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Linking Carbon Pricing Jurisdictions

Lan Wang



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Lay Summary

This thesis develops knowledge in regarding to the opportunities and barriers of the linkage process underlying the international cooperation framework in carbon pricing jurisdictions. The linkage concept helps individual cap-and-trade systems to capture the benefits in economics, politics and administration along with the emission reductions to meet their mitigation commitments. Linking different carbon pricing jurisdictions could potentially increase market liquidity and develop joint political commitment in mitigating climate change.

With the growth trend in focusing on international cooperation for carbon markets, especially after Paris Agreement, there has been increasing interest in bottom-up international linkage field on carbon markets, with recent research also drawing on relevant parts of the linkage model literature. The thesis builds on this perspective, and address the current knowledge gap in understanding the roles and process of linkage underpin the concept of international cooperation for climate actions. In particular, the research questions consider: the factors that influence the linkage decision for international cooperation; the features of a novel linkage readiness concept for the cooperation between carbon pricing jurisdictions; the methods in designing an efficient linked carbon market; and the implications to policymakers for a cooperative approach.

The research for the thesis is undertaken within the context of regional linkage, with a case study of two jurisdictions, the EU and China. Two inductive studies, which adopt a qualitative case study methodology while one deductive study contains a hypothesis test for the linkage model. The research findings from qualitative researches are drawn from semi-structured interviews, document analysis, and observations. The quantitative research is derived from a hypothesis test for linkage model in constructing exchanging rate in carbon markets.

The studies focus on the area where more interests in constructing a “linkage-ready” carbon market for international cooperation in climate actions; highlighting the complexities of factors and relationships underpinning decision making of linkage; and revealing the different types of potential linkage models that occur or proposed to link the two carbon pricing jurisdictions. The study contributes to improve and propose the linkage frameworks for the carbon pricing jurisdictions understanding how the designs or implementations of

carbon markets can make a positive impact on the linkage preparation for a well-functioned linked system in the future.

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Abstract

This thesis develops our understanding of the linkage and process underlying the international cooperation framework in carbon pricing jurisdictions. The linkage concept is for cap-and-trade systems to capture the benefits in economics, politics and administration along with the emission reductions to meet their mitigation commitments. The thesis also identifies potential barriers in linking carbon pricing jurisdictions.

There has been an expanding stream of literatures within linkage field focusing on the international cooperation framework, recently enhanced through the Paris Agreement Article 6. The thesis builds on this perspective and address the current gap in understanding the roles and process of linkage underpin the concept of international cooperation for climate actions. In particular, the research questions consider: the factors that influence the linkage decision for international cooperation; the features of linkage readiness for the cooperation between carbon pricing jurisdictions; how to design an efficiently linked carbon market; and how these implications to policymakers for cooperation at an individual level.

The research for the thesis is undertaken within the context of regional and national linkage, at locations in EU and China. Two inductive studies, which adopt a qualitative case study methodology while one deductive study contains a hypothesis test for the efficient in the linkage model. The research findings from qualitative researches are drawn from semi-structured interviews, document analysis, and observations. The quantitative research is derived from a hypothesis test for linkage model in constructing exchanging rate in carbon markets by comparing two marginal abatement costs.

The studies make the theoretical contributions by developing the concept of linkage readiness for international cooperation in climate actions; highlighting the complexities of factors and relationships underpinning decision making of linkage; and developing a working definition and determine model for the exchange rate in carbon market, which effectively overcomes the barriers in the existing linkage frameworks proposed by the literatures. On a

practical level, the study also introduces the improved frameworks to guide policymakers, who with interests in international cooperation in market-based mechanisms.

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Abbreviations

EU ETS	European Union Emission Trading System
EP	European Parliament
DG	Directorate-General
PMR	Partnership for Market Readiness
UNFCCC	United Nations Framework Convention on Climate Change
NDRC	National Development and Reform Commission
MEE	Ministry of Ecology and Environment
CDM	Clean Development Mechanism
JI	Joint Implementation
MRV	Monitoring, Report and Verification
KP	Kyoto Protocol

Chapter I Introduction

1.1 Initial Overview and Motivations

Anthropogenic greenhouse gas (GHG) emissions have increased since the pre-industrial era, largely driven by economic and population growth (IPCC¹, 2014). The greenhouse effect caused by anthropogenic GHG emissions are extremely likely to be the dominant driver of the observed global warming since the mid-20th century (IPCC, 2014). The IPCC Fourth Assessment Report (2007) identified serious consequences which could include an endangered ecosystem for threatened species, a higher frequency of extreme weather occurrences and a decrease of world food production if the global mean temperature increases by 2°C above 1990 levels. Based on the IPCC report, the 2°C global temperature target was agreed by participating members in UNFCCC and written into the Copenhagen Accord in 2009 (UNFCCC, 2009). Notwithstanding this target, the UN Environmental Programme Adaptation Finance Gap Report (Olhoff, 2016) clearly showed that there is an urgent need to strengthen climate actions. However, a gap in the finance available for adaptation costs in developing countries still exists and the estimate of this gap has been climbing to as high as USD 150 billion by 2025 (Olhoff, 2016).

Climate finance refers to technology transfer and financing through public, private or alternative sources to support mitigation and adaptation actions in developing countries, which was agreed to be increased by USD 100 billion a year in 2020 (UNFCCC, 2017). Climate policy is significant for long-term mobilization to meet upfront capital requirements towards this 2°C target while the emission trading system (ETS) is a key market-based political instrument in climate policy (World Bank, 2012). However, an isolated ETS often has a limited liquidity and a limited effect in addressing emissions reduction in the global context (Burtraw et al, 2013). Emissions from one jurisdiction could be leaked to another jurisdiction without an ETS or with less stringent climate policy (Fankhauser and Hepburn, 2009). An ETS jurisdiction can also suffer vulnerable climate policy driven by a swinging domestic political environment (Flachsland et al, 2009). For example, there were unsustainable climate policy changes in carbon budgets in the UK Climate Change Act after the general election²

¹ IPCC-Intergovernmental Panel on Climate Change

² At the end of November 2008, UK Parliament passed the first Climate Change Act setting legally binding GHG reduction target of an 80% cut from 1990 levels by 2050. However, in the 2010 general election, David Cameron in 2011 approved fourth carbon budget stated a new emissions performance standard that reduced mitigation target allowing gas-fired stations without carbon

(Lockwood, 2013). In Trump's administration, the United States announced its withdrawal from the Paris Agreement (White House, 2017) and the Environmental Protection Agency (EPA) has suspended national emission trading plans replacing them by a new proposal for emission regulations (EPA³, 2017) which are less stringent than former President Obama's climate plan. Linkage of ETSs can potentially reduce the risk of climate policy change.

The importance of linking ETSs from a research perspective is shown by literature for a number of reasons. A stable climate policy framework can provide a more reliable carbon price signal for investors and therefore can ease financing for low-carbon development in the long-term. Based on current literature, linkage results in momentum for political support of domestic climate policies and reducing uncertainties (Ranson and Stavins, 2016). In terms of economic considerations, linkage generates economic gain between two ETSs with different marginal abatement costs (Rehdanz and Tol, 2005). Moreover, the linkage between two carbon markets could benefit from increasing market liquidity. This advantage is especially obvious for a smaller market linked with a larger one because linkage will bring more participants into the trading platform in the smaller market and enlarge the supply of allowances (Jaffe and Stavins, 2008).

In theory, there are two types of linkage processes. Top-down is determined through a centralized multilateral decision-making process under the UNFCCC framework (Tuerk et al, 2009). Regions with closer geographic, economic or political relationships find it easier to implement ETS links by degrees or in unilateral, bilateral and multilateral ways through top-down procedures such as ETS linkages between EU members, and the linkage between the California, Quebec and Ontario ETSs under the Western Climate Initiative (Ranson and Stavins, 2016). Bottom-up is a sub-national or individual decentralized decision-making procedure, which is not a legally binding agreement between Parties (Tuerk et al, 2009). This type of linking describes only part of the programme elements aligned across two regions such as the Clean Development Mechanism under the Kyoto Protocol (Burtraw et al, 2013). Much of the academic literature has aimed at analysing the economic, political and regulatory implications for linking but disregarded the relationships between them. The academic motivation for the present thesis is to address this gap in the literature while the

capture until 2045. In 2017 election, Conservative government requested Committee to review fifth carbon budget for increasing emission reduction target again.

³ EPA-Environmental Protection Agency

practical motivation for the research is to explore opportunities to improve linkage methods between two ETSs.

In this thesis, a case study of the EU-China ETS link is applied as an example to address ‘what-if’ type of questions about linkage. There are three reasons for choosing this linkage. First, China, as the largest emitter in the world, is planning to launch an emission trading scheme in 2020. The initial coverage sector in China national emission trading system is only the power sector (China Emissions Exchange, 2018). The EU ETS is the most mature ETS scheme with more than 20 years of operational experience. Second, it would be beneficial to explore market differences between the China and EU ETSs as the two systems have different market designs, and are located in developing and developed regions respectively. Third, the China ETS is going to be the largest carbon market in the world whilst the EU ETS contains 31 countries (EU Commission, 2017), and it would be beneficial to understand stakeholders’ appetite for such type of “regional to national” linkage. The two markets have different models in formulating climate policy decisions. These unique characteristics for this case study serve the objectives of the research questions for the thesis and would generate new knowledge for future researchers.

1.2 Research objectives and questions

This research focuses on explaining how a linkage decision is formulated and proposes innovative approaches for early opportunities linking different ETSs. However, this research only considers regions which are concerned about climate change and have existing emission trading systems. To understand the research objectives, three research questions are posed as follows.

Question 1: What are key drivers and barriers for linking two different carbon markets?

Although empirical research revealed the benefits of linkage outweigh the expected costs (Ranson and Stavins, 2013), existing international linkages are still rare around the world. A systematic analysis of economic, political and regulatory factors implied for influencing linkage decisions has been carried out by existing literature but we are interested in whether these factors are still the key drivers for linking two heterogeneous carbon markets in developing and developed countries.

Question II: Question II: *How the compatibility of the two ETSs influenced by policy diffusion framework? What are the implications?*

Compatible carbon market design is recognized as a crucial factor for linking (Burtraw et al, 2013). Related literature has explored key elements in carbon market design but how the extent of compatibility in such designs could influence the decision to link has never been studied. Thus, the thesis will make recommendations for improving the compatibility of linking ETSs to ease links in the future.

Question III: *What is a potential linkage model for a regional and multi-country ETS with heterogeneous market designs?*

Linking carbon markets has become a challenging topic, where direct and indirect models have been proposed (Flachsland et al, 2009). However, the direct and indirect models have their limitations from economic and political perspectives (Jaffe and Stavins, 2007) and these models have barriers when applied to linking the China and EU carbon markets. Thus, the thesis will research linkage models between regional and multi-country ETSs with different market designs.

1.3 Research Findings and Relationships between Papers

We have made several original contributions to linkage models in this research as illustrated in three papers. In the first substantive study, we focused on exploring the key drivers for the linkage decision to answer Question I and II. We applied a single case study between the China and EU ETSs by identifying factors through field work by semi-structured interviews, observations and documentary analysis. Our findings show that the level of carbon price, political trust and uncertainties, compatible carbon market design, economic cost, environmental effectiveness, and public inputs and social pressure are key factors for the linkage decision. Compared to the literature, we found political concerns and environmental effectiveness outweigh economic considerations when referred to linkage. Meanwhile, there exists a trade-off between the level of carbon price, economic growth, and environmental effectiveness. Conflicting perspectives in considering the competitiveness of the electricity sector were also raised when making an international linkage decision.

Direct and indirect linking models in literature are not appropriate for linking the China and EU carbon markets. Thus, the second study contributes to the development of a new linkage

model between a regional and multi-country ETS with heterogeneous market designs. The second study is designed to answer the research Question II. The second substantive study looks at how the policy diffusion influences for compatibility of carbon market designs to the linkage decision. Compared to the existing literature, this study shows the policy diffusion through learning mechanisms largely influences for the compatibility of carbon market designs.

The third study in this thesis attempts to answer the Question III. The concept of exchange rate proposed for potential linking two different carbon markets. However, the definition and determination of exchange rate are unclear in the literatures. Thus, in the third substantive study, we compared the different definitions given in the literatures and proposed for the working definition of exchange rate for the linkage of carbon markets. Then we explored the exchange rate determination theory based on the marginal abatement cost and expanded it to encompass the linked carbon market depends on the empirical data in China and in the EU. To define the mitigation efforts measured in the same units of carbon allowances, we applied marginal abatement costs in carbon markets to show different inputs to achieve an equal additional tonne of mitigation.

All three studies demonstrated insights for improving linkage models and a better understanding of the linkage decision making process. The first study identifies concerns and obstacles for international collaboration, which provides the motivation to raise the research questions for the second and third studies respectively. Another point to note is that the first study recommended that 'compatible carbon market design' is one of the key drivers for a linkage decision. The last paper building on previous chapters, outlines in detail 'how much compatibility is needed for linkage'.

1.4 Structure of Thesis

This chapter gives an overview of the whole thesis introducing the research background and contributions from literature. Chapter 2 answers Question I exploring the key drivers for carbon market linkage and proposes potentially feasible forms of linkage between the China and EU ETSs. Chapter 3 first applies a qualitative method to identify how the policy diffusion influence for the carbon market linkage. Chapter 4 discusses the potential linkage method. This chapter develops an 'exchange ratio' linking model for a regional and multi-country ETS

with heterogeneous market designs and answers Question III. Chapter 5 draws conclusions from the research, notes some limitations and proposes ideas for future research.

Chapter Two Key Elements of Linking Carbon Jurisdictions: Taking EU and China as Example

2.1 Introduction

Scholars have argued that linkage between ETSs can address global climate change in a more cost-effective and efficient way (Anger, 2008; Flachsland et al, 2009). In principle, the literature shows that important motivations for international policy architectures are driven by a variety of economic, political and regulatory implications. For example, for economic benefit, linkage creates cost-effectiveness for mitigation, increasing carbon-market efficiency and incentivising low-carbon investments (Jaffe et al, 2009; Zetterberg, 2012; Jegou, 2014). From a political aspect, linkage encourages covered industries to accept domestic climate policy and presents long-term commitment with a stable climate policy and active in global climate action (Bodansky et al, 2016; Mehling et al, 2018). Meanwhile, linkage also provides a mechanism for jurisdictions to share best practices and harmonize ETS design features (Rasons and Stavins, 2013; Burtraw et al, 2013). However, the motivations for linkage developed in literature are based on experiences in carbon markets over the last decade and, as yet, there is no study to investigate and test the series of hypotheses about why systems choose to link from stakeholders' perspective.

Thus, in order to fill the academic gap, the objective of this chapter is to investigate the key drivers for linkage from stakeholders' perspectives and provide insights into identifying the trade-off between expected benefits and drawbacks when linking two cap-and-trade systems. To achieve these research objectives, this study sought to address two, interrelated research questions: what the key drivers and barriers are to linking two different carbon markets and how these factors influence linkage decision making.

To answer these questions, it begins with an examination of interdisciplinary literature on a variety of economic, political, strategic and regulatory factors of ETS linkage. This research conducts a case study between the Guangdong ETS and the EU ETS, and an inductive field study of stakeholders who are involved and responsible for ETS implementation is engaged, to develop the concepts. Then a methodology of grounded theory (Glaswer and Strauss, 1967) is used to gather and analyse the data. The grounded theory is a process of category identification and integration of meaning from the data, which specific suits for the theory

development (Glaswer and Strauss, 1967). After categories emerge from the data analysis, political considerations, economic costs, environmental effectiveness, compatible carbon market design and public engagement are five dimensions shown as the key drivers for linking two ETSs.

The literatures (Jaffe and Stavins, 2007; Flachsland et al, 2009; Burtraw et al, 2013) emerged the three factors that influence the decision in considering political, economic and administrative benefits or drawbacks from the linkage. Comparing with the theoretical concepts in the literature, this chapter shows three conclusions were derived about stakeholders' views on the reasons to initiate ETS linkage. Firstly, the major finding of this chapter is the political considerations outweigh other drivers in the decision to develop a link between two systems, although much of the existing literature argued that lower costs to achieve the same level of mitigation is obviously the primary goal of linkage. However, it is important to recognize that an ETS is policy driven, rather than a market-based, instrument and the desire or trust in political considerations appear to have much higher impact on real-world decisions regarding linking.

Secondly, two additional drivers for linkage were detected: environmental effectiveness and public engagement. As the increasingly public awareness in that the emissions have negative impacts for the health and risk for life security due to frequently extreme weather happened, the pressure from public to encourage developing climate policy and creating an incentive for the linkage decision. The quality of emission reduction activities and levels of ambition in mitigation targets are also considered when it refers to the link between two ETSs.

Thirdly, there exists a conflict with linkage from the perspective of competitiveness in the power sector. The argument is that different groups of stakeholders have different interests and the decision of linkage depends on the whether the linking is the priority in the local climate change policy.

For policy application based on these findings, the research has implications for the role that a decentralized linkage between two ETSs may play in future international climate policy cooperation, if two ETSs have great differences in market design. Furthermore, the research

also indicates that the possibility of achieving near-term direct linkage for the hypothetical case, i.e. between the Guangdong ETS and the EU ETS, seems unlikely.

The remainder of this chapter is organized as follows. Section 2.2 describes the literature review of theoretical concepts in economic, political and regulatory categories that influence the ETS linkage. Section 2.3 introduces the methodology of grounded theory for collecting and analysing data. Section 2.4 presents the findings developed from the case study. Section 2.5 discusses the findings and compares with existing literature on whether and how the factors have influenced decisions about linking emission trading systems, with explanations and then describes the limitation and conclusions.

2.2 Literature for dimensions in linkage factors

An increasingly number of linkages have emerged in the last decade. Specifically, after the Paris Agreement, bottom-up climate policy architecture is suggested as a potential success framework to boost carbon market linkages. This international cooperation trend results in the growth discussions in the literature to explain voluntary collaborations of international, sub-national or regional carbon jurisdictions showing self-interest in the cooperation for climate action. According to the scholars, the motivations and barriers for the linkage decision-making could be classified in economic, politics and regulation these three dimensions (Flachsland et al, 2009; Rasons and Stavins, 2013; Mehling et al, 2018).

2.2.1 Benefits for the linkage

2.2.1.1 Economics

- Efficiency and cost effectiveness

Economics benefits of linking two different emission trading systems are discussed clearly in the literatures. The simulation by Anger (2008) suggested there was a Pareto improvement of efficiency when linking emissions trading schemes and no system will be worse off after linking. Cost effectiveness could be achieved by the reallocation of different marginal abatement costs from two different carbon markets. System with the higher marginal abatement cost could reduce costs for compliance by purchasing credits from lower price system.

The most significant described economic motivation for linkage is the minimisation of mitigation costs in efficiencies across systems, since more options are available in larger

systems (Chichinisky and Heal, 1995; Edenhofer et al, 2007; Flachsland et al, 2009; Grull and Taschini, 2012; Rasons and Stavins, 2013). The joint systems could provide an opportunity to achieve the lowest cost to society for low-carbon development and to receive aggregate cost savings for governments (Mehling et al, 2018).

- Improve carbon market liquidity

From international emission trading, the expansion indicates an integration of scope and coverage with more liquidity in the market and lower transaction costs (Jaffe et al, 2009; Zetterberg, 2012; Jegou, 2014). Arguments for enlarging emission trading systems' sizes by diversifying multi-regional buyers and sellers has been mixed. The creation of a larger system with more players could effectively absorb market shocks, reducing price volatilities (Flachsland et al, 2009; Rasons and Stavins, 2013).

- Certainty for investments, reducing leakage and market distortions

Linkage is a long-term commitment with fewer possibilities to loosen climate policies, which provides confidence and incentivises firms to invest optimal amounts in low-carbon innovations (Mehling et al, 2009; Calel and Dechezlepretre, 2012; Burtraw et al, 2013). In addition, leakage and competitiveness distortions describe the economic side of the same coin of linkage (Fankhauser and Hepburn, 2009). The equalisation of carbon prices after linkage could potentially reduce the risks of carbon leakage and limited market distortions (Nicholas Stern, 2008; Jaffe et al, 2009; Flachsland et al, 2009; Haites and Wang, 2009; Burtraw et al, 2013).

- Distributional impacts for social welfare

Distributional impacts refer to the distribution of efficiency gains across regions, industries and installations. The distribution of net gain may not benefit all parties within the ETSs. Similar to an international trading agreement, sellers in the pre-linkage, higher-priced system will receive a lower price for the allowances they sell, while buyers in the pre-linkage, low-priced system will have to pay a higher price for the allowances. There exists potential the benefit of net gains for maximising national welfare (Rasons and Stavins, 2013) and this net welfare could be used as substantial support to further low economic development (Carbone et al, 2009). Increasing carbon price impacts reducing local air pollution and enhancing energy security by encouraging reducing fossil fuel imports (Calel and Dechezlepretre, 2012).

2.2.1.2 Political

Linkage decisions driven by political and administrative factors have more benefits than with economic motivations (Mehling et al, 2018). The political consequences from linkage depend on various considerable factors under different scenarios. Linkage between two carbon markets has implications for both domestic and international dimensions.

- Linkage implications for domestic

The linked systems will require strong and stable domestic political support, which enhance domestic business actors' acceptance of climate policies and improve public awareness (Flachsland et al, 2009, Zetterberg, 2012; Green et al, 2014). This linkage results in the momentum of political support of climate policies and regulatory stability (Bodansky et al, 2016). A barrier to the termination of linkage (Pizer and Yates, 2014) also increases confidence in the market to incentivise low-carbon investments.

- Linkage implications for international

International strategy is a key driver for deciding whether to link carbon markets. Linking carbon markets in two different countries represents an instrument of international cooperation and signals a commitment to long-term climate policy (Jaffe and Stavins, 2007). The benefit of this institutional linkage lock-in is the dynamic efficiency of climate policy with consistency for governments, which normally have limited commitment power (Jegou, 2014). Linking could also be an effective means of addressing the politically sensitive issues of competitive distortions between countries with different prices of carbon or other forms of subsidies for low-carbon activities. Linkage contributes greater cooperation across jurisdictions to achieve mitigations (Flaschland et al, 2009; Burtraw et al, 2013). This coalition reduces the fundamental risks of free riding (Burtraw et al, 2013). Cooperation in carbon markets represents active global burden sharing (Rasons and Stavins, 2010; Rasons and Stavins, 2013). The carbon market is a diffusion process, which encourages experimenting with pilots to reduce uncertainties, by sharing information, knowledge and learning lessons across borders (Biedenhopf et al, 2017). This diffusion also influences the third countries to inmate constructing their own individual emission trading systems and boosts influence in shaping their own national climate policies (Jaffe et al, 2010; Rasons and Stavins, 2013; Burtraw et al, 2013).

This diffusion power could be even stronger when ‘near aboard’ is applied. For example, the EU as a climate change leader, uses linkage as part of its overall plan to encourage other countries to do the same (Green et al, 2014). The external governance literature indicates a systematic understanding of traditionally European neighbourhood policy diffusion processes. The stronger the relationship with the EU, the more power national governments have to adopt or be in favour of following EU policy designs. Switzerland is as an example for this. The EU seen as the climate leadership aspirations in the EU climate governance. Given its power and carbon market size, the EU can be seen as attempt to influence the design and rules of any nations especially with the closer political and economic relationship, like Switzerland (Rutherford, 2014). Switzerland is in EFTA⁴ and involves for ENP⁵ and learning from EU is just reflecting the power of policy imitators (Muller and Slominiski, 2016). In addition, successful joint institutional frameworks could build with more confidence if partners are either in geographical proximity (Rasons and Stavins, 2013) or there is prior historical of cooperation with benefits such as EEA⁶ or NAFTA⁷ membership (Gorlach et al, 2015) and particular cultural and institutional context (Biedenhopf et al, 2017).

2.2.1.3 Regulation

- Regulatory certainty

Three aspects considered to create linkage among systems have processed slowly: environmental integrity, necessity of harmonisation in certain elements of carbon market design (Jaffe et al, 2009; Gorlach et al, 2015) and the power of negotiation dependent on market sizes (Newell, 2013). The linked carbon markets will naturally lose a certain degree of regulatory flexibility, but in return, will provide investors with a higher confidence of regulatory certainty.

2.2.2 Costs for the linkage

2.2.2.1 Economics

However, on the downside, linkage constraints could result from the economic side. The larger partner in a linked system will likely have greater influence on the carbon allowance

⁴ European Free Trade Association

⁵ European Neighbourhood Policy

⁶ European Economic Area

⁷ North American Free Trade Agreement

price accessible for market manipulation. Unequal net welfare of selling distribution between countries can lead to winners and losers (Newell et al, 2013). This even creates an incentive for relaxing emission caps for more benefits in selling permits to generate revenues, which is harmful for environmental effectiveness (Westskog, 2002, Zetterberg, 2012). One example to discuss for this argument is the Kyoto Protocol. Although the expectation of international emission trading efficiency gains were about 50% and up to 75% in the case of the Kyoto Protocol (Weyant and Hill, 1999), the result was not met for this prediction. This failure of the Kyoto Protocol reflected in the potential encouragement of free riding in international climate agreements (William Nordhouts, 2015) and selling 'hot air' allowances with lower prices to emission trading systems. Linking two carbon markets however this also contributes to importing volatilities from other markets

2.2.2.2 Political barriers to linkage

The linkage barriers are reflected in divergent political priorities of different nations and regions (Tuerk et al, 2009). The political priority between mitigation and economic reflects in different carbon market design elements in reduction targets and allocation methods. Challenges are critical to environmental effectiveness, when they refer to uncertainty over quality and integrity of emission reductions (Rasons and Stavins, 2013). The different levels of ambitious in emission reductions have risks (Zetterberg, 2012), which lower stringency jurisdictions have incentives to loosen emission caps further, due to financial flow after linkage (Bodansky et al, 2016). The policy development is normally shaped by powerful, interested stakeholders or domestic policy preference (Biedenkopf et al, 2017). There exists a trade-off between environmental effectiveness and economic competition, which influences the political feasibility over linking. The trade-off reflects in potential constrain for the linkage decision because of the higher carbon price after linking (Tuerk et al, 2009). Allowance allocation is a political issue and could possibly lead to adverse competitiveness affects (Nicholas Stern, 2008). To address this competitiveness, the EU solution was free allocation to installations, especially in Phase I (Fankouser and Hepburn, 2009).

One obstacle for political consideration of linkage is it translates into losing sovereignty and autonomy for jurisdiction (Mehling et al, 2018). Although an argument for reducing limited control over the market after linking (Tuerk et al, 2009), the carbon price will be determined by integrating the supply and demand of two systems and most nations have to be the price

takers in the linkage (Rasons and Stavins, 2013). The cooperation between two systems also requires them to harmonise mitigation targets in international agreement. The three purposes of international action in climate change are effectiveness, efficiency and equity (Tuerk et al, 2009). In the negotiation of collaboration, linkage could differentiate responsibilities, depending on countries' capabilities (Bodansky et al, 2010). However, this equity principle for bargaining over burden sharing equally is dependent on economic and development situations (Flachsland et al, 2009).

2.2.2.3 Regulation

The willingness to accept a loss of control in market design and emission reduction targets depends on whether the policy objectives of the two systems can successfully be mixed to create a new single system. Significantly different emission reduction targets, allowance price collars and MRV⁸ could make linkage very difficult, and it is notable that most linking decisions have so far been made when at least one market was still at the design stage (Burtraw et al, 2013).

In the alignment of linking processes, other factors in market design also influence the implementation of administrative rules. Besides emission targets with strongly political acceptability, additional elements include the recognition of external trading units, sector coverage, banking, registries, new entrants and closures, compliance periods (Tuerk et al, 2009; Sterk and Kruger, 2009; Zetterberg, 2012) and robust enforcement measures (Jegou, 2014). ETS covering both upstream and downstream emissions could post double accounting consequences that prevent linking with a system with only upstream regulation. ETSs with inadequate MRV systems would post challenges for the stakeholders and the public of the partner ETS to support linking.

On the legal compatibility side, linking would require formal legal consents from both partners to accept trans-boundary trading and the transfer of allowances or emission reduction credits (Flachsland et al, 2009; Rason and Stavins, 2013; Jegou, 2014). The negotiations between domestic authority agency and foreign nations will take long time to set a legal framework of legislature and appropriate implement in regulations to make link possible (Rason and Stavins, 2013). California and Quebec, as an example, described as legal

⁸ Monitoring, Report and Verification

challenges to work through from planning of linking protocols to final establishment (ClimateWaire, 2013c; Burtraw et al, 2013). The Table 2-2 concludes the literature reviews on factors that influence the linkage decision.

2.2.3 Summary and Emerging Gap in the Literature

The literature reviewed for the motivations and barriers for the linkage decision-making in aspects of economics, politics and regulation dimensions as determinants factors. For example, in the factor of economics, maximize of social welfare, reducing mitigation costs and increasing the market liquidity positively influence for the linkage decision-making, however, it also includes the possible negative impacts on importing the volatility from other markets, the risks of incentive relaxing the emission cap. In the matter of factor in politics, the linkage indicates share-burden in climate action, the long-term stable climate policy commitment however, it also reflects for the loss of sovereignty and autonomy for jurisdiction. The motivations in sharing administrative costs, best practices and lessons consider in the factor of regulation, however, it requires the regulators' loss certain level of control over carbon market regulations.

Although the literature reviewed motivations and barriers in economics, politics and regulation dimensions, there is still a gap to understand how the trade-off between the factors determine for the outcomes of the international existing ETSs' linkages, which is shown in table 2-1. The scholars tried to show how the linkage decision made by considering the benefits and barriers between the factors and dimensions in the procedure but without further explanations. For example, in the literature, Mehling et al (2018) tried to explain the benefits in political and administrative dimensions might be drivers for decision more than economics, especially when both systems are applied in absolute emission targets. Ranson and Stavins (2013) found out although face the political obstacles, many nations and sub-nations still have chosen to establish links, which might because of the geographic near for the two regions.

Therefore, the further study is designed to develop for understanding how the trade-off between factors influence in the linkage decision-making procedure. Hence, the study research questions emerge into:

SQ1: What are the trade-offs between the factors in three dimensions considering both benefits and costs and explain by the theory?

And

SQ2: How the trades-offs influence outcomes of decision-making for international climate policy cooperation, taking linkage ETSs as an example?

Table 2-1. Existing World Carbon Jurisdictions Linkages

System 1	System 2	Type of Linkage	Enact. Date	Effect. Date	Price at Enactment #1	Price at Enactment #2
27 EU nations	EU ETS	Multilateral	2003	2005	none	NA
Norway	EU ETS	One-way		2005		
Norway	EU ETS	Multilateral	2007	2008	€0	€20
Iceland	EU ETS	Multilateral	2007	2008	none	€20
Liechtenstein	EU ETS	Multilateral	2007	2008	none	€20
Switzerland	EU ETS	Two-way (under negotiation)	NA	NA	NA	NA
California	Quebec	Two-way	2012/2013	2014	\$14	none
California	Quebec Ontario	Multilateral	2017	2018		
EU ETS	CDM	Indirect	2004	2005		
Delinking systems			Enact. Date	Delinking Date		
RGGI⁹	Any states' CAT system	Delinking	2005	2013		
RGGI	New Jersey	Delinking		2011		
Australia	New Zealand	Two-way	/	2014		
Australia¹⁰	EU ETS	Two-way (One-way first)	2013	2014		

Sources from Rason and Stavins, 2013; Burtraw et al, 2013; Tuerk et al; 2009.

2.2.4 Multi-level governance in foreign policy decision-making theory

⁹ RGGI-Regional Greenhouse Gas Initiative. Member states passed legislation until 2008. CAT-cap and trade system

¹⁰ Repealed by Australian government decided linking negotiations have not been pursued (EU ETS, 2014)

The foreign policy decision making, as a subfield of theory in international relations, refers to the choices made that affect a nation's actions on the international stage and an analysis of foreign policy decision is an approach that could further support for understanding the pattern of policies' makings (Mintz and Jr, 2010). Similar, linking international ETs is an environmental foreign policy decision making reflecting that one national or regional actions on addressing the global climate change on the international stage with other national or regional actors.

Environmental foreign policy is conceived interplay between domestic environmental decision making in policies and international forces (Harris, 2007). In order to deliver environmental policies, the environmental foreign policy action is required from different level of agency and actors to participate (Grubb et al, 2014; Marsden et al, 2014). From the policy perspective, the crossover and interaction between domestic and international actors including forces shaping environmental policies and determining whether the countries cooperate to address global climate change (Harris, 2007). In the literature, it stated that the multi-level institutions and actors have different motivations and perspectives, which could address different drivers for long-term decision making in climate policies (Roelich and Gieseckam, 2019). These interactions reflect in the term of 'multi-level governance' system in climate policy that the continuous negotiations among several territorial tiers to reach the outcome of decision-making (Marsden et al, 2014). Thus, identifying and aligning the diversity interaction of actors could improve decision-making approach to build momentum of climate change mitigation (Roelich and Gieseckam, 2019).

The approach to understand why the regional or national behaviours in international environmental cooperation in environmental foreign policy theory is through Foreign policy analysis (FPA) (Harris, 2007). In the literature (Below A, 2014), it applied foreign policy analysis on Kyoto Protocol to investigate why different countries had different decisions in assigning or ratifying this international environmental agreement. Scholars reviewed different decision-making models in FPA that could provide detailed understanding pathway for the particular environmental policy at international level (Mintz and Jr, 2010; Below A, 2014).

In the literature, there exists several of decision models to analysis the foreign policies, in which are categorized into rational and cognitive schools (Simon H, 1985).

The rational actor model is a traditional theory in the rational school to review the international relations (Mearsheimer, 1995). Scholar argues the foreign policy analysis should proceed with rational decision-making model that the actors try to compare the costs and benefits of several alternative options of policies and choose one maximum the utility (MacDonald P, 2003). However, the rational decision-making model has commonly overshadowed for the foreign policy analysis because it suffers stronger assumption that the decision is chosen only depends on Pareto efficiency achievement (Weimer D L, 2008).

The cognitive schools of theories in the foreign policy analysis have emerged the psychology factors of groups, coalitions and leaders in the decision-making procedure and it introduced bounded rationality and the cybernetic model, bureaucratic politics, organizational politics, and prospect theory (Mintz, 2007). The cognitive schools of theories argued that the decision makers try to balance between the benefits of better decision-making and the deliberation costs of the decision (Smith and Walker, 1993). As acquired the full information is costly, the policymakers made the decisions by heuristic shortcut by their previous experience (Conlisk J, 1996).

Herber Simon (1985) argued that the homo economics refers to rational school and homo psychologist refers to cognitive school. To analysis the environmental foreign policy in linking ETSs, the rational actor model limited in strong assumptions that the actors' pure goal-oriented regardless of costly information and national preference. In contrast, the bounded rationality oversimplified the decision-making procedure by heuristic choice and the process of information selection by policymakers is difficult to observe (Lau and Redlawsk, 2001). Thus, a poliheristic decision model is introduced (Mintz et al, 1997). Comparing with rational actor model and cognitive models, the poliheuristic decision model combined rational and cognitive to analysis foreign policies as a bridge (Mintz et al, 1997).

For this linkage study, the poliheristic decision model is better to apply for analysing international carbon market cooperation. First, the poliheristic decision model for foreign policy analysis contains two stages wherein the policymakers first eliminating politically

unacceptable alternatives (Dacey and Carlson, 2004). This heuristic process could better explain policymakers directly reject the foreign policies when consider noncompensatory political loss aversion such as intra-party rivalry and competition or paramount of security matters for a nation (Mintz and Geva, 1997). This political demission consideration could reflect in the linkage literature that the benefits and costs in aspect of political factor influence significantly for the decision-making procedure. For example, the intra-party rivalry and competition appeared in election over ETS in Australia triggered failure of linkage with EU ETS. In 2011, the Australian government passed the Clean Energy Act and proposed linkage with EU ETS in 2012 (IETA, 2013). However, the Australia's Opposition Leader Tony Abbott has made unequivocal promised to repeal the Act before the election, which resulted in quickly postponed linkage with EU ETS after he became the Prime Minister in 2013 (Teeter and Sandberg, 2017).

Second, the poliheristic decision model also employs a traditional rationale decision procedure based on cost-benefit analysis in maximum the utility and minimum the risks to select from the remaining alternatives (Mintz, 1993). This procedure could provide a traditional tool for studying how the value trade-offs refer to economic, political and regulation dimension drive the decision in linkage ETS as a foreign policy.

However, the cost-benefit analysis in the second stage of poliheristic decision model has its own limitations. The literature argued that costs and benefits could not accurately quantify (Mintz and Derouen, 2006). In the literature, linking ETSs is seen as a leverage to achieve unanticipated benefits, not just cost reductions. For example, the additional benefits include transforming environment as common good into a private good with rights and the public good with free-ride problem into an attractive club good to compliance mitigation targets (Richard Benwell, 2008).

Furthermore, to reach the decision-making, is also influenced by the multi-level governance system with interactions between different tiers of actors, which stated before. The interactions from domestic and international forces also reflected in the considerations of the poliheristic decision model.

Thus, in order to understand the linkage ETSs, as cooperation in environmental foreign policy between two carbon jurisdictions, the study is to integrate multi-level governance theory

and poliheristic decision model in FPA for in-depth explanations of how and why decisions are made by policy makers. The integration of two theories illustrated in the chart one as following.

The integration of the two theories to analysis linkage ETs has two benefits. First, the poliheristic decision model provides both rational actor model and cybernetic approach by considering human psychological factors (Alex, 2004). It could generate the noncompensatory conditions for linkage and systematic categorize the factors in economics, politics and regulations in the literature based on cost-benefit analysis with further exploration in unquantified factors. Second, integration of the two theories could both investigate the policy decision process by multi-level governance framework with interactions between actors and provide the explanations of outcome of decisions for how and why made by policy makers to link ETs.

Chart 2-1: Theoretical framework for FPA in linkage decision-making

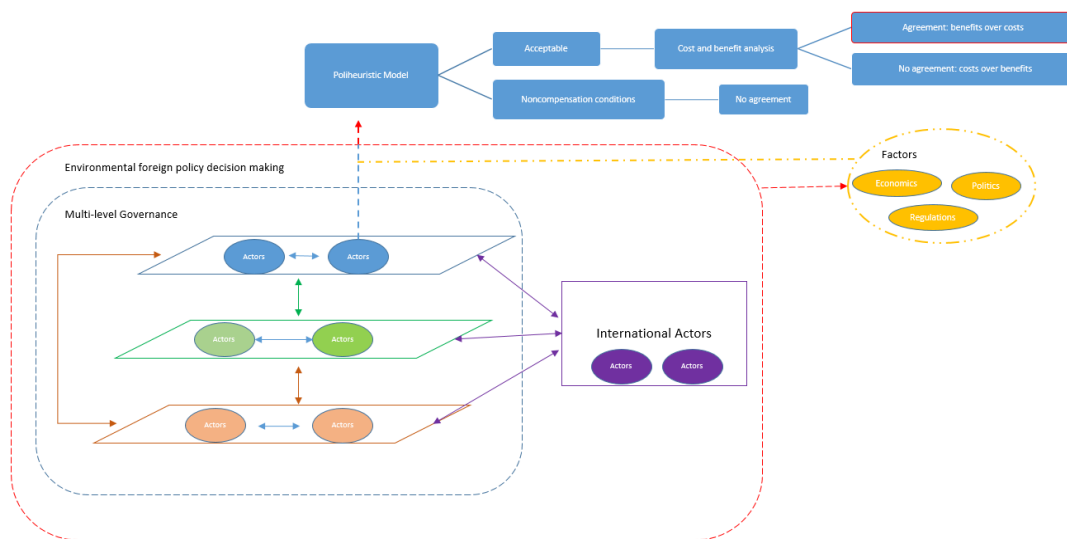


Chart drew by writer

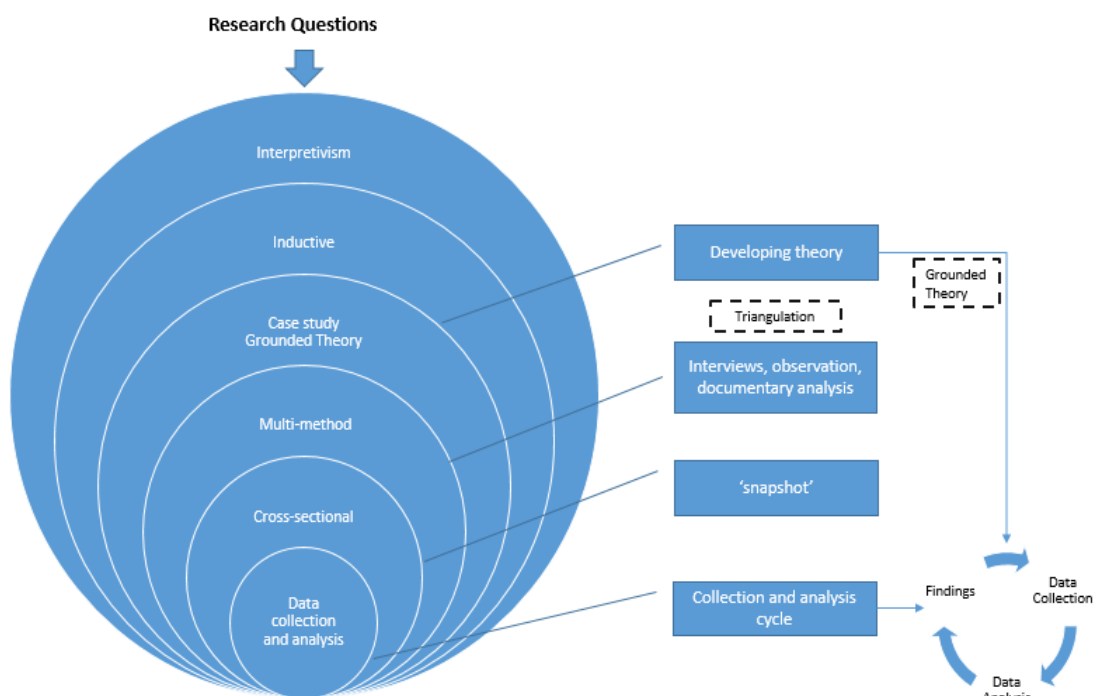
2.3 Methodology

2.3.1 Research strategy: interpretivism approach

Methodology is an approach to studying social phenomena, which contains a complete process from a research approach to choices of methods to use for technical data collection and analysing (Corbin and Strauss, 2012). Before conduct studies, the examination of research philosophy is fundamental to understanding the development and nature of

knowledge (Saunders et al, 2009). The different research philosophies embedded with different assumptions underpin the research strategy and design (Johnson and Clark, 2006). Corbin and Strauss (2012) suggested this procedure is like “onion” with six layers, which is shown in Figure 2-1 gradually from outside “research questions” to inside “data collection and analysis” step by step. The research questions are fundamental for the research structure. There exists a debate whether choices of research rely on either positivist or interpretivist research philosophy (Corbin and Strauss, 2012).

Chart 2-2: Methodology process



Deduction in positivist approach involves developing theory by constructing hypothesis and is subjective to a rigorous test, while inductive approach is for better understanding better the nature of a problem, particularly in the context in which such events were taking place (Easterby-Smith et al, 2008). Choosing a methodology over positivist or interpretivist approach strongly linked to the desired outcome of the study with the research questions (Mills, 2014). According to this study, the nature of the research questions aims to understand the phenomenon in linking ETSs occurred in the international cooperation of environmental policies and provide further in-depth explanations. According to the choices of methodologies, asking ‘why something is happening’ is more appropriate to undertaking the research inductively under interpretivist (Guba and Lincoln, 1994).

2.3.2 Research strategy: grounded theory and case study

In the *“Handbook of Qualitative Research”*, it concludes seven methodologies in interpretivism approach along with the desirable outcomes, which showed in table 2-3 as bellow (Lincoln et al, 2011).

Table 2-2 Choices of Methodologies in Interpretivism Approach

Qualitative Methodology	Outcome
Ethnography	Knowledge of Culture
Grounded theory	Knowledge of Process and Outcome
Historical research	Knowledge of History
Case study	Situated Knowledge
Phenomenology	Knowledge of Lived Experience
Action research	Knowledge of Process, Outcome and Change

Reference: Handbook of Qualitative Research, Lincoln et al, 2011

In this section, it explains why grounded theory and case study were chosen to substantively guide the research among these seven methodologies.

As this study is to explore how and why two carbon jurisdictions decided to link ETSs in the decision-making procedure, it is to seek gaining the knowledge of process and outcome. Based on the table 2-3 showed above (Lincoln et al, 2011), the suitable choices of qualitative methodologies are grounded theory, case study and action research.

Comparing with these three methodologies, action research is distinguished from other methodologies by characteristics in its action oriented (Lincoln et al, 2011). The action involvement intended to produce research-informed change to live issues, which also include changed the participants in the research as well (Reason and Bradbury, 2008). The research contains iterative in planning, action and review after the action took place (Torbert, 1999). The action research is not suitable for this study as the underpinnings of the research questions do not intend to compare the changes of practitioners for the live situation during the research with any experiment actions took.

Grounded theory is appropriately employed in the study that there is little known about an interested phenomenon (Glaser and Strauss, 1967). A defining characteristic of grounded theory is that it aims to develop theory grounded in data (Corbin, 1994). Briefly, the grounded theory is inductively generating theory from data as explanatory scheme comprising a set of concepts related to each other through logical patterns of connectivity with iterative process in data collection and data analysis (Mills et al, 2014).

Reviewing the methodology in case study, it is defined as an intensive study and developmental factors of an individual unit of interest (Stake, 1995). The case study is focus on an exploratory form with providing an in-depth knowledge of process of that unit. By the definition of case study, qualitative research is usually used in cases where suitable for in-depth study of a phenomenon required (Mills et al, 2014). Thus, the methodology of case study is appropriate for the purpose of answering questions about 'how' and 'why' for a phenomenon occurred (Yin, 2003).

The choice of methodologies for the research is depend on the research questions and objectives, and not as being mutually exclusive (Saunders et al, 2005). To this study, the grounded theory research strategy is applied as part of a case study.

First, this research is an explanatory research answering the questions about 'how' and 'why' linkage ETSs occurred, it is suitable for applying the case study to explore a process of cooperation in ETSs for further in-depth explanations in the decision-making procedure. Hartley (2004 p.325) indicated the case studies are particularly useful in exploring new processes and behaviours and the case study could provide in-depth understanding for investigation of a contemporary phenomenon (Yin, 2009). Case studies are also applied in the literature (Rasons and Stavins, 2013; Flachslan et al, 2009) to identify the factors that potential influencing for the decision-making.

Second, the research aims to identify the pathway for the policy decision-making in linkage ETSs. It is required to understand the behaviours of groups of stakeholders with the interactions. For this purpose, grounded theory is particularly helpful for explaining and predicting actors' behaviours upon developing theory, especially for the area with limited

literature (Goulding, 2002). It is practical for linkage study as the linkage research has been increased only after the Kyoto Protocol agreement.

Grounded theory is a methodology with a systematic procedure to follow in the data analysis of categorising data with outline general terms (Strauss and Corbin, 2008). The procedure of guide advocated by grounded theory is only focusing on core or central theme that could emerge from data (Sanders et al, 2005). It is particularly a better methodology to link data with the final theory building, avoiding rigorous to substantiate the explanation seeking to advance and it is better investigating the interactions between stakeholders for this research.

Third, Fernandez et al (2002) stated that grounded theory and case studies can be applied as a combination for the research because the grounded theory is consistent with interpretive case study to investigate social or organization context (Hughes and Jones, 2003). The literature (Halaweh et al, 2008) also argued the case is to understand the content while grounded theory provides procedures of data coding, comparing, categorizing and saturating with a positivist attitude. Thus, for this study, it applied the case as an illustrator to in-depth exploring the linkage decision-making, with a systematic methodology procedure from data coding to analysis based on grounded theory methodology.

2.3.3 Research design: method and data

This section details the qualitative research methods used including open interviews, semi-structured interviews, observations and documentary analysis. The ethical is consideration during the data collection and the ethical approvals granted in the beginning of the study.

The qualitative methods have advantages in accessing a range of stakeholders (Huff, 2009) and benefits to understand the complex phenomenon because it could identify the interactions between people involved (Cresswell, 2007). In the literature, it identified qualitative methods in questionnaires, surveys, interviews, observations and contextual inquiries (Saunders et al, 2000).

Comparing with the single method of data collection, the multi-methods of data collections are useful as they allow the researcher to better evaluate that findings are trustable and inferences made from the data (Tashakkori and Teddlie, 2003). Moreover, the benefits from multi-methods for qualitative research could be used for different purposes in a study and

confidence in addressing the most important issues (Saunders et al, 2005). In this research, the methods of data-collections are semi-structure interview, observation and documentary analysis. The multi-methods of data collections first advantage for triangulation, which is used to strengthen the validate findings from two or more independent sources of data (Burg, 2000). Second the multi-methods of data collections could solve a puzzle found in the initial method for unexplainable results.

Within the main study, the semi-structured interviews were the predominant in one of the three methods for data collection and generating findings to answer the research questions. The methodologies in case study and grounded theory are applied dominant method by semi-structured interviews because it is helpful to reveal and understand the 'how' but also focusing on answering the 'why' research questions (Robson, 2002; Easterby-Smith et al, 2008). Meanwhile, interviewees are viewed as active roles with the interviewers in constructing meanings that allow researcher and interviewees to develop unexpected themes (Mason, 2002). This active roles in the semi-structured interviews is suitable to detect detailed reflections of linkage from different stakeholders with flexible following up questions depend on the previous answers. Thus, in the study, the method of semi-structured interviews is appropriate to use for investigating the different perspectives of actors in the linkage decision-making procedure.

Observations is the second method applied for this study. Silverman (2013) advised it is crucial not what you hear but what you can see. The ways of stakeholders' behaviours could address the nagging problem and imposing the interpretation upon the data (Miles and Huberman, 1984). The role of the observational method used in this study contributes to data collection and data analysis. This was particularly for the events that helped to identify the groups of stakeholders and different attitudes of stakeholders at the initial stage in the research process. The observations of stakeholders assisted in developing and understanding the linkage case, and the data analysis from the observations could be used to contextualise of findings emerged during the interviews.

Data collection from documents is the third method for analysis in this study. Document analysis has advantage because the data from documents is permanent form reliable that can be reanalysis (Robson, 1993). More importantly, the data collection from documents

could provide the interpretations that can be placed on the results. Understanding the nature and original purpose of records could reference to data quality, consistency, and completeness (Hakim, 1994). In this study, the data collected from the documents from two sources: governmental archives for linkage decision-making, the research reports published by interviewees' institutions for linking or collaboration international ETSS¹¹. The data from the documents is additional source of evidence that seeks to convergence along with data sources in semi-structured interviews and observations. Also, it is effective to reduce the bias when corroborating findings across data sets based on triangulation validity against the accusation (Bowen, 2009).

The methods of data collections in questionnaires and surveys are widely designed the same set of questions collecting the responses from a large sample of stakeholders (Dillman, 2007). Questionnaires and surveys are widely applicable with quantitative analysis while are very caution applying in qualitative analysis as following reasons. First, the questionnaires and surveys are difficult to tailor designed for each stakeholder with interactions or further following questions to detect interesting context (Bell, 2005). Scholars (Oppenheim, 2000; Saunders et al, 2005) argued it is far harder to produce a good questionnaire with precise answers researchers would like to receive from participants, especially it is unlikely to go back to those participants for further declarations in the qualitative research. Second, the answers provided from questionnaires and surveys should be selected carefully because the answers would remain anonymous and it is required researchers to collect additional data using another questionnaires or surveys designed (Dillman, 2007). Third, Robson (2002) argued the method of questionnaires or surveys is required researchers obtain enough information prior, which indicates they are not particularly good for exploratory or researches requiring to investigate interactions with large open-ended questions. The nature of research questions for this study, aim to explore the linkage decision-making based on the different perspectives from different stakeholders. The questionnaires or surveys could not capture the details with exploration for this study. Thus, the methods of questionnaires and surveys are not suitable for this study.

Content analysis is a method for studying the meaning contained in the body of a message and the data collection approaching is to measure the frequency of topics or words counts

¹¹ The list of documents used in this study showed in Appendix

in the contents. The root of content analysis is in a quantitative approach, commonly using and analyzing in mass media, for example, the newspapers (Kirsty, 2018, p453). The preference of content analysis is a method prior designing for a purposed hypothesis testing with strict rules for investigation in statistics analysis (Berelson, 1952, p18). This linkage study is not testing the hypothesis setting prior the data collection and analysis. Thus, content analysis is not appropriate applying for this research.

2.3.4 Ethical considerations and approval

Throughout the research design, the ethical issues were a fundamental consideration of the study. For this study, the ethical research framework is ensuring to inform the interviewees that their participations are voluntary. Another ethical consideration is avoiding any harms towards the participants in this study. According to this regards, degree of confidentiality must be approved and guaranteed to participating individuals that the contents could be disclosed or not. The interviewees may not want their perspectives to be identified by senior level managers. The ethical procedures were monitored strictly within University of Edinburgh and the governments where research was carried out. The research was defined as 'level two' based on the university's ethical procedures for research. Thus, prior the interviewed individuals, the purpose of interviews together with a consent form were sent to the interviewees. In this study, the table 2-4 showed the information of stakeholders and institutions involved in this study based on different degrees of confidential that agreed with interviewees in advance.

2.4 Empirical study design

2.4.1 Overview

The previous section considered appropriate research design in methodologies and methods for the study. This section illustrates how etic issues (Stake, 1995) and operationalised empirical study to answer the research questions from the literature review.

2.4.2 Empirical case descriptions

The number of cases chosen for a qualitative research has no conclusion because it strongly depends on what the case is and how it is chosen for the study (Flyvbjerg, 2006). The objective selection of case is to achieve the greatest information on a given phenomenon for maximum understanding-oriented not the maximum number of random cases to study (Flyvbjerg, 2006).

For this study, the case aims to explain the linkage decision-making with in-depth explanations from stakeholders' perspectives. Thus, the case embedded for this study is required to provide deeper causes of a given linkage phenomenon. Comparing to multiple cases identifying the frequencies of the phenomenon, the extreme or deviant single case is more appropriate for generating maximum the utility of information contents for an in-depth study (Flyvbjerg, 2006).

For this study, a purposively single case was chosen because it could allow in-depth analysis from the different perspectives of stakeholders. Although literatures (Burtraw et al, 2013; Rasons and Stavins, 2015) studied existing linkage theories locale within the European countries or California and Quebec, this research took the EU and China case as it is unique to study for the following reasons.

First, the ETS in China cooperating with EU ETS is not like linking the ETSs within the EU area, which has stronger historical cooperation in politics and economics already. For example, Norway has stronger economic relationship with EU as one of the members of EEA-EFTA and they already have some compatibility regulations in economics before emission trading system linkage. Linking with EU is a significant element to keep developing Norway GDP growth and prevent domestic industries for distortion competitiveness with other industries in EU (EDF, 2015).

Second, EU ETS and carbon markets developed in China were designed independently, unlike California ETS and Quebec ETS are developing under a Western Climate Initiative sharing with the common guidelines and aiming for collaboration with regional carbon markets for combating climate change prior linkage (Air Resources Board, 2013).

The case of China and the EU could be viewed as typical case with characteristics that could provide enough insights for understanding the linkage decision-making procedures and the findings could generalize hints for common across the cooperation in emission trading systems in the world.

2.4.3 Data sampling

Given the literature review in the multi-level governance framework in the climate policy decision-making procedure, this study is required to conduct a multi-level approaches for the different groups of stakeholders. It is also important to note that the EU and China have different procedures in the decision-making for climate policies. Thus, this section shows the methods of sampling data for this empirical case and identifying different levels of stakeholders in the samples of the EU and China.

2.4.3.1 Methods of sampling

There are two types of sampling. First is the probability sampling for quantitative research, which the selection sample represent for larger population. The other one is non-probability samples, which is for the inductive research (Burg, 2000).

There are four common types of non-probability sampling methods, which are convenience sampling, purposive sampling, snowball sampling and quota sampling (Burg, 2000). The convenience sample is referred to availability sample, which indicates the category of the samples are depend on who are easily accessible. While purposive sampling is based on researcher's own special or expertise to select representing the population. The quota sampling is to create own matrix or table with cells and fill in the category based on the study focus by using such as gender, age characteristics (Burg, 2000). Comparing to the other three types of non-probability sampling methods, this chapter is applied for a snowball sampling. Unlike convenience or quota samplings, the snowball sampling is selecting the stakeholders based on the identifications of criteria such as involving in the linkage decision procedure or expertise in the linking carbon markets. Only relevant and active involving in the linkage decision-making representative stakeholders are selected for the research purpose. The research subjects are asked for the names of other people who will possess the same attitudes as they do (Burg, 2000).

Snowball sampling is a nonprobability sampling strategy and it is usually described as the best and convenience way to locate subject with certain characteristics necessary in a study. This sampling method is also frequently used when researcher adopts grounded theory (Saunders et al, 2009). In this research, the subgroups of stakeholders are already recognized in the literature. The classifications in literature are based on which the groups of

stakeholders could influence in the climate policy decision-making. The detailed information is showed in below.

2.4.3.2 Identification groups of stakeholders

The approaches to identify EU and China stakeholders are based on different procedures. The carbon market design and operations are different in multi-level governance for both the EU and China. For the EU, a snowball sampling is first developed by attending EU ETS or ETS linkage-relevant events in Brussels¹² to identify stakeholders who are actively participating in ETS climate policy decision-making processes or have powers to engage with and influencing EU Commission regulators. This approach ensured the research sample could be representative of other stakeholders who engage in ETS design issues. For China, the initial decision in the identification of stakeholders is based on preconceived theoretical framework. The research begins with a partial framework of ‘policy decision procedure’ concepts in different subgroups of multi-level governance in the environmental policy decision-making procedure. The selection stakeholder procedure approach also reflects the reasons why the groups or subgroups were chosen for multiple comparisons.

The subgroups of stakeholders in both EU and China recognized in the literature are all considering climate policy issue is important but the levels of the consideration for the priority of climate change aspects are different. Although the subgroups of stakeholders have different levels of political powers, in this research, the different levels of political powers are not considered. This is because both China and EU policy decision-making procedures involve mix of top-down and bottom-up procedures. All the different levels’ stakeholders could influence the decision making. In the following contents show detailed explanations for the subgroups of stakeholders chosen in EU and China.

2.4.3.3 Key informants of EU Stakeholders

Attending ETS relevant events in Brussels pointed to approaching stakeholders from academia, ENGO or EU institutions who advocate or are actively involved in lobbying climate

¹² Three events attended:

‘The Missing Link: What future for other carbon markets joining EU ETS’ event in Brussels

‘2018 State of EU ETS report’ event in Brussels

‘Developing the EU Long Term Climate Strategy’ event in Brussels

policy decision-making procedure in EU Commission and Parliament. All events held by EU institutions or ENGOs invited the EU Commission to comment at the end and pages of policy recommendation reports were generated afterwards. Stakeholders, especially analysts in EU policy or ETS design, were selected for contacting for this research.

Non-national actors play important roles in environmental legislation and linkage decision-making procedure. EU institutions could provide covered entities with knowledge, support or commercial opportunities for introducing emission trading systems (Skjarseth and Skodvin, 2003). In the policy decision making procedure in EU, it appears some activities of representatives trying to influence the legislative authorities through public relations work (Skjarseth and Wettestad, 2008). The approach of representatives' objectives of influencing the decision making in European institutions, is called lobbying (Skjarseth and Wettestad, 2008). The non-state actors such as industries and green organizations have shown lobbying to vary degrees in all phases of EU policymaking (Andersen and Eliassen, 2001). Non-state actors' supportive and converging positions evolve in the EU ETS for international carbon market linkage.

- *Environmental Non-Governmental Organization*

The emergence of ENGOs in Brussels has been an increasing influence on EU institutions' environmental legislation and policymaking. They provide expert political, legal and technical advice to EU institutions and decision makers for raising awareness of environmental problems, integrating and strengthening environmental contents across sectors. ENGOs, as priority institutions in EU, are able to provide efficient input into EU policies. Because ENGOs represent EU public interest on citizens' behalf to EU decision makers, especially in the European Commission, European Parliament and Council of Ministers and inform the public about the EU initiative of environmental legislations. Meanwhile, the ENGOs have ability to increase influence the legitimacy of specific political proposal by regular meetings about EU agenda with policy-makers in several countries. For example, the urging of Climate Network Europe (CNE) forced the EU into entering into the Kyoto Protocol and promoted reducing GHGs in 2002 (G8, 2008). The ENGOs have been taken for seriously because they are acting as monitors for member states, help the DG in the EU Commission. Without ENGOs' participation, the EU environmental legislation is far less effective (Skjarseth and Wettestad, 2008).

- EU institutions

The EU institutions include a higher-level of direct governance of climate policy, which involves the Commission, Council and Parliament. This depends on the EU standard decision-making procedure, which is called 'ordinary legislative procedure'. The EU decision-making procedure reflects the harmonization between different degrees of member states and community institutions (Skjarseth and Wettestad, 2008). Since the 1993 Amsterdam Treaty introduced a co-decision procedure, the role of the EU Parliament was increasingly crucial as co-legislator with the Council.

A proposal from the Commission passes to the EP and Council for a first reading. If both Council and EP do not agree on the first reading, then the second reading will take place in Parliament. The Commission needs to explain positions to the EP to seek assistance with EP amendments (Skjarseth and Wettestad, 2008). If the amendments are rejected by Commission, the only situation that EP can accept it is that an absolute majority of its complement members supported for the amendments (Nugent, 1999).

However, if we assume the Commission proposes ETSs independently, the Commission have different ways of influencing the decision-making process with external experts, which is requires by Council of Ministers (Nugent, 1999). The EP and the Council need to carry out no more than three readings for the ET Directive and if both approve the text, the establishment of a carbon market is to be law. The EP has been depicted as the greenest EU institution with a large environmental committee (Wurzel 2002, 70). A complex, formal decision-making phase, which detailed in Appendix I, includes drafting EU law, the review and adoption by the EP and the Council and external stakeholders. Carbon market legislature is the result of inter-institutional bargaining between EU institutions and stakeholders.

- International regimes

International regimes provide opportunities and learning experiences for global carbon markets and puts pressure on mitigation target achievement (Skjarseth and Wettestad, 2008). This pressure influences policy diffusion and increases the government willingness to implement innovative policy instruments, such as emission trading systems (Oberthur and Tanzler, 2007). In context of international organisation, non-binding guidelines can facilitate the development of certain policies and enhance legitimacy (Bush et al, 2006). For example,

the UNFCCC as an international institution influences the EU ETS to accept the Kyoto Protocol in coordination of activities in Clean Development Mechanism (CDM) and Joint Implementation (JI) (Skjarseth and Wettestad, 2008). International institutions affect carbon market policy diffusion based on the principles of precautionary actions or globally held workshops, seminars to make countries aware of the cost and benefits flowing from different policy options. World Bank, for example, launched a partnership for market readiness (PMR) programme, funded since 2011. Currently, there are 35 countries participating in programmes to implement or establish their own emission trading mechanisms. Meanwhile, the World Bank holds forums in various forms, including meetings, workshops, public technical notes or guidance documents online to support carbon pricing instrument innovation (World Bank, 2017). These forums are for countries to share experiences and knowledge for the further exchange and preparation for coordination in ETSs in the future.

The Appendix I shows the policy making-decision procedure in EU. Table 2-3 summarized the propositions of different subgroups of stakeholders that involved in the climate policy decision-making procedure.

Table 2-3: Propositions of multi-level stakeholders in linkage decision making in the EU

<i>Levels</i>		Role in EU ETS	Role in linkage decision-making process
Non-state actors		No right to initiate or veto legislative proposal ¹³ however reflect development converging and supportive/opposed to linkage emission trading systems and shows the preferences	Lobbying integrated in policy-making process ¹⁴ . Indirect structural influences in economic growth ¹⁵ and direct instrumental influences based on administrative, scientific and financial resources ¹⁶ .
	Member state	Majority members in Council could decide whether to initiate linkage and start negotiations; Commission acted request from member states and estimated broadly supported ¹	Member states in Council and Parliament could show ETS as a preference/interest option ¹⁷ . Decentralised ETS allocation method to different NAPs (national allocation plans), depending on varying national emission reduction ambitions ⁴ .
EU institutions	<i>Commission</i>	DG in Commission initiates linkage ETS to legislation	Pushes the integration and harmonization of environmental ambitions between Council and Parliament ¹⁸ Set centralised EU ETS designs, regulations and EU level reduction target.
	<i>Council</i>	Council raised proposal presented majority member states preferences of emission trading; Chair of Council supported for initiative	Qualified majority of Council of Ministers approved ET Directive, a result of intergovernmental bargaining with Parliament. Decentralised policy delivery system to member states for implementation.
	<i>Parliament</i>		Co-decision with Council to approve ET Directive, along with carbon market design amendments. Decentralised emission allowances into member state level.
International regime		Pressure, opportunities and learning from international climate regime accelerates EU ETS initiative, e.g. UNFCCC and Kyoto Protocol ¹⁹ .	External effected for EU ETS decision-making on altering cost and benefits of available design options ⁸ EU ETS coordinates with international rules and procedures, e.g. ET Directive linking with CDM and JI.

¹³ Grant et al, 2000. *The effectiveness of European Union Environmental Policy*, London Macmillian Press.

¹⁴ Andersen and Eliassen, 2001. *Making Policy in Europe*, London Sage Publications.

¹⁵ Newell. P. N, 2000. *Climate for Change: Non-state Actors and the Global Politics of the Greenhouse*. Cambridge University Press.

¹⁶ Skjarseth, 2004. *International Regimes and Norway's Environmental Policy: Crossfire and Coherence*. Aldershot, UK: Ashgate.

¹⁷ Henrik Selin, 2015. *EU Environmental Policy Making and Implementation: Changing Processes and Mixed Outcomes*. Annual Review of Environment and Resources.

¹⁸ Jon Birger Skjarseth and Jorgen Wettestad, 2015. *EU Emissions Trading Initiation, Decision-making and Implementation*. UK: Ashgate.

¹⁹ Skodvin, T. and Andresen, S. 2006. 'Leadership Revisited', *Global Environmental Politics* 6:3, 13-27.

2.4.3.4 Key informants of Chinese stakeholders

China's climate policy is formulated by inside and outside stakeholders, with a consensus led by a dominant governmental agency. However, the expert organizations such as Chinese top universities or institutions could also influence the policy decision-making by providing reports in evaluation policies options or economics positions for the government (Hart et al, 2014).

The development of climate policies in China is governed at different levels, which involve both state and provincial authorities (Tsang and Kolk, 2010). On 21st March, the Central Committee of the Communist Party of China announced the 'Deepening Reform Program for the Party and State Institutions'. Climate change, mitigation and adaptation duties from the NDRC transferred to the newly constructed Ministry of Ecology and Environment (MEE) of the People's Republic of China (The Central Government of China, 2018).

The Appendix II shows the multi-levels of the administrative structure in Chinese climate policy decision-making procedure. The inter-links in different levels of governance refer to vertical and horizontal relationships (Tsang and Kolk, 2010). The climate policy decisions from the highest levels of the ministries of central government reach down to various levels below, to local sectors like covered entities or provincial institutions like environmental exchange platforms. The horizontal level indicates the different authorities are in the same level of jurisdictions but have different duties coverages and functions. The vertical level indicates different levels of jurisdictions. There exists interactions in this complex structure. First, the policy decision-making is basically from top to bottom for practices. However, the bottom level such as provincial level also provides suggestions for policies in monitoring and implementation to the top level (MacBeath, 2007). This web of different responsibilities over governance left much room for political interference and dealing with conflicts of divergent perspectives.

The national/pilot's carbon market, previously established by the National Development and Reform Committee (NDRC), was determined by a complex number of factors, such as policy recommendation aspects from expert organizations with technical expertise (Tsang and Kolk, 2010). The inter-links and interactions of a multi-level governance structure partly

determined policy decisions. Foreign organizations, such as World Bank and ADB²⁰, and domestic NGOs are not considered in the scope of study, as they have limited political power over the Chinese carbon market's policy formation process.

Increasingly, scientific information and professional knowledge is becoming crucial for climate policy in China. The experts in different institutions act as think tank for governmental and international research projects in carbon market. For example, the Expert Panel was selected for an international conference, writing up an IPCC report and attending as a delegation supporting environmental negotiation (Ksenia Chmutina, 2010). On average, one third of the delegation team in previous COPs were representative of the expert community (Hart et al, 2014). The Expert Panel is financed by state budget and contains participants from different sectors, including the academia area of top universities and research institutions, provincial institutions such as industry and environmental exchanges. The Expert Panel still provides the supportive developing climate change policy advices to the state of Council and MEE instead of NDRC.

Political leaders frequently consult with this expert community on research topics and draw their substantive conclusions (Jost Wubbeke, 2013). The open academic discussions forums held by expert organizations invite officers working in relevant departments or even from government for suggestions. The panel largely engages in primary national market design and GHG inventory and participates as an advisory committee for international environmental negotiations specializing in climate change in the UNFCCC. There is a positive interaction between the experts' knowledge and political values (Jost Wubbeke, 2013). The Expert Panel was a main resource for the NDRC when shaping policies and testing under different scenarios (Hart et al, 2014).

2.4.5 Data collection

A combination of multiple data collection is typical for theory building for an inductive research process. Diverse data sources support the triangulation of robust analysis and provides strong constructs of hypothesis tests (Eisenhardt, 1989). The triangulation methods in data collection is crucial for the issue of validity (Burg, 2000). Literatures indicate, more than two methods of data collection refer to the triangulation, which are used to investigate

²⁰ ADB-Asian Development Bank

the same phenomenon and it is viewed as a mutual confirmation of measures and validation of the findings (Flick, 1983; Fnafl and Breitmayer, 1989; Leedy, 1993; Burg, 2000). The data collection is categorized into primary data collection and secondary data collection. For the inductive research, it focuses on the primary data collection to develop the theory. In the literature, there are six methods applied for the data collection, which are interviews, questionnaires and surveys, observations, focus groups, ethnographies, and documents and records (Saunders et al, 2005). Meanwhile, the methods chosen for data collection are embedded in the research design, which is required for the criteria in whether the data is accessible and targeting for sufficient information to answer the research questions (Burg, 2000). In this chapter, it conducted three data collection methods, which the interview is a major collection method available for large number of information and observation and document analysis are additional two data sources for verification of findings.

Literature reveals different carbon market linkages in the cost-effective aspect of economics (Flachsland et al, 2009) and reports the analysis of barriers of linking carbon markets, based on projects taken (Ranson and Stavins, 2013). Although this research speculates about advantages and obstacles for linking, these conclusions are based on technical analysis. Stakeholders' views for linking between different ETSs are unknown, especially whether or not the linkage decision is influenced by multi-level stakeholders. The following range of methods are applied in this chapter for developing linking methodology and data triangulation.

2.4.5.1 Open interviews

The initial open interviews from ETS stakeholders provide wider information for carbon market design views and insights into potential global ETS prospects. This drafts an outline for subgroups' indicative interviews, along with literature reviews later.

2.4.5.2 Semi-structured interviews

Inductive interviews determine how stakeholders' perspectives for compatible EU ETSs and China ETSs and which international cooperation theory is appropriate. The semi-structured interviews are based on a general list of topics shown in Appendix III, which are common to stakeholders and cover areas of prospect about different jurisdictions' carbon market linking.

Each topic has open questions to more easily explore stakeholders' views not addressed by interviewer.

2.4.5.3 Observations

Observation is one of the methods in data collection for triangulation applied in grounded theory. The participant observation emphasis is on discovering the meanings of those stakeholders' actions for international climate policies in ETS cooperation. When stakeholders negotiate with each other, the process of interactions and communications that tends to share a sense of order is called symbolic interactionism (Saunders et al, 2009). In the observation role, we purely act as the observer. For example, in the workshop held by Carbon Watch 'Missing linkage in the EU?', the observation data came from the presentations, statements, and discussions with perspectives from the workshops. Primary observation took place while attending the workshops for international ETS collaboration in the EU and China, without revealing the purpose of the activity, making a note of who said what at the time. The list of workshops attended for the observations showed in Appendix III.

2.4.5.4 Document analysis

Additional documented information from participants, either from public reports (published online) or provided directly by events held by institutions (documents from workshops, etc.) enabled a data triangulation after the interviews and questionnaires. This created insights to further investigate what the attitudes of participants for ETS and ETS international linkage. Addition, the documentation also revealed how they represented their positions for international linkage of ETS. Table 2-4 shows the brief information for stakeholders who participated in the interviews for this research.

Table 2-4. Stakeholders participating in the interviews

Sectors	Name and Position	Number of Interviews	Subgroup of stakeholders
<i>EU Commission</i>	EU ETS reform (confidential)	1	Government
<i>European Parliament</i>	EU ETS implementation (confidential)	1	
<i>University</i>	Sun Yat-sen University, Guangdong, China Dr WeiChi, Li Director in the Climate Centre at Sun Yat-sen University Professor XueLan Zeng Director in Guangdong ETS carbon market design	2	Academia
	Central University of Finance and Economics, China Professor Yao Wang Director at Centre of Green Finance Dr Bo Chen Lecturer at Centre of Green Finance	2	
<i>Research Institutions</i>	National Centre for Climate Change Strategy and International Cooperation HaiYan Liu Associate director in NCCC and director in CDM development	2	
	NE Nomisma Energia Matteo Mazzoni Director	1	
	I4CE Charlotte Vailles Project manager in industry, energy, climate	1	
	IETA Associate director in energy market	1	
	ERCST Andrei Marcu Director	1	
	Bruegel Dr. Georg Zachmann Senior fellow	1	
	Sandbag	1	

	Patricia Buckley Carbon and energy data management		
<i>Covered Entities</i>	Scottish Power (confidential)	1	Industry
<i>China Emissions Exchange (CEEX)</i>	CEEX, Guangdong Ji Bao Senior fellow in ETS design Yuan Li Research fellow in ETS operation Meng Meng Director	3	Think Tank and E-NGO
	Shanghai Environment and Energy Exchange Dong Zhao Senior fellow in ETS operation WenJing Zhan Associate director in China national ETS design	2	
	China Emissions Exchange, Shenzhen Sha Yang Senior fellow in Shenzhen ETS operation	1	
<i>E-NGO</i>	Greenpeace EU Unit Tara Connolly EU policy assistant Sebastian Mang EU climate and energy policy	2	
	WWF Europe Sam Van de plas Senior policy officer at climate and energy programme	1	
	Carbon Watch Femke de Jong Policy director	1	
<i>International regime</i>	World Bank Bin Ye Senior research fellow	1	

2.5 Data Coding and Analysis

The research following grounded theory principles is based on an iterative process (York et al, 2016). Flexible interaction connections between empirical data and conducting theory are based on the logic of the back-and-forward cognitive process (Van Maanen et al, 2007). Research analysis begins with semi-structured interviews for data collection, while simultaneously exploring concepts and gathered categories. The research goals are to explore and verify which factors influence linkage decisions in the international carbon markets. Once no more additional insights emerged from the data analysis, the iterative procedure stopped. The theory created from gathered conceptual categories and identified properties to generate a hypothesis depends on relationships between different elements of theory. The essential features of concepts followed 'analytic' and 'sensitizing' procedures to form the framework of the core of the emerging theory (Glaser and Strauss, 1967). This research carried out coding and analysis data concurrently, by labelling and sorting similarities in characteristics from transcripts.

Data analysis follows four steps from the initial opening codes to final theoretical dimensions. This procedure is recommended in grounded theory (Gioia et al, 2013; Strauss and Corbin, 1998). First, detailed line-by-line initial coding, which is very suitable for grounded theory, was developed and used to sufficiently investigate the designated characteristics of concepts (Charmaz, 2014). This approach of data analysis is first-order data. The first-order data is looking for potential categories emerging from similar characteristics. The second-cycle coding represents advanced ways of reorganizing data coded for similarities and differences in 'linking facts logically with one another' to develop more specific themes (Morse, 1994). Axial coding applied in this second cycle coding describes properties of concepts and explores the relationship between each concept (Saldana, 2016). The second cycle coding aims for emerging first cycle codes to the more accurate phrases with collective meaning and major components. Research goals were reviewed throughout this iterative procedure to cover key features explaining which factors influence the decision to cooperate in carbon markets. Grouping similarities in the first cycle coding reduced initial numbers of codes, sorting and relabelling them into seven conceptual categories.

The Table 2-5 and table 2-6 illustrate examples of the process from interview transcriptions to aggregate theoretical dimensions. The first order codes are abstract, with key properties

descriptions from the original data, while the second cycle coding grouped initial coding into subcategories, based on similar properties from final first cycle codes.

Table 2-5 Examples from transcripts to first and second order coding

<i>Transcriptions</i>	<i>Initial first cycle codes and descriptions</i>	<i>Final first cycle codes</i>
<i>There are several aspects if you are talking about the two-way link, the certain thing is to be harmonized, which is price was applied for the mechanisms</i>	'Carbon Market Design' Harmonized in design elements and carbon price	<u>Harmonized in carbon market design and price</u>
<i>Because in the aim is the common goal which is the.....we are using the CO₂ emission</i>	'Environmental target' Common goal of emission reduction	<u>Similar environmental reduction goals for cooperation</u>
<i>This is for carbon leakage with the notion that move outside the Europe to offshore their productions and move to other regions where they would pollute even more</i>	'Carbon leakage' Reason for carbon leakage outside the EU	<u>Carbon leakage happens, due to international price competition</u>
<i>I think there is something need to be understood as well..it is not all....er...en....it is the strongly correlate what you expected in term of economic growth and industrial production</i>	'Economics growth' Strong correlation between economic growth and industrial productions	<u>Correlation between economic growth and carbon price</u>
<i>This is an absolute quick condition for linking. But, by linking carbon markets, you really integrate climate policies between two countries, so this is then afterwards it becomes quite difficult</i>	'Climate policies' Integrated climate policies are difficult for two different countries	<u>Difficulties of linkage in integrated climate policies between two countries</u>
<i>So the role of carbon pricing definitely carbon pricing as we have seen in the EU ETS in the past decade, it does not have any influence on the end competitiveness position of these industries.</i>	'Carbon price' No influence on industries' competition	<u>Carbon price is not influenced for EU power industries' competition</u>
.....

Table 2-6. Example of second order categories to aggregate theoretical dimensions

<i>First order codes</i>	<i>Second order categories</i>	<i>Aggregate theoretical dimensions</i>
<p><i>Long-term carbon price guidance is crucial</i> <i>Signal guidance for investors of right decisions</i> <i>Carbon price as a long-term signal for investments</i> </p>	<p><i>Carbon price as long-term guidance to market</i></p>	<p><i>Carbon price functions</i></p>
<p><i>Accept high carbon price to decarbonisation</i> <i>Trade-off between decarbonisation and carbon price</i> </p>	<p><i>Correlation between carbon price and decarbonisation</i></p>	
<p><i>Difficulties in changing and preparing domestic rules</i> <i>Reducing emission cap is a highly political problem</i> </p>	<p><i>Political trust and control</i></p>	<p><i>Political considerations</i></p>
<p><i>Uncertainty of changes and priorities of political sides</i> <i>Problem of uncertainty in long-term commitment strongly influences choices</i> </p>	<p><i>Political uncertainties</i></p>	
<p><i>Carbon market size of volatile and liquid</i> <i>Market size influences linkage decision</i> </p>	<p><i>Carbon market similar sizes</i></p>	<p><i>Compatible carbon market design</i></p>
<p><i>Ideally harmonized and offset credits</i> <i>Copy and paste from EU ETS</i> </p>	<p><i>Harmonization elements of carbon market design</i></p>	

*Global competitiveness comparisons
 Not harm competitiveness in industries
*

*Even the power translates into indirect costs for industry
 Lower mitigation costs
*

*Main issue of linkage is decarbonisation
 International cooperation is needed for emission reductions
*

*Sectors relax emissions
 Sectors tried to lower cap
*

*Less transparency of public inputs
 Information asymmetry for stakeholders
*

*Social pressure on environment not influenced by government
 Social anxiety for windfall profits from linkage
*

International competitiveness

Economics costs for emission reductions

Cooperation for decarbonisation

Stringency for sectors

Public input and transparency information

Social pressure for emission reductions

Economics costs

Environmental effectiveness

Public input and social pressure

2.6 Findings

After the inductive process of data analysis finally emerged to theoretical dimensions across interviews, the motivations and factors influencing linkage decisions could fall into six dimensions of theory: 1) carbon price function, 2) political consideration, 3) compatible carbon market design, 4) economics cost, 5) environmental effectiveness, 6) public input and social pressure. According to understandings and investigations, the six theoretical dimensions are described in the following section.

2.6.1 Carbon Pricing Function

Carbon pricing function is a dominant category by logic, which links other themes in the chain. With a clear picture, there are two dimensions: whether carbon pricing as a signal to investors could generate decarbonisation and whether it is at an appropriate level reflected by boosting low-carbon investment.

A complex relationship is mentioned for the trade-off between decarbonisation and carbon pricing. On one side, raising carbon price could effectively be reflected in emission reductions among covered entities. The prices in Phase III were described as 'too low'. The arguments against lower carbon prices were 'not passing inadequate mitigation targets in emission trading systems' and 'did not drive cleaner production and consumptions in energy and materials in Europe'. Thus, before the beginning of Phase IV, the EU ETS carried out market reform to increase the 'lower carbon price' trading in the market. Various methodologies are planned for correcting the carbon pricing in reducing oversupply problem, for example, the implemented regulations in market stability reserve (MSR), back loading and annually linear reduction in free allocation to covered entities. Raising carbon pricing is a major improvement in EU ETS Phase IV to effectively incentivise significantly switching traditional energy sources.

Meanwhile, carbon pricing as guidance for investment also measured whether the current infrastructure of carbon market is effective or not. Although long-term carbon price signalling is extremely difficult, it provides sufficient information to investors in the market to make the right investment decisions. Carbon pricing is a crucial indicator for industries. They would choose to invest in renewable or low-carbon technologies if many energy choices,

like coal or nuclear, were available at the same time. However, the covered entities in EU concern about the carbon price increasing especially after the market reform. The energy-intensity industries consider that boosting carbon price because of stringency of free allowances is not 'a good thing' for them. Although higher carbon prices could drive decarbonisation, it would eventually draw economic concerns. If the lack of allowances in the future is happened, the covered entities will be aware and won't accept a super high carbon price. Balancing the level of carbon pricing and signals for investment generating decarbonisation is also an issue in China.

2.6.2 Carbon Market Design Compatibility

Carbon market design compatibility is the second category identified because of the ambitiousness of mitigation targets and the political commitments of tackling climate change 'translating' into ETS designs. The carbon market design has already been pointed out to be one barrier in linkage between two different jurisdictions (Mehling et al, 2017). Literature has studied different elements in the carbon market and evaluated level of difficulties in those elements' alignment in emission trading systems (Burtraw et al, 2013). The compatibility of carbon market design is frequently mentioned among stakeholders, as these categories have a close causal relationship with other categories. Categories especially energy coverages, cap setting, international credits usage, allocation and benchmarking methods and data transparency are viewed as important features in emission trading mechanisms, while carbon market size also impacts linkage decisions.

2.6.2.1 Differences and harmonization of carbon market design

Recently, EU and China both have paid attention on the harmonisations of ETSs' designs. Various designs of mechanisms are viewed by stakeholders as big difficulties in linking regional or national ETSs at the moment. The harmonization of carbon market design has pointed to significant obstacles in moving from current cap-and-trade mechanisms to trade across jurisdictions.

The importance of harmonization already mentioned by the stakeholders. The both stakeholders in China and EU stated:

"Several aspects about cooperation, the critical thing is to be harmonized. This is essential and I think it is an absolute condition for linking those. It is probably important harmonized for which all sets of use".

“Copy and paste”, “pretty much the same” and “without any more changes” are frequently mentioned when referring to the Switzerland and EU ETSs linkage, as a reference to illustrate the significance of keeping ‘the same system and rules’ under carbon market design. The following contents show the key elements in the harmonization of carbon market designs.

- Robust data collection

Although the emission cap is set before the allocation of allowances, the effective cap relies on ‘very good data’ in advance. A higher quality of data collection, especially for the power sector, determines the efficiency of carbon market cap setting. However, the robust data of emitted GHGs from the power sector is very difficult to get. The reason for this difficulty is based on the different methodologies carried out for calculations in different jurisdictions.

- Coverages and allocation methodologies to power industries

Coverage and allocation methodologies affects carbon prices. It is important and complex to clear separate measurements for different emissions among industrial sectors. For example, certain industries in the EU, like the glass, pulp and chemical sectors, require the comprehensive separating the emissions from the different sources. In the industrial production procedure, the emissions could be from either self-generated energy or imported the energy from outside. When it refers to the sectoral allocation methods, the accurate calculations of emissions for industry is depend on how the clarified separation of emissions from based on different original sources. This issue is also crucial for China to learn how to treat energy and components of markets including the differentiations in power industries and production processes.

A stakeholder in European Parliament talked about the considerations of carbon market design especially for the allocation methodology in power generations when refer to potential linkage with EU ETS:

“In EU ETS, there auctioning for power sectors and so for the free allocation benchmark for the industry. Ideally it is the similar system”

Despite for the allocation methodologies, several stakeholders indicated the coverage of the carbon market is “important to capture the main sectors for industries” operations and to clarify which manufactural sectors are under the ETS. The EU ETS expands the market

coverage from original power and energy industries to aviation sectors and CCS installations, petrochemicals productions over the Phases. Thus, comparing with EU coverages, if thinking about the linkage decision, it needs to consider “covering parts or whole sectors as the EU”. However, concerns over different regulations of power sectors in China and the EU, especially the electricity companies, result in barriers of cooperation.

Meanwhile, the arguments raised for the allocation method in power sector set by relevant authority in China because the covered entities in power stations receive almost 95% free allowances, including requested stricter benchmarking rules, which mentioned are “deeply problematical from the start”.

- Cap setting

Initial determined emission caps reflecting central motivation of mitigation target achievement of governmental commitment. Cap setting, whether in absolute or intensity targets, influences the levels of differences for linkage in the future and may affect the behaviour of firms. The emission cap impacts the environmental consequences. The presence of the cap, associated with the allocation methodology of energy industries, creates difficulties in aligning. This difficulty directly stated in the interviews for highlighting the different types in absolute and intensity cap settings between China and EU prospectively:

“I mean, the main major problem could be the driver to approaching the cooperation linkages with the Chinese ETS, because currently, both the European Union and China manufactory caps are different.”

Discussions about the recently closed EU ETS reform started the technical approaches for implementing emission caps in Phase IV. EU ETS carried out several ways to address the oversupply problem in back loading, Market Stability Reserve (MSR) or a linear reduction for cap emissions, which were already previously observed. The basic features of the updated regulations in the EU ETS for stringency in emission allowances and annual cap declines are aim to meet the Paris Agreement goals. Thus, it highlighted “The technique issues are quite important, as you want to make sure that supply and demand are well met”. Although it still needs time to show the consequences after the reformed of ETS, it provides real flexibility and certainties in politics, as rules were set in advance and everyone acknowledges the adjustment. Thus, EU is currently more ‘cautious’ about linkage decisions from a market function efficiency perspective. Brussels may not accept windfall profits from different

constituencies within two jurisdictions, with respect to different cap settings, *“because it eventually results in tight system buying allowances from the weaker system and get significantly manipulations”*.

2.6.2.2 Carbon market size

One of the most basic features of the program is the identification of carbon market sizes, which indicate how many portions of the economy is regulated in the system and responsible for compliance. Diversification of carbon market sizes is recognized as a motivation for cooperation, such as with Switzerland and the EU. The one with larger market size will have greater market power than the smaller one. Meanwhile, the differences in the carbon market sizes also represent a motivation for the linkage. The stakeholder who is responsible for negotiating linkage between Switzerland ETS and EU ETS stated that:

“It makes sense to link with the larger system that is liquid, as the EU ETS is 20–25 times larger than the Swiss one. ”

The various market sizes also affect which stakeholders are engaged in discussing the negatives of volatile importing and the momentum of carbon price fluctuations after linkage. It is notable that a smaller size of mechanism could be easily impacted by a larger system through the supply and demand of joint allowances in the market. This is happening when the EU system links with China’s national ETS, as the EU ETS is much smaller.

2.6.3 Political Considerations

Collaboration between emission trading systems is a way to build joint support for climate policies and abatement efforts. Literature reviewing existing linkages over the last decade demonstrate that the political preferences for linking two jurisdictions means they are normally acting in their own-interests (Stavins et al, 2013). Although pattern of data suggests a variety of factors influence international linkage, political consideration is the most important one among those variables, which has an effect on policy decisions.

2.6.3.1 Political position in negotiations

Linkage agreements are formal recognitions of two different jurisdictions (regional, national or sub-national government) for each other’s GHG mitigation programmes. Although linkage could be straightforward, one key element influences for international agreement is the

political position in negotiations. From existing cooperation examples, balanced positions in the negotiation procedure is a core focus. ETSs between California and Quebec, Norway and Switzerland with the EU present existing experiences from stakeholders that are described as ‘clearly political, strategic decisions, with “no question about who is leading”’.

However, once the negotiation refers to China and EU, it suddenly becomes much more of a discussion about whether who is going to lead the negotiations. Because of the market size and economic power, “China is going to be either a dominant partner or at least, to be an equal partner with EU”. Thus, the negotiations could take long time or even could be a barrier for the linkage.

2.6.3.2 Political desire

Challenges of a political and regulatory nature have already been emphasized as linkage decision factors (Egenhofer, 2007; Mckibbin et al, 2008), with the political preferences as a core motivation for two carbon-market-based cooperative climate policies. Majority of the stakeholders in both EU and China indicated the linkage decision is the “*super high-level decision*” from the governments and “*whether there is a real political desire to align to be an agreement*” is the key determinant for the linkage.

Specific links between California, Quebec and Ontario, Switzerland and the EU, as examples, reflect strong political preferences from policymakers for cooperation in advance. “*There is another issue between Switzerland and the EU, which is more about the political*”. At the same time, the failed cooperation between Australia and the EU also showed that changes in policy priorities are key for collaborations because, “*Australia had been changing of government and they dropped the carbon market*”. From a political perspective, linking normative mutually accepts each other’s effort levels in mitigation activities (Flachsland et al, 2008). “*Real trust and confidence*” is important for controlling environmental effectiveness. “*The most important factor for linking is trust in each other and political confidence between two countries*”. However, this trust is also impacted by the geographic factor, which is explained in the next section.

2.6.3.3 Political signal for cooperation

A desire for linking is viewed as one jurisdiction is “*desperate*” acting “*from the real commitment*”. Integrating climate policies provide conditions for long-term market guidance

of low-carbon investment. Meanwhile, it is a “political signal that two countries are considering climate actions and are willing to work with each other” especially few countries such as US intends to withdraw from the Paris Agreement currently. The stakeholders in EU stated it is a good opportunity for both EU and China taking lead in the climate change in the world:

“The US is not going to do this. China is going to do this. EU is going to do this. This creates an opportunity for cooperation and a leading position in the climate action in the world”.

The adoption of long-term climate targets which strengthen the acceptance of domestic climate policy and are active in sharing efforts in the global-burden have three, distinct political implications in the international cooperation between two carbon jurisdictions (Flachsland et al, 2009).

2.6.3.4 Political control

The question arises whether the benefits outweigh the gain of losing political control after joint carbon market linkage. Policy makers are cautious about this trade-off between overall efficiency improvement and the reduced control over carbon markets. The concerns of losing certain control over the carbon market stated from the stakeholders in the EU institutions: *“You link with other systems then you could not fully control anymore”* Especially as, *“it is unlikely that Beijing will fully follow what Brussels is proposing in the regulations and vice versa”.*

Stakeholders have concerns over political control, both in emission reduction targets and joint supply and demand. This reflects a variety of strategic considerations, starting from whether combined emission caps result in environmental effectiveness and welfare transactions, based on different stringencies of climate policies. *“ETS has been supposed to be market-based, but is highly political”* and control over these elements over time that have *“lots of highly political questions that distributed facts to the market”.*

2.6.3.5 Political uncertainties

A key question about the possible collaboration of climate policy architectures is the uncertainty. Although linkage implies long-term international political commitment, the uncertainties in climate policies particularly influence the merging of two carbon jurisdictions.

The political uncertainties present in two aspects. First, it is from the “absent of political commitment” and it is “hard for long-term projection”, because “no policy makers can commit something in such of statement”. The reason for no long-term commitment from government is that there is still an existing probability of “changing the priorities in policies in the future”. The problem of uncertainty has been identified both in the EU and China. Due to this perspective, “it is extremely difficult to develop long-term stable price guidance to investors in the market”.

2.6.4 Economic cost

The economic implications are viewed as crucial motivations for linkage, which have been detailed in several literatures. Rather than the literature referring to economic implications in short-term or long-term efficiencies, the most common and frequently word both countries’ stakeholders used is ‘competitiveness’ and how this ‘competitiveness’ would be after linkage impacts business activities for domestic economic growth. The linkage between two ETSs should not so “harm for the local industries”. The authorities are aim to maintain their provisions to against dealing with additional pressures from international competitiveness. Industrial stakeholders stated they concerned about:

“Dealing with trading things under competitiveness within one country, within the European Union and between the EU and China”.

Especially, the industries in EU showed more concerns about competitiveness after linkage than Chinese industries, because “the companies are worried about and afraid of the EU importing from China”. The pressures from ETS linkage could raise the potential of carbon leakage because of the collaboration. The experts in think tank indicated that the productions in EU could move offshore, outside of Europe and move to other regions where they would pollute even more.

However, some arguments discussed separating the power sector from other industries, when they referred to competitiveness and carbon leakage. Although power industries are facing auctioning all allowances, it is not perceived to be international competitiveness, due to the limitations of energy transportation. Taking electricity industries as examples, the power supplies on in domestic or geographic near, as long as electricity lines are already there. These electricity line connections could be domestically or in European areas, but not

reaching overseas. At the same time, electricity market reform has taken the full focus of the power sector. State-owned power industries in China, with controlled electricity prices, can't possibly meet international competitiveness.

In the EU ETS, the percentages of auction allowances and lower carbon prices to power and energy intense industries like steel, chemicals and cement are not significantly influenced by end-product prices. The stakeholders in EU described the reasons of carbon leakage happened previously are because the EU Commission not carried out enough stringency climate policies and provided additional compensations for these power generations:

“Europe has been extremely and overly generous in terms of compensating these industries and this is the advantage of all allowances being handed out for free, instead of auctioned”.

This is described as a *“deeply problematic”* factor embedded in the EU ETS, which has not been fully corrected yet. This is one conflict raised for whether economics is a major motivation for linking two carbon jurisdictions. Arguments indicated that reducing compliance costs for mitigation, from a theoretical perspective, could not explain the existing linkages of global carbon markets. The costs for compliance for covered entities in carbon markets are not high, due to lower carbon prices and less strict punishment schemes. On the contrary, some indicated the intrinsic motivation of collaboration is economics. The basic rationale of the incentive for linking cap-and-trade systems is international trading between countries, which Norway, Switzerland and EU linkages are a good example, which stated by the stakeholders for the reason:

*“Norway is the member of European economic area”.*²¹

Although Switzerland is not involved in the central European institutions such as European court of justice, the economic motivation supposes for Switzerland linkage with the EU ETS because *“they are in the same continent and trade a lot of things”*.

²¹ EEA is European Economic Area including EU member states and Iceland, Liechtenstein and Norway. EEA constructs a single internal market that guarantees equal rights and obligations within the single market for free movements of goods, services, persons and capital (EEA, 2019). <https://www.efta.int/eea/eea-agreement>

Equal carbon prices after linkage imply a fairness of competitiveness in importing and exporting businesses. These closely existing international relations in economic trading enhance political communication and trust in reality.

2.6.5 Environmental Effectiveness

After the Paris Agreement, it is conceivable that countries are cautious about national emission reduction ambitions. Commitments made by countries translated to ambitious mitigation targets. The political aim for emission trading system establishment is to achieve decarbonisation. When considering linking two carbon jurisdictions, the issues of driving decarbonisation and meeting with targets are listed as priorities in the decision process. The emission reductions would be undermined *“if one country keeps emissions at a business-as-usual level and then links with the carbon market of a country that already has an absolute emission reduction target”*.

Under the Paris Agreement, the reduction objective is expressed as an absolute reduction target, whereas countries like China apply intensity targets, which is the emission-per-unit of economic activity. The concerns are over safeguarding environmental effectiveness to properly ensure what actual quantity of abatement in carbon pollution takes place.

2.6.6 Public input and social pressure

Data analysis linked public input and social pressure to linkage decision making, especially in the EU, compared to China. Transparency in climate policy making and public emission data information is encouraged for more individuals to participate in the climate change issue. Social pressure for climate action is not influenced by government.

Well-intentioned environmental people can shape and impact such environmentally oriented decision-making. However, as climate policy decision making is a top-down procedure, the limitations of the power of public and social impact on climate policy are obvious.

2.7 Stakeholder Consultations and Discussions

Our goal in this study is to identify the key factors that matter and investigate the trade-off between benefits and drawbacks for the linkage decision making. Before fieldwork started,

we introduced conceptions and dimensions in linking from literature. Although detailed linking motivations were described in existing studies, based on model constructions in economics, politics and regulations, we applied qualitative methodology in conducting research in the EU and China carbon markets' linkage to provide inside views of influenced dimensions, comparative with existing factors in literature. In the following sections, we elaborate on the process outlined in our research and discuss contributions in theory toward understanding the policy decision making with key elements.

2.7.1 Theoretical Contributions

This study makes three important contributions to an understanding of foreign policy decision making in carbon market, when it relates to two different carbon jurisdictions. The findings show that carbon market design compatibility, economics, carbon price function, political considerations, environmental effectiveness and public information and pressure influence linkage decisions in the EU and China. The degree to which each motivation plays a role, however, differs according to interactions between theoretical dimensions and multilevel governance for climate policy. This study provides in-depth explanations of motivations and determinants for the international linkage architectures between two emission trading systems discussed in the literatures.

The following discussions highlight the detailed additional and different concepts after comparing the literatures and the findings in this study.

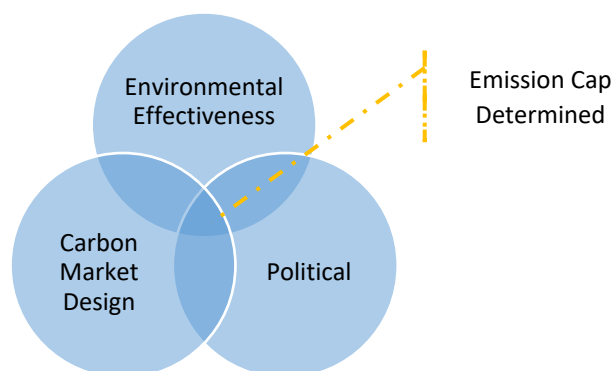
2.7.1.1 Compatible emission cap designed

Based on findings, it is revealed that the compatible emission-cap design is crucial for environmental effectiveness, carbon market design and political consideration. Literatures already indicate the key elements in the compatible carbon market design are emission reduction targets, monitoring reporting and verification, offset mechanism, registration system, price cap/floor, borrowing and coverage (Sterk et al, 2006; Jaffe and Stavits, 2007; Mace et al, 2008). Our findings suggest that the emission cap, designed as key element in three theoretical dimensions, indicate its crucial role in linking decision-making compared with other elements in emission trading mechanism design.

Harmonisations of emission targets and prices is viewed as a condition for collaboration between carbon markets (Rasons and Stavins, 2013; Burtraw et al, 2013). As an advance determination of emission reduction caps, it reflects ambitious mitigation goals by countries. The decision-making process depends on the political attitudes of a climate governance trade-off between economic growth and decarbonisation. The incentives of stringency for mitigation goals could have consequences in affecting firms' behaviour of reduction activities with environmental effectiveness (Marschinski, 2008). A challenge for jurisdictions around the world when considering international linkages, with the substantial characteristics of implementing climate policies in feasible combinations with different types of targets (Mehling et al, 2017). A main determinant of carbon prices, including stringency of market-based mechanisms, is the choice of how many allowances are allocated to covered entities.

In the literature (Burtraw et al, 2013), for the directly bilateral linkage, whether the carbon market applies absolute or intensity emission target might not provide a technical barrier for linking or the functioning of market-based mechanisms. The technical problem is posing a political barrier for decisions. For policy makers, rather than generating economics gains of bilateral trading, based on different carbon prices, they had the unique perspective of putting decarbonisation first, with emphasis on the level of mitigation target set. It is our belief that political acceptability of the environmental integrity of emission reductions is complicated for multiple levels of climate policy governances (Ransons and Stavins, 2013). Chart 2-3 illustrates the key elements in environmental effectiveness, carbon market design and political consideration.

Chart 2-3: Key elements in environmental effectiveness, carbon market design and political consideration



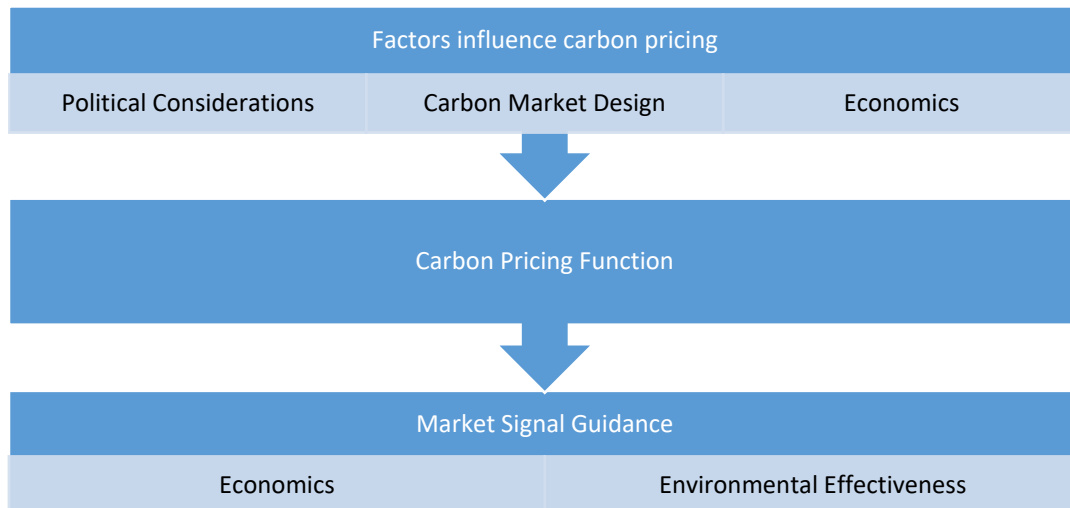
Sources: Mehling et al, 2017; Burtraw et al, 2013, Rasons and Stavins, 2013; findings from this study

2.7.1.2 Carbon pricing Function

Comparing with other dimensions, carbon pricing as a core dimension shows the obvious process from it determined to the effects it has on society and industry. Literature reviewed carbon pricing in linking in two aspects: prices in emission trading and the financial market (Westskog, 2002; Flachsland et al, 2009; Calel and Dechezlepretre, 2012; Rasons and Stavins, 2013). Although linked mechanisms could result in increasing market liquidity and price stability, it also imports market volatility from one system to the other (Babiker et al, 2004; Paltsev et al, 2007; Mackibbin et al, 2008).

In this study, findings reveal that the most significant concern is whether the carbon pricing function works well as guidance for low-carbon investment and an incentive for environmental effectiveness after linking, rather than enlarging markets or stable trading carbon prices. The environmental risk is associated with different carbon market designs in linking and it is difficult to address this problem by changing stringency during negotiations (Haite and Wang, 2006). Our findings indicate that a sufficient level of carbon price could incentivise decarbonisation in reducing local air pollution. Moreover, carbon pricing as guidance leads firms to invest optimal amounts in R&D (research and development) in low-carbon innovations, enhancing energy security by prohibiting importing fossil and fuel from overseas (Calel and Dechezlepretre, 2012; Westskog, 2002). The relationship summarized presents in the Chart 2-4.

Chart 2-4: Carbon Pricing Function as main categories



Sources: Findings from this chapter also shows similar in references Calel and Dechezlepretre, 2012; Westskog, 2002.

This appropriate level of carbon pricing is determined by interactions between the supply and demand of allowance trading in ETSs. Corresponding to the supply side, the emission cap illustrates a total number of permits in carbon market design, which is decided by regulators (Grull and Taschini, 2010). Covered entities' total volume of pollution and abatement costs combined generate demand for emission allowances (Grull and Taschini, 2012). Linking affects the overall amount of permits available in the market, the flows of allowances from lower mitigation cost systems to higher cost systems. Different levels of ambition in emission caps strongly effect the supply side if one considers multi-jurisdictional linkage. As allowances are allocated to the market before compliance, the stakeholders in academia subgroup described it as 'fixed supply with flexible demand'.

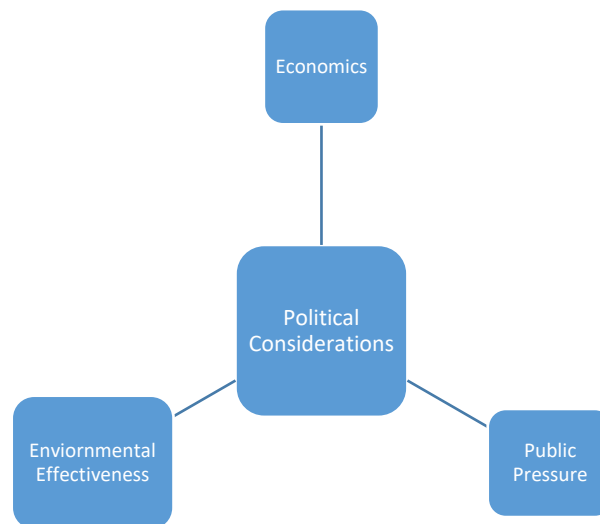
2.7.1.3 Competitiveness in Economics

Economic implications were widely discussed in literature, from short-term efficiency in the lowest cost for mitigation (Chichinisky and Heal, 1995; Edenhofer et al, 2007, Flachsland et al, 2009) to the dynamic efficiency of long-term confidence in political commitment to climate change and supporting investments in low-carbon innovations (Helm et al, 2005; Montgomery and Smith, 2007). Although studies showed linkage benefits in welfare gains in transactions based on MAC (marginal abatement cost) differentiations (Westskog, 2002; Grull and Taschinim 2012), findings of research indicated most participated stakeholders were concerned about the competitiveness in international trading and the consequences of carbon leakage by inequal production prices. This politically sensitive problem of competitive distortions between two jurisdictions with different carbon prices could be effectively addressed by linkage (Houser et al, 2007; Reinaud, 2009; Flachsland et al, 2009). However, arguments also pointed out that this asymmetric carbon price only accounted for little of the share of GDP growth, which is not a significant influence on production prices in international trading, particular in the circumstances where the differences are not too large (Reinaud, 2005; McKinsey and Ecofys, 2006; Morgenstern et al, 2007). The stakeholders in Think Tank and E-NGOs showed two perspectives, based on different sectors. Fewer concerns for competitiveness in power industries are due to geographical transportation limitations and there is an expected larger effect in commercial industries with higher energy intensity industries such as pulp, glass, steel or paper.

2.7.1.4 Trust in Political Considerations

Although the argument for the major motivation of linkage is for aggregate cost savings, under a voluntary basis in the Paris Agreement, countries hold commitments with respective differentiated responsibilities (Bodansky, Hoedl, Metcalf and Stavins, 2015). Existing empirical experiences of international linking, such as Australia suspended linking proposal with the EU ETS, California, Quebec and Ontario multilateral linking as evidence shows that, even though several listed benefits and motivations are mentioned in literature, the real desire of regulators' to link jurisdictions is the crucial element in political considerations. Our findings suggest that the political considerations for linkage decisions are influenced by environmental effectiveness, economics and social pressure dimensions, which the relationship presented in the Chart 2-5.

Chart 2-5: Relationships between four dimensions affecting ETS linkage decision



Sources: Findings from this chapter and similar shows in references Bodansky, Hoedl, Metcalf and Stavins, 2015.

2.7.1.5 Economics-geographical near

From findings, economic support for political considerations is not from the aspect of the lowest cost for mitigations, but from the international trading consideration in a 'political trust' aspect. The stakeholders pointed out that the geographically near and existing international trade created 'trust' between countries, which built foundations in advance for negotiating climate policy integrations. The geographic proximity (Ransons and Stavins, 2013)

affects the integrity of emission reductions. This explanation in international trading theories between a close pair of nations is indicated in a 'gravity model', which is associated with transportation cost and information disclosure for markets (Tinbergen, 1962). Political economy theories provided insights into trade agreements between countries located geographically close to each other with similar economic conditions and they may have a history of mutually beneficial agreement on other issues (Ransons and Stavins, 2013). This also reflected the findings of stakeholders considering 'political trust' from geographically near or even closer economic relationships before. The evidence showed that countries in the EEA (European Economic Area) or EFTA (European Free Trade Association) are believed to have more motivation to link carbon jurisdictions with each other than with 'far-flung jurisdictions'.

2.7.1.6 Public pressure-air pollution attention

Our study findings highlight social and public pressure on climate action, including the collaboration issue for jurisdictions. Previous linking theories have not described so much about this dimension. The public gradually pays attention on climate change and energy security issues (Corner et al, 2011). Literature previously showed the attention to climate change fell, compared to other issues such as economy, education or terrorism threatens (Upham et al, 2009). However, public and social pressures gradually appeared, especially when climate change related to health problems and social media advocates for public attentions internationally. One cannot ignore that these representative public concerns over climate change influenced government decisions through media and the press. One example is increasingly environmental protests appear in the worldwide, which significantly influences for the climate policy decision-making. The literature indicated the climate protest increases effective for both independence and climate action support (Carmichael and Robert, 2017). Although in comparative politics theories, the policy priorities represent 'national interest' for policymakers, the definition of 'national interest' is discussed for scope.

2.7.1.7 Environmental effectiveness-international political commitment

Scholar has already stated that comparing to economic benefits, political reason may be the main driver for the linkage decision (Mehling et al, 2018). Linkage provides a momentum of political support for climate action (Bodansky et al, 2015) and indicates a signal for continuing to control emissions, which creates a barrier to terminate an existing established linkage

(Pizer and Yates, 2014). When justifying national emission caps, regulations could point to international pressure from the commitment to agreements (Flachsland et al, 2009). In our findings, the effectiveness to cut GHG emissions on scale and achieve the mitigation target is basic support for negotiations of a post-Paris global treaty between the EU and China. This burden-share of emission reductions globally, and further climate policies for enhancing mitigation activities to an acceptable level are required to assist international collaboration responses (Nicholas Stern, 2008).

2.8 Chapter Conclusion

2.8.1 Findings and Theoretical Contributions

In the Kyoto Protocol, countries separated into Annex I and non-Annex I countries. However, until the Paris Agreement, China's role in international climate action is more important as a global issue. Increased international attention aimed better coordination at climate-related policy activities. Both the EU and China leaderships have shown the ability to adapt to or resist both internal and external climate change pressures over time. This research offers clear views to refine the categories of influencing linkage decisions with qualitative study and to investigate how these categories interact with each other. The study indicates carbon price function, political considerations, compatible carbon market design, economic costs, environmental effectiveness and public input and social pressure dimensions. These findings strongly reinforce previous categories mentioned in linkage literature. A focus on the specifics of cross-sectional analysis of research findings could also reflect the motivation for linking political considerations and environmental effectiveness over economic benefits. Although the Chinese carbon market is still underdeveloped, China's position in the international climate negotiations deviated from the original positions in developing countries.

2.8.2 Policy Implications

This study indicates the political implications that the political reason plays a significant role to incentive providing sufficient supports for linking decisions as a long-term strategy for climate action collaboration. But even politically motivated linking will face the environmental effectiveness problem. Thus, the compatibility of levels of ambition is the key element to make the linkage political feasibility, which also impacts on global climate commitments. Besides top-down procedure, bottom-up process could be the possible

incremental approach for establishing international ETS linkage. Robust reduction data and information disclosure increases political trust for integrating climate policies. It could start from a 'memoranda of understanding' of strategies and emission trading mechanisms before any formal negotiations are codified. Minimum political uncertainty, associated with coordination among jurisdictions, also indicates carbon price stability and incentivises low-carbon investments. In findings, political trust and historical correlation between countries creates a solid foundation for carbon market collaboration. In fact, China has already collaborated with the EU since pilot ETs were established. It is crucial for China to learn from the experiences of the EU ETS. Meanwhile, EU intended to assist China to design the carbon market in the elements of register, MRV and trading platform. Finally, to clarify 'de-linking' regulations involved in a treaty of coordinating multi-jurisdictions. This 'de-linking' treaty would be beneficial for all parties with certainty in a case of an eventual unsuccessful linkage happening.

Furthermore, potential linkage forms are suggested from different perspectives. Given challenges and motivations for linkage and cooperation, stakeholders described possible linkage forms under international policy architectures. These perspectives were described, based on existing national or subnational linkage examples and the current situation in each carbon market. To make the collaboration politically feasible, the suggested frameworks are top-down procedures, which directly reference the Paris Agreement, and the other is a decentralized process, which is the soft link between two emission trading systems.

2.8.3 Practical Implications

This chapter provides the practical implications as follows. Firstly, it is important to recognize that potential linkage negotiation is not for a short-time period. Although we listed a variety of economic, political and administrative factors influencing linkage decisions, currently the EU and China are focusing on their own obstacles in carbon market operations. The EU ETS has just finished market reform in Phase IV. Subsequently, measurements were applied for oversupply implementations. The EU Commission is more concerned with environmental effectiveness by linkage achievement. Although China has announced the establishment of a national ETS, the regulations of mechanism, from allocation to compliance, still need to have the details clarified. In the initial stage of an operational ETS, sector coverage only includes power industries and the national trading platform is under developed. Thus, the

current time for considering linkage is not perfect. The timeframe for linkage is for a future, long-term period.

Secondly, proposed linkage forms are categorized into top-down procedures under the Paris Agreement or bottom-up procedures for soft links. Some stakeholders argued that the linkage decision is depend on the super high-level of political desire and cooperation. This requires for a political strategic procedure when at the start of carbon market design. California, Quebec and Oriento linking is a good example of success, which indicates compatible designs under the same framework are better applied from the initial stage. Direct dialogue between two jurisdictions implies a clear route from the beginning for international mitigation transfer. Article 6 provides a foundation for voluntary linking by the recognition of emission reductions by internationally transferred mitigation outcomes (ITMOs²²). ITMO is an additional safeguard in place to ensure emission reduction and accurate accounting of mitigation outcomes before exchanges. This ITMO offers guidance on how to account to ensure that participating countries make appropriate adjustments for reductions. Once parties negotiate under clear and consistent guidance for environmental effectiveness, the greater possibility that expansion linkage between nations could happen in the future.

Another possibility is a decentralized procedure mentioned by most of the stakeholders. It contains a 'soft link', sectoral or regional linkages. Regional linking is not like major countries' linkage negotiations and it would be easier for regional cooperation, especially in neighbouring or cross-border locations. The basic concept of regional linkage would be very realistic, by not sacrificing domestic control over ETSs. Sectoral linkage is more straightforward than regional linkage. Stakeholders concerned that industry, particular for crucial sectors such as power stations in carbon markets, have more motivation for cooperation and this procedure could start from an overlap of the same technologies in similar GHGs covered in the mechanism. The perspective from stakeholders is that the indirect linkage under CDM of KP is not possible as a recommended type of international architecture to link ETSs. Because there were too many disadvantages of CDM criticized in

²² ITMOs-International Transfer of Mitigation. Under Paris Agreement 6, the ITMO is the measurement for transferring mitigation outcomes from one region to another based on the negotiations (Paris Agreement, 2014).

https://unfccc.int/sites/default/files/presentation_from_singapore_art_6.2_1.pdf

the literature for indirect linking international ETSs. The major reason is uncertainty of accurate mitigation outcomes and the lower price of CER (Certified Emissions Reduction) by selling 'hot air' allowances, strongly influenced by environmental effectiveness. Besides, the World Bank proposed mitigation value to calculate the exchange ratio between two systems was also mentioned by stakeholders considering one possible way for building a global carbon market.

2.8.4 Limitations

In order to obtain the data regarding for the policy decision-making theory, the inductive process applied in this research simplifies contacted the relevant stakeholders in cross-section. However, the linkage process evolves for more than one-year from initiative preparation to completion (Rason and Stavins, 2013). Thus, the factors capture for the general pattern in the linkage decision-making is better to observe and tracing the stakeholders in long-term.

This study also faces the challenges of self-selection stakeholders with sampling method. The potential barrier for the data obtained is the snowball sampling limited to observe broader perspectives in the linkage decision-making. However, as the triangulation data collection method, the number of relevant official governmental documents and administrative archives add more sufficient support for the findings.

Chapter 3 Linking Carbon Markets: Concepts, Case Studies and Linkage Readiness Pathway

3.1 Introduction

Increasing countries are developing and implementing ETSs to make their effort to curb emission reductions. Alongside the growing number of ETSs, the linkage between jurisdictions is starting to take place. The scholars investigate the divergent ETSs' designs could significant create the barrier for the linkage (Stavins and Jaffe, 2007; Tuerk et al, 2009; Flachsland et al, 2009; Burtraw et al, 2013). The policymakers would make the decision for the requirement of aligning certain features of ETSs prior linkage to ensure the compromises of climate actions (Hawkins et al, 2014). The decision will also be influenced by the type of linkage, which can be direct in unilateral, bilateral, or indirect through a common third system.

The literature proposed policymakers to overcome the obstacles in moving from current state of unrelated emission trading systems to a linked system by harmonization of ETS designs (Mace et al, 2008; Tuerk et al, 2009; Goers et al, 2012; Burtraw et al, 2013). Meanwhile, the scholars have tried to explain the choices of shaping designs of emission trading systems and lead the designs to convergence trend by policy diffusion theory (Gulbradsen et al, 2019: 18; Heggelund et al, 2019). The investigations in the literature applied for process tracing relating to the key elements decomposed from the global carbon markets (Flachsland et al, 2009; Sterk and Kruger, 2009; Burtraw et al, 2013; Bodansky et al, 2015; Stavins and Rasons, 2015). Besides the ETS establishments, the literature also indicated the diffusion effects in similar designs in the ETSs appearing influence for the linkage result (Gulbradsen et al, 2019). However, there is little work showed in the literature to explain how the policy diffusion influences in the changes of ETSs in the decision-making process during the linkage preparation period. Thus, in this chapter, it aims to fill the academic gap in two research questions: which and how policy diffusion influence for the changes of ETSs' designs in the linkage procedure.

In the literature, the policy diffusion contains learning, competition, emulation, and coercion mechanisms (Maggetti and Gilardi, 2016). In the literature, it identified the officials have learnt lessons from best practices of existing carbon markets, to avoid the same problems

happened (Elkins and Simmons, 2005; Shipan and Volden, 2008). The scholars applied process tracing method through key features of the ETSs designs to examine the diffusion mechanisms and showed the reasons for the harmonization (Mace et al, 2008; Flachsland et al, 2009; Goers et al, 2012; Zetterberg, 2012; Stavins, 2013; Burtraw et al, 2013; Stavins, 2013). Thus, to answer the research questions, this chapter draws on case studies in California and Quebec, Norway and EU based on the process tracing method and analysed data from archives, documents, and semi-structured interviews.

In the findings and discussions, it showed the diffusion mechanisms in sophisticated learning, economic competition and emulation appeared to influence for the changes in the ETSs' designs for the linkage. Moreover, the choices of registration and emission target in decision makings are motivated by the political drivers, which mainly customized depend on domestic circumstances rather than the diffusion mechanisms. The policy diffusion mechanisms also examined between the China pilots ETSs and the EU ETS, which indicated the similar results. Moreover, the findings also provided practical implications for the policymakers in designing and implementing ETSs prior linking with the international carbon markets.

The remainder of this chapter is organized as follows. Section 3.2 describes the background for existing international linking framework. Section 3.3 presents the literature reviews in the theory of policy diffusion theory and key features examined in the chapter. Section 3.4 reviews methodology for this chapter, noting the methods of data collection and analysis. Section 3.5 provides illustrative the findings for identifying the explanations from process tracing through key features in the linkage ETSs and section 3.6 shows the discussions linking explanations with diffusion mechanisms. The section 3.7 concludes.

3.2 Background

3.2.1 Type of Linkage

A formal term of linking refers to exchange carbon allowances or offset credits between two different emission trading systems (Jaffe et al, 2007). A formal linkage is a direct linking, which may exist in several forms depending on different legal frameworks decided by the agreement of both parties and the directions of exchange flow of allowances. The direct linkage contains bilateral and unilateral forms (Mehling and Haites, 2009). Compared with direct linking, indirect linking through the common third mechanism such as CDM between

two markets could be seen as a short-term linkage. It is a process of linking but not achieving a final stage. This type of indirect linking implies a preparation for ongoing formal linkage. The details of different types of linkage are described as follows.

3.2.2 Unilateral Linkage

Unilateral linkage is a one-way link, under which the cap-and-trade mechanism would allow qualified entities to surrender allowances from the exporting program for the purpose of compliance (Mehling and Haites, 2009). The driver for a higher carbon-priced scheme to link unilaterally with another scheme is purchasing allowances from a lower carbon-priced market to achieve net cost savings. Unilateral linkages have to be flexible to allow regulators to implement changes which might be needed in the scheme (Holt et al, 2007). The control flows of allowances under unilateral link could be managed through setting up a specific amount of time for valid holding importing credits by regulators. In addition, the regulators could direct manage the flow of allowances such as imposing a limitation for purchase credits outside the jurisdiction (Mehling et al, 2009). However, the increasing demand may lead to carbon price raising for exporting program but also could benefit for a revenue inflow from the foreign system (Haites and Wang, 2009).

3.2.3 Bilateral Linkage

A bilateral linkage would allow participants in both systems to purchase allowances from each other for domestic compliance. A bilateral linkage would call for a balance between supply and demand and equivalence in carbon prices. It would require a binding agreement that each party take the greatest interest in predicting and stabilising demand under uncertainties (Turek, 2009). A good bilateral linkage results in cost effectiveness and abatement efforts across global collaboration of cap-and-trade markets. However, as amendments cannot be made unilaterally, each participant risks losing control of emission targets and political priorities and it is harder to change the program rules (Burtraw et al, 2013). If unilateral linkage presents the short-term flexibility, the bilateral linkage represents a long-term certainty commitment for the climate actions.

3.2.4 Linkage with Degrees

Empirical research pointed out significantly that obstacles for unrelated emission trading systems linked cap-and-trade programmes trading cross borders and jurisdictions (Burtraw

et al, 2013). The incremental aligning of key elements in cap-and-trade programmes is called “linkage with degrees”. Instead of a full bilateral linkage between jurisdictions, a linkage with degrees between two participants could provide a significant share of both benefits and obstacles for regulators. Prior to the establishment of a formal linkage, a linkage with degrees would provide a good opportunity to carefully evaluate the economics and impacts of programme design on each intra-country cap-and-trade mechanism. Differences in market designs are obstacles which can potentially be anticipated and addressed by policymakers through a staged approach (Burtraw et al, 2013).

3.2.5 Indirect Linkage

If two systems are not direct linked, they can indirect linkage through the common third system, such as CDM under Kyoto Protocol. Under this framework, the countries implementing cap-and-trade systems could link with other countries without emission caps. It provides an opportunity for participating in cooperation in climate actions without accepting the official binding agreement (Flachsland et al, 2009). Although the indirect linkage such as CDM enhances the political feasibility to encourage more participants for emission reductions, it has higher risks in environmental integrity and potential for carbon leakage comparing with direct linkage (Tuerk et al, 2009).

3.3 Literature Review

Linkage plays a significant component of a larger international climate policy architecture (Jaffe et al, 2009). “Linkage ready” of carbon markets refers to a basis in potential a near-term role for a future international agreement in the climate policy cooperation (Burtraw et al, 2013). Prior the official cooperation, the “linkage ready” status contains two sides: political and technical supportive (Ewing, 2017). Politically, the transparency of supportive in priority is required for linkage readiness while technically, the literature identified that the harmonized carbon market designs and practices are needed (Flachsland et al, 2009; Stavins, 2013).

Scholar argued the harmonization in carbon market designs or linkage of ETSs could be viewed as one of climate policy diffusion outcomes globally (Gulbradsen et al, 2019). Policy diffusion refers to an interdependent but uncoordinated decision making (Elkins and Simmons, 2005:36). Regarding to international policy diffusion, it appears when one

government policy decision choice of establishing ETS could be systematically conditioned by prior policy choices made by other countries (Simmons et al, 2006: 787). In the literature, the diffusion process is generally leading to convergence through spreading across different contexts in policies and institutions, and this convergence is mainly motivated by clear leaders or strong market pressures (Elkins and Simmons, 2005:38). For emission trading systems, the convergence of policy diffusion reflects in harmonization of rules and regulations within an existing institution (Gulbradsen et al, 2019: 16).

In the literature, it argued that tracing international diffusion in carbon markets could find in shaping designs of emission trading systems (Gulbradsen et al, 2019: 18). As emission trading systems is a highly complex markets, the design which reflects international diffusion has many dimensions (Gulbradsen et al, 2019: 18). From the literature, it investigated the similarities of ETS designs to trace the policy diffusion for the trend of convergence (Gulbradsen et al, 2019: 20). Thus, the scholars detailed analyzed what are the key elements could reflect the properties of ETS and the reasons for the harmonization (Mace et al, 2008; Flachsland et al, 2009; Goers et al, 2012; Zetterberg, 2012; Stavins, 2013; Burtraw et al, 2013; Stavins, 2013).

From the literature, not all elements are selected for reflecting the policy diffusion and required harmonization to show the convergence. The criteria for ETS properties' selections are depend on how importance of these elements to determine of ETS effectiveness (Underdal et al, 2015). In general, it showed five groups of key features concluded from the literatures (Mace et al, 2008; Flachsland et al, 2009; Goers et al, 2012; Zetterberg, 2012; Stavins, 2013; Burtraw et al, 2013). The subgroups are technical issues in MRV and trading system designs, emission reduction goal, allocation method, cost management and enforcement and contingencies (Mace et al, 2008; Goers et al, 2012; Burtraw et al, 2013). The scholar viewed these five groups of key features as dependent variables and the policy diffusion as independent variable and tried to find the explanations for the relationship (Gulbradsen et al, 2019: 25).

From the literature review, the policy diffusion is passing through four mechanisms: coercion, competition, learning and emulation (Maggetti and Gilardi, 2016). literatures identified the learning is common mechanism for climate policy transferring because in theory, policy

makers are easier to adopt policy if the policy has been successful in other areas (Volden 2006, Gilardi, 2010). For carbon market designs, national officials have made extensive efforts to learn from best practices, which could effectively influence for the ETS designs, leading to convergence (Elkins and Simmons, 2005; Shipan and Volden, 2008). Besides, policy diffusion could also observe regarding to economic competitions between nations (Elkins and Simmons, 2005). Comparing policies with economic competitors also influence for similar adoptions of policies as regions seek to secure economic benefits (Maggetti and Gilardi, 2016). For example, to environmental policy, scholar argued the motivation of Norway implementing market designs for ETS compatible with EU ETS is economic competition (Underdal et al, 2015).

Although in the literature, the linking is viewed as the one of the outcomes statuses in convergence of policy diffusion in shaping similarities of ETSS' designs (Gulbradsen et al, 2019: 20), it indicated not all elements of ETSS required for the same (Gulbradsen et al, 2019: 20). This argument also raised in other literatures, for instance, in the aspect of MRV, conflicts raised on whether the rules should be identical for the linkage readiness (Haite and Wang, 2006; Flachsland et al, 2009; Sterk and Kruger, 2009). In the case of allowance tracking system, there is no consensus on whether the regulation is required to be harmonized because there exists a trade-off between transparency in the information disclosure and active trading activities by industries (Sterk et al, 2006; Haite and Wang, 2006).

Moreover, in the literature, scholars discussed linking the systems with absolute and intensity emission targets is possible (Ellis and Tirpak, 2006; Marschinski, 2008). In reviewing the practical example of EU ETS, the absolute emission target is a "must condition" for the linkage readiness (EU Commission, 2012b). The scholar also argued the differences between theoretical and practical are because political feasibility that could constrain the selections of properties (Burtraw et al, 2013). Most of the literatures have tried to apply policy diffusion theory to explain why to design ETSS, however, there is little work to show how the policy diffusion effects in the linkage procedure to implement the ETSS.

Thus, to track the procedure of linkage in convergence between two ETSS and show the reasons, this chapter is aim to detail investigate how the properties of ETSS' changes reflecting the policy diffusion mechanisms by applying the empirical studies. This study also

aims to explain the different policy diffusion mechanisms under different conditions and political constraints in different jurisdictions.

The research questions raised are as follows:

SQ1²³: Which ETS design properties are most likely to diffuse? Do different design properties spread?

SQ2: What are the implications of these convergences of ETS designs for cross-jurisdictions relating to linkage?

The following section illustrates the subgroups of design properties.

3.3.1 Properties of ETS design in policy diffusion

3.3.1.1 Monitoring, Reporting and Verification

MRV is viewed as a significant element in aligning two ETSs and in the development of a carbon market because it determines whether the ETS is a common, functional and politically acceptable mechanism (Hautes and Mullins, 2001). Scholars have argued that it is not necessary to have identical MRV regulations if the schemes are robust and can ensure accurate data in governing their emissions limitations (Hautes and Wang, 2006). However, much literature insists that the consistency and stringency of the MRV is likely to be a precondition for the linking (Flachsland et al, 2009; Sterk and Kruger, 2009; Burtraw et al, 2013; Bodansky et al, 2015; Stavins and Rason, 2015). Harmonisation of MRV is crucial for the environmental integrity. Because if one jurisdiction in a linked system has a lack of motivation to track and identify accurate data from emissions, these loopholes will be exploited for double counting between two jurisdictions or to undermine environmental effectiveness (Bodansky et al, 2015; Tuerk et al, 2009). One benefit raised by minimising differences in MRV regulations is to reduce competitive distortions; this provides a safeguard for prohibition of carbon leakage (Hautes and Wang, 2006).

3.3.1.2 Allowance Tracking System

The essential features in an allowance tracking system are transparency of registries with different types of credit and the ability to monitor transactions of allowances between emission trading systems (Hautes and Wang, 2006). Tracking traded credits in a trading

²³ SQ refers to sub question for this research

platform plays an important role for linking by avoiding double counting, maintaining the integrity of the allowances during creation, transfers and cancellation (Bodansky et al, 2015). There exist discussions over whether the expanding system is trading cross-markets with the extent of public access to data (Haites and Wang, 2006). Tracking individual trades could easily give access to oversight of monitoring of the market in aggregate (Bodansky et al, 2015). However, scholars also show that different rules of trading information disclosure to the public could influence trading activities by firms if they are seeking to secure associated trading strategically as private information (Sterk et al, 2006²⁴).

3.3.1.3 Emissions Reduction Goal

- *Emissions Cap*

The different types of emissions targets adopted by individual systems pose a problem in the linking (Sterk et al, 2006; Green et al, 2014). In common, two types of emissions targets are applied in existing emissions trading systems, which are an absolute target and intensity target (Frankel, 1999; Kolstad, 2005). Comparing the absolute emissions target with limited total emissions in a specific time period, the intensity emissions target is defined as emissions per unit of output or activity such as GDP²⁵. In the literature, it is argued that comparable emissions targets must support the linkage (Flachsland et al, 2009) and linkage is most straightforward if both schemes employ absolute targets (Mehling et al, 2018). The reason is for the problem raised with respect to the defining of the stringency of the caps (Edenhofer et al, 2007; Marschinski, 2008). Because the economic growth is unknown, when an intensity emissions target converts into an absolute target, the total quantity of emissions depends on the relevant level of economic activity. However, linking the system with different emissions targets is technically possible (Ellis and Tirpak, 2006). Based on an analytical approach, the literature proposes a suitable tax on traded credits from the intensity target system to restore Pareto efficiency (Marschinski, 2008). Otherwise, it could easily result in negative economic and environmental performances by introducing 'hot air' into the linked system (Haites and Mullins, 2001).

²⁴ Sterk et al, 2006. Reading to link up? Implications of design differences for linking domestic emissions trading schemes. Joint Emissions Trading as a Socio-Ecological Transformation, Working paper. https://wupperinst.org/uploads/tx_wupperinst/JETSET_WP_1-06.pdf

²⁵ GDP-gross domestic product.

- *Scope, Timing, and Coverage*

The differences in scope and coverage between ETS sectors, geographic and GHGs are not problematic for the linkage as long as there is accurate accounting for executed international transactions and no significant carbon leakage from regulated to unregulated GHGs (Sterk and Schule, 2009; Goers et al, 2012; Metcalf and Weisbach, 2010; Mehling et al, 2017). However, the divergence in the regulations in terms of coverage in indirect or direct GHGs could result in accounting discrepancies or distribution effects in distortions by double counting (Haïtes, 2003; Sterk et al, 2006; Ransons and Stavins, 2013). The double accounting could lead to double payments for end-users (Sterk et al, 2006) and the indirect coverage of GHGs could also harm the political goals of a scheme with regard to the ‘a ton is a ton’ principle (Mullins and Haïtes, 2001).

3.3.1.4 Allocation Method

The allocation method in ETS could be categorized into two types depending on how the covered entities receive the allowances from the government: auction and free allocation (Pang et al, 2018). The free allocation methods are based on two criteria: grandfathering (historical) or source of basic data in output-based or input based (Burtraw et al, 2013), which refer to allocation methods. Scholars argue a variety of allocation methodologies not representing them as a technical challenge for linking (Tuerk et al, 2009a). However, the allocation affects the distribution of benefits unequally to linkage parties, in revenue generating from the issuance of allowances (Burtraw et al, 2013). If a system with the free allocation method linking a system with auction, allocation in the first place shows a subsidy in a competitive advantage with trade implications and this leads to reduced efficiency and production behaviours in both systems (Blyth and Bosi, 2004; Burtraw et al, 2013). Thus, in the literature, it recommends harmonisation to reduce distortions introduced by linking (Sterk and Schule, 2009).

The treatment of new entrants and exits can also result in distributional implications (Tuerk et al, 2009a) if some portion of allowances is given away free, but this element of design is not difficult to align and is crucial to influence the performance of the linked market (Burtraw et al, 2013).

3.3.1.5 Cost Management

The cost management includes banking and borrowing, offset mechanisms and price collars or floors (Burtraw et al, 2013). The contentious issues in cost management are in the debate regarding environmental certainty and price management (Sterk and Kruger, 2009; Flachsland et al, 2009b; Tuerk et al, 2009; Haites and Mullins, 2001). The controversy is whether these designed elements should be provisions because of the additional price certainty above the emissions cap (Sterk and Kruger, 2009; Stavins and Rasons, 2015). Banking and borrowing is to bring forward allowances to future years, which maintains a cumulative multi-year emission cap, and there could be economic benefits to this approach (Murray et al, 2008). It is viewed as indirectly allowing temporal flexibility for all market participants, who could possibly carry with surpluses on into the future (Jaffe and Stavins, 2007). However, the banking and borrowing may not be problematic and could even incentivise for investments if two systems are setting comparable emission caps and resolving all surplus allowances (Sterk and Schule, 2009; Jaffe and Stavins, 2007; Burtraw et al, 2013). Meanwhile, a solution is proposed in the literature for limiting total quantities of banking and borrowing in a linkage (Haites and Mullins, 2001; Barons and Bygrave, 2002).

Several authors cite harmonisation of the recognition of external credits for compliance, including rules and protocols, as a critical element that must be aligned before the linkage (Sterk et al, 2009; Tuerk et al, 2009; Flachsland et al, 2009b; Burtraw et al, 2013; Hawkins and Jegou, 2014; Stavins and Rasons, 2015). In the linked system, the eligibility of different types of offset credits is a significant barrier for linking in terms of economic, political and environmental implications (Edenhofer et al, 2007; Hawkins and Jegou, 2014). The offset mechanism has indirect impact for the carbon price because the allowance and offset credits could be interchangeable (Zetterberg, 2012; Sterk and Kruger, 2009). Thus, it is important to compare the stringency of regulations according to specific sectors, limitations of quantities, or geography (Zetterberg, 2012).

3.3.1.6 Price Collar

Price management with ceilings or floors represent a challenge prior to linking (Hawkins and Jegou, 2014; Haites, 2013; Rason and Stavins, 2013; Zetterberg, 2012). The different designs in the price management could influence the carbon price level in the linked system. A price floor indicates that government sets a minimum price on polluting, which presents

restrictions on installations buying allowances from cheaper markets, leading to a whole market by default (Fankhauser and Hepburn, 2009). Scholars argue that a price floor has advantages for economic implications, with incentives for technology innovations (Wood and Jotzo, 2009). On the other hand, price ceilings are controversial for the environmental integrity of the scheme (Hepburn, 2006). A price ceiling is difficult to implement, as it is an integral design element associated with environmental and political consequences to prevent high carbon price raising (Haites and Wang, 2009).

3.3.1.7 Enforcement and Contingencies

Scholars indicate each system must contain effective enforcement for compliance (Haites and Mullins, 2001; Haites and Wang, 2006). If covered entities could not remit sufficient credits for compliance, penalties must be imposed and collected and the regions should implement a penalty system if it appears too weak for enforcement (Metcalf and Weisbach, 2012). If a linked system has no compliance force, participants with lower penalties have an incentive to sell the allowances to a stronger enforcement system and pay the penalties, which is effectively performing as a price ceiling with negative repercussions for environmental linking (Haites and Mullins, 2001; Metcalf and Weisbach, 2012). However, the different designs in the enforcement elements should not matter as long as the other linked system, considering penalties and enforcements from the other scheme, is satisfied (Haites and Wang, 2006).

3.4 Methodology

This section details the methodology and method for this chapter. Initially, consideration is given to the research design. The explanations described for adopting the methodology in comparative case studies and method in process tracing. Then the main empirical study is introduced detailed with validity and reliability. Finally, the steps taken in the data analysis for the final findings.

3.4.1 Research Design

The question concerning the design of the research is whether it should be apply for deductive approach for developing theory by testing the hypothesis or inductive approach to develop theory after data collection and analysis (Sauders et al, 2000). The different approaches are depend on the purposes of the research and the nature of the research

questions raised. The deduction approach emphasises moving from theory to data that mainly is to explain the causal relationships between variables (Collis et al, 2003). While inductive approach emphasises on gaining a close understanding of the research contexts or the meanings of human attach to the events (Saunders et al, 2000). The inductive approach for this chapter is more appropriate than deductive approach because it more focuses on investigating the explanations and establishing different views of linkage readiness between two carbon markets rather than testing the casual relationship for the variables.

3.4.2 Research Strategy-Case study

In the inductive approach, a range of five methodologies could be applied, which are narrative research, phenomenology, grounded theory, ethnography and case study (Creswell, 2007). A case study is a methodological approach for systematically gathering enough information about a particular event or social setting, which incorporates a number of data collection measures to help the researcher effectively understand how it operates or functions (Hamel et al, 1993; Burg, 2000). The case study was chosen for this research. First, it is suitable to answer the research question of “why”, as well as “what” and “how” questions (Saunders et al, 2000). Second, the choice of case study strategy is made to gain a rich understanding of processes being enacted (Morris and Wood, 1991) and it is most often used for explanatory and exploratory research (Saunders et al, 2000). The various and combination data collection techniques normally employed by the case study and these sources of evidences are converged to the case based themes (Hartley, 2004).

3.4.2.1 Multiple cases

Yin (2003) distinguished case study into four types based on two dimensions: single case or multiple cases, and holistic case or embedded case. For the first dimension, a single case refers to a unique case or extreme case, which typical to provide the opportunity to observe the phenomenon few considered before (Yin, 2002). A multiple-cases selection is to generalise the findings based on more than one case. Thus, the findings in the first case could be checked whether it also occurred in the other cases, and as consequence, to generalise the final findings for the research (Yin, 2002). In the literature, some scholars argued that multiple cases are in favour of single-case study (Eisenhardt,1989; Barton, 1990) however, Dyer and Wikins (1991) suggested the single case study if it could present for the vigorous evidence. For the second dimension, holistic or embedded case refers to the unit of analysis

(Yin, 2003). Holistic case is only concerned the organisation as a whole to analysis whereas if the research examines a number of sub-units within the organisation, it is defined as embedded case (Saunders et al, 2000).

In this chapter, the case study is categorized to multiple case and holistic case based on the two dimensions above. This research is treated the regional ETS as a whole to analysis. The multiple cases are considered for two reasons. First, the analysis could be done through a rich contextualized and “thick description” through various sources (Geertz, 1973). These two intensive cases constructed a cross-cut research design, which focused on exploring the time-related issue-linkage between two ETSs over time. Second, the general pattern could be obtained comparing cross the multiple cases. It is able to analysis the similarities and differences between cases and provides the further understanding the differences in literature within each situation. Meanwhile, the initial findings generated from the first case could be checked whether it occurred in the second case, which enhance the validity of the final findings. The multiple cases for this chapter allows creating a more convincing theory from the wider discovering of the linkage evolution.

3.4.2.2 Case selection

The case selection for this chapter is from non-probability samples, that each case selected from the total population is unknown, unlike the statistical importance for the probability sampling based on the already known population (Stake, 1994). Although scholars argued there is no agreement on what the non-probability sampling should be, it still requires for following the principles reflecting the key features for case selection (Curtis et al, 2000). In the literature, it indicates it is important to justify the rigour of the research with discussions for a set of criteria as “guidelines” to select the non-probability cases, which illustrate as follow (Miles et al, 1994; Patton, 1990; Curtis et al, 2000):

- The method of sampling is based on purposive or theoretical sampling criteria, which the cases should be relevant to the conceptual framework and addressing the research questions.
- Although samples are small, each case should be typically generate a large amount of information.
- The samples are designed to make possible for understanding of new or existing theory about the phenomenon studied, which refers to analytic generalizations.

- The sample should be reflexive and explicit with ethical considerations.
- The sample should provide a convincing descriptions and explanation. This criterion raises the issue about the reliable sources of information to produce believable results.
- Sampling plan is feasible, which indicates the ability to obtain the information with sufficient capability.

3.4.3 Research Method-Process Tracing

Process tracing is originated as a technique within case studies to examine intermediate step in cognitive decision making and make better inferences about historical explanations (George, 1979). In the literature, the method of process tracing is aimed to investigate how that process took place and what the outcome the process is generating (Checkel, 2014). Scholar applied process tracing as a qualitative method tool to apply for descriptive inference from diagnostic pieces of evidence to explain a part of sequence of phenomena over time (Collier, 2011).

In the literature, the process tracing is applied for examinations in theories of international relations and climate policy diffusion because process tracing provides context for the mechanisms of policy diffusion. The explanatory variables could be detected in process tracing for decision-making of shaping behavior and interests in empirical case studies (Kelley, 2004a). As this research aims to in-depth understanding the differences in diffusion effects on changes of ETSs' properties and investigate the implications of convergence for linking, the method of process tracing benefits in systematic and contextualized comparisons between different ETS linkage in the empirical cases.

In the literature, process tracing has already applied for analyzing the policy diffusion in expanding ETS establishments after Paris Agreement. Gulbrandsen and Underdal (2019: 30) applied the process tracing approach through studying the small N-cases comparative global carbon markets and investigated the economic competition and erosion as main diffusion mechanisms for ETS establishments globally. Comparing to Gulbrandsen and Underdal (2019) work, process tracing in this study is advantage in tracing ETS evolutions and examining the explanatory variables across the whole linkage procedure from ETS implementations to final linkage outcome. This tracing is to systematic analysis and identify the contextualized as the

climate policy diffusion in ETS linkage and shed light on unique historical, political, and economic characteristics for different explanations.

3.4.4 Empirical Case Design

3.4.4.1 Empirical Case Selection

In this chapter, two cases of California and Quebec, and EU and Norway embedded in the sample for studying the linkage readiness between two carbon markets. In the table below, first column showed the criteria from the literature and the second column illustrated explanations that the decisions about choice of the cases.

First, based on the methodology case selection criteria, the cases of California and Quebec, and EU and Norway are satisfied with the conditions. In the table below, first column showed the criteria from the literature and the second column illustrated explanations that the decisions about choice of the cases.

Table 3-1 Relevance of the criteria in the literature to selection of case studies

CRITERIA FOR THE SELECTION	CASE 1: CALIFORNIA AND QUEBEC	CASE 2: EU AND NORWAY
RELEVANCE TO CONCEPTUAL FRAMEWORK	Yes: based on conceptual in linkage example for linkage readiness	Yes: focus on particular type of linkage readiness within EU area
POTENTIAL GENERATING RICH INFORMATION	Yes: especially for archival material and evaluation documents from government	Yes: especially from the EU official documents and potential for field study with interviews
ANALYTIC GENERALIZABILITY	Yes: a range of geographical context within WCI was sought	Yes: A range of historical economic context was sought
ETHICAL CONSIDERATIONS	Not a determinant but considered	Not a determinant but the choices of stakeholders were considered
POTENTIAL TO GENERATE BELIEVABLE EXPLANATIONS	Considered credibility for archival material and evaluation reports from governments	Considered credibility of archival material and interviews involved
FEASIBILITY	Yes: access to archival material and official governmental documents	Yes: accessibility of documental archives and interviews including workshops

References: Miles et al, 1994; Patton, 1990; Curtis et al, 2000

Second, the case of California and Quebec, EU and Norway share similar commons in the pattern of linkage. California, Quebec, EU, and Norway ETSs have been developed over five years and officially linked over five years (World Bank, 2018). The carbon markets have

already been mature, and the operations of linking are stable. Both California and Quebec, Norway and EU have completed procedures for the linking, from preparations in negotiations, stakeholders' consultations, implementations to the final linking auction began (EDF, 2019). Thus, the two cases of linkages provide large information through archives and clearly showed the details how the ETSs implementations to meet the harmonization conditions.

Analysing California and Quebec, Norway and EU could allow this study to show the whole pattern of linkage procedure, by applying process tracing method. Meanwhile, California, Quebec, Norway, and EU have different characteristics in economic and political situations. For example, California has much more manufactures than Quebec, which would burden more in emission reductions. On the contrary, Quebec generated over 90% of electricity by renewable sources, which has much advantages linking with California (IEA, 2019). Norway has smaller carbon market than EU and it is required to consider carbon price effects after the linkage (Carbon Watch, 2015). Thus, analysing the cases could imply a general pattern in harmonization for world carbon jurisdictions with different situations.

In conclusion, the two cases of California and Quebec, Norway and EU are best practices in linkage, which could show the completed procedure for this study. Also, their unique backgrounds in economics and politics could provide additional information in explanations of diffusion in ETS designs for linkage.

3.4.5 Empirical Case Design-Data Collection

This section details the specific research techniques used for data collection and data analysis. For this chapter, there are three approaches for the data collection: primary data from 11 semi-structured interviews and secondary data from 40 archives and evaluation reports from governments. The methods in data collection are considered along with validity and reliability.

The data collection for answering the research questions could be from the primary and the secondary. The primary data refers to the new data collected for the research, normally through observation, interview and questionnaire while secondary data includes both raw data and public summaries (Saunders et al, 2000). Alongside the selection decision process, it needs to consider whether the data is suitable for answering the research objective, and

its accessibility and validity (Kervin, 1999). The suitability criterion is the data coverage, which ensure the data covers the period of the research and all unwanted data are excluded (Hakim, 2000). Based on the principles of accessible, credibility and validity of data collection, three types of data collected for this chapter, which are semi-structured interviews, archives and evaluation reports from governments.

- Documents

In the literature review, the existing studies provide an idea of the availability of governmental documents and archives for two independent data sources, which contain the full references to the approach of data collection (Zetterberg, 2012; Burtraw et al, 2013; Hawkins et al, 2014). Within the main study, documents as the predominant method of generating findings and it is the best method to explore the research questions. In this chapter, the relevant public and administrative governmental documents for carbon markets reflected the substantive developments in the linkage process for the linkage readiness. After the examining periodic and final reports of the ETS linkage, it is easily to get a clear picture of how the governments and the linking fared over time.

The benefits of the documents from governments are easier and feasible to approach with sufficient credibility and validity (Saunders et al, 2000). Document is an efficient and effective way of gathering the data from manageable and practical resources. Bowen (2009) indicated as documents are “non-reactive” data sources that could be reviewed several times and unchanged by the research process, making the data collection from documents are accessible and reliable. Furthermore, it is important that the documents contain the information for tacking changing and development especially if a public event happened (Yin, 1994). Thus, the secondary data in documents is feasible to provide comparative and contextual data in a longitudinal study (Saunders et al, 2000).

- Interviews

The difference between structured interviews or semi-structured interviews is whether there are interaction between the researcher and participants (Healey, 1991). Semi-structured interviews are “non-standardised”. The benefit for the semi-structured interviews is the order of the list of themes or questions prepared that could be adjustment in the conversation for further potential exploration on the research questions (Healey and

Rawlinson, 1994). The semi-structured interviews are particular suitable for “seeking new insights” (Robson, 2002). In this chapter, the data from semi-structured interviews as the additional independent source for valid data analysis and it provides opportunities to probe answers where the interviewees could focus to explain their responses.

3.4.5.1 The Valid and Reliable of the Data Collection

The detailed assessment of reliability and validity in data collection involve in an assessment of the methods used to collect the data (Dale et al, 1988). The proposed quick assessing of the data is to check the source of the data via authority or reputation of the source (Dochartaigh, 2002). When the data exists, it can provide an indication of who is responsible for the data. The literature argues that the official archives or printed publications from well-known institutions and governments are found to be reliable and trustworthy (Saunders et al, 2000). However, the bias in deliberate distortion occurs if the data is recorded intending for any advantages. Thus, in the case study strategy, the reliable data collection need to use triangulate multiple sources of data. The triangulation refers to use two or more independent sources of data or collection methods of data techniques to corroborate the research findings within one study (Saunders et al, 2000). This triangulation in data collection refers to a “cross-check verification” with other independent data sources to further test the validity (Patzer, 1996).

In the literature, the reliability is concerned for non-standardised interviews that whether the alternative researcher could reveal similar information (Silverman, 2007). The various types of interview bias are concerned in the literature (Easterby-Smith et al, 2008). One perception is related to the interviewers that the topic is sensitive information for them to answer. The other one is the bias from the nature of participants agreed to interviews, for example, always one particular group of individuals or organisations willing to participate for data collection (Robson, 2002). To overcome the bias, two technical approaches proposed from the literature applied for the data collection from semi-structured interviews (Easterby-Smith et al, 2008). First, variation selection for the stakeholders in the purposive sampling that is particular informative for the research questions (Neuman, 2005). In the data collection of this chapter, three sub-groups of stakeholders are selected based on the case studies and depend on the variation principles. Meanwhile, the checklist for demonstrating the interviewing competence applied based on the literature suggestions to ensure reliability

(Saunders et al, 2000). The prepared questions and checklist, including the data source are shown in Appendix IV and Appendix V.

3.4.6 Empirical Case Design-Data Analysis

The data analysis contains document and interview analysis with coding to merging to the final themes for a reduction procedure. The noting analysis commences at an early stage of documents analysis, coding enabled the process of data reduction with the formal process of analysis. Document analysis presents that documents are used for interpreting to give the meaning around the assessment topic (Strauss et al, 2008). Miles and Huberman (1994) identified the analytic strategy in a general order:

- Data collection into text
- Codes developed or identified in the data
- Codes transferred to categorical labels or themes
- Materials could be sorted by these categories with similar phrases, patterns, or relationships
- Sorted materials examined the isolate meaningful patterns and processes
- Identified patterns comparing with previous research and theories.

In this chapter, the analytic strategy is applied for the following phases.

a. Selection relevant context from documents

Identify pertinent information and separating it from the overall content is the first step of document analysis (Corbin and Strauss, 2008). The analysis of data starts from skimming, reading the documents to select relevant information for the research problem and purpose. The documents selected for the analysis are not treated as precise background information but to choose the relevant contents for tracking the changes in the ETS regulations for the linkage readiness. The public governments' documents are assessed for completeness and comprehensive. At the same time, in order to reduce the biases from analysis, the considerations that the document was "written as a result from the firsthand or from the secondary resource" are also concerned (Hodder, 2000).

b. Initial coding of selection data and conducting questions for interviews

After the selection of data from documents, the next process is carefully reviewing and re-reading the data for closer coding performance and category construction based on the common pattern through characteristics (Bowen, 2009). In the document analysis, the

scholar argued the documentary contents could be analyzed by interview technique that treats the documents like transcriptions to highlight the “answer within the text” (O’Leary, 2014). The selected contents are interpreted through organizing information into categories with emerging themes. The examples of documents selected and the data analyzed are given in Appendix IV. Initially, the similar patterns and properties are clustered into different substantive categories. The prepared semi-structured interview questions are based on these substantive categories from the initial document analysis. For this chapter, NVivo is applied for analysis the data. Based on the selection context, a line-by-line detailed coding process that advocated in the literature (Charmaz, 2014) was applied. The “in vivo” coding method (Saldana, 2015) was undertaken to draw on the words and meanings for the first-order categories.

c. Thematic analysis

The second phase of coding allows for more advanced investigating the themes emerged from the codes that generated in the first phase. The process refers to the thematic analysis, which is a recognition of general pattern with emerging the codes to generate themes and categories (Fereday et al, 2006). At this stage, “pattern” coding method is applied as the literature suggested the “pattern” coding is focused on developing explanatory for the findings thematically and conceptually (Saldana, 2015).

d. Iterative process

It is an iterative process for data analysis to conduct the research findings (Baxter and Jack, 2008). The initial findings from documents compared with interview transcriptions to re-analyze for the potential themes constructions. After iterative process in back-and-forth reviewing data in the context, it reached the theoretical saturation. Then the empirical knowledge and understanding are developed. In the iterative process of data analysis, the initial codes were tested whether they could cover all the insights from the additional information gathered. This process further indicates the verification of the findings from the data (York et al, 2016).

The example of how the document data analysis for this chapter is shown in Appendix VI.

3.4.7 Reliability and Validity

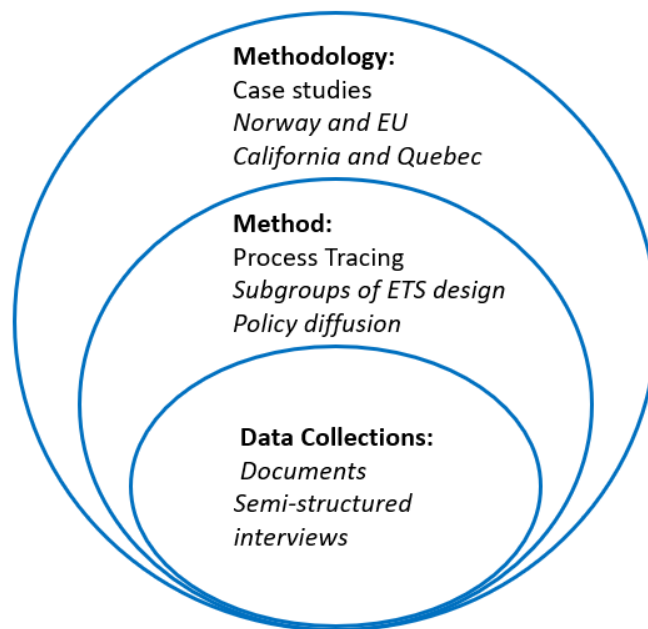
Reliability of the research extents to which the methods of data collected or the analytic procedure yield for the consistent findings (Easterby-Smith et al, 2008). Robson (2002) identified there are potential threats to reliability, which are participant bias, observer error

and observer bias. To avoid these threats, findings from this chapter derived from a number of different perspectives across both governments, industries and academic institutions in different locations. The variety perspectives from different subgroups reduce the participant bias that it is not possible for the participants saying what they thought other people wanted them to say. The triangulate methods of data sources enhance the valid of the findings, which lessen these threats to reliability. Meanwhile, the two cases of California and Quebec, Norway and EU have different locations dealing with the bias concerns. The literature (Easterby-Smith, 2012) argued for “researchers need to look for evidence that might confirm what one currently believes to be true”.

The validity of the inductive research is not based on the quantities in the sample. In contrary, it is concern the “quality of the data” and the evidence the data contains, given the purpose of the research study (Bowen, 2009). The scholar set up three criteria for judging the validity: authenticity, plausibility and criticality (Easterby-Smith et al, 2012). The authenticity refers to whether the research has in-depth understanding the case and this has been addressed in the analytic approach and reliability. The plausibility and criticality criteria judge for the researcher tackling a topical issue and questioning existing assumptions (Easterby-Smith et al, 2012). The criteria of plausibility has been demonstrated by the current level of international cooperation in climate actions within the field outlined in the policy and academic literatures. The criticality of the research is demonstrate in the analysis challenging the assumptions in existing linkage readiness framework regarding to carbon market designs, which illustrated in the literature reviews.

In conclusion, the methodology applies case study with the method of process tracing for investigating the climate policy diffusion in convergence of ETS designs for linkage readiness. And the process passing through different mechanisms, which are also the explanatory variables for the trend of convergence. The chart 3-1below illustrates the methodology steps.

Chart 3-1 Methodology Process



3.5 Findings

The empirical findings of this chapter are drawn from data analysis on 40 documents and 11 semi-structured interviews. This section is first overviewing the cases in California and Quebec linkage, Norway and EU linkage, then to answer the research questions of SQ1 and SQ2. This section organizes as follows: the first part introduces the overviews of cases and the second part illustrates the process of changes in the ETSs' designs during the linkage.

3.5.1 California and Quebec Linkage Case Overview

The central concept for WCI is to be a centre for comprehensive, flexible, market-based regional cap-and-trade participants to collaborate for climate change. This framework encourages regional carbon markets to emerge but each ETS has its own authority for governance and to implement regulations separately. The WCI develops a series of recommendations for the carbon market's design template, including scope, tracking system, auction operation, monitoring. State or provincial members would adopt and implement regulations under the same framework (WCI, 2008). Both California and Quebec joined WCI (Western Climate Initiative) in 2008 and adopted the recommended operation rules of cap-and-trade mechanisms (ARB, 2013). The joined framework would facilitate future links

between members in the WCI (WCI, 2008). Thus, California and Quebec finalised their cap-and-trade programme regulations for linkage in December 2013 and the linkage was ready to proceed on 1 January 2014 (ARB, 2013).

Prior to linkage, California and Quebec had proposed amending systems to harmonise certain aspects in each ETS such as mutual usage and recognition of joint auction and additional provisions to enhance market security, allowing verification of the identities of market participants (ARB, 2012). After evaluation of economic and environmental impacts for proposed amendments, staff in California and Quebec provided a detailed report for programme implementation and promoted linkage by public process (ARB, 2013). California and Quebec are benefits of joining WCI in reducing administrative costs through transactions across jurisdictions and enhancing security and the efficiency of ETSs after linking (AB, 2012). The linkage procedure presents the strategic process from the current state of unrelated systems to a broader cap-and-trade architecture that enables trading across the jurisdictions. The incremental implementations in California and Quebec were intended to overcome obstacles but under the condition of contributing to good administration (ARB, 2013). As Quebec established ETS later than California, in which the carbon market was in a learning-by-doing period, the jurisdiction of Quebec mainly followed the guidelines that already existed in California.

One point is worth to notice that because California and Quebec both applied for the WCI framework with guidelines in carbon market designs prior official linkage, they already had similar elements in scope, coverage, compliance period and auction process (ARB, 2013).

3.5.2 Norway and EU Linkage Case Overview

Norway established its emissions trading system in 2005, amending it to link with EU ETS unilaterally in 2007, then implementing official bilateral linkage in 2008 (Norwegian Ministry of the Environment, 2009). Norway was the first non-European country to become a member in the EU ETS in 2008, which covered about 40 percent of GHGs in EU. Norway, is a member in the EEA with closer economic relationship with EU had motivation to integrate the EU ETS legislation into the EEA agreement (ICAP, 2019). Thus, from the start, the Norwegian carbon market was designed to be compatible with EU ETS, which indicated that many features of ETS are similar. However, before the official linkage, the Norwegian ETS was still amended

twice - in June 2007 and February 2009 - to implement features in line with Directive 2003/87/EC of the EU ETS during the Kyoto commitment period from 2008 to 2012 (Norwegian Ministry of the Environment, 2008). The documents for the linkage readiness present all tracking changes in Norwegian ETS regulations in order to compatible with EU ETS based on administrative records from the Norwegian government (Norwegian Ministry of the Environment, 2008). After the implementations, the Norwegian ETS was finally full harmonised with the EU ETS by the start of Phase III in 2013 (European Commission, 2012).

3.5.3 Changes of Elements in Carbon Market Designed for Linkage

The following section presents the empirical findings regarding the changes of elements in the carbon market designed for linkage. The implementations of elements are categorized based on literatures and explanations on principles in policy, economic, equity and best practice in market functioning. The findings generated from data analysis through documents, reports, and stakeholders' perspectives.

According to the literature review, the key properties of ETSs' designs for investigating the policy diffusion procedure as follows: (1) registration, emission target; (2) enforcement allocation method, covered entities, offset limitation, and penalty; (3) offset protocols, covered threshold and GHGs, banking; (4) joint auction process, tracking process, and compliance period.

3.5.3.1 Changes in registration and emission target

- Changes in Registration

Although literature argued that the different registry platform does not preclude linking as long as both mechanisms are effective to retire and create allowances trading across the markets (Mace and Anderson, 2009), the registration was still required to be identical prior to linkage. The implementations proposed in the coordinated system aimed to improve information transparency to avoid double counting of emission reductions, to make sure of environmental effectiveness. These are reflected in the regulations changed in Quebec for disclosing all affiliated entities and associations of the covered industries (ARB, 2011; ARB, 2017). The EU directly applied a single Union system for registry to ensure strong security measures in the holding, transfer, and cancellation of allowances (European Commission, 2018).

Prior to linkage, California and Quebec incorporated the concepts of “Know-Your-Customer” to disclose all information in affiliated entities, account representatives and account consolidation (ARB, 2013). Meanwhile, they raised a new regulation in “Allowance Price Containment Reserve” to make sure the initial auction prices were the same for participants. Norway also applied Commission Regulation (EU) No 1031/2010²⁶ to procure a common joint EU auction on the platform of the European Energy Exchange (Norwegian Ministry of the Environment, 2008). According to the implementations, there would be minimum transparency loss in the transactions and regulators could more easily govern the functioning of the emissions trading system regarding managing volumes of greenhouse gas emissions allowances, especially after surplus in the EU up to 2020.

The stakeholders also indicated that the registration is significant for long-term mitigation commitment to reduce the risks of fraud in the trading system and carbon leakage appearing. Meanwhile, the transparency of registration makes it easier for administrative monitoring of environmental integrity based on transactions of allowances in the linked mechanism.

- Changes in emissions target

The findings indicate that the stringency of climate policy reflects the ambitiousness of the setting-up of the emissions target in the ETS designed by government. From the case studies, the linked systems are all subject to the same type of emissions target. In the cases, California and Quebec have set up absolute emissions caps of 40% and 20% reductions below the 1990 level by 2030, while Norway implemented the emissions target to the absolute number of 40% compared to the 1990 level. At the same time, Norway submitted the Intended Nationally Determined Contribution (INDC) for compatibility with the EU (European Commission, 2015; Norwegian Ministry of the Environment, 2008).

The clear changes exist in requirement of absolute emission target especially for the EU ETS before and after the Phase I (Commission, 2008). From the report, the policy triggered after ‘shocked event’ that carbon price dropped to zero after the oversupply in Phase I and financial crisis during 2007 to 2008 (Commission, 2011). Peter Zapfel (was the EU

²⁶ <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:302:0001:0041:EN:PDF>

Commission's Environment Directorate) indicated the EU in the first phase loosely linking to emission target as industries considered the trading instrument allowing too much authority to influence power industries such as BP and Shell (Zapfel and Vainio, 2002). After 2006, the key actors in the Commission (DG Clima) changed the preference after five rounds of stakeholders' consultations (Commission, 2008) to tight emission target and this stringency mitigation target was received positive feedback in Copenhagen summit (Commission, 2011).

Thus, in the following ETS detail reviewing for phase II and phase III, the EU insisted to keep the efforts to achieve the emission target and effective carbon price, which indicated the absolute emission target is a must for the linkage (Commission, 2008). According to the changes of the EU requirements, interviewed Brussels insiders pointed out the Norway ETS had changed the emission target to absolute to meet the condition of the EU. This is because the intensity target gives no certainty to environmental outcomes and does not limit total emissions by nature. The interviewed Brussels insider further pointed out the reason for intensity target is not allowed for the linkage with the EU:

"The intensity emission target is strongly correlated with economic growth and industrial productions and may create more administrative burdens. And, intensity emissions target would have risks in lowering carbon prices in the linked market and creating distortions in competitiveness because it presents the flexible, controlling supply side of allowances in the market by the government."

3.5.3.2 Changes of elements shaped by competitiveness and market power

The elements of ETS in allocation method, covered entities, offset limitation, and penalty are required to be comparable prior the linkage because of pressures from international competitiveness and market power. However, these elements could be designed differently depend on jurisdiction's own characteristics if it comparable to their emission targets that would achieve in Kyoto Protocol and Paris Agreement. The changes in allocation and coverage appeared obvious because these two elements could directly link with economic performances and industrial costs, especially for intensity industries.

- Changes in allocation methods

According to the empirical case studies, it could show clear changes in the allocation methods during the linkage procedure. As different jurisdictions have different characteristics in energy suppliers, there was no strict standard for implementing the allocation method prior the linkage. For example, Quebec used average historical emissions intensity between 2007 and 2011 and adjusted for production output, while California combined produced-based and energy-based methodologies for distribution (ARB, 2006; ARB, 2011).

For Norway and EU linkage, the allocation “free of charge” for the Norwegian covered entities during the trading period 2008 to 2012 was calculated on the basis of the installations’ average historical emissions intensity between 1998 to 2001²⁷ (Norway Environmental, 2005) and it is different from the EU, which originally set up the common output-based allocation method.

After the linkage between Norway and EU, the EU ETS changed its allocation method in more significant auction preference initially held by Commission (Commission, 2011). The stakeholders in Brussels indicated the international competitiveness remained strongly considerations in the EU and for the linkage. The interviewers in Brussels indicated from the experience, the EU was prohibited windfall profits made by energy-intensity industries and carbon leakage by industrial relocation, thus the EU is seeking for specific assessment for allocation method with linkage partner in order to meet the mitigation target.

Furthermore, the stakeholder in Norway also indicated the economic concerns for different allocation method were the main motivation for regulators to follow EU ETS because EU ETS incorporates with EEA. The stakeholder mentioned:

“A lot of the stakeholders are talking about the competitiveness and it is a certain concern for industries in EU”.

²⁷ Source: Statistics Norway and the Pollution Control Authority. Nearly 80% of the total ETS emissions are from combustion installations and most of these emissions are from oil and gas extraction, gas processing plants and the production of plastic.

These competitiveness concerns are raised regarding the acceptability of making the link based on whether the certain energy intensity industries could receive additional supports from government by increasing free allocation to the industries. Large free allocation may facilitate reduction in competitive pressure by affecting carbon prices in a wider market.

- Changes in covered entities

Sector coverage refers to the portion of the economy that is regulated under emissions trading systems and identification of covered entities is the basic feature of the carbon market, which determines parties' needs to comply with their emissions (Sterk and Schule 2009).

From the cases, it is not important whether the covered entities or GHGs are identical for the linked system, but they need to be compatible, so that similar proportions of their economic activities are covered in the system. In the case of Norway's linkage with the EU, Norway implemented coverage in the design procedure, which included energy sectors in oil and gas, and petrochemical industries into ETS²⁸ to be compatible with EU ETS even though this makes carbon tax and ETS significantly overlap (IETA, 2015) The development of EU coverage in aviation industries codified in Directive 2008 and Norway also complied with the aviation industry (Commission, 2008).

Additionally, in the EU, two thirds of emissions were from the production of electricity and heat but Norwegian emissions from these categories were relatively small. However, the industries built on the natural resources of hydro power, oil and natural gas presented about 60% of the emissions. Thus, the Norwegian ETS expanded the scope of coverage in the industries in hydro power, oil, and natural gas to be comparable with EU ETS (Norwegian Ministry of Environment, 2008). For California and Quebec, although the scopes of their coverage differ, the proportions of coverage in emissions and economic activities are similar (ARB, 2010).

²⁸ Main sectors in Norway now responsible for GHGs: petroleum and energy, transport, the manufacturing industries, primary industries and waste management. The main purpose is to identify measures that will result in cost-effective emission reductions.

The stakeholders discussed more about the motivations for the Norway ETS implementations in coverage are from competitiveness problem for different coverage between the jurisdictions. The “competitiveness concern” is also a “main driver” for Norway to implement the coverage in the emissions trading system, which overlapped the industries already involved in the carbon tax system. The ENGO stakeholder indicated:

“As Norway is an EEA member, it is important to impose equally constraints on the productions in covered entities for mitigation.”

The stakeholders in academia also stated that differences in the coverage of industries even in GHGs are feasible, if the traded instruments are presented dominant equivalent as much tons as CO₂ equivalent emissions in the market. This also shows the explanations in the implementation for expanding scope of coverage in Norway in power and aviation industries

- Changes in offset mechanism-offset limitation

The literature cited offset mechanism as the critical element that must be harmonized and aligned in credit rules and protocols before the linkage (Sterk et al, 2009; Tuerk et al, 2009, Flachsland et al, 2009b, Burtraw et al, 2013). The compatible offset mechanism reflects comparable stringency of the programme. In the offset mechanism, there are two elements considered for the linkage: offset protocols and offset limitations. If alignment of offset protocols seems unattainable, a more rudimentary approach proposed in the literature is limitation on certain types of compliance instruments (Burtraw et al, 2013). Otherwise, the unaligned offset credits markets refer to injection of supply and risk for ‘freeing up’ of domestic allowances (Sterk et al, 2009; Zetterberg. 2012).

This fact also holds for the cases in California and Quebec, Norway and EU linkages. For California and Quebec, the offset protocols are different except ozone-depleting substance projects, but the limitations are the same for 8%. Norway and the EU both accept offset credits from CDM or JI, but Norway could use credits from nuclear projects, which is restricted in EU ETS. After the first phase, Norway implemented its limitation of usage to 20% and stopped using credits from wind and hydro to comply with the EU. The stakeholder from Brussels stated the reason:

“it would undermine the market mechanism and reduce the market efficiency and how many offsets are allowed need to be negotiated prior linkage”

The limitation of offsets is part of steering amount of allowances in the system and they influence the carbon pricing and economic performances for industries. For market function, the quantity of offset credits to trading market may have consequences for oversupply and carbon price drops.

- Changes in penalty

Penalties are essential to make acts of non-compliance unattractive to the covered entities (Mace and Anderson, 2009). The penalties in designed elements are not required to be the same. However, it requires to implement comparable sufficient enforcement for market participants in the system. Quebec and California both consistently applied WCI guidelines in penalties, but Quebec still increased the penalty to “per-ton” for compliance. The penalty for non-compliance in the EU was set to €100 per ton however increased with the European index of consumer prices in 2013 (Commission, 2015). Norway also implemented charges ranging from €40 to €100 to be the same as EU ETS prior to linking and raised the cost after 2013 (EDF, 2015).

The explanations in the literature argues that there is a risk of outflows of allowances from weaker enforcement systems to ones with stronger enforcement, which reduces the effectiveness of the market function (Haite and Mullins, 2001; Haite and Wang, 2006). The stakeholders also presented the same concerns about non-compatible penalties that covered industries. Meanwhile, the stakeholders also indicated that higher penalties in the system would incentivize covered entities to mitigation and active trading in the market. The stakeholder stated:

“if the penalty price was lower than the traded carbon price, industries play the game around”.

After 2006 carbon price in the EU ETS reached rock of bottom, the policy makers fear that the carbon price would fall again. Lower carbon price would significantly reduce the effectiveness of carbon market for environmental protections, particularly for energy-

intensives. In the report of the Commission (2011), it indicated the lower penalties would result in relocation industries in the less stringency regions.

3.5.3.3 Changes for equal share of responsibilities

The elements in offset protocols, covered threshold and GHGs, and banking are required to be consistent to support best practice for carbon market. The findings indicate that it is not essential for them to be compatible permit linking if the elements show the equal share of responsibilities based on their own economic and geographic characteristics.

- Limited changes in offset protocols

The linking offset mechanism indicates whether to recognize offset credits generated from the projects issued to use for compliance with each other (Burtraw et al, 2013). From the empirical examples, Norway and the EU have different offset protocols, especially in nuclear activity (European Commission, 2018; Norwegian Ministry of the Environment, 2008). The Norwegian ETS could accept the offset credits generated from nuclear generation projects while the EU rejects nuclear being involved in the system. California only allowed three protocols for the offsetting from 2012, while Quebec did not even have one similar protocol in its offset mechanism (ARB, 2011). However, it did not create a barrier for the linking. The document stated prior to the linkage, Quebec was introduced to the environmental integrity of projects by assessing with California staff (ARB, 2013).

The findings show the offset protocols can be different in two systems, but it is required to evaluate the environmental integrity of the projects. Thus, the differences in the types of offset protocols may not present significant difficulty in the linkage if the technical and environmental concerns in one emissions trading system have been discussed already with the other system.

The stakeholders indicated that it should be cautious about offset protocols chosen. The different protocols could generate cheaper offset credits from the non-allowed projects in the other system. For example, EU ETS restricted the rules of importing international credits from CDM. The stakeholder stated:

“For potential linkage with EU ETS, it needs for carefully determining the additionally. However, it not presents the barrier currently.”

- Changes in coverage threshold and covered GHGs

The scope of coverage includes coverage threshold and GHGs (Stavins, 2007). The findings indicated California and Quebec have the same coverage of GHGs because they both applied for WCI recommendation regulations thus there are no changes (ARB, 2006; ARB, 2013). While Norway and EU have different covered threshold for different industrial sectors and GHGs but these differences are acceptable (European Commission, 2007; Norwegian Ministry of the Environment, 2008). The EU ETS included CO₂ and N₂O emissions in the system while Norway contained additional one perfluorocarbons (PFCs) into the system (Norwegian Ministry of the Environment, 2008) from 2008 to 2012. In the phase III, the EU ETS added PFCs into the mechanism (Commission, 2015).

In the procedure, the differences in covered GHGs not influenced for the linkage decision-making. The stakeholders indicated the coverage threshold and covered GHGs are significantly related to economic size and main industrial activities in the regions. The linkage partners could have different coverage scope if the amount of GHGs in the mechanism has already covered the certain percentages of economic activities. The findings showed tightening the coverage such as including PFCs in the EU ETS has been viewed as a precautionary measure, as a part of effort to share the equal responsibilities to achieve the mitigation targets promised in PA.

- Changes in banking

The different rules in banking result in competitive advantages of carbon pricing over schemes. In the case studies, there was not much changes for California and Quebec as they already had the same limitation of holdings (ARB, 2011; ARB, 2016). However, in the case of Norway and EU, the changes of banking rules appeared after 2006 the EU carbon price dropped to zero (Commission, 2011). Before phase 2 in the EU ETS, the banking was not allowed and it changed in the end of phase 2 that unlimited banking could be allowed to hold for phase 3 (Commission, 2018). The Norwegian carbon market designed in not allowed banking credits from phase I to Phase II (Norwegian Ministry of the Environment, 2008).

The changes in the EU ETS in banking was because a significant oversupply in the phase I and II (Commission, 2011). The stakeholders indicated that banking rules were influenced for the carbon pricing and the mitigation efforts should equally burden by different unions dependent on their own situations. Interviewed stakeholder stated:

“Banking and price management influence the overall supply and demand in the market prior linking. They largely impact on environmental integrity and equally sharing burden. However, if there already exist stringent regulations in the trading system, banking and price management are not significant.”

3.5.3.4 Changes for market management

- Changes of joint auction process and tracking system

Prior linkages, the systems of California and Quebec, Norway and EU had their separate auction procedures and platforms. The changes appeared for establishing united auction and trading tacking systems in the earlier stage of linking (European Commission, 2015; ARB, 2015). The documents of linkage readiness reports by stakeholder’ consultations by the EU Commission indicated that in the initial stage of linking ETSs negotiations, the joint auction process and tracking system was already discussed before other elements such as offset mechanisms negotiated (European Commission, 2006). In the official linking document of the EU, it directly stated that Norway was required to join the auction platform by the EU in the first place (European Commission, 2009). This earlier requirement for joint mechanisms established also in the linkage readiness report of California and Quebec (ARB, 2013).

Meanwhile, in the linkage readiness report of California and Quebec, it clearly described the implementation process in joint auction finally facilitates the united auction price for both participants in their linked system regardless of currency exchange rates (ARB, 2013). The report also indicated that the joint auction process can reduce the administrative burden of operating linked ETS and improve the information transparency (ARB, 2013). This reason also found by the interview. The stakeholder indicated the joint auction system not only saves administrative costs but also makes it easy for regulators to project volume and control the auction revenues.

For the Norway and EU, the interviews by stakeholders referred the joint auction procedure and tracking system would maximum benefits for market practice and governmental control and stabilise for the trading and tracking carbon price. The stakeholders from EU also stated that the joint auction process and tracking system facilitate equal economic competitiveness but with medium risk to environmental integrity. The implementations in the joint auction process and trading platform are the technical challenges. If both systems have already designed a robust auction process and tracking system, full alignment is not necessary.

- Keep same in compliance period

Before the linkage, California and Quebec, and Norway and the EU already had the same compliance periods for trading (European Commission, 2007; Norwegian Ministry of the Environment, 2008; ARB, 2010; Ministry of the Environment of Quebec, 2018; European Commission, 2007; Norwegian Ministry of the Environment, 2008). From the start, the Norwegian ETS was designed into three phases to compatible with the EU ETS, which were phase I from 2005 to 2007, phase II from 2008 to 2012, and phase III from 2013 to 2020 (Norwegian Ministry of the Environment, 2008). In the linkage readiness report, it stated that difficulties can be raised if two systems have different compliance periods and the EU was required Norway to amend the ETS in June, 2007 and February 2009 to bring key features of the ETS were to compatible (Holton and Thea, 2011).

The stakeholder in Brussels explained an identical compliance period could convenience for managing the carbon markets, both for monitoring supply and demand of allowances in the emission trading system.

“The identical compliance period efficiently avoids industries playing the game around by using the new compliance period”.

Meanwhile, the stakeholder in EU also indicated if the government has a long trend of allocations, the same compliance period makes it much easier for government to provide compliance period allocation.

3.5.4 Summary Findings

After cases studies between California and Quebec, Norway and EU, the findings drew from documentary analysis of process tracing for identifying changes of elements and the structured interviews from stakeholders to explain the reasons. According to the findings, the key features in the carbon market design could be categorized into four subgroups based on different levels of changes and different motivations for changes, which is showed in the table 3-2 below.

Table 3-2 Summary of findings for changes in elements and motivations

Motivations	Elements in ETS		Changes California and Quebec	Changes Norway and the EU
Policy drivers	Registration		Disclosing all affiliated entities: “Know-Your-Customer” and new regulation in “Allowance Price Containment Reserve”	United registration and trading system for transparency and minimum transaction costs
	Emission Target		Set up absolute emission targets	Norway changed the emission target to absolute
Market management	Enforcement	Compliance period	Designed the same	Norway implemented to be same with the EU
	Auction	Auction process Tracking system	Changed to united auction platform	Changed to united auction platform
Economic competitiveness and market power	Allocation	Allocation method	Quebec adjusted for production output, California combined produced-based and energy based	Changed to increase auction percentages
	Enforcement	Penalty		
	Coverage	Covered entities	Keep differences but the coverage of economic activities is similar	Norway included more coverage in energy sectors to compatible with the EU ETS, expanding to aviation industry
	Offset mechanism	Offset limitation	Changed to the same limitation to 8%	Norway increased the limitation of usage and stopped using credits from wind and hydro
Equity	Offset mechanism	Offset protocols	Keep differences	Norway accepted the credits from JI

	Coverage	Threshold	Implemented to the same in the designing procedure	The EU added PFCs into mechanism
		Covered GHGs		
	Banking	Limitations of holding	Implemented to the same in the designing procedure	The Norway changed to restrictions in credits

Based on the findings, it showed a perspective that Norway presented interest-based adjustments with the policy convergence of the EU. The evidences in documents presented the trend from Norwegian ETS initial designed differed comparing to EU ETS but gradually changing the shape similar within the EU (European Commission, 2007; European Commission, 2009; Norwegian Ministry of the Environment, 2008). From the documents of Norwegian Government revealed that from 2001 afterward, the Norwegian pollution regulations have come and strongly correlated with EU because the EEA closer economic relationship (Norway Ministry of Foreign Affairs, 2014). At the same time, the trend also reflected in the process of Quebec ETS implementing regulations based on California existing ETS regulations (ARB, 2006; ARB, 2010; ARB, 2013). It is not surprisingly to see that Norway and Quebec, closely linked with the EU and California by economic and political ties, triggered the harmonization requirements for the carbon market designs in the climate policy.

3.6 Discussions

In the discussions, it begins with confronting with explanations between findings and literatures for the ETS design diffusion in the linkage by process tracing in the changes of ETSs' designs. Then the discussion turns to explore the implications for different diffusion mechanisms in the theory applying for the ETS convergence in linkage. The last section discusses the potential linking between EU ETS and China ETS with detected implications from findings and provides the practical recommendations.

3.6.1 Explanation variables and diffusion mechanisms

In the literature, the compatibility of the ETS designs are easier for the international linkage (Flachsland et al, 2009b; Tuerk et al, 2013; Ranson and Stavins, 2016). In the theory, the linkage could be viewed as convergence of climate policy diffusion on ETSs designs (Elkins and Simmons, 2005; Shipan and Volden, 2008). Meanwhile, the literatures also provided

explanations for ETS establishments and linkage based on the theory (Flachsland et al, 2009b; Hawkins and Jegou, 2014; Gulbrandsen et al, 2018). In the following section, it compared the explanations from literature and findings in this research by process tracing on the empirical case studies of Norway and the EU, and California and Quebec.

3.6.1.1 Elements changes due to market management for linkage

Tracking the design features in Table 3-2, the substantial ETS designs for linkage were examined. The findings showed the changes elements in united auction and enforcement of systems are motivated by convenience market management after linkage.

According to the literature, it explains that there could be a competitive advantage with trade implications if two systems have different auction processes in the first place (Blyth and Bosi, 2004; Burtraw et al, 2013) and it recommends harmonisation to reduce distortions and increase efficiency in the linked system (Sterk and Schule, 2009).

Comparing to the literature, besides the reasons already showed in literature for equally competitiveness to enhance market efficiency, findings also indicated an additional explanation for the harmonization in auction and enforcement systems for the linkage. The findings more emphasis on technical challenges for jurisdictions in preparing the best practice and easily implementation in practical for the relevant authorities. The reasons explained more for saving administrative cost and convenience for governmental management for carbon markets.

3.6.1.2 Elements changes due to economic competition and market power for linkage

From the findings, the elements in allocation method, penalty, covered entities, and offset limitation changed prior linkage due to economic competitions.

- Allocation method

In the literature, allocation method is a key element to determine which party could benefit from revenue generated from the linked system. Different allocation methods in grandfather or output-based model could result in a competitive advantage in international trading (Blyth and Bosi, 2004; Burtraw et al, 2013). The principle for allocation is to incentivize cost-effectiveness across different sectors (Flachsland et al, 2009b). Thus, in respect of reducing

distortions in economic competitiveness, it is recommended to be harmonization in allocation method introduced by linking (Sterk and Schule, 2009; Mace and Anderson, 2009; Burtraw et al, 2013). Meanwhile, the risks were identified for output-based allocation method, to encourage increasing production earning a larger allocation in the future (Tuerk et al, 2009a).

- Conflicts in scope of coverage

In the literature, there is no consensus on scope of coverage for the linkage. One side, the literature describes the differences in scope and coverage, including sectors and GHGs that are not problematic for the linkage as long as they feature transparency in registry and tracking to execute double counting (Goers et al, 2012; Burtraw et al, 2013; Metcalf and Weisbach, 2010; Mehling et al, 2017). On the other side, literatures argued that the differences in the scope of coverage would result in double counting and competitive distortions (Haite, 2003; Sterk and Schule, 2009; Goers et al, 2012; Metcalf and Weisbach, 2010; Mehling et al, 2017).

The findings found for elements in allocation method, covered entities, offset limitation and penalty are not necessary to be identical but it is required to be sufficient comparable because they have impact on economic competitiveness, which are similar with the literatures explained before. The greater the sector's exposure to international trading, the more the effect on it of linking in competitiveness between two jurisdictions. Industries, for example, in the EU that have higher exposure in their trading with Norway, will be limited in passing the additional carbon price passing-through to their consumers. In fact, 70% of the export in Norway was to EU market in 2004 (Statistics Norway, 2004). Thus, the relative economic position between Norway and EU influenced the consequences of Norwegian implemented designs for compatible depend on the rational choice based on the economic interests.

Industrial stakeholders in the EU stated that if the increased EUA price because of different allocation method or offset limitation led to higher product price compared to the Norwegian product price, then competitive distortions appear. The stakeholder from industry identified the potential international competition raised from different designs of carbon markets, indicated:

“We consider how to hedge the risks in competitiveness”.

Besides, competitiveness deterioration is related to the concern with the carbon leakage problem. The stakeholders in academia and government showed concerned:

“It is important to think how to measure the carbon leakage in the system and how to avoid the competitive distortions in the sectors in order to deal with the carbon leakage”.

3.6.1.3 Policy diffusion through economic competition mechanism

The theory of policy diffusion aims for understanding the process of policies are adopted with causal mechanisms to identify how ideas get transferred (Heggelund et al, 2019). In the policy diffusion theory, coercion, competition, learning, and emulation are key mechanisms to move ideas, norms, and policies for ETS designs (Gilardi, 2013). Meanwhile, the scholars also indicated the domestic and external drivers were also identified for the ETSs’ designs diffusion across jurisdictions (Heggelund et al, 2019).

According to the findings, the changes of ETS designed and implemented for linkage due to market management and economic competition are basically concerned by the economic competition mechanism of policy diffusion effects. It is showed in the stakeholders’ perspectives for the clear preferences to reduce the risks of being disadvantages positions when the industries are competing in the global marketplace. Especially for the case of Norway and the EU, as the stakeholder indicated the Norway is the member of EEA and EFTA, the Norway is motivated to integrate into the EU ETS. The compatible with the elements would provide an even global economic and regulatory playing field, which also mentioned by the literature (Skjarseth and Wettestad, 2008).

3.6.1.4 Changes of elements due to equity and sophisticated learning mechanism

In the findings, it indicates the elements in offset protocols, coverage threshold, covered GHGs, and banking are due to equity requirements as prior conditions for the linkage.

- Offset protocols

Literatures cited the harmonization of recognition of offset mechanisms including rules and protocols is a critical element that must be aligned and comparable before the linkage (Sterk et al, 2009; Tuerk et al, 2009; Flachsland et al, 2009b; Burtraw et al, 2013; Hawkins and Jegou, 2014; Stavins and Rasons, 2015). Although it appears the stricter condition for the harmonization in the offset mechanism in the literature, the findings showed that the significant consideration for the offset protocols is whether the protocol indeed presents sufficient additionally for the environmental integrity. Thus, even though the offset protocols are different based on each regional unique situation, the differences can be mutually acceptable in condition of equally stringency in environmental effectiveness of the projects.

- Coverage threshold and GHGs

literatures (Stavins, 2007; Sterk and Kruger, 2009; Burtraw et al, 2013) argued that aligning the coverage threshold and GHGs could reduce administrative costs and would have implications for their ability to link, but would not be essential for exchanging allowances across programmes. The findings indicated the similar for the elements in coverage threshold and covered GHGs that differences are not significant as a barrier for the linkage readiness. Taking example of California and Quebec, although the coverage threshold and covered GHGs are not identical, the total percentages of GHGs in overall covered in two systems are similar (Government of Quebec, 2009; ARB, 2010). The findings confirm an exceptionally important issue in two trading systems cooperating is the equal share of responsibilities in mitigation and distribution of costs and benefits.

- Cost management-banking

Cost management, which includes elements of banking and borrowing, is in the debate about environmental integrity and price management (Haite and Mullins, 2001; Sterk and Kruger, 2009; Tuerk et al, 2009) regarding the risks of carrying surpluses on into the future (Jaffe and Stavins, 2007). However, the quantitative restrictions in banking constrain the allowances for trading in the market, which is a piece of strategic management to address the relative effect on overall performance of the linked system. The findings presented banking rules will not influence the environmental effectiveness largely if there exists some limitations of usage and the emission cap is stringent. If the two systems show the criterion of mutual

equity in burden-share of mitigations and costs, there is no need for implementations in the elements.

3.6.2. Elements diffusion through sophisticated learning mechanism

In the literature, the diffusion in carbon markets could take form of different levels of sophisticated learnings, which include correcting the design flaws learning from other systems' failures (Gilardi, 2013). The learning mechanism in carbon market diffusion indicates positive response and appears in the early stage of development, especially for the governments with no experience in the relevant policy decision (Muller and Slominski, 2015). In the literature, the sophisticated learning enables more accurate differentiation to varying circumstances in the carbon market designs (Wetttestad and Gulbrandsen, 2018). This evidence showed in the changes and keeping different in offset protocols between Norway and the EU and different covered GHGs between California and Quebec. For example, the Norway learned lessons from the EU ETS phase I in banking and borrowing with strict limited of holdings however it contains the differences in the offset protocols depend on its unique natural resources.

3.6.3 Elements changes due to policy drivers

The changes of elements in registration and emission target are viewed by political driven as must pre-conditions for carbon market linkages. In literature, one reason coordination of emission targets with stringency is difficult is because it depends on how to define the "stringency" of the emissions target prior to linkage (Burtraw et al, 2013). From an efficiency perspective, if the levels of stringency for schemes set up the emission targets based on absolute numbers according to the same base year, the linkage is more straightforward for comparing the absolute targets between two systems (Mehling et al, 2018).

The compatibility of emissions targets is important for the linkage because the cap-and-trade programme is designed to support the attainment of the mitigation goals (Edenhofer et al, 2007; Marschinski, 2008). In the literature, there are two different types of emissions targets, which present in terms of absolute and intensity (Sterk et al, 2006; Green et al, 2014). Different types of emissions targets could pose problems in the linkage (Frankel, 1999; Kolstad, 2005). Although the linked systems are not required for the identical mitigation

targets, the compatibility refers to similar stringency of emissions reduction goals, which are equivalent to or stricter than between two systems (ARB, 2012).

From findings, it indicated that a clear assessment for mitigation efforts from both sides is required before an official political agreement on the linking between two emissions trading systems. Although literature shows the differences in registration and emissions targets could be categorized into technical challenges (Burtraw et al, 2013), the linkage might not be politically feasible because of these differences. According to the findings, the different designs in registration and emission target elements could create strong risks of increasing the overall emissions after linkage, even beyond the level under their own operating ETS independently, for example, the potential increasing the carbon leakage.

3.6.3.1 Political driver as intermediate factor for diffusion mechanisms

In the literature, the domestic political factors as intermediate factors and the domestic context as important determinant for the adaptations of the policies and ETSs' implementations (Biesenbender and Tosun, 2014). The roles of governments and domestic political parties play active in the innovative ETS design features. The scholar argued domestic political factor influences rejection or accepting the certain features in the ETSs designs as well as creating the new regulations to issue linkages (Gulbrandsen et al, 2019).

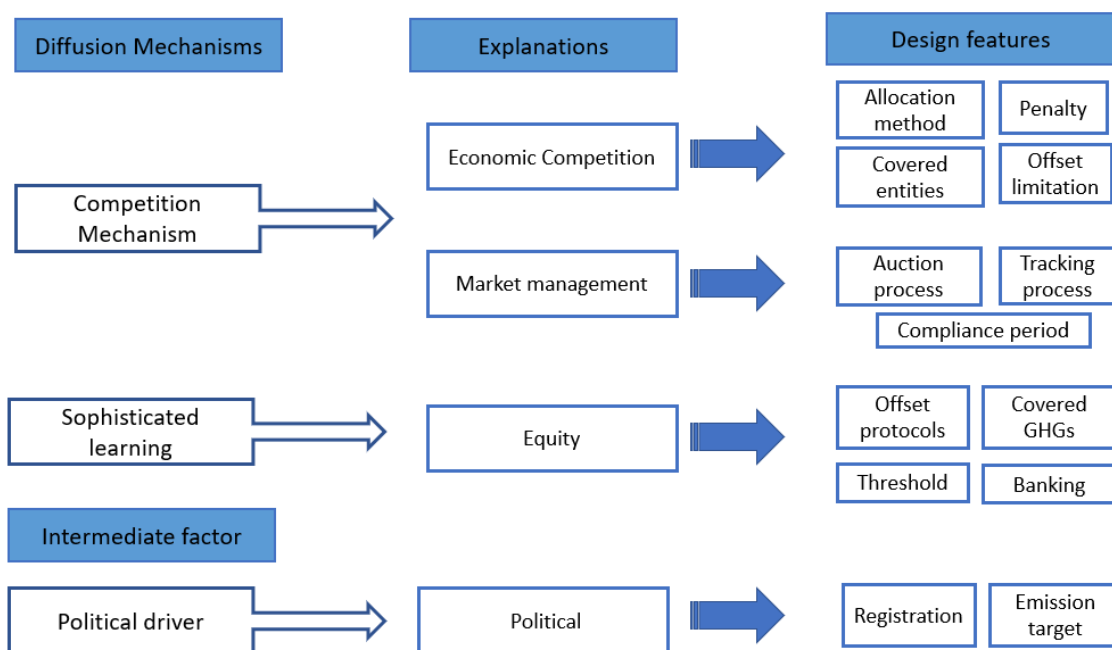
In this chapter, the findings showed the similar pattern with political drivers of certain ETS implementations for linkage as well. In the findings, it showed the harmonization in robust registration and comparable emissions targets are required in linkage because the elements are determined the stringency of the commitment. The policymakers could assure the relative efforts in comparable levels of emission reduction efforts between the systems. Thus, the compatible registration and emissions target ensure the political concerns on environmental integrity. The harmonization in the elements make the linkage politically possible, otherwise, the differences could direct result in preclude linkage in the first place. The document from the EU ETS (Commission, 2019) and stakeholder in Brussels revealed for political driver for compulsory absolute emission target:

“The absolute emission target is a must prior for the linkage as it is required from political concern”

Thus, the features in registration and emission target shaped by domestic politics, which act as mediate variable of international diffusion to designs and implementations. Scholars also indicated similar conclusions that the role of governments and institutions in certain domestic politics could change the direction of policy making in climate change and ETS designs (Harrison and Sundstrom, 2010; Beisenbender and Tosunm 2014).

Summing up, the table 3-2 below showed the diffusion mechanisms and external factor influence in the linkage process.

Table 3-2 Diffusion mechanisms and design features of changes for linkage



The discussions have focused on the relationships between diffusion mechanisms, intermediate factor, and the changes of designs of ETSs to link cross-border. As showed in the table, the economic competition and sophisticated learning as main diffusion mechanisms investigated in the findings and discussions. However, the features of the ETSs' designs also reflect the different adaptations with local conditions, which make the difficulties to link with other carbon markets.

To further step investigate how the diffusion mechanisms and political perspectives influence the design of ETS and linkage, the following section is focusing on the process tracing in the China ETS establishment. In the literature, it showed China has learnt lessons from the EU ETS to establish pilots ETSs and China national ETS (Duan et al, 2014). Thus, the following section has two aims. First, to detect the diffusion mechanisms by process tracing and compare whether the similar patterns also showed in the findings and discussions in the cases of California and Quebec, Norway and the EU. Second, to indicate how the diffusion mechanisms influence the feasibility of potential linkage between China ETS and other carbon markets in the future.

3.7 Policy diffusions investigated between China ETS and the EU ETS

There are literatures have investigated for the reasons of establishing pilots carbon markets in China and discussed institutions to incorporate implement seven ETS pilots preparing for national carbon market (Duan et al, 2014; Lo, 2016; Goron and Cassisa, 2017). However, there is less literature on the reasons and drivers for implementations and discussed for the diffusion in relation with ETS designed features changes (Lo, 2016; Heggelund et al, 2019). Thus, in this section, it first tested whether the establishing and implementing China ETS was also influenced by the diffusion mechanisms and fill the academic gap. Second, it aims to provide practical implications for whether the linking could be ready with the EU ETS in the future based on the findings.

China ETS is going to be the largest carbon market in the world in the future. Since seven pilots ETSs started designing to operation in China in 2014, EU has already provided the supportive (National Development and Reform Committee, 2015). The two regions have already cooperated in the ETS designs and sharing information with mutual learning the experiences in the carbon market (European Commission, 2018). In the literature, it identified the similarities of pilots ETS and existing ETSs to indicate diffusion. For example, the Shenzhen pilot ETS designs had more common with California's design, which proved to be diffusion by simple emulation (Heggelund et al, 2019). Thus, the diffusion effects and mechanisms may investigate in the China pilots ETSs establishment with the EU ETS. Meanwhile, it is a good opportunity to provide systematic suggestions for policymakers to make the domestic national ETS linkage ready preparing for the future cooperation in

practical implications because the details of the national ETS have not designed yet in China (National Development and Reform Committee, 2017).

In order to examine the policy diffusion mechanisms and how it influences for the linkage, the results based on the process tracing of implementations of ETSs by policy documents and interviews with key stakeholders in China, including government officials, academics, and experts, which detailed in the appendix IV. In this section, there are five specific designed features to determine the strength of the diffusion as these designs were made public at time of writing: (1) emission target, (2) allocation method, (3) offset mechanism, (4) coverage, (5) enforcement management.

3.7.1. EU and China Positions on Linking

The EU viewed its emission trading system as an important building block to the international carbon market establishment (EU Commission, 2012). EU legislation provides the possibility to link the EU ETS with other cap-and-trade systems in the world at regional or national level.

In November 2011, China developed seven pilots' emissions trading systems in Beijing, Chongqing, Shanghai, Shenzhen, Tianjin, Hubei, and Guangdong (National Development and Reform Committee, 2011). Among the seven pilot ETSs, the one in the Guangdong emissions trading system is the largest (National Development and Reform Committee, 2011). In 2017, China announced a plan to establish a national emissions trading system with the initial coverage of the electricity sector (National Development and Reform Committee, 2017).

From the document analysis in case of California and Quebec, the cooperation indicates the potential ability to enter into the official agreement. When developing the California emissions trading system, the California Air Resources Board (2006) indicated that linking with other cap-and-trade systems is desire. The linkage to California could enlarge the carbon market to contain aggregate emissions reductions with economic effectiveness, especially with the members under WCI (LAO, 2012). Similarly, Norway aimed to link with the EU ETS from the initial design of the emissions trading system and the elements in the compliance period and type of emissions target are designed for compatibility in the first place (Norwegian Ministry of the Environment, 2008). Although the international linkage is not a priority on the China policy agenda currently (Xi, 2018), China has already cooperated with

the EU in supportive assisting the projects in designs of pilots' and national emissions trading systems from 2014 until now (European Commission, 2018). Thus, the early cooperation between China and EU in carbon markets present a potential linkage readiness opportunity.

3.7.2 Designed features of ETSs

Based on the policy diffusion theory, the following contents show analysis of key features between individual carbon market designs in emission target, allocation method, offset mechanism, sector coverage, and enforcement management between China ETS and the EU ETS

- Relative Stringency of Targets

The emissions cap is the element that must be compatible and consistent for the linkage. However, the EU and China applied for different types of emissions cap. The EU set up an EU-wide emissions cap in absolute emissions reductions, to cut overall 43% of emissions relative to 2005 with an annually linear reduction factor of 1.74% (EU Commission, 2013). China committed to lowering the carbon intensity of GDP²⁹ by 60% to 65% by 2030, comparing the base year to be 2005 (National Development and Reform Committee, 2015). The explanation for main OECD countries setting up their absolute emissions cap is because they had already seen their emissions peak and start to decline (IETA, 2015). However, the developing countries setting up the intensity emissions cap relative to economic development because they will continue to grow with the potential emissions plateau in the future (World Business Council for Sustainable Development, 2012).

The EU concerns about the intensity of the emissions cap would result in relaxing the overall emissions after linkage. Currently, the EU and Switzerland have signed for a linkage agreement while the EU and Australia have also considered the possibility of linking their systems (EU Commissions, 2017). The conditions for linking with EU ETS include systems compatibility: they must have the same basic environmental integrity, a mandatory nature of the system and the existence of an absolute emissions cap (EU Commission, 2009). The EU requires an absolute emissions cap to reflect the policy priority in environmental integrity.

²⁹ The China intensity emissions target is measured by tCO₂/GDP.

However, due to different economic developments, the compatibility of the emissions cap in China appears no harmonisation with the EU ETS.

There are no diffusion effects investigated in the feature, however, it appeared more clearly that the emission target could be from domestic political driver. The emission target set up by China reflected the national conditions in economics, which the regulations were considered issues of differences in fairness. As the stakeholder in China stated:

“The intensity emission target is fully reflecting to our own situations with our own characteristics. And this decision was made by thoroughly researches from many regions.”

The literature suggested China should set transparent and predictable rules in the emissions cap and encouraging external stakeholders to assess the abatement efforts was proposed (Xi, 2018).

- Allocation Method

After the market reform of the EU ETS, free allocation to manufacturing industries will decrease from 80% to 30% in 2020, while power generators have not received any free allowances since 2013 (EU Commission, 2013). In China, although the allocation method has not announced yet, in pilots’ trading systems in China, free allocation is the primary method applied currently (International Carbon Action Partnership, 2019). Only Guangdong has already carried out auctions for industries but it only accounts for 5% in total. Auction is a complementary allocation method to Hubei ETS (National Development and Reform Committee, 2015). In the long-term, the aim for pilots’ ETSs allocation majority of allowances for free is considering the risks of potential carbon leakage happened (Xi, 2018). However, when it comes to the allocation method, the EU and China are currently far apart.

The allocation method of grandfather and auctions are emulating from the existing EU ETS however, the percentages of the free allocation are controlled. The large difference between these two systems in allocation revealed the competitiveness to help enterprises comply with the ETS regulations and increased the companies’ international competitiveness. The stakeholders in China have described the concerns of negative impacts of international

trading and distort product prices. The stakeholder from China indicated the learning procedure from the EU ETS from the allocation method:

“The EU shared the experiences with us to establish the carbon markets, including the carbon price management. We are learning the experiences from the EU ETS Phase I to prevent the carbon price dropped to zero, however, China is more willing to design the ETS regulations with its own characteristics.”

- Recognition of Offsets

As the EU ETS was oversupplying allowances in the market, it set up stricter rules for using international credits from CDM or JI (European Commission, 2011). The regulations stated the power station could not use the international credits to a maximum 4.5% of its verified emissions in the period from 2013 to 2020 and the aircraft operators in the EU could only use up to 1.5% of its verified emissions from 2013 to 2020 (European Commission, 2013). In June 2012, the National Development and Reform Committee (2012) released the rules in offsetting carbon emissions voluntarily by using credits CCERs from the offset projects, which the protocols are the same as CDM projects.

As noted in the findings, the framework indicates offset limitation for the linkage systems should be comparable. This is because when two systems are linked, the offsets recognised in one system will be available for compliance in the other since the offset credit and allowance are interchangeable. For China, the guidelines for the offset protocols could be a simple emulation form of diffusion from the international regulations in CDM methodologies, which also the EU ETS applied the similar guidelines.

- Sector Coverage

The EU ETS operates in 31 countries and covers about 11,000 power plants and manufacturing installations, which accounts for 45% of total EU GHGs (EU Commission, 2018) China national ETS will only cover CO₂ from its power sector first, but it accounts for 30% of emissions in total (National Development and Reform Committee, 2017). The scope for the national ETS is expected to gradually expand to an additional seven sectors, including aviation in the future (International Carbon Action Partnership, 2019).

Although the EU covers more sectors of entities than China, the percentages of total emissions in scope coverage are similar. Additionally, China covers the energy intensity industries as in the EU ETS. For the covered entities, whether to include aviation into the ETS is still discussed in China. Based on the literature argument, including aviation into the ETS was viewed as a kind of coercion from the EU (Heggelund et al, 2019). The Civil Aviation Administration of China indicated including aviation into the ETS would give the domestic airlines competitive advantages, however, the stakeholder in China insisted whether to expand the covered entities should regulate by own decision makers but not influenced by international guidelines.

“We learnt the lessons and tried to cover the certain percentages of economic activities into the ETS. We had communications with the stakeholders in the EU ETS with experience. However, the carbon price gave the airlines for competitive advantages and whether to include it into the ETS should China its own to make the decision, not asked or influenced by the other countries or other international institutions”.

- Enforcement Management

In the EU ETS, covered industries have a penalty of €100/tCO₂ imposed rising with the inflation rate if the companies fail to comply and surrender enough allowances (EU Commission, 2015). For the China national ETS, the punishment for non-compliance and the relevant information will be disclosed in the national credibility information system (National Development and Reform Committee, 2017). However, the details have not been developed yet. The rules in penalties in current existing pilots' ETSs in China are relative weaker than the EU ETS that Tianjin even has no penalty rule (China Beijing Environment Exchange, 2014).

The stakeholders in China indicated the stringency of enforcement management in national ETS could be stronger than any of the existing pilot ETS in China. From the interviews, it is clear to show that the enforcement management designed was motivation for industries to mitigate and the regulations of MRV and enforcement were learnt from the EU ETS in the early stages of pilots ETSs. However, when the regulations translated into Chinese own system, it should consider the economic situations and provided the enough support and preparation time for the industries to get ready for carbon prices.

“The EU ETS is an important model to learn. However, the regulations need to be modified comparing to Chinese own situations, especially giving sufficient time for industries to prepare for carbon costs and still left competitive advantages in the market.”

3.7.3 Summary for China and the EU

The summarized of elements in China ETS including the pilots’ schemes and EU ETS is presented in Appendix V. From the analysis of pilots testing stage and national ETS establishment stage, it was showed that the choice of ETS designs and sectors were influenced by domestic political driver, and the diffusion occurred from the EU ETS in the forms of competitive, emulation and sophisticated learning mechanisms.

In examine the process tracing of certain features of ETS designs in China, the officials learnt running pilots carbon markets by sophisticated learning from existing experiences from the EU in coverage and simple emulating guidelines in offset protocols and allocation method. From the stakeholders, it could be clearly viewed their acquired knowledge from the EU ETS assisted China to establish pilots ETs. However, when the regulations translated into China, the officials implemented the percentages of auction, coverage, and penalty costs based on local economic situations and international economic competitiveness considerations. Meanwhile, the national ETS establishment is not only learning from the international experience from the EU ETS, but also learning the lessons from internal pilots’ experiences. The diffusion appeared internal influenced to China carbon market as well. Furthermore, the domestic political driver is the main motivation for China to set up the intensity emission target, with significantly customized to domestic economic circumstances. The table below showed the ETS designs with implementations relating to diffusion process.

In aspect of practical implications for the linkage between the EU and China, the offset mechanism and scope coverage are different but comparable and could possibly be mutually acceptance for the bilateral linkage. Literature (Xi, 2018) discussed for flexibility in designs of penalty and offset credits usage that would allow the regulator to change the rules in response to requirements through linkage negotiation.

To make the cooperation more feasible, the transparency and a stricter allocation method are required to implement in China. The less stringency of allocation method would affect

the economic efficiency gained by linked system. Moreover, the emission target represents the political priorities in the climate policy. Thus, it is creating a significant barrier for the implementation in the future. For China, a “linkage ready” carbon market needs to implement in an absolute emission target.

However, the literature also argued that China has its own unique situation. Covered entities could not pass through the costs because the government still controls the energy and other energy-intensive commodity prices. Thus, for policy feasibility, China could set the foundation with regional neighbours now for cooperative opportunities in the future (Xi, 2018).

3.8 Conclusions

This chapter begins by exploring how the ETS diffusion effects the linkage as convergence outcomes between two different jurisdictions. Then this study proceed tracing with examination of changes across emission trading systems in the linkage procedure and compare their design properties in the empirical cases of Norway and the EU ETS, California and Quebec. For each change of designed feature, this study provides explanations and extents to discuss how policy diffusion mechanisms influence the implementations observed.

3.8.1 Theoretical contributions

The literatures have tried to explain the policy diffusion acting as motivation to design the similarities in certain ETS’s key elements and the harmonization of ETS designs could lead to linkage as an outcome (Mace et al, 2008; Flachslan et al, 2009; Goers et al, 2012; Zetterberg, 2012; Stavins, 2013; Burtraw et al, 2013; Gulbradsen et al, 2019). The literatures explained the reasons for designing ETSs but little work to show how the diffusion effects in the linkage procedure to implement ETSs. Meanwhile, in the literature, there existed different perspectives about whether the key elements such as absolute or intensity emission target should be harmonization prior the linkage (Ellis and Tirpak, 2006; Marschinski, 2008).

Thus, in this chapter, it answered the two research questions: which ETS properties are most likely to diffuse and implications of convergence in ETS designs. In the findings, it first reviewed the argument over conflict perspectives in ETS design and showed the emission

target as compulsory feature to be harmonization prior the linkage. At the same time, the features of coverage and offset mechanism were not required changes in the linking procedure. Second, the findings provided the detailed explanations for the changes in economic competition, market management, equality, and political drivers. Moreover, the findings indicated the economic competition and sophisticated learning as two main policy diffusion mechanisms to influence the changes. Additionally, the findings showed the changes of ETSs also reflected the local characteristics in nature and economic situations due to political concerns.

3.8.2 Practical contributions

This chapter provides the practical implication that it is crucial to prepare harmonisation of critical designed elements for future linkage readiness especially in the start early of ETS establishment. The case of China and the EU first reviewed and confirmed the findings from empirical cases that the sophisticated learning and economic competition as two main policy diffusion mechanisms to influence ETS designs. Meanwhile, the case also showed the practical implications from the findings that the earlier preparation for linkage would allow regulators and stakeholders to offer considerable adaptability and become more familiar with the elements of design.

In the designing and implementation procedures for the case of China and EU, it provides the suggestion for regulators in China to start from informal cooperation and information exchange with other jurisdictions first, and then to more formal arrangements on uniform standards and best practice on technical implementations of a linked trading system.

3.8.3 Research limitations

In order to advance knowledge regarding to the ETS designs diffusion in the linkage procedure, the study has collected data by process tracing only from relevant official archives. However, in reality, there existed multiple rounds of discussions in public consultants or higher-level dialogue prior the changes of the ETS designs for the linkage. This complex interaction is not addressed in this study. The unavailability of public open dialogue was problematic for the data collections and this may loss certain information in investigating factors effect for changes of features in the negotiations.

The other factor also needs to be noted, the self-selection of interviewed key stakeholders into the embedded cases to identify diffusion mechanisms, which may have resulted in the challenges. However, in this study, the major data is from official documents for process tracing of changes, which may reduce being less evident from self-selection of stakeholders in this study.

Chapter 4 Explore the Linkage Method of Carbon Markets

4.1 Introduction

Since 1997 the agreement of the Kyoto Protocol has tried to provide tangible value for the mitigation efforts in carbon markets through the projects undertaken in CDM and JI. However, this has faced increasing criticism for selling 'hot allowances' under KP in the emission trading mechanisms, which could strongly imply risks for the environmental effectiveness (Ellerman et al, 1998). In the post-KP world, the Paris Agreement proposed ITMOs to correctly account for the emission reductions and transfer between countries to meet their NDC achievements (Paris agreement Article 6, 2015). However, the ITMOs also face great challenges regarding robust accounting methods on matters of environmental integrity and governance (Mehling et al, 2018). Thus, how to recognise the mitigations and transactions 'authorized by participating Parties' in cooperative approaches is gradually discussed in the literature (Aldy Joseph, 2015).

Similar to the concepts developed in KP and ITMOs, incremental discussions for 'exchange ratio' as indirect linkage between two ETSs was proposed in the literature (Burtraw et al, 2013). A conversion rate of units was briefly introduced as a potential idea for linking different scope of rights for each unit and this could be based on amounts of greenhouse gas emissions (Mehling and Haites, 2009). However, different discussions took place among scholars about how to determine the 'exchange rate' that could be applied between the different carbon markets (Burtraw et al, 2013; Aldy, 2015; Marcu, 2017). An example of simply setting up an exchange rate of 1:1 or 3:1 for linking California and RGGI ETSs based on the electricity market model was initially illustrated in the literature (Burtraw et al, 2013). Yet, in the literature, it appeared to highly discuss the potential linkage method proposed for two different carbon markets, with reasonable carbon pricing for the right signal. This study aims to extend the existing literature for proposing a potential linkage method in exchange rate based on the literature reviews of existing linkage methods.

In this chapter, it has two research subjects, which are:

- *S1³⁰: What is the proposed linkage method in 'exchange rate'?*

³⁰ This is the first sub-research objective for Chapter 4.

- *S2³¹: How to compare the exchange rate linkage method with existing linkage method?*

The chapter begins with revealing the literature for the existing linkage methods, with identifying the advantages and disadvantages. The chapter also reviewed the literature in trading ratio for trading different pollution credits and methodology framework for equilibrium carbon pricing in the linked system and estimating emission transitions. The direction output function is applied to derive the quadratic form of marginal abatement cost curve with robustness tests. Meanwhile, partial equilibrium for aggregate supply and demand is used to estimate the supplier and importer in the linked system.

This study applies the empirical data from China and the EU for estimating the supplier and importer in the linked system. The result indicates that no matter in one-for-one trading ratio or proposed 'exchange rate' trading ratio, the EU will always be an importer in the linkage market as the autarkic marginal price of the EU is much lower than the regional marginal price. However, under the 'exchange rate' scenario, the quantity of imports will be effectively decreasing because the 'exchange rate' will result in increasing the equilibrium price based on the aggregate supply and demand.

After this introduction, section 4.2 introduces the background for the motivation of innovation in the linkage method for carbon market in the literature and the reason for taking China and the EU as a case study. Section 4.3 reviews the existing trading ratio in the literature and identifying the gap. Section 4.4 introduces modelling framework. Section 4.5 applies the models with panel data in China and the EU and 4.6 shows the results to estimate the equilibrium under two scenarios. 4.7 discusses the explanations for the results, governance, and political feasibility for exchange rate. Finally, Section 4.8 concludes for the theoretical contributions and policy implications.

4.2 Background

Since the past few years, much political effort has been geared towards establishing the global emission trading system. The framework for approaching linkage is widely discussed

³¹ This is the second sub-research objective for Chapter 4.

in relevant literature. Based on its characteristics linkage could be categorised into two processes, 'top-down' and 'bottom-up' (Zapfel and Vainio, 2002). 'Top-down' is defined as a centralised multilateral decision-making process under the UNFCCC framework; 'bottom-up' is a sub-national or individual decentralised decision-making procedure (Zapfel and Vainio, 2002). The top-down approach is a formal link with joint jurisdictions of participants while bottom-up is not a legally binding agreement with parties (Tuerk, Mehling, 2009). Direct linkage between two trading schemes can take several forms (Jaffe, Ranson and Stavins, 2010). Three direct linking methodologies exist for a top-down procedure: multilateral, bilateral and unilateral linkage. Indirect linking and linkage by degrees including sectorial linkage are bottom-up procedures. The linking mechanism either, direct or indirect, aims for recognising units for compliance and allows for adjustment of different types of tradable units (Bodansky, 2002). A step forward for efficiency perspective, economics applied the marginal abatement cost of emission reductions as a tool to provide a measure of stringency in the market (Zetterberg, 2012).

However, the direct linkage may conflict policy objectives in some market design features, requiring harmonisation. For example, a price cap could lower reduction costs but compromise simulation of technology innovations (Flachsland and Marschinski etc, 2005). Concern about the legal compatibility of negotiations with foreign authorities and sacrificing some political controls over the carbon market also has proven challenging for direct linking (Rason and Stavins, 2013). Compared with direct linking, developing indirect linking is preferable in the initial phase for establishing a joint trading mechanism with the fewest procedures for commitment. An incremental discussion of 'exchange ratio' as indirect linkage between two ETSs was proposed (Mehling and Haites, 2009; Burtraw et al, 2013; World Bank, 2016). A response to the failure of the top-down model, the Paris Agreement encouraged cooperation through individual jurisdiction coalition (UNFCCC, 2015). A conversion rate of units was briefly introduced as a potential idea for linkage of different scopes of rights for each unit; and this could be based on amounts of greenhouse gas emissions (Mehling and Haites, 2009). The conversion ratio enabled fungibility of carbon assets trading in a heterogeneous market to improve the liquidity of the carbon market and leverage new carbon investment (World Bank, 2015).

4.3 Literature Review

4.3.1 The Rational Signal from Carbon Price

4.3.1.1 Carbon Allowance

The pollutions seen as externalities failed to be captured in the cost of productions in the market (Stern 2006). To fix the failure of the market, government sets up binding targets and assigns property rights to the pollutions, which enable them to be traded in the carbon market (Stern, 2006). In theory, the environmental regulation is categorised in a command-and-control and market-based mechanism (Stavins, 2003). The market-based mechanism is putting a 'price' on pollution that indicates each firm could decide whether to reduce the emission or purchase the corresponding 'price' (Fischer, 2005). Regarding the concept of market-based regulation, the theoretical basis for the legal nature of emissions allowance represents the right to emit one tonne of carbon dioxide equivalent³² during a specified period (Stern, 2007). The other Kyoto GHGs could convert into carbon dioxide based on the Global Warming Potential (IPCC, 2007) and the total convert number in carbon dioxide is called carbon dioxide equivalent. Appendix VI shows the convert ratios between other GHGs and carbon dioxide.

4.3.1.2 Carbon Pricing

In the finance theory, the asset value is required for detailed analysis from market supply and demand, regardless of information and transaction costs (Fama, 1991). As for carbon allowance, the price is also determined by overall supply and demand. For example, the carbon price drops in the economic recession because of demand reducing and increases in the boom due to scarcity of supply (Baran, 2016). Similarly, for the linked carbon markets, the aggregate supply and demand determines the level of carbon price trading in the joint ETSs.

In the finance theory, an asset price could offer rational signal to the economy depends on whether the asset trading price is 'correct' reflecting its fundamental value. If the trading prices are far from intrinsic values, the arbitrages would attract too much or too little capitals to invest real needed resources (Lamont et al, 2003). Carbon allowances, as financial

³² The different Kyoto GHGs convert into carbon dioxide based on Global Warming Potential (IPCC, 2007). IPCC Fourth Assessment Report: Climate Change 2007. Intergovernmental Panel on Climate Change 9 (Cambridge University Press, Cambridge).

commodities trading in carbon market, share the similar features. In the literature, it indicated if the carbon allowance trading price is far from the true mitigation cost to reach the targets, the carbon price would not be seen as right signal for industries (Stavins, 2003). Additionally, if the capitals are not flowing into the right resources in the carbon market, the carbon leakage would happen (Stern, 2006).

In the literature, the scholars have already discussed the concerns of carbon prices after the linkage (Burtraw et al, 2013; World Bank, 2016) and indicate it is significant to forecast carbon price before the linkage happens (Aldy and Stavins, 2012). In the literature, it also indicated it is significant to reflect 'true value' in the carbon price to fairly sharing the burden of mitigations between the two jurisdictions (Flachsland et al, 2009). For example, the scholar argued the carbon price in EU ETS mismatched its true cost for pollution based on estimation of social cost for carbon in the linked union (Bayer and Aklin, 2019). Burtraw et al (2013) also illustrated one allowance currency in one carbon market may be worth or less than another because the different levels of efforts required for mitigations in different jurisdictions.

Although the literature stated the carbon price is not required to be equal to social cost of carbon or marginal abatement cost, the estimation for difference between the two is essential because carbon price measures policy efficiency. Too much deviations from the true costs of carbon could not provide the right signals for industries for sufficient mitigation activities (Bayer and Aklin, 2019). Thus, in empirical cases, governments have tried to control supply side in the single or linked carbon markets by justified quantities of allowances in the trading system.

For example, the European Union postponed the auctioning allowances in short-term and hold in market stability reserve in long-term to reduce supply side to increase carbon price (EU ETS, 2019). The California and Quebec linked system, strategic decrease the offset credits usages for compliance from 2019 to 2025 (California Air Resources Board, 2019). In the literatures, it also discussed options in setting up limitations of offset credits for compliances or constructing a conversion ratio to control the supply side of linked carbon markets (Burtraw et al, 2013; World Bank, 2018).

4.3.1.3 Trading Ratio in Emissions

The concept of trading ratio in carbon market has already introduced in the literature before. In the literature, the trading ratio refers to different number of permits required for exchange for each unit of emission from different sources (Montgomery, 1972). The scholars have argued the one-to-one trading ratio would not bring the optimize in the permit trading markets but introduced an exchange trading ratio in single permit market to improve efficiency (Muller and Mendelsohn, 2009; Holland and Yates, 2015). This concept of conversion ratio also discussed in the way of linking two carbon markets from the literature. The conversion ratio is defined as exchange rate altering the fungibility of jurisdictional abatement efforts and refers to exchange permits from two different carbon markets in the joint trading platform with certain ratio (World Bank, 2018). Burtraw et al (2013) proposed an example for California and RGGI exchanged carbon permits for linking. In the study, it examined the carbon pricing under assumptions of exchange ratio one-to-one and 3 to 1 in linking markets of California and RGGI. The results indicated the exchange ratio would change one jurisdiction position from importer to exporter (Burtraw et al, 2013).

The benefits of constructing trading ratio in the permit market could allow regulators to governance mixed pollution and implement existing permit market in size and scope (Holland and Yates, 2015). In the literature, the trading ratio is calculated based on marginal damage costs for different sources (Farrow et al., 2005) and Holland and Yates (2015) improved the model away from marginal damage costs but embedded with information asymmetries. In the study, it indicated the magnitude of the improvement for trading ratio model depends on how uncertainties the marginal abatement costs that the regulators need to consider (Holland and Yates, 2015). The marginal abatement costs also identified as important factor in linking two carbon markets. Quemin and Perthuis (2018) argued linkage with exchange rates based on marginal abatement costs could employ an adjust for different stringencies of jurisdictions with economic and non-economic criteria. In the study, it highlighted the exchange rates have potential to increase mitigation ambition over time and incentive for both jurisdictions moving to full linkage (Quemin and Perthuis, 2018).

Although the scholar pointed out the uncertainty in marginal abatement cost estimation, estimating in marginal damage cost also exists feasibility and uncertainty limitations. The literature discussed the difficulties for policy makers to know how certainty the damage from

different sources and still exists uncertainty to compare policy differentiation (Fowlie and Muller, 2013). Meanwhile, comparing to Holland and Yates (2015), the exchange rate allows for one carbon allowance presenting for uniformly or non-uniformly mixed of pollutions and expands the concept from the single permit market. Moreover, Fowlie and Muller (2013) showed in theory, limited differences between expected and realized abatement costs in emission trading regime.

Thus, in this chapter, the exchange rate defines to alter relative compliance value of permits leading to full link and follows Quemin and Perthuis (2018) applying the partial equilibrium model in a deterministic framework but improved the model with quadratic-form of marginal abatement cost functions applied in the literature (Fowlie and Muller, 2013; Holland and Yates, 2015). The marginal abatement costs are adjusted for the exchange rate in equilibrium.

Furthermore, in the literature, although it proposed the methodology for the exchange rate (Burtraw et al, 2013; World Bank, 2018; Quemin and Perthuis, 2018) , it is lack of discussions over how the exchange rate implies for linking carbon markets from political feasibility perspectives. Thus, this study provides a case study between China and EU with numerical results and policy discussions to understand two research questions:

SQ1: How to measure exchange rate for linking carbon markets?

SQ2: What exchange rate implies for linking two carbon markets from political feasibility?

4.4 Modelling Framework

There are two emission trading systems 1 and 2 to regulate mixed pollutions. Let e_i denotes the emissions level for two jurisdictions, with $i \in \{1,2\}$. For generality, the two jurisdictions will have emissions under business-as-usual, BAU_i with $i \in \{1,2\}$. The two carbon markets have binding caps set up by governments, w_i with $i \in \{1,2\}$. Thus, each jurisdiction has to face the abatement amount $\alpha_i = BAU_i - w_i \geq 0$ with $i \in \{1,2\}$ to meet the mitigation target.

The abatement cost functions are $C_i, i \in \{1,2\}$. In the theory, the marginal abatement cost curve is convex with a positive slope because it indicates that when one additional abatement occurs, the more the cost for the mitigation, as the higher costs for the

technologies need to apply (McKinsey, 2009). Scholar argued the governors aim to minimize compliance costs in the full linkage between the two carbon markets (Flachsland et al, 2009).

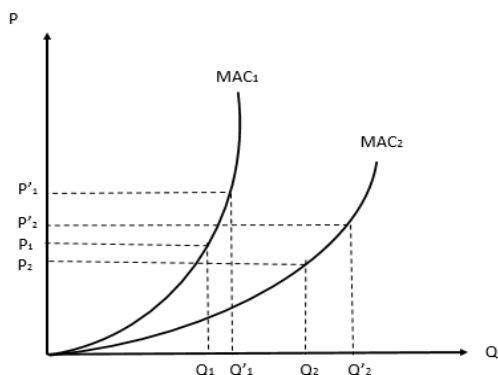
$$\min_{e_i, i \in (1,2)} \{C_1(BAU_1 - e_1) + C_2(BAU_2 - e_2)\} \quad \text{subject to } e_1 + e_2 \leq w_1 + w_2 \quad (1)$$

Let ρ presents the exchange rate in allowances in jurisdiction 1 converted into allowances in jurisdiction 2, with $\rho > 0$. Thus, each unit of allowance in ETS 1 is equal to ρ unit in ETS 2. Based on the formula (1), the condition transfers to $\rho e_1 + e_2 \leq \rho w_1 + w_2$. Thus, to minimize joint compliance cost in the full link carbon market equals to:

$$\min_{e_i, i \in (1,2)} \{C_1(BAU_1 - e_1) + C_2(BAU_2 - e_2)\} \quad \text{subject to } \rho e_1 + e_2 \leq \rho w_1 + w_2 \quad (2)$$

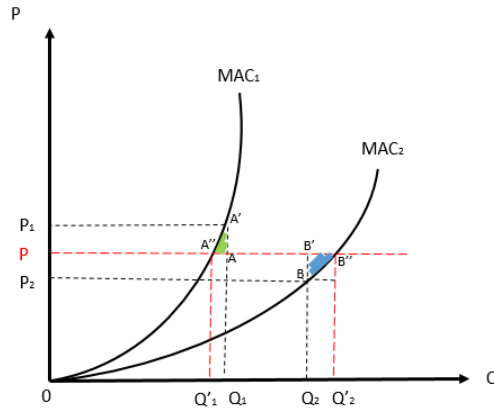
The different regions have different shapes of marginal abatement cost curve as it reflects the different costs of technological options available for mitigations in the regions (Ellerman and Decaux, 1998). For example, Figure 1 illustrates two different MACs for ETS 1 and ETS 2.

Figure 4-1: Two Regional Different Marginal Abatement Cost Curves



In Figure 4-1, ETS 1 the emission reduction commitment is Q_1 with an autarkic marginal price of P_1 where region two has the less marginal cost of P_2 of Q_2 reduction. The additional mitigation efforts are shown in $(Q'_1 - Q_1)$ and $(Q'_2 - Q_2)$ with respect to the costs increasing in $(P'_1 - P_1)$ and $(P'_2 - P_2)$. Under the full linkage, the MACs in ETS 1 and ETS 2 presents as below

Figure 4-2: MACCs after linkage



The number of total emission reductions is $(Q_1' + Q_2')$. The abatement cost for region one is the area of $(OAA''Q_1)$ and the mitigation cost for region two is the area of $(OBQ_2 - BB'B'')$. Under the full linkage, the exchange rate for two ETSs could be one to one or with the ratio $\rho > 0$. From the Figure 2, it shows for ETS 1 imports cheaper allowances from ETS 2 in reducing the cost in the area of $(AA'A'')$ while region 2 gains from the exporting allowances in the area of $(BB'B'')$. To achieve the mitigations, the mitigations $(Q_1' + Q_2')$ should be equal or larger than the original mitigations from two regions of $(Q_1 + Q_2)$.

If we assume the variation emissions between the two ETSs after the full linkage is $\Delta_i(\rho) > 0$, with $i \in \{1,2\}$, $\rho \in [0,1]$. At the equilibrium, the amount of emissions transfer between the two ETSs is $-\rho\Delta_1(\rho) = \Delta_2(\rho)$ as ETS 1 is the importer under the full linkage with the exchange rate ρ . Thus, for the linked carbon market, the governor tries to obtain the minimize mitigation cost in:

$$\min_{e_i, i \in \{1,2\}} \{C_1[BAU_1 - e_1 - \Delta_1(\rho)] + C_2[BAU_2 - e_2 + \rho\Delta_1(\rho)]\} \quad \text{subject to } \rho e_1 + e_2 \leq \rho w_1 + w_2 \quad (3)$$

When the linked market achieves ρ -equilibrium, $\rho \in [0,1]$, the characteristic in first condition is:

$$C'_1[BAU_1 - e_1 - \Delta_1(\rho)] + \rho C'_2[BAU_2 - e_2 + \rho\Delta_1(\rho)] \quad \text{subject to } \rho e_1 + e_2 \leq \rho w_1 + w_2 \quad (4)$$

According to the Figure 2, at the ρ -equilibrium linked market, the equilibrium price P^* is characterized by:

$$C'_1[BAU_1 - e_1 - \Delta_1(\rho)] = P^* = \rho C'_2[BAU_2 - e_2 + \rho \Delta_1(\rho)] \quad \text{subject to } \rho e_1 + e_2 \leq \rho w_1 + w_2 \quad (5)$$

According to the formula (5), the jurisdiction marginal abatement cost curves are adjusted with exchange rate in the equilibrium.

4.4.1 Methods for Marginal Abatement Cost Curve

In the formula (5), the first derivatives of abatement cost functions $C_i, i \in \{1,2\}$ represent for marginal abatement cost curve (MAC) function. In the literature, the direct mitigation efforts are reflected in marginal abatement cost curve (MACC) in different regions (Ellerman and Decaux, 1998). The marginal abatement cost determines marginal and average costs for emission abatement and illustrates potential benefits from emission trading of linking various regions. In the literature, the marginal abatement cost curve could either derive from a top-down procedure by the CGE³³ model or a bottom up procedure based on technologies (Ellerman and Decaum, 1998; Kesicki, 2010).

4.4.1.1 Bottom-up Approach to MAC Curve

The expert-based approach built upon the assumptions proposed by experts from technical perspectives that supported developing the baseline of emissions and potential costs for the corresponding emission reductions. The benefits for the expert-based MAC detailed for the extensive technologies with easy understanding of the specific technology abatement curve (Kesicki, 2010). McKinsey (2007) first derived the global marginal abatement cost curve from a bottom-up procedure for the pathway to achieve emission reduction based on different technologies chosen. However, the bottom-up technical model has been criticised for limited

³³ Computable General Equilibrium.

information disclosure in baseline estimation methodology and providing no responses to macroeconomic feedbacks (Ellermand and Decaux, 1998).

4.4.1.2 Top-Down Approach to MAC Curve

Compared to the bottom-up procedure, a top-down approach derives the marginal abatement cost from summarising the CO₂e price and absolute emissions level in respect of the carbon price (Ellermand and Decaux, 1998). The first top-down MAC model was generated from Emissions Prediction and Policy Analysis (EPPA). The literature assessed the robustness of MAC that the abatement cost in a region is largely independent of the other regions (Ellermand and Decaux, 1998). The regional abatement efforts have no relationship with other regions no matter how close the geographic locations or differences in the trading schemes and extent of the market. The robustness indicates that at time T, the region has a unique marginal abatement cost curve (Ellermand and Decaux, 1998). However, the drawbacks of the top-down approach for the MAC curve are lack of technological details and possibly unrealistic implications for the physical applications (Kesicki, 2011). Meanwhile, the top-down approach does not capture all effects of emission trading.

4.4.1.3 Directional Output Function

Coggins and Swinton (1996) applied the directional output function to estimate marginal abatement costs of sulphur dioxide for fourteen coal-burning industries. Reig-Marinez et al (2001) used the method to present the structure of production technology and created a productivity deviation index for estimating marginal abatement costs based on 18 local ceramic producers. Recently, the directional output function has been applied to estimate the integration of regional MACs. Du et al (2015) constructed the integration marginal abatement cost curve based on the integration of thirty provisional panels data in China.

Comparing with top-down procedure and bottom-up procedure to estimate the MAC curve, the directional output function applies better in developing countries or for specific industries (Wang and Wei, 2014b). The directional output function only required to access for productions and emissions panel data, which benefits with limited information available, and lead to reduce modelling fitting errors (Wen and Wu, 2011). For example, empirical studies measured MACs by directional output function in power, waste, and water industries in Canada and for 30 Chinese provinces (Chen, 2010; Wen and Wu, 2011; Zhou et al, 2014).

Furthermore, the production-based approach is estimated based on the production structure in one region, which covers all the regulated entities in the emission trading system. The model enables capture of the characteristics of the region in trends. Compared with the top-down approach in CGE models, the analysis based on the directional output function is straightforward and it is not necessary to respond for the whole economy. The approach for estimating the abatement costs in the directional output function is more transparent compared with the technical bottom-up approach.

4.4.2 Model for Estimation Marginal Abatement Cost Curve

The directional output distance function (Fare et al, 2002) represents the theoretical framework underlying production technology. In the model, it introduces the inputs to the productions generating a set of possible outputs, which contain the good outputs and bad outputs. The good outputs in the literature refer to one unit of GDP growth (Du et al, 2015) and the bad outputs refer to the pollutions. In the model, let $y = (y_1, y_2 \dots \dots y_n) \in R_n^+$ denotes the good outputs and $b = (b_1, b_2 \dots \dots b_n) \in R_n^+$ denotes a vector of bad outputs. $x = (x_1, x_2 \dots \dots x_n) \in R_n^+$ represents the inputs. The possibilities of the set of outputs produced by the technology is described as:

$$P(x) = \{(y, b): x \text{ can produce the set of } (y, b)\} \quad (6)$$

The function is bounded and closed, convex shaped according to the theoretical properties (Fare et al, 2002). Thus, if $P(0) = \{0,0\}$ and more inputs of production go with more set of outputs, that if $x' \geq x$, then $P(x') \supseteq P(x)$.

The properties for the good output and bad output are satisfied as follows (Marklund and Samakovlis, 2007):

First property: If $(y, b) \in P(x)$ and $0 \leq \theta \leq 1$, then the $P(\theta y, \theta b) \in P(x)$

The first property assumes that if it holds the input fixed for the productions, it is feasible to reduce one output by reducing proportionally the other outputs in the set as well.

Second property: if $(y, b) \in P(x)$ and $y' \leq y$, then $(y', b) \in P(x)$

The second property assumes that if it holds the input constant for the production, reducing of good output in the production can be without reducing the quantities of other outputs.

The two theoretical properties indicate that if we hold the input constant, reducing quantities of good outputs can be done without reducing the amount of emissions. However, reducing the amount of emissions must be done along with decreasing the proportion of quantities for good output in terms of revenue simultaneously. The properties refer to each bad output like emission commands on its own shadow price (Fare et al, 2002). Let the β is the maximum of expansion of the good outputs and contraction of bad outputs for the given technology production. The vector $(g_y, -g_b)$ represents the direction of the output vector. Then the directional output function is defined as:

$$D(x, y, b; g) = \max_{\beta} \{ \beta : (y + \beta g_y, b - \beta g_b) \in P(x) \} \quad (7)$$

Based on the directional output function, it could derive the shadow price by applying the revenue function. Let $p = (p_1, p_2 \dots \dots p_n) \in R_n^+$ to present the prices of the good, and $q = (q_1, q_2 \dots \dots \dots q_n) \in R_n^+$ to present the prices of the bad outputs, which refer to the cost of emissions.

The revenue function could be written in terms of good output and bad output:

$$R(x, p, q) = \max_{y,b} \{ py - qb : (y, b) \in P(x) \} \quad (8)$$

According to the direction output function (6), the possible set of outputs is:

$$(y, b) \in P(x) \text{ if and only if } D(x, y, b; g) \geq 0 \quad (9)$$

Thus, replace Formula (9) in Formula (8), then we could get:

$$R(x, p, q) = \max_{y,b} \{ py - qb : D(x, y, b; g) \geq 0 \} \quad (10)$$

Fare et al (2002) show that the directional output function could be rewritten in:

$$D(x, y, b; g) = \min_{p,q} \{ R(x, p, q) - (py - qb) / (pg_y + qg_b) \} \quad (11)$$

The calibration of Formula (11) to obtain the MAC is to apply the envelope theorem in the theory of productions, which yields:

$$\frac{\partial D(x,y,b;g)}{\partial y} = -\frac{p}{(pg_y+qg_b)} \leq 0 \text{ and } \frac{\partial D(x,y,b;g)}{\partial b} = \frac{q}{(pg_y+qg_b)} \geq 0 \quad (12)$$

The marginal abatement cost is expressed by taking partial deviation of y and b on equation (11)

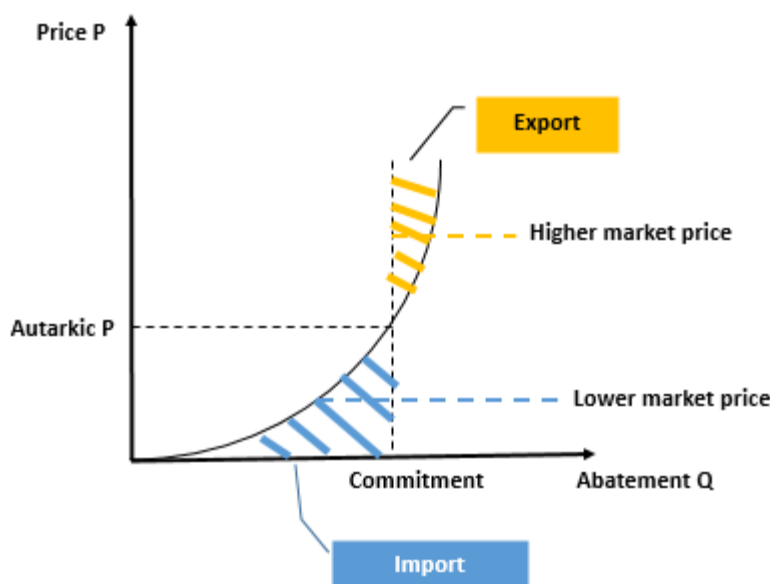
Then the marginal abatement cost could be calculated presenting in Formula (13):

$$C'_i = -\frac{y_m}{b} \left(\frac{\frac{\partial D(x,y,b;g)}{\partial b}}{\frac{\partial D(x,y,b;g)}{\partial y_m}} \right) \quad (13)$$

It assumes that in the perfect competitive market, at least one output P could be sold at the price y_m . The output direction vector $(g_y, g_b)=(1,1)$, which indicates the model seeks to expand the one good output presented in GDP and to reduce one bad output presenting the tonne of emission abatement.

The equilibrium of the aggregate supply and demand are summing up the amount of regional committed abatements and allowances issued. Figure 4-3 shows that the market price and the committed shadow price determine whether one region is a supplier or an importer in the carbon market. After estimation marginal abatement cost $C'_i, i \in \{1,2\}$ based on equation (13), it could estimate the equilibrium after linkage based on equation (5) for variations transferring from ETS1 to ETS2 with exchange rate $-\rho\Delta_1(\rho) = \Delta_2(\rho)$.

Figure 4-3: Regional Imports/Exports for Carbon Allowances



4.5 Data

4.5.1 Data Resources

The penal data for China and the EU are collected from the 2017 China Statistics Yearbook and the Eurostat respectively. The data applied for China is aggregated from 30 provinces³⁴

³⁴ The China aggregate data from 30 provinces excludes Tibet because the data is unavailable.

from the year 2001 to the latest update data available for 2016; the data applied for the EU is aggregated from 28 EU members³⁵ in the same time period as China.

To derive the marginal abatement cost, the first step is to estimate the shadow price in the directional output function, shown in Formula (13). The variables of input and output are required for the function. In this study, we apply the input variables in capital, labour and energy for the production activities. The good output is GDP and the bad output is the emissions generated from the production procedure. The direction vector (g_y, g_b) is (1,1) in this study, which is applied in the literature for estimating the integration of MAC (Du et al, 2015).

4.5.2 Measurement of Emission Reductions

4.5.2.1 Emission Targets

The EU baseline emission target is 5650.4 million tonnes of CO₂ equivalent in the base year 1990 according to the panel data from Eurostat. In the first Kyoto Protocol commitment period, 2008 to 2012, the EU-15 members agreed to 'burden-share', reducing absolute emissions 8% below the 1990 base year level (EU Commission, 2018). In 2012 the EU over-achieved the mitigation target by decreasing nearly absolute 19% emissions compared with the 1990 level. In the second Kyoto Protocol commitment period, from 2013 to 2020, the EU members agreed an even more ambitious mitigation target to reduce absolute 20% emissions below the 1990 base-year level (EU Commission, 2018). From the calculations of total emissions in million tonnes CO₂ equivalent, the EU met the mitigation target in 2017, which reduced the absolute 22% below the level of the base year.

China as one of the non-Annex I countries of the Kyoto Protocol, had no emission commitment until it adopted the Copenhagen Accord (NDRC, 2009) in 2005, which committed it to reduce overall by 2020 its CO₂ intensity target per unit of GDP by 40% to 45% below the base year 2005 level. In September 2016 China committed in the Paris Agreement to lower its carbon intensity target by 2030 to below 60% to 65% compared with the base year level (NDRC, 2016). In 2017, the National Development and Reform Committee announced that China had met the intensity target, which was three years ahead of schedule

³⁵ The first period of Kyoto Protocol commitment is for the EU 15 members; however the members had expanded to 28 by the second period of the Kyoto Protocol commitment.

(NDRC, 2017). According to the emissions calculated based on the IPCC guidelines (2006) in fossil fuel consumptions, it indicated that absolute emissions were increasing until the year 2016. From 2017 absolute emissions appeared to be decreasing. However, as China set up the intensity emission target, the overall emission reductions in absolute quantities are significantly influenced by continuously growing GDPs from the base year 1990 to 2017.

4.5.2.2 Measurements of Emissions

The measurement of CO₂ is estimated based on the guidelines under IPCC Fourth Assessment Report (2007). The total quantity of emissions generated is associated with the different activities, which presents as:

$$emission_i = Activity\ or\ production\ rate \times EF_i \quad (14)$$

Where the emission factor is a representative value relating the quantity of the pollutions to the atmosphere associated with the activities taken places. Although the technology in different plants could be the same, the different ways of operation could result in different emission factors (Olague, 2017). The emission factors shown in the IPCC Emission Factors Database depends on a continuously iterative revised process estimating the average value of emission factor for treating the same activity based on national level (IPCC, 2007).

In this chapter, we assume the activity or production rate is based on the fossil fuel consumptions for the total number of end productions generated. Thus, Formula (12) could be replaced by estimating, which illustrates:

$$emission_i = \sum_{j=1}^i FUEL_j \times NCV_j \times EF_j \quad (15)$$

Based on the IPCC (2007) guidelines, $FUEL_j$ is the fossil fuel consumed for the production activities. Then the total $emission_i$ is converted to the CO₂ equivalent based on the GWP shown in the Appendix VI.

$$GHG = \sum_i^n emission_i \times GWP_i \quad (16)$$

Thus, the emission reduction (ER) equals to

$$Emission\ Reduction\ (ER)_i = Emissions_i - Emission\ Target_i \quad (17)$$

Where $i \in (1,2)$

4.5.3 Production Inputs and Output Variables

4.5.3.1 Input Variables

The capital variable in the directional output function is not available from the Eurostat or Yearbook. In the literature the annual capital investment is estimated by depreciating the investments to the starting year (Du et al, 2015; Fu et al, 2015). In this study, the annual capital investment is based on the capital return cost, which depreciates the capital to equal annual investments to the starting year 2001.

$$CRC = PV \times \frac{r \times (1+r)^i}{(1+r)^i - 1} \quad (17)$$

Where the CRC is the depreciated capital, PV is the present year capital investment; r is the depreciated rate, which in this study is applied to the long-term interest rate, and i is the number of years back to 2001.

From the penal data in the European Central Bank and People's Bank of China, the long-term interest rates are 1.31% and 4.35% respectively. The input data of capital investments for both China and the EU are calculated based on Formula (17), shown in Appendix VIII.

From the data it is clearly seen that China has expanded capital investments in a continuously increasing trend from the year 2004 to 2017. While the EU also shows gradual growth, however, its invested capital dropped quickly and dramatically in 2009 when the financial crisis happened.

The input of data for labour is measured as the number of employed persons at the end of each year; the data is from the Eurostat and China 2017 Yearbook. Energy consumption presents the standard coal equivalent for each year, which could be obtained from the China Yearbook. Energy consumption is measured in the thousands of tonnes of oil, which could be obtained from the Eurostat.

4.5.3.2 Output Variables

GDPs are obtained from the penal data in the 2017 China Yearbook and the Eurostat. According to the literature (Zhou et al, 2013), the output of the GDP is deflated to the base year price. Thus, each year of the GDP is deflated to the base year 2004 price to net the inflation effects in both China and the EU. Based on the data from the Eurostat and Yearbook,

the EU and China GDP deflators for 2017 are 1% and 4% respectively. The higher GDP deflator in China compared with the EU is because its economic growth is much quicker than in the EU in the time period.

The output of emissions is calculated based on Formula (13) and Formula (14). In this study, the emission estimation in China includes eight types of fossil fuel consumptions based on the Yearbook. The eight fossil fuels are coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil and natural gas. Each of the fossil fuels consumed could generate the amount of GHGs in CO₂, CH₄ and N₂O by different emission factors (China Yearbook, 2017). Compared with China the total energy consumption in the EU is highly dependent on the usage of crude oil and natural gas. Emissions for each year in China and the EU are presented in Appendix VIII.

Before conducting the shadow price, the input variable capital investment and the output variables in GDP and emissions show a similar trend. Especially, this is clearly pointed out for the year 2009 in the EU, which could be because it was the year the financial crisis happened, leading to reduced capital investments in production activities, which would result in decreasing GDP and emissions simultaneously.

4.6 Results

4.6.1 Unit Root Tests for the Variables

Before the estimation of the regression model, the unit root test is applied for dependent variables and independent variables for the robustness of the regression. In this study, the Augmented Dickey-Fuller Test (2002) is applied to check the unit roots and stationery for the variables with at least one leg. The null hypothesis for the ADF test is that the variable contains a unit root, and the alternative hypothesis is that the variable is stationary. The results of the unit root tests are shown in Appendix XI for variables of the EU and variables of China. According to the results, showing the unit root tests for the dependent and independent variables of China and the EU, the p values are small and all passed the t-tests under 95% significant level, which indicates that the variables are stationary and the quadratic form of regression for the marginal abatement cost curve could be estimated.

4.6.2 Marginal Abatement Cost Curves for China and EU

Based on the CO₂ emissions, input variables and output variables, the MAC could be derived by Formula (13) from the directional output model with respect to the different emissions. The results of MACs are fit for the quadratic forms, which is the form³⁶ commonly derived from directional output model for MAC in the literature (Coggins and Swinton, 1996; Ellerman et al, 1998; Marklund and Samakovlis, 2007; Lee and Zhang, 2012; Du et al, 2015; Fu et al, 2015).

For the EU MAC, it could be seen that variable emission reduction (ER) is significant to the abatement cost, in which the t-statistic is much greater than the critical value under 99% significant level and the coefficient is 0.0217. Thus, the marginal abatement cost curve for the EU is represented in:

$$MAC_{EU} = 0.0217ER^2 + \varepsilon, \text{ where } \varepsilon \text{ is the residual}$$

Table 4-1 for EU MAC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER2_TO_THE_BASE_YEAR	0.021742	0.000390	55.80559	0.0000
EU_ER_TO_BASE_YEAR_MT_	0.008724	0.701244	0.012440	0.9903
C	32.47117	279.0111	0.116379	0.9097
R-squared	0.999943	Mean dependent var		22572.46
Adjusted R-squared	0.999931	S.D. dependent var		13991.82
S.E. of regression	115.8762	Akaike info criterion		12.54210
Sum squared resid	134272.9	Schwarz criterion		12.67247
Log likelihood	-78.52362	Hannan-Quinn criter.		12.51530
F-statistic	87475.44	Durbin-Watson stat		3.202149
Prob(F-statistic)	0.000000			

Comparing to the EU, the China MAC is estimated variables of ER^2 and ER are significant to the abatement cost, in which the p values are small and t-statistics values are much higher than the critical value under 99% significant level. The coefficients for ER^2 and ER are -0.2293 and 1140.6. Thus, the marginal abatement cost curve for China is represented in:

$$MAC_{China} = -0.2293ER^2 + 1140.6ER + \varepsilon, \text{ where } \varepsilon \text{ is the residual}$$

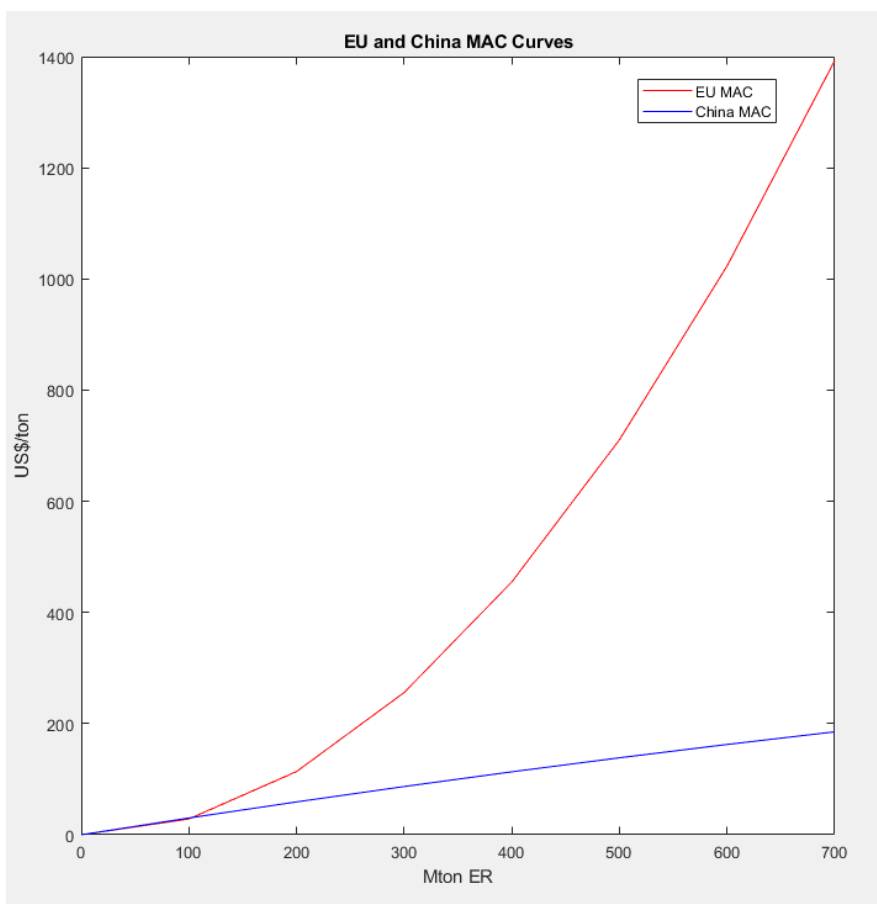
³⁶ Quadratic form in $MC = aQ^2 + bQ$ in the literature

Table 4-2 for China MAC

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER2	-0.229368	0.049156	-4.666104	0.0005
ER01	1140.685	86.87400	13.13034	0.0000
C	23773.64	32566.87	0.729995	0.4794
R-squared	0.974350	Mean dependent var		531652.1
Adjusted R-squared	0.970076	S.D. dependent var		452803.6
S.E. of regression	78329.09	Akaike info criterion		25.55208
Sum squared resid	7.36E+10	Schwarz criterion		25.69369
Log likelihood	-188.6406	Hannan-Quinn criter.		25.55057
F-statistic	227.9223	Durbin-Watson stat		1.431298
Prob(F-statistic)	0.000000			

The exchange rates are 3.549 and 0.706 for Yuan and Euro, respectively. Thus, the MAC curves for the EU and China are shown as below.

Chart 4-1 EU and China MAC Curves



According to chart 4-1, the marginal cost curves for the EU and China are different. It is apparent that the marginal abatement cost of China is much lower than for the EU. The potential explanations for the lower marginal abatement cost are because China has initiated the climate actions later than the EU, and any technologies to improve the efficiency would result in larger emission reductions. The explanations also proposed in the literature (Ellerman et al, 1998; Bohringer et al, 2001) identify the lower marginal abatement cost in developing countries. For the EU, more abatements result in increasingly marginal abatement costs faster. While in China, more mitigation leads to increasingly marginal costs but with decreased speed of growth. The decreasing growth for marginal abatement costs depends on the quantities of emission reductions and the developments in the technologies for the mitigations because the additional investments for technologies in mitigations will lead to increasing efficiency in the emission reductions.

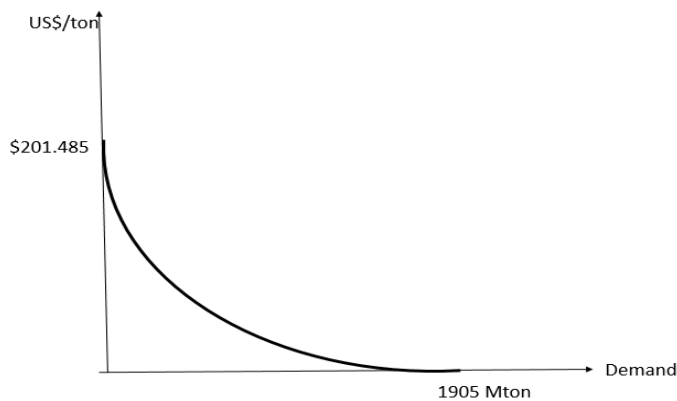
4.6.3 Estimation International Trading after Linkage

4.6.3.1 Aggregate supply and demand after linkage

The aggregate demand curve for the EU and China depends on their marginal abatement cost curves. To obtain the aggregate demand curve, there is a need to assume the mitigation commitment for China and the EU. As China has committed to a carbon intensity target below 60% to 65% by 2030 compared with the base year 2005 level, it is required to estimate the GDP growth for the year 2030 to obtain the absolute quantities of emission reductions. The data of China's GDP is obtained from the China 2017 Yearbook. After estimating the annual growth of GDP, the average rate for GDP increase for China is 9.125%. Based on the previous calculations of emissions for China, the carbon intensity is 955 tons CO₂e/Million. Thus, the commitment transferred to the quantity of absolute mitigation is to reduce 775 million tonnes of CO₂e. The EU needs to mitigate 1,130 million tonnes compared to its base year 1990 level.

Thus, the aggregate demand curve is constructed in Chart 4-2. If the market price is equal to zero in the case of competitive permit markets, the total aggregate demand is 1,905 million tonnes in the linked system. As one-dollar price increases in the market, the aggregate demand diminishes. When the market price reaches \$201.485, China switches from being a permit supplier to being a permit demander since the international permit price exceeds its marginal abatement cost with purely domestic compliance with the commitment.

Chart 4-2: Aggregate Demand Curve



Throughout the exposition in this section of aggregate supply and demand curves for China and the EU, the study considers two scenarios for the linkage system. The first scenario is exchanging the carbon allowance one for one trading across the market. The second is to exchange carbon allowances based on the comparison of one tonne CO₂e of the marginal abatement costs between the two jurisdictions. We assume all regions are price takers and no market power are exercised in the linked system.

4.6.3.2 One-for-one trading in the linkage

Under one-for-one scenario, from the previous section the aggregate demand curve is already derived based on the China and EU marginal abatement costs and the quantity of absolute emission reductions. The autarkic marginal abatement costs for China and the EU to meet their commitments are \$201.485 and \$3,629.00 in respect of emission reductions of 775 million tonnes and 1,130 million tonnes respectively. The area of the curve under the autarkic price represents the total cost for the abatements. Thus, the total cost for China and the EU is 14.5 billion. The linked system marginal cost equalises in such a way that the total amount of the abatements is the same in the case that the jurisdiction meets the commitments alone. Thus, the linkage equilibrium marginal price will be \$762.00 under the one-for-one scenario. The equilibrium price is much lower than the EU marginal abatement cost, thus there exists a risk for China selling 'hot air' allowances in the trading system. As the regional marginal price is lower than the EU autarkic marginal abatement cost, then the EU is importing the allowances from the linkage system. At the equilibrium of linkage

marginal price, the EU abatement is 518 million tonnes, which imports 612 million tonnes of allowances from China.

4.6.3.2 Exchange rate-based trading in the linkage

For exchange rate-based trading in the linkage, the exchange rate is based on the comparison of a one tonne mitigation cost between China and the EU. If we assume China and EU abatements comprise the same units of emissions, for example, 50 million tonnes, from the marginal abatement cost curve, the exchange rate for the EU and China could be 1.85, which indicates near 2 allowances in China could convert to 1 EUA in the linked market. Both China and the EU need to meet the commitments of emission reduction targets. The exchange rate will change the aggregate supply and demand curves, reducing surplus allowances available in the linked market, which will increase the regional marginal price. The total regional abatement cost to meet the commitments increases to 17 billion, which is 2 billion more than the one-for-one trading ratio. Thus, the regional equilibrium price will increase to \$871.00/ton. Under this scenario, the regional marginal price is still lower than the EU autarkic marginal price, which indicates the EU will still import the allowances from the linked system. However, under the scenario of exchange rate, the EU will mitigate 554 million tonnes, which decreases imports 36 million tonnes from the linked system.

4.7 Discussions

4.7.1 Explanations

According to the results, the EU would be importer both under one-for-one trading and exchange rate-based trading in the linked system as the equilibrium carbon price would be remain lower than the EU autarkic marginal price. At the same time, the result shows China would gain for the social welfare of carbon allowances exports. According to the result, it showed the cost benefits of linkage between two carbon markets, which highly discussed in the economic literature (Chichinisky and Heal, 1995; Edenhofer et al, 2007; Flachsland et al, 2009 ; Grull and Taschini, 2012; Rasons and Stavins, 2013). Meanwhile, in the literature, it showed three main factors for influencing import and export in the linked carbon market (Burtraw et al, 2013).

4.7.1.1 Carbon Market Design

The major influence factor for carbon pricing in linked carbon market is the ETS designs. As showed in the literature, it argued the major difficulty for linking two carbon markets is to negotiation compatibility of carbon market design in elements of methods for carbon allowances allocations, offset credit mechanisms, and percentages of emissions covered in the market design (Mehling et al, 2018). These elements would largely influence for the in carbon pricing in the linked system (Flachsland et al, 2009). The jurisdiction of carbon allowances obtain with lower prices or for free would export the cheaper carbon allowances to the higher carbon price jurisdiction.

This reason also could explain for the result in this study. Comparing the EU and China, China has higher percentages of the carbon allowances allocate with lower costs or for free than the EU (NDRC, 2018). Meanwhile, in the beginning of the China national ETS, only power industries would cover in the system, which contains 40% of total emissions and it also allows for 25% of offset credits to compliance. Additionally, the lower carbon costs also reflect in the shapes of marginal abatement cost curves between the two countries. The EU has steeper MAC curve, which indicates one additional tonne of mitigation in the EU is more expensive than in China. The differences of these elements designed lead to the supply of carbon allowances in China have lower costs than the EU, which explains the reason China always as exporter in the linked system.

4.7.1.2 Industrial structure

Another explanation for China as exporter in the linked system is the factor in industrial structure. The literature compared the jurisdiction has low-carbon industries would suffer greater economic loss to reduce CO₂ emission than the province has high-carbon industries. It showed the costs for technology innovation and energy consumption changes would be much lower for jurisdiction that has the high-carbon industries than the jurisdiction that has higher percentages in renewable or already applies clean technologies (Yang and Lei, 2016).

According to the China Statistic Yearbook (2018), it showed more than 80% of the power, steel, and mining industries used coal combustions for generations (China Statistic Yearbook, 2018). Meanwhile, the total number of the power, steel, and mining industries account for over 50% of emissions in China (China Statistic Yearbook, 2018). On the contrary, the EU has developed clean energy for all Europeans package binding 32% for renewable energy and

actions for coal transitions (EU ETS, 2019). Although China is currently reforming the electricity market to reduce coal combustions, the mitigation cost is still lower comparing with the EU. Thus, after linking the system, China with lower carbon cost for transitions would benefits from trading allowances with the EU.

4.7.2 Information and Implementations relating to Governance

Regarding to the governance of exchange rate in the linked market, it requires to extend consider which conditions could be include and the information needed to be obtained by regulator to implement the exchange rate in the linked system.

First consider the data required for exchange rate determination in the model. According to the equation (5), the regulator needs to obtain the information of first derivative of abatement cost C'_i , industrial emissions e_i , and business-as-usual BAU_i , $i \in [1,2]$. According to the quadratic forms of marginal abatement cost curves, the regulator also would need to be aware of carbon price P_i . If we assume the daily emissions, carbon prices could be observed from the trading market and statistics bureau, the calculations in abatement cost C'_i and business-as-usual BAU_i are required for econometrics for the regulator. However, the challenges embedded as the uncertainties in the assumptions for the calculations. Thus, the regulator at least needs to agree on the same methodologies such as IPCC suggested as prior conditions to implement the exchange rate. Alternatively, the literature (Quemin and Perthuis, 2018) suggested to identify the exchange rate would change proportionally with changes in the parameters in the model. However, the inaccuracies would occur to prove exchange rate is likely difficult, which can lead to detrimental results (Quemin and Perthuis, 2018).

Second, from the practical perspectives, the large market size and factual autarky prices would be with a time lag in one compliance period could increase administration costs for governance exchange rate in the linked system. If we assume the exchange rate in the linked system is adjusted daily basis, taking China and the EU as an example, the large market sizes require regulator to review more than 12,000 sources in the EU ETS (Holland and Yates, 2015) and 10,000 power industries in the China ETS (NDRC, 2018). Although it is feasible to deal with the data, it still needs system to contain all update data and practical for the calculations.

Although the exchange rate seems not favorable than one-for-one trading because of complex information and calculations required for the governance, it has incentive for two linked jurisdictions to raise mitigation ambition with more emission reductions and becoming gradually traded with parity. However, the exchange rate could raise more interests for linkage from economic developing areas such as China because it could induce a transition to increasing carbon price with reflecting its own characteristics showing in the parameters.

4.7.3 Political Feasibility

Although the literature proposed for the linkage carbon market, it still has barriers for the exchange rate-based trading for the political feasibility. The literature indicated the affordability of the local economy should be considered when designing for the exchange rate-trading not only based on theoretical basis (Quemln and Perthuls, 2018). It highlighted because the differences in economic development levels, the reduction targets demonstrate the different carbon costs, which would lead to challenges in exchange rate negotiations between two jurisdictions. In the case of the EU and China, China would face inequities of economic developments in different provinces. In the literature, it argued the low developed provinces in China would first ensure the economic growth rather than mitigations (Liu et al, 2011).

Moreover, the literature also indicated exchange rate in linked system also requires reflecting the carbon leakage and natural resource endowments considerations (Yang and Lei, 2016). This also discussed in the literature for different carbon prices when linking two carbon markets (Burtraw et al, 2013). The literature showed local with sufficient natural resources in wind, solar, and thermal would have higher carbon costs for additional mitigation than the areas with limited natural resources (Yang and Lei, 2016). At the same time, the carbon leakage would also happen when linking with lower carbon price jurisdiction and higher cost jurisdiction (Flachsland et al, 2009). This leakage also required for consideration for designing the exchange rate-based trading system to show equity of sharing burden in mitigations in the linked system.

4.7.4 Limitations

To analysis the one-for-one trading and exchange rate-based trading, the study has two limitations. The directional production output function has its own limitation. The estimation of directional distance function depends on how the researcher chooses the direction vectors and which variables include in the output variables in the vectors. In the literature, it argued to determine the direction vectors endogenously, which would result in different efficiency combinations in inputs and outputs of productions for the industries (Fare et al, 2013), which indicates each industry could have its own directional vectors in the model. However, in this study, it is simplified the vectors based on a national level and applied the vectors from empirical studies in estimating marginal abatement cost curves in China and the EU.

Moreover, in this study, the estimation of exchange rate and equilibrium price based on model derived. However, the exchange rate could be influenced by indirect factor such as the political feasibility discussed before.

4.8 Conclusion

This chapter has laid out research for the implications of a linked system between China and the EU on environmental effectiveness and estimated the different compliance costs under two scenarios - trading one-for-one or trading in an exchange rate - proposed in this chapter for the linked system.

There are several theoretical contributions for this study. First, the literature (Burtraw et al, 2013; World Bank, 2013) suggest different definitions and methodologies to determine exchange rate trading across the carbon markets. This study aims to fill the gap for the literature through reviewing the fundamental carbon allowance definition and definitions of exchange rate proposed in the literature, given the own working definition of the exchange rate in the linked system. Second, this study compares the different methods for estimating the marginal abatement cost and applies the directional output function to estimate the regional marginal abatement cost and compares it with the purchasing power parity.

In this study, we estimate the linkage between China and the EU under two scenarios, which are one-for-one allowance exchanging trading across the linked market, and the proposed

exchange rate based on the marginal abatement cost in the linked system. The result shows that under both scenarios, the EU will always be the importer in the linked system as the autarkic marginal abatement cost of the EU is much higher than the regional marginal price. However, the result also indicates that under Scenario B for trading based on the exchange rate proposed in the study, it reduces the risks of 'hot air', which is selling much cheaper allowances with risks of carbon leakage from the China market as the regional marginal abatement cost increases, compared with the equally exchanging scenario.

Furthermore, this study also shows the policy implications for providing a potential method to link the individual emission trading systems, which have different types of emission targets, such as the absolute mitigation target and the carbon intensity target. It also provides the suggestion that it is possible to reduce the risks of purchasing 'hot air' from the international permit markets by applying the exchange rate.

Chapter 5 Conclusion

5.1 Overview

This chapter illustrates the contribution the thesis makes to carbon market theory and practice. The chapter shows conclusions for the key concepts developed and briefly summarised from the previous chapters. It also considers the applicability of the concepts to policy and practical implications, and some limitations of the research. Finally, the chapter indicates the areas for future research.

5.2 Summary of Research Aims

The aim of the thesis is to develop understanding of the decision and process of linkage between individual carbon markets, and their impact for international cooperation in addressing climate change, by considering:

Question I: *What are key drivers and barriers for linking two different carbon markets?*

Question II: *How the compatibility of the two ETSs influenced by policy diffusion framework? What are the implications?*

Question III: *What is a potential linkage model for a regional and multi-country ETS with heterogeneous market designs?*

Interpretivist, constructionist approaches were taken for the inductive studies to answer research questions Question I and Question II while a deductive approach was designed to answer research question Question III.

For the Question I, the Chapter II indicates carbon price function, political considerations, compatible carbon market design, economic costs, environmental effectiveness and public input and social pressure dimensions. Especially, the political considerations and environmental effectiveness over economic benefits for the linkage decision-making between two different nations.

To answer the Question II, we developed data collections from a qualitative case study. The research design was applied and an extensive array of findings from several data collections from interviews, documents, archives and observations in the linkage workshops. In the Chapter III makes explicit explanations for the linkage readiness framework. The findings indicate that same registration and comparable emission cap are the conditions for developing a “linkage readiness” carbon market. The findings also provide further explanations for the technical reason for easier administrative management and cost savings. As long as the designed elements reflect for the economic efficiency and equally burden-sharing in the mitigation efforts, differences could be potential mutually acceptable in the agreement of direct linkage.

Chapter IV designed deductive research proposed a hypothesis of “exchange rate” based on marginal abatement cost curves on allowance trading in the market is more efficient than the one-to-one exchange used in the partial equilibrium model. The Chapter II, Chapter III and Chapter IV both answered the research Question III. The findings from chapters all proposed a bottom-up linkage procedure for international carbon market linkage. Especially, easier for regional cooperation. The official linkage could be gradually evolution from a “linkage readiness” framework or a “exchange rate” proposed as financial ratio with mitigation efforts reflections trading across the carbon markets for the indirect linkage in advance.

The evidence presented and analysis of findings from Chapter II, Chapter III and Chapter IV have led the thesis to develop a concept of linkage in carbon markets for international cooperation framework in the climate change.

5.3 Empirical Contributions

5.3.1 Learning the Motivations and Barriers for Linkage

Several factors in economics, politics and administration facilitated the development of the linkage decision for international cooperation in climate actions, as already shown in previous chapters. It is important to understand the motivations and barriers for the linking carbon markets. The findings let us generate in-depth explanations, which emerged inductively from the studies, to indicate why some jurisdictions are motivated towards the

official bilateral linkage, such as EU members. The drawbacks of linkage detected from this research also indicate the barriers for bilateral linkage.

After summarising the motivations and barriers for linking, which was purposively initiated at different case locations, and supported by the different relevant subgroups of stakeholders, recognition of reasons for the ETS linkage enriches explanations, allowing greater understanding of how the linkage decision-making emerges from different perspectives. The findings provide relevant stakeholders with a clear picture for the ETSs linkage procedure and recognises their roles in the process.

5.3.2 Linkage Readiness Process

The thesis provides an in-depth understanding of the linkage process for the two individual jurisdictions. Although in the literature it makes clear that differences in designs of elements in carbon markets could lead to negative impacts on linkage (Burtraw et al, 2013; Zetterberg, 2015), there is no consensus on the identifications of the categories of key features.

The thesis investigates the different characteristics in the carbon market designs and the purposes of the implementations for linkage readiness. When the thesis summarises the elements and characteristics from the empirical linkage cases, the principles of what is politically required for environmental effectiveness, market management, economic efficiency and equity emerge, showing the requirements of harmonisation for the key features prior to the linkage between two individual jurisdictions. Further explorations in the thesis enrich the literature in terms of identifying when implementations for the 'linkage-ready' are necessary. Furthermore, the study points out that some features such as registration are required for a higher level of harmonisation in the empirical than the literature does (Haites and Wang, 2006; Sterk et al, 2009; Hawkins and Jegou, 2014) and that this is because of the practical reasons of aiding management and cost saving in administrations.

5.4 Theoretical Contributions

5.4.1 Factors for Decision Making in the Linkage Theory

The research has justified the factors embedded in the linkage theory and explored the additional powerful explanatory factors for better understanding of the policy decision-

making process under the linkage theory. First, the emerging categories in politics, economics and administration were also detected in the empirical inductive study in the research, which verified the results from the existing linkage theory (Flachsland et al, 2009; Stavins et al, 2018). The study helps highlight the key drivers and identify the trade-off between the political, economic and administrative factors for different individual jurisdictions to cooperate in the carbon markets for climate actions.

The study investigates whether the political consideration is the predominant factor that strongly influences the decision-making in the linkage theory. The political reason detected that underpins the linkage theory indicates that although the carbon market allows the credits to be traded across jurisdictions, the emission trading system, in theory, is still a political instrument rather than a market-based instrument. Thus, no matter how much the economic or administrative benefits could be gained after the linking of two individual jurisdictions, the barrier in the political consideration could preclude the linkage in the first place.

5.4.2 Redefining Harmonisation by explanations of policy diffusion framework

The literature states that harmonisation of the key features in the carbon market designs is investigated for harmonisations between two individual emission trading systems (Haite and Wang, 2006; Sterk et al, 2009; Hawkins and Jegou, 2014) but without a clear explanations. Thus, this thesis addresses the gap in the literature by investigating the four principles to redefine the 'harmonization of the carbon market designs', to improve the explanation in policy diffusion theory proposed in the literature. The four principles are: the political arrangement required for environmental effectiveness, market management, economic efficiency and equity that justifies the harmonisation in the carbon market designs. These principles also affect the potential types of linkage in bilateral, unilateral or indirect linking between the individual ETSs.

5.4.3 Conceptual Exchange Rate Model for Linkage

The Paris Agreement 6 encourages transferring mitigation efforts from one jurisdiction to another as a cooperation framework in the international architecture (Paris Agreement, 2015). The literature has developed different 'exchange rate' models that tried to measure the emission reductions embedded in the credits trading across the markets (Burtraw et al,

2013; World Bank, 2014). In the literature, the 'exchange rate' is either defined as a relative value that helps facilitate the fungibility of the units, which not presents as tonnes of reducing CO₂e from the atmosphere (World Bank, 2014), or the concept of exchange rate is applied for measuring the exchange ratios for different emissions exchanged through trade (Holland and Yates, 2013). This thesis reviews the nature of the concept of 'carbon allowance' in the ETS and proposes a working definition of exchange rate, in which it is measured by marginal abatement cost curve for the mitigation efforts estimating with Power Purchase Parity in the foreign exchange rate. In the study, we construct and accept the hypothesis that exchange rate in carbon allowances trading across systems measured by marginal abatement cost curve could improve the efficiency of the market. This new conceptual exchange rate model in the carbon markets is proposed as a new framework for the linkage theory.

5.5 Policy and Practical Contributions

Given the potential contribution of the improved linkage framework for international architecture cooperation in climate change, there are a number of points of interest for policy makers and practitioners.

The research emphasises the improving linkage framework for two individual emission trading system. For the policy makers, support of policy priority in environmental effectiveness is crucial for international cooperation in addressing climate change. From the context of the factors that determine decision-making procedure in the linkage theory, it indicates that to make the linkage feasibility, policy supports for long-term emission reductions and communications with potential participants regarding construction in emission trading system could strongly influence the potential linking in the future.

The thesis also contributes by proposing an improved linkage readiness framework for policy makers. The harmonisation in an improved framework could be seen as a systematic assessment for policy makers to implement for the compatibility of elements in market designs with their potential linking partner. Meanwhile, the improved framework also could be viewed as a guideline for policy makers or practitioners to assist or initiate a 'linkage ready' cap-and-trade system in the first place.

This thesis proposes a new concept in the exchange rate model for trading across markets. This new concept of exchange rate provides practitioners and policy makers with a consideration that embeds the mitigation efforts in the carbon allowance to link the systems. This exchange rate concept and model could also be seen as a financial innovation for potential linkage of emission trading systems based on the principles of UNFCCC for a cap-and-trade system: equity, effectiveness and efficiency (UNFCCC, 2012).

5.6 Research Limitations

In order to advance knowledge regarding linkage theory, the inductive process applied in this research simplifies contacted the relevant stakeholders in cross-section. However, the linkage process evolves for several years from initiative to completion (Ranson and Stavins, 2013).

In reality, the interactions between relevant subgroups of stakeholders could affect each other's considerations in the time length of the decision-making process (Skjarseth and Wettestad, 2008). In fact, the research has already found conflicts of interest and spillover effects from the different perspectives. The embedded cases in the research draw upon investigations based on the scope of regional level for discovering how macro factors influence the linkage process.

Another limitation needs to be noted in self-selection for the stakeholders from the government, which may result in challenges for adequate information provision due to security and confidentiality considerations. Thus, in the research, besides the interviews taken from the stakeholders in governments, number of relevant official governmental documents and administrative archives are included to add sufficient information for the findings.

Finally, it is anticipated that the exchange rate model proposed in this research is the theoretical value, where the limitations are from the assumption of perfect competitive market with no transaction costs.

5.7 Areas for Future Research

The research has revealed the factors and improved linkage framework for the international cooperation in climate change. The features are discovered in the findings which can be considered for future studies. The research demonstrates the regional linkage process between two individual emission trading systems. However, the ratification of the international agreement is also influenced by the negotiation process. Putnam (1988) has already investigated the existence of a two-level game theory in the negotiating international trading agreement. The interactions between domestic and international level stakeholders result in the win-set, which is the possibility of ratifying agreements (Putnam, 1988). This could be an additional area for studying the interactions between two-level stakeholders to influence decision-making in the linkage theory in future.

In addition, this research establishes the concept of exchange rate and improves the linkage framework based on the two regional jurisdictions. In future research, it could extend to multi-regions linkage or indirect multilateral linkage from a bottom-up approach.

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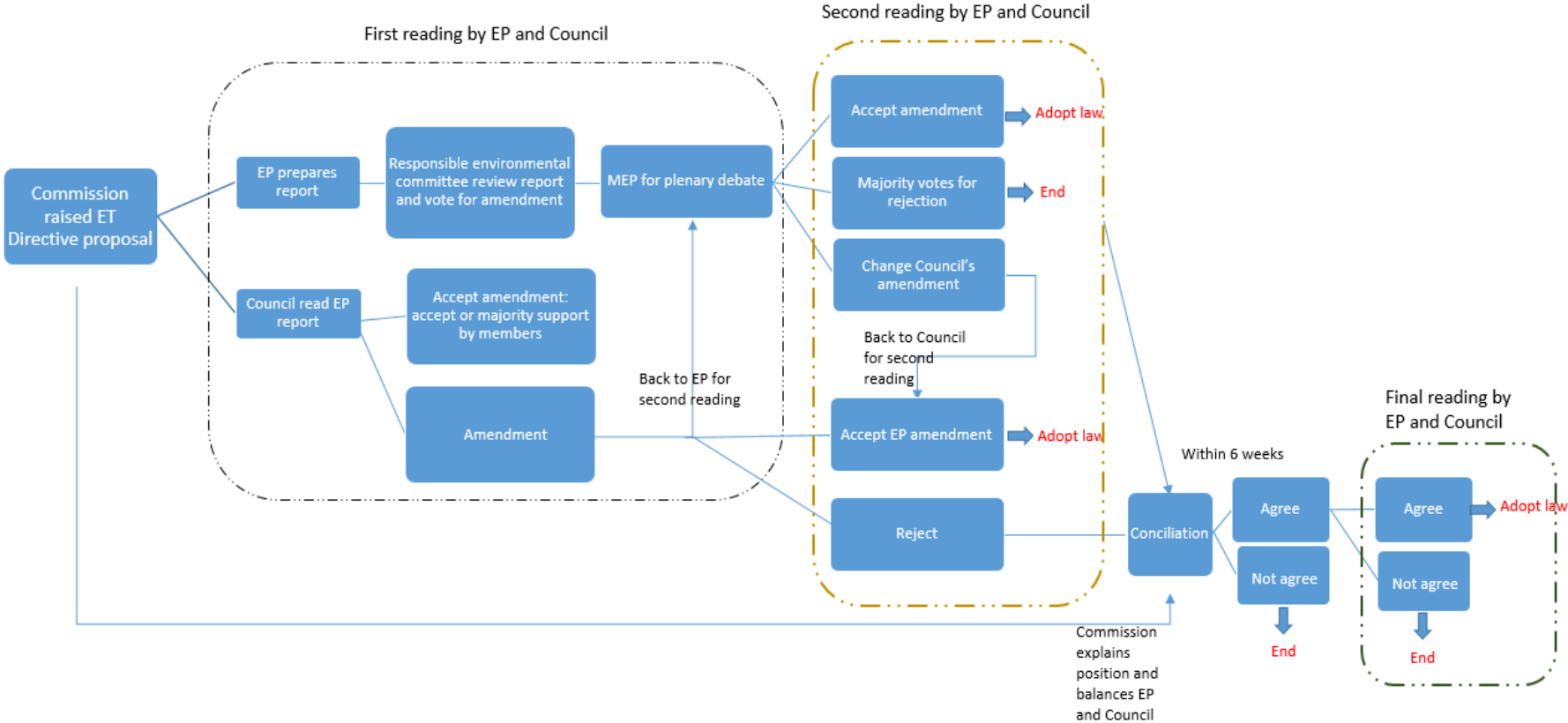
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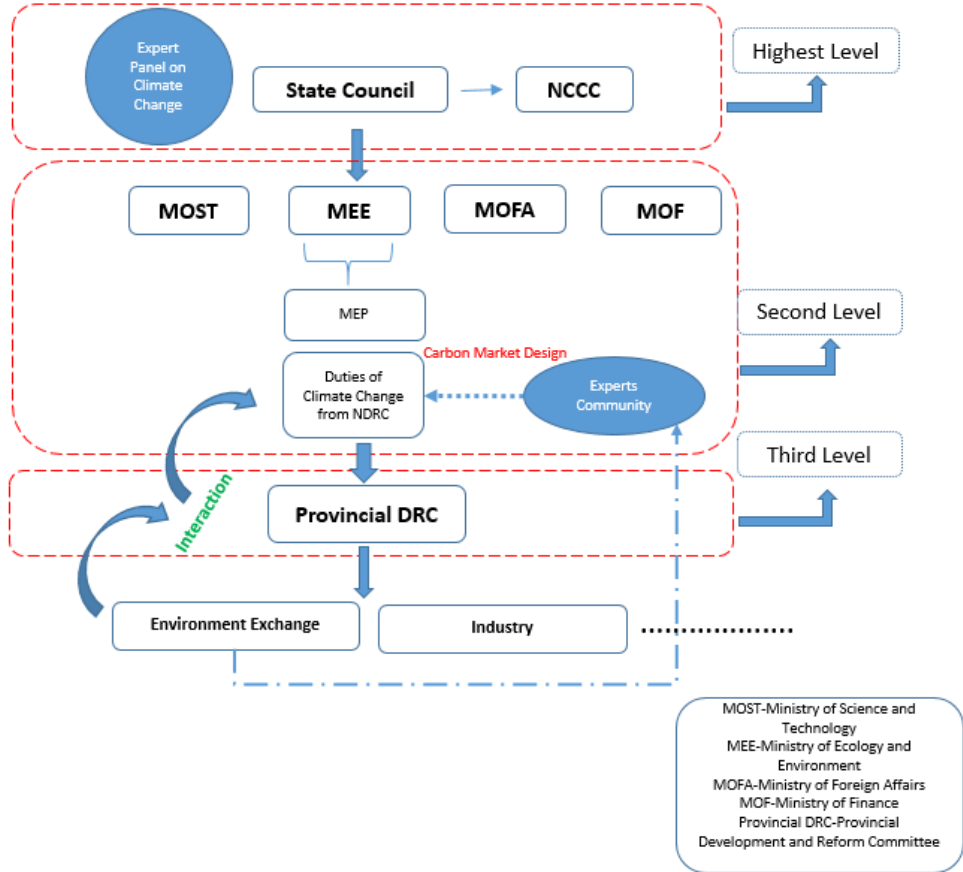
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Appendix I EU Emission Trading Directive Legislative Procedure



Appendix II. Chinese Climate Policy Legislative and Implementations Procedure



Appendix III. Questions for semi-structured interviews for Chapter II

- a. Currently the China national ETS is being established. In what aspects could China's national ETS learn from the pilot ETSs operating in provinces such as Guangdong? (warm up question)

China has taken the first step towards launching its much-delayed carbon market, which only covers the power sector. Currently there are seven pilots ETSs existing in China.

- b. What do you think about linking China's national ETS with the pilots ETS? (positive or negative) and how?

- c. What is most important to consider when linking the national ETS with the ETS pilots?

The long-awaited scheme of China ETS is expected to be the world's largest carbon market after 2020. Currently the EU ETS is the largest one since it launched in 2005.

- d. Even though Chinese pilots ETSs have not existed for a substantial amount of time yet, what could China's national ETS learn from the EU ETS?

- e. What are the benefits of linking China ETS with the EU ETS in the future? What are the disadvantages? And why?

- f. Have you ever heard about existing international carbon markets linkage or any cases are under negotiations for linking?

- g. What could we learn from the existing experiences? And how could these experiences provide best practice for China ETS linking with EU ETS?

- h. In which ways could China's ETS be linked with EU's ETS?

- i. Could you please give me some explanations for considering why this is the best way?

- j. How could political acceptability be ensured of the ETS in China?

Based on what we talked about before.

- k. When could the linkage between the European and Chinese trading markets linkage happened?

- l. Why could this linkage happen in this amount of time?

- m. Do you have any additional thoughts or ideas about linking national ETS with pilots ETS or international carbon linkage with China?

- n. Could you recommend anyone else that I could speak to who might help me to understand this topic?

- o. Do you have any other reports or documents which you recommend I should take a look at?

End

Appendix IV. Data Sources for Chapter III

DATA SOURCES: DOCUMENTS	TOTAL NUMBER: 24
AIR RESOURCE BOARD STATE OF CALIFORNIA: CALIFORNIA EMISSION TRADING SYSTEM	Assembly Bill No. 32
	California Cap On Greenhouse Gas Emissions And Market-Based Compliance Mechanisms.
	Final Regulation Order
	The Governor's Climate Change Pillars: 2030 Greenhouse Gas Reduction Goals
	Regulation for the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms
	California Greenhouse Gas Emissions for 2000 to 2016
	Facts About Holding Limit for Linked Cap-and-Trade Programs
	Linkage Readiness Report
	Discussion of Findings Required by Government Code section 12894
	Proposed Amendments to the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanism
Proposed Linkage of California's Cap—and-Trade Program with the Canadian Province of Quebec's Cap-and-Trade Program	
ONTARIO MINISTRY OF THE ENVIRONMENT	Ontario Announces Results of First Joint Ontario, Quebec, California Cap and Trade Program Auction
NORWAY MINISTRY OF FOREIGN AFFAIRS	Ten facts about the EEA
NORWEGIAN MINISTRY OF THE ENVIRONMENT	Norwegian National Allocation Plan for the emissions trading system in 2008-2012
	Norway's Fifth National Communication under the Framework Convention on Climate Change
	Supplementary Report to Report No 54 (2000–2001) to the Storting, Norway's Climate Policy
	Letter of 04.12.02 from the Norwegian Minister of Environment to the EUs Commissioner for the Environment
	Memo on Proposal for a Law on Greenhouse Gas Emissions Trading, 28 June 2004
EUROPEAN COMMISSION	Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme
	Establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

	Further guidance on allocation plans for the 2008 to 2012 trading period of the EU Emission Trading Scheme
	REGULATIONS: on the timing, administration and other aspects of auctioning of greenhouse gas emission allowances pursuant to Directive 2003/87/EC
	Ensuring the integrity of the European carbon market
	Amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814
DATA SOURCES: SEMI-STRUCTURE INTERVIEWS	TOTAL NUMBER: 14
1	Greenpeace EU Unit
1	EU Parliament
2	WWF European Policy Office
1	EcoAct
2	IETA
1	Sandbag
1	Centre for European Policy Studies
1	European Parliament
1	WWF North America Policy Office
1	IEA
1	European Commission (former)
1	Confederation of Norwegian Business and Industry

Appendix V. Questions and Interviewees for semi-structured interviews for
Chapter III

(Warm up introducing the research aims and questions)

- a. How did the existing carbon market linkage readiness framework in which you were involved develop?
- b. Which barriers occurred in the ETS design and negotiation process?
- c. Which enablers occurred during the ETS design and negotiation process?
- d. What are the most important features for success for the linkage readiness?
- e. How long did it take to develop the linkage and why?
- f. What could China learn from your/previous experiences of setting up international carbon markets linkage and/or current negotiations for linking?
- g. Which best practice could these experiences provide for the ETS designs?
- h. Could you recommend anyone else that I could speak to who might help me to understand this topic?
- i. Do you have any other reports or documents which you recommend I should take a look at?

End

Sectors	Name and Position	Number of Interviews	Subgroup of stakeholders
<i>EU Commission</i>	Federal Office for the Environment, Switzerland Sophie Wenger Hintz Linking ETS	1	Government
<i>California</i>	Public Information Officer at California Air Resources Board Dave Clegern Branch Chief, Project Assessment Branch - California Air Resources Board Mary Jane Coombs	2	
<i>University</i>	Central University of Finance and Economics, China Professor Yao Wang Director at Centre of Green Finance Dr Bo Chen Lecturer at Centre of Green Finance	2	Academia
<i>Research Institutions</i>	National Centre for Climate Change Strategy and International Cooperation HaiYan Liu Associate director in NCCC and director in CDM development	2	
	I4CE Charlotte Vailles Project manager in industry, energy, climate	1	
	ERCST Andrei Marcu Director	1	
	Bruegel Dr. Georg Zachmann Senior fellow	1	
	Shanghai Environment and Energy Exchange Dong Zhao Senior fellow in ETS operation WenJing Zhan	2	

ENGO

Associate director in China national ETS design		
Greenpeace EU Unit Tara Connolly EU policy assistant Sebastian Mang EU climate and energy policy	2	
WWF Europe Sam Van de plas Senior policy officer at climate and energy programme	1	
Carbon Watch Femke de Jong Policy director	1	Think Tank and E-NGO

Appendix VI Examples of Documents sampling and Data Analysed

Documents	Contents Selected	Data Analysed
Discussion of Findings Required by Government Code section 12894 (Air Resources Board, 2013)	The potential equivalence of California’s and Québec’s climate programs can be examined in terms of each jurisdiction’s emission reduction goal, the role of the Cap-and-Trade program in achieving each jurisdiction’s reduction goal, and the rules and requirements incorporated into each jurisdiction’s Cap-and-Trade program regulations.	Equivalent to or stricter for the emission cap
	Québec protocols are limited to livestock waste digesters, small landfill gas recovery, and ODS destruction. Québec limits approved projects to those in Canada. That requirement is parallel to California’s regulation, with California’s currently approved protocols extending only within the United States. ²⁵ In developing the linkage amendments to the Cap-and-Trade Regulation, ARB did a thorough analysis of the three protocols currently adopted by Quebec. That analysis can be found in the <i>Initial Statement of Reasons</i> noticed on May 9, 2012. Based on the final documents, the Québec offset program and protocols meet the AB 32 offset requirements.	Offset protocols can be different but must be additional and mutual acceptable

Appendix VII Comparison and harmonization between EU and China carbon markets

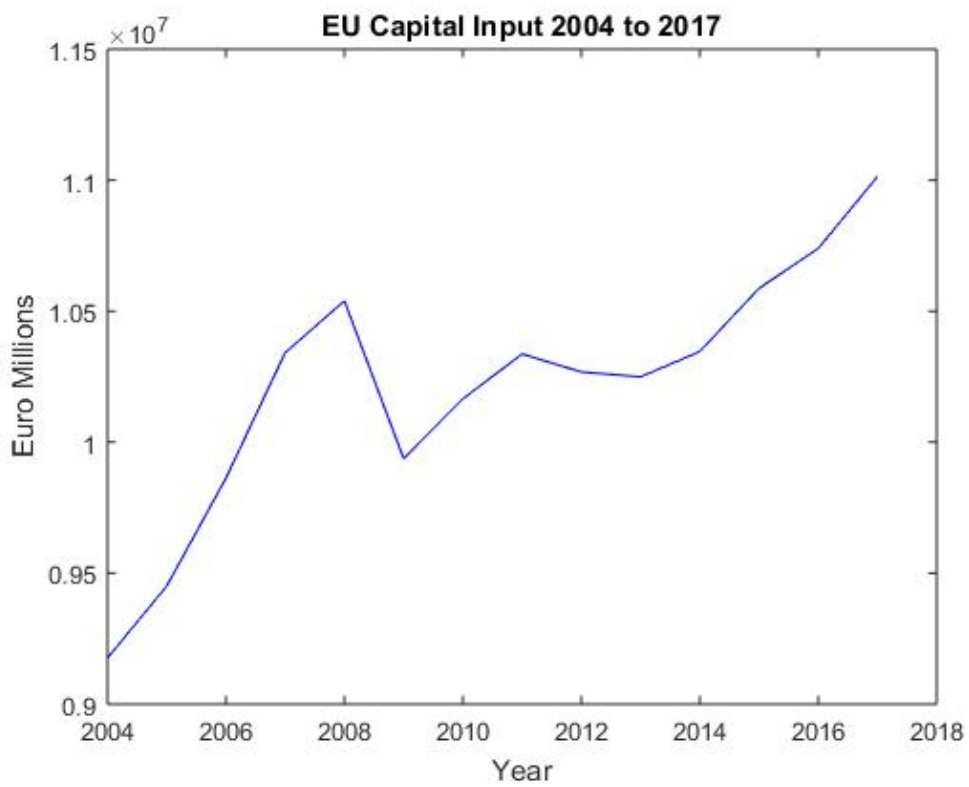
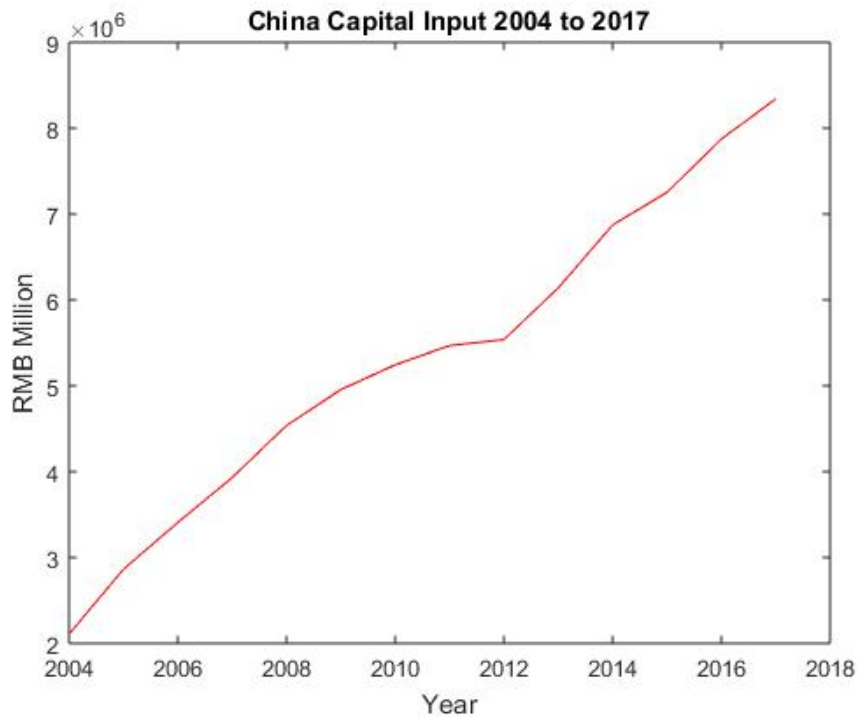
Design feature	EU ETS	Seven pilots ETS and China national ETS	Implications on linking
General position on linking	Positive to link with national or regional ETS	Have cooperated with the EU in pilot ETSs designs	Both parties positive to cooperate with each other for carbon market designs; however linkage is not policy priority in China
Stringency of emissions cap	Absolute emissions cap	Intensity emissions cap measured in tCO ₂ /GDP	Not harmonisation EU requires compatible absolute emissions cap
Distribution of allowances	Free allowances for manufacturing industries will decrease to 30% in 2020 and no free allowances for power generators	Only Guangdong ETS both applied free allocation and auction. The other pilot ETSs are all based on free allocation	Not harmonisation Significant differences in allocation methods would result in market distortions and carbon leakage
Recognition of offsets	EU relies on the credits from CDM from the least developing countries and JI. Limitations of international credits: 11% of its allocation during 2008 to 2012 or credits maximum 4.5% of its verified emissions in the period from 2013 to 2020, or 1.5% verified emissions for aircraft operator	The offset protocols in China are based on CDM methodologies Offset limitations: Beijing-5% but at least 50% must be located in Beijing Chongqing-8% Guangdong-10%, but 70% of total offset credits must be based on Guangdong projects Hubei-10% for new entrants and 15% for participants	Harmonisation The offset limitations and protocols are similar between pilot ETSs and EU however the only barrier is the EU is committed only to purchase CDM credits from least developing countries. The negotiation still needed for the offset mechanism

		Shanghai-5% Shenzhen-10% Tianjin-10%	
Sector coverage	<p>Power stations and other combustion plants $\geq 20\text{MW}$</p> <p>Oil refineries; coke ovens; iron and steel plants; cement clinker; glass; lime; bricks ceramics; pulp; paper and board; aluminium; petrochemicals; aviation; ammonia; nitric, adipic and glyoxylic acid production; carbon capture; transport in pipelines and geological storage of CO_2</p> <p>Covers 45% of overall GHGs in the EU</p>	<p>China ETS-30% of total GHGs: initially only covers power sector but will include petrochemical, chemical, building materials, steel, nonferrous metals, paper and aviation</p> <p>Beijing-50% of total city's emissions: heat supply; power generation; cement; petrochemical; car manufacturing; public buildings</p> <p>Shanghai covers 57% city's emissions: steel; petrochemical; Chemical; non-ferrous metal; power; building materials; textile; paper; rubber, and the chemical fibre industry</p> <p>Guangdong covers 42% of the province's total energy consumption: power; cement;</p>	<p>Harmonisation</p> <p>Both systems cover similar percentages of total GHGs and include the energy intensity sectors</p>

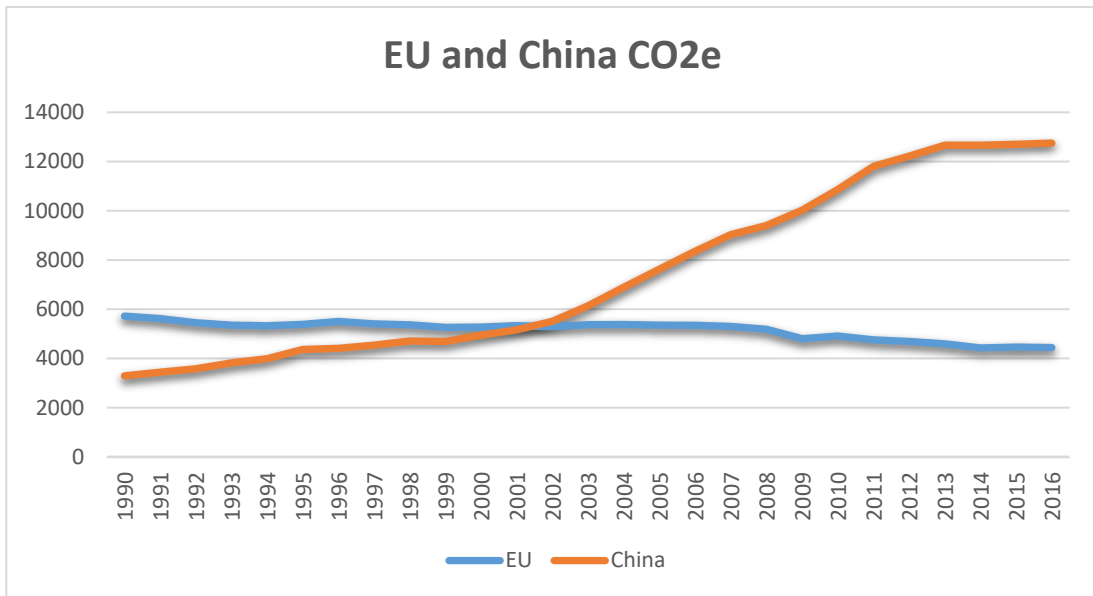
		<p>steel; ceramics; petrochemical; non-ferrous; plastics and paper</p> <p>Shenzhen covers 50% of total emissions: power; gas; water supply; public and financial institution that use buildings</p> <p>Tianjin covers 60% of the city's total emissions: iron and steel; chemicals; electricity; heat; petrochemical; oil and gas mining; civil construction</p> <p>Hubei covers 35% of the province's total emissions: steel; chemical; cement; automobile; manufacturing; power generation; glass; paper</p> <p>Chongqing covers electricity; aluminium; iron and steel,</p>	
Enforcement management	For non-compliance industries, the penalty will be €100/tCO ₂ rising with the inflation rate	<p>China ETS: there will be a penalty; however the details have not been designed yet</p> <p>Shenzhen: to deduct non-compliance allowances from next allocation and fine three times average price in the compliance period</p>	<p>Not harmonisation</p> <p>The differences in the enforcement for non-compliance need to be similarly rigorous to establish confidence in the market</p>

		<p>Guangdong: information disclosures in credibility system, deducting twice the amounts from next allocation and fine ¥50,000.</p> <p>Beijing: three to five times average price per ton for non-compliance emissions</p> <p>Hubei: deducting twice amount of non-compliance allowances from next allocation</p> <p>Shanghai: deducting same amount of non-compliance allowances and fine between ¥50,000 to ¥100,000</p> <p>Tianjin and Chongqing have no penalties for non-compliance</p>	
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Appendix VIII China and EU Capital Inputs



Appendix VIII China and EU China and EU Calculated Total Emissions Based on IPCC Guidelines



Appendix X GWP in IPCC

GWP Kyoto Gases (IPCC, 2007)

Greenhouse Gas	Global Warming Potential (GWP)
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	25
Nitrous oxide(N ₂ O)	298
Hydrofluorocarbons (HFCs)	124 – 14,800
Perfluorocarbons (PFCs)	7,390 – 12,200
Sulfur hexafluoride (SF ₆)	22,800
Nitrogen trifluoride (NF ₃)	17,200

Reference: IPCC Fourth Assessment Report: Climate Change 2007

Appendix XI Unit Root Test for China and the EU Variables

- The unit root tests for EU variables

The Unit Root Test for the EU independent variable ER

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-1.238953	0.8517
Test critical values:		
1% level	-4.992279	
5% level	-3.875302	
10% level	-3.388330	

*Mackinnon (1996) one-sided p-values.

The Unit Root Test for the EU independent variable ER²

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-0.396045	0.9721
Test critical values:		
1% level	-4.992279	
5% level	-3.875302	
10% level	-3.388330	

*Mackinnon (1996) one-sided p-values.

The Unit Root Test for the EU dependent variable shadow price P

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SHADOW_PRICE(-1)	-1.171543	0.324412	-3.611277	0.0056
C	851228.6	558552.4	1.523990	0.1618
@TREND("2005")	154665.2	87841.36	1.760734	0.1121
R-squared	0.593257	Mean dependent var		167310.5
Adjusted R-squared	0.502870	S.D. dependent var		1239304.
S.E. of regression	873801.4	Akaike info criterion		30.41141
Sum squared resid	6.87E+12	Schwarz criterion		30.53264
Log likelihood	-179.4685	Hannan-Quinn criter.		30.36653
F-statistic	6.563509	Durbin-Watson stat		1.398083
Prob(F-statistic)	0.017456			

- The unit root tests for China variables

The Unit Root Test for China Independent Variable-ER

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.028256	0.1621
Test critical values:		
1% level	-4.886426	
5% level	-3.828975	
10% level	-3.362984	

*Mackinnon (1996) one-sided p-values.

The Unit Root Test for China Independent Variable-ER²

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-3.020819	0.1707
Test critical values:		
1% level	-5.124875	
5% level	-3.933364	
10% level	-3.420030	

*Mackinnon (1996) one-sided p-values.

The Unit Root Test for China Dependent Variable-shadow price P

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.919551	0.1885
Test critical values:		
1% level	-4.886426	
5% level	-3.828975	
10% level	-3.362984	

*Mackinnon (1996) one-sided p-values.