A Transnational governance , governance models and port performance : a systematic review
33	Public-private interests and conflicts in ports: a content analysis approach
34	A literature review on port sustainability and ocean’s carrier network problem
35	Assessment of surface ship environment adaptability in seaways: a fuzzy comprehensive evaluation method
36	The northern sea route versus the Suez canal: cases from bulk shipping
37	Identification and selection of environmental performance indicators for sustainable port development
38	Towards sustainable ASEAN port development: challenges and opportunities for Vietnamese ports
39	Developing an indicator system for measuring the social sustainability of offshore wind power farms
40	New environmental performance baseline for inland ports: a benchmark for the european inland port sector
41	Port authority corporatisation: leading towards their privatization
42	Pollution emissions, environmental policy, and marginal abatement costs
43	The impact of greening on supply chain design and cost: a case for a developing region
44	Toward a smart sustainable development of port cities/areas: the role of the “Historic Urban Landscape” approach
45	Environmental sustainability in seaports: a framework for successful innovation
46	Identification of occupational health, safety, security (OHSS) and environmental performance indicators in port areas
47	Environmental sustainability in seaports: a framework for successful innovation
48	A procedure for identifying significant environmental aspects in sea ports
49	Determination of environmental initiatives and measures for port systems: The case of Koper Port
50	Green shipping management
51	urvey on environmental monitoring requirements of European ports
52	Foreign participation and competition: a way to improve the container port efficiency in China?
53	Sustainable development of deep-water seaport: the case of Lithuania
54	The sustainability of mediterranean port areas: environmental management for local regeneration in valencia
55	Ballast water management infrastructure investment guidance
56	Current practices in European ports on the awarding of seaport terminals to private operators: towards a code of practice guide
57	Public-private partnerships for the provision of port infrastructure: An explorative multi-actor perspective on critical success factors
58	Strategic challenges to container ports in a changing markete nvironment
59	Port-city relationships in Europe and Asia
60	The economics behind the awarding of terminals in seaports: towards a research agenda
61	The green port grade evaluation method based on AHP
62	Risk assessment in the istanbul strait using black sea mou port state control inspections
63	Economic impacts of the Kra canal: an application of the automatic calculation of sea distances by a GIS
64	Tragedy of commons: analysis of oil spillage, gas flaring and sustainable development of the Niger delta of Nigeria
65	Port spatial development and theory of constraints
66	Container port efficiency in emerging and more advanced markets
67	Modeling the effects of unilateral and uniform emission regulations under shipping company and port competition
68	Application of game theory and uncertainty theory in port competition between Hong Kong port and Shenzhen port
69	Environmental governance mechanisms in shipping firms and their environmental performance
70	Local sourcing and fashion quick response system: the impacts of carbon footprint tax

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71	Developing supply chain security design of logistics service providers
72	Research on the impacts of ports construction on regional economic development
73	Environmental management of ports and harbours — implementation of policy through scientific monitoring
74	Ports and regional economic development: global ports and urban development: challenges and opportunities
75	Strategic investments in accessibility under port competition and inter-regional coordination
76	The relation between port performance and economic development
77	Charging for port facilities
78	Sustainable port infrastructure, practical implementation of the green port concept
79	Assessing port governance models: Process and performance components
80	Sustainable development of deep-water seaport: The case of Lithuania
81	Pollution prevention at ports: clearing the air
82	Nordic container port sustainability performance—a conceptual intelligent framework
83	Strategic environmental assessment of port plans in italy: experiences, approaches, tools
84	Impacts of sea port investment on the economic growth
85	Functional differentiation and sustainability: a new stage of development in the Chinese container port system
86	Evaluation of port development based on the theory of the driving force and the law of entropy weight
87	The river plate basin - a comparison of port devolution processes on the east coast of South America
88	A literature review on green port-related studies
89	Reliability and risk evaluation of a port oil pipeline transportation system in variable operation conditions
90	A differentiation framework for maritime clusters: Comparisons across Europe
91	Modeling port competition from a transport chain perspective
92	Study on green logistics operation system of port based on AHP-fuzzy comprehensive evaluation
93	An exploratory study on low-carbon ports development strategy in China.
94	Multi-objective decision support to enhance environmental sustainability in maritime shipping: a review and future directions
95	Current status and trends of the environmental performance in European ports
96	Evaluating the effects of green port policy: case study of Kaohsiung harbor in Taiwan
97	The private and social cost efficiency of port hinterland container distribution through a regional logistics system
98	The governance structure of port authorities : Striking a balance between economic , social and environmental goals
99	Hinterland operations of sea ports do matter: dry port usage effects on transportation costs and CO2 emissions
100	Port-centric logistics
101	Port choice strategies for container carriers in China: a case study of the Bohai bay rim port cluster
102	The regional management of the seas around the United Kingdom
103	Green port strategy for sustainable growth and development
104	A conceptual application of cooperative game theory to liner shipping strategic alliances
105	Enhancing sustainable mobility: a business model for the Port of Volos
106	Examining sustainability performance at ports: port managers’ perspectives on developing sustainable supply chains
107	Managing European cross border cooperation projects on sustainability: a focus on MESP project
108	Restructuring of environmental management in Baltic ports: case of Poland
109	Port investment and container shipping markets: roundtable summary and conclusions
110	Sustainability practices to achieve sustainability in international port operations
111	A study on competitiveness analysis of ports in Korea and China by entropy weight TOPSIS

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