

## Innovation of Cold Chain Logistics System of Agricultural Products From Low-carbon Perspective

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### Abstract

To effectively implement agricultural cold chain logistics coordination and balance quick development and environmental protection, under the perspective of low carbon analysis of its implementation, on the basis of driving factors, combining with the characteristics of cold chain logistics, further study of agricultural products cold chain logistics carbon emissions cause and its "benefit against" phenomenon, introduce the third party and the fourth party logistics enterprise, realize low-carbon agricultural products cold chain logistics system innovation, in order to provide reference for low-carbon sustainable development of cold chain logistics in China.

### Keywords

Low-carbon perspective, Cold chain logistics system, Agricultural products.

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### 1. Introduction

In the context of the growing demand for fresh food in China and Chinese consumers' increasingly high demand for food quality and safety, China's cold chain logistics market has developed rapidly in recent years. According to statistics, the overall size of China's cold chain market will exceed 250 billion yuan in 2018 and reach 450 billion yuan in 2022. In the rapidly developing cold-chain market, companies represented by e-commerce, express delivery and start-ups have chosen to increase cold-chain logistics. In April 2018, the general office of the ministry of commerce and the standardization administration of the People's Republic of China jointly issued the circular on replicating and popularizing typical experience models for the standardization demonstration of cold chain circulation of agricultural products, and identified 31 pilot cities and 285 pilot enterprises to participate in the standardization demonstration of cold chain circulation of agricultural products. In September 2018, the general office of the general administration of market supervision issued a notice on strengthening the supervision and administration of frozen and frozen foods, which pointed out that supervision and administration of frozen and frozen foods should be strengthened to crack down on violations of laws and regulations. We will strictly enforce the responsibility of business operators, strengthen routine supervision, supervision and spot checks, and crack down on violations of laws and regulations.

However, the development of China's cold chain logistics is both opportunities and challenges. In recent years, a series of climate anomalies caused by global warming (such as rainstorm, drought, blizzard and haze, etc.) have gradually caused people to rethink the relationship between industrial development and environmental protection. Countries around the world have taken measures to control greenhouse gas emissions. On the one hand, China needs to accelerate the development of cold chain logistics of agricultural products and improve the level of development; On the other hand, the rapid and large-scale development of the logistics industry should be avoided. How to realize the

coordination of the two has become one of the important problems to be solved urgently in the field of cold chain logistics in China.

## 2. Academic Research on Low-carbon Cold Chain Logistics System

In order to alleviate the contradiction between logistics development and environmental protection, domestic and foreign scholars have conducted qualitative and quantitative studies on the design, management and optimization of low-carbon logistics (supply chain). Sbihi et al. [1] proposed that economic and environmental factors should be combined in the study of logistics operation (reverse logistics, waste management and vehicle paths, etc.) to jointly optimize and realize the greening of logistics system. Dong qianli et al. [2] made an in-depth analysis of the key breakthrough points in the operation of low-carbon logistics, and proposed a low-carbon strategy for freight logistics. Qin xinsheng [3] built a conceptual model of carbon footprint management of logistics enterprises based on greenhouse gas emission inventory, took the operation reality of a logistics enterprise as an example to calculate its total carbon emissions within a limited time, and proposed Suggestions on future carbon footprint management of logistics enterprises based on the calculation results. Fang jian et al. [4], on the basis of full analysis of carbon emission measurement and relevant information disclosure, draw lessons from relevant foreign experience in the construction of low-carbon supply chain, and put forward the key issues and factors to be considered in the network design of low-carbon green supply chain in China. Peng xiyang [5], Chen siyuan et al. [6] all studied supply chain management and optimization from a low-carbon perspective, indirectly demonstrating the importance of considering carbon in supply chain management.

The quantitative research on low-carbon logistics focuses on the optimization of transportation and storage. Based on the proposed reverse logistics network, Kannan et al. [7] studied the logistics decision-making problem of considering the minimum carbon footprint and operation cost at the same time, and verified the applicability of the model by taking the recycling of plastic products as an example. Yang et al. [8] took the logistics and transportation network of urban DC as the research object, established the distribution route optimization model considering carbon tax, and took urban fruit and vegetable distribution as an example for simulation. The research found that the establishment of low-carbon distribution network helped 3PL achieve cost savings of 9.2% and carbon emission reduction of about 54.5%. Qian guangyu [9] also analyzed the VRPTW problem of fresh agricultural products when the carbon emission cost was considered. Tang et al. [10] made an in-depth analysis on the emission reduction problem of the inventory system for periodic stocktaking, constructed an inventory decision model that considered carbon emission reduction target, and sought the best inventory strategy by minimizing enterprise cost as the decision target. Hua et al. [11] and liu qianchen et al. [12] all considered the single-stage inventory optimization decision problem when carbon footprint was involved.

Through literature review, found that although the existing research on the logistics supply chain network design, management mechanism and optimum logistics warehousing and distribution, and so on fully considering the influence of carbon emission factors, but more is given priority to with universal network or supply chain logistics system, does not distinguish between different supply chain or logistics niche, such as carbon emissions significantly cold-chain logistics, only a few scholars studied the carbon footprint of fresh cold chain problems, and give priority to with single-stage unilateral quantitative decision-making, few cold-chain logistics network involving agricultural products shall be overall carbon optimization analysis. On the basis of agricultural products cold chain logistics development, the diversification of cold chain to meet customer needs as the guidance, to build highly efficient environment-friendly agricultural products cold chain logistics system, minimize logistics links of carbon emissions, carbon optimization to realize the cold chain logistics, will become the inevitable trend for the sustainable development of cold chain logistics. In view of this, on the basis of fully analyzing the driving factors and carbon emission sources of agricultural cold chain logistics, this paper introduces the third party and the fourth party logistics to re-structure

the low-carbon and environmental protection agricultural cold chain logistics system, and points out the development direction of further realizing carbon optimization in the future.

### **3. Driving Factors for the Implementation of Low-carbon Cold Chain Logistics System of Agricultural Products**

The cold chain logistics system from the perspective of low carbon refers to bringing the carbon emission generated in the operation of cold chain logistics into the consideration of logistics management and decision-making, so as to realize the energy saving and emission reduction in the link of cold chain logistics. Low carbon and environmental protection cold chain logistics requires logistics operators to not only consider the cost saving and service level improvement, but also pay attention to the overall carbon emission reduction of the cold chain, build a multi-objective decision-making system, and achieve the development of cold chain logistics and energy saving and emission reduction "mutual benefit and win-win". However, the construction of low-carbon and environment-friendly cold chain logistics system of agricultural products not only depends on the initiative of logistics operators, but also stems from the comprehensive influence of various factors inside and outside the cold chain.

#### **3.1 Overall Status of the Vertically Integrated Developing Cold Chain**

The cold chain of agricultural products includes multiple supply nodes such as farmers, wholesalers at all levels, distributors and retailers, etc. The increasingly intensified market competition makes more and more enterprises gradually abandon the narrow development concept of "self-benefit maximization", actively seek cooperation between the upstream and downstream nodes of the cold chain, and establish the overall optimal development concept. Cold chain and the development trend of vertical integration on logistics service providers to architecture cold-chain logistics system, the reasonable planning of cold chain logistics resource allocation, reduce energy consumption, improve the whole competitive power of supply chain, and carbon based on optimization of cold chain logistics system more contribute to form the core competitiveness of the whole cold chain, to expand the cold chain vertical integration brought about by the "bonus".

#### **3.2 Consumers' Increasing Recognition of Environmental Protection**

With the deterioration of the global environment year by year, consumers gradually realize the importance of environmental protection. "Environmental protection" is no longer a verbal appeal, but more into people's consumption concept. Many countries, such as France, Germany and Japan, have implemented carbon footprint labeling systems for some products. According to the research, more and more consumers prefer to buy environmentally friendly products with a small carbon footprint. When goods the carbon footprint of a big enough impact on consumer behavior, fresh cold chain stakeholders will start to look for in a more low carbon environmental protection way to realize the value of the goods, the logistics activity throughout the commodities from raw materials procurement to sales (is), and then to waste disposal (reverse logistics) of the whole process of life cycle, accompanied with carbon footprint on the supply chain of the sexual further promote the cold-chain logistics operators to architecture fresh cold chain logistics system, in order to reduce the carbon footprint of goods cold-chain logistics links, the proportion of carbon. It is worth noting that although the planting activities of agricultural products have the highest carbon emission ratio in their life cycle, in terms of the operability of carbon emission reduction and the rationality of market demand, the reconstruction of fresh and cold chain logistics system is easier to meet consumers' requirements for low-carbon and environmental protection of commodities.

#### **3.3 International Competition Environment and National Policy Orientation**

In response to the global climate warming, complying with the trend of the international emissions, many countries according to their own carbon emissions problem formulated the corresponding laws and regulations and policy measures, such as a carbon tax and carbon emissions trading system and government subsidies, etc.), represented by the European Union's part to join the United Nations

framework convention on climate change in the country or region, for the import of carbon intensive products or service set up barriers to higher carbon tax, the increase in China's enterprises to participate in the international market competition is difficult at the same time, also inspire their own logistics links especially cold chain logistics links with large Numbers of carbon carbon optimization. China is also expected to gradually open its carbon emission trading rights to enterprises in the first half of 2017. The implementation of domestic carbon trading will have a significant impact on the economic activities of enterprises related to cold chain logistics. Both the passive guidance of the government's mandatory "emission reduction" policy and the active optimization of enterprises' carbon cost saving and participation in international market competition have contributed to the construction of low-carbon cold chain logistics system for agricultural products.

## 4. Low-carbon Agricultural Products Cold Chain Logistics System Analysis Motivation

### 4.1 Origin of Carbon Emission of Agricultural Cold Chain Logistics

Based on life cycle theory, the carbon footprint of a commodity with the whole process of life cycle, therefore, every cold chain logistics activity will lead to the increase of carbon emissions, however, agricultural cold chain logistics, the cause of the high carbon emissions is not completely from the logistics operation itself, its also and the structure of agricultural products supply chain, logistics activity is closely related to such factors as the participants.

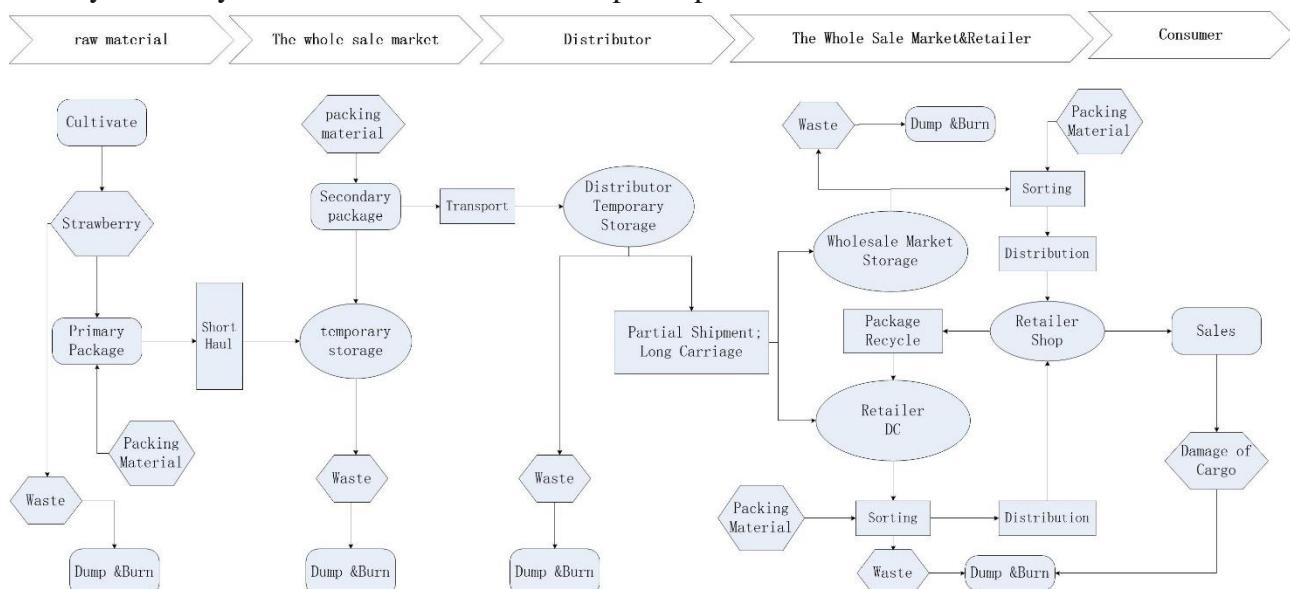


Fig. 1 Cold chain logistics system of strawberry

#### 4.1.1 Multi-tiered Agricultural Supply Chain

Tradition of fresh agricultural products supply chain mostly involved farmers (or farmers cooperatives), origin of wholesalers, distributors or distributors at all levels, XiaoDe multiple links such as wholesalers and retailers, is "spin" supply chain though to some extent to meet the consumer demand for part of the spatial span larger agricultural products, but also caused the low efficiency of the supply chain, the rise of carbon emissions. As shown in Fig.1, sales of strawberry, for example, its cultivated by farmers to the final consumer market has experienced roughly five supply chain, each node of strawberry logistics supply operations (such as packaging, processing, loading and unloading car) will produce corresponding damage and waste, node number, the more the higher the proportion of damage and waste. A large amount of waste and cargo damage not only reduces the effective amount of fresh agricultural products at each node, but also causes a large amount of carbon emissions, indirectly increasing the unit carbon footprint of the final commodity. In addition, the particularity of commodities makes fresh agricultural products pay more attention to the timeliness of logistics activities, while the multi-level supply chain of agricultural products invisibly extends the

storage and transit time of low-temperature commodities, resulting in the increase of the cooling time of the supply chain and the increase of greenhouse gas emissions. It should be pointed out that the marginal cost of fresh agricultural products will also increase with the increase of the vertical nodes of the supply chain, which will lead to the increase of the unit price of commodities and harm the interests of consumers.

#### 4.1.2 Decentralized Cold Chain Logistics Operation

In recent years, although the cold chain logistics of agricultural products in China has been developing rapidly, the lack of high-level third-party cold chain logistics service providers makes the current cold chain logistics activities of agricultural products still mainly run by the node enterprises themselves, lacking effective overall planning. Figure 1, the strawberry in the cold chain of each node in warehousing, transportation, packaging and processing is done by the node enterprises organize, such short-term and partial views of logistics operation cannot obtain the effective scale effect, not only cause the cold chain logistics operation efficiency is low, also can cause the node enterprises of cold chain logistics resources excessive investment, resulting in the increase of agricultural products cold chain potential carbon emissions. Especially when the service objects of cold chain logistics of agricultural products are not limited to a single variety, the degree of integration between the logistics operation systems of multi-product warm agricultural products is not high, and the vehicle vacancy rate in terminal distribution is too high, which results in the waste of part of the existing logistics resources and indirectly increases the carbon emission of the cold chain system.

#### 4.1.3 Low Penetration Rate of Logistics Standardization and Low-carbon Technology

The application scope of logistics standardization and unification is relatively small and the application rate is low, which increases the carbon emission in the supply chain of agricultural products to some extent. As shown in figure 1, strawberries are initially packed once after picking. When transported to the wholesale market of the producing area, secondary packaging is carried out to facilitate long-distance transportation and loading and unloading. After the commodities arrive at the wholesale market of the selling place through the distributor, they are re-packed due to the different transportation environment and customer needs. The low applicability of standardized logistics packaging and logistics operation leads to repeated packaging and frequent loading and unloading trucks in the process of cold chain, and the resulting severe cargo damage and packaging waste aggravate the carbon emission of cold chain logistics links. The use of some disposable pallets and packaging materials is also one of the factors contributing to the high carbon footprint of agricultural cold chain logistics. In addition, the lack of low-carbon environmental protection technology is also one of the main reasons for the high carbon emissions of agricultural cold chain logistics. Because of energy conservation and emissions reduction technology cost is higher, and the domestic carbon trading has not been given a detailed implementation rules, the vast majority of agricultural products cold chain logistics service provider is not in the storage at low temperature and low temperature transport these carbon high link application technology to reduce emissions, high energy consumption, poor cooling effect of refrigerated warehouses and the use of mechanical refrigeration vehicles in the cold chain logistics, leading to a large amount of greenhouse gas emissions.

#### 4.1.4 Improper Waste Disposal

Is perishable fresh agricultural products cold chain logistics operation of the main object, therefore, its operation process will inevitably produce unable to sell due to deterioration of goods, packaging and transportation of waste, etc., traditional agricultural product logistics system in the treatment of these wastes is used more nodes nearby landfill or burned ways, although access to lower the cost of waste disposal, but improper handling can cause agricultural products cold chain logistics link high carbon emissions, is not conducive to the sustainable development of cold chain logistics.

#### 4.2 "Efficiency Contradiction" of Low-carbon Cold Chain Logistics of Agricultural Products

The low carbon and environmental protection cold chain logistics system of agricultural products has a profound impact on the cold chain stakeholders and the sustainable development of society and environment. However, the implementation of low carbon cold chain logistics of agricultural products also intensifies the phenomenon of "benefit contradiction" in the logistics system to some extent. Win min goods (mainly commodities at low temperature) more than normal product's biggest difference is that goods from production to storage and transportation and distribution of every part needs strict temperature control, and represented by fruits and vegetables than half of fresh agricultural products processing, the processing of cold chain products (such as filling of milk, fruit juice, etc.) on the changes of temperature and humidity in the logistics operation of a higher sensitivity.

Under the condition of convergence in commodity prices, consumers tend to choose high freshness of fresh agricultural products, this kind of consumer orientation and food safety factor considering make terminal retailers require cold-chain logistics of fresh agricultural products increase overall and refrigeration for preservation technology input, to improve the quality of sales of agricultural products, and prolong the shelf life, stimulating demand. However, excessive preservation equipment, refrigeration equipment use exacerbated the carbon emissions in the links of fresh agricultural products cold chain logistics, cold storage, for example, according to relevant data statistics, China's only food cold storage industry's annual electricity consumption accounted for about 1.6% of the national total output around, huge power consumption caused a high proportion of carbon emissions, and compared with the loss of the regional refrigeration technology and has significant rise. The implementation of low-carbon cold-chain logistics system will reduce the consumption and time of refrigeration equipment to some extent, which is contrary to the "high quality" fresh agricultural products pursued by cold-chain stakeholders.

#### 5. Composition of Cold Chain Logistics System for Agricultural Products

Cold-chain logistics development and implementation of carbon optimization between although there are many factors of "benefit" against, but low carbonization of cold chain logistics operation is the agricultural products supply chain and logistics industry to enhance the core competitiveness and realize sustainable development inevitable trend, therefore, reduce the cold chain logistics overall carbon emissions, agricultural cold chain logistics activities need to planning, the integrated logistics services level without falling, establish a low-carbon cold-chain logistics system of agricultural products, see Fig.2.

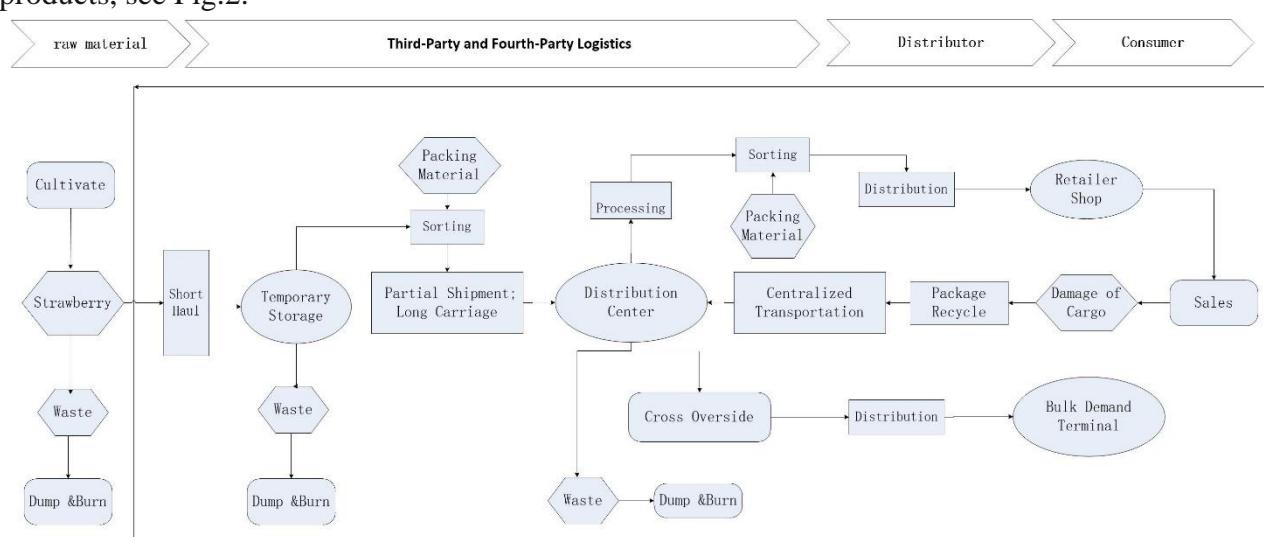


Fig. 2 Low-carbon cold chain logistics system of agricultural products

In order to effectively avoid excessive level agricultural products supply chain is a series of negative effects, combining the theory of core competence, we reconstruct the agricultural cold chain logistics system in the introduction of a third party, the fourth party logistics enterprise, using its specialization

and scale of logistics operation and information processing ability, to make unified agricultural products supply chain logistics activities and reasonable planning, by compressing the supply chain level, shorten the time of fresh agricultural products in cold chain circulation. The optimization of specific nodes in the system is shown in Fig.2.

### 5.1 Agricultural Farmers

In the reconstructed logistics system, 3PL will directly harvest agricultural products from the producing area in the planting area, and undertake the short-distance transportation from the field to the cold-chain logistics center of 3PL producing area. At the same time, in the planting node of fresh agricultural products, the packaging activities of farmers are reduced. Through cooperation with 3PL, recyclable commodity packaging and loading tools (such as pallets) are provided.

### 5.2 The Third-party Logistics Enterprises

By professional 3 pl to replace the original distributors at all levels of the supply chain and ChanXiaoDe hub, from the precooling of origin of agricultural products to the long-distance transportation, storage and processing to the terminal and city distribution, the whole cold chain logistics operation by a third party, the fourth party logistics service providers to complete cooperation, to reduce cold chain logistics activities of the intensification of carbon emissions.

First, the standardized logistics operation of 3PL is used to reduce the input of packaging materials in the distribution of fresh agricultural products, so as to reduce the carbon footprint caused by repeated packaging and cargo losses caused by standardized and unified logistics equipment and logistics operations. Secondly, in the long distance transportation, through rapid accurate logistics information network and 3 pl science as a whole, according to the downstream products demand information on the mode of transportation, aviation, railways, highways and their combination) and route optimization, the fresh agricultural products accurate, safety, low carbon service sales market in the 3 pl cold-chain logistics distribution center (DC), the demand for some larger terminal customers, can use DC cross overside reduce frequent cargo; Again, near the end of cold chain logistics distribution center, according to market demand for fresh agricultural products for centralized processing, packaging and label assignments, and through reasonable planning, fast delivery, low carbon city, when faced with a variety of different product temperature distribution of agricultural products, DC can be used more temperature were cool storage type to match replace traditional mechanical refrigerated ice truck distribution, reduce the frequent switch doors, vehicles and refrigeration energy consumption carbon emissions. Finally, make full use of the developed urban distribution network of 3PL to recycle recyclable packaging equipment, logistics waste and corrupt goods at retailers, reduce the empty load rate of vehicles, and realize the centralized disposal of waste in the middle and lower reaches of the supply chain.

### 5.3 The Fourth Party Logistics Information Platform

Agricultural products logistics system of low carbon requires a lot of data analysis and high-speed information transmission network, therefore, to the introduction of the fourth party logistics enterprise restructuring of agricultural products cold chain logistics system, the use of its perfect logistics information network and database to realize the agricultural products supply chain information interconnection between each node, the temperature control, logistics status and demand for fresh agricultural products information and so on carries on the monitor, while ensuring the quality of agricultural products to reduce carbon emissions.

### 5.4 Terminal Link

As much as possible in order to reduce carbon emissions, agricultural products supply chain terminal node based on low carbon agricultural products cold chain logistics system to logistics information network extends to terminal vendors, it can be predicted based on the platform of adjust shelves display and promotion, and we will not sell in a timely manner, serious corruption of fresh agricultural products and packaging waste stored in a designated place, by vehicles according to the seller is

responsible for the urban distribution information in the input information platform for centralized recycling. The recovered waste will be directly sent to the garbage waste treatment plant by 3PL for specialized and centralized treatment.

## Acknowledgements

First and foremost, I would like to show my deepest gratitude to my supervisor, Dr. Liu Dong su, a respectable, responsible and resourceful scholar, who has provided me with valuable guidance in every stage of the writing of this thesis. I shall extend my thanks to my friends, especially my three lovely roommates, for their encouragement and support.

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