

THE ROLES AND IMPACTS OF INSTITUTIONS AND STAKEHOLDERS IN THE
DECISION-MAKING OF CHINESE PORT CLIMATE ADAPTATION

by
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Abstract

Despite a rise of global concerns on climate change and adaptation in recent years, a review of articles published over the past two decades shows that research on port climate adaptation is still in its infancy (Panahi et al., 2020). Seaports play a pivotal role in the global supply chain and transportation networks and profoundly influence the regional economy and are highly exposed to marine natural disasters and climate change threats. The adaptation strategy is regarded as a practical approach to reducing vulnerabilities of the seaport to climate change. A significant research community covering various subjects on the study of port climate adaptation is emerging and forming (Panahi et al., 2020). However, the existing scholarships on port climate adaptation remain to focus on developed countries' ports and lack of diversification background. There is still a limited contribution of researchers from developing countries in port climate research. The growing leadership role of Chinese ports in global transportation and supply chain network makes researchers need to pay more attention to adaptation's status quo. In the complex context of port reform and development, in what way and to what extent do the institutions and stakeholders in the decision-making environment to China's port system affect the process of establishing and implementing adaptation mechanisms in ports, requires further research. This literature is partly formed by the work of Panahi et al. (2020). It explores the roles of and interaction between institutions and stakeholders in climate change adaptation of the Chinese port system, based on the decision-making theory. This paper undertakes an in-depth case study on Ningbo-Zhoushan port, one of China's most representative regional ports. We identify that the inadequate supply of institutions and the absence and misbehaviors of main port stakeholders cause institutional imperfection of port adaptation system to varying degrees. This paper is one of the first attempts to fill the gap in research on climate change and adaptation in Chinese ports. In addition, by bringing together concepts from social science fields into interdisciplinary research, we further prove and develop decision-making theory through case studies within the Chinese social and institutional system framework.

Keywords: port climate adaptation; institutional imperfection; decision-making theory; Chinese institution framework

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Chapter 1 Introduction

Climate change is shaping and changing the development mode and pathways of society and economy in the process of urbanization (Gu et al., 2011). Climate issues on the human community, social economy, and the natural environment have been at the forefront of research in the international community since the 1980s. An increasing number of scholars recognize the potential impacts of climate changes on economic growth, human security, and social welfare. Climate change with the continuous growth of population and social economy as well as urbanization will significantly increase the risks of population and asset exposure, particularly to port cities in emerging countries (Hanson et al., 2011)

Seaports, as pivotal facilities and sea-land interface, connecting ocean logistics and inland transportation and undertaking logistics transportation and commercial functions, play a significant role in the global supply chains and significantly influences the world's economy (Ng et al., 2018). Over 80% of the world's trade volumes are carried out by maritime transportation (Becker et al., 2012; Ng and Liu, 2013). In 2017, the volume of goods loaded and unloaded in developing country ports shared 59.5% and 63.4% in world seaborne trade (UNCATD, 2018).

The complexity of climate change creates uncertainty and challenges to the development and safety of seaports (Awuor et al., 2008; Becker et al., 2013; Asariotis & Benamara 2017; Oh & Reuveny, 2010). In the past decade, A growing number of international organizations and scholars conveyed a signal that climate change is bringing increased risks and negative impacts on human society. For example, IPCC (2007) reported that heavily-populated deltas in South, East, and Southeast Asia, will be at the most significant risk of increased floods from the sea and rivers due to global warming. China's Second National Climate Change Assessment Report (2011) reveals that global climate change is further exacerbating storm damages in China's coastal regions and diminishing the functions of seaports. The extreme weather on coastal cities and ports in China will become more evident over the next three decades. Coastal ports are highly exposed to marine natural disasters and climate change threats, and its vulnerability may weaken or limit its ability to handle and survive in risks (Berle et al., 2011). For the port cities, adapting ports to

changing environments will be vital in maintaining sustainable development (Hanson et al., 2011). Taking an adaptation strategy to reduce vulnerabilities is a far more cost-effective alternative for ports than mitigations (Pielke et al., 2007; Stern & Britain, 2006).

Scholars have paid increasing attention to climate adaptation in ports in recent years. The diversity in research topics and methods is evident in the past decade. Such sustainability, uncertainty, and risks, decision-making, perceptions, and attitudes of stakeholders, policy, resilience, and planning are added into the investigation (See Pierson et al., 2015; Ng et al., 2018; Bolle et al., 2018; Yang et al., 2018). There is a rise in concepts of institutions, stakeholders, and perceptions in recent years, which are mostly treated as barriers in the study. The scarcity of discussion of institutions and stakeholders in port-related study remains evident (Panahi et al., 2020).

Another limitation associated with the emerging literature is that the existing scholarship in this field, however, tends to study the port climate adaptation in the case of western countries. In other words, there is still a limited contribution of researchers from developing countries in port climate research. The vulnerability of developing countries to climate risks means that more efforts and resources are needed to break down barriers to knowledge dissemination and fill long-standing gaps (Sarkodie & Strechow, 2019).

The growing leadership role of Chinese ports in global transportation and supply chain network make them need to pay more attention to port security. Despite a rise of national attention to climate adaptation, climate change issues are still not the priority agenda in the transport sector and the local level (Peng et al., 2015). As the development and structural reform of China's port system, decentralization and integration have been an important development trend. Most existing studies about Chinese port mainly concrete on evolution path (e.g., decentralization, regionalization, integration, institutional transformation) and development (i.e., competition and cooperation, sustainable development), but a few focus on climate issues. There is still a lack of sufficient concern and in-depth research on port climate adaptation in China.

In response to the above research gaps, this study draws on findings by Panahi et al. (2020) and extends it to the context of Chinese port reform and social environment. We combine the institutions, stakeholders, and decision-making theory to explore one crucial issue regarding regional port development: How do institutions and stakeholders influence the establishment and implementation of port climate adaptations in China? The study undertakes an in-depth case study on Ningbo-Zhoushan port, one of China's most representative regional ports. We will investigate the progress of current port climate adaptation actions and the influential factors of institutions and port stakeholders in climate adaptations in ports and explore the interaction between institutions and stakeholders in the decision-making process within the Chinese social institution framework, based on decision-making theory.

The research questions of the case study include:

- 1) What is the current progress of Chinese port climate adaptation actions (e.g., planning, institution)?
- 2) In what way and to what extent do institutions and stakeholders affect the institutional imperfection of port climate adaptation, based on the theoretical model?
- 3) What are the role and effects of the institutions and stakeholders (or decision-makers) on climate adaptation's decision-making process within the Chinese social institution framework?

The rest of the study is structured as follows. The article starts with a section on the literature review and identifies research gaps. The theoretical background and methodology can be found in Chapters 3 & 4. The following Chapter 5 explores the progress of port climate adaptation actions (e.g., planning and institutions) with the case study of Ningbo-Zhoushan Port. Chapter 6 illustrates the influential factors to port climate adaptations from the perspective of institutions, stakeholders, the climate risks, and the port's adaptive capacity. Chapter 7 analyzes the "institution-stakeholders" relationships in the decision-making process within the Chinese social and institutional system. Chapter 8 provides a general summary of the findings, contributions, and limitations of this study and future research gaps.

2.1 General review of the previous study of port climate change adaptation

The study of climate change adaptation does not get much academic attention in early port-related studies (He & Ng, 2019). However, the opinion like that taking a proactive strategy is far more cost-efficient than a reactive strategy in reducing the port vulnerabilities (Pielke, 2000) is gradually recognized. There is a rise in climate adaptation research. The study well synthesizes the overall focus and trends of research on climate change adaptation in the port industry published in major academic journals in the last 15 years (Panahi et al., 2020).

During the period 2005-2009, only a few studies focus on the ports, which are often encompassed within such a broad concept as coastal areas and port cities. Economic analysis focusing on sustainability, innovation, and development issues is the dominant topic of limited research. The study raises the importance of sustainability pathways to address climate challenges and economic development (Sathaye et al., 2006; Hall, 2007). Nicholls et al. (2008) point out that the urgency of climate change adaptation for the ports as economic engines for regional development. Besides, the examination of understanding of port managers in adaptation planning is also preliminarily investigated. However, adaptation remains a separate awareness and response within limited fields and countries (Becker et al. 2010). Overall, there are very limited studies and countries engaged in the research work about climate adaptation by ports during this period.

The contributions to the study of port climate adaptation are mainly produced in the past decade. A significant research community, in which three pioneers A.H. Becker, A.K.Y. Ng, and B. Brooks, in this field, make outstanding contributions, covering a wide variety of subjects on port climate adaptation is emerging and forming. During the second period, 2010-2014, studies of ports become more precise in semantics and space. The rise of several important concepts with adaptation inside the expressions (i.e., adaptation lesson, sustainability, adaptation enforcement, etc.) could be noticed. Similarly, adaptation measures, strategies, risks, challenges/barriers, and investment are being a new research

topic. For example, Ng et al. (2013) studied climate change impacts and risks to port adaptation with the failure mode approach. Port governance, ownership, and stakeholders that are not even mentioned in the earlier this period also become a new center of research. As a strategic economic sector at risk, Becker et al. (2013) proposed a paradigm shift in planning, investment, and operation is not a choice but a necessity. A paradigm shift refers to a fundamental change to the issue with a new and different way to solve climate change. Ng et al. (2014) found that the institutional interactions can convert barriers into catalysts facilitating institutional change and further emphasized the necessity of a paradigm shift within the institutional system.

In the period 2015-2019, the breadth and depth of research have been greatly improved based on the previous research and the continuous growth of the research community. The port is beginning to be studied as a system when studying the uncertainty, adverse events, and adaptation approaches (See Justice et al., 2016; Randrianarisoa & Zhang 2019), but it is still treated as an isolated facility and is barely considered in transportation networks and urban planning. The diversity in research topics and methods is evident. Concepts such as decision-making, policy, resilience, and planning are added into the investigation (See Peirson et al., 2015; Ng et al., 2018; Bolle et al., 2018; Yang et al., 2018), as ports being a critical element of transportation networks and coastal cities. Similarly, the challenges from uncertainties inside the problem, governance model, or stakeholders also lead to a rise of study (Walker et al., 2015).

Additionally, more analytical approaches are employed to measure port adaptation planning to maintain economic issues and social well-being. For example, Xiao et al. (2015) apply economic modeling to evaluate the port investment in coastal disaster preventions. Benefit-Cost analysis is used to measure the infrastructure and structure design for the port adaptation planning (Chow et al., 2017; Disegni et al., 2017).

By summarizing the trends and themes of existing studies, we can know that most research on climate change still focuses on three core aspects: identifying climate impacts or risks on ports; developing and assessing the approaches port taking; analyzing factors within and outside the system impeding the implementation of strategy and actions. An increasing

number of studies in recent years examine the implications of exogenous and endogenous factors (e.g., political and economic environment, governance structure, stakeholders) on the port adaptation actions. Scholars claim that the research community is more concentrating on the early identification stages rather than the actions (Panahi et al., 2020).

However, as the critical elements of successful planning, the discussion on governance model and stakeholders are still very limited, and this scarcity becomes more evident at higher levels. Considering the strong connection among policy, stakeholders, and planning, institution, governance, and stakeholders' role became more significant in the decision-making environment for port adaptation planning and implementation.

2.2 Port stakeholders in climate adaptation

Port stakeholders generally are referred to those individuals and organizations, who share various goals and missions regarding the port's future development and engage in port management and operation, business, trade, and services. Port climate adaptation activities involve multiple stakeholders from a wide range of organizations across the private and public sectors (Becker, 2016). It is believed that crucial port stakeholders' decisions and behaviors on climate change will significantly impact the formulation and implementation of climate adaptation strategies and actions. Port management groups, employees, and shareholders (possess shares and voting rights) are included to internal stakeholders as direct participants in climate management. At the same time, a broad range group of stakeholders from the fields of administrations, business, environment, and academy are included as external port stakeholders. Policymakers from government departments and environmental organizations should take responsibility to provide guidance and climate policy, on which port's actions to climate change heavily reply policy, for protecting the public asset and the formation and implementation of long-term adaptation measures (Becker et al., 2012). The economic stakeholders like shipping companies benefit from the positive externalities of port development, and environmental stakeholders and industry scholars provide advice for port climate management and actions.

The role of and barriers from all stakeholders in establishing and implementing climate adaptation strategies and activities are the main centers of existing research. The understanding of port stakeholders about climate change risks, to a large extent, affect their participation in ports' adaptation planning and strategies (see Becker, 2012; Camp et al., 2013; Ng et al., 2013; Van Der Voorn et al., 2017; Ng et al., 2018). Some scholars analyze stakeholders' cognitive and psychological distance to climate change, thus leading to undesirable engagement in climate adaptation. Similarly, the implications from attributes (interest, responsibility, and capabilities) of stakeholders, as well as complicated relationships between stakeholders on port precautions, are explored (Becker, 2016; Walker et al. 2015).

2.3 Institutions and port climate adaptation

The institution was first introduced to the port climate adaptation study during the second period 2010-2014, with more emphasis past five years as the depth of research on decision-makers and decision-making environment (Panahi et al., 2020). As defined, institutions (also called “institutional environment”) are the sets of formal or informal rules (e.g., laws, regulations, and norms) guiding human perceptions and behaviors (Strambach, 2008; North, 1990). A broader explanation to the institution can be more than a rule (written or unwritten) but rather a particular organizational structure named institutional arrangements. Such firms, bureaucracies, cooperative networks, or governance systems, of which “constitution and operations are governed by the institutional environment” (Martin, 2000). In other words, the institutional arrangement is embedded within institutional settings and environment, which influence structure or form, and will be a catalyst to institutional change (North, 1990).

Institutional change or reform has become popular in the port industry around the world in the past decades. The drivers and impediments to institutional change in port governance systems are two major research topics. Variation and change in institutions and policies could promote climate change management at a local or sectoral level (Strambach, 2008).

In this context, the port industry's governance and institution issues have been extensively studied from prospects like the social-economy, neo-institution, evolution, and geography. Notteboom et al. (2013) employ the evolutionary theory to reveal that institutional plasticity and path-dependency shape the interaction dynamics between institutions and port governance. Institutional plasticity refers to the degree of flexibility and dynamism of the governance framework that allows actors to make changes to optimize the framework and adapt it to the changing social and economic environment. For path-dependence, it can be understood as a continuity or inheritance in the path of structural change and development of institutions in regulating organizational and actor behavior (Strambach, 2008). Besides, it identifies that transition cost (Marshall, 2013) and property rights could lead to the path dependency in the institutional change (Notteboom 2009). Space is another driver to explain the re-distribution of power in governance structures (Ng et al., 2018).

For challenges and barriers originated from institutions on adaptation planning, as Notteboom (2013) points out, the challenges posed by a changing external environment (economic or political preferences) force organization to develop new routines to cope with them. Furthermore, when there is an incompatibility between new routines, knowledge bases, and institutional environment (governance structure) can become the new organizational routines' barriers (Hall & Jacobs 2010). For example, Wang et al. (2015) reveal that the political environment and fragmented governance structures may act as barriers to planning implementation. In addition to the institutional structures, Casey and Becker (2019) propose the conceptual values may barriers to the design and implementation of climate change adaptation plans. Another factor is derived from informal institutions. The informal institutions have value in delivering measures and policies and can fill gaps left by formal institutions (Hrelja et al., 2017). However, institutional erosion resulting from failed informal institutions may weaken the existing institutional setting and governance system governing climate adaptation (Ng et al., 2018). Moreover, a mismatch between ports' internal capacity building and institutional framework (O'Keeffe et al., 2016) could pose challenges to the formal structure of organizational involvement in climate adaptation.

Notably, most existing research contributions on institutional issues in port responses to climate change are from Western countries and based on Western ports (e.g., the United States, Canada, and Europe). It worth exploring the port climate strategy with a particular focus on intuitions within the unique political and economic system. Such research would be more complicated, especially when considering ports with different institutional backgrounds and organizational characteristics in the aspects of, i.e., policies, strategies, attitudes, capacities towards climate change risk and adaptation (Panahi et al., 2020).

2.4 Institutional changes and development in the Chinese port system

The growing leadership role of Chinese ports in the seaport industry and global transportation network generates many studies with various subjects. For example, port competition and cooperation, integration, economic growth, port governance reform, or change are the most generalized study (Gu et al., 2011; Huo et al., 2018; Notteboom & Yang, 2017; Pan et al., 2014; C. Wang et al., 2015; J. J. Wang et al., 2004; Wu & Yang, 2018; Xu & Chin, 2012). Besides, the reform or transformations of the port to adapt to the new geo-economics environment has been a global trend in countries and regions (World Bank, 2001), especially those with significant world-class ports and transportation routines in international trade and global supply chains. As a critical element of the international maritime transportation network, Chinese and foreign researchers have studied Chinese coastal ports, especially as the development and construction of Chinese coastal ports have entered a new phase around 2000.

Chinese seaports are experiencing a structural change in port governance systems (Notteboom & Yang, 2017). In the early 2000s, new geo-economic policies and the implementation of modern enterprise governance principles affect the Chinese seaport system. The Port Law (2004) could be viewed as a paradigm shift from the highly centralized ownership and control power to a decreolized authority with more local governments and businesses' involvement. The separation of administrative power and operations lead to a structural change in the port governance system, which give local

governments and port authorities more decision-making autonomy and responsibility in the management and development of harbor resources and the economy. The structural transformation of port governance is an essential feature of China's port development (Cullinane & Wang, 2006; Wang et al., 2004). Some scholars believe that institutional and political traditions deeply influence the reform path of port governance. Ng and Pallis (2010) identify the influence and role of port actors, institutions, and political traditions or culture on port governance's reform path. Notteboom et al. (2013) and Cullinane and Wang (2007) analyze how open-door policy and economic reform enhance structural changes within the port system. Meanwhile, the rapid growth of international trade and global maritime logistics brings enormous opportunities and challenges to the port industry in China (Xu & Chin, 2012), making it urgent for the Chinese port to strengthen its capacity through reform to adapt to the competitive market.

Accompanied by the port development, decentralization and integration are two significant trends in modern Chinese port reform. The evolution and decentralization process of Chinese port governance is generally divided into three periods: integrated under the control of the central government, joint managed by central and local government, and managed by the local port administration bureau (Cullinane and Wang, 2007; Xu and Chin, 2012). Decentralization is further driven after port reform entering the third phase (Qiu, 2008). The decentralization process is described as the re-distribution of power (administrative power and operations) between stakeholders from different spatial dimensions (Ng et al., 2018). The decentralization means that local governments have more control power and decision-making autonomy in managing port sectors. To date, the majority of Chinese ports have experienced a dramatic change in governance structure through the separation of administration and operation. Similarly, the institution plays an increasingly important role in the study of port reform and governance in the past decade, closely associated with the decentralization of governing power.

Another ongoing trend in the Chinese port industry is port integration. Government-initiated mergers or take-overs within the worldwide terminal industry have been prevalent (Junior et al. 2003). In the context of economic reform and decentralization, most Chinese seaports under the governmental intervention at central and local levels have experienced

a regional port integration triggering the port governance reform and institutional changes since around 2007 (C. Wang et al., 2015). They reveal that port decentralization and integration are further driven by dynamic magnitude between government and markets. The discussion on Chinese seaport integration in terms of progress, dynamics, patterns and pathways, impacts, and institutional issues is evident (Notteboom, 2002; Ng et al., 2015; C. Wang et al., 2015; X. Wang et al., 2004; Notteboom & Rodrigue, 2008).

2.5 Research gaps

Despite a rise of global concerns on climate change and adaptation in recent years, a review of articles published over the past two decades shows that research on port climate adaptation is still in its infancy (Panahi et al., 2020). In the past five years, we can see a rise in interdisciplinary studies with various subjects such as stakeholders and institutional examinations within and outside the port system. However, the growth in research publications has not altered the apparent imbalance between developed and developing countries in terms of the number of studies and researchers. There is still a lack of attention and in-depth analysis of port climate adaptation in the research community, particularly in developing countries.

As the concepts of institutions and stakeholders and their roles and functions in port climate adaptation are attracting attention in mainstream research, we can see that surveys and findings remain limited to Western ports and lack background diversification. Research on climate adaptation in China is still limited to policy, institution building, agriculture, and water resource management, etc. Some scholars incorporate climate risks and precautionary measures into the study of safety governance of China's ports. However, the discussion of climate adaptation in port systems has not yet become mainstream in China. On the other hand, the rounds of reforms of China's port governance system have prepared China's ports for the fast-changing geo-economic and geo-political environment (Notteboom & Yang, 2017). In the context, how the complex political and economic

environment and decision-making environment to China's port system affect the process of establishing and implementing adaptation mechanisms in ports requires further research.

On the other hand, the port stakeholders' role has been a new center of study since 2010. As a broad range of stakeholders in the port industry, research has not yet successfully integrated stakeholders' interactions while mainstreaming climate change adaptation (Panahi et al., 2020). Port climate adaptation planning is usually viewed as the responsibility of planners and managers (key port stakeholders), with a low level of cooperation with other stakeholders.

At higher levels of the port governance system, how the role and understanding of those stakeholders with high power and high interest like policymakers affect adaptation actions should be further explored. And what about the general public? Therefore, we will include a broader range of stakeholders into the study and explore the questions like how they perceive climate changes and adaptations, their roles, and functions are in the decision-making environment, and how their perceptions influence the establishment and implementation of adaptation systems. Furthermore, the implications of the dynamic relationship between institutions and port stakeholders for the port climate adaptation regime in the Chinese institutional environment also will be explored.

3.1 Theory of decision-making

Decision-making theory is initially developed for public administration and policy science, explaining how individuals should make rational choices under risk and uncertainty (Oxford Concise Dictionary of Politics). Decision making, taken in an environment intertwined with uncertainty and risk, is the selection of a procedure to weigh alternatives and find a solution to the problem. Snyder claims that the role of individuals (decision-makers) playing in the process of management and administration in private and public organizations cannot be neglected at all. In economics study, people are usually assumed to be rational beings whose decisions are usually treated as the result of rational choices. Rationality means that an individual in the decision-making process is not affected by emotional or perceptual factors. However, in sociological research, it is generally accepted that both rationality and sensibility influence human decisions in a real-life.

This paper is developed based on Simon's decision-making theory (H.A. Simon, 1959; H.A. Simon, 1979). One of Simon's decision-making theory's core principles is bounded rationality means that the decision-making of humans is constrained by time and knowledge. That being said, decision-makers (humans) cannot know all the knowledge and information during the process of recognizing and discovering problems. It is argued that actors pushing the institutional change are subject to bounded rationality (Boschma & Frenken, 2006). It stems from the limits of man's abilities and cognition to comprehend the complexity and uncertainty of issues, like climate change and disaster risks, and in turn, affect the attitudes and perceptions of decision-makers in producing or updating institutions.

Meanwhile, the sunk cost of the previous decisions, individual preference, and group behaviors can influence the priority of decision making. In addition to the subjective limitations, the decision-making process also involves enormous challenges from the objective environment such as culture, institution, and information. Lempert and Collins (2007) propose that along with the uncertain nature of dangerous risks, decision-makers

also need to consider the trade-offs and the non-linear process and new thresholds issues within the governance system when they decide to manage risks. From the view of the institutional decision, the substantial barriers from the subjective consciousness and objective environment would limit and distort human decision behaviors in terms of the formulation and establishment of the institution and resulting in institutional imperfection.

3.2 Institution and decision-makers

The institution, in essence, is a decision-making result of human perceptions of everyday things. An institution's decision-making process, including the establishment and implementation stage, is determined by people and influenced by their thoughts and values. The values are complicated, mixed with subjective and psychological factors, rational cognition, experience, and limited by the unique social and cultural environment. Behind the establishment, implementation, and modification of institutional rules and mechanisms in any field and at any level, human beings are involved. An individual's subjective and objective cognition about the surrounding environment determines his behaviors, which in turn give impetus to institutions' incremental evolution. Also, establishing a social or organizational system is based on the collective behavior and consensus of the vast majority of society responding to the environment. Therefore, there is a dynamic interaction between people and institutions that affect each other and restrict each other. This study will employ the decision-making theory to explore how the interaction between human beings (decision-makers) and institutional factors affects port climate adaptation planning.

The decision-maker concept is also used to describe the role of port stakeholder having in the act or progress of deciding something, which may influence the pattern and direction of port development to a varying extent. The primary decision-makers of China's ports include not only port group managers and significant shareholders (municipal government

and SASAC¹), but also agencies who are responsible for port planning and policy. General port decision-makers are considered those are participating in port-related activities, but the influence of their decision-making on port governance, planning, and the policy is minimal.

Decision-makers are those who are influenced by social, political, economic, cultural, and psychological factors and can be individuals or groups. An objective condition to be a subject of decision-making is to have a position, authority, and a high level of knowledge, ability, psychological and other qualities, and play a leadership role in making decisions. Group decision making is more common in public social organizations and is mainly based on group participation in decision making. Leaders of port groups and government agencies, for example, are the dominant decision-making group in the development of security management strategies and systems. The referendum vote is also a group decision. The managers who are involved in support of port security decisions and who implement the decisions are the decision implementer, not makers. Thus, we can divide the port stakeholders into decision-makers (core group managers, government leadership, experts) and decision implementers (general managers, government supervisors)

3.3 Institutional imperfection

As defined, institutional imperfection is "the gap between the existing and the desired institutional arrangement and governance structures" (Roth & Kostova, 2003). The imperfection characterizes that institutions' conditions (e.g., structures, rules, and systems) are not well defined or established, and the inconsistency between current institutions. Chinese scholar Deng (2002) proposed that the insufficient supply of institutions essentially causes imperfection or deficiency. There are two types of imperfection: general institutional imperfection and core institutional imperfection. The shortages and defects of and mismatches between institutions may cause conflicts in the process of establishing a

¹ SASAC: State-owned Assets Supervision and Administration Commission of the State Council

system. In general, countries or organizations with unfavorable initial institutional environments will face more institutional imperfection, which would further constraint the people's cognition and ability to build new rules and governance structures and make them more tend to adopt informal alternatives (Roth & Kostova, 2003).

Deng (2002) argued that the process of institutional change is an iterative game of equilibrium and disequilibrium between supply and demand of institutions, and the insufficient supply is the norm in the changing process. The absence of non-core institutional rules may reduce the governance structure's efficiency but does not make the institutional structure ineffective. During the Chinese economic transformation and institutional changes, the institutional shortage has become a common phenomenon. Simultaneously, omissions and lack of flexibility and foresight from institutional subjects (e.g., policymakers) would also result in imperfection at the establishment, implementation aspects, and the unbalance of systems.

Socio-economic and political reforms cause institutional change. The internal and external environment (e.g., information and culture), stakeholders (decision-makers and implementers), and type of problem would affect the institutional imperfection in the formulation and implementation process. Therefore, based on the decision-making theory, we can propose an original conceptual model (Figure 1) to analyze the factors leading to institutional imperfection.

Figure 1. Conceptual model

4.1 Research approach

The methodology is applied for the qualitative information of this research. This study undertook an in-depth case study on Ningbo-Zhoushan Port in China. Case studies can enable researchers to collect the data and information in a real-life and investigate a contemporary phenomenon in depth (Yin, 2009) and answer the real-life questions that may not be obtained through experiments or surveys. Additionally, it allows researchers to code and analyzes data at the microscopic level (Zainal, 2007). Although, case studies are perceived as lacking in rigor due to bias in the researchers, research methods, and data. Many existing scholars also did similar studies, which has proven the value of the case study.

The interview is an essential research approach for data collection when we conduct qualitative studies. Interviews and semi-structured interviews are widely applied in the case of studies. It enables researchers to communicate with the 'right' people, know-how interviewees understand their world, and how individuals interpreted and attributed meaning to their experiences (Simons, 2009). At the same time, interviews can allow researchers to have a deep understanding of respondents' perceptions and thoughts by face-to-face or telephone. To better understand the current climate impacts at each port area, the questionnaire was also not used to compensate for the data gaps from the interviews. The questionnaire is another basic method employed for data collection and statistics. The rationale to choose the questionnaire for data collection is that it can offer the quantitative and qualitative analysis of the research questions.

The research was conducted in the following stages. The first stage was the design of the interview and questionnaire and the recruitment of respondents. Two volunteers were first recruited to conduct an interview experiment to modify unreasonable questions. Secondly, we collect raw case data, including all the information about the port adaptation plan and institution, as well as stakeholder's perception through the interview. Next, we aggregate

and translate data from interviews, questionnaires, and documentary reviews to create a database. Because the interviews were conducted with Chinese people, it was necessary to translate the collected content into English. The database can be used to evaluate data, improve the reliability of research, and help researchers examine, track, code, and analyze the data. Then, we encode and classify data to obtain core information and concepts. Finally, we make an in-depth data analysis and write a case study narrative.

4.2 Participants selection

The sample selection was based on standards that participants who are familiar with and knowledgeable about port development, security management, governance structures, and port-related policies, or understand the Chinese social systems and decision-making mechanisms. Based on the standards, the targeted respondent groups mainly include managers and operators of port and shipping companies, officials from subnational governments and port authorities, scholars and researchers in the port industry, and even the general public.

The selection began with researchers and port managers, who share their knowledge, perceptions, and experience in port climate management. The snowball sampling technique was used to expand the sampling pool. With their recommendation, we had access to many potential interviewees, and most of them agree to participate in the research project. We interviewed officials from local governments and port authorities and had access to information such as urban climate adaptation planning and policies, transport (ports) emergency plan, and development strategy. Also, we connected with several scholars from research institutions knowing Ningbo-Zhoushan Port to help us better understand the current port climate adaptation planning and actions. Port (security) managers, as the formulator and implementor of port policies, knowing much more port climate adaptation information, were also invited to participate in this survey. The appointments with each interviewee were confirmed at least one week in advance to allow them to make proper preparation. The semi-structured interview with 13 participants relevant to the Ningbo-Zhoushan port was conducted between July 2019 and August 2020.

Table 1. Details of interviewees

The questionnaire was conducted and collected online via Tencent Questionnaire. This platform was established by Tencent, operating China's biggest mobile communication tool — the WeChat. WeChat is now the most popular and influential instant messaging social tool, having over 1 billion registered users from various industries in China. The sizeable online population can help the researcher to collect the questionnaire data with low time and cost. At the same time, we can integrate and analyze data more quickly.

4.3 Semi-structured interview and questionnaire design

A semi-structured interview was designed to collect data on port stakeholders' perceptions of climate change adaptation planning and adaptation policies. The qualitative measurement includes comments and knowledge on climate changes or public safety issues and decision-making institutions. For example, questions like how the port adapts to climate change, what adaptation strategy or planning the port and the port authorities develop and implement, and how factors affect the port adaptation system through interviewing relevant personal.

The interview questions were divided into three parts: climate change and adaptations in N-Z port; the perceptions of port stakeholders on climate adaptation process; the decision-making mechanism for climate issues in the context of port reform and Chinese institutional framework.

The questionnaire involved 22 interviewees working at ports and terminals in Ningbo and Zhoushan. The questions, including significant climate change risks on port operations and port cargos. This process could bridge the data gap of interviews and documents by scoring the consequence of climate change impacts. We evaluated the frequency, severity, and

duration intensity of each climate change using a five-point (Likert) scale (see Appendix 2), concerning the evaluation criteria of Ng et al. (2013).

4.4 Data coding and analysis

The first-hand data we collected mainly from the semi-structured interviews and questionnaires. The second-hand data is mainly accessed through detailed reviews on published literature, official reports and yearbooks, government documents, and internal reports from companies.

To ensure the validity and reliability of the information collected, the critical information mainly from insiders and government) was rechecked and reconfirmed between different interviewees. The information obtained from each interviewee was transformed into text and translated into English at the same time. After the data collection, we imported all data into a database and then started coding the text.

Based on previous research experience on the semantics analysis, the coding process is divided into the following stages. The first is open coding, which is a process of decomposition, validation and conceptualization, and data classification. We searched all keywords in expressions and words from the interview. A common concept generally was represented by many different words and expressions (e.g., policy and institution, adaptation, and precaution). Therefore, we needed to identify related and similar words and expressions to harmonize spatial context. This step gave rise to several concepts, and to simplify the analysis, we performed a second round of coding. We categorized different types and levels of concepts, such as laws, supervisory systems, and policy systems. On this basis, we abstracted and further classified the concepts in terms of institutional context, subjective perceptions, and status quo of adaptation.

4.5 Ethical consideration

We have the approval of this research from The Psychology/Sociology Research Ethics Board through a detailed explanation of the project content and research approach. Before starting the interviews and questionnaires, the researcher will go over the entire process briefly. It should give the participants a basic idea of what the study is about and how they will participate. The participants will also be informed of their rights. First, the identity of all participants will be anonymous throughout the study. Second, participants have the right to withdraw their data at any time before or during the interview without repercussions or consequences. Finally, we will provide an informed consent form for the participant to sign. This document will ensure the participant's privacy and the right of withdrawal. If the interviewee expresses an interest in the project, they could leave their information in the document. When the project is ended, they will be provided with a summary of the projects.

5.1 Introduction

Ningbo-Zhoushan Port (N-Z port), as a critical hub of the national transportation system, is located in one of China's most developed regions – the Yangtze River Delta (YRD), with highly developed urbanization and economic level as well as a dense population. All of these bring strong impetus to the development of the port and regional economy. Meanwhile, Ningbo-Zhoushan Port, located at the intersection of the eastern coast of China and the "golden waterway" of the Yangtze River, is adjacent to Shanghai's port and its economic influence radiates to the Yangtze River Delta economic circle. For the natural conditions, N-Z port has a vast harbor with long deep-water shorelines and a length of about 220 kilometers from north to south, enjoying a natural advantage for establishing deep-water ports. In terms of economic strength, after the announcement of the two ports' merger, the cargo throughput and container throughput of Ningbo Zhoushan Port ranked first and third in the world in 2019. The port has opened 240 international routes and connected more than 600 ports in more than 100 countries.

Ningbo-Zhoushan Port, as a typical Chinese coastal port, is one of the pioneers that started the wave of coastal ports integration at a national scale after the Port Law. The port law (2004) fills legal gaps in governing port and lays the port reform's legislative and political foundations. Governments and port authorities control Ningbo port and Zhoushan port at the local level, where port authority plays dual roles: the administration bureau and a business group. In 2004 and 2008, the modern enterprise institution (also called modern corporate governance) was successively established in Ningbo port and Zhoushan port. This change means that the dual role of port authorities playing in the port governance system ended with the separation of administration and operation by establishing a port administrative bureau and port business entity. The formulation of modern corporate governance in the port system represents a complete separation of port ownership and operation. As a municipal department, the port administration bureau is responsible for

port administration, and the port group is in charge of the daily operations and business management.

Although the two ports' merger was announced in 2006, the final integration took place in 2015. Ningbo-Zhoushan Port Management Committee (NZPMC) was first formed to responsible for planning management, resource development, construction project, and formulation and implementation of rules and regulations for the two ports in 2005. The name of "Ningbo-Zhoushan Port" was first applied in 2006, but the integration process did not go as smoothly as expected. During the ten-year integration process, the two ports formed a business group (Port Co., Ltd) for daily operations and management. Under the support of the central government and guidance of the MOT on port transformation and upgrading, the establishment of Provincial Seaport Group and Ningbo-Zhoushan Port Group prompted the official merger of Ningbo Port and Zhoushan Port in 2015. The successful integration of two ports and the mode of N-Z port integration across the neighbor region and government-driven provides lessons for regional port integration of other coastal ports.

What climate change response strategies and measures plans are port and port authority taking in the complex context of port system reform and climate change? And how about the current progress of the port climate adaptation plan in development and implementation?

5.2 Climate response strategies and measures of N-Z Port

Climate response strategies and measures for the port system are usually similar to those for urban planning or transportation systems. Both mitigation and adaptation are vital parts of urban disaster prevention and mitigation mechanisms and urban emergency adaptation management. Through the analysis of in-depth interviews and documents, it is found that at present, the climate response system of Ningbo-Zhoushan Port on coping with climate change and extreme weather events is dominated by mitigation strategy and supplemented by adaptation strategy.

For the mitigation strategy, the “green port” and emission reduction plan as a long-term and priority climate response strategy of N-Z port walks far ahead of the adaptation strategy in terms of institutions and actions. With the development of the National Sustainable Development Strategy and the concept of MOT’s green transportation, in early 2010, N-Z port introduced the “green port” plan into the port’s sustainable development strategy. It took energy conservation and emission reduction (ECER) actions into the actual business process. For example, by the end of the year 2017, Ningbo port reduced carbon emissions by 9,200 tons per year and saved more than 20 million-yuan costs by using the LNG (liquefied natural gas) container truck, clean energy power, and other green technologies (source from China Port Website). For each port area of Ningbo-Zhoushan Port, the climate mitigation strategy has been gradually adapting to the broad mix of port business, such as maritime and land transportation, loading and unloading, storage, and construction. Besides, MOT sets a system of evaluation criteria for the construction and development of a green port. Local governments and agencies have also incorporated emissions reductions into their performance systems, which prompt the port to develop and implement mitigation strategies and measures.

Since the National Climate Change Programme passed through in 2007, China has been working on building a climate change response framework including laws, policies, and plans along a policy system to guide communities and organizations on how to respond to climate changes proactively. Climate mitigation is far more mature and developed than adaptation in research, strategy, and measures, as well as the design and implementation of institutional policies. In contrast, the study and application of climate adaptation institutions in China remain at an initial stage (study support and plans), defined by Adger et al. (2013).

5.2.1 Climate adaptation measures of N-Z Port

Though adaptation to climate change is still not considered a priority response strategy by ports and port authorities (experts from the Chinese port industry), adaptation actions occur.

N-Z Port's climate adaptation measures are mainly composed of three components: emergency response plan, separate construction planning, and applications of information technology.

Emergency response plan

The emergency response plan is regarded as a primary defense strategy and measure employed by ports and port authorities to respond to port security emergencies. There are substantial overlaps in adaptation and emergency management, significantly reducing vulnerability and improve resilience capacity. However, they are fundamental differences because the former aims to deal with long-term climate change, and the latter means a temporary solution to the short-term climate crisis. Due to knowledge dissemination and inadequate attention, the concept of “climate adaptation” is often regarded as, or equivalent to, emergency or disaster risk management by governmental agencies, industries, and social communities at the regional and local levels. Ningbo Zhoushan Port is not the only port in China to view emergency management as a short-term adaptation strategy to deal with temporary weather events.

The following is an example of an emergency plan for typhoons and strong winds in the Zhoushan Port area in 2018. According to the *Zhoushan Typhoon Defense Emergency Plan*, *Zhoushan Marine Typhoon Emergency Plan* (municipal government, 2017), and the "Three Prevention" Emergency Plan (local Transportation and Maritime Port Bureau, 2017), Zhoushan port authority formulate a plan and set up a temporary emergency response group responsible for supervising and guiding the disaster defense work of local port and shipping enterprises. The investigated ports and terminals do not dedicate the department or committee responsible for developing and implementing climate adaptation. Quoting the words from a manager of Zhoushan port:

“The port and port authorities have no plans yet to establish an adaptation system to deal with long-term climate change issues. Because although some climates cause economic damages to port operations, these climate issues are still not a major concern compared to the port’s economic development. At present, for climate issues such as typhoons and

strong winds, we have special response plans to guide us, which have proven to be effective in addressing short-term climate crises.”

Construction and reconstruction plan

Construction and reconstruction planning as part of port infrastructure upgrades and expansions, to a large extent, also increase the resilience of ports. The old berths and breakwaters built in the early stages of Ningbo and Zhoushan ports have been vulnerable to varying degrees of marine hazards; thus, ports need a reconstruction or upgrade to extend service life and ensure defensive capabilities to withstand extreme disasters. For example, the breakwater construction project is currently the primary plan for ports and terminals in the Zhoushan area to counter seawater intrusion. Many early-built ports rarely have breakwaters due to the protection of islands. In recent years, the negative impacts of seawater backflow are highlighted with the expansion of the port business, making it urgent for those ports to build breakwaters. Citing the comments from a port security manager of Beilun container port to the port construction plan:

“For non-obvious risks such as the sea-level rise and port flooding, we protect our ports mainly by enhancing modern port construction. The standards and capabilities of our port construction planning are at the forefront of the national port industry. Although port construction is isolated from climate management, there is a safety construction standard for the level of resistance to various natural risks in port construction depending on the port class.”

It will take time to see whether the investment in port construction and the current construction requirements (standards and capacity) are adequate to deal with climate change or marine hazards such as storm surges and coastal erosion. There is still a long way to integrate or link port construction planning and standards to climate management systems.

Technology application

Early warning and forecasting systems are a prerequisite for accurate risk identification, assessment, and preparation. The port relies heavily on techniques from external agencies in obtaining weather information in the surrounding port area. However, the information cannot be used for real-time systematic analysis and forecasting of the whole port. Continuous monitoring and reliable forecasting of hazard parameters are critical to produce accurate warning information and make immediate actions. Thus, there is an urgent need to establish a platform for seeking timely response for decision-making of port climate adaptation and reducing the economic and material impacts of climate issues as much as possible through real-time risk identification and assessment. Taking the Ningbo Port as an example, under the support of the Ningbo government and Meteorological Bureau, Ningbo Port Meteorological Center (NPMC) was established in 2016 for providing professional and reliable weather services to ports and logistics enterprises across Ningbo ports areas. To date, a three-dimensional meteorological observation network has been initially formed, with radars and various instruments set up on land and at sea in the port area. This technology can comprehensively detect coastal winds, weather, and temperatures and provide early warning services of strong winds and typhoons for port departments and terminals.

In the case of Ningbo-Zhoushan Port and the Port Authority, we can see that their short-term adaptation measures, which are more homogeneous and lack integrated planning, focus on increasing the resilience of hardware facilities and developing emergency plans. The development of the adaptation system is still in the initial stage of responding to climate disasters. A single emergency response measures cannot improve the port's adaptive capabilities and resilience in the long-term. Overall, at the port's strategic level, they are not yet ready to prioritize adaptation as a strategy to address climate variability and changes, which may be related to a lack of understanding and attention, as discussed in the next chapter.

5.3 The current progress on port adaptation systems

5.3.1 Adaptation governance structure

The discussion on progress on climate adaptation in N-Z ports will include the decision-making mechanisms for port responses to climate and key port decision-makers' involvement in governance mechanisms at government scales and port level. In terms of the overall governance structure, the decision-making system of Ningbo Zhoushan Port in response to climate disasters is characterized by a multi-level and multi-polar governance structure. In contrast, the internal governance structure of the port is still flattened (See figure 2). Port managers at the upper levels of the port have more responsibility for developing plans, while managers at the lower levels own more autonomy in actions.

Figure 2. Structure model for Ningbo-Zhoushan port's adaptation governance

Since ports are an essential part of urban planning and public safety governance, government agencies with additional security and regulatory functions, such as fire-fighting departments, emergency departments, and maritime bureaus, will also be involved in the emergency management process. At the same time, subnational governments and port authorities have institutional responsibilities for the development and implementation of the port group's adaptation plans. For example, the local port direct administration bureau plays a vital administrative oversight role in developing plans for port-related emergencies and overseeing port security management activities, such as inspecting and supervising the equipment, facilities, and processes in port operations. At the port level, N-Z Port Group, as a business entity, is also the main decision-maker responsible for

developing institutions and plans as well as conveying them directly to each of its subsidiaries. Through subsidiaries, the group can indirectly manage the adaptation activities of terminals and berths. The detailed roles and responsibilities of each port decision-maker in the climate adaptation governance system are shown in Table 2.

Table 2. Roles and responsibilities of main port stakeholders in climate adaptation governance system across institutional levels

Overall, multi-level and multi-polar actors' participation will become the norm in regional port emergency management for the governance structure. However, Are the overall coordinating bodies and participatory mechanisms between local governments and ports to address climate change truly established? The answer is no (from most respondents).

5.3.2 Process framework of port climate adaptation governance

As an important urban transportation facility, the port's adaptation governance is also part of the city's emergency adaptation management planning. According to the interview, we know that the N-Z port climate adaptation's unidirectional process includes two stages: risk management and emergency (adaptation) management.

The risk management consists of risk identification, risk assessment of the level and scope of climate risk, risk mitigation, and risk reduction. The climate information services for

risk identification and assessment are mainly provided by local governments (meteorological bureau, maritime bureau) or the port's internal meteorological platform in cooperation with third parties. For instance, the Ningbo Port Meteorological Center (NPMC) is an internal platform providing climate services only to ports and terminals in the Ningbo region. Mitigation, proven to be a useful risk-reduction precaution for N-Z port, is also integrated into its climate adaptation framework.

As explained earlier, Ningbo Zhoushan Port currently employs emergency management as a short-term adaptation strategy to deal with temporary weather events. The emergency adaptation management involving preparation, response (plan and actions), and recovery are at the center of port safety governance. The preparation phase's main tasks include the establishment of reasonable defense and control measures, appropriate strategies and procedures, and the stockpiling of necessary resources and response teams. The essence of an emergency response plan or management is a set of procedures or standards for handling emergencies (i.e., natural disasters, anthropogenic hazards, societal hazards, and public health emergencies). The typhoon defense emergency plan in Zhoushan port is developed with institutional guidance from governments and departments at the regional and municipal levels. Zhoushan Port Administration, as an executive body of the decision, formulate plans and set up a temporary emergency response group responsible for supervising and guiding the disaster defense work of local port and shipping enterprises.

The straightforward implementation steps of emergency are shown here:

- 1) the port authority communicates typhoon information to ports and terminals;
- 2) the port group starts the emergency response plan according to the typhoon intensity level;
- 3) the port authority notifies ports and terminals to carry out typhoon prevention measures and coordinates the security checks between port stakeholders and governmental departments;
- 4) emergency rescue and disaster relief, the material and personnel deployment;
- 5) post-disaster recovery and loss statistics reporting.

5.4 The institutional imperfection of port adaptation planning

Based on the progress made so far, we find that the climate adaptation system in Ningbo Zhoushan Port is still limited to short-term climate change and relies heavily on emergency adaptation measures. “*N-Z port's adaptation actions are ahead of the establishment of institutions and mechanisms*” (an official from port authority). The port climate adaptation system is still in its infancy and primarily aimed at responding to short-term climate hazards. The development of the port emergency response plan relies heavily on local governments and port authorities. N-Z port's typhoon prevention plan is currently the only dedicated emergency plan published by the port authority. To some extent, the port's plan also highlights the homogeneity and scarcity in planning for the port in response to climate change. Besides, by analyzing the relevant plans issued by the port and port administration bureau in recent years, we found that: emergency plans are copied without considering the actual situation; the definition of safety standards lacks consistency; the port not revised and updated immediately (e.g., 2009 and 2018 Zhoushan Typhoon Prevention Plan) and lack practical exercises of plans.

The linkage management mechanism among government departments, port authorities, and ports are not well developed. For example, in terms of risk identification, the monitoring and early warning systems of fire-fighting departments, maritime authorities, meteorological departments, and emergency management departments are still isolated and disconnected, not conducive to risk management or joint emergency operations in ports. In particular, the port of Zhoushan is in a weak position in terms of risk management monitoring and early warning and lacks sound emergency management and recovery mechanism.

As a critical element of the city's transportation network, port security management is part of its emergency management planning. A complete public safety governance framework (Figure 3) should be a cyclical process that includes risk management, emergency management, and crisis management. By comparing climate governance processes in ports, we have identified current institutional gaps in crisis management in ports, particularly in terms of accountability.

Figure 3. Process framework of urban public safety governance

Local governments, port authorities, and other security administrations have oversight responsibility and authority over port security governance, resulting in a multi-level and multi-polar management structure. It is hard to form a regional cooperative governance pattern for a regional. In the decision-making process of multi-agency participation in port adaptation planning and measures, the blurred and overlapping of responsibilities between departments may, to some extent, lead to the participant's misbehaviors. For example, there are multiple departments (safety supervision, maritime, fire-fighting, and port administration) with concurrent jurisdiction over security management at terminals. This overlapping of supervisory responsibilities will weaken the port's direct administrative department's supervisory function over port security and affect the port's normal operations. The continued expansion of N-Z port also increases the difficulty for port groups to supervise the terminals at each port.

Inadequate supply of institutions and the absence and misbehavior of main port actors cause institutional imperfection of the port adaptation system to vary degrees, which is a common phenomenon in the port industry's institutional change.

6.1 Theoretical model

In the previous chapter, we found that the institutional and port stakeholders in the establishment and implementation of the N-Z port adaptive governance system, to some extent, led to the phenomenon of institutional imperfection in port climate adaptation planning. In this chapter, based on Simon's decision theory and institutional imperfection, we will develop a conceptual model (see figure 4) to analyze. We will analyze the impact of the institutional environment, stakeholders (decision-makers), and adaptive capacity on the climate adaptation institution's decision-making process in N-Z port. As mentioned before, the institutional decision-making process of climate adaptation includes two parts: establishment and implementation.

Figure 4. Analysis model of factor influencing institutional imperfection based on Decision-making Theory

6.2 Institutional environment

6.2.1 Climate adaptation policies system

Adapting to climate change is a complex and ongoing process. Chinese ports, especially those as state-owned enterprises, are heavily influenced and constrained by the institutional environment. With the absence of external support (e.g., laws and policies), port emergency management mechanisms and planning alone will not give ports peace of mind against future long-term climate threats.

Since the central government released China's National Climate Change Programme (called Programme) in 2007, more than 100 adaptation-related policies and plans successively conducted by governments and departments from national to local during 2008-2013 (Peng et al., 2015). The policy system for climate adaptation has undergone preliminary development at the macro level and important fields (e.g., agriculture, ecosystems, and water resources). How are adaptation policies developing in areas where transport and climate intersect?

Table 3. Institutions related to climate adaptations in Chinese port sector, 2002-2019

We collate policies and regulations related to port security and climate adaptation in Table 3. Since the National Climate Change Programme issued in 2007, a series of national, sectoral, and local adaptation policies have been issued, contributing to the rapid development of national climate change adaptation policies (Peng et al., 2015). At the national level, the Programme (2007) and the National Climate Change Planning (2014-2020) defined the overall framework for China's climate response and formed the top-level design of the entire system, based on which a top-down climate adaptation policies system has been initially developed. National Climate Change Adaptation Strategy (2013) issued by the National Development and Reform Commission (NDRC) and legislation (like Port Law and Production Safety Law) played an important role in the formulation and implementation of adaptation policies and measures for local and sectoral actions. Legislation and policies are the basis on which port administrations exercise their responsibilities. The MOT has issued two guidelines for port authorities and ports to develop precautionary measures and workflows for managing dangerous goods in ports.

However, departmental regulations without a legal basis are unlikely to help ports effectively adapt to long-term, complex climate change.

As decentralization gives local governments more controlling power and financial autonomy in governing the transport sector (Walker et al., 2015), local governments' central role in the regional response to climate risks is strengthened. Climate policies and planning are integrated into the government's comprehensive work, including urban development, ecological and environmental protection, disaster prevention and mitigation, and social health and welfare. At subnational scales, the Zhejiang provincial government has accelerated local adaptation policies (He et al., 2012). However, significant limitations can be seen in the local government's level of awareness of the importance of climate change adaptation and their ability to develop specific adaptation policies and plans as policies are moved downward along the system. Institutional imperfection in the legislative framework for climate disaster management in the transport sector still is evident. The homogeneity and scarcity of adaptation institutions are more pronounced at the local government level and in the transport sector than at higher government and other sectors (Peng et al., 2015). A respondent argued that subnational governments and departments have limited ability to make climate change adaptation policies tailored to local conditions due to the lack of expertise and knowledge (a government official). Inadequate local and sectoral adaptation policy systems cannot provide strong institutional support for a port climate adaptation mechanism. Overall, port climate change adaptation remains not at the priority agenda of local governments and port sectors.

The central government formed a top-level design for a comprehensive climate adaptation policy system, but the progress of adaptation policy at the local level and transport sectors is still lagging. Furthermore, the gap between top-level design and local actions will be evident when policies and regulations are formulated and implemented from top to down along the system. Considering adaptation as part of urban disaster preparedness and mitigation system/emergency management, or conflating the two concepts, can be partly attributed to "issues of understanding" in the initial stages of planning (Moser & Ekstrom, 2012). The lack of adequate knowledge, data collection and sharing, unified standards of

climate risk evaluation, quantifiable targets all make the adaptation institutions more formalistic at the local level.

6.2.2 Administrative territoriality principle

The principle of administrative territoriality grants local governments and agencies jurisdiction over persons and businesses within their jurisdiction. Subject to the principles of hierarchical management and territoriality, regional ports' adaptation plans (emergency management and adaptation mechanisms) are supervised by municipal port authorities in accordance with government and transport regulations. In other words, although Ningbo Zhoushan Port has been merged and is operated and managed under a single port group model, the development of climate response policies, systems and programs are still under the respective administrative bodies, like the direct port administrations in Ningbo and Zhoushan.

On the other hand, the territoriality principle also limits the development and implementation of a unified adaptation planning or system at the group level, thus forcing ports to decentralize the actual responsibility for risk management to individual subsidiaries. The foundations and capabilities for constructing ports and terminals at different port areas and individual policies and regulations in different administrative regions will be barriers to developing a unified adaptation planning.

Some scholars have explored the possibility of administrative mergers, referring to the administrative division of regional ports as a constraint on the internal coordination and development of port systems. They have proposed that the integration of administrative entities could lead to a more coordinated and efficient allocation of port resources and promote the integration of port security management systems. City mergers are not unprecedented; for example, Wuhan City was formed by merging three towns. However, the administrative integration of two cities is far more complicated than that of a single port, and it takes much longer for the institutions and agencies to mesh. Therefore, for the

time being, even if Ningbo and Zhoushan can break down administrative barriers in the future, a slow remedy does not address immediate needs. In promoting the establishment of a port climate adaptation system, it may be more meaningful to explore how to improve consensus and cooperation among local governments and institutions on port climate security.

6.2.3 Supervision and accountability system

The supervision system is established to track and monitor the system's implementation, clarify the functions and responsibilities of each department, and improve the system or implementation through feedback. Although China has initially established a modern supervisory system for state-owned enterprises (SOEs), in the process of SOE reform, the phenomena of multiple supervision, repeated supervision, and inadequate supervision have occurred from time to time, affecting the efficiency of port adaptation systems and measures. The supervisory mechanism for the port system's internal and external climate adaptation has not yet been formed. The port supervision system for internal security governance mainly consists of regional and local governments and port departments, with each department having its independent supervisory mechanism. Due to the low level of interaction between multiple actors, poor coordination between mechanisms, and inconsistencies in safety standards or objectives, a comprehensive and useful regulatory system cannot be formed.

The weakness of core supervisors in a multi-body supervisory system and poorly defined responsibilities are another issue. Lack of consensus among multiple monitors on the direction and requirements for climate adaptation measures and capacity building in ports may lead to insufficient monitoring incentives. The supervisory bodies in the different administrative divisions of the regional port groups have inconsistent supervision standards in terms of safety management and processes. The principle of "hierarchical management" has, to some extent, also resulted in confusion and overlapping of administrative procedures and powers. Party organizations and supervisory authorities within the port

system lack institutionalized supervisory processes and clear objectives for developing and implementing of port safety systems. The implementation process of the Port Climate Adaptation Mechanism cannot be effectively monitored and improved if the direct port administration and the government do not assume the central oversight body's responsibility.

Accountability is part of improving security management (crisis management) in government and business. Accountability is a system that requires accountable entities to fulfill their responsibilities and obligations to the organizations and members under their jurisdiction and to hold them accountable for the negative consequences of their administrative failures. The system is established to enhance government accountability and to select more competent managers. According to the country's constitution and laws, administrative accountability means that the government and civil servants must be held accountable (legal, moral, and political) and subject to internal and external supervision. The decision-making power and process of the head of Ningbo-Zhoushan Port (as a state-owned port enterprise) is also subject to accountability and regulation. On the other hand, the accountability system is usually combined with a performance evaluation system for governments and leaders, pushing local governments and departments to play a more active role in the formulation and implementation of policies and measures. Energy conservation and emission reduction are now included in the government accountability and performance evaluation system as an essential evaluation indicator of local government green development.

However, there are many obstacles to the accountability of subjects responsible for port security. At present, the limitations of administrative accountability in China are reflected in the single homogeneous accountability, i.e., the government's administrative accountability, which is usually the accountability of higher-level departments to lower-level departments and administrators. The blurred division of responsibilities among subjects makes it difficult to hold individuals accountable when the collectives participate in port climate management's decision-making process.

6.3 Major climate change impacts on the N-Z Port

China's Second National Climate Change Assessment Report (2011) confirmed that global climate change would further exacerbate climate damage in China's coastal regions and reduce the functions of seaports. In the future 30 years, the frequent extreme weather and meteorological disasters will be a significant threat to port operation and facilities, such as loading and unloading machinery, lighting systems, safety systems, warehouses, and transportation in terminals.

Ningbo and Zhoushan have vast areas and a large number of islands and have widely different meteorological characteristics. Storm surges, extreme weather events (such as hurricanes and typhoons), and secondary disasters are listed as primary threats to ports' infrastructure, shipping and terminal operations (IPCC, 2012; IPCC, 2007). According to the survey, the most significant risks to port production and operations were found to be typhoons, strong winds, and storm surges, followed by extreme heat and precipitation. Secondary hazards caused by sea-level rise have little impact on ports. Based on the documents and survey, we have sorted out several types of weather elements that have a high impact on port operations and cargos (Table 4). The study identified and evaluated the main climate risks on port business in each port area (Table 5).

Table 4. The high impact of weather conditions on port operations and cargos

Table 5. Main climate risks on port businesses in each port area of N-Z port

According to the climate and hydrological records (Ningbo-Zhoushan Port Overall Plan, 2011), it is found that most of the ports in the Ningbo and Zhoushan region are highly susceptible to typhoons from July to September every year. The average number of typhoons affecting this area from 1949 to 1989 is 3.9 per year (strong typhoons account for 82%). It was observed that the frequency and adverse impact of typhoons landing on port areas have generally increased in recent years. During the typhoon season (July – September) of each year, storm surges and strong winds caused by typhoons pose a highly adverse threat to the safety of port machinery, facilities, and personnel, often resulting in the disruption of port operations such as loading and unloading, storage and transportation. The data from the National Maritime Bureau displays that 90% of the control of offshore operations and ships was caused by extreme coastal weather. Extreme high temperatures and extreme precipitation have a high impact on port operations; the former has a more significant impact on the liquid chemical and crude oil cargoes at the terminals. Extreme precipitation affects a broader range of cargoes, including major cargoes other than containers and crude oil.

Sea level rise is often cited as the most significant climate change risk affecting port operations. Sea level rise has been recognized as the main threat to the safety and operations of maritime transportation and shipping facilities (Nursery-Bray et al., 2013; IPCC, 2007). UNCTAD's (2018) reported that seaports and other transport infrastructures in those coastal areas are particularly vulnerable to the high rate of sea-level rise combined with storm surges or waves. It was reported that the coastal areas below 5.0 meters above sea-level go to vulnerable areas to sea-level rise and storm surges. The altitude of Ningbo coastal suburbs and Zhoushan's urban area is less than 4 meters above sea level. According to the 2019 Bulletin of China Sea Level (Table 6), from 1980-2019, the average sea-level rise in China's coastal sea areas is 3.4 mm/year, higher than the global average data. Compared with data in 2018, the rising rate of sea-level change in the East China Sea is the highest (38 mm) in all four China Seas. From the historical data, the rate and threats of regional sea-level cannot be ignored. Considering the continuous rise of sea-level, the probability of severe seawater intrusion in low-lying coastal areas will increase, especially when encountering seasonal sea tide and extreme weather (typhoons and storm surges) and

further exacerbate the risk on port operations. However, most interviewees reported that the impact of sea-level rise on port operations and cargo is insignificant in the short term, although during the typhoon season, short-term sea-level rise due to storm surge and tidal influences can lead to seawater inundation in some port areas.

Table 6. Sea level rise of China seas

6.4 Port adaptive capacity and resources

As a comprehensive modern hub port, N-Z has 771 productive berths of varying tonnage, with the largest number of large and very large deep-water berths in the country. Some of the early-built berths and breakwaters have been subjected to varying degrees of coastal erosion and need to be reconstructed or upgraded to extend their service life and ensure defensive capability against extreme disasters. Protected by the island barrier, the construction and resistance level of breakwaters at Zhoushan Port was low in the early days. In recent years, with the expansion of port operations, the negative impacts of seawater intrusion and storm surges have been highlighted, and the port is building a large number of breakwaters. In addition, according to the anchorage plan (2014), N-Z Port will build and upgrade ten new refuge anchorages, which can accommodate large ships to shelter from typhoons and enhance the ships' security and the port's disaster prevention and mitigation capabilities.

For the monitoring and early warning system, with government support and cooperation with third-party agencies, the Ningbo Port Meteorological Center was established in 2016 to provide professional and reliable meteorological services for ports and logistics enterprises in Ningbo's port areas. Ningbo Port has initially formed a three-dimensional meteorological observation network, setting up radars and various instruments on land and

at sea in the port area to detect coastal wind direction, weather, and temperature comprehensively, and providing strong wind and typhoon warning services for port departments and docks.

The frequent occurrence of high-risk meteorological disasters in recent years has posed a challenge to port security management. To better adapt to unexpected weather risks, some terminals have invested resources in establishing security response teams to deal with emergencies. Besides, the port conducts safety training programs in coordination with local port authorities and maritime authorities to deal with emergencies. By practicing unique contingency plans, the port staff improves their ability to deal with secondary incidents caused by climate disasters and strengthens cooperation within the port and with the port authorities.

6.5 Perceptions and decisions of port stakeholders

In addition to the above objective factors, the subjective perceptions of key port decision-makers on climate change and climate policy can directly or indirectly influence port adaptation's decision-making process. Some interviewees admitted that they have become increasingly aware of climate change and extreme weather in recent years and expressed concern about climate change's negative impacts. However, most interviewees remained optimistic about the port's ability to cope with disaster risk. A port manager argued that climate change and the negative impacts we are currently facing are short terms. On the one hand, port and port staff have years of experience responding to general climate hazards. Islands act as natural barriers to reduce damage to port facilities from climatic hazards. Continued investment in port construction and early warning systems objectively improves the port's ability to adapt to short-term climate risks while providing a certain degree of favorable psychological implication for decision-makers.

"The impact of climate on port operations and port development is still very small compared to markets and policies. In general, climate adaptation mechanisms are not yet

in place, but the precautions, infrastructure, and information systems at ports are adequate to meet current needs." (A respondent from a research institute)

However, although Ningbo Zhoushan Port has established a group management structure through the merger, it is still essentially at the stage of resource integration, and the integration of business, management, and systems within the port has been hindered in many ways. With the continued expansion and construction of the port, the ability to manage and supervise the various port areas and terminals has been weakened, and it is almost impossible to control all companies' safety management.

Climate change and its impacts have been a concern for governments and the public in the past two decades. The climate change adaptation policy is still not a priority on the agenda of ports and government decision-makers. "Climate change is a very macro and distant issue for the port sector," replied one participant. Port adaptation strategies and planning rely on policy and financial support from local authorities and governments. While emergency management and disaster preparedness and mitigation mechanisms are developed at the central and local levels, the process of institutionalizing port climate adaptation planning requires participation and coordination across sectors and matching of adaptation mechanisms and capacities within the port.

On the other hand, a vast majority of respondents' perceptions of climate change measures and policies were limited to the concepts of mitigation (energy efficiency, green ports), risk management, and emergency management. In contrast to adaptation and emergency response, mitigation strategies are more widely accepted, not only because of their remarkable successes but also because of policy support. The widespread knowledge, right technology, and human resources provide perfect conditions for the establishment and implementation of emission reduction systems, in which the general public is also positively involved. On the other hand, supervision and accountability systems for mitigation measures are relatively well developed, and active promotion within ports breaks down administrative boundaries. However, these factors are still lacking in the establishment of adaptation institutions.

6.6 Findings and Discussion

Based on the decision-making theory and model, we analyze how the institutional environment, climate issues, port internal adaptive capacity, and port decision-makers influence the institutional weaknesses in the port adaptation system's decision-making process. First, the establishment and implementation of port adaptation mechanisms depend on and are influenced by external policy and legislation system. Institutions play a crucial role in facilitating the process of port adaptation to climate change. The central government formed a top-level design for a comprehensive climate adaptation policy system, but the progress of adaptation policy at the local and transport sectors is still lagging. Local climate adaptation systems are therefore characterized by lagging legislation and prioritizing plans. Furthermore, the gap between top-level design and local actions will be evident when policies and regulations are formulated and implemented from top to down along the system, due to policymakers' perceived limitations at and below the sub-government level.

Similarly, in the changing process of port governance reform, the shortcomings of the port industry's external supervision and accountability system and administrative division are not conducive to establishing a long-term and stable adaptation strategy or planning for ports and the port sector. Competition and games between local governments make it difficult to coordinate port administrative resources across administrative boundaries, affecting the reasonable allocation of port resources and improving the overall adaptive capacity. Also, the misalignment of powers and responsibilities and overlapping functions of external administrative bodies lead to institutional entities' misbehavior.

The understanding of decision-makers to risks is limited by time and information, thus preventing them from making entirely rational perceptions and decisions about climate response. Limited understanding (knowledge and perceptions) of climate risks and adaptation among key port decision-makers and inactive engagement of external port stakeholders (i.e., academics, industry experts, collaborators, etc.) in port climate adaptation planning has, to some degree, led to a shortage and inadequacy of internal adaptation mechanisms in ports. The more optimistic climate change projections by

policymakers make it less likely that ports will have adaptation mechanisms in place in the short term. It is found that in terms of port planning, construction, and operations, Chinese port policymakers are more likely to consider the short-term impacts of extreme weather (Wu & Ji, 2013).

Considering the above factors, for a regional port hub, short-term emergency plans and measures alone will not be sufficient to address future long-term threats. But ports and port authorities still need a paradigm shift to replace emergency response systems to deal with long-term climate changes.

Chapter 7 Institutions and decision-making system in the Chinese social institution framework

7.1 Institutions in Chinese social and institutional framework

Port reform is a microcosm of China's reform and development within the Chinese social institution framework. The economic and political systems are the fundamental institutions of the Chinese social framework. In general, the Chinese social system has undergone a process of centralization to regional decentralization and a shift from a central-planned economy to a market-oriented economy. The process of institutionalization is not a one-time process and requires learning from existing institutions. The sophisticated existing institutions observed in the developed world have all undergone long periods of development. It is inevitable for a country without a good institutional system to use existing institutions to explore the right path of institutional development appropriate to national conditions. The impetus for institutional reform is endogenous, as a result of being driven by stakeholders of the existing system, which is also endogenous to the country's history, culture, social norms, technology, etc. (Xu, 2011).

Decentralization is the ultimate embodiment of the reform of the decision-making system. Sub-national governments are empowered to formulate and implement local policies. Decentralization can promote local government to initiate and implement market-oriented reforms and provide incentives for local officials to develop the local economy. Nevertheless, on the other hand, local governments need to take the risk of policy implementation failure. “Enablement does not come automatically with empowerment” (Xu, 2011). Without sufficient ability and resources to formulate policy, local governments cannot take policy actions and have to rely on the central government. The government is in a dilemma that even if it gets legal authority, decentralization does not work. At the same time, a lack of incentives for local governments to implement adaptation policies that would not draw the attention of officials to climate issues.

The existing institutional framework of port governance follows a top-down hierarchical management structure from central to local and from local to the port. This governance

system for ports implies decentralization of authority along a "spatial-jurisdictional" (Wang et al., 2004). Decentralization and the separation of administration and businesses have given ports much room to grow, but without local policy support and guidance, they have little resources and capacity to adapt to the climate.

7.2 Decision-making process

Policy-making in government is carried out in response to the challenges of social problems. There are three elements influencing government decisions: the public, the higher levels of government, and the government decision-makers themselves. Their decisions involve a complex interaction between social, institutional, cultural, and informational factors. The decision-making process is often the result of a game between the decision-maker, the issue, and the public. However, not all social issues become policy-making issues that governments need to get involved in. The process by which social problems are selected is the result of the interaction between the problem itself, the cognition of the public, and the decision-maker. The public and decision-makers' perceptions are influenced by the cultural, public opinion, and information environments where they live.

The decision-makers, shareholders, and issues are elements that influence decision-making within an organization. State-owned ports, as a social resource and public organization, rely heavily on port managers and government officials' decisions and the participation of shareholders for its security management. In the integration of port administration and operations, a local Port Authority works as the main decision-maker in dealing with climate issues. In the current port governance model, port authorities and ports are more likely in a parallel position for climate management. Vague division of responsibilities and cognitive differences between different decision-makers complicate the decision-making process in ports for developing and implementing adaptation systems.

7.3 The dynamic institution-stakeholders relationship in the decision-making process

Institutions are the rules of society and organizations, governed by national policy frameworks, legal institutions, and ideologies. Humans, as groups within societies and organizations, are subject to institutions.

The relationship between human beings and institutions in the Chinese social environment is characterized by a "leader-centered" organizational culture and governance model. Although Marxism and communism influence China's political system, institutions' formation is still subtly shaped by China's history, culture, and traditions. In public organizations, government and state-owned organizations, the principal decision-maker is at the heart of organizational decision-making and has a decisive influence on the formulation of organizational goals and systems, resource allocation, and performance appraisal.

A decision-making system that lacks constraints is likely to transform group decisions into individual decisions. To some extent, direct decision-makers' motivation and quality affect the outcome of the system's decisions. The primary decision-maker has a strong influence on the identification of the decision problem, the decision orientation, the decision process, and the decision outcome. Therefore, if the decision-making process is not constrained and regulated by an external institution, the actions of critical decision-makers can directly affect the outcome of the decision. When decision-makers' decisions are forward-looking, they can produce positive results for the organization, and conversely, deviations can lead to mistakes. The decreasing hierarchy of institutional constraints also contributes to the phenomenon of single decision making to some extent. In other words, the involvement of multiple decision-makers in the port adaptation decision-making process overcomes the disadvantages of single decision making to a certain extent.

On the other hand, the decision-making process in a regional and decentralized system, where central and local aligned interests or goals can maintain and strengthen the system. A consensus among policymakers across different levels can positively mobilize personnel motivation and organizational resources to achieve effective interaction between institutions and human.

8.1 Summary

The Chinese port system's reform and development are still under intense discussion in the international and domestic port research. Port reform is a microcosm of China's reform and development within the Chinese social institution framework. Since the Port Law (2004) was issued, the decentralization of control power and the separation of administration and business in the port industry have, to some extent, facilitated the regionalization of China's seaports. The integration and regionalization of port mitigate homogeneous competition and waste of port resources. Ningbo-Zhoushan Port is one of the pioneers of regional port integration in the country. China is severely affected by climate change and extreme weather. The National *Climate Change Programme* (2007) has contributed to the China climate adaptation policy system's development. To study the major climate risks and progress of port climate adaptation in the port industry, we invited stakeholders from Ningbo-Zhoushan Port to share their perceptions on climate issues and the implementation of port climate adaptations.

Given that the literature review emphasized the gaps in the institutions and stakeholders, Chapter 3 mainly reviews the concepts of decision theory, bounded rationality, and institutional imperfection. A preliminary theoretical model based on decision theory is also developed. Limited by the missing data on port climate and adaptation construction in official databases, this study conducts a case study to break down the data barriers and create a research database.

Chapter 4 examines the current climate adaptation in Ningbo Zhoushan Port. This chapter finds that the current strategy for coping with climate change at the port is dominantly based on mitigation, supplemented by adaptation. The adaptation to climate change is still not considered a priority response strategy by ports and port authorities. Besides, by examining the adaptation governance structure and the process framework of security governance in ports, we find that the inadequate supply of institutions and the absence and

misbehaviors of main port stakeholders cause institutional imperfection of port adaptation system to varying degrees.

Based on the above findings, Chapter 6 analyses how the institutional environment, climate issues, adaptive capacity, and decision-makers affect or lead to the missing adaptation institutions in ports. We find that climate adaptation policies and legislation are lagging at the sub-governmental level and below. Lack of supervision and accountability systems and administrative restrictions also contribute to the lag in port adaptation planning. On the other hand, most stakeholders' judgments about climate change and the adaptive capacity of ports are on the optimistic side, indirectly influencing their decision making on engagement and support for climate adaptation planning in ports. Inactive engagement of external port stakeholders (i.e., academics, industry experts, collaborators) in port climate adaptation planning has, to some degree, led to a shortage and inadequacy of internal adaptation mechanisms in ports.

The progress of and influential factors to the climate change adaptations of N-Z port are studied based on the decision-making theory's conceptual model. The decision-making environment and the interaction between the institution and port stakeholders on port climate adaptation planning need further study. Therefore, in chapter 7, we deeply analyze the institution and human (decision-makers) factors with decision-making theory on climate adaptation within the Chinese social institutions' framework. Finally, Chapter 7 explores the role of and the interaction between institutions and decision-makers in the decision-making process in the unique Chinese social and institutional environment.

8.2 Discussion

There is still a long way to go for public and private organizations to institutionalize climate adaptation. Climate change and adaptation have not yet become institutional issues at the local government and port level due to insufficient knowledge dissemination and attention. The central government has given more discretionary powers to local governments. However, local governments' limited capacity in climate management and differences in

development objectives has led to a significant gap between local government adaptation policies and the national institutional framework and legislative system.

As a mechanism for responding to short-term emergencies, emergency management can alleviate the adaptation pressures of ports to some extent. However, if it is used as a long-term mechanism to cope with future climate change, its effectiveness needs to be further studied. In the short term, the shortage of adaptation institutions will persist, giving local governments and port enterprises more flexibility in dealing with climate issues. For example, port companies can transfer climate risks to the market by purchasing insurance.

However, adaptation cannot be simply left to the market, nor the central planning. Local government agencies and ports, as critical stakeholders, should have critical roles and responsibilities in the climate adaptation process. In particular, ports should take on a social organization's responsibility and business ethics without getting caught up in an obsession with "good" security mechanisms. For example, ports and terminals will not be able to respond effectively to extreme weather if they lack an integrated or systematic response mechanism. At present, a paradigm shift is what the port needs in institutions and governance models to better adapt to climate change. For example, the port should take a medium- to a long-term perspective to build and improve their climate adaptation measures and plans. Simultaneously, administrative divisions limit the allocation of emergency resources to regional ports and the development of mechanisms for intra-port cooperation and regional interdepartmental linkages. A particular climate management and planning agency or committee should be established between the port, the government, and port authorities to overcome the administrative obstacles. The agency or committee can include general stakeholders such as researchers, private operators to achieve relatively centralized management. Through this committee, ports can avoid unnecessary regulatory coordination and resource consumption in climate governance and adaptation planning. The government is also responsible for strengthening and improving the external supervision and administrative accountability mechanisms for port security and effectively raising the awareness of the responsibility of government officials.

8.3 Contributions, Limitations, and Recommendation

In this article, we make significant contributions to the current academic literature on the following aspects. First, the existing literature has revealed that the scarcity of discussion of institutions and stakeholders in port-related study remains evident (Panahi et al., 2020) and is extended mostly based on the Western ports' case study. This paper represents one of the first attempts to fill a gap by exploring the roles of and the interconnection between institutions and stakeholders in port climate adaptation of a Chinese port with decision-making theory. Holding the institutional environment and context of port reform in China is uniquely valuable for studying port climate adaptation in developing countries.

Secondly, this thesis critically explores and expands the decision-making theory by bringing together concepts from social science fields into interdisciplinary research in a case study. The analysis of the interaction between institutions and decision-makers in the decision-making process within the Chinese social and institutional environment can provide a different angle on understanding theories. Furthermore, this study highlights the unique role of local governments and port group play in implementing port adaptation policies and actions by investigating and analyzing key port decision-makers' perceptions and roles in climate issues and planning. This study also provides a practical reference value for developing climate adaptation systems and decision-making systems in Chinese ports.

Admittedly, the theoretical building is only a preliminary concept that needs further validation and development. This study raises the need for a paradigm shift in institutional roles and governance models for ports to better adapt to climate change but does not give a clear path or pattern that addresses all stakeholders how they should act and contribute to adaptation plans. In this paper, it only focuses on one regional port and does not examine other ports or small ports; and lacks a linkage study with urban planning and sustainable development. Such a lack of network-thinking outlook in the study is evident. In the investigation, ports are mainly treated as facilities isolated from urban transportation systems and supply chain networks (Panahi et al., 2020). To make the qualitative result more generalized, there is a need to examine the findings with more examples from other

ports. During the interview, the knowledge dissemination barriers and bias of each individual may have a minor impact on data processing.

Considering the limited contributions of research from developing countries, we argue that future studies should focus more on climate change mitigation and adaptation of ports and transport facilities in emerging countries. Such research would be more complicated when considering ports in countries with different organizational and institutional characteristics. Thereby we can expect a difference by political and institutional, socio-cultural factors in western countries, which can be included in such study. Meanwhile, this study indicates how stakeholder perceptions influence the adaptation process, but there are generally no suitable quantitative research methods to verify this. A few cutting-edge studies have explored the approach to improve people's risk cognition and engagement with climate change. The study found that using traditional media to change individual perceptions and behaviors may not lead to greater public climate engagement (Schuldt et al., 2018). Virtual reality (VR) technology offers us another research possibility. VR would create an immersive environment with highly interactive visual and auditory stimuli to participants (Kinatader et al., 2014). With the widespread use of VR products, whether it is possible to stimulate emotions and perceptions through new technologies to influence people's decision-making behaviors, such as increasing their participation in institutional development for climate adaptation, deserves further research.

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Appendix 1 — Semi-structured Interview

Part A: climate change and adaptations in N-Z port

1. Major climate change in Ningbo Zhoushan port and surrounding areas

- a) What are the main climate threats the port faced?
- b) Which operations and/or cargos are more affected by these climate risks?
- c) How do you perceive climate change on ports?

2. The progress of port adaptation planning

- a) What response strategies, institutions, procedures do the port (or terminal) have in place to deal with climate risks?
- b) At which stage are the planning and systems for climate change adaptation in ports?
- c) What roles and functions do the governments and port authorities play in port adaptation measures?

Part B: The perceptions of port stakeholders on the climate adaptation process

- 1. Within and outside of the port, are there any factors, directly and indirectly, affect the establishment and implementation of adaptation measures and systems? Like climate policy, technology, knowledge, and culture, etc.
- 2. If exists, in what ways and to what extent, do you think these factors influence the process?
- 3. Given the nature of public services of the state-owned port, do you think Ningbo Zhoushan Port should improve the effectiveness of climate adaptation in ports?
- 4. For the external institutional environment, what factors do you think could facilitate the development of a port adaptation system?
- 5. In your view, should general stakeholders such as shipping/maritime operators, academics and professors, and even the general public be involved in decision-making on climate management in the port or transport sector? Why?

Part C: Institutional background and development of a regional port

1. What is the impact of regional port integration on port operations and management, regional economies, and governance system?
2. How do institutional reforms in the integration of Ningbo Zhoushan Port interact with the port's climate adaptation strategies or actions?
3. Institutional framework
 - a) The influence of China's hierarchical management (decentralization of administrative power) and decision-making system on the implementation of adaptation policies at local and sector.
 - b) What are the roles and responsibilities of governments and authorities across various levels in response to climate change?

Appendix 2 — Questionnaire

Definition for measurement

Five-Point Scales	1	2	3	4	5
Value	Very Low	Below Average	Average	Above Average	Very High

1. Very high – It is very highly likely that the stated impacts of climate change will occur, with a very large value like 90% for frequency, severity, and duration of events.
2. High - It is highly likely that the stated impacts of climate change will occur, with a relatively large value like 70% for frequency, severity, and duration of events.
3. Average - It is likely that the stated impacts of climate change will occur, with a medium value like 50% for frequency, severity, and duration of events.
4. Low - It is unlikely that the stated impacts of climate change will occur, with a relatively small value 30% for frequency, severity, and duration of events.
5. Very low - It is very unlikely that the stated impacts of climate change will occur, with a very small value like 10% for frequency, severity, and duration of events.

Questions

Part A — climate change impacts

1. What are the major climate change risks to ports and surrounding communities?
(multiple choice)
 - ☐ Sea level rise
 - ☐ Strong winds
 - ☐ Typhoons & Storm surges
 - ☐ Extreme weathers (high temperature & precipitation)
 - ☐ Other

2. Evaluation of climate impacts on port operations.

Based on your knowledge, how would you rate the frequency, severity, and duration of climate change impacts on port operations with the Five- Point Scales?

a) Impacts from sea level rise and its secondary disasters on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Ship navigation			
Port machinery & equipment			
Loading & unloading			
Storage & transportation			
Construction & infrastructure			
Health & safety of staff			

b) Impacts from strong winds on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Ship navigation			
Port machinery & equipment			
Loading & unloading			
Storage & transportation			
Construction & infrastructure			
Health & safety of staff			

c) Impacts from typhoons & storm surges on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Ship navigation			

Port machinery & equipment			
Loading & unloading			
Storage & transportation			
Construction & infrastructure			
Health & safety of staff			

d) Impacts from the extreme high temperature on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Ship navigation			
Port machinery & equipment			
Loading & unloading			
Storage & transportation			
Construction & infrastructure			
Health & safety of staff			

e) Impacts from extreme precipitation on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Ship navigation			
Port machinery & equipment			
Loading & unloading			
Storage & transportation			
Construction & infrastructure			
Health & safety of staff			

2. How would you rate the frequency, severity, and duration of climate change impacts on port cargos with the Five- Point Scales?

a) Impacts from sea-level rise and its secondary disasters on following port operations	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Container			
Ores			
Coals			
Crude oil			
Liquid chemical			
Bulk cargo			

b) Impacts from strong winds on following port cargos	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Container			
Ores			
Coals			
Crude oil			
Liquid chemical			
Bulk cargo			

c) Impacts from typhoons & storm surges on following port cargos	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Container			
Ores			

Coals			
Crude oil			
Liquid chemical			
Bulk cargo			

d) Impacts from the extreme high temperature on following port cargos	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Container			
Ores			
Coals			
Crude oil			
Liquid chemical			
Bulk cargo			

e) Impacts from extreme precipitation on following port cargos	Frequency of climate occurrence (1-5)	Severity of climate impacts (1-5)	Duration of climate impacts (1-5)
Container			
Ores			
Coals			
Crude oil			
Liquid chemical			
Bulk cargo			

RESPONDENT'S BACKGROUND INFORMATION

Please answer the below questions after the self-reports

1. Position: _____
2. Location (port area): _____
3. what is the most common way for you to approach and understand the climate change events?
 - a) Real experience
 - b) Information on media
 - c) Communications with people
 - d) Others _____