Enhancing Farmers' Engagement in Biomass Supply Chain through Risk perception-Motivation-Behavior change Model: A case study of National Bioenergy Power industry area, Northeast China

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Graduate School of Engineering
Kochi University of Technology

A dissertation submitted to Kochi University of Technology in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Environmental System Engineering

Kochi, Japan
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Abstract

The growth of huge external costs caused by pollution, along with the shortage of fossil fuel reserves, create additional concerns that represent strong motivations for the development of a new type of power plants assumed to be environmentally friendly and based on endogenous resources. The use of biomass is a promising alternative to fossil fuels, which would mitigate environmental pollution and optimize energy structures. In China, a major application of biomass is combustion to generate electricity and heat. However, the current straw-based biomass power plants face difficulty in development. Because farmers have various risk perceptions, not a few of them are willing to cooperate with the middleman, who takes on the responsibility to collect straw from the farmers. Their risk perceptions decrease the motivation in participating crop straw collection activities. To solve the problem of insufficient collected straw for the biomass power industry, the National Bio-energy Power industry area in Wangkui County, China was selected as a case study to investigate the empirical problems. This study was divided into eight chapters.

Chapter I introduces the current situation of biomass supply chain and the barrier of development of biomass power plants in China. The dilemma in developing biomass power plant is derived from the situation introduction.

In Chapter II, the external cost of coal-fired and biomass power plants was compared, using the lifecycle approach. The results highlight that the external costs of a coal-fired plant are 0.072 US $/kWh, which are much higher than that of a biomass power plant, 0.00012 US$/kWh. The external cost of coal-fired power generation is as much as 90% of the current price of electricity generated by coal, while the external cost of a biomass power plant is 1/1000 of the current price of electricity generated by biomass. The external cost of coal-fired power plants could be resource to incentive biomass power plants.

In order to solve environmental problem and fully utilize crop straw, in Chapter III, stakeholders' perceived risks were investigated based on interviewing with stakeholders in National bioenergy industry area in Northeast China. Combing the developing dilemma, literature review on problems in biomass power plants, and investigation in China, problem is formulated. The problem formulation results indicate that farmers' risk perceptions are the root causation of the barriers in the biomass supply chain.

In Chapter IV, to comprehensive understanding farmers' risk judgement in supplying straw, an exploratory FROSS (Farmers' Risk perception Of Straw-Supply) model which in including vertical (different income level villages) and horizontal (different risk perception aspects) analysis was generated to assess farmers' risk perception with quantitative approach. The results of vertical analysis show that both economic factors and trust factors are statistically significant. However, policy guidance factors can only predict farmers' risk perception in village with high annual income. Horizontal analysis confirmed by factor analysis that farmers' risk perception can be conceptualized along two dimensions, named: personally (related to economic and trust factors) and environmentally related risk perception. The predictors can predict 80.5% of personally related risk perception, while only 16.2 % of environmentally related risk perception. The results demonstrate that currently economic and trust factors are crucial factors affecting farmers' risk perception. Therefore, to solve economic and trust problems, this study tends to divide the solution into short-term and long-term strategy.

In Chapter V, explore new incentive scheme for straw supply as the short-term target. A Stackelberg game theory is applied to model biomass supply chain and design incentive scenarios to cooperate stakeholders under risk and uncertainty. The impacts of incentive to the farmer and the middleman were demonstrated. The results show that with incentive, both the quantity of straw supplied by the farmer and stakeholders' profit will increase. Particularly,

incentive to the farmer has remarkable effect. In order to obtain incentive resources. However, the development of biomass power plants should not depend on economic incentive all the time. Therefore, in the long-term, to be sustainable development, trust between farmers and middleman or the biomass power plant should be built in Chapter VI. In this section, the relationship between distrust factors and risk perception, transaction cost and farmers' engagement in supplying straw were investigated, respectively. Finally, a conceptual trust enhancement model in straw-supply was generated based on the analysis.

In Chapter VII, in line with the empirical analysis, a RMB (Risk perception-Motivation-Behavior) model was derived to emphasize the significance of analysis of risk perception and motivation in behavior change and summary the behavior change process. In this model, it is highlights that accurately analysis of stakeholders' risk perception is foundation of investigating stakeholders' motivation to change their behavior. Moreover, in order to change behavior, extrinsic motivation should be given to stimulate intrinsic motivation. Behavior can be changed automatically with intrinsic motivation.

In conclusion, from empirical perspective, this study analyzed the stakeholders' risk perception and explored approaches to mitigate stakeholders' risk perception to reach cooperation situation based on a case study in biomass power industry area in Northeast China. Theoretically, this study derived exploratory RMB model expecting to further improve organization cooperation by mitigation of risk perception and enhancing motivation.

Keywords: biomass supply chain; engagement; risk perception; RMB model

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With all memory that happened like a dream, the three-year study will finish soon. Everything that happens is a step of growing up. Now I would like to capture every moment. However, *no hand can make the clock strike for me the hours that are passed (Byron)*. What I can do is cherishing the memory and giving my sincere gratitude to people that I met. First of all, I would like to express the deepest appreciation and sincere thanks to my supervisor, Professor Tsunemi Watanabe, who has both kind and sympathetic heart towards suffering people and the substance of a genius of conveying a spirit of adventure in new researches and passion and sincere attitude to teaching and guiding students. During the three years study, Professor Watanabe gave me detailed and professional advice on my research. His hard working and rigorous thinking way sets an excellent example of a good researcher. Moreover, his enthusiastic attitude towards life and encouraging support help me overcome difficulties in the three years. His determination of working for people's happiness, love for nature and society will always guide me how to be a responsible social people.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

1.1.1. Overview of biomass power production in China

The biomass resources in China are abundant, widely distributed and have large various and output (Zhao and Wang, 2012). The current amount of biomass resources in China is 540 million tons of standard coal equivalent (TCEs); the available amount is around 280 million TCEs (Chen et al., 2013). The large quantity of biomass provides great potential for biomass power generation. However, the effective utilization rate of biomass resource is low (**Fig.1.1**). The efficiency of direct-combusting is extremely low, approximately 5% to 8% (Gao et al., 2009). In addition, a considerable amount of biomass is burned in the open field, which not only leads to waste of energy resources, but also cause environmental problem. To effectively use of biomass resources, regulation and law are needed in detail, such as "*The Renewable Energy Law of The People's Republic of China*", "*The Tentative Management Measures for Allocation of Price and Expenses for Generation Electricity by Renewable Energy*", and "*The Medium and Long Term Development Plan for Renewable Energy*", which are significant to the development of biomass power industry development in China.

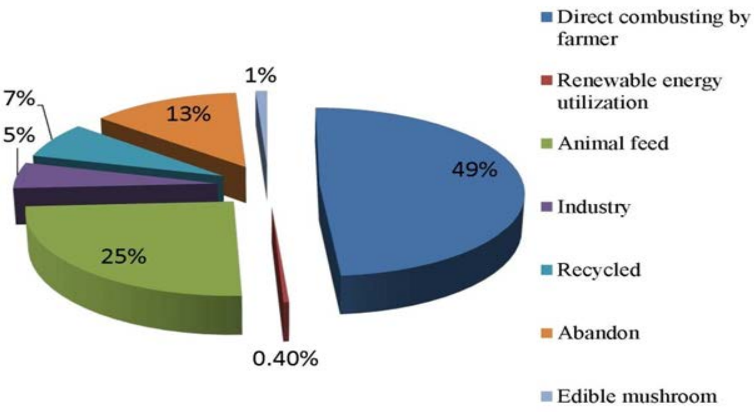

Fig. 1.1 The structure of straw consumption in China

The process of electricity generation in biomass power plant is a complex process. **Fig. 1.2** displays the process from straw collection to power generation (Wang et al., 2014). Generally, this process consists three stages, including field harvesting, collecting, and conversion. To be specifically, straw is harvest and removed from the farmland. The middleman who take in charge of collecting straw from farmers purchase straw with a certain price, and then process the straw and store the processed the straw. The biomass power plant would purchase the processed straw from the middleman when the power plant needs it. The ash content is supposed to apply as appropriate to agricultural soil to recycle nutrients, however, the part hasn't widely used in China, particularly in the north part of China.

Collecting straw from field is challenging for straw-based biomass power plants in China due to the characteristic of straw resources: (a) unlike the other renewable resources, straw resources are scattered in the large farmland. To collect enough quantity of straw for power generation, the biomass power plant and the middleman need to cooperate with large number of farmers. (b) Large truck cannot get into the farmland to collect straw due to the poor road condition in the countryside, and the protection of farmland. Therefore, labor is need in collecting straw. (c) To save straw collecting time and labor, farmers prefer to burn the straw in the farmland instead of selling to the biomass power plant. Motivation of cooperating with the middleman is low due to various farmers' risk perceptions (Yu et al, 2012). Moreover, to keep sustainable straw supply, long-term relationship with farmers is significant in the future. To do that, building trust between the middleman and farmers is the key issue for the development of biomass power plants.

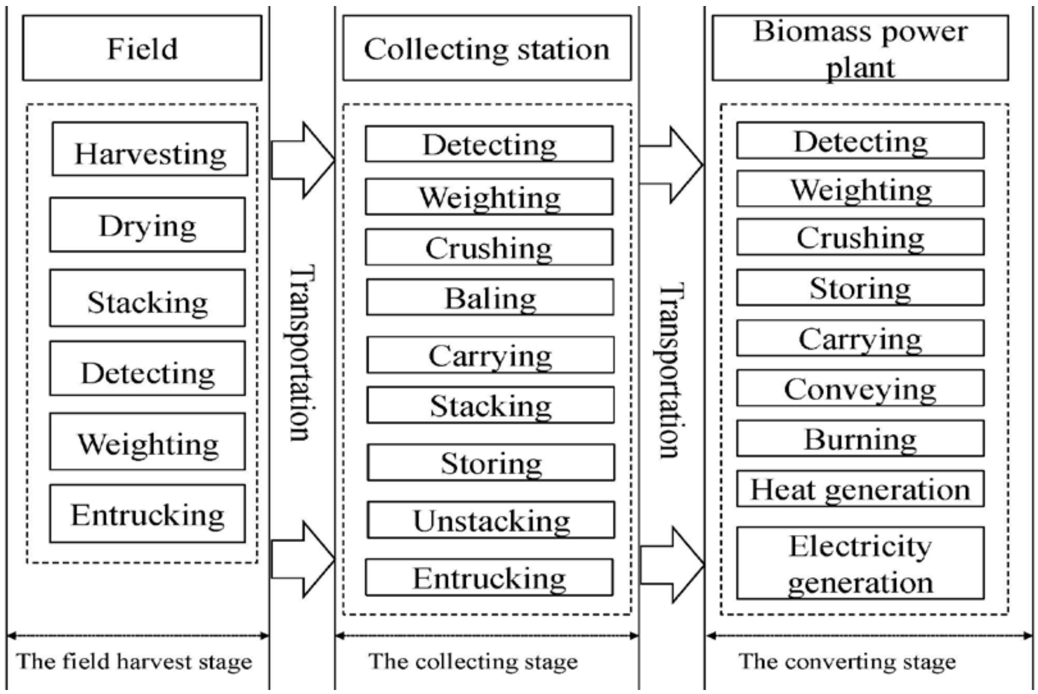

Fig. 1.2 structure of biomass supply chain

1.1.2. Outlook of policies in biomass power industry in China

In order to utilize the abundant straw resources in China, the central government has proposed the goal of biomass power development in both "The Eleven Five-Year Plan" and "The Twelve Five-Year Plan". Without the support of the government, the biomass power industry could not survive. However, even with the support of the government policy, particularly subsidies, many biomass power enterprises suffering deficit. Improving incentive policies on biomass energy utilization could be an important challenge in the process of this industry development. In order to find the root problem of biomass power development, this part of the study deep analyzes the development of policy related with biomass power industry.

1.1.2.1. Legal

China has four laws on the development of renewable energy and utilization:

• "*Electricity Law*" (April 1996) Article 5: the state encourages and supports the use of renewable energy and clean energy generation;

• "*Energy Saving Law*" (implemented in 1998, and revised in 2007) Article 7: the state encourages and supports the development and utilization of new energy and renewable energy;

• "*Circular Economy Promotion Law*" (2009) Article 23: if the conditions permit, the region should make full use of renewable energy.

• "*Renewable Energy Law*" (implemented in Jan 2006 and revised in Dec 2009): there are five restrictions, i.e., the total volume target of development and utilization, mandatory grid connection, differentiated price, cost-sharing and special funds.

1.1.2.2. Industrial development guidance and planning

For the development of industry in China, there are various kinds of guidance, including "*Guidance Catalogue for Industrial Structure Adjustment*" (2005, 2011), "*Guidance Catalogue for Foreign Investment*" (2004, 2007, and 2011) and "*Guidance Catalogue for Renewable Energy Industry Development*" (2005). **Table 1.1** displays the plans that related to biomass power development goals since 2006.

Table 1.1 Strategic goals of biomass power generation development

Content	To 2010	To 2015	To 2020
Installed capacity	4000 MW	8000 MW	24,000 MW
Generating capacity		480 billion kWh	
Demonstration project	Direct-firing power; gasification power	Direct-firing power; co-firing power; combine heat and power.	
Biomass planting			The forest used as energy covers about 20 million ha.
Technology research	Power generation technology.	New equipment; boiler corrosion control; measure and test of co-firing.	

Source: Source: summarized according to "12th Five-Year Plan for Renewable Energy Development", "Mid-and Long-Term Plan for Renewable Energy Development", etc.

1.1.2.3. Supporting laws and regulations

To facilitate the development of biomass power industry, several supporting laws and regulation were issued by the central government. The details of these laws are shown in **table 1.2**.

Table 1.2 Laws and regulations related with biomass power industry

Law/ regulation	Issued time	Content
Agriculture Machinery Promotion Law	From 1998	• Agricultural machinery popularization license and combined cross-regional operation license nationwide issued by Ministry of Agriculture (MOA) (Ministry of Agriculture, 2000). • Vehicles with license can be driven on country roads and provincial trunk highways, and free through any toll gate (Ministry of Agriculture, 2000). • The management sector should carry out work on agro-machinery maintenance, spare parts and fuel supply (Ministry of Agriculture, 2007). • Financial subsidies to farmer who purchase agro-machinery is provide (Central Committee of the Communist Party of China, 2004).

Project construction law		• The project needs to undergo environmental impact assessment (State Environmental Protection Administration, 2006). • The local governments should plan the comprehensive utilization of straw resources (General Office of the State Council, 2006). • Project planning and location should be reasonable, avoiding being duplicated. The size should not be less than 12 MW (Ministry of Environmental Protection, 2008). Within 100 km radius, only one project can built and the size should be no more than 30 MW (National Development and Reform Committee, 2010).
Electricity purchasing regulation in Renewable Energy Law	2006	A full compulsory emption system for renewable energy power generation is carried out. A grid enterprise purchases on-grid energy in areas covered by its grid (State Electricity Regulatory Commission Sinopec, 2007).
Project development subsidy regulation	2006	• Grant subsidies: the fund is for weak profitable and welfare project. • Discount loan: the loan includes all and partial discount that its cycle is 1 to 3 years and its rate no more than 3% annually (Ministry of Finace, 2007; Ministry of Finance, 2006). • Renewable energy generation project subsidy=(Renewable energy feed-in − De-sulfurized coal-fired feed-in tariff of local provincial grid)* Renewable energy power generation on-grid electric quantity (National Development and Reform Committee, 2006). • Grid connection subsidy standard of a project is in line length, i.e., 0.01 yuan/kwh (<50 km), or 0.02 yuan/kwh (≥50 km and < 100 km), and/or 0.03 yuan/kwh (≥ 100 km) (National Development and Reform Committee, 2006).
Electricity price law	2006	• Biomass power project tariff and its subsidy standard are the de-sulfurized coal-fired feed-in tariff of a local provincial grid +0.25 yuan/kwh. • The power generation project would enjoy the subsidies for 15 years from the production data (National Development and Reform Committee, 2006). • The agricultural and forestry biomass generation tariff (except of bidding projects) adjusted to 0.75 yuan/kwh from July 1, 2010 (National Development and Reform Committee, 2010).
Customs law	2005	This law is to establish fund to support renewable energy development. The fund-acquiring channel is by levying the attached tariff to electricity users. • The attached tariff standard varied several times: 0.001 yuan/kwh starting effective from June 30, 2006 (National Development and Reform Committee, 2006); 0.002 yuan/kwh to July 1, 2008 (National Development and Reform Committee,

		2008); 0.004 yuan/kwh to November 20, 2009 (National Development and Reform Committee, 2009); 0.008 yuan/kwh from January 1, 2012 (Ministry of Finance, 1999).
Enterprise income tax law	1997	• In the project construction stage: (1) the imported equipment can enjoy value added tax (VAT) and customs duties exemption (State Council, 1997); (2) if the domestic equipment is used for at least 5 years, it can offset the income tax against the VAT in 40% the equipment investment (Ministry of Finance, 1999). This policy ended on January 1, 2008 (Science and Technology Education Department of the Ministry of Agriculture, 2008). • In the project operational stage: (1) for biomass power generation, exemption from the tax 5 years since the production data (ended before January 1, 2008); (2) for biomass fuel purchase, since January 1, 2009, the tax is exempted.
Law on science and technology progress	2006	• National Science and Technology Support Program (NSTSP) by Ministry of science and technology: focusing on solving major scientific and technology problems. • National Science Foundation of China (NSFC): playing a guidance role in supporting basic research. • National Torch Plan (NTP): promoting the commercialization of high-tech achievement, industrialization of high-tech goods and internationalization of high-tech industry. • National New Production Plan (NNPP): promoting new product development and technological achievements. • 973 (National key basic research and development program, known as 973): solving the main scientific problems in national strategic needs. • National energy application technology research and engineering: Focusing on new energy technologies, engineering, etc. (State Council, 2008).

1.1.2.4. The relationship among laws and regulations

In line with the legal, guidance and plans, and regulations, they don’t exist separately. To deep understanding the law and regulation for biomass power industry, the relationship between them are described in **Fig. 1.3**.

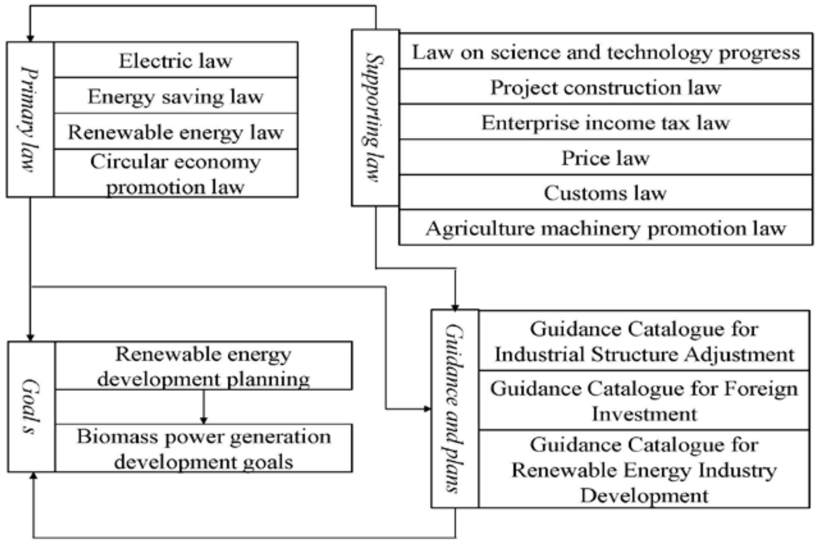

Fig.1.3 The relationship among laws and regulations

1.1.2.5. Policy problems analysis

Although the government has made great effort in making policies to promote biomass power industry, biomass power plants still face bankrupt. Even a large amount of subsidies have been invested, the effects seems low. The problems existing in the policy are displayed in the stages of power of generation in **Table 1.3**.

Table 1.3 Problems existing in biomass power generation

Project	Content
Scientific fund	Duplicated research funds. As shown in Table 2, there are similar project in the NSTSP, the NSFC and 973.
Project planning	The location or site of some project is unreasonable. With 100 km, there are several biomass power plants., such as in Jiangsu province.
Project approval	• The scale of some projects is beyond the policy provisions, in which the scale is no more than 30 MW, i.e., the Yuedian Zhanjiang project is 2*50 MW. • Local government only evaluates the theoretic straw resources, instead of people' willingness to supply straw.
Project construction	No subsidies to farmers who supply straw. The subsidies to the biomass power plant are large. However, one of the vital barriers influencing biomass power plant surviving is insufficient straw. To

	solve this problem, farmers are important role.
Straw collection stage	Lack of laws and regulations on contracts between farmers and middleman, middleman and the biomass power plant. There are contracts between middleman and biomass power plant, but not effective.

1.1.3. The feasibility of development biomass power plant in Northeast China

In China, biomass is an alternative energy to coal. Particularly in Northeast China, crop straw is an attractive alternative for two reasons. As shown in **Fig. 1.4**, the total output of straw in Northeast China ranks three following Northern China and Yangtze River region. However, in term of output of straw per ha, Northeast China is the highest, 2.51 ton/ha. When calculated straw output per capital, the Northeast China is considerably higher than the other areas. **Fig. 1.4** indicates the characteristic of Northeast China, that is, large farmland with less population than the other regions. The abundant crop straw has huge potential of electricity generation. In Northeast China, the total electricity generation capacity is around 162 MW to 470 MW (**Fig. 1.5**). **Table 1.4** shows the current biomass power plants in Northeast China. The total capacity is 190 MW, which is far from the potential electricity generation capacity.

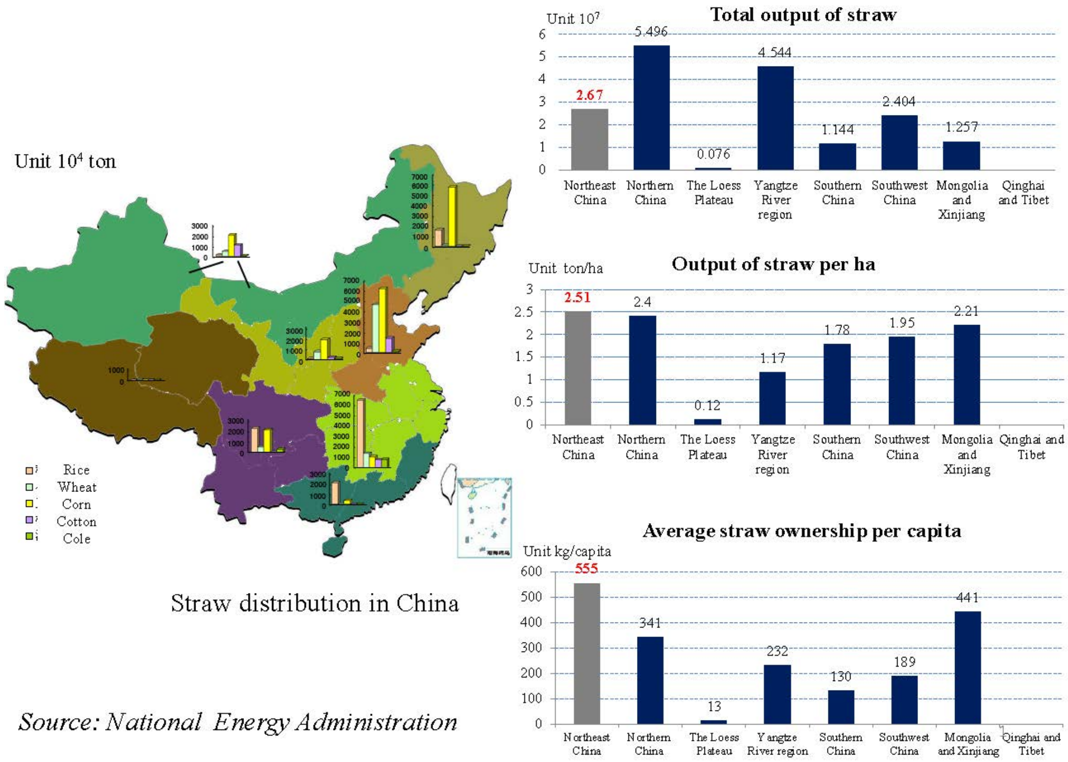

Fig. 1.4 The straw distribution in China

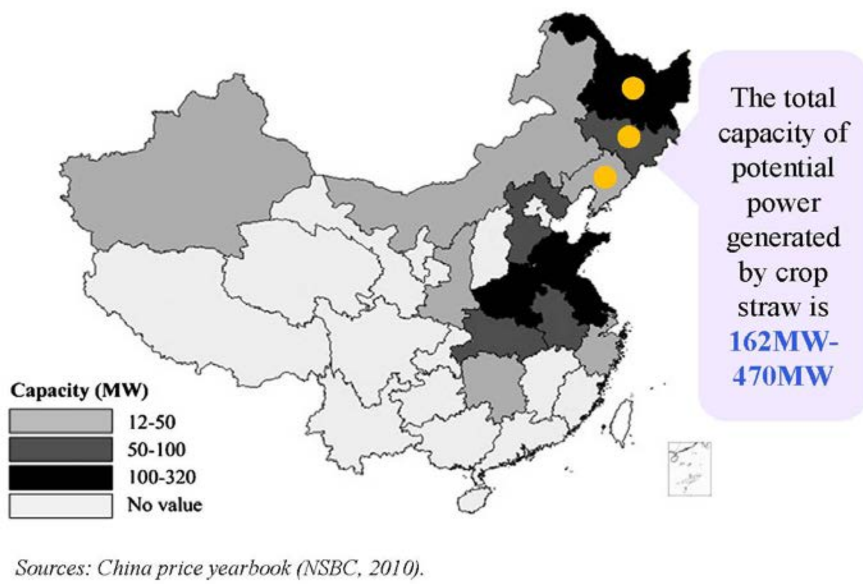

Fig. 1.5 Capacity (MW) of power generation industries based on crop residues installed by provinces in 2009.

Table 1.4 Subsidies table of straw-based power plant projects in 2010 from Jan to June

Location	Project	Installed capacity (MW)	Subsidy ($)
Heilongjiang	National Bioenergy Wangkui power plant	30	1,410,563.17
	Tangyuan bioenergy power plant	30	360,669.95
	Qinghequan bioenergy power plant	12	404,509.18
	Qingan heat and electricity bioenergy power plant	15	379,618.78
	Jiansanjiang bioenergy power plant	24	580,990.16
	Total capacity in Heilongjiang Province	111	
Jilin	National Bioenergy Liaoyuan power plant	25	1,003,163.49
	National Bioenergy Meihe power plant	12	634,464.37
	Huaneng Changchun bioenergy power plant	30	499,735.04
	Total capacity in Jilin Province	67	
Liaoning	National Bioenergy Heishan power plant	12	469,384.81
	Total capacity in Liaoning Province	12	

To be specifically, there are two main reasons. First, it is abundant in this region. The total crop straw production is approximately 96,283,700 tons (Statistical Year Book of Heilongjiang Province, 2010; Statistical Year Book of Jilin Province, 2010; Statistical Year Book of Liaoning Province, 2010.), which can produce 77,026,880,000 kWh of electricity (based on a case study in Wangkui, the crop straw electricity generation rate in 2014 was 800 kWh/ton). This quantity of electricity would meet 30.53% of Northeast China's demand (China Electric Power Committee, 2013). Second, power generation using the renewable energy source of crop straw poses far fewer risks to national security, the economy, the environment and public health. Therefore, biomass power generation, particularly power generation using crop straw, has great potential and could replace many coal-fired power plants in Northeast China.

Currently, however, there are only five large biomass power plants (installed capacity ≥ 25 MW) in Northeast China. Barriers persist in promoting their development, such as in the collection of crop straw and technological innovation. Some biomass power plants have already gone bankrupt or switched to other industries. Compared with investors in coal-fired power plants using cheap coal, biomass power plant investors obtain considerably smaller profits. Without government subsidies, biomass power plants cannot survive.

1.2 Problem statement in biomass power development

With high straw potential in Northeast China, the biomass power plants should develop smoothly. However, the real situation is disappointed. Even the quantity of straw is sufficient in theory, there are numerical barriers when operate the biomass power plant. To accurately diagnose the current problem, problem statements in developing biomass power plant are described below.

(1) Difficulties in fuel supply and high cost

With the government's effort to develop biomass power plant, increasingly investors are interested in investing biomass power plant, which is good news for renewable energy development. However, to reduce the transportation cost, biomass power plants usually built near the resources. Occupying the favorable position which leading t centralization of biomass project becomes serious in recent years. Meanwhile, in China, particularly in the Northeast China, biomass power plants are straw-based power plants. The seasonal nature of straw characteristics affects the continual supply. Moreover, because of low density of straw, transportation is also difficult. In addition, in order to control the cost, biomass power plants usually cut down purchasing price. However, farmers refuse to sell the straws with few profits, especially during the busy farming season. This is another cause of feedstock shortage.

(2) Core technology and equipment shortage

Nowadays, biomass power plants in China face various challenges. There are problems such as the shortage of technology, the low capacity utilization, and the weak industry foundation. Most biomass power plants still depend on importing technology and equipment. The domestic technology of biomass power generation equipment is still at the primary stage, which cannot meet the demands for the links of production and the sustainable development. However, even imported equipment, the biomass power plants still meet difficulties caused by transportation methods, work habits and culture (Zhao and Yan, 2012). For example, in Demark, the crops are planted in large areas, Farmers use harvesters to harvest the crop straw. After the harvest, straw are compressed and packaged into a standard size by packager. However, in China, small family owns the farmland. Crops are planted in small areas and harvested by hand and small machines. Therefore, it cannot fit the import fuel conveying systems. Moreover, the key parts in the equipment cannot be produced in China due to lack of core technology.

(3) Immature straw supply chain

Expect technology problems, another difficult that biomass power plant confronting is how to cooperate stakeholders in the straw supply chain. As the most biomass power plants complained, lacks of straw become the hugest problem which influencing the biomass power plants surviving. The detail problems are shown in **Table 1.5**. In biomass supply chains, farmers produce and supply raw material, which is used for biomass power plants. Thus, farmers' willingness to supply straw affects the quantity of biomass power plant's feedstock directly. Farmers' responses to supplying crop straw to middlemen are likely to be influenced by their risk perception and the level of risk that they face. Currently, because farmers perceive various risks, not a few of them are willing to cooperate with the middleman, who takes on the responsibility to collect straw from the farmers. Farmers' decision making in cooperating with middlemen is significant to promote the development of straw-based biomass power. In reality, however, farmers' unwillingness to sell their crop straw to middlemen causes insufficient raw material in biomass power plants. Their perceived risks decrease the motivation in participating crop straw collection activities.

Table 1.5 Summary of the problems existing in biomass power plants

Problems	**Description of issues**
Financial	High capital costs
Social	Lack of farmers' willingness to participate straw supplying
	Lack of farmers' and village community awareness
	Lack of long-term cooperation safeguard with farmers
Policy and regulatory	Lack of incentives to farmers to supply straw
	Lack of support for sustainable supply chain solutions
Institutional and organizational	Lack of supply chain standards
	Lack of organization norms and rules on decision making and supply chain coordination
	Immaturity of change management practices in biomass supply chain

1.3 Research Objectives

To promote biomass power plants in Northeast China, sufficient feedstock for biomass power plants the basic condition. As the role of suppliers, farmers are the crucial in collecting straw. In order to reach the research goal of sustainable biomass industry, generally, there are two steps, that is, short-term and long-term. In the short-term, economic incentive to farmers are necessary. However, the development of biomass power plants would not always depends on economic support. Therefore, in the long-term, trust between middleman and farmers should be built to mitigate farmers' risk perception which could reduce transaction cost of crop straw.

Based on the real situation in biomass power industry in Northeast China, the objectives in this study is as follows:

(1) Comparing the external costs of coal-fired power generation and biomass power generation to better understand the total cost in life cycle.

(2) Based on a case study in a biomass power plant in Northeast China, to identify stakeholders' risk perception in order to formulate problems.

(3) To assess the determinants of risk perceptions held by farmers from vertical (different income level villages) and horizontal (different risk perception aspects) perspectives.

(4) Mitigating farmers' risk perceptions.

- Designing incentive scenarios to identify the optimal incentive strategy based on a game-theoretic approach.

- Generating trust enhancement model by investigating the correlations among trust, demographics, risk perception, perception of lowering transaction price and farmers' engagement.

(5) To propose Risk perception-Motivation-Behavior change model based on the results of risk perception assessment, economic incentive, correlations between trust and other factors and strategies to mitigate risk in biomass supply chain.

1.4 Research goal

To facilitate the biomass supply chain, mitigation of stakeholders' risk perception is necessary, particularly to mitigate the risk perception of farmers, who are the key for straw supply but at the lowest position. Farmers' risk perception is one of the main causes of high cost in biomass power plants. Therefore, the goal of this research is to mitigate farmers' risk perception, increase farmers' willingness to supply straw and build long-term relationship with middleman and the biomass power plant, which would enhance the sustainability of biomass power plants.

To reach the research goal, short-term and long-term strategies are needed (**Fig. 1.6**). In the short-term, to motivate farmers to increase their willingness to cooperate with the middleman and the biomass power plant are the effective way. Because of farmers risk perceptions, mostly related to economic risk, farmers are heisting to supply straw. Give incentive to farmers, not only could mitigate their risk perception, but also would foster farmers' trust towards the middleman, even towards the local government. With economic incentive, farmers could feel that their activities of supplying crop straw are being valued and cared. In the long-term, trust should be built between farmers and the middleman. Trust is the lubricant in the human relationship, which can mitigate risk and improve traction (Boon and Holmes, 1991; Nooteboom, 2002). With trust building, biomass power plant can obtain sustainable straw from farmers. Considering long-term development of biomass power plant, trust building is crucial.

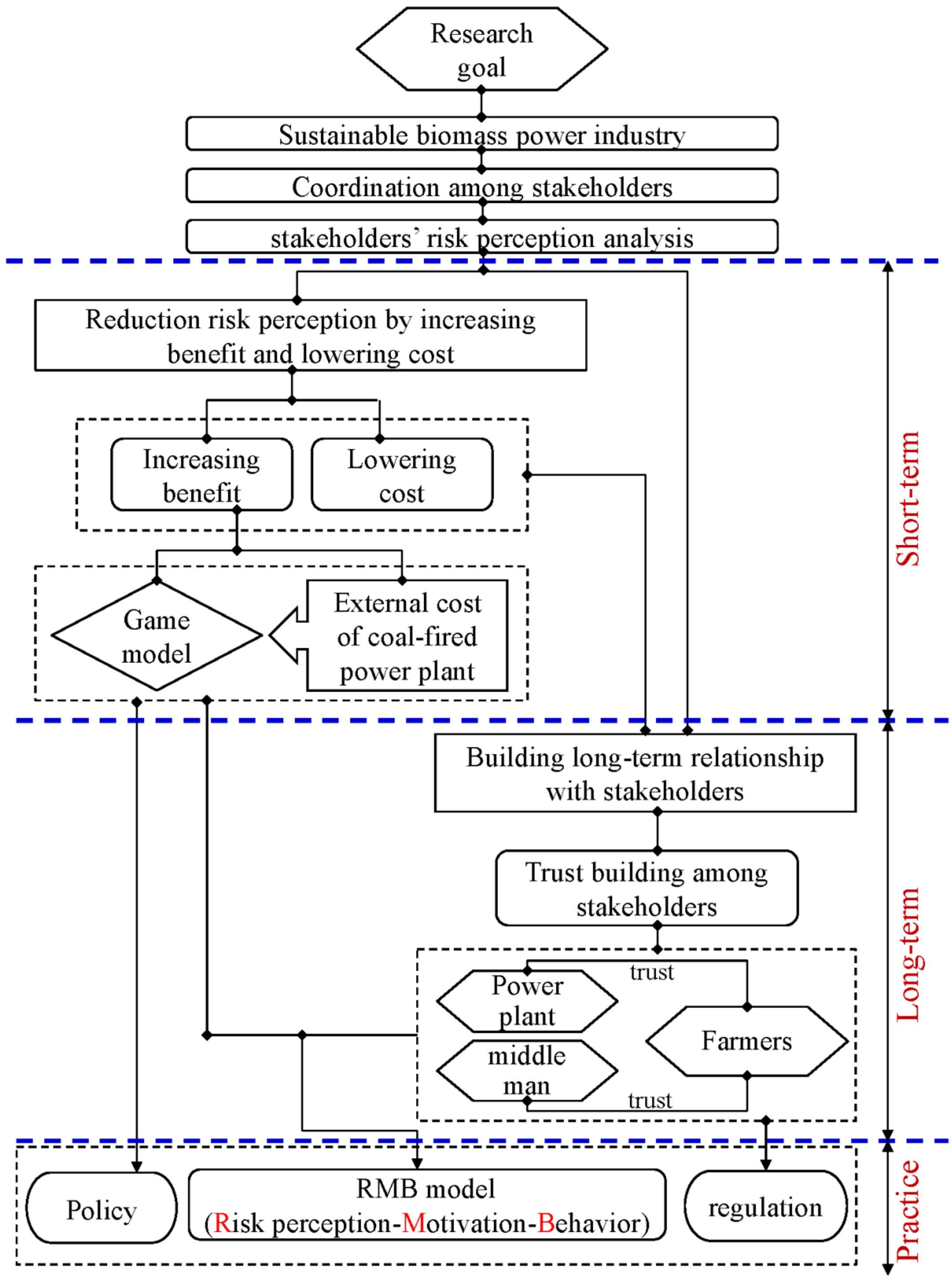

Fig.1.6 Research goal

1.5 Research framework

This thesis is organized in following nine chapters as shown in **Fig. 1.7**. Chapter I introduces the current situation and barriers in development biomass power plant in Northeast China is derived, which are the dilemma in promoting biomass power plant. In line with literature review, investigation in a case study of biomass power plant in Northeast China, the risk perception of the biomass power plant, the middleman and farmers were investigated and qualitatively assessed. Problems causing the current dilemma are formulated in Chapter II. It shows that in biomass power plant supply chain, farmer is the crucial role in supply straw. The relationship between farmers and middleman determine the quantity of straw supply. Therefore, in Chapter III, farmers' risk perceptions were detailed analyzed. To mitigate farmers' risk perception, both short-term strategy and long-term strategy are needed. In the short-term, economic incentive is still necessary. However, which stakeholder should be given and how much should be subsided could be effective are the key in incentive system. Chapter IV analyzed government's subsidy strategy choice based on game theory. Moreover, in Chapter V, external cost of a coal-fired power plant and a biomass power plant was compared to be the subsidy resource in the short-term. However, the biomass power industry shouldn't depend on government's subsidy. Thus, in the long-term, trust mechanism, particularly, trust between the middleman and farmers, should be built as an important approach of mitigating risk perception, lowering transaction cost and maintaining long-term relationship (Chapter VI). Based on the analysis of above chapters, Risk perception-Motivtion-Behavious change was derived in Chapter VII to intend to change the current situation in biomass power industry to ideal situation. The thesis concludes by summarizing the main findings and pointing directions for future study in Chapter VIII.

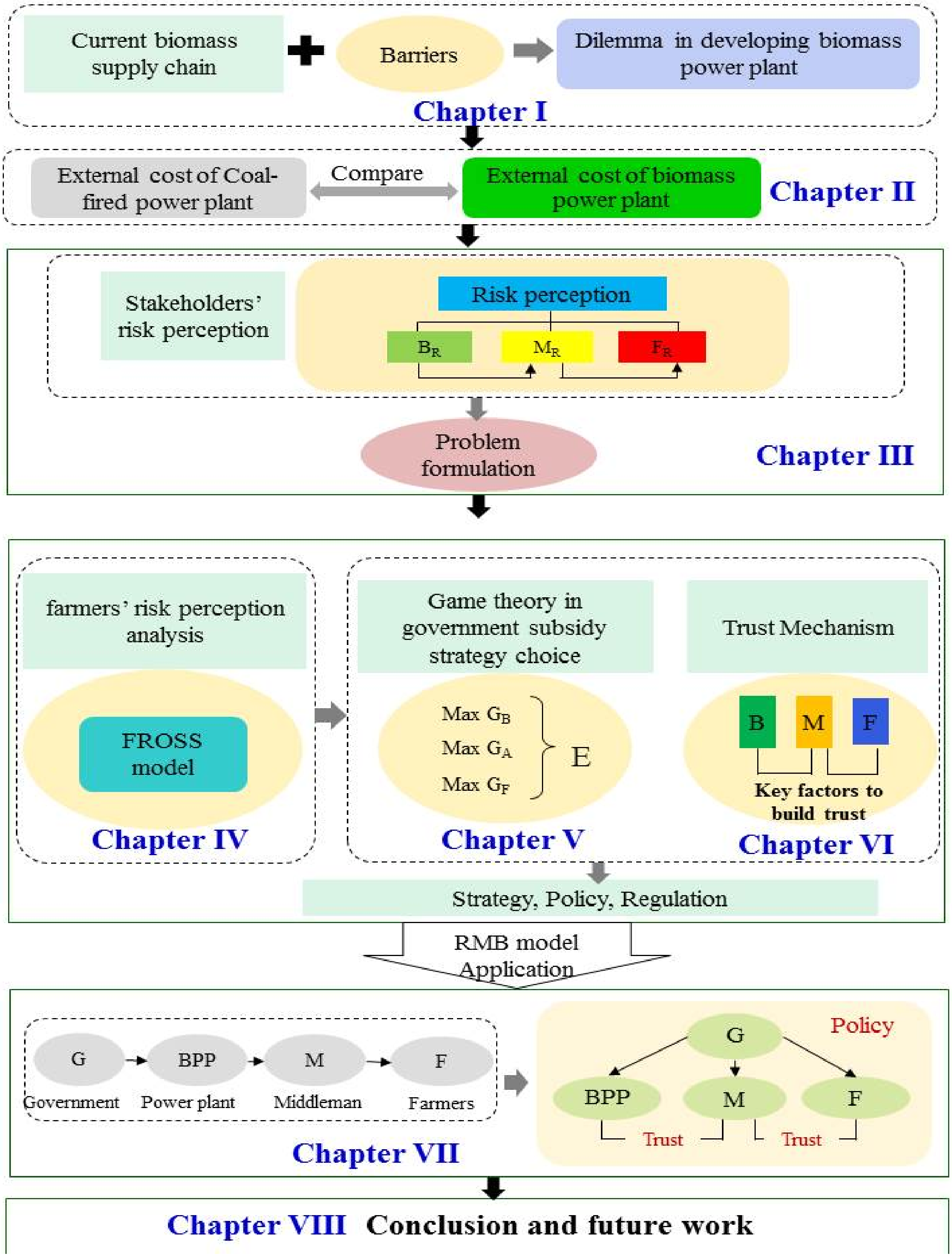

Fig. 1.7 Research framework

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CHAPTER 2: MONETIZATION OF EXTERNAL COSTS USING LIFECYCLE ANALYSIS—A COMPARATIVE CASE STUDY OF COAL-FIRED AND BIOMASS POWER PLANTS IN NORTHEAST CHINA

2.1 Introduction

The use of coal remains dominant in electricity generation in China, the world's largest producer and consumer of coal [1]. A major reason for coal's domination of Chinese production and consumption is its low market price. China's rapid economic growth is heavily dependent on cheap energy, with over 70% of its energy needs met by coal. Coal-fired power plants generate 78.6% of China's electricity [2]. However, this apparently cheap fuel has grave repercussions, as reliance on coal comes with heavy environmental and social costs. Every step in the process of coal-fired power generation, from mining to combustion, causes severe damage to China's environment. The low price of electricity accounts for just a fraction of its true total costs; in fact, society pays the external costs of mining and burning coal. The burning of coal emits sulfur and nitrogen oxides (causing acid rain), particulates, mercury and other toxic metals [3]. Moreover, the mining of coal injures and kills workers.

In China, biomass is an alternative energy to coal. Particularly in Northeast China, crop straw is an attractive alternative for two reasons. First, it is abundant in this region. The total crop straw production is approximately 96,283,700 tons [4–6], which can produce 77,026,880,000 kWh of electricity (based on a case study in Wangkui, the crop straw electricity generation rate in 2014 was 800 kWh/ton). This quantity of electricity would meet 30.53% of Northeast China's demand [2]. Second, power generation using the renewable energy source of crop straw poses far fewer risks to national security, the economy, the environment and public health. Therefore, biomass power generation, particularly power generation using crop straw, has great potential and could replace many coal-fired power plants in Northeast China.

Currently, however, there are only five large biomass power plants (installed capacity ≥ 25 MW) in Northeast China. Barriers persist in promoting their development, such as in the collection of crop straw and technological innovation. Some biomass power plants have already gone bankrupt or switched to other industries. Compared with investors in coal-fired power plants using cheap coal, biomass power plant investors obtain considerably smaller profits. Without government subsidies, biomass power plants cannot survive.

The author believes that a fundamental reason for the low popularity of biomass and corn straw power plants is the inaccurate perception of the external costs associated with coal-fired and biomass power generation. Most people, particularly policy makers, are aware of the sacrifices that are made to generate electricity with coal-fired power. However, the external costs, including environmental and social costs, are invisible in the short term. There is a strong possibility that the external costs associated with coal-fired power plants are undervalued. Therefore, biomass power plants are perceived as much less attractive than coal-fired power plants.

This study has three objectives: (1) to accurately estimate the external costs of coal-fired and biomass power generation in Northeast China; (2) to compare the two types of power generation plants with per kWh; (3) to discuss policy implications on the basis of the results of this comparison.

2.2 Literature Review

Life cycle costing can be tracked back to the literature reviews on neoclassical welfare economics. There are two highly influential works, Pigou (1920) and Coase (1960), contributed significantly. However, the issue of getting the price right is still as much debated by researchers and policy makers [7,8]. Including all social, environmental and other costs in energy prices would provide consumers and producers with appropriate information to decide about new investments and development [9]. Hall emphasized in 1990 that even if the life cycle cost may not be accurately estimated, a mere investigation on this aspect would contribute to greater economic welfare [10]. Thus, exploring energy life cycle cost prices would help policy making and national strategy formulation. One policy could be to introduce the internalization of external costs into the current electricity price, to truly reflect social and environmental impacts [11].

For the electricity generation section, there are a number of researchers focusing on electricity external costs [9, 12–14]. In summary, the main reasons for studying the external cost of power generation include: (a) to provide and diversify multiple technologies; (b) to propose future policy implication; (c) to emphasize the social and environmental impact of external cost. Rafaj internalized external cost in coal-fired power generation using the global multi-regional MARKAL model, which indicted that structural changes and fuel switching in the electricity sector result in significant reduction of emission of both local pollution and CO2 on a global scale [15].

Dimitrijevic´ et al. estimated the external costs from coal-fired thermal plants in Bosnia and Herzegovina, mainly focusing on sulphur dioxide emissions [16]. In addition, the external cost of electricity generation mix is also highlighted by researchers, which are significant for further energy directions. Rentizelas incorporated life cycle external costs in optimization of the electricity generation mix. The results indicated that renewable energy, especially wind and biomass, should be the new generating capacity [17]. Since biomass power generation project is still on the primary stage, external costs of biomass co-fired with coal power generation are estimated in many studies [18–21]. One of the insights from these studies is that fossil power generation, particularly coal-fired power generation, with adverse impacts and its high life cycle costs are widespread, and therefore policy and decisions need to be made in an energy diversity framework so that outcomes are socially acceptable, environmentally benign and economically viable.

The aim of this research is to stress the highly adverse impact of coal-fired power plants compared with biomass power plants in China with life cycle structures. Although many studies have demonstrated the externalities of coal-fired power plants, they didn't integrate all stages and mainly focused on air pollutants. The National Research Council in the United States has studied the environmental and health costs of coal mining and transportation on a national scale [22], but it has not taken the costs of coal mine construction into account. Nkambule et al. [23] emphasized the external costs of transporting coal to a power station in South Africa, rather than those throughout the lifecycle. Grausz [24] calculated the social costs of coal using a lifecycle assessment. Mahapatra et al. [11] examined the environmental impacts of the coal combustion stage in the twin cities of Ahmedabad and Gandhinagar in Western India. Castelo Branco et al. [25] performed a lifecycle assessment for a coal-fired plant in Brazil, focusing only on carbon capture and storage (CCS), instead of the all pollutants. The Dutch research institute CE Delft [26] evaluated the external costs, focusing on the coal combustion and coal mining stages on a global scale. This research includes all stages in coal-fired power generation combining the situation in China to monetize the external cost. In addition, to our best knowledge, few researchers have estimated the external cost of biomass power generation in China. In order to compare the two kind of power plant, the respective life cycle breakdown structures are proposed.

2.3 Methodology

Lifecycle analysis, examining all the stages of resource utilization, is central to measuring its full costs and critical to informing the public and guiding policy formulation. Many previous studies have examined the lifecycle stages of coal and oil, but without systematic quantification of all the lifecycle stages [11, 27–29]. This paper intends to advance the understanding of the measurable and quantifiable costs of a 600 MW coal-fired generation power plant and 30 MW biomass power plant. In other words, costs at every stage of coal-fired generation, from coal mine construction to electricity generation were analyzed. This approach was undertaken because understanding the whole measureable and quantifiable cost structure at the lifecycle stages of the coal-fired generation power plant and the biomass power plant would be helpful for Chinese people to have a correct perception of the external costs of those two types of power plant.

This study uses a 600 MW coal-fired power plant with extensive flue gas cleaning to estimate the external costs because this 600 MW coal-fired power plant has high conversion efficiency and would emit less pollutants than other kinds of coal-fired power plant. This means that its estimated external cost is expected to be lower than that of ordinary types of coal-fired power plant.

To rigorously examine the different damage endpoints, this paper identifies and compares multiple lifecycle stages of a coal-fired and a biomass power plant using a framework of environmental externalities, or "hidden costs". Externalities occur when the activity of one agent affects the well-being of another outside of any type of market mechanism. They are often not accounted for in decision making and, consequently, distort decision-making outcomes and harm social welfare [30–32]. This work derives monetary values for these externalities with implications for policy making.

Literature reviews were conducted to identify the impacts of a 600 MW coal-fired power plant over its lifecycle to quantify those that are quantifiable and tabulate and monetize those that can be monetizable. Because there are certain variations in the monetization of damage, the optimal monetary value was derived on the basis of low and high values estimated in developed countries and by incorporating environmental and social realities in China. The monetizable impacts found are public health damage from NOX, SO2, PM, and mercury emissions; the public health burden associated with coal mining; and geological damage and groundwater drawdown loss. This study estimates the damage costs of pollutants through a combination of literature review data from developed and developing countries. The external costs per kWh of a coal-fired power plant and a biomass power plant are estimated on the basis of estimated pollutants' values.

2.4 Damage Costs of Classical Pollutants

The Chinese government now imposes strict regulations to improve the abatement efficiency of pollutants discharged by coal-fired power plants. However, there is no criterion for the damage costs of classical pollutants. To estimate the external costs of pollutants, there are four approaches. The first is the top-down approach proposed by Hohmeyer [33], which depends on the previous damage cost. This analysis is highly aggregated, being carried out at regional or national levels, with estimates of total quantities of pollutants emitted. However, this analysis is considered simplistic for policy use. The second is using pollution control as an agent for damages developed by Bernow and Marron [34]. This estimates damages by the cost of reducing emissions of pollutants causing the damage, by arguing that the level of pollution abatement decided by policy makers is the economic optimum, however, this approach emphasizes that policy makers take the main role in providing information of costs and damages, which is an untenable point of view. The third one is a bottom-up approach suggested by Ottinger et al. [35], but this method doesn't involve primary data. All these approaches have been considered to be insufficient for assessment of external costs. This paper uses the fourth approach that was developed by the ExternE (Externalities of Energy) program funded by the European Union (EU), which has been running since 1992 under the funding of the European Commission, using both a top-down and bottom-up approach and applying to all countries. This study determines the damage costs through literature reviews. In this paper, two types of damage cost factors were calculated to conduct the monetary valuation. Among the main pollutants, CO2 relates to climate change, while SO2, NOX and PM2.5 cause health damage. Regarding the damage costs of CO2, studies performed by the EU using top-down and bottom-up approaches suggest that under a full-flexibility EU-wide allocation of CO2 emission permits, the marginal abatement costs are approximately 20 Euros per tonne based on both top-down and bottom-up approaches [36,37]. However, because many reductions will be required to keep climate change impacts at the minimum acceptable level, CO2 cost is likely to rise in the future.

In this paper, future damage from CO2 is not considered. For CH4 emission, a factor of 34 times of CO2 value is applied to reflect the relative impact of methane on global warming compared with that of CO2 [38,39].Regarding SO2, NOX and PM2.5, the impacts of these increased air pollutants, that is, mortality and morbidity, are reflected in the large numbers of diseases and deaths. In the New Energy Externalities Development for Sustainability project, the final estimates of the damage costs per tonne for specific pollutants as well as mortality and morbidity effects are taken into account, which would not only include health but also quality of life effects [40]. In the NEEDS (New Energy Externalities Developments for Sustainability) project which is part of the ExternE Project, the damage to health due to SO_2, NO_X and PM2.5 emissions from coal-fired power plants is quantified using the dose-response model and monetized by the Value of Life Year (VOLY) questionnaire on willingness to pay for the extension of life expectancy and the improvement of quality of life throughout respondents' lives [40]. The European VOLY analysis was based on the situation of EU. In order to make universal estimates for VOLY, the NEEDS projects produced a global, average VOLY estimate. The final estimates of air pollutants are adjusted on the basis of the calculated Purchasing Power Parity (PPP), harmonized index of consumer price (HICP) and GDP in China (PPP factor for China is 3.84 and population is 1,320 million) [26]. For CO, fly ash, furnace residue, gangue and polluted water, because few studies evaluate these damage costs, this paper takes data directly from the total sewage price (TSP) of China [41]. The external cost factors of pollutants are summarized in **Table 2.1**.

Table 2.1. External cost factors of pollutants of coal-fired power in China.

Pollutants	External Cost Factor (US$/t)
CO_2	27.410
CH_4	931.94
SO_2	4842.7
NO_x	4459.4
CO	165.99
$PM_{2.5}$	19,471
Fly ash	23
Furnace residue	16.5
Gangue	1.2
Contaminated water	3.32

2.5 External Costs of a 600 MW Coal-Fired Power Plant

Past researchers have demonstrated that the entire coal fuel cycle is associated with dire impacts on both the environment and human health. They have called for the consideration of all the stages in the lifecycle of coal-fired electricity supply, including mining, processing, transportation and electricity generation [28, 42–46]. Considering all the stages, rather than focusing on coal combustion, is a significant step toward revealing the true costs of coal-fired electricity generation. The results can affect public policies and private investments [47–50].

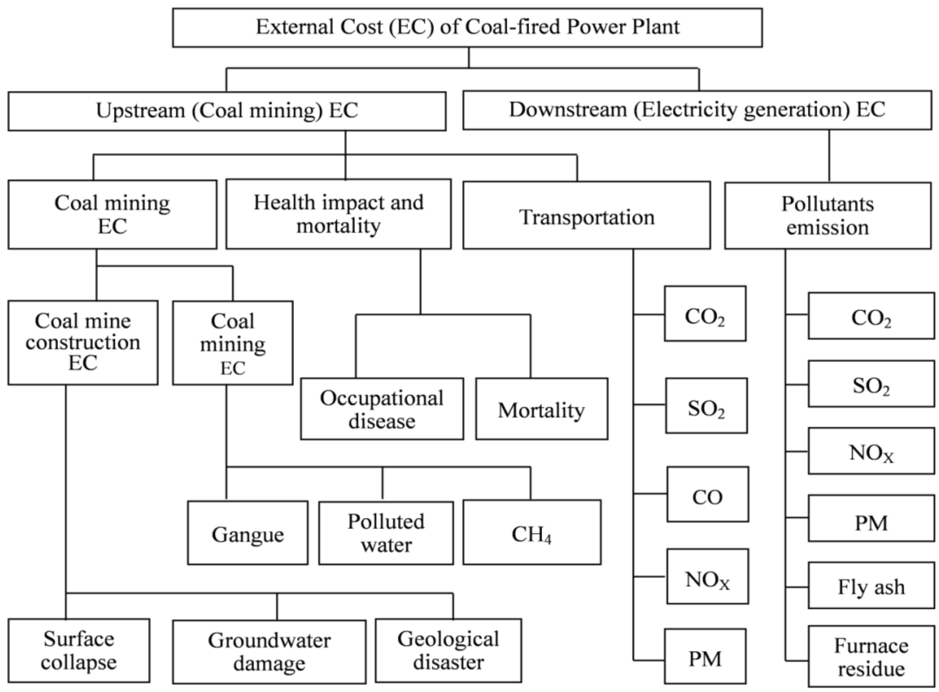

Figure 2.1. External costs of a coal-fired power plant in its lifecycle.

However, no research integrates all of stages of coal lifecycle in China. Coal mine construction, coal mining, transportation and coal combustion release many chemicals responsible for climate forcing. Coal also contains mercury, lead, cadmium, arsenic, manganese, beryllium, chromium and other toxic and carcinogenic substances [28]. Coal mining, processing and washing releases large amounts of chemicals and particulate matter annually, which contaminate water and harm ecological systems and community public health [51–55]. Coal transportation leads to CO_2, CH_4 and NO_X emissions. In addition, coal combustion results in emissions of NO_X, SO_2, particulates matter and mercury, all of which negatively affect air quality and public health [56]. The structure of the external costs of coal-fired power plants is shown in Figure 1. In this study, the considered 600 MW coal-fired plant is a modern power plant with coal conversion efficiency of 40%, which is the highest in China. The emissions are based on pulverized coal combustion plants equipped with extensive flue gas cleaning.

2.5.1. Coal Mine Construction

Each external cost factor is explained as follows:

2.5.1.1. Surface Collapse

Coal mine construction has significant impacts on land resources. Surface collapse is the main disaster caused by coal mine construction; it not only damages land ecosystems, but also leads to other serious ecological harm, such as forest and vegetation damage and farmland collapse [57]. Until 2008, surface collapse caused by coal mining reached 800,000 ha, resulting in more than $9.7 billion of economic losses [58]. The average cost of damages due to surface collapse is $\$1.4 \times 10^4$/ha. According to statistics by the National Bureau of Statistics of China [59], mining 10,000 tons of coal will lead to 0.10–0.29 ha of surface collapse, with an average of 0.20 ha. In 2008, the total cost of surface collapse cost due to coal mining in China was approximately $640 million. At the end of 2008, 40 cities had suffered from mining collapse incidents, which caused 25 other serious disasters that year [58].

2.5.1.2. Contaminated Underground Water

Coal mine construction is a complex process that produces several types of contaminated water, such as coal mineral water. These types of contaminated water are discharged in huge amounts and have complex chemical compositions. For example, in 2008, the total coal production was 7.9×10^7 tons; however, $12 million was lost due to declining underground water levels [60]. Contaminated water seeping into the ground can pollute underground water, which threaten human health and biological survival.

2.5.1.3. Geological Disaster

Coal mine construction causes surface collapse as well as leads to frequent landslides, mudslides and avalanches because of damaged mountain stability. At the end of 2008, in Shanxi Province, which has the largest coal reserves in China, more than 2,940 ha had experienced geological disasters, involving over 1,900 villages and approximately 95,000 people that year. In the last 10 years, over 500 people have been injured in geological disasters. In Heilongjiang Province, 193 ha in Jixi city has undergone surface subsidence after 80 years of coal mining; in the Hegang coal mining area, 63–67 ha of land has undergone surface subsidence, with the deepest subsidence of up to 30 m. The expanding scale of coal mining in China, with an estimated annual cost of $3.2 billion is dramatically increasing various geological disasters [61].

2.5.2. Coal Mining

2.5.2.1. Gangue

In the process of coal mining, solid wastes such as gangue, fly ash and slime are released. Gangue contains the main pollutants. Gangue from an open pit occupies a large land area and causes spontaneous combustion because of the harmful substances it contains, such as sulfur and carbonate, which emit large amounts of smoke, SO_2, CO, and H_2S. According to the Consultation Report on the Gangue Industry in China [60], from 2008 to 2009, gangue emissions made up 10%–15% of the amount from coal mining. By the end of 2008, an accumulated 5 billion tons of gangue occupied the 120 ha of land, with disposal costs of $3.1 billion [60].

2.5.2.2. Contaminated Water

In the coal mining stage, chemicals are directly and indirectly emitted into water supplies from mining and processing. Chemicals in the waste water contain ammonia, sulfur, sulfate, nitrates, nitric acid, tars, oils, fluorides, chlorides and other acids and metals, including sodium, iron, cyanide and additional unlisted chemicals [62]. In 2008, the coal mining industry produced 2.559 billion tons of waste water, constituting 11% of total industrial waste water emissions and generating at least $1.08 billion in costs [63]. If health damage in disability-adjusted life years due to these emissions were calculated, the costs would be appallingly similar.

2.5.2.3. Methane (CH_4)

In the coal mining process, methane adds to explosion risks and mine fires. Methane is emitted during coal mining and is 34 times more potent than CO_2 during a 100-year timeframe (this is the 100-year global warming potential; a common metric in climate science and policy used to normalize different GHGs to carbon equivalence) [64]. When methane decays, it can yield CO_2, which can accelerate global warming. Based on the statistical data from the National Bureau of Statistics of China [65], mining one ton of coal emits 7–8 m^3 of CH_4. This paper uses the central value 7.5 m^3 (5.3 kg) as the calculation value [65].

2.5.3. Health Impact and Mortality

The Chinese State Administration of Work Safety [66] records occupational injuries and disabilities, chronic illnesses and mortality in miners in China. Black lung disease (or pneumoconiosis), leading to chronic obstructive pulmonary disease, is the primary illness in underground coal miners. In 2008, pneumoconiosis increased by 10,829 people, among whom were 9672 (89.32%) coal mining industry workers. Generally, miners contracted pneumoconiosis at a young age, with an average age of 37.5 [67]. Because there is no effective treatment for pneumoconiosis, patients must undergo lung lavage surgery once a year to survive. By 2008, coal workers' pneumoconiosis had killed 669 coal workers in China. Because coal mines refuse to provide afflicted mine workers with occupational disease diagnostic reports, workers have to incur costly medical expenses. Thus, the workers must suffer from physical and economic pain. In China, underground mining accidents cause 3,800–6,000 deaths annually, although the number of mining-related deaths has decreased by one-half over the past decade [68]. From 1991 to 2008, the country produced 28.26 billion tons of coal, with 103,633 people killed in coal accidents, that is, 3.68 average deaths per million tons of coal, as shown in **Figure2.2** [69]. In 2009, according to the Chinese State Administration of Work Safety, 2631 coal miners were killed by gas leaks, explosions or flooded tunnels [70].

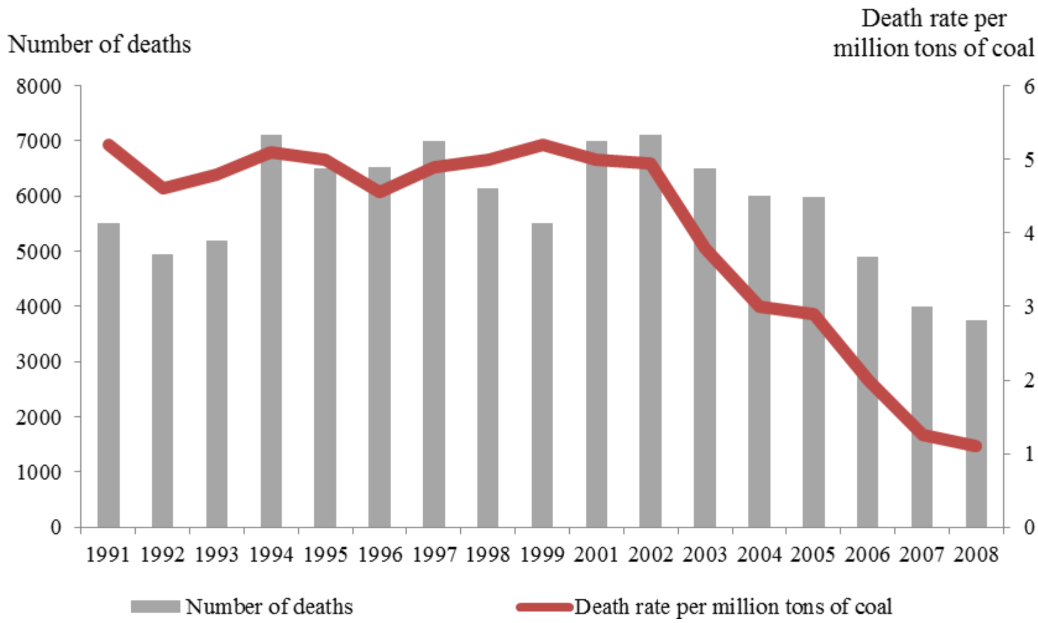

Figure 2.2. Number of people killed in coal mine accidents and death rate per million tons of coal.

2.5.4. Transport

Coal transportation presents direct hazards. People in mining communities complain of road hazards and intense dust levels. Dust can prove fatal to those suffering respiratory and cardiovascular diseases. In many cases, the dust is so thick that it coats people's skin and the walls and furniture in their homes. This paper will not focus on the cost of emission impact for lack of data, but rather on the costs of pollutant emissions. **Table 2.2** shows pollutant emission intensity in coal transport [71, 72].

Table 2.2. Pollutant emission intensity in coal transport.

Pollutant	**CO_2**	**SO_2**	**NO_x**	**CO**	**PM**
Emission intensity (kg/million ton·km)	13,757	80	67	25	54

To calculate emissions by transporting coal from the 600 MW coal-fired power plant in Harbin city, Heilongjiang Province, this study uses 550 km as the distance from the coal mine to the power plant, which is the shortest distance from Qitaihe coal mine to Harbin by train. The breakdown of external cost in various stages are described in detail in **Table 2.3**.

Table 5.3. External costs of coal power plant.

Item	Impact	Data	External Cost
Coal mine construction	Surface collapse	Mining 10^4 t coal causes 0.20 ha of surface collapse. The average cost of damage from surface collapse is $14,375/ha. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$0.20 ha / 10^4 t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$14,375/\text{ha} = \$4.20 \times 10^5$
	Contaminated underground water	The economic loss in Hebei Province in 2008 was $1.1550 × 10^7. The total coal production in Hebei Province was 7.91479×10^7 t. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$\frac{\$1.1550 \times 10^7}{7.9148 \times 10^7 t_{coal}} \times 1.4544 \times 10^6 t_{coal} = \$2.1224 \times 10^5$
	Geological disaster	The economic cost of geological disasters due to coal mining is approximately $3.2226 × 10^9 annually. In 2008, the total coal production was 2.802×10^9 t [73]. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$\frac{\$3.2226 \times 10^9}{2.802 \times 10^9 t_{coal}} \times 1.4544 \times 10^6 t_{coal} = \$1.673 \times 10^6$
Coal mining	Gangue	Gangue occupies 10%–15% of coal production—with an average of 12.5%. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually. The damage cost of gangue is $1.2/t.	$1.4544 \times 10^6 t_{coal} \times 12.5\% \times \$1.2 / t_{gangue} = \$2.18 \times 10^5$
	Contaminated water	In 2008, the total coal production was 2.802×10^9 tons. In 2008, the quantity of polluted water attributed to coal mining was 2.559 billion tons. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually. The damage cost of polluted water is $3.32/t.	$\frac{2.559 \times 10^9 t_{water}}{2.802 \times 10^9 t_{coal}} \times 1.4544 \times 10^6 t_{coal} \times \$3.32 / \text{t}_{water} = \$4.41 \times 10^6$
	CH_4	CH_4 emission is 5.3 kg CH_4/t coal. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually. The damage cost of CH_4 is $931.94/t.	$0.0053 t_{CH_4} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$630.43 / t_{CH_4} = \$4.9 \times 10^6$

Table 5.3. *Cont.*

Item	Impact	Data	External Cost
Health impact and mortality	Occupational disease	In 2008, 9672 people in the coal mining industry contracted pulmonary diseases. The average duration of medical treatment is 9.87 years [74]. People must undergo lung lavage surgery once every two years, with each surgery costing $3299.89 [75]. In 2008, the total coal production in China was 2.802×10^9 ton. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	In 2008, the pulmonary disease cost: $9.672\times10^3 \text{persons}\times \frac{1}{2}\times9.87\text{years}\times \$3.2999\times10^3 = \$1.575\times10^8$ Pulmonary of 600MW coal-fired power plant: $\frac{\$1.575\times10^8}{2.802\times10^9 t_{\text{coal}}}\times 1.4544\times10^6 t_{\text{coal}} = \$8.175\times10^4$
	Mortality	The average deaths per million tons of coal was 3.68. The actual cost of mortality was $32,999/person [76]. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$3.68 \textit{deaths}/10^6 t_{\text{coal}}\times 1.4544\times10^6 t_{\text{coal}}\times \$3.2999\times10^4/\text{death} = \$1.77\times10^5$
Transport	CO_2	The pollution emission intensity is 13.757 ton/10^6 ton·km. The CO_2 value is $27.41/t. The distance between the coal mine and the power plant is 550 km. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$13.757 t_{CO_2}/10^6 t_{\text{coal}}\cdot\text{km} \times1.4544\times10^6 t_{\text{coal}} \times550\text{km} \times\$27.41/t_{\text{CO}_2} = \$3.02\times10^5$
	SO_2	The pollution emission intensity is 0.08*t*/10^6 tons·km. The SO_2 value is $4842.7/t. The distance between the coal mine and the power plant is 550 km. A 600 MW coal-fired power plant combusts approximately 1.4544×10^6 t coal annually.	$8.0\times10^{-2} t_{\text{SO}_2}/10^6 t_{\text{coal}}\cdot\text{km} \times1.4544\times10^6 t_{\text{coal}}\times 550\text{km}\times \$4,842.7/t_{\text{SO}_2} = \$3.1\times10^5$

Table 5.3. *Cont.*

Item	Impact	Data	External Cost
Transport	NO_X	The pollution emission intensity is 0.067 t/10^6 tons·km. The NO_X value is \$4459.4/*t*. The distance between the coal mine and the power plant is 550 km. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.0670 t_{NO_X} / 10^6 t_{coal} \cdot km \times 1.4544 \times 10^6 t_{coal} \times 550 km \times \$4,459.4 / t_{NO_X} = \$2.4 \times 10^5$
	CO	The pollution emission intensity is 0.025 *t*/10^6 tons·km. The CO value is \$165.99/*t*. The distance between the coal mine and the power plant is 550 km. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.0250 t_{CO} / 10^6 t_{coal} \cdot km \times 1.4544 \times 10^6 t_{coal} \times 550 km \times \$165.99 / t_{CO} = \$3.3 \times 10^3$
	PM	The pollution emission intensity is 0.054 *t*/10^6 tons·km. The PM value is \$19,471/t. The distance between the coal mine and the power plant is 550 km. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.054 t_{PM} / 10^6 t_{coal} \cdot km \times 1.4544 \times 10^6 t_{coal} \times 550 km \times \$19,471 / t_{PM} = \$8.4 \times 10^5$
Coal combustion	CO_2	The pollution emission rate is 1,598 kg/t. The CO_2 value is \$27.41/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$1.598 t_{CO_2} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$27.41 / t_{CO_2} = \$6.370 \times 10^7$
	SO_2	The pollution emission rate is 16 kg/t. The SO_2 value is \$4842.7/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.016 t_{SO_2} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$4,842.7 / t_{CO_2} = \$1.1 \times 10^8$

Table 5.3. *Cont.*

Item	Impact	Data	External Cost
Coal combustion	NO_X	The pollution emission rate is 7.8 kg/t. The NO_X value is $4459.4/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.0078 t_{NO_x} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times 4,459.4 / t_{NO_x} = \$5.1 \times 10^7$
	CO	The pollution emission rate is 0.24 kg/t. The CO value is $165.99. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^9 t coal annually.	$0.00024 t_{CO} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$165.99 / t_{CO} = \$5.8 \times 10^4$
	PM	The pollution emission rate is 0.39 kg/t. The PM value is $19,471/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.00039 t_{PM} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$1,9471 / t_{PM} = \$1.1 \times 10^7$
	Fly ash	The pollution emission rate is 0.102 t_{flyash}/t_{coal}. The fly ash value is $23/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.102 t_{flyash} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$23 / t_{flyash} = \$3.41 \times 10^6$
	Furnace residue	The pollution emission rate is 0.028 $t_{furnace}/t_{coal}$. The furnace residue value is $16.5/t. A 600 MW coal-fired power plant combusts approximately 1.4544 × 10^6 t coal annually.	$0.028 t_{furnace} / t_{coal} \times 1.4544 \times 10^6 t_{coal} \times \$16.5 / t_{furnace} = \$6.7 \times 10^5$
		Damage cost	$\$2.6 \times 10^8$

2.5.5. Coal Combustion

The last stage of the coal lifecycle is combustion to generate energy. This research focuses on a 30 MW coal-fired power plant. The by-products of coal combustion include CO_2, SO_2, NO_X, PM, fly ash and furnace residue. Data from China's Environmental Protection Department demonstrate that the electricity industry is significantly responsible for China's industrial pollution emissions (**Figure 2.3**). Along with the primary emissions of PM, SO_2 and NO_X contribute to an increase in airborne particle concentrations through secondary transformation processes [76–79].

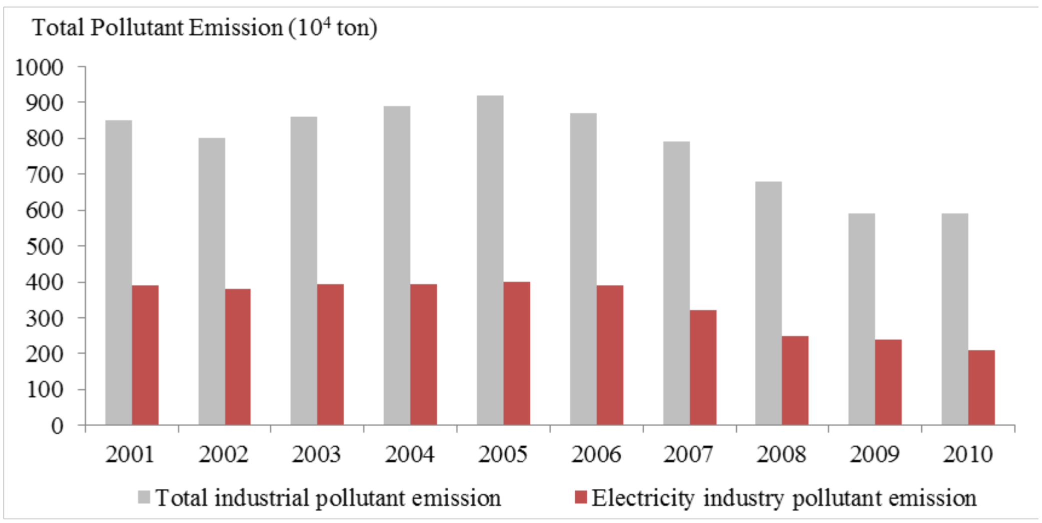

Figure 2.3. Total industrial and electricity industry pollutant emissions in China (2001–2010).

In recent years, China has recorded low air quality. Visibility is low even in the daytime, particularly in winter. People wear thick masks to protect themselves from the polluted air. Coal power plants are the main contributors to this pollution. Fly ash ponds and contaminants readily migrate into water supplied to household and agricultural use, contaminating the environment and threatening human health. This paper focuses on calculating the damage values of pollutants emitted by a 600 MW coal-fired power plant on the basis of the damage value per pollutant. **Table 2.4** shows the pollution emission rate of a 600 MW coal-fired power plant [80, 81]. **Table**

2.3 summarizes the data in this study and calculates the external costs of a coal-fired power plant at each stage.

Table 2.4. Pollutant emission rate for a 600 MW coal-fired power plant.

Pollutant	**CO_2**	**SO_2**	**NO_X**	**CO**	**PM**	**Fly Ash**	**Furnace Residue**
Emission rate (kg/t)kg/t	1598.00	16.00	7.80	0.24	0.39	102.00	28.00

2.6 External Costs of a 30 MW Biomass Power Plant

To compare the external cost of a coal-fired power plant and a biomass power plant, the external costs of the National Bio Energy power plant in Wangkui are calculated. Most researchers study the multiple benefits of biomass energy displacing fossil fuel, such as improvements in the environmental, increase in the diversity of energy supply and reduction of the effects of energy price volatility on the economy and national economic security. However, while biomass power generation offers societal benefits, it also has environmental externalities throughout its lifecycle. **Figure 2.4** shows the lifecycle of a biomass power plant. This study analyzes the external costs at each stage of biomass power generation.

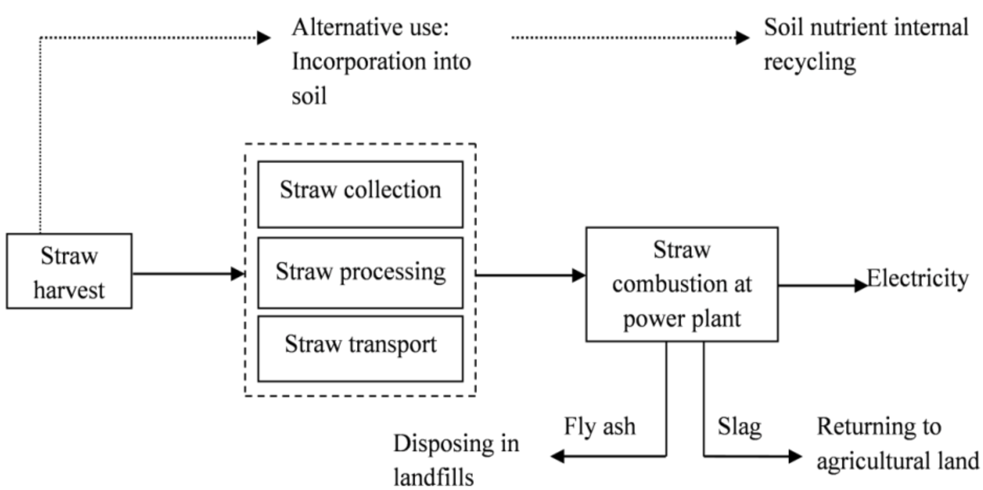

Figure 2.4. Lifecycle system of biomass power plant.

Because only a few corn straw-based power plants operate, the data sources are very limited. This paper has access to information from the National Bio Energy plant in Wangkui, which is the first corn straw-based power plant in China. Therefore, this section uses the National Bio Energy power plant as its empirical data source.

In Wangkui, many types of straws are produced, such as corn straw, soybean straw and rice straw. Corn straw, however, comprises the bulk of the county's straw production. In the recent years, the annual production of straw has been approximately 2.516 million tons. Only 0.5% is used to feed livestock and 40% is burned in the field after harvest. The biomass power plant was established in Wangkui because of the region's abundant corn straw produce. Annually, approximately 0.2 million tons of crop straw is used for electricity generation. The authors assess the external costs of the straw-based power plant in each phase—straw collecting, straw processing, straw transport and straw combustion—and compare the results with those of the coal-fired power plant.

Straw agents from different collecting stations use trucks to transport crop straw. Crop straw compressing and baling productivity depends on the collecting stations' conditions. The baling size is regulated to 150 cm × 130 cm × 120 cm, and the bale weight is 400–450 kg. According to data from the National Bio Energy power plant in Wangkui, the emission factors of diesel are mainly CO_2, SO_2, CO, NO_X and PM. The collection and transportation emissions are calculated on the basis of diesel pollutant emission factors (**Table 2.5**) and diesel consumption rates in different types of trucks (**Table 2.6**) [72]. Because crop straw ash can be used as fertilizer, this paper does not consider it a pollutant.

Table 2.5. Emission factors of diesel.

Item	Value (g/L)
CO_2	2753
SO_2	0.5850
NO_x	0.1445
CO	0.09900

PM	0.01445

Source: IPCC (2006) guidelines and European Environment Agency (2006) [30,31].

Table 2.6. Diesel consumption rates in different types of trucks.

Phase	Truck Type	Diesel Consumption Rate (L/km)
Straw collection	Heavy diesel truck	0.37
Straw transport	Medium-sized diesel truck	0.10

The baled crop straw is delivered from different collecting stations to the biomass power plant using 16-tonne heavy-duty diesel trucks with an average round-trip distance of 20 km. From crop field to collecting stations, a 5-tonne medium-sized diesel truck is used with an average round-trip distance of 30 km. Diesel is the only fuel used in these processes. Annually, 200,000 tons of processed crop straw with less than 25% water content is needed for power generation. However, because of high water content after harvest, agents have to collect approximately 270,000 tons of crop straw to satisfy biomass power plant needs after crop straw becomes dry. In terms of straw processing stage, annual diesel consumption is 1.43×10^9 kJ, and one liter diesel emits 36,944.72 kJ. Diesel consumption in straw collection, transportation and process is calculated (**Table 2.7**). With the assistance of the Wangkui National Bio Energy power plant manager, emission pollutants from biomass power plant are calculated (**Table 2.8**).

Table 2.7. Diesel consumption in straw pre-treatment stages.

Phase	Diesel Consumption (L)
Straw collection	162,000
Straw process	38,706.0
Straw transportation	92,500.0

Source: Calculated by Authors.

Table 2.8. Direct emissions generated by biomass power plant operations.

Item	CO_2	SO_2	NO_x	CO
g/kWh	0.019	0.0015	0.00060	0.00020

Source: Calculated by Wangkui National Bio Energy power plant manager.

Table 2.8 shows that the utilization of crop straw increases pollutant emissions mainly because of the diesel fuel used in transportation. The combustion of crop straw also emits CO_2 into the atmosphere. However, because CO_2 is absorbed during plant growth, a sustainable balance is maintained between the CO_2 emitted and absorbed. Therefore, CO_2 and other greenhouse gas (GHG) emissions from crop straw, which is of biogenic origin, should be considered GHG neutral [82]. The 30 MW biomass power plant generates 200 GWh annually. Factoring in the pollutants' damage values, the total external costs of the 30 MW biomass power plant are shown in **Table 2.9**.

Table 2.9. External costs of a 30 MW biomass power plant.

Phase	Emission Factor	Total Amount of Pollutants (ton)	Cost ($)
Straw collection	CO_2	445.99	12,225
	SO_2	0.0948	459.00
	NO_X	0.0234	104.35
	CO	0.0160	2.6398
	PM	0.0023	44.783
Straw processing	CO_2	106.56	2,920.8
	SO_2	0.0226	109.42
	NO_X	0.0056	24.972
	CO	0.0038	0.6270
	PM	0.0006	11.682
Straw transportation	CO_2	245.65	6733.3
	SO_2	0.0134	64.879
	NO_X	0.0092	41.026
	CO	0.0541	8.9260
	PM	0.0013	25.312
Straw combustion	SO_2	0.30	1452.52
	NO_X	0.12	535.12
	CO	0.04	6.60
Total cost			24,771

Source: Calculated by the authors.

2.7 Results and Discussion

2.7.1 Comparison of External Costs of a Coal-fired Power Plant and Biomass Power Plant

The results obtained and expressed in cost per kWh of coal-fired power plant and biomass power plant in various stages are summarized in **Figures 2.5** and **2.6**. **Figure 2.5** illustrates that the coal combustion stage contributes the majority of external costs. However, for a biomass power plant, straw collection causes most external costs. The coal-fired power plant is a 600 MW unit (3,600 GWh/year) and the biomass power plant is a 30 MW unit (200 GWh/year). The total external costs per kWh of coal-fired power plant and biomass power plant are $0.072/kWh and $0.00012/kWh, respectively. The external cost per kWh of the coal-fired electricity is 600 times as much as that of the biomass electricity. Environmental performance of biomass power plant is considerably higher than that of coal-fired power plant.

In previous research, Faaij [83] and Sáez [84] also studied the externalities of biomass-based electricity production compared with coal power plant in The Netherlands and Spain, respectively. Both external costs and benefits are included in those researches. The results show that on a total cost basis bio-energy could even be competitive with coal. However, the external costs gap between biomass and coal in life cycle is not as huge as the result in China. In Faaij and Sáez's studies, soil erosion and fertilizer pollutants are considered as external cost resources. However, in China, biomass, mainly crop straw, is considered as agricultural waste. Biomass energy is by-product of crops instead of growing biomass energy crops. Thus, soil erosion and fertilizer pollutant are not considered. In addition, in those studies, the external costs in coal mine construction, coal mine, health impact are not included. Considering coal combustion rate and low effect of dedusting equipment in coal-fired power plant in China, the external cost associated with pollutant emission in coal-fired power plant in China is considerably higher.

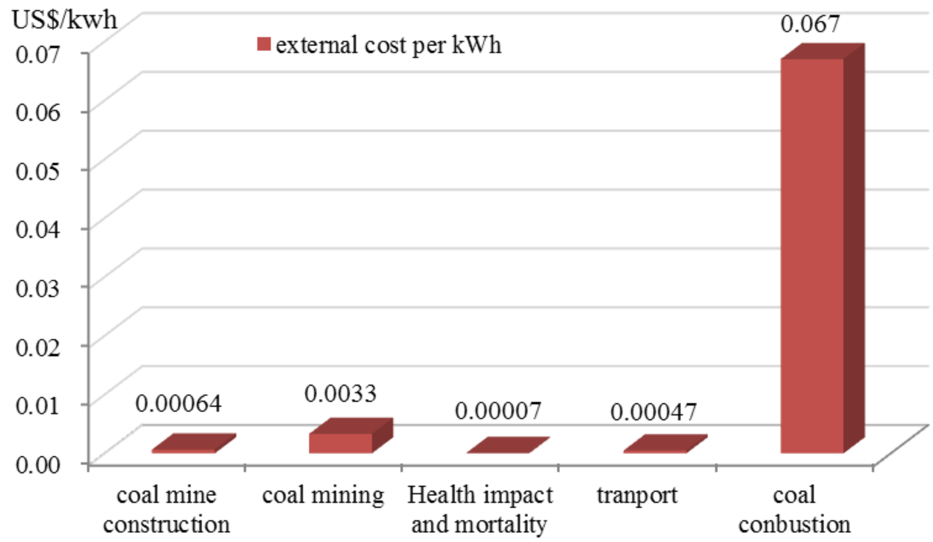

Figure 2.5. External costs of a 600 MW coal-fired power plant per kWh.

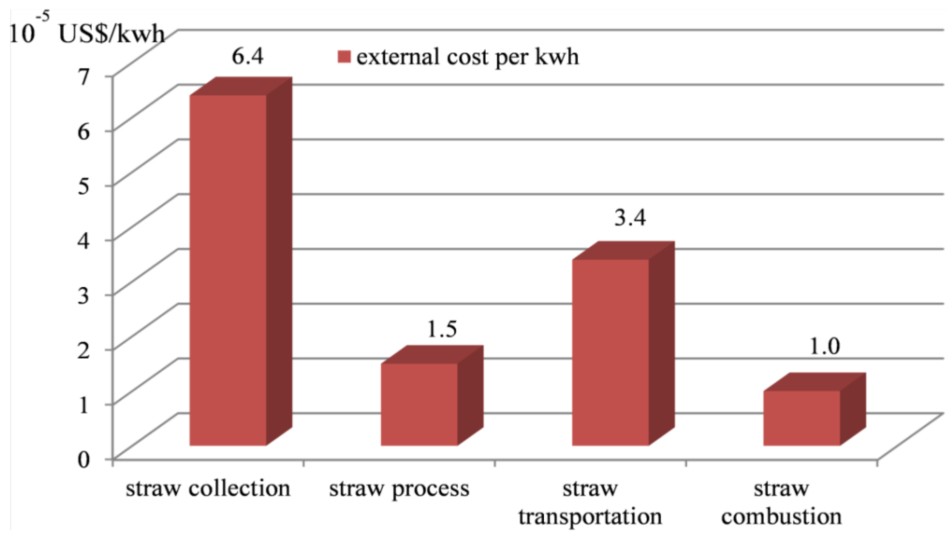

Figure 2.6. External costs of a 30 MW biomass power plant per kWh.

Comparing the external costs of a coal-fired power plant and biomass power plant with the current electricity prices, respectively, the external cost of coal-fired power plant is almost 90% of the current price of coal, while the external costs of biomass power plant is 1/1,000 of the current price of electricity generated by biomass power plants. The external cost of the 30 MW biomass power plant is almost negligible compared with that of the coal-fired power plant

(**Figure 2.7**). If the external cost of each power generation is added to each of the current electricity prices, the total price of coal electricity is 1.9 times higher than its original price, and considerably higher than that of biomass electricity (**Figure 2.7**). Today, the primary reason biomass energy is less used and more difficult to promote is that coal is considered a more economical commodity. Results of the above analyses demonstrate that the coal is not economical, it is cheap. However, the apparently cheap coal actually sacrifices the natural environment, sustainable society and human happiness. The results also demonstrate that despite its lower generating capacity and higher raw material costs, a biomass power plant is not inferior to a coal-fired power plant.

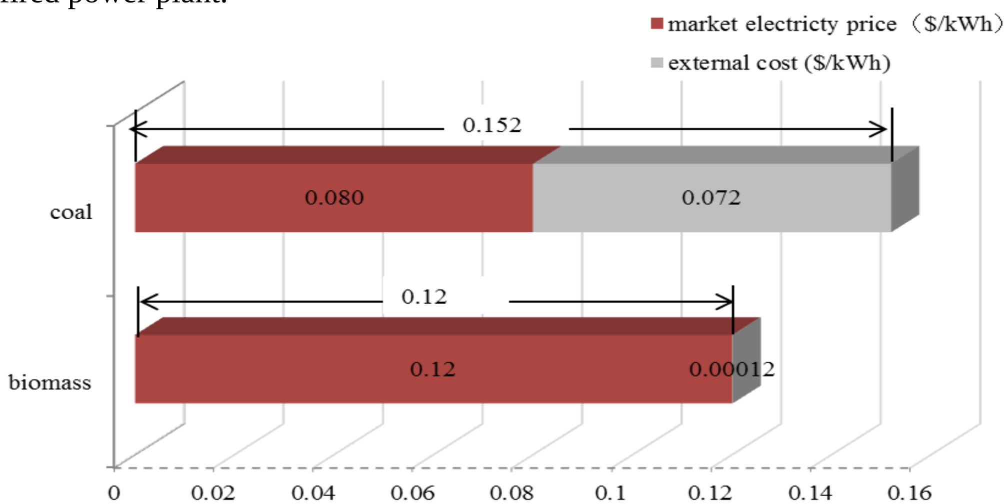

Figure 2.7. Comparison of external costs and total lifecycle cost of biomass power generation and coal-fired power generation.

It is noteworthy that reducing or eliminating the utilization of coal fuel is possible because China, especially Northeast China, is a large agricultural country with vast farmland that produces abundant biomass. Referring to total external costs of the coal-fired and biomass power plants in this study, as shown in Tables 3 and 9, for the 600 MW (3600 GWh) coal-fired power plant, $260 million external cost would occur and the 30 MW (200 GWh) biomass power plant cost $ 24,771 external cost. Replacement part of coal-fired power generation with biomass power generation would potentially reduce a significant amount of external costs, particularly in abundant biomass resources areas.

Table 2.10 shows the estimated quantity of pollutant emissions and the external costs of the two power plants by pollutant. In the lifecycle of the 600 MW coal-fired power plant, 10 types of pollutants are emitted in considerably larger amounts in comparison to the biomass power plant. Among these pollutants, the quantity of CO_2, SO_2, NO_X, CO and PM emission from the coal-fired power plant is 162 times, 2,941 times, 4,013 times, 181 times and 8,095 times, respectively, that of the biomass power plant. External costs associated with SO_2, NO_X, and PM for the biomass power plant are particularly lower than those with coal-fired power plant. In addition, during the coal mine construction and coal mining phase, surface collapse and geological disasters would occur, causing high economic damage and destroying large areas of grassland and forest. The occupational disease and mortality costs are not as high as pollutant emission costs and disaster costs.

The external costs in coal mine construction, coal mining, heath impact and mortality, transport are extremely small and even can be neglected compared with those of coal combustion; however, it is necessary to be aware of the occurrence of those costs. Furthermore, there is much room for improvement of estimation of these costs. Besides, in this study, the CH_4 value is estimated based on Global-warming potential 100 (GWP 100) from IPCC 2013 [63] which is 34. If GWP 20 of 72 is taken account, the external cost of coal mining stage would be $0.0055/kwh and the external cost of coal-fired power plant would increase to $0.074/kwh. This improvement issue is discussed in the next section.

Note that the biomass power plant has effects of reducing air pollution, that is, negative external costs, although they are not quantified in these analyses. If the crop straw cannot be recycled as resources, it is burned in the open field, which can seriously pollute the environment. Although the government imposes regulations on prohibiting burning crop straw in open fields, farmers have no other alternative to deal with large amounts of crop straw. A major factor causing the haze in Harbin in October 2013 was the burning of crop straw in open fields [85]. The promotion of biomass power plant is expected to reduce this haze.

Table 2.10. Comparison of a 600 MW coal-fired power plant and a 30 MW biomass power plant.

Comparison Component	Comparison Item	Coal-Fired Power Plant		Biomass Power Plant	
		Quantity (g/kwh)	Cost (US$/kwh)	Quantity (g/kwh)	Cost (US$/kwh)
Pollutant	CO_2	648.6	1.8×10^{-2}	4.0	1.1×10^{-4}
	SO_2	6.48	3.1×10^{-2}	0.0022	1.0×10^{-5}
	NO_X	3.17	1.4×10^{-2}	0.00079	3.5×10^{-6}
	CO	0.103	1.7×10^{-5}	0.00057	9.3×10^{-8}
	PM	0.170	3.3×10^{-3}	0.000021	4.1×10^{-7}
	CH_4	2.14	2.0×10^{-3}	–	–
	Fly ash	41.2	9.5×10^{-4}	–	–
	Furnace residue	11.3	1.9×10^{-4}	–	–
	Gangue	50.5	6.1×10^{-5}	–	–
	Contaminated water	–	1.3×10^{-3}	–	–
Disaster	Surface collapse	–	1.2×10^{-4}	–	–
	Geological disaster	–	4.6×10^{-4}	–	–
Health and mortality	Occupational disease	–	2.3×10^{-5}	–	–
	Mortality	–	4.9×10^{-5}	–	–
Total	–	–	0.072	4.0	1.2×10^{-4}

Source: Calculated by the authors.

2.7.2 Precision of Estimation of External Costs

Uncertainties persist in this study. It is imperative to accurately estimate the damage cost of each pollutant and disaster to fully comprehend the external costs. However, some estimations are made with insufficient precision. In this section, reasons for insufficient precision are discussed. First, referring to coal-fired power plants, most researchers focus on the existing adverse effects on air pollution, rather than the impact on water and land which can threaten the living environment in the long run. If adverse impacts on water, land and human health in coal mining area were determined with proper metrics, the external costs would be more reasonable. Second, among the pollutants, CO_2, SO_2, CO, NO_X, and PM have international damage cost standards calculated and estimated by European countries. However, regarding other pollutants such as fly ash, furnace residue, gangue and contaminated water, there are no international damage cost standards. Third, in the phases of coal mine construction and coal mining, surface collapse and geological damage destroy the ecological balance and take a considerable term to recover from. The long-term losses can be even higher than the external costs calculated in **Table 2.10**. However, there is no research on the external costs of geological damage and recover cost. The calculation in this paper is based on national amendment compensation, which does not account for recovery and sustainable development costs. These factors influence the precision in estimating the external costs of coal-fired power plant. Fourth is about occupational disease and mortality costs. **Figure 2.5** shows that health impact and mortality costs constitute only a small part of the external costs of a coal-fired power plant in its lifecycle. However, the calculation is based on the unsound compensation system for occupational disease and mortality and coal mine owners' improprieties to evade compensation to mine workers. Specifically, one reason for lower external costs is that the compensation from coal mine owners in China are significantly lower than that of developed countries [86]. Second, some coal mine owners try to conceal their occupational disease and mortality records. Furthermore, a large amount of compensation is deducted by the local government; this deductive value is not counted or included in the health impact and mortality costs.

2.7.3 Direction of Sustainable Energy Policies and Overall Measures

This section first demonstrates that biomass is a sustainable energy source in Northeast China on the basis of the findings in the previous sections and second suggests overall measures to promote biomass power generation.

First, in the total lifecycle cost, biomass power plants are superior to coal-fired power plants. The total lifecycle cost in this research includes electricity market price and quantified external costs (**Figure 2.8**). However, for coal-fired power plants, there is still a large part of unquantified external costs because of insufficient precision evaluation standards. Based on the results in the research, the total lifecycle costs of a coal-fired power plant are considerably higher than those of a biomass power plant, that is, the competitive cost of a biomass power plant are higher than that of a coal-fired power plant. As shown in Figure 8, the total lifecycle cost of a biomass power plant and coal-fired power plant is $0.12 per kWh and $0.152 per kWh.

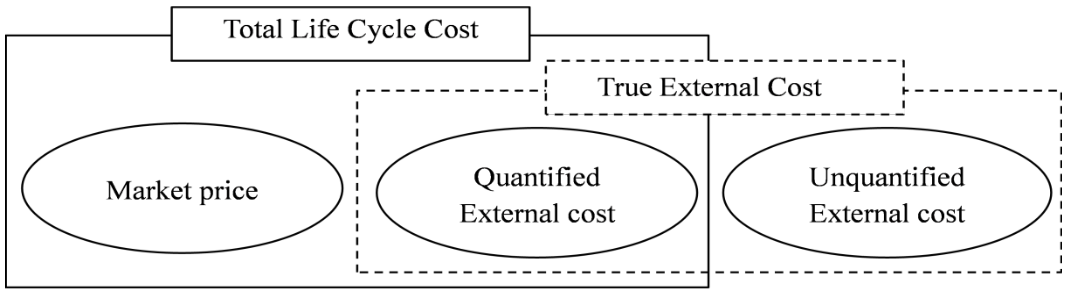

Figure 2.8. Relationship of total lifecycle cost and true external cost.

Second, in line with the external costs and quantity of pollutant emissions, the biomass power plant is far superior to the coal-fired power plant. In addition, biomass has negative externality. Recycling a large amount of crop straw as energy resources reduces the haze occurring from burning straw in open fields.

Third, the biomass power plant can accommodate social characteristics, such as an abundant straw crop in Northeast China. As mentioned in the Introduction, if the total crop straw production in Northeast China were used for electricity generation, theoretically, 30% of the demand could be supplied. However, less than 5% of electricity is now generated by biomass. The biomass power plant in Wangkui can generate approximately 200,002,600 kWh. That is, a single 30 MW biomass power plant can satisfy the electricity demand in the entire area. Thus, biomass is a sustainable energy source in Northeast China with higher economic competitiveness, environmental performance and better social accommodation.

Three overall measures are suggested and discussed to realize the energy policy direction: a market price mechanism to incorporate external costs, governmental subsidy systems and policy implications of the size and capacity of biomass power plants as compared to coal power plants. If the market price setting is based on the total lifecycle cost, the biomass electricity can be supported by the general public. Thus, incorporating the external costs of coal-fired and biomass power plants into the price of the electricity generated by each type can be a potentially effective policy step with regard to reducing their negative impacts and moving toward sustainable energy use. Strengthening the governmental subsidy systems is proposed because they are expected to financially and technically ease the operations of biomass power plants and sustainably develop the biomass power industry. In terms of sustainable energy supply and biomass power development, size and capacity of biomass and coal-fired power plants are proposed to enhance the efficiency of electricity generation and environmental performance.

2.8 Conclusions

This paper intends to advance the understanding of the measurable and quantifiable costs of a 600 MW coal-fired generation power plant and 30 MW biomass power plant. Concretely, the structures of external costs are built in line with coal-fired and biomass power plant life cycle activities. The external cost of coal-fired power plant and biomass power plant was compared, using the lifecycle approach. In addition, the external costs of a biomass power plant are calculated for each stage for comparison with those of a coal-fired power plant. This approach was undertaken because understanding the whole measureable and quantifiable cost structure at the lifecycle stages of the coal-fired generation power plant and the biomass power plant would be helpful for Chinese people to have correct perception of the true external costs of those two power plant types.

The results highlight that the external costs of a coal-fired plant are 0.072 US $/kWh, which are much higher than that of a biomass power plant, 0.00012 US$/kWh. The external cost of coal-fired power generation is as much as 90% of the current price of electricity generated by coal, while the external cost of a biomass power plant is 1/1,000 of the current price of electricity generated by biomass. If the current electricity price is combined with the external costs quantified in this study, the total lifecycle costs of coal-fired electricity and biomass power generation amount to $0.152/kWh and $0.12/kWh, respectively. In addition, for a biomass power plant, external costs associated with SO_2, NO_X, and PM are particularly lower than those of a coal-fired power plant. It should also be noted that the biomass power plant has the positive effect of reducing air pollution, that is, negative external costs though they are not quantified in these analyses.

Some estimations of external costs of coal-fired power plants are made with insufficient precision. First, proper metrics have not been developed to represent the impact on water and land which can threaten the living environment in the long run. Second, among pollutants such as fly ash, furnace residue, gangue and contaminated water, there are no international damage cost standards. Third, in the phases of coal mine construction and coal mining, the estimation does not account for recovery and sustainable development costs. Fourth, occupational disease and mortality costs are estimated based on the existing unsound compensation system. With the improvement of estimations in the future, it would be even clear that the significance of developing biomass power plant.

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CHAPTER 3: IDENTIFYING STAKEHOLDERS' PERCEIVED RISK IN STRAW SUPPLY CHAIN BASED ON A CASE STUDY IN NORTHEAST CHINA

3.1 General introduction

Biomass power generation system is a complex process that transforms raw material into electricity, including various risks, for example, human factor risks, technology risk, organization risk, policy risk. It is important to highlight that mitigating risk of stakeholders involved in biomass power systems would promote biomass power industry development to some extent. This part contributes to the identification and analysis of main stakeholders' risk, aiming exploring approaches to mitigate risk and promoting biomass power industry development in China. The objective of the study is to determine, analyze and discuss the main stakeholders' risk perception and to formulate the problems in biomass supply chain. Based on a case study of National-Bio Energy power plant in Wangkui County in Heilongjiang Province, interview and questionnaire approach were used to explore the perception risks of main stakeholders. The survey results indicate that farmers' risk perceptions are the root cause of biomass supply and high cost in biomass power plant.

3.2 Methodology

This study aims to identify and analyze risks of key stakeholders in biomass power plant in China. A case is taken in Wangkui County in China. An investigation into the National-Bio Energy power plant area is conducted to explore stakeholders' risk perceptions which are determined by personally selected sources of values, interests, and individual experiences. In this case, National-Bio Energy power plant and the local government are in good relationship with sufficient communication. However, there is information gap between the power plant and the farmers (crop straw suppliers). This is because agencies take the responsibility of collecting crop straw from farmers and carrying it to the power plant.

The first step of the survey on stakeholder risk perceptions is to identify key stakeholders related to biomass power plant. The process was conducted with the help of local government who were familiar with the power plant since it was established. The selected stakeholder representatives were interviewed to identify risk. Then, this study analyzed perceived risk of main stakeholders aiming to rank risk perception and propose strategies to mitigate main risks. Finally, problem is formulated based on the results of analysis of risk perceptions.

3.3 Case study of National-Bioenergy power plant area in Wangkui County

3.3.1 The background of Wangkui County

As the center of Heilongjiang Province, Wangkui County belongs to Suihua City. **Fig.3.1** and **Fig.3.2** illustrate the main location of the place referred to this paper. Wangkui County governs 7 towns and 12 townships, covers 2,314 square kilometers, and has a population of 442,867 thousand. The annual agricultural yield is over 1,197,000 Ton, with stalk production of 1,113,000 Ton. This area basically depends on agriculture. Meanwhile, the industries grow very fast. Wangkui enjoys a plenty of stalk resources, and its utilization will positively contribute to the energy consumption in the area, which is significant to improve the economic and social development.

Through the spot survey of rural resident about 1,000 households in Wangkui, the output of straw or purchasing is about $111.3*10^4$ ton (shown in **Table 3.1**). Furthermore, the density of straw resource is high. In 50 km radius, there are 340 villages, and the output of straw is about

251.6*10^4 ton (shown in **Table 3.2**). In 30 km radius, there are 161 villages, and the output of straw for purchasing is about 144.5*10^4 ton, which can fully supply the biomass power plant (shown in **Table 3.3**).

Fig.3.1 The location of Suihua City in Heilongjang Province

Fig.3.2 The location of Wangkui County in Suihua City

However, currently, on one hand, the stalk is basically used for cooking (roughly 50% to 60%), with direct combustion. The utilization efficiency is 5-8%. On the other hand, there are substantial stalks that are burned directly inside the plowing field. This kind of situation wastes the precious energy resources, as well as seriously pollutes the environment.

Table 3.1 Crop straw output in Wangkui County

Species	**Acreage (10^4 mu)**	**Total crop production (10^4 ton)**	**Total crop straw Production (10^4 ton)**
Corn	119.5	62.7	81.3
Soybean	79.4	13.1	14.3
Rice	40.9	43.9	15.7
Total	239.8	119.7	111.3

(Note: 10000 square meters=15 mu)

Table 3.2 Crop straw output in 50 km radius

Species	Acreage (10^4 mu)	Total crop production (10^4 ton)	Total crop straw Production (10^4 ton)
Corn	247.1	129.7	168
Soybean	164.2	27.1	29.6
Rice	142.5	151.1	54
Total	553.8	307.9	251.6

Table 3.3 Crop straw output in 30 km radius

Species	Acreage (10^4 mu)	Total crop production (10^4 ton)	Total crop straw Production (10^4 ton)
Corn	154	80.9	104
Soybean	94	15.5	17
Rice	62	65.8	23.5
Total	310	162.2	144.5

3.3.2 The introduction of National-Bio Energy power plant in Wangkui County

National-Bio Energy power plant, belonging to National Grid Company, was established in 2006. The biomass power plant is located in the developing area, taking 110 thousand square kilometers. This project imported biomass direct combustion technology of BWE Company from Denmark. The total investment was 553 million RMB. In 2007, the biomass power plant injected into National Grid Company to generate electricity, which became the first power generation company combusting yellow straw in the world. In 2011, the output value of this company was 140 million RMB, as well as increasing 20 million RMB incomes of farmers. In addition, this power plant could reduce 100000 tons of CO_2 emission annually. Biomass power plant could provide clean and reliable energy to local economy development, and contribute to local power grid. It could also replace small steam coal-fired power plants whose development has been strictly controlled by the government, so as to reduce the coal consumption for power generation, which will be beneficial to the local environment and ecology protection. It is consistent with the government's sustainable energy strategy.

Wangkui biomass power plant is one of the important components of new energy base construction in Wangkui County. The total capacity is 25MW. In line with the National Renewable Energy utilization target, National-Bio Energy power plant aims to import the oversea mature biomass power generation technology and devices through international cooperation, so as to absorb and achieve the commercialization and scaling up of the biomass power generation.

3.3.3 Stakeholder relationship in the supply chain of National-Bio Energy power plant

Although the biomass power supply market is not completed, the relationship among stakeholders is significantly important for the biomass power plant development. From macro perspective, the current stakeholder relationship is shown in **Fig.3.3**.

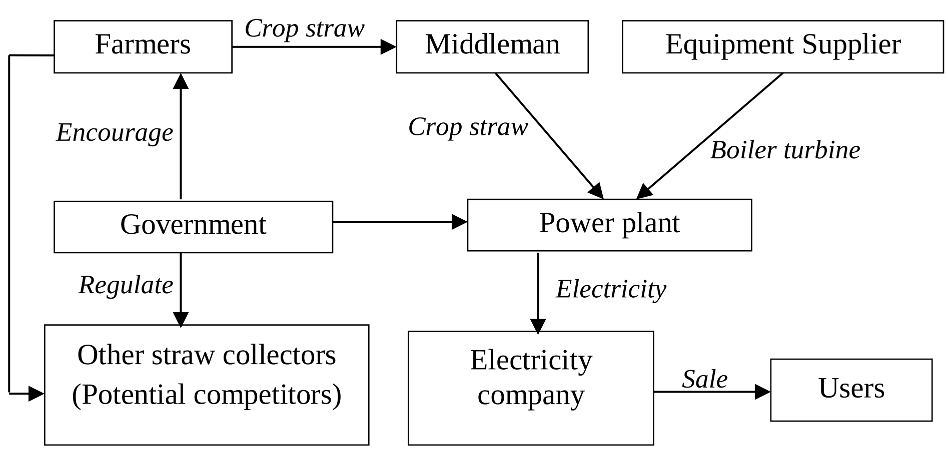

Fig.3.3 The current stakeholder relationship

In this relationship, farmers are the suppliers of biomass. Between farmers and power plant, the middleman plays a vital role in collecting biomass. However, in order to get more profit, farmers might sell the crop straw to other factories instead of biomass power plant. This kind of situation causes lack of crop straw for power plant. The local/central government, as a kind of coordinator, takes the responsibility of encouraging farmers to sell crop straw to agents, and giving subsidy and controlling the price of electricity.

For biomass power plant, the difficulty in crop straw collection hinders biomass power development. The main stakeholders in biomass collection and supply systems include farmers, middleman and power plant owners. Because the long distance transport of raw material is not feasible, the market of biomass will be local or regional, usually within 30 km. In order to collect more crop straw, biomass power plant also set sub-agents in remote area in case of lack of raw material in some year, as it is shown in **Fig.3.4** (F indicates farmers).

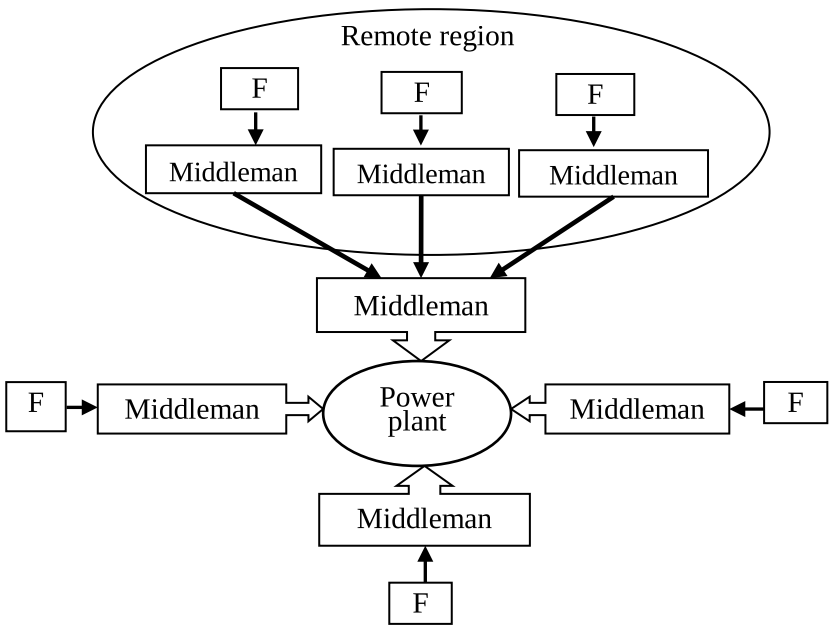

Fig.3.4 Multi-middleman supply system

3.3.4 Stakeholder risk perception analysis

A national biomass market does not exist at present in China now. The study suggests that a long-term agreement among stakeholders is essential to stabilize the biomass feedstock price, which can be beneficial not only for the power plant but also for the agents and farmers who are involved in biomass trading. In order to build long-term agreement among stakeholders, it is essential to analyze risks, and try to reduce the risk and building balancing benefit through which win-win relationship can be built. In biomass power industry, power plant, agent and farmers are the main stakeholders. Government is also significant in the system, taking the role of coordination and making regulation or policy to give incentive to the stakeholders involved in biomass power system. The risks of main stakeholders are shown in from **Fig.3.5** to **Fig.3.7**.

- *Biomass power plant*:

Natural risk is one of the vital risks that people cannot control, especially in raw material collection process. From macro social risk perspective, macro-economic fluctuation influences the developing speed of electricity industry. It is evident that the amount of biomass power generation takes a small amount of the whole country's electricity generation. However, considering if coal power generation is in serious financial loss in most areas, the central government would balance benefits of all parties. Thus, the expectation of rising price of renewable energy might not be as strong as before, which means that macro-economic fluctuation may bring negative influence on biomass power industry. Policy risk refers to policy environment stability and uncertainty. Nowadays, biomass power industry is at the beginning stage of development, which is difficulty to survive without policy support. The Chinese government issued a series of laws and regulations, for example, Renewable energy electricity prices and cost-sharing management pilot scheme, intending to encourage biomass power plants development. However, with technology improvement and industrialization of biomass power generation, the policy will be adjusted, which probably influences biomass power electricity price and power plant revenue. In biomass power technology level, because the biomass power project in China develops late, the technology is not mature, causing low combustion efficiency and biomass waste. For example, the biomass power project in China lacks independent research capability in some equipment, such as vibrating grate and dust removal device. The supply and demand risk is relatedly low, because of the Blanket Guarantee Acquisition Policy. It means that the Electricity Grid Company purchases as much electricity as the power plant produces. Under the government renewable energy policy, the Blanket Guarantee Acquisition Policy will not be changed for coming some years.

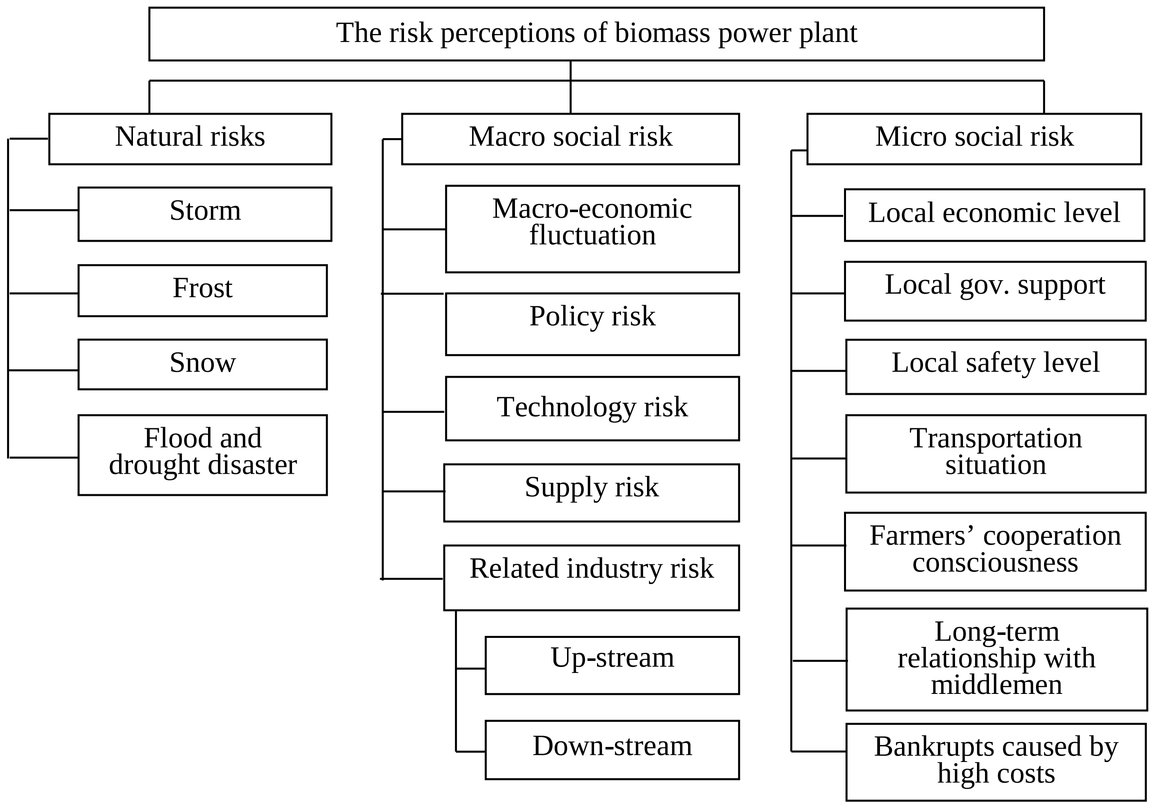

Fig.3.5 The risk perceptions of biomass power plant

From micro perspective, local economic level, local government support, local safety level, transportation situation, farmers' cooperation consciousness, long-term relationship with middlemen and bankrupts caused by high costs have great impact on the development of biomass power industry. Biomass power industry, especially for the supply, collection and transportation processes, requires the support of local region. The development level of biomass power plant closely relates to crop production scale, climate condition, the number of transportation trucks and transportation condition. For example, transportation limitation will influence the biomass supply rate and quantity; thereby affect the power plant's normal operation. In addition, farmers' awareness would also influence cost change. In the biomass collection process, because of the large quantity of biomass is needed, some farmers who want to get more profit with less crop straw might sell biomass not reaching standard, such as mixing dust or not dry enough crop straw, to the power plant, which increases costs for biomass power generation. Another considered risk is regional security level. If the security level is low, biomass power plant may face risk of losing raw material. Moreover, to have long-term relationship with the middleman is the guarantee of sustainable feedstock. The most important risk perception is bankrupt caused by high cost. The cost of biomass power generation is considerably higher than that of fossil power generation. With the increasing price of feedstock, biomass power plants are facing deficit and bankrupt.

- *Middleman*

Middlemen are the connection between power plant and farmers, taking a considerably important role in biomass supply chain. During crop straw collection, building trusts with farmers is an essential step without which it would be troublesome to collect crop straw from farmers. In China, on account of no formal crop straw market, negotiating crop straw price becomes difficult part since both agents and farmers are eager to get more profit. In addition, the limited crop straw collection time, from the middle of October to November 5th, the bad road condition, and cold weather, increase the difficulty in crop straw collection. Since the labor cost becomes increasing higher, the middleman cannot obtain much profit, which is the main reason that some agents give up the job. After crop straw collection, middlemen also take charge of crop straw storage, processing and transportation. The most important business objective for agents is to obtain profit, which stimulates middlemen's motivation for crop straw collection. However, nowadays, the middlemen's profit is decreasing. As it is indicated in the **Table 3.4** below, middleman can get only 40 yuan/ton averagely, with taking the main collection risks (storage risk, processing risk, transportation risk), causing some agents to consider quitting the job. However, for some middlemen who already build sound relationship with farmers, it is much easy to collect crop straw. Since the farmers trust the agents, they would like to let middlemen collect crop for free. In this case, middlemen can get more profit.

Table 3.4 the profit that middleman can get (Yuan/ton)

Cost (Labor, transportation, electricity, oil, etc.)	**Average cost** (Crop straw)	**The average price that power plant provides**	**Profit**
190	40	270	40

Source: the author's investigation

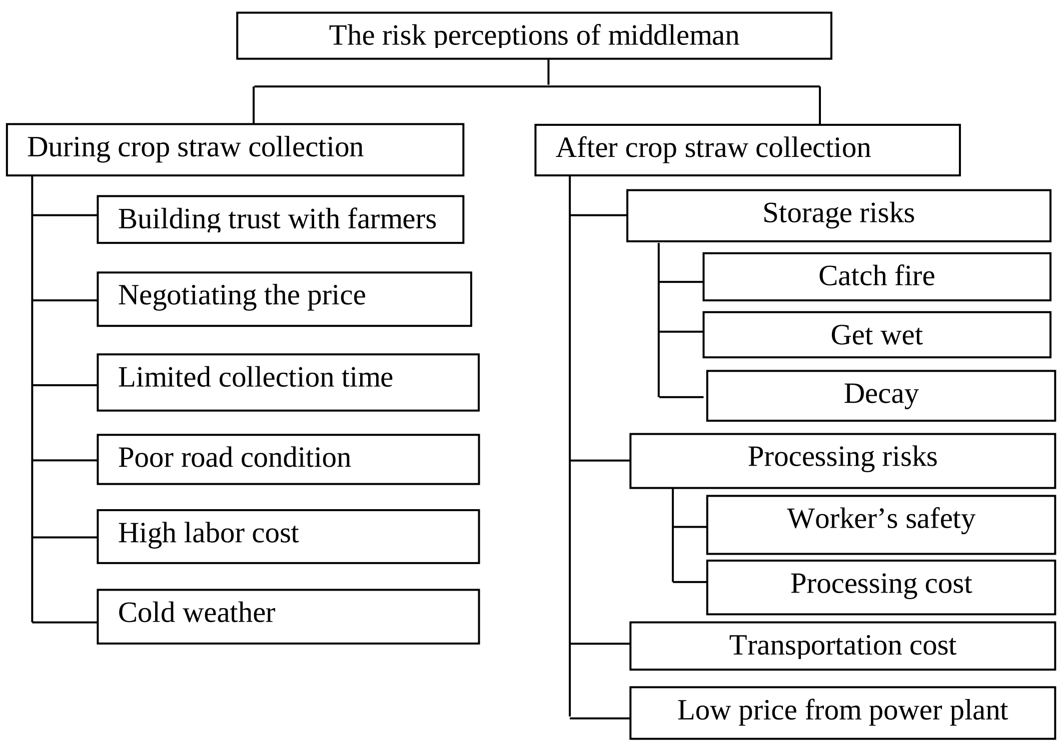

Fig.3.6 the middleman's risk perceptions

- *Farmers*

Farmers are the crop straw suppliers, whom the power plant operation relies on. However, farmers have less motivation to sell their crop straw mainly because they can get less profit and they have to worry that middleman might destroy the farm land. Since few farmers have environmental awareness, they prefer to burn crop straw directly in the field. In that case, it is no necessary for them to consider the limited time of cleaning the field and the destruction of farm land. Conversely, if the farmers trust the middleman, they may have less trepidation of destruction of farm land. Nowadays, some middlemen already built trust with farmers, and those farmers would like to give the crop straw to agent without charging money. However, for poor farmers, they consider profit more than other factors.

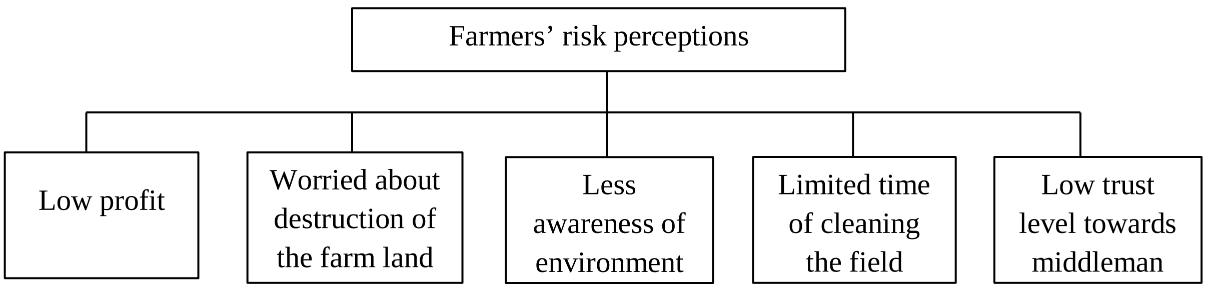

Fig.3.7 the risks of farmers

3.4 Results

This study divided risk into controllable risk and uncontrollable risk. From the biomass power plant's perspective, the risks of local government support, local social safety level, transportation situation and farmers' awareness are could be controlled. For middleman, the risks of building trust with farmers, negotiating the price (with farmers and the power plant), and the risk of biomass collection after using new harvester can be controlled. For farmers, trepidation of farm land, less awareness of environment, and less trust of agents are under control. This study focuses on controllable risks, and tries to explore strategies to mitigate controlled risks.

In this study, interview method has been used to score each risk. During the interview, each stakeholder stated and valued the risk from their own standpoints or benefits. However, if stakeholders evaluate their own risk (for example, power plant staffs evaluate risks from R1 to R4), they may expand the surface risks level, ignoring potential risk level. From this perspective, this risk assessment value combined different stakeholders' value to ensure the mean value approaching to the objective reality. For the risks related to biomass power plant, in addition to two factory directors, one government officer and two middlemen were selected to give scores of each controllable risk. Because power plant and government have sound connection since the power plant was established, thus, the government is familiar with the growth process of the power plant. Also, a middleman is selected to assess the risk from objective perspective. In terms of agents, two factory directors, two middlemen and one farmer scored the risk. Middlemen are the connection between farmers and power plant. Therefore, it seems reasonable that power plant directors and farmers give scores of middlemen's perception risk. For farmers' item, four farmers and one agent gave scores. This study uses the mean score to rank the risk. 0 is the lowest level and 10 is the highest level. (P: power plant director, G: government officer, M: middleman, F: farmer)

Table 3.5 Key stakeholders' risk score

stakeholders	Risks	Scores					
		G	P	P	M	M	Mean
	Bankrupts R_1	10	10	10	10	10	10.0
	Long-term relationship with middlemen R_2	9	10	10	9	9	9.4
	Local government support R_3	10	10	10	8	7	9.0
Power plant	Local safety level R_4	8	5	4	6	7	6.0
	Transportation situation R_5	5	5	6	9	8	6.6
	Farmers' cooperation consciousness R_6	7	8	9	8	9	8.0
		P	P	M	M	F	
	Building trust with farmers R_7	8	9	10	10	8	9.0
Agents	Price negotiation with farmers R_8	6	7	9	10	7	7.8
	Price negotiation with power plant R_9	6	6	8	9	5	6.8
		F	F	F	F	M	

	Trepidation of farm land R_{10}	7	7	7	8	3	6.4
Farmers	Environmental awareness R_{11}	2	1	3	2	3	2.2
	Low trust to middleman R_{12}	8	9	7	10	9	8.6
	Low profit R_{13}	9	9	10	9	7	8.8

Source: Author, *2013*

Apparently, the value rank of power plant's risk is as follows: $R_1>R_2>R_3>R_6>R_5>R_4$. It is no doubt that bankrupt caused by high cost is the most crucial perceived risk. Generally, in biomass power plant, the major cost is caused by feedstock. With the increasing price of straw, biomass power plant is in difficulty to deal with deficit problem. To have sufficient straw, maintaining long-term relationship with middleman is basic for straw supply. The government's support considerably contributes to the biomass power plant growth, without which the power plant will bankrupt. Biomass power plant cannot get profit in first 6 years since it was established. Although the power plant is financially becoming stronger, government's support is still an essential element for biomass power plant to survive. For example, the Chinese government has begun to carry out the policy of purchasing all the electricity generated by biomass power plant, guaranteeing the sale channel. Farmers' awareness is also an extremely important factor that influences the crop straw supply. With low awareness and low motivation of selling crop straw to middleman, it will be difficult to cooperate with farmers in biomass collection. In terms of agents, results were $R_7>R_8>R_9$. Building trust with farmers is substantially vital in biomass collection. Specifically, in the Northeast of China, each farmer has approximate 10,005 square meters. It is extremely hard for farmers to harvest all crop straw in such broad land. However, for middlemen who haven't built trust or failed to build trust with agents, they suffered a lot from price negotiation with farmers. For farmers, the most considerable factor is profit. In their opinion, selling crop straw can obtain less profit, however, at the same time; they should burden the risk of farm land trepidation. In that case, it makes farmers feel easy to burn the crop straw in the field.

3.5 Problem formulation

As highlighted in the results, risk perception of bankrupt caused by high cost is the most crucial problem. In order dig root cause of high cost, **Fig.3.8** outlines the causation relationships among problems and difficulties. It is clear to notice that there three main root reasons leading high cost in biomass power generation. Red line, green line and blue line demonstrate root causations of farmers' risk perception, straw characteristics, and immature technology, respectively. This research focused on the red line which root causation is farmers' risk perception. Although researchers complain that the characteristics of straw is one of the problems hindering the development of biomass power plant (i.e. Liu et al., 2014). However, it is not the main problem. Technology is important, as shown in this figure. As in other industries, technology is the hardware facilities, which cannot be ignored. Meanwhile, software facilities are also as significant as hardware. In biomass power industry, stakeholders' cooperation in the straw supply chain can be one of the most important software. Therefore, to solve the red part in the figure, mitigating farmers' risk perception and encouraging farmers' willingness to supply straw are significant to facilitate biomass power industry.

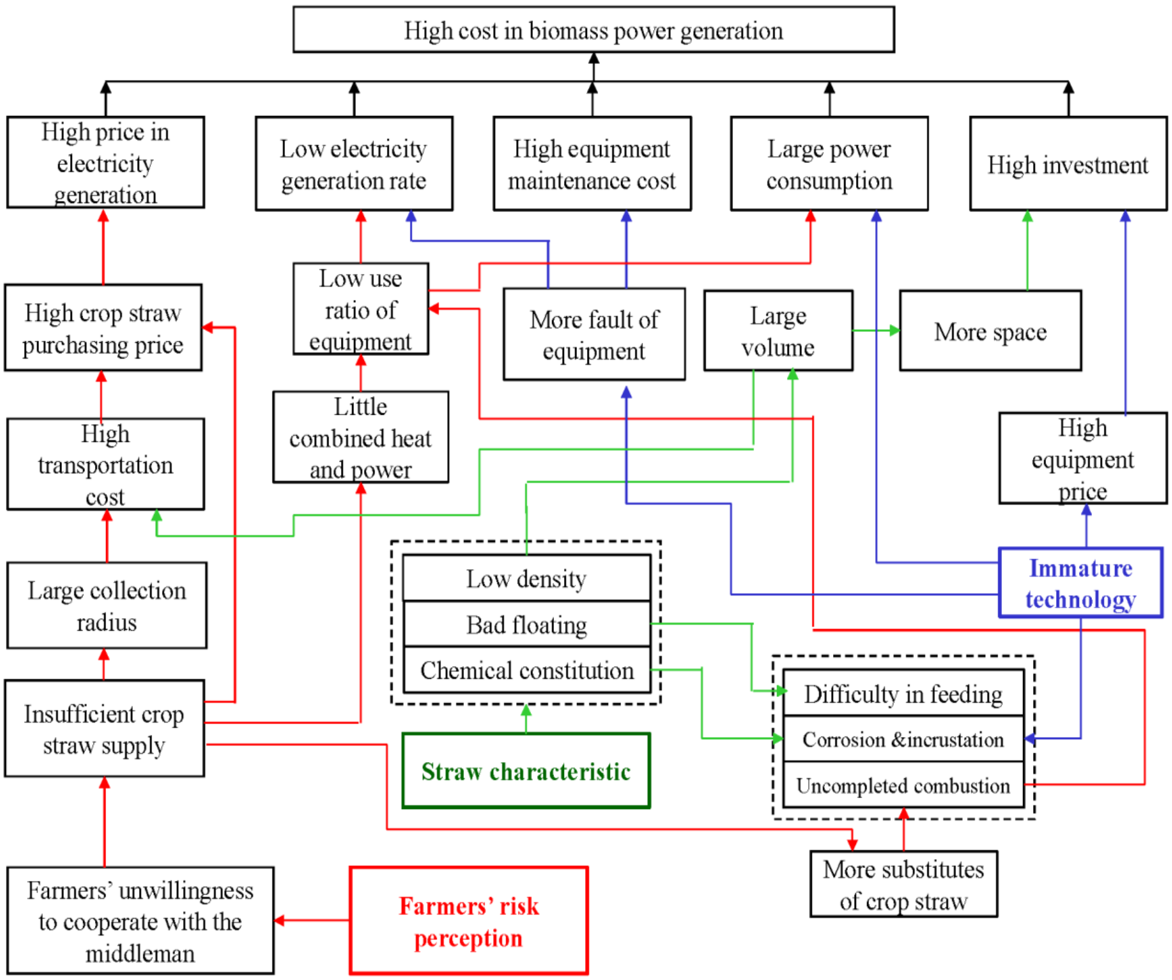

Fig. 3.8 Causation relations among current problems

As stated in research scope and goal, this study focuses on mitigate farmers' risk perception to facilitate cooperation between farmers and middleman or biomass power plants. Based on the result of **Fig 3.8**, to farmers' risk perception is the one of the keys that caused high cost. In order to clarify the relationship of stakeholders' specific risk perceptions, problems are formulated in **Fig. 3.9**. As it shown in **Fig.3.9**, in the biomass power plant part, lack of trust on the middleman cause no long-term relationship between the two stakeholders, which lead to unstable crop straw supply and difficulty in ensuring crop straw quality. Adding crop straw may be stolen by other people for selling (regional safety level) and farmers have low awareness of selling straw, biomass power plants face dilemma of insufficient feedstock. As described in **Fig.**

3.8, less mature technology and characteristics of straw are also main causes of high cost as well as insufficient straw and low combustion efficiency. High operation cost put biomass power plant in predicament in surviving.

As the direction of the red line (middleman), lack of trust on biomass power plant causes cost of training and cultivating new middleman, unstable straw supply and difficulty in ensuring straw quality leading to high cost in biomass power plants. Lack of mutual trust between middleman and farmers causes few collection of straw resulting in middleman's depress in the job of collecting straw and high collecting price from farmers which will make middleman obtain low benefit and have low motivation in crop straw collection. Moreover, time consuming caused by few collection, bad village road conditions also lead to insufficient straw collect and low benefit.

In terms of farmers, because of lack of trust on middleman, farmers have the risk perception of outweighing benefit and trepidation in destruction of farmland while middleman collecting straw, these risk perception finally lead to middleman's insufficient straw and low benefit, as well as farmers' low motivation in selling straw. In addition, high cost of harvesting straw also has negative impact on farmers' supply straw. Moreover, in rural China, farmers have lack of awareness of environment (air pollution caused by burning straw in the open field), adding time consuming in harvesting straw, farmers prefer to burn straw instead of selling to middleman. This phenomenon not only results in insufficient straw for middleman, but also causes environmental problems. **Fig. 3.9** also indicates that education to farmers is also important in straw supply activities. For example, regional safety level, farmers' awareness of supplying straw, farmers' awareness of environment. From the analysis in **Fig. 3.9**, it shows that in the crop straw collection activities, farmers are the key roles who decide the quantity of straw.

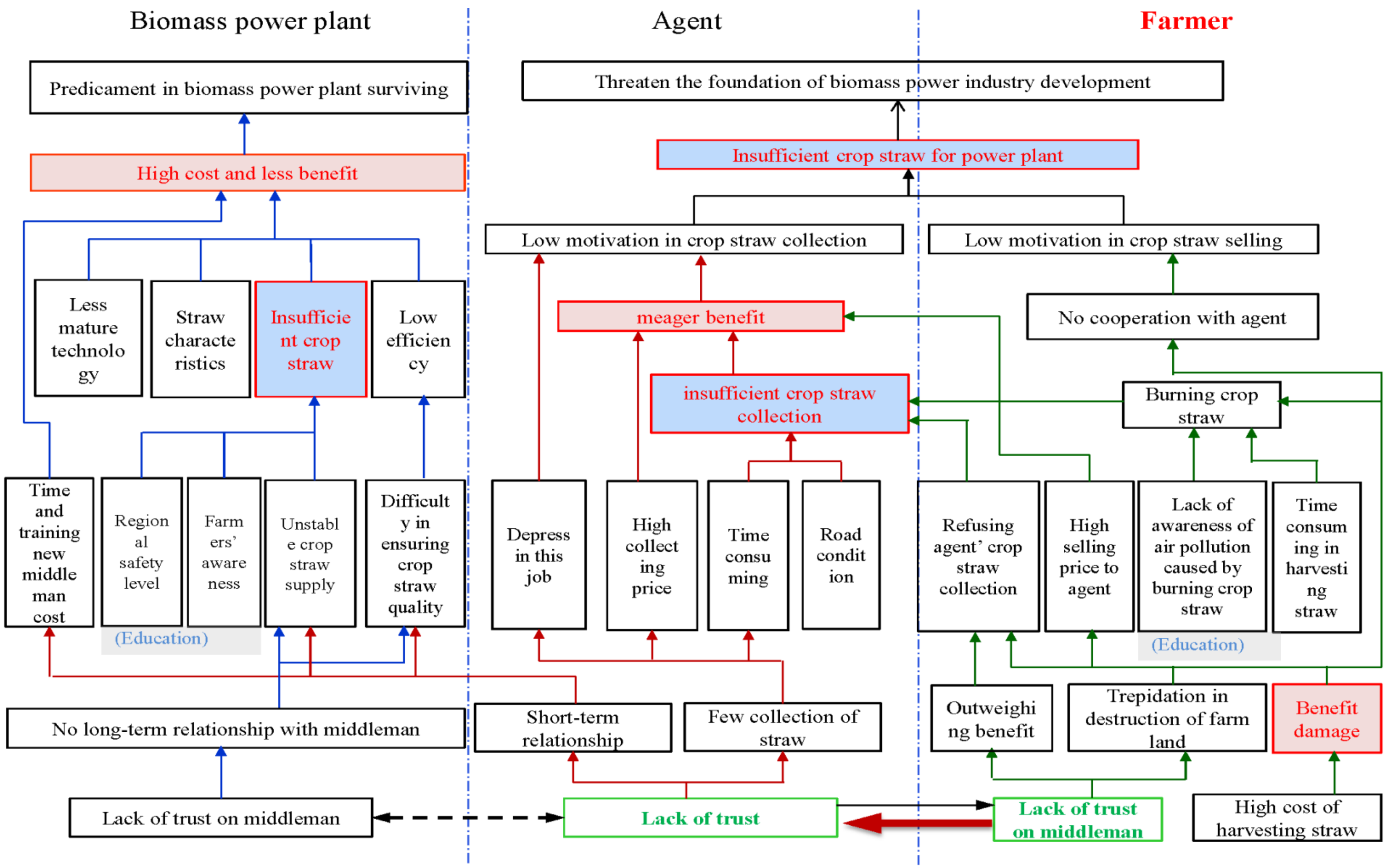

Fig.3.9 descriptive and explanation of problem formulation

Source: investigation in September and October, 2014

3.6 Conclusions

Biomass power industry is a promising industry, which is beneficial not only for environment but also regional development. However, as each party involved in the project is facing various risk. Mitigating risk and increasing stakeholders' motivation to participate in the project is significant to solve biomass collection problem. One seemingly basic but nonetheless crucial finding is that, various risk factors co-occur with biomass power operation. They are not limited to uncontrollable risks but also cover a very broad spectrum of controllable risk that is related to stakeholders. In this part, in addition to identify and analyze the key stakeholders' risk perceptions (the biomass power plant, middlemen and farmers), problem that causes insufficient straw is formulated to highlight the root cause. The results indicate that in the biomass supply chain farmer is the crucial role in biomass supply. Therefore, in the Chapter III, affecting factors of farmers' risk perceptions is analyzed to find the influencing factors of farmers' low motivation of supplying straw.

Reference:

1. Liu Jicheng, Wang Sijia, Wei Qiushuang, Yan Suli. Present situation, problems and solutions of China's biomass power generation industry. Energy Policy (2014), 70: 144-151.

CHAPTER 4: EXPLORING FACTORS AFFECTING FARMERS' RISK PERCEPTIONS OF BIOMASS-SUPPLY: A CASE STUDY IN THE NATIONAL BIOENERGY INDUSTRY AREA, CHINA

4.1 General introduction

The growth of huge external costs caused by pollution, along with the shortage of fossil fuel reserves, create additional concerns that represent strong motivations for the development of a new type of power plants assumed to be environmentally friendly and based on endogenous resources. The use of biomass is a promising alternative to fossil fuels, which would mitigate environmental pollution and optimize energy structures (Hu et al., 2014). In China, a major application of biomass is combustion to generate electricity and heat (Wang et al., 2003). The amount of crop straw produced in China was 820 million tons in 2009, which is more than enough to develop straw-based biomass power plants (Ministry of Agriculture of the People's Republic of China, 2011). However, the current straw-based biomass power plants face difficulty in development. Because farmers have various risk perceptions, not a few of them are willing to cooperate with the middleman, who takes on the responsibility to collect straw from the farmers. Their risk perceptions decrease the motivation in participating crop straw collection activities.

Indeed, farmers' behaviors and decision making are influenced by different determinants indirectly via risk perception (Hardaker and Lien, 2010). The concept of risk has received considerable interest from academics (Sitkin and Pablo, 1992) (Beck, 1992) (Hardaker et al., 2004), and individuals' reactions towards particular risks vary because of the risk type (Sitkin and Pablo, 1992). If there are substantive differences in the way that different sections of society perceive risk, it is important to consider how rural communities and farmers perceive risks. A better understanding of farmers' risk perceptions and the factors influencing these risk perceptions is an integral component of developing rural policies and programs that are supported and implemented on a rural scale (Hardaker et al., 2004) (Botterill and Mazur, 2004) (Geurin L.J. and Genrin T.F., 1994). Studies of farmers and rural perceptions of risk focus on various topics, including climate variability and change (Krogmann et al., 2001) (Pannell, 2003) (Shrapnel and Davie, 2000), biotechnology (Clark and White, 2002), risk perception in adopting innovation (Geurin L.J. and Genrin T.F., 1994) (Dalgleish and White, 2001) (Coakes and Fisher, 2000) (Cary et al., 2002), and risk in rural locations (Pannell, 1998). Han and Zhao (2009) illustrate factors determining farmers' attitudes toward fertilizer application by examining farmers' risk perceptions (Pannell, 1999). Naylor and Courtney (2014) explored the factors that influence the way farmers respond to particular risks, using the case of bovine tuberculosis (McGee, 1998). There is a large amount of literature on agricultural risk (Han and Zhao, 2009) (Naylor and Courtney, 2014). However, there are no studies that investigate farmers' risk perceptions or factors influencing such risk perceptions of biomass-supply activities.

Farmers' responses to supplying crop straw to middlemen are likely to be influenced by their risk perception and the level of risk that they face. In biomass supply chains, farmers produce and supply raw material, which is used for biomass power plants. Their decision making in cooperating with middlemen is significant to promote the development of straw-based biomass power. In reality, however, farmers' unwillingness to sell their crop straw to middlemen causes insufficient raw material in biomass power plants. In order to create appropriate strategies to reduce the level of risk perceived by farmers, identifying farmers' risk perceptions and factors that influence risk perception is significant.

The objective of this study is to provide, through an exploratory analysis of data from a farmer survey, empirical insights into farmers' risk perceptions and factors affecting risk perception. This is based on a series of questionnaires conducted with farmers in three different income level villages in Northeast China. Due to the limited social science literature on straw collection activities, it is meaningful to draw on the wider literature around risk perception and risk perception affecting factors, which are described in the next section. The methodology is then presented via the results of an in-depth multivariate analysis of the data collected through a questionnaire survey. The findings are then presented, and the implications for understanding the farmers' risk perceptions and affecting factors are discussed. A conclusion is provided in the final section. By exploring the farmers' risk perceptions and affecting factors, this paper provides an empirical contribution to the literature and provides valuable pointers for reducing the level of risk perceived by farmers in supplying crop straw to straw-based biomass power plants, which is significant in solving the problem of insufficient feedstock in biomass power plants in China.

4.2 Literature review

It is significant to make a new risk perception model (Sjöberg, 2002), particularly, if the model can be as fully explained as possible (Sjöberg, 2012). The purpose of this research is to provide a new conceptual framework which could combine a theoretically comprehensive overview of key psychological determinants and practical determinants in supplying crop straw in China. While factors that influence public risk perceptions are clearly complex and multidimensional (Slovic, Fischhoff, and Lichtenstein, 1982), past research has examined a range of factors which influences risk perceptions of public and public responses to risk perception, including: characteristics of individuals (e.g., psychological traits, socio-demographics), characteristics of the risk or practice in question, and characteristics of social and environmental contexts (e.g., political conditions, geographical setting, culture) (Wejnert, 2000; Finucane, 2000; Haw et al., 2000). Based on the reality of crop straw collection, this research reorganized primarily influential factors in detail as four key dimensions, namely: socio-demographic characteristics, policy guidance factors, economic factors, and trust factors. The current section expands on this broad conceptual structure by outlining and delineating each of these dimensions in further detail.

4.2.1. Policy guidance factors

Policy guidance factors include government economic incentives to farmers and education or guidance on the knowledge of cooperating with the middleman to collect crop straw. Biomass power offers unique advantages for utilities to meet government policy, but it needs government subsidies for another decade (Critchlow and Leroi, 2012). Before the implementation of the Renewable Energy Law, China did not have the price policies or economic incentives to support biomass power generation. After the implementation of the Renewable Energy Law, the Chinese government has provided temporary and long-term subsidy policies for electricity prices for biomass power generation. Although the Chinese government makes a huge investment into biomass power generation, biomass power plants still face difficulties in biomass supplying. It is questionable whom the subsidy should be given. Accordingly, this study aims to provide a reliable assessment of the economic incentives to farmers tentatively.

Farmers' knowledge of risk factors is generally regarded as a cognitive aspect of risk judgment (Sundblad et al., 2007). Once people have determined an assessment of a particular risk, their opinions can be difficult to change (Covello et al., 1984: 226; MacCrimmon and Wehrung, 1986: 41). However, it is relatively unclear to what extent a cognitive understanding of collecting and selling crop straw can predict farmers' risk perceptions. In particular, there is an important gap between a farmer's "subjective" knowledge (e.g., burning straw in the field is natural) and the actual "evidence" (e.g., burning straw contributes to air deterioration). Some researchers use one-item measures to assess subjective knowledge (Kellstedt et al., 2008; Malka et al., 2009; Menny et al., 2011). However, Reser et al. (2012) and Roser-Renouf and Nisber

(2008) suggested that this kind of measurement should be avoided because of lower reliability and the confusion of different types of knowledge. Also, a number of studies have objectively assessed the influence of knowledge in predicting risk perception (Tobler et al., 2012a; Reser et al., 2012); however, researchers have failed to make a conceptual distinction between different kinds of knowledge. This study provides two interrelated specific knowledge veins, namely, the knowledge on the adverse impact of burning crop straw in an open field and knowledge on significance of energy generation by crop straw. This knowledge should be conveyed or taught by the local government. Therefore, the two knowledge veins are under the policy guidance dimension.

4.2.2. Economic factors

It is widely recognized that farmers perceived risk influenced by economic factors (Yang et al., 2014; Uri, 1998). Sparks et al. (1994) concluded that the perceived benefit had an influence on one’s attitude toward risk. The importance of perceived economic benefits for the acceptance of risk was also emphasized by Frewer et al. (1995). This should be stressed especially in China, since there is a great economic gap between the rich and poor. The poor even find it hard to afford their children’s education fees. Economic loss, such as lack of funds and low prices of agricultural products, can be critical in influencing farmers’ cooperation (Zheng et al., 2011). Therefore, before farmers participate in an activity, they first consider the economic and profit effects (Barnes et al., 2013). Since economic factors were the main driver of farmers’ cooperation with the middleman to collect crop straw in our study area, this study summarizes economic factors as a dimension to highlight the impact on farmers’ risk perceptions.

It is worth noting, however, that past studies have primarily focused on the income factor as the economic factor (Zheng et al., 2011; Khan et al., 2015; Yang et al., 2014). It is true that income influences farmers’ risk perceptions and decision making. Yet, it might not accurately capture farmers' attitudes toward cooperation in supplying crop straw. Accordingly, to further investigate the influence of economic factors on farmers' risk perceptions, this study adopts a wider and detailed approach to economic factors, measuring a respondent's reaction with loss outweighing benefits, meager profits and cost of farmland damage.

4.2.3. Trust factors

Inevitably, the way in which people approach and evaluate risks is influenced by other people (e.g., other people's previous credibility and other people's attitudes in trading) (Joffe, 2003). In fact, trust plays a crucial role in how people perceive risk and respond to risk in social construction (Petts et al, 1997; Spangler, 1984; Finucane, 2000: 4; Siegrist and Cvetovich, 2000). "Trust" in this paper is defined as a person's expectation that other individuals in the social relationship can be relied upon in ways that are competent, caring, and predictable (Beckwith et al., 1999: 54). In this study, because of middleman's lack of understanding and caring about farmers' feeling, and prediction of misbehavior of middleman due to farmers' experiences, farmers cannot rely on the relationship with middleman. A number of research studies cite the declining level of trust in public institutions that influences organizational performance (Randall, 2002; Petts et al, 1997; Trettin and Musham, 2000; Slovic, 1999). In risk management and risk communication, trust is an essential element in political establishments (Slovic, 1999).

In previous studies, trust was identified as a perceived characteristic of risk (Saba and Messina, 2003). This characteristic can take the form of trust in the information provided by producers (Grunert et al., 2011). Lagerkvist (2013) applied informational trust in the food supply chain. Trust as an important factor to predict risk perception has been used in many fields (Mah, 2014; Burda, 2014; Ross, 2014). It is surprising that few studies have looked at the role of trust factors in driving farmers' risk perceptions. No study has mentioned trust as a factor influencing biomass supplies. Thus, the current study measures trust factors obtained from a field survey, and it is hypothesized that trust factors significantly influence farmers' risk perceptions of supplying crop straw.

4.2.4. Socio-demographic characteristics

It has been consistently documented that socio-demographic characteristics influence risk perception. In risk perceptions of pesticide use in fields, it has been reported that young growers have higher risk perceptions in northern Greece (Damalas and Hashemi, 2010). By contrast, in southwest Iran, a study discovered that there are no liner relationships between pesticide risk perceived by farmers and their ages (Hashemi et al., 2012). In addition to age, education level is often identified as a stable predictor of farmers' risk perceptions. Studies have discovered that high education levels have an influence on increasing risk perception and assessing the appropriateness of information for reducing risk (Yang et al., 2014; Zhou and Jin, 2009; Barnes et al., 2013). Lastly, it is sometimes assumed that a higher income lowers risk perceptions. A number of studies have explored farmer perceptions toward risk, finding that farmers tend to be risk averse with respect to income (Bauer, 1995; Binswanger, 1980; Hardaker, 2006; Hardaker et al., 2004; Pannell et al., 2000; Smith et al., 2000). Given the inconsistent effect of socio-demographics, they mainly serve as predicting variables here to assess the influence on risk perception.

4.3 Methodology

4.3.1. Participants

The data is based on region-wide sample of 275 farmers who produces corn straw around the straw-based National Bioenergy Power Plant in northeast China. The farmers were randomly selected from three different income level villages. The first group of farmers who supplied crop straw to the middleman was introduced by village committees. Additional farmers were found by asking interviewed farmers whether they knew other farmers who were crop straw suppliers (snowball effect). During the first phase of the study, 50 farmers were interviewed: 15 farmers from a low income level village, 20 farmers from a medium income level village, and 15 farmers from a high income level village. In the next phase of this study, 300 farmers answered the questionnaires with the assistance of village committees. Finally 275 valid samples were obtained and composed of 189 male and 86 female respondents. The age of the respondents ranged between 35 and 79, with a median age bracket of 45-54.

4.3.2. Procedure of questionnaire survey design

During the design stage of the questionnaire survey, input factor attributes were obtained from the literature review and previous investigation results in the straw-based National Bioenergy Power Plant industry area. In addition, to ensure that the survey questions could be easily understood and effectively reflect farmers' real situations, the questionnaire was modified after 50 farmers were interviewed in-depth. To avoid ambiguous answers and reduce bias, a pilot study was conducted among another 30 villagers before the questionnaire was distributed. Following trial and tested approaches (Urquhart, 2009; Pike, 2008), a series of statements on risk perception and risk perception predictors were included in the survey, all of which required Likert scale responses. This approach ensured consistency in the data, which is important for further statistical analysis.

4.3.3. Measures

4.3.3.1 Risk perception

The respondents were asked to "indicate the degree of risk perception to 12 items on a scale from 1-very low to 4-very high." The first two questions were asked the respondents to judge how likely they thought that they would be cheated by the middleman and to what degree they distrust middleman. Four questions were asked the respondents to evaluate how seriously they thought the economic risk was to their participation in crop straw dealing activities, such as risk perception of cost outweigh benefit, little profit, extra cost caused by farmland damage and insufficient cleanup of farmland by middleman. The respondents were also asked two questions on how they would consider about insufficient time and labor impacts. Another three questions were asked on how much they were concerned about air deterioration caused by burning straw in open fields. Lastly, a question of overall risk perception was asked how much risk they would face in supplying crop straw. Higher scores indicated greater perceived risk.

4.3.3.2 Policy guidance factors

The respondents answered three questions on how much policy guidance impacted on what a scale from 1-very low to 5-very high in terms of their perception, social policy (knowledge on adverse impact of burning straw and knowledge on significance of energy generation by crop straw), and economic policy (impact of government economic incentive) (Skitka et al., 2002; Pike, 2008). Higher scores indicated greater policy guidance impacts. A high reliability index of this question group was obtained (Cronbach's Alpha=.737).

4.3.3.3 Economic factors

Three questions were used to assess the economic factor impact on motivation toward cooperation with the middleman. The respondents were asked to rate how they would describe (a) meager profit (e.g., high straw collecting cost), (b) outweighing benefit (e.g., no payment after selling straw), and (c) cost due to farmland damage from the middleman collecting straw. The participants were asked to rate from 1-very low to 5-very high. A reliable scale was obtained here as well (α=.872).

4.3.3.4 Trust factors

On a 5-point Likert scale, the respondents answered four questions about the trust degree they perceived, such as (a) trust of the middleman's behavior toward farmland not being damaged, (b) trust of the middleman to clear the farmland without extra cost to farmers, (c) trust of not being cheated, and (d) the general trust feeling toward the middleman. A reliable index was obtained (α=.897).

4.3.3.5 Socio-demographic characteristics

Finally, a range of socio-demographic information was collected, including the respondent's gender (1=male), age, education, and income. All respondents (n=275; mean age =51.48; age range from 35 to 79; 31.3% women) completed the survey. The respondents were self-identified as "illiterate" (17.1%), "1 to 3 years of primary school" (20.4%), "over 3 years of primary school" (21.5%), "middle school" (25.8%), and "high school" (15.3%).

4.4 Farmers' risk perception of straw-supply (FROSS) model

Based on the previous discussions, a risk perception model with a conceptual overview of the overarching dimensions and predictor variables is demonstrated in **Fig. 4.1**. The affecting factors of farmer's risk perception in biomass-supply can be described as a function of policy guidance factors (i.e., government economic incentives and guidance on the significance of supplying biomass), economic factors (i.e., outweighing benefits and meager profits), trust factors (farmland damage, farmland clean up, being cheated), and key socio-demographic characteristics. While these dimensions are deemed to be particularly critical in explaining farmers' risk perceptions of biomass-supply, the framework (**Fig.4.1**) is not meant to provide an ultimate explanation, nor is the list of included predictors meant to be exhaustive.

Here the following three issues should be addressed: (i) the government economic incentive can be an economic factor; however, the incentive is determined by government policy. Thus, this study deems the factor to be in the policy guidance dimension. (ii) Many previous studies found that farmers' income level influence their risk perception significantly. In this study, therefore, influence of income level into risk perception is carefully explored. This issue is illustrated with the vertical aspect in the model. (iii) Since no research has been conducted to categorize farmers’ risk perception in biomass-supply, it is meaningful to classify farmers’ risk perception and to identify the influential factors on each category of risk perception. In line with factor analysis, farmers’ risk perception has been categorized into two dimensions, namely, personally concerned risk perception and environmentally concerned risk perception, respectively. It would be essential to reduce farmers’ particular risk perception. Therefore, risk perception categorization and predicting factors on each risk perception dimension were discussed in the horizontal aspect of the model.

The aim of this paper is not to explore the complex interrelationship between these dimensions. Instead, this current study tries to seek a useful and practical framework to (a) structure the key dimensions, (b) validate the importance of political guidance factors, economic factors, and trust factors, (c) verify the influence of political guidance factors, economic factors and trust factors on different economic level farmers, and (d) explore factors affecting personally related risk perception and environmental related risk perception.

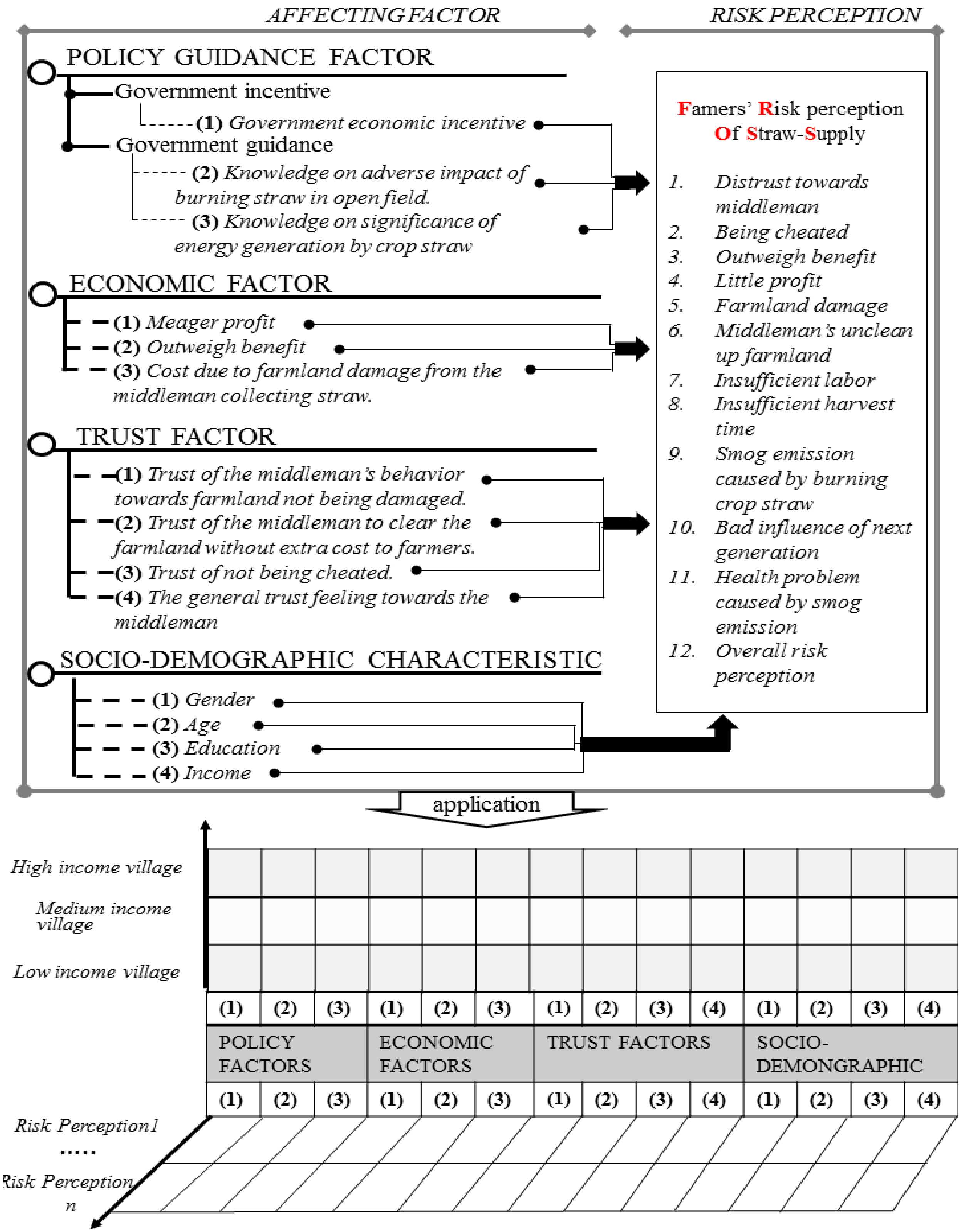

Fig.4.1 Farmers' Risk perception Of Straw-Supply (FROSS)

Source： *Author, 2015*

4.5 Results

4.5.1 Descriptive statistics

The mean scores of risk perception not including overall risk perception increase with the age increasing, while decrease with the education level and income level decreasing, as shown in **Fig.4.2**. In line with the Chi-square test of the demographic data, age (*p=.000*, $\chi^2(36)$ =76.853), education (p=.000, χ^2 (72) =242.141), and income (p=.000, χ^2 (36) =128.709) were statistically significant.

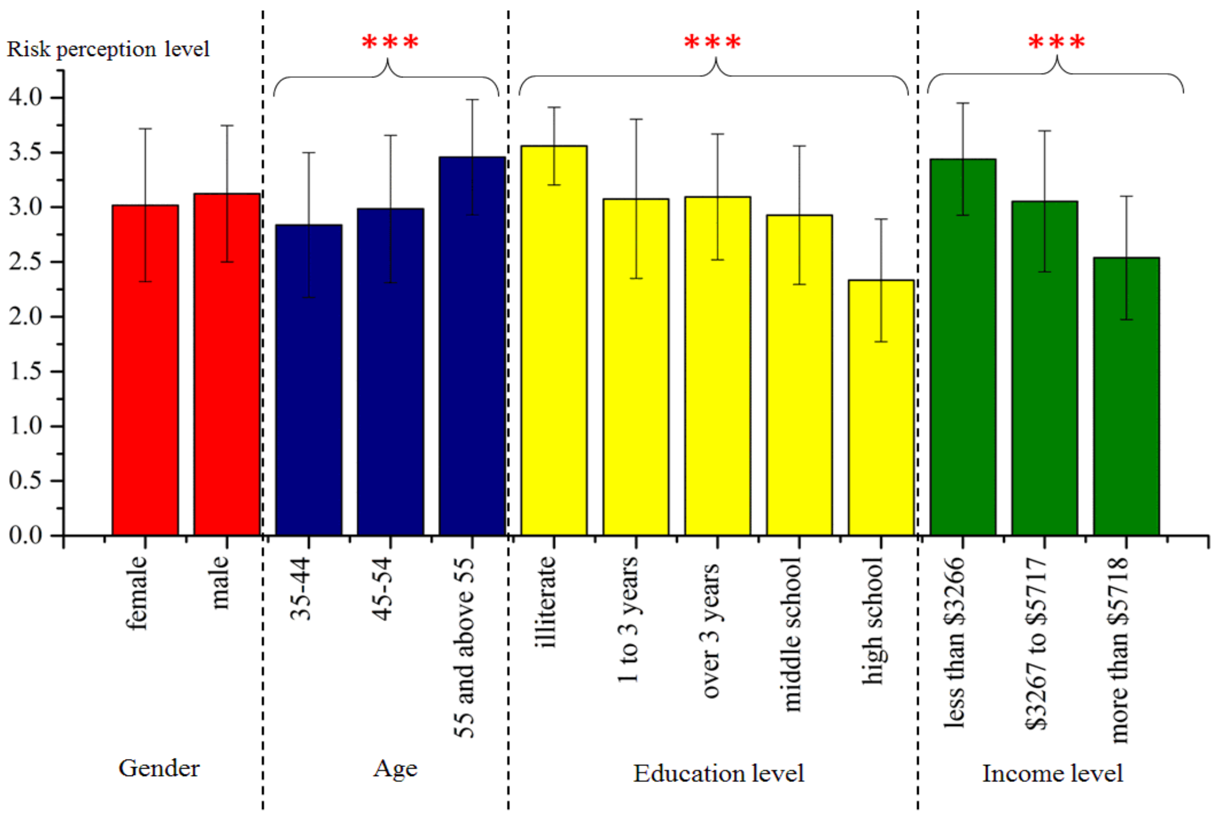

Fig.4.2 Sample means, standard deviation and confidence

Source: Author, 2015

Table 4.1. Descriptive statistics and correlation coefficients between risk perception and influencing factors

	Mean	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11
1. Risk perception	3.073	.5369	1										
2. Government's economic incentive	2.58	.918	-.635**	1									
3. Knowledge of adverse impact of burning straw	2.77	1.046	-.703**	.497**	1								
4. Knowledge of significance of energy generation by straw	2.87	.940	-.616**	.395**	.552**	1							
5. Meager profit	3.00	1.207	.856**	-.532**	-.647**	-.582**	1						
6. Outweigh benefit	3.56	1.120	.737**	-.504**	-.593**	-.500**	.655**	1					
7. Cost of farmland damage	3.49	1.151	.722**	-.468**	-.628**	-.492**	.703**	.727**	1				
8. Trust of no farmland damage	3.14	.941	-.802**	.574**	.576**	.574**	-.743**	-.673**	-.683**	1			
9. Trust of no extra cost caused by unclearing farmland	3.24	1.147	-.775**	.486**	.633**	.565**	-.704**	-.575**	-.553**	.648**	1		
10. Trust of no cheating	3.20	1.271	-.826**	.546**	.616**	.549**	-.738**	-.585**	-.616**	.672**	.674**	1	
11. Trust feeling	2.99	1.187	-.870**	.554**	.644**	.587**	-.787**	-.658**	-.620**	.724**	.705**	.742**	1

Note: 1. Dependent variable: risk perception

2. Independent variables: government's economic incentive, knowledge of adverse impact of burning straw, knowledge of significance of energy generation by straw, meager profit, outweigh benefit, cost of farmland damage, trust of no farmland being damaged, trust of no extra cost caused by unclearing farmland, trust of no cheating, trust feeling.

3. $^{**}p<0.01$. All variables are coded so that higher values reflect higher correlation.

Source： Author, 2015

An overview of the correlations, mean, and standard deviations of the variables is provided in **Table 4.1**. All of the predictor variables are significantly correlated with risk perception, absolute values ranging from *r*=0.616 to *r*=0.870. While trust feelings, suffering loss, trust of no cheating, and trust of no farmland being damage have the strongest correlations with risk perception, knowledge of the significance of energy generation by straw is the least correlated.

4.5.2 Farmers' risk perception of straw-supply (FROSS) model

Using a theory-based approach, a hierarchical multiple regression analysis was used to evaluate to what extent social-demographic characteristics, policy guidance factors, economic factors, and trust factors can explain and predict the risk perceptions of farmers' biomass-supplies (**Table 4.2**). Starting with a baseline model, the influence of relevant socio-demographic characteristics is presented in Model 1. The results show that both education and income are significant predictors, explaining a total of 47.5% of the variance in risk perception (F (4, 270) =61.099, $p<.001$, Adj. R^2=.467). In other words, a higher education level and income are strongly associated with the decreased risk perception of farmers' biomass-supplies.

Model 2 tested whether policy guidance factors explained any additional variance in risk perception while controlling for socio-demographic characteristics. An inspection of the beta weights revealed significant effects for (a) the government's economic incentive, (b) knowledge guidance from the government on the adverse impact of burning straw in an open field, and (c) knowledge guidance from the government on the significance of energy generation by biomass, explaining an additional 24.1% of the variance in risk perception (F (3, 267) =75.695, $p<.001$, Adj. R^2change=.241). Thus, the increased government's economic incentive and knowledge guidance toward the biomass-supply are also associated with higher risk perceptions.

Model 3 explored the influence of the economic factors of farmers concerning the risk perception above and beyond the effect of policy guidance factors and socio-demographic characteristics. All of the economic factors, suffered losses, outweigh benefits, and farmland damage costs were significant predictors, explaining an additional 14.7% of the variance in the risk perception of the biomass-supply ($F (3, 264) = 95.182$, $p<.001$, Adj. R^2change=.147). Thus, the suffered loss, outweigh benefits, and cost of farmland damage were all associated with increased risk perceptions.

Model 4 investigated the explanatory power of trust factor influences on risk perception in addition to socio-demographic characteristics, policy guidance factors, and economic factors. The trust of no farmland being damaged, trust of no extra cost caused by unclearing up farmland, trust of no cheating, and overall trust feelings were found to be significant predictors, explaining an additional 5% of the variance in the risk perception of the farmers' biomass-supplies ($F (4, 260) = 38.131$, $p<.000$, Adj. R^2change=0.050). The higher the trust in no farmland damage, cleaning up the farmland, no cheating, and overall trust feeling perceived by the farmers, the lower their risk perception of biomass-supply.

In the final model, education, income, suffered loss, outweigh benefits, farmland damage costs, trust of no farmland damage, trust of no extra cost caused by unclearing up farmland, trust of no cheating, and overall trust feelings were all identified as significant predictors, accounting for 90.9% of the total variance in the farmers' biomass-supply risk perceptions ($F (14, 260) = 197.674$, $p<.000$, Adj. R^2=.909).

Table 4.2. Farmers' risk perception of straw-supply model results

Independent variable \ Regression model	Model 1 (β-value)	Model 2 (β-value)	Model 3 (β-value)	Model 4 (β-value)
	Socio-demographics	Policy guidance factors	Economic factors	Trust factors
Gender	.053	-.001	.030	.016
Age	.010	.015	-.017	-.031
Education	-.405***	-.178***	-.167***	-.099***
Income	-.363***	-.171***	-.109**	-.082**
Government's economic incentive		-.232***	-.102**	-.046
Knowledge guidance of adverse impact of burning straw		-.323***	-.072*	-.023
Knowledge guidance of significance of straw energy generation		-.200***	-.050	.012
Suffer loss			.396***	.168***
Outweigh benefit			.188***	.113***
Farmland damage cost			.104**	.070*
Trust of no farmland damage				-.104**
Trust of middleman's cleaning up farmland				-.074*
Trust of no cheating				-.168***
Trust feeling				-.249***
N	275	275	275	275
Adj. R^2	.467	.709	.859	.909
△adj.		.241	.147	.050
F_{change}	61.099***	75.695***	95.182***	38.131***
df	(4,270)	(3,267)	(3, 264)	(4, 260)

Note: 1. Dependent variable: risk perception.

2. * $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

Source: Author, 2015

4.5.3 Farmers' risk perception of straw-supply (FROSS) model in different economic level villages

In this study, 275 respondents were from three villages (92 from a low income level village, 105 from a medium income level village, and 78 from a high income level village). The FROSS was also applied under different income levels to explore the concrete affecting factors of the farmers' biomass-supply risk perceptions. In line with the local government's interview, annual averaged incomes in the three income level villages were estimated to be \$2,756 per person, \$4,919 per person, and \$7,034 per person, respectively. To illustrate the differences between the respondents who are in the low, medium, and high income levels, the homogeneity test of variance showed unequal variances among the three villages ($p=.000$), and a one-way ANOVA analysis was conducted (F (2, 272) =147.538, $p=.000$, Mean Square = 20.550). Thus, the Welch test and the Brown-Forsythe test were used to back up the results (Welch test p=.000, Brown-Forsythe $p=.000$). To determine the differences between two groups, a post-hoc test was used (**Table 4.3**). As **Table 4.3** shows, respondents from the low income level village had significantly higher mean responses to all of the model variables than those from the medium and high income level villages. The mean differences among the three income level villages are statistically significant.

Table 4.3. Comparisons of mean responses of respondents in three income level villages in risk perception

	Mean	**SD**	**Low**	**Medium**	**High**
Low	3.548	.2280		-.5135*	-.9837*
Medium	3.034	.4731	.5135*		-.4702*
High	2.564	.3582	.9837*	. 4702*	
Total	3.073	.5369			

Note: * the mean difference is significant at the 0.05 level, SD=Standard Deviation

Source: Author, 2015

Based on the predictors in the farmers' biomass-supply risk perception model, a multiple regression analysis was conducted to identify the specific factors affecting the farmers' risk perceptions and assess to what extent the factors can explain and predict the risk perceptions of biomass-supply (**Table 4.4**). In the low income level village, one socio-demographic characteristic, income, influenced the farmers' risk perceptions. One policy guidance factor, knowledge on adverse impact of burning straw in the open field, can predict farmers' risk perception. All three economic factors can predict risk perception. In the trust factors, trust of no farmland being damaged and the overall trust feeling had impacts on the farmers' risk perceptions of biomass-supply. All of the significant factors explained 85.8% of the variance in risk perception (F (7, 84) =79.748, Adj. R^2=.858, $p=.000$).

Exploring the beta weight in the medium income level village, the economic factors (a) suffer loss and (b) farmland damage cost, and all of the trust factors were statistically significant to predict the farmers' risk perceptions, explaining 89.7% of the variance in the risk perception (F (6, 98) =152.716, Adj. R^2=.897, $p=.000$). In the high income level village, education, the policy guidance factors including the government's economic incentive and knowledge guidance on the adverse impact of burning straw, economic factors including suffered loss and outweigh benefit, and trust factors such as trust of no farmland being damaged and no cheating were found to be significant predictors, explaining 84.2% of the variance in risk perception (F (7, 70) =59.767, Adj. R^2 =.842, $p=.000$).

Table4.4. Summary results of farmers' risk perceptions of s-supply in three economic level villages

Model / Independent variable	Low economic level (β)	Medium economic level (β)	High economic level (β)
Education	*n.s*	*n.s*	-.089*
Income	-0.082**	*n.s*	*n.s*
Government's economic incentive	*n.s*	*n.s*	-0.161***
Knowledge guidance on adverse impact of burning straw	-0.100*	*n.s*	-0.150***
Suffer loss	0.154**	0.174***	0.157***
Outweigh benefit	0.184***	*n.s*	0.361***
Farmland damage cost	0.215***	0.159***	*n.s*
Trust of no farmland damage	-0.218***	-0.112**	-0.264***
Trust of cleaning up farmland	*n.s*	-0.160***	-0.162***
Trust of no cheating	*n.s*	-0.193***	*n.s*
Trust feeling	-0.251***	-0.301***	*n.s*
N	92	105	78
Adj. R^2	.858	.897	.842
F value	79.748***	152.716***	59.767***

Note: 1. Dependent variable: risk perception

2. * $p< 0.1$, ** $p< 0.05$, *** $p< 0.01$

3. Only significant factors were listed (*n.s* = not significant)

Source: Author, 2015

4.5.4 Dimension exploration of farmers' risk perception of straw-supply

Judged on a scale of 1 to 4, the mean value of the overall risk perception of the farmers' biomass-supply was considerably high ($\bar{x}$=3.073, SD=.5369). In order to explore the farmers' risk perceptions of the biomass-supply, a factor analysis was used. The results of the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity indicated that the variables are suitable for factor analysis (KMO=.852, Bartlett's test of sphericity=1478.724, *df*=36, *p=.000*).

The factor loadings of the personally concerned and environmentally concerned risk perceptions are presented in **Table 4.5**. In order to optimize factor loading structure to easily read, the correlations which are below 0.6 have been removed, including risk perception of being cheated and little profit. Thus, the nine risk perception items were split into six "personally concerned risk perception" items and three "environmentally concerned risk perception" items. The average risk perceptions of the two items are significantly different, $\bar{x}_{personal}$ =3.049 and $\bar{x}_{environment}$ =1.936, respectively.

Table 4.5. Factor loading for personal concern risk perception and social concern risk perception

Factor loading / Risk perception	Factor loading	
	Personal concern risk perception (α=.891)	Environmental concern risk perception (α=.888)
Distrust towards middlemen	**.853**	.103
Cost larger than income	**.856**	-.186
Farmland damage	**.808**	-.131
Agents' insufficient clearing up of farmland	**.728**	-.314
Insufficient labor	**.884**	-.082
Insufficient time	**.618**	-.163
Aerosol emissions caused by burning crop straw	-.162	**.871**
Bad influence for generations caused by fossil fuel use and burning straw	-.099	**.886**
Health problems caused by aerosol emissions	-.120	**.919**

Note: 1. Extraction method: principal component analysis.

2. The variance explanation of the personally concerned risk perception is 42.857%. The variance explanation of the environmentally concerned risk perception is 28.701%.

Source: Author, 2015

In line with the factor analysis, the farmers' risk perceptions of the biomass supply can be conceptualized as having a two-dimensional structure, in addition to examining to what extent socio-demographic characteristics, policy guidance factors, economic factors, and trust factors can explain both the personally concerned risk perception and environmentally concerned risk perception. In order to systematically analyze the differences in the determinants of the personally concerned risk perception (Model A) and environmentally concerned risk perception (Model B), two separated regression analyses were run using the same variables (**Table 4.6**) as those which were included in **Table 4.2**. There are several results that should be examined. First, when controlling for all other variables in the regression, age, education, meager profit, outweigh benefits, trust of the middleman to clear the farmland without extra cost to farmers, and trust of not being cheated on the financial return were significant predictors of personally concerned risk perceptions, but not environmentally concerned risk perceptions. Second, income and trust of no farmland clean up were significant predictors of environmentally concerned risk perception, but they could not predict personally concerned risk perception. Third, only the trust of the middleman's cleaning up of the farmland could predict both the personally concerned risk perception and the environmentally concerned risk perception. Comparatively, while the socio-demographic characteristics, policy guidance factors, economic factors, and trust factors jointly explain 80.5% of the overall variance in personally concerned risk perception ($F(8, 266) = 142.161$, $p = .000$, Adj. $R^2 = .805$), they explain only 16.2% of the variance in the environmentally concerned risk perception ($F(4, 270) = 14.283$, $p = .000$, Adj. $R^2 = .162$).

Table 4.6. Impact factors of personal concern risk perception and social concern risk perception

Risk perception affecting factors \ Regression model	Personally concerned risk perception Model A	Environmentally concerned risk perception Model B
Age	-.060*	*n.s*
Education	-.106**	*n.s*
Income	*n.s*	.186**
Suffer loss	.219***	*n.s*
Outweigh benefit	.093*	*n.s*
Trust of no farmland damage	*n.s*	.241**
Trust of agent's clean-up of farmland	-.116**	.202*
Trust of no cheating on financial return	-.245***	*n.s*
Trust feeling	-.223***	*n.s*
N	275	275
Adj. R^2	.805	.162
F	142.161	14.283

Note: entries are standardized beta coefficients, *p<.05, **p<.01, ***p<.001 (*n.s* = not significant).

Source: Author, 2015

4.6 Discussion

Farmers' risk perceptions of the biomass-supply are complex and vital for supplies for biomass power plants. The purpose of this paper was to explore and provide a systematic and detailed understanding of the determinants of the risk perceptions of farmers' biomass-supply. To this extent, this farmers' biomass-supply risk perception model is advanced, combining policy guidance factors, economic factors, trust factors, and socio-demographic characteristics to explain and predict farmers' biomass-supply risk perceptions. Using a sample of the National Bio-energy Power industry area in northeast China, the current study validates the predictors in the farmers' biomass-supply risk perception model can predict farmers' risk perception of biomass-supply in both vertical dimension (different income level) and horizontal dimension (personally and environmentally concerned) .

The methods of field survey in this study explored the farmers' risk perceptions of unwillingness to supply biomass. While the results do not necessarily represent the views of the entire biomass-supply area in China, the risk perceived by the farmers provides meaningful results for biomass supplying to solve the insufficient biomass problem in the biomass industry. While Augustenborg et al. (2012) investigated the farmers' perceptions in the adoption of energy crops for the development of the bioenergy industry in Ireland, the present study is the first contribution to build a farmers' biomass-supply model and to identify the predicting factors of the farmers' risk perceptions of biomass-supply, which are likely to influence their willingness to cooperate with the middlemen and biomass power plants. The results from this study will be significant for the engagement of farmers as stakeholders in the biomass power industry in China, and will assist in the development of larger studies on the stakeholders' engagement in this new industry.

4.6.1 Evidence for farmers' risk perception of straw-supply (FROSS) model

As emphasized previously, the aim of this study was to build a model which can explore the risk perception affecting factors as fully as possible. The current study has identified four conceptual dimensions: policy guidance factors, economic factors, trust factors, and socio-demographic characteristics, which all play a significant role in explaining and predicting farmers' risk perceptions of biomass-supply, accounting for 90.9% of the variance, which is considerably large. Overall, trust factors can predict risk perceptions beyond other factors (**Table 4.2**). This study also applies to the empirical evidence for three different income level village communities. The results identified the concrete influence factors of farmers' risk perceptions by using the farmers' biomass-supply risk perception model.

4.6.1.1 Socio-demographic characteristics

Demographically, the farmers varied considerably. Surveys were completed from three different kinds of income level villages where the main agricultural product was corn. In terms of the model's components, demographic characteristics such as education and income were found to be negative and to have a statistically significant impact on the farmers' risk perceptions of biomass-supply, implying that better educated and higher income farmers generally have lower risk perceptions of biomass-supply. However, in terms of applying the model in three different income level villages, the income factor was negatively and statistically significant to predict the farmers' risk perceptions in low income villages, while the education level was also negatively and statistically significant to predict the farmers' risk perceptions in high income villages. In the medium income level villages, neither education nor income was statistically significant. It is not surprising that farmers at low income levels are more likely to consider economic issues and their children's education in their daily lives. Generally, their education levels were lower than primary school.

However, in the high income villages, the farmers' education levels were higher (most had been educated in middle school and high school), implying that with more knowledge through educational experience, farmers have a lower risk perception of biomass-supply. Additionally, their attitudes toward biomass supplying were positive. While some research suggested that higher incomes and education provided people with no sense of a lowered risk perception (e.g., Kellstedt et al., 2008; Vander, 2014), the current study found little support for this result. The current results of income and education predicting farmers' risk perceptions significantly are consistent with other recent research (e.g., Zheng et al., 2011; Barnes et al., 2013; Akerlof et al., 2013; O'Connor et al., 1999). An individual's age, gender and income influence the perception of risk (Flynn et al., 1994; Dosman et al., 2001). Particularly, this study found that socio-demographics characteristics accounted for a relatively large amount of variance in farmers' risk perceptions of biomass-supplies in the model, which means that income and education are significantly vital in predicting farmers' risk perceptions. While in Vander Linden's study of determinants of climate change risk perceptions, socio-demographics characteristics only explained 6% of the variables of risk perception (Vander Linden, 2014).

4.6.1.2 Policy guidance factors

The biomass power industry in China is still in the growth stage. The government's support and guidance are necessary for the development of this industry. Especially, in the biomass collection stage, farmer is the key group to determine the quantity of raw material. Appropriate economic incentives and the guidance of the farmers can be vital for increasing the biomass supply. Today, the government has a subsidy system for biomass power generation, and many studies have emphasized the necessity of continuing subsidies by comparing the external costs of coal and biomass, or the subsidy costs and benefits (Kitson et al., 2011; Jiang and Tan, 2013; Zhao et al., 2014). However, to the authors' best knowledge, no research has considered the economic incentives to farmers in China. Apart from the government economic incentives, the government's education and guidance of the knowledge on biomass energy are also considered to be impact factors.

Previous researchers have examined, to a substantial degree, the impact of the role of knowledge on the risk perception of climate change (e.g., Tobler et al., 2012a; Roser and Nisber, 2008). In China, farmers' cognition of the significance of biomass-supply comes from government's education and guidance. In order to explore the influence of the government's guidance, this study divided the government's education and guidance of knowledge into two types, confirming knowledge about the (a) adverse impact of burning straw in open fields and (b) the significance of the energy generation of crop straw.

Overall, in the farmers' biomass-supply risk perception model (**Table 4.2**), all policy guidance factors can negatively and significantly predict risk perception on the top of the demographic characteristics, but only the government's economic incentive is statistically significant for controlling economic factors. After controlling for trust factors, the government's economic incentive factor quickly lost its significance. One possible explanation is that the government' economic incentive to farmers on biomass-supply does not exist nowadays and the government' guidance is limited. It is hard to elicit farmers' trust of the possibility of the government's economic incentives and necessity for the supply of biomass. Moreover, upon closer examination of the three income level villages, the policy guidance factors (including the government's economic incentive and knowledge on the adverse impact of burning straw in open fields) can significantly predict the risk perceptions of farmers in the high income level villages with higher educational levels. The educational level is one factor causing this result, while another explanation may be that the high income level villages are government pilot villages under the policy of Building New Rural. The local government has more connections to these villages and has gained more trust from farmers in these villages. In terms of personally concerned risk perception and environmentally concerned risk perception, no policy guidance factors are statistically significant, which implies that the policy guidance of the biomass-supply is weak in rural China.

4.6.1.3 Economic factors

The greater risk perception in developing countries is consistent with the widely accepted hypothesis of decreasing risk perceptions with respect of wealth (Lucas and Pabuayon, 2011). Economic factors cannot be dismissive in influencing the farmers' risk perceptions. The current research finds that economic factors are significant in the overall farmers' biomass-supply risk perception model, even controlling for trust factors. In particular, suffering loss and outweigh benefit factors can strongly predict farmers' risk perceptions of biomass-supply. Even in three different economic level villages, the economic factors significantly predict farmers' risk perceptions, particularly for farmers in low economic level villages. These findings are consistent with the research conducted in the Philippines, where the risk aversion of farmers was affected significantly by their wealth (Lucas and Pabuayon, 2011; Lobley and Potter, 2004). Although Binswanger (1980) found that economic factors showed a slight influence in risk perception (but not significant), this research found little support for this finding. However, with regard to the other research, the current research results were consistent with those of Moscardi and de Janvry (1977), which showed evidence of an association between risk perception and economic factors. Generally, during this investigation, farmers who have experienced economic loss while dealing with middleman tended to have significantly higher risk perceptions of biomass-supply. Additionally, their relatives, neighbors, and friends had the same tendency because of information dissemination. Although not many farmers experience economic loss, the negative information dissemination increases their risk perception.

When the risk perception was divided into personally concerned risk perception and environmentally concerned risk perception, it is not surprising to find that most farmers were concerned with their personal risk during biomass supply activities. This finding may be explained by the fact that in rural areas of China, farmers still have a low awareness of the environment, because farmers focus more on their economic situation since their material life is not sufficient. Economic factors, such as suffering loss and outweigh benefits, are significant factors for predicting personal risk perception. It is true that lack of an economic guarantee still exists. Some farmers who have been visited in the industrial area, especially farmers with some level of education, are reluctant to supply biomass before a formal contract can be developed to guarantee their economic benefits. A number of respondents also brought up the fact that they have several accesses to deal with crop straw, such as heating house and feeding livestock. However, the quantity of crop straw is too much that it cannot be utilized all annually. Therefore, burning the crop straw on the farmland is the easiest way to clean it up, saving time, labor, and budget. They also indicated that burning the crop straw in an open field reflects less risk than selling the crop straw in their perception. More specifically, personal risk perceptions dominate farmers' behavior choices.

Although the economic factors of suffering loss and outweigh benefits only significantly correlated with personally concerned risk perceptions, it remains questionable whether economic factors would also breed concern for the environment with farmers' increasing awareness. To some extent, farmers may realize that environmental problems can be converted into economic problems, which may influence their risk perceptions. Thus, the role of economic factors (and in which way they influence risk perception) clearly deserves more attention in the future.

4.6.1.4 Trust factors

Surprisingly, relatively little research has investigated the role of trust factors in influencing farmers' risk perceptions. The current study focused on assessing the influence of trust factors on farmers' risk perceptions of biomass-supplies. The results indicate that trust factors, that is, (a) trust of no farmland being damaged, (b) trust of no extra costs caused by unclearing up the farmland, (c) trust of no cheating, and (d) the overall trust feeling can predict the farmers' risk perceptions of biomass-supplies beyond economic factors. In other words, the higher the farmers' trust on the middleman in crop straw collection is, the lower the risk they perceive, confirming that trust factors significantly influence the farmer's perception of biomass-supply. Furthermore, previous studies have identified trust as a perceived characteristic of risk (Saba and Messina, 2003). This characteristic can take the form of trust in the information provided by others and personal knowledge (Grunert, 2002; Siegrist and Cvetkovich, 2000). In line with other related research (e.g., Sharp and Smith, 2003), the present research also supports the hypothesis of many social capital researchers that "people who know and trust one another are more likely to be able to work together to find a solution to a problem that is mutually acceptable to everyone." In particular, the trust of no farmland being damaged was identified as a predictor in all three economic level villages. A likely explanation for the significance of this trust is that the farmers' main income depends on farmland, although younger farmers usually have part time jobs in the county during the non-busy farming period. Therefore, the trust of no farmland being damaged is a strong predictor of the farmers' risk perceptions of biomass-supplies.

Surprisingly, the trust of no farmland being damaged and the trust of middlemen cleaning up the farmland are the only two significant predictors among policy guidance factors, economic factors, and trust factors to predict the farmers' environmentally concerned risk perception. In particular, it is interesting to find that trust factors negatively predict personally concerned risk perception, while positively predicting environmentally concerned risk perception. It is easy to understand that people with high trust levels would have low personally concerned risk perception in supplying biomass. In terms of environmentally concerned risk perception, the result could be explained in that the trust of no farmland being damaged and middlemen cleaning up the farmland have strong connections. Farmers with these trust factors would like to supply crop straw, while at the same time, these farmers have the awareness of the environmental risk of burning straw in open fields. In other words, the farmers' willingness to supply crop straw is influenced by both trust factors and their perceived environmental risks. Overall, the trust factor's influence explained most of the variance in the risk perception of biomass-supply.

4.6.2 Implications for farmers' risk mitigation in biomass-supply and future research

The present study has important implications for mitigating the risk of biomass-supply. First and foremost, because farmers' risk perceptions of biomass-supply are influenced by socio-demographic characteristics, policy guidance factors, economic factors, as well as trust factors, risk mitigation processes could be effective when not only policy guidance is provided, but also economic loss problems are solved by economic incentives. Then, in the long-term, building trust is vital to solving the biomass-supply problem. Indeed, distrusting factors lead farmers to have lower policy guidance awareness and keep concerning economic factors. For example, through field survey, the authors found that many farmers believe that government would strength punishing rule of burning crop straw in the field instead of giving economic incentive to them regarding the crop straw supply issue. Moreover, farmers keep calculating if risk happens, how much economic loss they may suffer. In addition, the results also show that socio-demographic characteristics are largely various in predicting farmers' risk perceptions; particularly, education and income factors are statistically significant. Enhancing farmers' education levels and increasing income help lower farmers' perceived risk.

However, it takes a long time to increase farmers' education level. In order to mitigate farmers' risk perception, the first step would to make middleman and biomass power plant change their behaviors. Without middleman and biomass power plant's sincere behavior to farmers, farmers would not trust them. Actually, trust is bred from economic factors. If the middleman could ensure that farmers' economic benefit would not be damage in this crop straw collection activity, it is possible for farmers to increase their trust toward middleman.

Second, economic incentive is necessary to motivate farmers to participate in this activity. Here, it is important to note that farmers in different income levels of villages have different risk perception affecting factors. To some extent, the influencing factors have some indirect causal efficacy among the variables. At low income levels, to guarantee farmers' economic benefits (or at least no damage to their economic benefit) is the priority. With economic security, trust feelings, especially to government, can also increase, which can mitigate farmers' risk perceptions. In medium income level villages, economic factors are still important to predict risk perceptions. Therefore, for farmers in low and medium income level villages, economic factors are still dominant.

Third, to increase farmers' awareness of environment, in the long-term, increase education level is significant. In line with the results in this study, in rural China, farmers consider their personal risk instead of the environmental risk. Although economic incentives are necessary in the short-term to guarantee the farmers' benefits, in the long-term, to increase farmers' awareness of the environment is an important task not only for air quality improvement, but also for energy conversion.

However, the current study is, of course, not without limitations. First, it should be noted that the results of the current study are based on the investigation of farmers' risk perceptions in northeast China. Although in China almost all biomass power plants face the same problem of the lack of raw material, it remains unclear to what extent the results can predict this in other areas or other cultures. Second, the aim of this study was to examine the key impact factors to predict farmers' risk perceptions of the biomass-supply. The list of determinants is based on the literature and investigation, which is certainly not exhaustive. Future research could also constructively build on the current study by further exploring the interrelated nature of policy guidance factors, economic factors, and trust factors.

4.7 Conclusion

This study provided a farmers' risk perception of straw-supply model based on investigation in northeast China. Using a series of analysis measures, the model consisted of two dimensions, the vertical dimension (different income level villages) and horizontal dimension (different risk perception components). The results provided evidence for the influence of policy guidance factors, economic factors, and trust factors in both the vertical dimension and horizontal dimension, and the findings show that the predictors can explain more than 90% of the variance in farmers' risk perceptions of straw-supply. Moreover, in different income level villages, the influencing factors of farmers' risk perceptions are varied. This study also demonstrated the distinguishing differences of the influencing factors between the two dimensions, personally (related to economic and trust factors) and environmentally related risk perception. The predictors can predict 80.5% of personally related risk perception, while only

16.2 % of environmentally related risk perception. The results demonstrate that currently economic and trust factors are crucial factors affecting farmers' risk perception. Taken together, these results indicate that to motivate farmers cooperating with middleman in straw supply, economical incentive is necessary in short-term. In the long-term, building trust and increasing farmers' education level should be the target in the sense of straw-supply environmental protection. Therefore, to solve economic problems, in Chapter IV and V, explore new incentive scheme for straw supply as the short-term target. In Chapter IV, a Stackelberg game theory is applied to model biomass supply chain and design incentive scenarios to cooperate stakeholders under risk and uncertainty.

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CHAPTER 5: A STACKELBERG GAME THEORETIC ANALYSIS OF INCENTIVE EFFECT FOR CHINA'S STRAW-BASED POWER PLANT SUPPLY CHAIN UNDER UNCERTIANTY AND RISK

5.1 General introduction

China is confronting huge challenges to balance energy demand and environmental improvement. With rapid economy development, China's energy consumption rose significantly, by 9.1% during 1992 to 2010, which is much faster than the world average of 2.6% (Yang et al., 2008). Nowadays, China's energy consumption is still dominated by coal, accounting for 70.5% of the total energy consumption (National Bureau of Statistics of China, 2005-2011). With the increasing seriousness of air pollution in China, the environmentally friendly renewable energy sources have been attracted people's attention.

Crop straw, which is abundant in China, approximately 728 million tons annually, is one of the most utilized sources of renewable energy (Shen et al., 2010) and the supply is expected to keep rising in the future as agricultural production increases (Huang et al., 2010; Yang et al., 2008). Without utilizing the agriculture residues, the crop straw would be burned in the farmland, which not only increases air pollution, but also destroys farmland nutrition and waste biomass energy. In this regard, utilization of crop straw for electricity generation has gained great attention and support in recent years in China. Straw-based biomass power generation is developing rapidly in China. By using crop straw as an alternative energy, the external cost would decrease considerably greater than that of fossil fuel (Wang et al., 2015). The biomass power industry not only utilizes superfluous agricultural residues reducing agricultural burden, but also increase farmers' income (Matsumura et al., 2005). Meanwhile, the industrial processes increase employment in regional areas, which boosts rural development (Narodoslawsky et al., 2008). With the significance of utilization of crop residues in rural China, the bio-energy from crop residues has been targeted in the Twelfth Five-Year Plan for national and social development.

However, implementation of straw-based biomass generation like other sources of renewable energy has been an uphill battle for government and developers to promote. Almost 70% of straw-based power plants are under financial deficit in 2012 (Wang, 2012), although straw-electricity was all purchased by State Grid Corporation of China with fixed price 1.5 times to conventional electricity (National Development and Reform Committee). The critical reason is that the raw material cost accounts for more than 55% of the straw-based power generation's total cost (Zhang et al., 2013). The main obstacles of high cost are not because of shortage of crop residues, but lack of supply chain management. An important issue is the fact that, in China, crop residues scatter in large areas. Without cooperation with farmers, it is impossible to collect crop straw. Thus, farmer becomes the key stakeholder in supply crop straw. Now, biomass electricity generation power plant can receive incentive from government. However, the effect of economic incentive doesn't solve the dilemma of lack of raw material in biomass power plant. It is essential to consider how to give incentive to stakeholders to guarantee optimize their benefit.

Abstracting from such setting, this study proposes a Stackelberg game theoretic approach to model and analyze the process of providing incentive to farmer and middleman under uncertainty and risk. In biomass supply chain, three players are considered: biomass power plant, middleman, and farmer. Game theoretic approaches have been widely used in renewable energy field (Wen and Zhang, 2015 ; Sun et al., 2013; Bai et al., 2012; Lise et al., 2006). Nasiri (2009) is the first researcher who has applied game theory into biomass generation industry (Nasiri and Zaccour, 2009). Wen (2015) developed a design of straw acquisition mode for China's straw power generation based on Nasiri' model (Wen and Zhang, 2015). However, in reality, players make decisions under uncertainty and risk. To authors' best knowledge, there is no study considering uncertainty and risk in game-theoretic approach in biomass power generation industry. Therefore, the objective of this study is to (1) simulate the current situation (bench mark), situation of incentive to farmers and situation of incentive to middlemen; (2) verify the simulation with a case study and find equilibrium under the three scenarios; (3) discuss the optimal incentive strategy.

The remaining contents are organized as follows. Section 2 provides literature review on biomass supply chain and Stackelberg Game Theoretic approach. Section 3 proposes a Stackelberg Game model among main stakeholders, straw-based power plant, middleman, and farmers, in straw supply chain under uncertainty and risk condition. In Section 4, the model is applied to the case of National Bioenergy power plant in China. The incentive effect results are obtained and discussed under risk situation. Finally, section 5 gives conclusions.

5.2 Literature review

In recent years, game theory has been used to make decisions in marketing economics, supply chain management, etc. The solutions provided by game theory are usually arrived at the interaction between the "players" who are involved in the game. Game theory has been widely studies to solve the coordination among stakeholders in supply chain. A number of works have discussed game theory from perspective of coordination, economic stability and supply chain efficiency (Esmaeili et al., 2009; Zhang and Huang, 2010; Leng and Zhu, 2009; Talat and Suvrajeet, 2008; Yue et al., 2006). In line with the different power in the supply chain, the player that makes its decision first is generally regarded to have more power over other players in the supply chain. In this regard, Stackelberg game is widely used in coordination of players with different power in the supply chain. For example, Choi (1991) and Lee and Staelin (1997) used

Stackelberg game in which the retailer specifies the retail margin first to model the situation with a power retailer (Choi, 1991; Lee and Staelin, 1997). Stackelberg game can be used to identify the best way for manufacturer to coordinate a channel in presence of a power retailer (Raju and Zhang, 2005). Leng and Parlar (2010) investigated a multiple-suppliers and single manufacturer supply chain to discuss Nash and Stackelberg equilibrium and coordinate it by the cost-sharing contracts (Leng and Parler, 2010). However, application of game theory in bioenergy is still under development. Benjamin and Houee-Bigot (2007) studied the crop markets and simulated the impact of alternative national and international policies using a partial equilibrium model (Benjamin and Houee-Bigot, 2007). Nasiri and Zaccour first applied Stackelberg game into biomass electricity generation supply chain in 2009 to propose a sequential game among electric utility, electricity generator, and farmer, based on Canadian situation (Nasiri and Zaccour, 2009). Sun et al. (2011) studies on the interaction mechanism of cost risks for biomass material supply in power generation based on game theory. The study shows the benefit of price alliance, abstracting China's case study (Sun et al., 2011). In Wen and Zhang' work (2015), a straw acquisition mode is designed for straw-based power plant in China based on Stackelberg game theory (Wen and Zhang, 2015). However, there are few researches considering players' risk perception factor into game theory.

Cognitive psychology believes that perception, motivation and attitude play an important role in decision making (e.g. Tsai et al., 2010; Wu et al., 2010). While stakeholders' risk perception plays a significant role in modulating activity during decision-making (Engelmann and Tamir, 2009). Bauer (1960) emphasizes that he is concerned only with perceived risk and not actual risk. Perceived risk appears when stakeholder is involved in situations where the consequences are uncertain (Fraedrich and Ferrell, 1992; Liao et al., 2010). Perceived risk theory also plays a role of facilitating marketers to realize the world through consumer-based thought. In addition, risk perception analysis can be useful in resource allocation decision in market

(Mitchell, 1999). Therefore, risk perception is also important factor affecting players' decision making in supply biomass. However, no research has been conducted combining stakeholders' risk perception into game model to validate incentive effect in the biomass supply chain.

In this study risk perception is considered risk coefficient. Risk coefficient is interpreted as follows: the maximum loss is assumed to be 10% of the original cost (OC/10). Each farmer is asked to participate in a bid of tossing a coin: if it is a "Head", farmer has to pay the maximum loss. If it is "Tail", farmer doesn't need to pay. When the probability of having "Head" is *p*, the expected loss is *p**OC/10. In this case, the farmer is asked again how much he feels he has to pay if he has to pay deterministically. This value depends on farmer's risk perception, *i.e.*, risk averse, risk neutral, and risk taking. This value can be interpreted as Certain Equivalent (CE). Risk coefficient (R) is given by:

R=Certain Equivalent (CE)/Original Cost

=CE/OC

5.3 The model

5.3.1 Background

In China, the agricultural ownership of farmland is household-responsibility unlike the U.S. and European countries. The crop holders are thousands of small farmer household, with small farming area and scattered distribution (Jiang et al., 2012). After the crop being harvested, farmers transport out some straws for house heating and livestock feeding. Most straws are abandoned in the farmland. With increasing economic level in rural China, farmers prefer to use gas for house heating. More crop straws become agricultural waste. To become feedstock for biomass power plant, there are two approaches to collect straws: (a) farmers transport straws out of farmland to pile them near the road first, then middleman conveys straws to the collection stations to process them before sending to the biomass power plant; (b) farmers who live near the biomass power plant can borrow the processing machine to process crop straws by themselves and send the processed straws to the biomass power plant by themselves. However, (b) is not the dominant collection mode, because there are very few farmlands near the biomass power plant. This study focuses on Mode (a). In Mode (a), the whole procedure needs a great deal of manpower, the occupation of middleman becomes necessary, which is to connect between biomass power plant and farmers. Middleman purchases crop straws from farmer with a certain price, and then transports crop straws to the collecting station. After being processed, crop straws are deposited and sold to the power plant when needed.

Therefore, farmers, middleman, and biomass power plant are playing different but critical roles in biomass supply chain. However, in reality, crop straw collecting process does not go smoothly. Each stakeholder has his own risk in this process. For example, for the biomass power plant, the most risk it faces is bankrupt because of high cost of feedstock. For middleman, building trust with farmers and lowering purchasing price are significant to guarantee their benefit. It should be noted that, through investigation in the biomass supplying area, farmers' risk perceptions, such as low trust towards middleman, cost outweigh benefit and little profit, cause high price of crop straw which leads to high cost of feedstock in biomass power plant. Particularly, farmers and middleman's risk perception lower their motivation to supply straw. Currently, the incentive is only given to the biomass power plant, which is not effective in straw collection. There is no connection between the local government and farmers. Without encouragement of the local government, it is difficulty for farmers to be aware of the significance of supplying straw. Particularly, without the economic benefit indemnification, most farmers will not take actions to supply straw to the middlemen. To ensure development of biomass power plant, it is necessary to design incentive mechanism appropriately. Thus, this study discusses appropriate incentive structure. The incentive mechanism includes incentive to farmer and middleman, as well as the biomass power plant (**Fig.5.1**) (Xing et al., 2008).

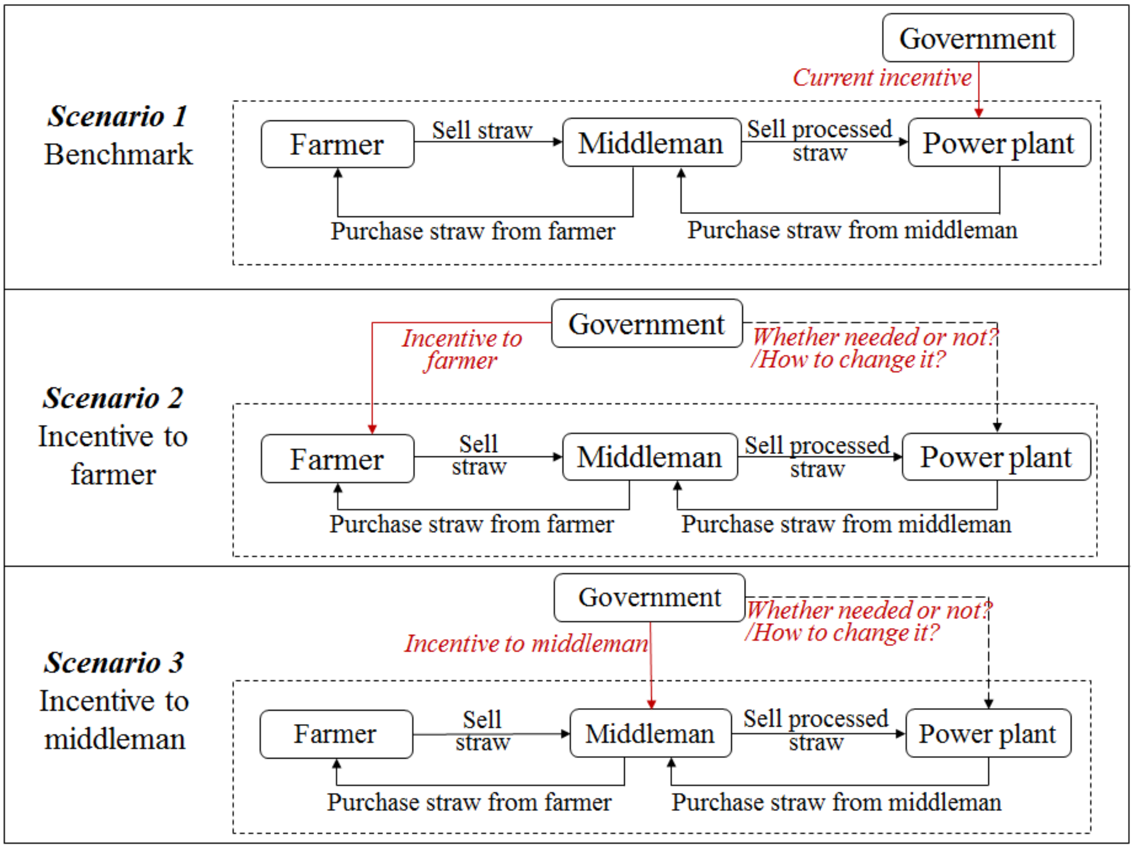

Fig. 5.1 Biomass supply chain under different subsidies situation

5.3.2 Stackelberg game model

5.3.2.1 Assumptions

Three players are considered in the game: the biomass power plant (player B), the electricity generator as well as crop straw consumer; middleman (player M) who acts between biomass power plant and farmers; farmer (player F) who supplies crop straw and decides the quantity of straw supplying. This setting is at each stage is a simplifying one player. However, it is not unrealistic from economy of scale and stability points of view (Nasiri and Zaccour, 2009). Before developing the model, some assumptions in the model should be made to turn the modeling results into reliable decision suggestions (Roos and Rakos, 2000). The assumptions in this study are as follows:

(1)The biomass types and planting condition do not lead to significant differences in the output of biomass quantity, collection and storage.

(2)Straw production and collection are one year. Seasonal factors, transporting and processing loss are neglected for calculating convenience.

(3)The biomass power plant is in the center of crop straw collection (Wang et al., 2013). The collection area is circular to minimize the transportation costs with an average distance from collection station L (km). In this study L is treated as a known variable and it is supposed that the annual output of crop straw in the circle is abundant (**Fig. 5.2**) (Xing et al., 2008).

(4) In this study, it is assumed that the farmer transports the crop straw to the collection station. To minimize transportation cost, the collection area is assumed as a circular island (Xing et al., 2008). The maximum radius of straw collection is denoted by R_{max} (m), and the radius of straw collection by R_i (m). Tortuosity factor β is introduced to adjust the transport distance which is not straight line. If the ratio of quantity of utilized crop straw to biomass feedstock output is k ($k \in [0,1]$). The crop straw collection cost is as follow:

$$C_q(q_2) = \int_0^{R_i} 2\pi r \cdot \alpha_i \cdot \beta \cdot k \cdot r \cdot p_t \cdot dr$$
$$= \frac{2}{3} q_2^{\frac{3}{2}} \cdot \beta \cdot \left(\pi \cdot \alpha_i \cdot k\right)^{-\frac{1}{2}} p_t$$

Where q_2 is the quantity of supplied crop straw by farmer (ton); α_i is crop straw output in unit area (t/m^2); P_t is the unit cost of biomass transportation (\$/t·km); Since most farmers usually harvest straw by themselves, the labor cost is neglected in this study. If

$$C_q = \beta \cdot \left(\pi \cdot \alpha_i \cdot k\right)^{-\frac{1}{2}} p_t$$
$$C_q\left(q_2\right) = \frac{2}{3} q_2^{\frac{3}{2}} \cdot C_q \qquad (1)$$

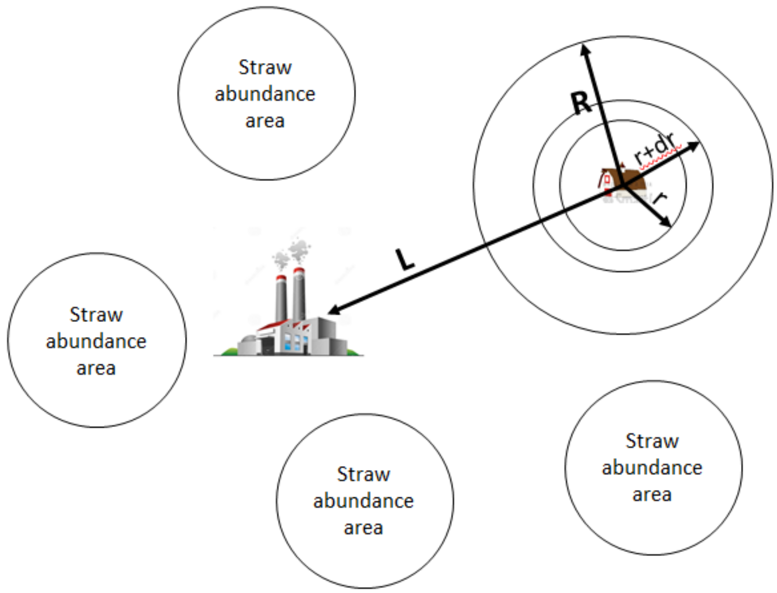

Fig. 5.2 Assumption of collection area, transportation distance, and supply quantity of straw

(5) In line with the Chinese policy, all electricity generated by biomass is purchased by State Grid Corporation of China with certain price P_e since 2010, which remains for a quite long time (National Development and Reform Committee). The P_e including government's incentive to biomass power plant is higher than price of electricity generated by fossil fuel.

(6) Limited by biomass power's installed capacity, there is maximal quantity of straw demand annually (q_1). This study assumes that the total amount of straws for biomass power plant is not more than q_1.

(7) There are thousands of farmers as crop supplier and more than one hundred middlemen serving for the biomass power plant. Although their behaviors are various, both farmer and middleman group have their own commonalities. Therefore, this study made the assumption that farmers and middlemen as two entities, player F and player M, respectively.

(8) In the biomass supply chain, all stakeholders, biomass power plant, middleman and farmer, are facing perceived risk. In order to accurately model the straw-supply situation, risk coefficient is considered in the game model. This study assumes that the risk coefficient of biomass power plant (R_B), middleman (R_M), farmer (R_F) belong to (0, 0.1), and R_B=R_M=R_F.

(9) In this study, no bargaining process is also assumed. Because of the unequal positions among biomass power plant, middleman and farmer, that is, biomass power plant is at the leading place while farmer is at the following position.

5.3.2.2 Stackelberg game decision model

In the Stackelberg game decision model, the biomass power plant moves first and announces its purchasing price from middleman. Knowing this, the middleman announces its purchasing rule and price to the farmer. Given the proposed purchasing rules and price, the farmer then decides the quantity of crop straw (q_1) that is willing to sell to middleman. This study focuses on the interaction among the biomass power plant, the middleman and the farmer instead. Therefore, the game is played sequentially (**Fig.5.3**). All the decision makers seek to maximize their own profit. In line with **Fig.5.3**, the decision problems of the three profit maximizing player are identified as follows with α_a, p_f, and q_1 as decision variables of biomass power plant (incentive coefficient to middleman), middleman (purchasing price from farmer), and farmer (quantity of crop straw provided by farmer), respectively.

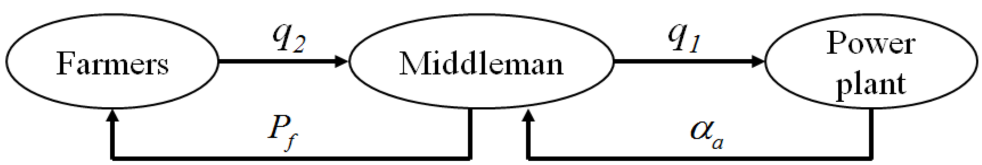

Fig.5.3 Decision variables in biomass supply chain

① **Scenario 1** the benchmark incentive situation

Biomass power plant---considering the risks that the biomass power plant may face, the maximization of profit of the biomass power plant is defined as follows:

$$\max_{\alpha_a \geq 0} \Pi_B = \left\{ \left(p_e - OC \right) r q_1 - p_a q_1 - C_1 q_1 - R_B (p_a q_1 + C_1 q_1) \right\}$$
$$= \left\{ \left(p_e - OC \right) r q_1 - \left(1 + R_B \right) (p_a q_1 + C_1 q_1) \right\}$$

Subject to: $p_a = p_m (1 + \alpha_a)$ (2)

Where OC is the biomass power plant's operation cost per unit of generated electricity ($/MWh); r is conversion ratio from biomass to electricity (MWh/ton); P_a is the price that biomass power plant provides to middleman; P_m is market price of processed biomass; C_1 is storage cost in biomass power plant.

Here R_B is referred as to be biomass power plant's risk coefficient. This is the rate of cost increase associated with uncertainty and risk perceived by the biomass power plant manager. If the manager has risk neutral attitude, this value becomes the expected increase rate. If the manager has risk averse attitude, this value becomes higher than the expected increase rate. Thus, this coefficient can be interpreted as the certainty equivalent.

This model clearly determines the biomass power plant's decision making on the amount of incentive to the middleman. The amount of biomass he receives from middleman, q_1, depends on the incentive which would associates with the generated electricity, rq_1. The market price of biomass production, p_m, reflects the most reasonable price estimated by biomass power plant in line with the current situation.

Middleman---the profit-maximization problem of the middleman is then given by:

$$\max_{p_a \succ P_f \geq 0} \Pi_M = \left\{ p_a q_1 - p_f q_2 - (\mathrm{C}_t \mathrm{L} + C_2) q_2 - R_M \left(p_f q_2 + (\mathrm{C}_t \mathrm{L} + C_2) q_2 \right) \right\}$$
$$= \left\{ p_a q_1 - \left(1 + R_M\right) \left(p_f q_2 + (\mathrm{C}_t \mathrm{L} + C_2) q_2 \right) \right\}$$

Subject to:

$$q_1 = 0.75$$
$$p_a = p_m \left(1 + \alpha_a\right) \qquad (3)$$

Where P_f is the crop straw purchasing price from the farmer ($/ton); C_t is the transportation cost ($/km·ton); C_2 is the storage cost in collection station ($/ton); L is the average transportation distance from collection station to biomass power plant (km); q_2 is weight of collected straws from farmer. Since the crop straws contain more moisture after purchasing from farmer than that biomass power plant purchases from middleman, q_2 and q_1 are not in the same weight. R_M is the risk coefficient of middleman.

Farmer---based on the price provided by middleman, the farmer decides his quantity of biomass supply. Taking into account the cost function (1), which are desirable properties, the farmer's profit maximization problem reads as follows:

$$\max_{q\geq 0} \prod_F = \left\{ p_f q_2 - C_q(q_2) - \mathrm{R}_F\, C_q(q_2) \right\}$$
$$= \left\{ p_f q_2 - (1+\mathrm{R}_F) C_q(q_2) \right\}$$

$$\text{Subject to:} \quad C_q(\mathrm{q}) = \frac{2}{3} C_q q_2^{\frac{3}{2}} \qquad (4)$$

Where $P_f{*}q_2$ stands for the farmer's income from selling crop straw to middleman, and $(1+\mathrm{R_F})C_q(q_2)$ represents the cost on self-collecting and transporting under the farmer's risk perception.

② **Scenario 2** Incentive to farmer

Farmer---the profit- maximization problem of the farmer after government' incentive is given by:

$$\max_{q\geq 0} \prod_F = \left\{ p_f q_2 + \alpha_{gf}\, p_m q_2 - (1+\mathrm{R}_F) C_q(q_2) \right\}$$
$$= \left\{ p_f q_2 + \alpha_{gf}\, p_m q_2 - \frac{2}{3} C_q q_2^{\frac{3}{2}} (1+\mathrm{R}_F) \right\}$$

$$\text{Subject to:} \quad C_q(\mathrm{q}) = \frac{2}{3} C_q q_2^{\frac{3}{2}} \qquad (5)$$

Where α_{gf} represents the incentive from government.

③ **Scenario 3** Incentive to middleman

Middleman--- the profit-maximization problem of the middleman after government's incentive is given by:

$$\max_{p_a \succ p_f \geq 0} \prod_M = \left\{ p_a q_1 + \alpha_{gm} p_m q_1 - \left(1+R_M\right)\left(p_f q_2 + (C_t L + C_2) q_2\right) \right\}$$

$$\text{Subject to:} \quad \begin{array}{l} q_1 = 0.75 \\ p_a = p_m\left(1+\alpha_a\right) \end{array} \qquad (6)$$

Where α_{gm} represents the incentive from government.

5.4 Equilibrium

As state before, the Stackelberg game plays sequentially. The biomass power plant that is the leader move first followed by middleman, then the farmer moves last. The leader player can anticipate the response of the follower to its strategic choice. Through using backward induction, the equilibrium solution starts from the farmer's decision problem.

5.4.1 Determination of equilibrium in the benchmark scenario (Scenario 1).

Proposition 1. Let $\partial G_F / \partial q_1 = 0$, the farmer's optimal strategy of supplying the quantity of biomass for the biomass power plant is calculated by

$$q_1^* = \begin{cases} \frac{3}{4}\left(\frac{p_f}{\left(1+R_F\right)C_q}\right)^2 & p_f \succ 0 \\ 0 & p_f = 0 \end{cases} \qquad \text{Subject to:} \quad C_q(\text{q}) = \frac{2}{3} C_q q_2^{\frac{3}{2}} \qquad (7)$$

The decision of the farmer's crop straw supply strategy depends on the middleman's purchasing price p_f positively. As expected, this quantity decreases with the farmer' risk perceptions and crop straw supplying cost increasing.

Proposition 2. By replacing q_1 from *Eq*. (7) to *Eq*. (3), let $\partial G_M / \partial p_f = 0$, the middleman's purchasing pricing strategy p^*_f under risk and uncertainty is given by

$$p_f^* = \begin{cases} \frac{3p_m\left(1+\alpha_a\right) - 4\left(C_t L + C_2\right)\left(1+R_M\right)}{6\left(1+R_M\right)}, & \alpha_a \succ \frac{4\left(C_t L + C_2\right)\left(1+R_M\right)}{3p_m} - 1 \\ 0, & \textit{otherwise} \end{cases} \qquad (8)$$

Proposition 2 states that the purchasing price from P_f will increase if middleman can obtain a better offer from biomass power plant. Or if middleman's risks decrease (R_M), the middleman can also offer a better purchasing price to the farmer. This result highlights that without increasing purchasing price from middleman, decreasing middleman's risk would be significant approach to increase purchasing price from the farmer.

Proposition 3. Based on *Eq*. (2), by replacing q from *Eq*. (7) and p_f from *Eq*. (8) in *Eq*. (2)**,** let $\partial G_B / \partial \alpha_a = 0$, the biomass power plant's pricing incentive strategy α_a is given by

$$\alpha_a^* = \frac{6r\left(p_e - OC\right)}{9p_m\left(1+R_B\right)} - \frac{4\left(C_t L + C_2\right)\left(1+R_M\right) - 6C_1}{9p_m\left(1+R_B\right)} - 1 \quad p_e \succ \frac{\left(1+R_B\right)\left[9p_m + 6C_1 - 4\left(C_t L + C_2\right)\left(1+R_M\right)\right]}{6r} + OC \qquad (9)$$

The Proposition 4 describes that when the electricity price from State Grid Corporation of China and the cost (e.g. operation cost, storage cost and transportation cost) are fixed, if the biomass power plant's risks, R_B, increase, the biomass power plant will decrease the incentive (α_a) to the middleman. Meanwhile, the biomass power plant has to increase the purchasing price from middleman if middleman has high risk perception.

Triplet $E^* = \left(\alpha_a^*, p_f^*, q_1^*\right)^T$ from (7) to (9) is the Nash equilibrium of the Stackelberg game in the benchmark scenario (Scenario 1). Put the biomass power plant's equilibrium incentive to the middleman α_a^* and the middleman's purchasing price strategy from the farmer into formulate (8) and (7), respectively. Therefore,

$$E^* = \begin{pmatrix} \dfrac{6r\left(p_e - OC\right)\dfrac{1}{\left(1+R_B\right)} + 4\left(C_t L + C_2\right)\left(1+R_M\right) - 6C_1}{9p_m} - 1 \\ \dfrac{3\left(p_e - OC\right)r - 4\left(1+R_M\right)\left(1+R_B\right)\left(C_t L + C_2\right) - 3C_1\left(1+R_B\right)}{9\left(1+R_B\right)\left(1+R_M\right)} \\ \dfrac{3}{4}\left[\dfrac{3\left(p_e - OC\right)r - 4\left(1+R_M\right)\left(1+R_B\right)\left(C_t L + C_2\right) - 3C_1\left(1+R_B\right)}{9\left(1+R_B\right)\left(1+R_M\right)\left(1+R_F\right)C_q}\right]^2 \end{pmatrix} \qquad (10)$$

5.4.2 Determination of equilibrium in incentive to the farmer scenario (Scenario 2).

Proposition 4. The farmer' optimal strategy of supplying the quantity of biomass for biomass generation q_1^{**} under incentive from government is given by

$$q_1^{**} = \begin{cases} \frac{3}{4}\left(\frac{p_f + \alpha_{gf} p_m}{C_q (1 + \mathrm{R}_F)}\right)^2 & p_f \succ 0 \\ 0 & p_f = 0 \end{cases} \quad (11)$$

The quantity of biomass from the farmers increases with increase incentive α_{gf} to the farmer.

Proposition 5. With the farmer's crop straw supplying strategy, the middleman's purchasing pricing strategy p^{**}_f under risk and uncertainty is given by

$$p_f^{**} = \begin{cases} \frac{3p_m(1+\alpha_a) - 4(1+R_M)(C_t L + C_2) - 2(1+R_M)\alpha_{gf} p_m}{6(1+R_M)}, & \alpha_a \succ \frac{4(1+R_M)(C_t L + C_2) + 2(1+R_M)\alpha_{gf} p_m}{3p_m} - 1 \\ 0 & , \ otherwise \end{cases} \quad (12)$$

After the government's incentive to the farmer, middleman's purchasing price is also influenced. Specifically, government's incentive to the farmer will decrease the middleman's purchasing price P_f^{**}.

Proposition 6. Given the middleman's price strategy to the farmer, the biomass power plant's pricing incentive strategy α_a^{**} is given by

$$\alpha_a^{**} = \frac{6r(p_e - OC)}{9p_m(1+R_B)} + \frac{4(1+R_M)(C_t L + C_2) - 4(1+R_M)\alpha_{gf} p_m}{9p_m} - \frac{6C_1}{9p_m} - 1 \quad (13)$$
$$p_e \succ \frac{9p_m(1+R_B) - 4(1+R_M)(1+R_B)(C_t L + C_2) + 4(1+R_M)(1+R_B)\alpha_{gf} p_m + 6(1+R_B)C_1}{6r} + OC$$

From proposition 6 above, the incentive from biomass power plant to the middleman α^{**}_a is affected by both biomass power plant and middleman's risk and uncertainty. In addition, with α_{gf} increases, α^{**}_a would decrease.

Triplet $E^{**}=\left(\alpha_a^{**}, p_f^{**}, q_1^{**}\right)^T$ from (10) to (12) is the Nash equilibrium of the Stackelberg game in the scenario of incentive to the farmer. By putting formulate (13) and (12) into (12) and (11), respectively, E^{**} is expressed as follows:

$$E_1^{**}=\begin{pmatrix}\alpha_a^{**}\\ p_f^{**}\\ q^{**}\end{pmatrix}=\begin{pmatrix}\dfrac{6r\left(p_e-OC\right)+4\left(1+R_M\right)\left(1+R_B\right)\left(C_tL+C_2\right)-4\left(1+R_M\right)\left(1+R_B\right)\alpha_{gf}\,p_m-6C_1\left(1+R_B\right)}{9p_m\left(1+R_B\right)}-1\\ \dfrac{3r\left(p_e-OC\right)-4\left(1+R_M\right)\left(1+R_B\right)\left(C_tL+C_2\right)-5\left(1+R_M\right)\left(1+R_B\right)\alpha_{gf}\,p_m-3C_1\left(1+R_B\right)}{9\left(1+R_M\right)\left(1+R_B\right)}\\ \dfrac{3}{4}\left(\dfrac{3r\left(p_e-OC\right)-4\left(1+R_B\right)\left(1+R_M\right)\left(C_tL+C_2\right)+4\left(1+R_B\right)\left(1+R_M\right)\alpha_{gf}\,p_m-3C_1\left(1+R_B\right)}{9C_q\left(1+R_B\right)\left(1+R_M\right)\left(1+R_F\right)}\right)^2\end{pmatrix} \tag{14}$$

5.4.3 Determination of equilibrium in incentive to the middleman scenario (Scenario 3)

Proposition 7. The optimal strategy for the farmer's supplying biomass for electricity is the same as Eq. (7) under government's incentive to the middleman.

$$q_1^*=\begin{cases}\dfrac{3}{4}\left(\dfrac{p_f}{\left(1+R_F\right)C_q}\right)^2 & p_f\succ 0\\ 0 & p_f=0\end{cases} \tag{7}$$

Proposition 8. Given the farmer's supply strategy, the middleman's pricing strategy P_f^{***} is given by

$$p_f^{***}=\begin{cases}\dfrac{3p_m\left(1+\alpha_a\right)+3\alpha_{gm}p_m-4\left(1+R_M\right)\left(C_tL+C_2\right)}{6\left(1+R_M\right)}, & \alpha_a\succ\dfrac{4\left(1+R_M\right)\left(C_tL+C_2\right)-3\alpha_{gm}p_m}{3p_m}-1\\ 0, & otherwise\end{cases} \tag{15}$$

As it is expected, after government's incentive to the middleman, in order to purchase more crop straw, the middleman would increase purchasing price from the farmer, P_f^{***}. The increasing rate depends on degree of government's incentive to the middleman.

Proposition 9. Given the middleman's price strategy to the farmer, the biomass power plant's pricing incentive strategy α_a^{***} is given by

$$\alpha_a^{***} = \frac{6r\left(p_e - OC\right)}{9p_m\left(1+\mathrm{R}_B\right)} - \frac{4\left(1+\mathrm{R}_M\right)\left(C_t L + C_2\right) - 6C_1\left(1+\mathrm{R}_B\right)}{9p_m(1+\mathrm{R}_B)} - \frac{3\alpha_{gm}}{9p_m} - 1,$$
$$p_e \succ \frac{9p_m\left(1+\mathrm{R}_B\right) - 4\left(1+\mathrm{R}_M\right)\left(1+\mathrm{R}_B\right)\left(C_t L + C_2\right) + 6C_1\left(1+\mathrm{R}_B\right) + 3\alpha_{gm} p_m\left(1+\mathrm{R}_B\right)}{6r} + OC \qquad (16)$$

With government's incentive to the middleman, the incentive from the biomass power plant to the middleman would decrease.

Triplet $E^{***} = \left(\alpha_a^{***}, p_f^{***}, q_1^{*}\right)^T$ from (7), (13), and (14) is the Nash equilibrium of the Stackelberg game in the scenario of incentive to the middleman. By putting formula (16) and (15) into (15) and (7), the Nash equilibrium E^{***} is determined:

$$E^{***} = \begin{pmatrix} \alpha_a^{***} \\ p_f^{***} \\ q^{***} \end{pmatrix} = \begin{pmatrix} \dfrac{6r\left(p_e - OC\right) + 4\left(1+\mathrm{R}_M\right)\left(1+\mathrm{R}_B\right)\left(C_t L + C_2\right) - 6C_1\left(1+\mathrm{R}_B\right) - 3\alpha_{ga} p_m\left(1+\mathrm{R}_B\right)}{9p_m\left(1+\mathrm{R}_B\right)} - 1 \\ \dfrac{3r\left(p_e - OC\right) - 4\left(1+R_M\right)\left(1+R_B\right)\left(C_t L + C_2\right) - 3C_1\left(1+R_B\right) + 3\left(1+R_B\right)\alpha_{ga} p_m}{9\left(1+R_M\right)\left(1+R_B\right)} \\ \dfrac{3}{4}\left(\dfrac{3r\left(p_e - OC\right) - 4\left(1+R_M\right)\left(1+R_B\right)\left(C_t L + C_2\right) - 3C_1\left(1+R_B\right) + 3\left(1+R_B\right)\alpha_{ga} p_m}{9C_q\left(1+R_B\right)\left(1+R_M\right)\left(1+R_F\right)}\right)^2 \end{pmatrix} \qquad (17)$$

5.5 Empirical case study

5.5.1 Case introduction

Heilongjiang Province is an important gain crops base in China. It is expected to become a base of biomass supply for electricity generation. Therefore, this study takes National Bioenergy Industry in Wangkui County in Heilongjing Province as an empirical study. The total investment of the biomass power plant is \$2.3 million and installed capacity is 30 MW. The demand of processed crop straw annually is 200,000 tons. With the help of the managers in the company and local governors, investigation was conducted in August, 2013 and September, 2014. After obtaining the data, the parameter values are assigned in Table 1. We ran a set of experiments on problems of different incentive situations corresponding to three different scenarios:

(1) Scenario 1: Current situation without government's incentive neither to the middleman nor the farmer;

(2) Scenario 2: Government's incentive to the farmer, where each stakeholder's profit is maximized;

(3) Scenario 3: Government's incentive to the middleman

.

Table 5.1 Parameter values from field survey

Parameter	**Value**	**Parameter**	**Value**
P_m	\$40/ton	r	860MWh/ton
C_1	\$5/ton	L	30km
C_2	\$6/ton	OC	\$0.05/MWh
C_t	\$0.8/km·ton	C_q	\$1/MWh

Source: investigation in 2014

5.5.2 Results and discussions

5.5.2.1 Scenario 1---current incentive scenario

By substituting parameter values into the model, the Nash equilibrium under current incentive situation can be determined as follow:

$$E^{*}=\left(\alpha_a^{*}, p_f^{*}, q_1^{*}\right)^{T}=\begin{pmatrix} \dfrac{43\left(p_e-0.05\right)}{3(1+R)}+\dfrac{(1+R)}{3}-\dfrac{13}{12} \\ \dfrac{860\left(p_e-0.05\right)}{3(1+R)^{2}}-\dfrac{5}{3(1+R)}-\dfrac{40}{3} \\ \dfrac{1}{12}\left[\dfrac{860\times\left(p_e-0.05\right)}{(1+R)^{3}}-\dfrac{5}{(1+R)^{2}}-\dfrac{40}{(1+R)}\right]^{2} \end{pmatrix} \tag{18}$$

Considering the impact of perceived risk by each stakeholder on α_a, p_f and q_1 under different p_e in current incentive scenario, the results are displayed in **Fig. 5.4(1)**, **Fig. 5.4(2)** and **Fig. 5.4(3)** with respect to the change of risk (from 0 to 0.1). By replacing α_a, p_f and q_1 into the profit model of the biomass power plant, the middleman and the farmer, we can plot the profit changing under perceived risk changing (**Fig. 5.4(4)**, **Fig. 5.4(5)**, and **Fig. 5.4(6)**).

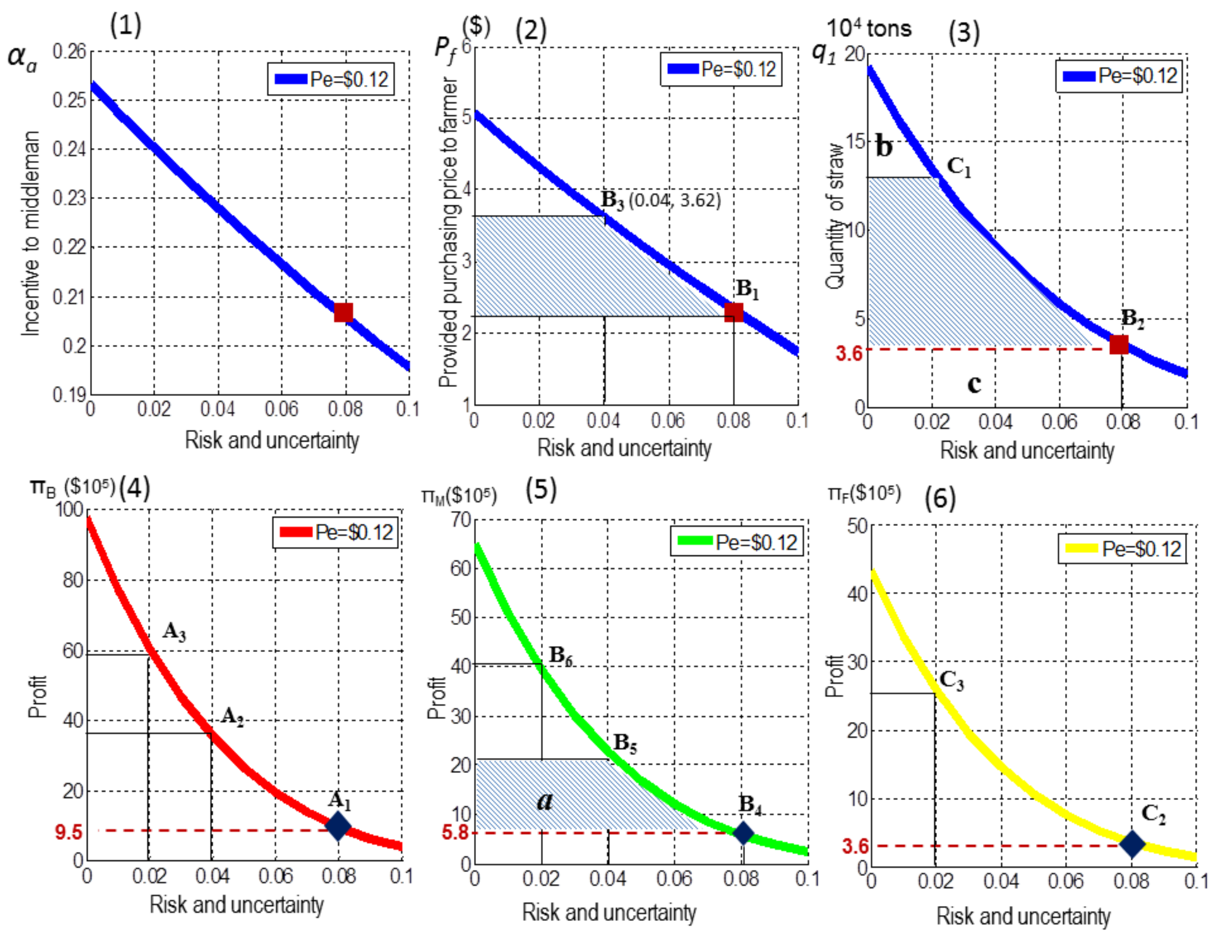

Fig.4.4. (1) the incentive α_a change under risk and uncertainty. (2) provided purchasing price to the farmer change under risk and uncertainty. (3) change of quantity of straw supplied by the farmer under risk and uncertainty. (4) profit of the biomass power plant is represented by $\Pi_B = \frac{1}{36(1+R)^6}\left[860(p_e - 0.05) - 40(1+R)^2 - 5(1+R)\right]^3$. (5) the profit of the middleman is $\Pi_M = \frac{1}{54(1+R)^7}\left[860(p_e - 0.05) - 40(1+R)^2 - 5(1+R)\right]^3$. (6) the profit of the farmer is represented by

$$\Pi_F = \frac{1}{81(1+R)^8}\left[860(p_e - 0.05) - 40(1+R)^2 - 5(1+R)\right]^3 .$$

Consider the impact of risk and uncertainty on biomass power plant's incentive to the middleman (α_a), middleman's purchasing price of straw from the farmer (p_f), the farmer's quantity of straw supply (q_1), and the biomass power plant's profit change (π_B). In line with **Fig.5.4**, it indicates that, in the current incentive scenario, the trend of the four lines indicates that perceived risk and uncertainty have considerable high impact on α_a , p_f, q_1 and π_B. Particularly, the profit of the biomass power plant decreases remarkably with the perceived risk and uncertainty increasing. Under the government's subsidy to the biomass power plant, $0.12/kwh, the biomass power plant would increase by more twice profit (from A1 to A2) by decreasing risk and uncertainty from 0.08 to 0.04.

In **Fig.5.4(3)**, with the biomass price provided by the power plant, the middleman provided purchasing price to the farmer is B1 under risk and uncertainty. However, with this price and the farmer' perceived risk and uncertainty, the quantity of straw that the farmer can provide is B2. In order to collect more straw to fulfill the contract with the biomass power plant, the middleman has to provide higher price to purchase straw from farmer (B3 which the middleman's perceived risk decrease to 0.04). In **Fig.5.4(5)**, when the middleman's perceived risk level is 0.04, the profit is $2,000,000. However, the current profit is approximately $840,000 because of the current risk and uncertainty. Thus, area *a* in Fig.**5.4(5)** become the middleman's risk cost.

From field survey, we know that, with increased pf from B1 to B3, the farmer also increases the quantity of straw supply, from B2 to C1. In order to obtain sufficient straw for normal operation (area *b*), the biomass power plant or the middleman has to collect straw in distant place, which is out of the island as it is shown in **Fig.5.1**. It would cause extra transportation cost. As the similar situation with the biomass power plant and the middleman, risk and uncertainty has negative relationship with profit. The farmer's profit will increase from C2 to C3 by decreasing risk perception and uncertainty from 0.05 to 0.02. (**Fig.5.4 (6)**)

5.5.2.2 Scenario 2---incentive to the farmer

By substituting parameter values into the incentive to the farmer model, the Nash equilibrium under government's incentive to the farmer can be determined as follow:

$$E_1^{**}=\begin{pmatrix}\alpha_a^{**}\\ p_f^{**}\\ q^{**}\end{pmatrix}=\begin{pmatrix}\dfrac{43\left(p_e-0.05\right)}{3\left(1+R\right)}+\dfrac{1}{3}\left(1+R\right)-\dfrac{4}{9}\alpha_{gf}\left(1+R\right)-\dfrac{13}{12}\\ \dfrac{860\left(p_e-0.05\right)}{3\left(1+R\right)^2}-\dfrac{5}{3\left(1+R\right)}-\dfrac{200}{9}\alpha_{gf}-\dfrac{40}{3}\\ \dfrac{1}{12}\left(\dfrac{860\left(p_e-0.05\right)}{\left(1+R\right)^3}-\dfrac{5}{\left(1+R\right)^2}+\dfrac{160}{3\left(1+R\right)}\alpha_{gf}-\dfrac{40}{\left(1+R\right)}\right)^2\end{pmatrix} \tag{19}$$

After repeated simulation, in this scenario, P_e=\$0.116 is suitable when consider the impact of risk changes on α_a, p_f and q_1 under perceived risk. Thus, here P_e is constant value. The results of α_a, p_f and q_1 changing as well as profit change of the biomass power plant, the middleman, and the farmer are displayed in **Fig.5.5**, with respect to the change of risk (from 0 to 0.1).

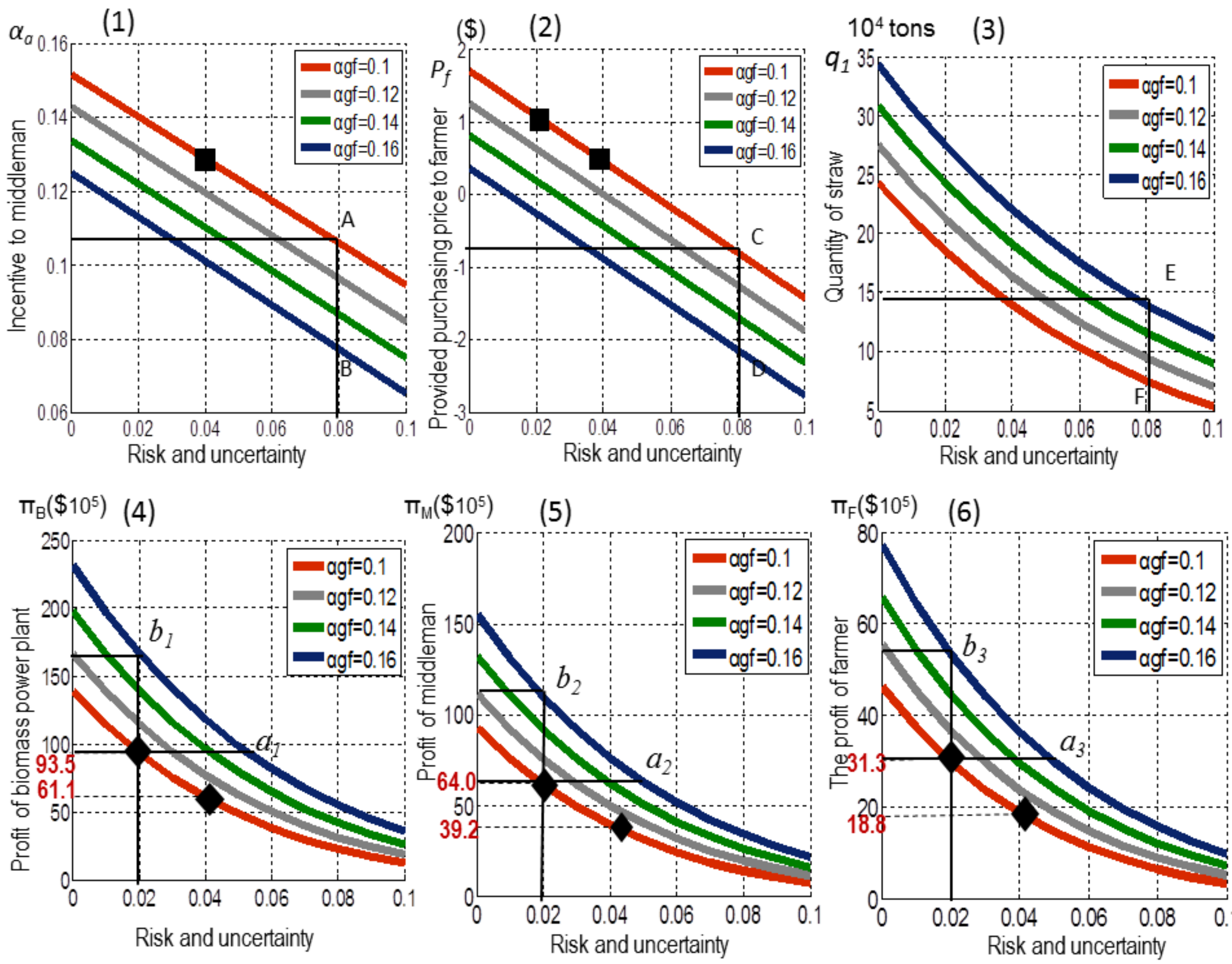

Fig.5.5 (1) the incentive α_a change with different incentive level to the farmer under risk and uncertainty. (2) Provided purchasing price to the farmer change with different incentive levels to the farmer under risk and uncertainty. (3) Change of quantity of straw supplied by the farmer with different incentive levels to the farmer under risk and uncertainty. (4) Profit of the biomass power plant is represented by $\Pi_B = \frac{1}{36(1+R)^6}\left[860(p_e - 0.05) - 40(1+R)^2 + \frac{160}{3}\cdot\alpha_{gf}(1+R)^2 - 5(1+R)\right]^3$. (5) the profit of the middleman is $\Pi_M = \frac{1}{54(1+R)^7}\left[860(p_e - 0.05) - 40(1+R)^2 + \frac{160}{3}\alpha_{gf}(1+R)^2 - 5(1+R)\right]^3$. (6) the profit of the farmer is represented by

$$\Pi_F = \frac{1}{108(1+R)^8}\left[860(p_e - 0.05) - 40(1+R)^2 + \frac{160}{3}\alpha_{gf}(1+R)^2 - 5(1+R)\right]^3.$$

As expected, the scenario containing incentive to the farmer result in significantly lower α_a and p_f than that in baseline scenario (current situation). With increasing of government's incentive to the farmer (α_{gf}), α_a and p_f decrease from A to B, and from C to D, respectively (**Fig5.5(1)** and **Fig5.5(2)**). The quantity of straw that the farmer supplies will increase with government's incentive increases. When exhibits certain amount of straw that the biomass power plant demands (q_1=200,000 tons), decreasing the farmer's risk perception results in lower incentives. For the profit change of the biomass power plant, the middleman and the farmer, increasing α_{gf} increases the profits of all stakeholders while increase perceived risk decreases their profits. When all stakeholders' perceived risk decrease to 0.02, all of them could obtain much higher profit than that in the current incentive scenario.

5.5.2.3 Scenario 3---incentive to the middleman

By further investigation of the equilibrium with the case study on the incentive to the middleman, some interesting results are distinguished. According to the parameters in the reality, substituting parameter values into the incentive to the middleman model, the Nash equilibrium under government's incentive to the middleman can be determined as follow:

$$E^{***}=\begin{pmatrix}\alpha_a^{***}\\ p_f^{***}\\ q^{***}\end{pmatrix}=\begin{pmatrix}\dfrac{43(p_e-0.05)}{3(1+R)}+\dfrac{1+R}{3}-\dfrac{1}{3}\alpha_{gm}-\dfrac{13}{12}\\ \dfrac{860(p_e-0.05)}{3(1+R)^2}-\dfrac{5}{3(1+R)}+\dfrac{40\alpha_{gm}}{3(1+R)}-\dfrac{40}{3}\\ \dfrac{1}{12}\left(\dfrac{860(p_e-0.05)}{(1+R)^3}-\dfrac{40}{(1+R)}-\dfrac{5}{(1+R)^2}+\dfrac{40\alpha_{gm}}{(1+R)^2}\right)^2\end{pmatrix} \tag{20}$$

By replacing $E^{***}=\left(\alpha_a^{***},p_f^{***},q_1^{***}\right)$ in Eq. (2), (4), (6), the profits change of the biomass power plant, the middleman, and the farmer can be plotted in Fig. 6. Here, *Pe* is constant value.

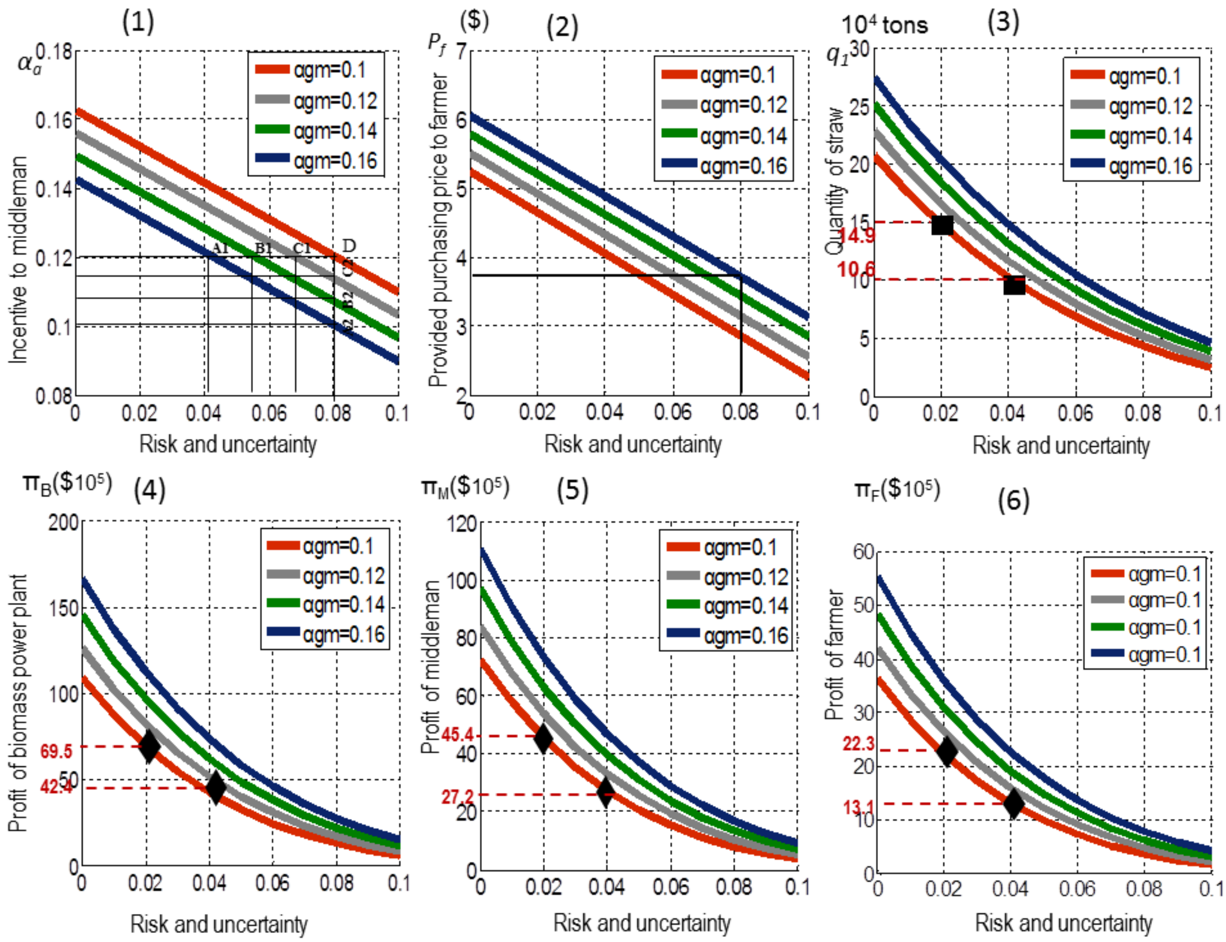

Fig. 5.6. (1) the incentive α_a change with different incentive level to the middleman under risk and uncertainty. (2) Provided purchasing price to the farmer change with different incentive levels to the middleman under risk and uncertainty. (3) Change of quantity of straw supplied by the farmer with different incentive levels to the middleman under risk and uncertainty. (4) Profit of the biomass power plant is represented by $\Pi_B = \frac{1}{36(1+R)^6}\left[860(p_e - 0.05) - 40(1+R)^2 + 40\alpha_{gm}(1+R) - 5(1+R)\right]^3$. (5) the profit of the middleman is $\Pi_M = \frac{1}{54(1+R)^7}\left[860(p_e - 0.05) - 40(1+R)^2 + 40\alpha_{gm}(1+R) - 5(1+R)\right]^3$. (6) the profit of the farmer is represented by

$$\Pi_F = \frac{1}{108(1+R)^8}\left[860(p_e - 0.05) - 40(1+R)^2 + 40\alpha_{gm}(1+R) - 5(1+R)\right]^3.$$

As the same trend with **Fig. 5.5(1)**, the incentive from the biomass power plant decrease from D to A2 with government's incentive to the middleman increasing, this means that purchasing price from the middleman decrease with the increasing incentive from government. However, comparing with **Fig.5.5(1)**, the power plant's incentive to the middleman is considerably higher under the same situation (R=0.04, α_{gf}=0.16). Moreover, purchasing price to the farmer (p_f) increases with government's incentive increases (α_{gm}). This result is different from **Fig.5.5(2)**. The differences of the two results highlight that with government's incentive, middleman prefer to purchase the farmer's straw with higher price to satisfy the biomass power plant's straw demand quantity. While if the farmer obtains the incentive, the farmer would like to provide straw with low price. It should be noted that the result line in **Fig.5.6 (2)** is more intensive than that in **Fig. 5.5 (2)**, which indicates the effect of incentive to the middleman is not as obvious as that to the farmer. In terms of the quantity of straw that the biomass power plant demands, that is 200,000 tons, in the incentive to the middleman scenario, to reach the quantity, the risk and uncertainty should be lower than 0.02. Even under the highest incentive (α_{gm}=0.16), still the risk and uncertainty should be controlled around 0.021, which is impractical in short-term. The results trend of profits is similar to **Fig.5.5**. However, under the same perceived risk level, more incentive should be invested to reach the same level of profit in **Fig.5.5 (4) (5) (6)**. For example, to reach $10 million profit, in **Fig.5.5(4)**, the lowest incentive level (α_{gf}=0.1) to the farmer is sufficient under 0.02 level of risk and uncertainty, while 0.14 incentive to the middleman should be invested in **Fig.5.6(4)** to achieve the same profit. Particularly, it is surprising to find that the profit decreases remarkably after obtaining incentive from government comparing with that in **Fig.5.5 (5)**. In terms of the farmer's profit, under the 0.02 risk level, the profit is approximately $ 3.6 million with 0.16 incentive to the middleman and around $ 2.2 million with 0.1 incentive. In **Fig.5.5 (6)**, under the same risk level, the farmer's profit could reach $3 million and approximately $5.3 million with 0.1 and 0.16 incentive, respectively. Moreover, generally, the result lines in **Fig.5.6** are more intensive than that in **Fig.5.5**. As stated before it means, the incentive to the farmer has higher effect. With these computational results, some conclusions are made as follows:

With government's incentive neither to the middleman nor to the farmer, the profit increases. The increasing ratio depends on the incentive level and the three stakeholders' perceived risk level.

(1) Under a certain perceived risk level, the biomass power plant can obtain target amount of straw with lower government's incentive to the farmer than that to the middleman.

(2) Incentive to farmer results in higher profit to the biomass power plant, the middleman and the farmer. Although incentive to the middleman could also increase profit of the three stakeholders comparing with the current situation, the increasing level is lower than incentive to the farmer.

(3) Generally, incentive to the farmer has high effect on both increasing quantity of straw and increasing profit of the three stakeholders.

(4) Perceived risk has an enormous impact on the value of α_a, p_f, q_1, and the three stakeholders' profit change. Decreasing perceived risk would be a significant way to increase crop straw collection and profit.

In this sense, it would, therefore, be interesting to see how risk and uncertainty and incentive will affect the profit change and social welfare.

5.5.2.4 Social welfare estimation

The solutions of our models have provided implications on how the perceived risk on the biomass supply chain has impacted on the profitability of each stakeholder under different subsidy incentive scenarios. Our model results can be further utilized to analyze social welfare; e.g., by estimating the social surplus as follows:

$$\text{Social welfare} = BS + MS + FS + IS - C_{incentive}$$

Where *BS, MS* and *FS* stand for the biomass power plant, the middleman, and the farmer surpluses, respectively. *IS* represents government's incentive surpluses, and *IC* is cost associated with government's incentive. In this study, the biomass power plant, the middleman, and the farmer's surplus are their net profits. Government's incentive surplus (*IS*) can be computed by

$\left(p_e - p_e^{'}\right)Q_{electricity}$, where p_e is the current electricity price purchased by the State Grid Corporation of China, and $p_e^{'}$ is electricity price after government decides to subsidize the middle and the farmer. The monetary incentive cost ($C_{incentive}$) can be computed by $\alpha_{gf}\left(\alpha_{gm}\right)\times q_1 \times p_m$. The social welfare for each scenario is shown in **Table 5.2**. Note that in the benchmark scenario in the table, 4 levels of perceived risk were chosen since the perceived risks of the three stakeholders are considerably high. It would be obvious to see the social welfare changing with the changed level of perceived risk. However, in the incentive to the farmer and middleman scenarios, only 0.04 and 0.02 level of perceived risks are used, because after given incentive, the perceived economic risk would decrease. This study assumes the perceived risk decrease to two alternatives, 0.04 and 0.02.

In all cases, the results indicate that incentive to the middleman and the farmer, regardless of perceived risk level, generally increases the net social welfare compared to the benchmark cases. Particularly, in the incentive to the farmer scenario, the social welfare increases dramatically. This supports our incentive to develop an economically feasible biomass power industry. However, in each scenario, the social welfare significantly decreases because of perceived risk of each stakeholder, from which we could say that impact of perceived risk on the biomass market is substantial. Furthermore, it is not surprise to see that the incentive to the farmer scenario generates highest social welfare. It implies that incentive to the farmer could be an effective strategy in developing biomass power industry.

Table 4.2 Social welfare for all scenarios (million $/year)

(Pe, R, α_{gf}/α_{gm})	Scenario	BS	MS	FS	IS	$C_{incentive}$	Social welfare
(0.12, 0.08)	1	0.946	0.584	0.360	0	0	1.890
(0.12, 0.06)	1	1.932	1.215	0.764	0	0	3.911
(0.12, 0.04)	1	3.549	2.275	1.458	0	0	7.282
(0.12, 0.02)	1	6.047	3.952	2.583	0	0	12.582
(0.116, 0.04, 0.1)	2	6.018	3.915	1.883	0.8	0.793	13.409

(0.116, 0.04, 0.12)	2	7.738	4.960	2.384	0.8	0.952	16.834
(0.116, 0.04, 0.14)	2	9.634	6.176	2.969	0.8	1.110	20.689
(0.116, 0.04, 0.16)	2	11.818	7.576	3.642	0.8	1.269	25.105
(0.116, 0.02, 0.1)	2	9.352	6.402	3.138	0.8	0.793	20.485
(0.116, 0.02, 0.12)	2	11.494	7.512	3.682	0.8	0.952	24.440
(0.116, 0.02, 0.14)	2	13.940	9.111	4.466	0.8	1.110	29.427
(0.116, 0.02, 0.16)	2	16.712	10.922	5.354	0.8	1.269	35.057
(0.116, 0.04, 0.1)	3	4.243	2.720	1.307	0.8	0.793	9.863
(0.116, 0.04, 0.12)	3	5.172	3.315	1.594	0.8	0.952	11.833
(0.116, 0.04, 0.14)	3	6.180	3.962	1.905	0.8	1.110	13.957
(0.116, 0.04, 0.16)	3	7.339	4.704	2.261	0.8	1.269	16.373
(0.116, 0.02, 0.1)	3	6.950	4.542	2.227	0.8	0.793	15.312
(0.116, 0.02, 0.12)	3	8.226	5.376	2.635	0.8	0.952	17.989
(0.116, 0.02, 0.14)	3	9.648	6.306	3.091	0.8	1.110	20.955
(0.116, 0.02, 0.16)	3	11.226	7.337	3.597	0.8	1.269	24.229

Source: author, 2015

5.6 Conclusion

The biomass power industry is anticipated to rapidly expend in the decades to come. To further promote the development of biomass power industry, approaches of removing obstacles need to be investigated. In line with the current biomass supply situation in China, this study proposed a Stackelberg game approach to model the incentive scenarios of biomass supply. We focus on optimizing economic incentive to stakeholders in the biomass supply chain, and incorporate them into the supply chain design model.

We first develop the benchmark scenario to identify the current situation: the current incentive from the biomass power plant to the middleman, middleman's purchasing price from the farmer and the quantity of straw that farmer could supply, that maximize the three stakeholders' profit. Second, incentive to the farmer model was further investigated. It found that the advent of a new incentive model will increase the farmer's motivation to participate in straw supplying activity. In addition, all stakeholders' profitability increases remarkably. In order to investigate the optimized scenario, inventive to the middleman model also built. Although all stakeholders' profits also increase, the incentive results are not as effective as that incentive to the farmer. Note that all the scenarios are under risk and uncertainty. The numerical results show that risk and uncertainty has huge impacts on stakeholders' motivation to participate the straw collecting activities. Decreasing perceived risk could be significant both in increasing the quantity of straw supplying and profitability. Finally, based on the three scenarios, social welfares under different cases are shown. To obtain the incentive resources, in Chapter V, the external costs of coal-fired power plant and biomass power plant are compared.

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CHAPTER 6: INFLUENCE TRUST AND FARMER-SPECIFIC FACTORS IN BIOMASS SUPPLY DECISION-MAKING IN CHINA

6.1 Introduction

The increasingly expensive fossil fuels and environmental degradation have forced many nations to consider renewable energy. In line with the abundant straw resources, developing biomass power plant has been a long-term target in China. However, due to lack of cooperation in the straw supply chain, biomass power plants in China face hindrance, even deficit in development. To guarantee sustainable development, building trust among stakeholders in fundamental issue. Without trust, farmer, with high risk perception, will not be willing to cooperate with power plant. Trust is the lubricant of society and the foundation of interpersonal communication (Qin et al., 2011). Trust is also the belief of a participant that the other participants will fulfill its promise (Liu et al., 2014). The degree of trust within a society is highly correlated with economic growth, reputation and the emergence and efficiency of large-scale organizations, including government (Knack and Keefer, 1997; Fukuyama, 1995; La Porta et al., 1997). Trust has been identified as an important interesting ingredient in SC (Supply chain). Especially for SC based on straw supplying market in rural China, trust is not only the base of all interactions, but also is an efficient mechanism to foster the cooperation between farmers (suppliers) and middleman (straw collector), and to reduce transaction costs and risks. Particularly, in the biomass supply chain (BSC) in China, farmers are the straw suppliers, who decide the quantity of straw supplying. In this sense, farmers take the critical role in the SC. To quickly establish the relationship between farmers and middleman who is the straw collector, the important precondition is to assess the trustworthiness of the partner.

Therefore, this study explores farmers' decision making from the perspectives of the key elements in building trust and improving farmers' engagement. This study aims to (1) contribute to empirical understanding of farmers' perceptions of risks in supplying straw; (2) provide the opportunities for improving trust, increasing farmers' engagement and lowing transaction cost. This study presents the results of a farmers' opinion survey of 275 respondents in National Bioenergy industry area in Wangkui County in Northeast China in 2014.

Northeast China is chosen to study for a number of reasons. First, the crop straw is abundant in this area, particularly crop straw output per capital is most in China (National Bureau of Statistics of China (NBSC), 2010). The total output is approximately 96,283,700 tons (Wang and Watanabe, 2015). Second, the National Bioenergy power plant is typical straw-based power plant. There are already 50 biomass projects distributing in 28 provinces in China. The problems they face are universal in China. In addition, the National Bioenergy power plant has developed 9 years in this Northeast area; their experience in collection of straw therefore has a relevance that extends beyond its own boundaries, and may contribute to our understanding of how farmers respond to trust, risk perception, transaction cost and engagement issues.

In the Section 2, literature review on some key theoretical concepts related to trust, risk perception, transaction cost and engagement are discussed. Then, Section 3 focuses on objectives and methodology. Results in Section 4 are displayed followed by the discussions and policy implementations in Section 5 based on our findings. Finally, conclusions are derived in Section 6.

6.2 Literature review

6.2.1 Trust and risk perceptions

Trust is defined as an individual's confidence in another's intentions, motives, and capabilities, and sincerity (Mellinger, 1956; Deutsch, 1960), or as one party's optimistic expectations in terms of the behavior of another when the first party must make a decision about how to act (Rotter, 1971; Mayer et al., 1995). Trust is regarded as effective tool in mitigating risk perception (Cvetkovich and Lofstedt, 1999; Poortinga ad Pidgeon, 2003). The concept of trust has been studied in various risk perception issues, ranging from climate change, radioactive waste, and genetically modified food to nuclear power plant (Poortinga and Pidgeon, 2003; Mah, 2014). The risk perception has a prominent place in the extant literature on trust (Boon and Holmes, 1991; March and Shapira, 1987; Mayer et al., 1995; Sitkin and Pablo, 1992). Slovic pointed out that high public concern about a risk issue (for example, nuclear power) is associated with distrust of the managers responsible for that issue; low public concern (as in the case, for example, of medical uses of radiation) is associated with trust in risk managers (Slovic et al., 1991). In general, trust in risk management is negatively related to risk perception. This is an important observation because it opens a possible pathway to affecting public risk perception and improving risk management: if we understood trust, and if we could affect levels of trust, then we might also be able to affect levels of risk perception and, ultimately, risk acceptance or rejection.

6.2.2 Trust and transaction cost

There is a growing recognition that relationships play an important role in supply chain management (Narasimhan and Kim, 2002). Meanwhile, transaction cost economics (TCE) has become one of the most frequently used theory studying such business relationships (Klein et al., 1990). In TCE, trust has been regarded as lubricant of social system (Vakis et al., 2003; Ruben et al., 2007b). Gulati (1995) defined that trust is the expectation that one party in the transaction will not behave opportunistically (Gulati, 1995). Trust develops through individuals' interaction (Nooteboom, 2002). But trust cannot develop immediately. With high risk and little trust at the beginning, individuals develop their relations and engage in transaction gradually. Therefore, trust is a relationship-based concept. This relationship can be created, reinforced, or decreased and destroyed by bilateral activities in a series of economic exchange (Suh and Kwon, 2006).

Trust can reduce opportunistic behavior, then mitigates transaction costs in business practice. Whenever trust exists, farmers can lower their guard and economize on transaction cost. Thus, trust could enable farmers to take less risk and less conflict, provide exchange credit, and offer warranty (Fafchamps and Minten, 1998). The economic value of trust also has to be considered when it is based on non-contractual mechanisms (Dyer, 1997). Non-contractual trust (e.g. goodwill) can reduce the procedure in formal contract such as document, monitor and enforce. In case of farmers' straw-supplying, farmers with high trust spend less time calculating their economic benefit. Because they trust the straw collector that he will not cheat them. As Dyer (1997) stated that trust also encourages farmers and buyers to make relationship-specific investments, which in turn enhance productivity in exchange relationship without fear of opportunism (Dyer, 1997).

6.2.3 Trust and engagement

Numerical body of literature have identified that public engagement is one of the important mechanisms for enhancing trust (Denhardt, 2002; Wynne, 2006; Brunk, 2006; Wart, 2007; Stebbing, 2009). In order to make practical policy for public, it is necessary to involve public members in decision-making and policy formulation activities (Rowe and Frewer, 2004). However, it does not necessarily mean that involving public making decision would enhance public trust. In effective public engagement may increase distrust (Involve and Guide Star UK, 2008). In order to have positive effect of public engagement, the first priority is to enhance trust level.

To facilitate farmers' willingness to supply straw to the biomass power plant, risk perception, trust and farmers' engagement are the vital aspects in the straw supply chain. And trust is the fundamental factor in affecting risk perception and farmers' engagement in straw-supply. However, no research has been conducted on the impact of trust factors on straw-supply in China.

6.3 Study objectives and methods

This study explores the influence effect of trust and farmer- specific factors in straw supply for biomass power plant in China, with particular reference to the two key processes---identifying farmers' risk perception, trust level and willingness in participate straw-supply and facilitating trust-building to improve farmers' willingness in straw-supply. Interview and questionnaire surveys were conducted in September and October in 2014, using random sample of 275 respondents from villages around the National Bio-energy power plant.

Based on a review of the literature, a questionnaire was designed by the authors. There are five kinds of questions in the questionnaire: (1) farmers' perception of trust feeling; (2) farmers' willingness of lowering traction cost if they have trust on middleman; (3) farmers' willingness to participate in the activity of straw-supply; (4) farmers' willingness to keep long-term relationship with middleman to supply straw; (5) farmers' socio-demographic characteristics.

This study adopted several measures to minimize sampling bias. Farmers were selected randomly from different villages. The first group of farmers who supplied crop straw to the middleman was introduced by village committees. Additional farmers were found by asking interviewed farmers whether they knew other farmers who were crop straw suppliers (snowball effect). During the first phase of the study, 50 farmers were interviewed: 15 farmers from a low income village, 20 farmers from a medium income level village, and 15 farmers a high income level village. In the next phase of the study, 300 farmers answered the questionnaires with the assistance of village committees. Finally 275 valid samples were obtained and composed of 189 male and 86 female respondents. The age of the respondents ranged between 35 and 79, with a median age bracket of 45-54.

6.4 Results and discussion

6.4.1. Perceptions of farmers’ straw-supply in Northeast China

Our survey revealed divided views on farmers’ straw-supply. In order to investigate factors that influence farmers’ engagements in straw-supply, risk perceptions of supply crop straw were investigated (**Fig.6.1**). Our results also indicate that a substantial proportion of respondents have high risk perception of straw-supply. Farmers have high personal risk perceptions, such as insufficient time of collecting straw, little profit, distrust towards middleman. However, in terms of environmental risk perception, farmers don’t have low awareness. For example, only 16.4% farmers agree that aerosol can cause health problem. 86.6% farmers don’t realize the bad influence into their next generation caused by fossil fuel and burning straw. In addition, through investigation, we found that trust factors lead to most of risk perception becoming the direct cause of farmers’ low motivation in participating straw collecting activity. For example, farmers’ concern that their farmland being damaged, the middleman may not clear up the farmland causing extra cost, and the middleman may not give payment after they sell their straw. The low trepidation of environment risk perception becomes the indirect cause of farmers’ unwillingness of straw-supply. Therefore, this study focuses on the influence of trust on risk perception, transaction cost, and farmers’ engagement in straw-supply.

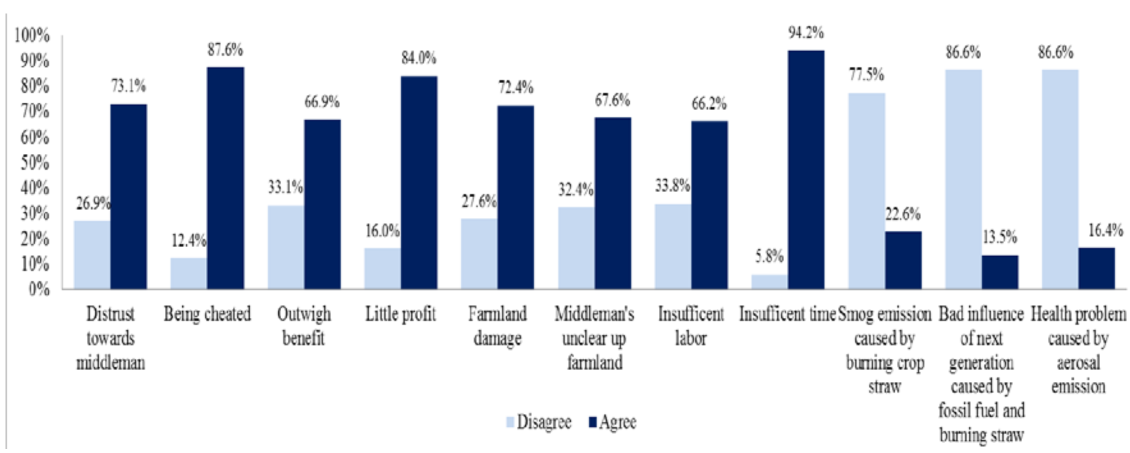

Fig.6.1 Risk perception in crop straw selling engagement

Summary of the responses to the statement "I would not cooperate with middleman mainly because I don't trust agent", "it is risky that agent's collecting straw would bring damage to the farmland", "Middleman cannot clear up the farmland when collecting the crop straw which will cause extra costs.", "It is risky to be arrears of payment or out of pay", "I am afraid that the straw harvesting cost is higher than straw selling price.", "I would like to burn straw in open field instead of selling to agent because the payment is so little that it is not worthy to sell.", "I don't have enough labor to harvest crop straw.", "It really take time to harvest crop straw and I cannot finish harvesting in regulated time.", "I would not burning crop straw in the farmland if I know it can cause air pollution.", "it is risky there is bad influence of next generation caused by fossil fuel and burning straw.", "it is risky that there is health problem caused by aerosol emission?". Responses are expressed as the aggregate percentage of "disagree" and "agree".

6.4.2. Trust

To find out what the respondents trusted and distrusted, their views on three key dimensions were asked in relation to farmers who are the straw-suppliers to the biomass power plant. To assist respondents in comprehending these trust-related concepts, this study provided a set of seven attributes that embody these three dimensions of trust. Indicators are also provided for each attribute. These key dimensions, attributed and indicators of trust were both referenced from the work of Pootinga and Pidgeon (2003) and Walker et al. (2008) and adopted from field survey. They are tabulated in **Table 6.1** below.

Table 6.1. The key dimensions and indicators of trust

Dimensions of trust	**Attributes**	**Indicators**
Distrust in motives	Integrity	The middleman is unable to be honest to obtain more benefit from farmers.
	Care	The middleman couldn't consider farmers' feeling when make price.
	Fairness	The middleman looks down on poor farmers.
	Humble attitude	The middleman's attitude is not good when trading with farmers.
Distrust in transparency	Openness	The middleman's purchasing price of straw is not open to farmers.
	Credibility	The middleman hardly fulfills his commitment.
Distrust in competency	Competence in terms of professional knowledge and technical expertise	The middleman doesn't have ability to deal with conflict with a modest approach.
		The middleman doesn't have ability to help farmers.

In relation to trust in motives, the results indicate that more than half of the respondents disagreed that the middleman has the trust characteristics (**Fig.6.2**). Especially, the attributes of humble attitude, competence of handling conflict, equal treatment, and transparence with disagreement of 57.09%, 56.0%, 57.8%, 57.5%, respectively, have the higher level of farmers' satisfaction. More than half of the respondents disagreed that the middleman could consider their situation (the "care" attribute), at 52.73%. 51.27% of respondents cannot rely on the middleman to keep promise based on their experiences (the "credibility" attribute). In terms of moral integrity attribute, 45.45% of respondents disagree that the middleman is an integrity person, and 34.91% of respondents have no preference opinions.

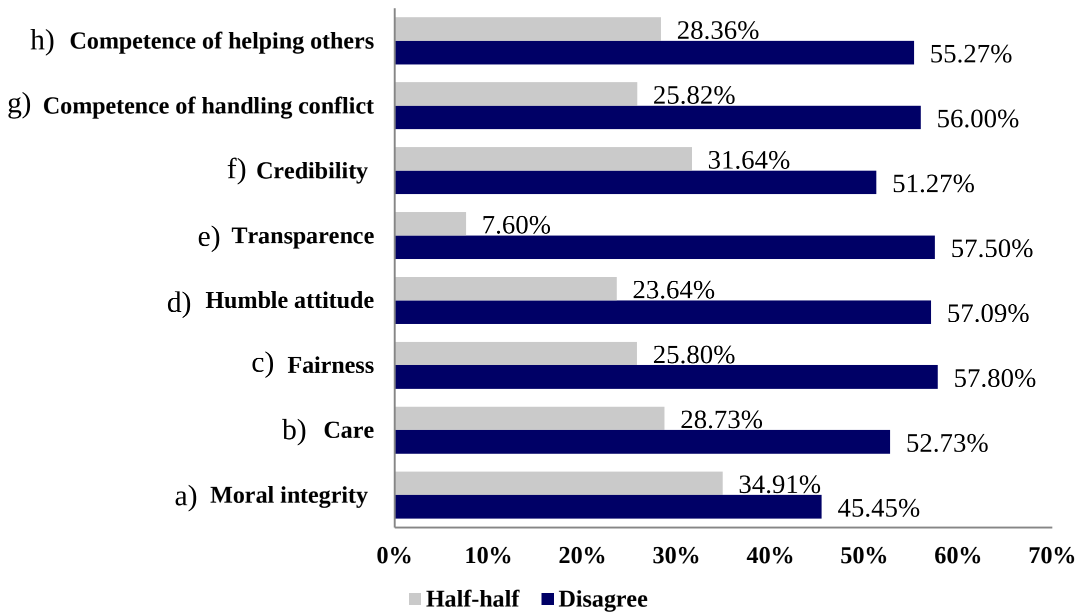

Fig. 6.2 Farmers 'perception of trust attributes

Summary of responses to the questions" To what extent do you agree or disagree with the following statement" (a) The middleman is an integrity person and reliable to trade with. (b) The middleman considers my situation and feeling, and tries to consider things in my position. (c) The middleman treated me as fair as the other households. (d) The middleman have good attitude when trading with me. (e) The middleman's crop straw purchasing price from other households is transparent to me. (f) Based on experience, I can rely on my middleman with complete confidence to keep their promises to me. (g) The middleman has the ability to deal with conflict with a modest approach. (h) The middleman has the ability to help others. (Expressed as aggregate percentage of "half-half", "disagree" and "strongly disagree" responses.)

Chi-square tests were performed to assess whether the socio-economic characteristics are significantly different among respondents who have different trust feelings. The results suggest that education (*p*=.000) and annually income (*p*=.000) are significantly different among these four groups of respondents. As shown in **Table 6.2**, people who have received higher level education have higher trust level. On the contrary, most percentage of lower education level respondents, have low level of trust feeling. Respondents of all four groups also tended to have low to moderate income (less than $3266). Another observation is that there 17% of respondents have distrust feeling, and 14% have trust feeling. Most respondents are can sometimes trust and most time trust, 40% and 29%, respectively.

Table.6.2 Selected demographic features by responses to trust level

Demographic features	TRUST LEVEL			
	Distrust (%)	Sometimes can trust (%)	Most time can trust (%)	Always can trust (%)
Share of respondents	17	40	29	14
Gender (*p*=.968)				
Female	22	37	27	14
Male	19	39	30	13
Education* (*p*=.000)**				
Illiterate	38	55	7	0
Primary school 1-2 years	44	50	2	4
Primary school over 3 yeas	12	57	28	3
Middle school	4	16	56	24
High school	2	12	49	37
Age (*p*=.325)				
35-44	13	30	39	18
45-55	16	37	32	15
>55	36	49	10	5
Annually income* (*p*=.000)**				
Less than $3266	43	52	5	0
Between $3267 and $5717	13	45	40	2
More than $5718	0	13	42	45

*** Indicates <0.001 significance level in chi-square test with p-value in the parenthesis.

6.4.3. Statistical analysis

Trust has great influencing on farmers' risk perception, perception of lowering transaction cost and farmers' engagement in crop straw supplying. As shown in **Fig.6.3**, farmers with higher trust level, intend to have lower risk perception, higher perception of lowering transaction cost and higher engagement in straw-supply comparing with that of lower trust level.

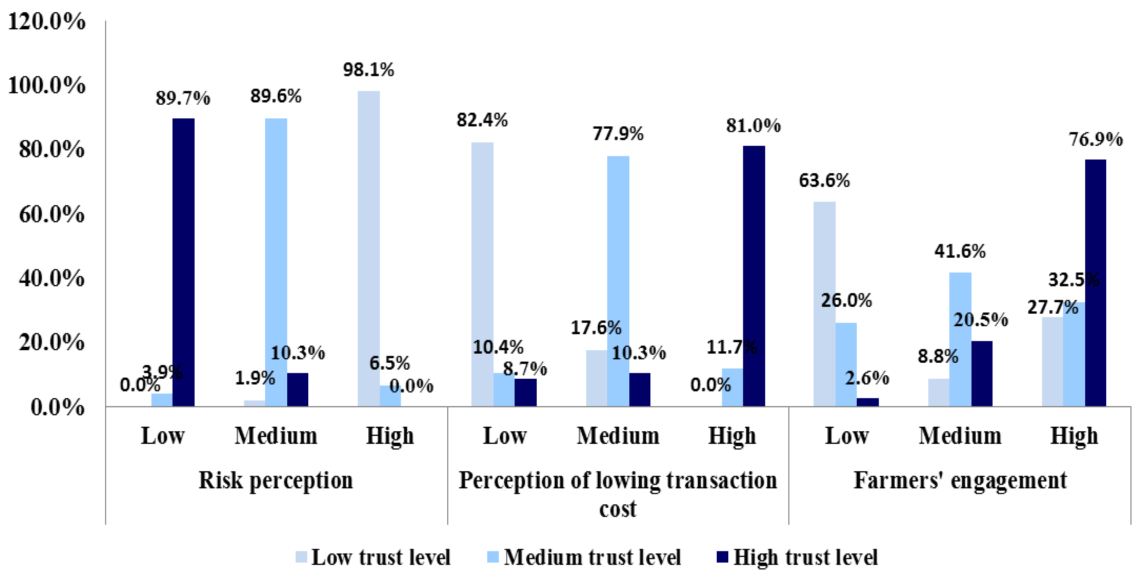

Fig. 6.3 Risk perception, perception of lowing transaction cost, and farmers' engagement influenced by general trust level.

To gain additional insights into the underlying factors affecting risk perception, lowering traction cost, as well as farmers' engagement in straw-supply, statistical analysis (multiple regression analysis) were conducted. **Table 6.3** below describes the variables of demographics, trust, perception of lowering transaction cost, and farmers' willingness of engagement in straw-supply that were employed in the multiple regression models. In addition, correlation coefficient between trust attributes, risk perception, perception of lowering transaction cost, and farmers' engagement is displayed in **Table 6.4** which indicates that most factors have high correlation.

Table 6.3 Definition of variables

Dependent variable	**Description**
Risk perception	Respondent's view on the likelihood of him/her being exposed to risk situation, such economic loss. On the scale of 1 (very low) to 4 (very high)
Perception of lowering traction cost	Respondent's view on his/her willingness to lowering the straw traction cost with trust feeling. On the scale of 1 (strongly disagree) to 5 (strongly agree)
Farmers' engagement	Respondent's willingness to participate in straw-supply activities. 1 (strongly disagree) to 5 (strongly agree)
Independent variable	**Description**
Gender	Dummy variable gives "1" to male, and "0" otherwise
Age	Age of respondent in years
Education	Categorized as "1" for illiterate, "2" for primary school 1-2 years, "3" for primary school over 3 years, "4" for middle school, "5" for high school.
Income	The income is calculated with US $.
General trust	Five variables on respondents' general trust feeling in middleman; "1" indicate the least trust and "5" indicated the most trust.
Transparence	Five variables on respondents' trust in the transparence of the middleman "1" indicate the least trust and "5" indicate the most trust.
Equal treatment	Five variables on respondents' trust in the equal treatment of the middleman; "1" indicate the least trust and "5" indicate the most trust.
Competence of handling conflict	Five variables on respondents' trust in the competence of handling conflict; "1" indicate the least trust and "5" indicate the most trust.
Competence of helping others	Five variables on respondents' trust in the competence of helping others; "1" indicate the least trust and "5" indicate the most trust.
Credibility	Five variables on respondents' trust in the credibility; "1" indicate the least trust and "5" indicate the most trust.
Moral integrity	Five variables on respondents' trust in the moral integrity; "1" indicate the least trust and "5" indicate the most trust.
Care	Five variables on respondents' trust in the care; "1" indicate the least trust and "5" indicate the most trust.
Humble attitude	Five variables on respondents' trust in the humble attitude; "1" indicate the least trust and "5" indicate the most trust.

Table 6.4 Descriptive statistics and correlation coefficients between trust attributes, risk perception, perception of lowering traction cost and farmers' engagement

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
General trust	2.42	1.05	1											
Transparence	2.39	1.61	.195**	1										
Equal treatment	2.30	1.22	.645**	.411**	1									
Competence of handling conflict	2.52	0.99	.577**	.103	.461**	1								
Competence of helping others	2.38	0.96	.436**	.080	.324**	.592**	1							
Credibility	2.56	1.04	.762**	.083	.574**	.465**	.384**	1						
Integrity	2.68	1.09	.734**	.121*	.541**	.480**	.380**	.691**	1					
Care	2.60	1.03	.694**	.139*	.606**	.511**	.386**	.605**	.648**	1				
Humble attitude	2.49	1.03	.756**	.187**	.598**	.481**	.329**	.674**	.632**	.605**	1			
Risk perception	3.78	1.09	-.844**	-.223**	-.682**	-.589**	-.486**	-.705**	-.704**	-.718**	-.773**	1		
Farmers' engagement	2.81	1.09	.526**	.085	.355**	.292**	.259**	.578**	.562**	.381**	.402**	-.523**	1	
Perception of lowering transaction cost	2.56	1.05	.846**	.068	.594**	.495**	.367**	.842**	.801**	.628**	.700**	-.746**	.549**	1

*$p<0.05$, **$p<0.01$

Source: author, 2015

6.4.3.1. Factors underlying risk perceptions

This results show that risk perception were affected by demographics, and trust attributes. In relation to the demographic factors, we found that farmers are more likely to regard risk perception of supplying straw as being higher if they have a lower income and less educated (**Table 6.5**). Risk perception of crop straw supplying is also affected by the perceived trustworthiness of the middleman. When farmers were divided into different groups based on trust level, it shows that farmers with medium trust level and high trust level have significant impacts on risk perception of supplying straw. The results also show that a lack of trust is associated with higher risk perception. Specially, the lack of trust in the general trust feeling, transparency, care attribute to the middleman, as well as a perceived lack of humble attitude is all more likely to lead to perceptions of great risks (**Table 6.6**). Among these trust factors, the humble attitude attribute in relation to the middleman (i.e. whether the respondents perceive good attitude and respect while trading the middleman) has the most influence on the likelihood of high risk perception, followed by the care of farmers. Our results suggest that the middleman does play a significant role in shaping farmers' perceptions of risk in crop straw-supply. This may reflect the middleman's direct influence in important ideas of risk management in cooperation with farmers.

Table 6.5 Regressions of demographic factors influencing risk perception, transaction cost and public participant.

Variable	**Risk perception**	**Perception of lowering transaction cost**	**Farmers' engagement**
No. of observations	275	275	275
Adjust R square	.692	.597	.229
F-value	154.700^{***}	102.624^{***}	28.142^{***}
Response=2 (medium trust level 2)	$-.451^{***}$	$.378^{***}$	$.172^{**}$
Response=3 (high trust level)	$-.573^{***}$	$.699^{***}$	$.323^{***}$
education	$-.199^{***}$	$.125^{*}$	$.223^{***}$
Income	$-.128^{**}$	*n.s.*	*n.s.*

*p-value<0.05, **p-value<0.01, ***p-value<0.005

Table 6.6 Regressions of trust factors influencing risk perception, transaction cost and public participant.

variable	Risk perception	Perception of lowering transaction cost	Farmers' engagement
No. of observation	275	275	275
Adjusted R square	.681	.844	.378
F-value	65.897***	165.885***	19.540***
General trust	-.450***	.386***	*n.s.*
Transparence	-.150***	-.085***	*n.s.*
Credibility	*n.s.*	.364***	.372***
Moral integrity	*n.s.*	.296***	.323***
Care	-.142**	*n.s.*	*n.s.*
Humble attitude	-.218***	*n.s.*	*n.s.*

Note: 1. Only significant variables are displayed in the table
2. *p-value<0.05, **p-value<0.01, ***p-value<0.005

6.4.3.2. Factors underlying perception of lowering transaction cost

Demographics and trust factors are the factors determining farmers' perception of lowering transaction cost but with a slightly different dynamic when compared with the findings relation to risk perceptions. The results show that farmers with high level of education tend to would like to participate in crop straw supplying activities. It is surprising that income is not significant in perception of lowering transaction cost (**Table 6.5**). One probable explanation is that farmers with higher level of education have perception of environmental risk, which is one of the important factors to motivate them to supply their straw. Generally, higher education farmers have higher income, which makes them consider less about the income of selling crop straw. On the contrary, farmers, with higher income and low education level, have lower environmental risk perception. Their only purpose of selling straw is to obtain economic benefit. Besides, without considering environmental problem and economic benefit, these farmers prefer to burn the straw in the open field. Also, the trust level has high positive impact on perception of lowering transaction cost as it is on risk perception (**Table 6.6**).

Regarding trust factors, farmers' willingness to supply crop straw depend on their trust in trust feeling, transparence, credibility and moral integrity of the middleman in the process of collection crop straw (**Table 6.6**). there findings suggest that a high level of distrust in the four aspects is associated with greater opposition to lower transaction cost of crop straw. It would be interesting to note that transparence attribute had the negative impact on perception of lowering transaction cost. It could be explained that one of the reasons that farmers would like to low transaction cost of crop straw is because China is a *Renqing* (a kind of human relationship) society, farmers would like to use lowering transaction cost to accumulate *Renqing* towards the middleman.

6.4.3.3. Factors underlying farmers' engagement in supplying crop straw

The results show that farmers' engagements in supplying crop straw were affected by education level and trust factors. Farmers with higher trust level would like to participate in crop straw collection activity better than low trust level farmers. The results also indicate that farmers with a higher education level tend to support straw-supply (Table 5). In terms of trust factors, farmers' engagement in crop straw depends on their trust in the credibility and the moral integrity (Table 6). The findings suggest middleman's credibility and integrity attitude towards farmers is the critical factor determining the quantity of crop straw in the biomass power plant.

6.4.4 Trust improvement model

With the results of statistical analysis, a trust improvement model is established by connection between risk perception, perception of lowering transaction cost, farmers' engagement in supply straw, demographic characteristic and trust attributed in the conceptual model in Fig. 4. Our model suggests that firstly, demographic characteristics, and trust attribute factors affect farmers' risk perception, perception of lowering transaction cost and farmers' engagement in straw-supply. And secondly, there is a correlation between trust and demographic characteristics, risk perception, perception of lowering transaction cost and farmers' engagement. Correlation between variables, which does not suggest causational relationship, is marked in a dash line in **Fig.6.4** while causational relationships are marked in solid lines.

The model also indicates that demographic characteristics and trust factors influence risk perception, perception of lowering transaction cost and farmers' engagement in different ways. For example, In relation to demographic characteristics, education is the most important factor that influence on risk perception, perception of lowering transaction cost and farmers' engagement. Income is only significant to risk perception. The trust attributes that matter differ in terms of risk perception, perception of lowering transaction cost and farmers' engagement. While it is the perceived trust feeling, transparence, care, and humble attitude that influence risk perception; another combination of trust attributes (including general trust feeling, transparence, credibility, and moral integrity) affect perception of lowering transaction cost. In addition, credibility and moral integrity have impact on farmers' engagement in straw-supply. The findings indicate the significance of trust on farmers' decision making of cooperation with middleman to supply crop straw.

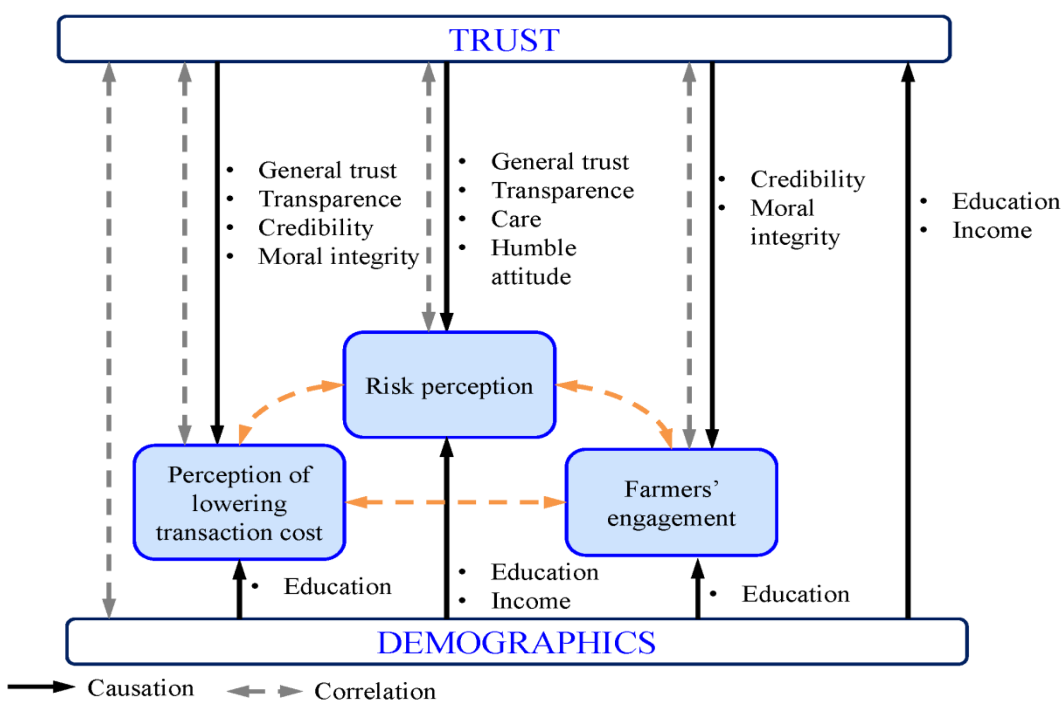

Fig. 6.4 Trust enhancement model in straw-supply

Source: Author, 2015

6.5 Policy implications

This study suggests that in the biomass power industry, to overcome the difficulty of collecting straw, the middleman's behavior is the utmost in building trust with famers. Our findings suggest that the middleman needs to ensure trust building receives as much attention as economic benefit in the process of communication with farmers. The trust improvement model (Fig. 4) specifies those factors of trust that can matter. "General trust", "transparence", "care", and "humble attitude" are the factors that affect risk perceptions, while "general trust", "transparence", "credibility", and "moral integrity" affect the perception of lowering transaction cost. In terms of farmers' engagement, "credibility" and "moral integrity" have high impact. These findings highlight the importance of trust feeling, transparence, credibility and moral integrity.

The second policy recommendation concerns farmers' engagement in crop straw supplying. Because collecting enough quantity of crop straw is critical for the development of biomass power plant. To motivate farmers to participate in this activity is the utmost step for the biomass power plant. As the straw collector, the middleman, plays a vital role between the biomass power plant and the farmers. To enhance farmers' trust towards the middleman, middleman's behavior change and designing mechanisms to ensure farmers' benefit can be improvement approach. Although an emerging body of the energy literature has suggested that public engagement can foster trust (e.g. Mah et al., 2014; Adams et al.), it is important to note that the engagement cannot be regarded as procedural solutions for the distrust (Aegerter and Bucher, 1993). Public engagement may further damage trust in some cases (Mah et al., 2010a). Without the middleman's behavior changing, farmers' engagement may cause even deep distrust leading to less engagement. On the contrary, with solid trust towards middleman, farmers could engage the activity with low risk perception. In this case, the engagement can foster trust. Fostering trust to enhance farmers' engagement can be discussed in the further study.

In this study, we have not ascertained the relationship between risk perception, perception of lowering transaction cost and farmers' engagement, but only focusing on the trust affecting risk perception, perception of lowering transaction cost and farmers' engagement, respectively. By finding the inside relationship among risk perception, perception of lowering transaction cost and farmers' engagement, it would be clear to find the significance of trust in the process of supplying straw.

6.6 Conclusions

This study has explored an under-research field relating to the analysis of decision making of straw-supply to the biomass power plant. We have focused on farmers' attitudes towards supply straw by examining demographic characteristics and trust factors influencing on risk perception, perception of lowering transaction cost and farmers' engagement. The principal findings are:

(1) Farmers around the biomass power plant area perceived high risk of economic loss. However, most of farmers' concerns are limited to personal benefit issues. Only farmers who have received high education concern environmental risk.

(2) Farmers have high levels of distrust in relation to the trust factors. The study also indicates that respondents with high level of trust have lower risk perception, higher perception of lowering transaction cost and higher engagement.

(3) The findings also provide additional insights into the underlying factors affecting risk perception, perception of lowering transaction cost and farmers' engagement. Results of analysis indicates that demographic characteristics and trust are the major factors that explain high risk perception, low perception of lowering transaction cost and low farmers' engagement in straw-supply.

(4) The analysis contributes to the literature on the trust by shedding further light on the complexity of the trust concept. Our conceptual model distinguishes and specifies trust factors that are particularly influential in the contexts of risk perception, perception of lowering transaction cost and farmers' engagement.

(5) To build trust between middleman and farmers, the middleman should behave well, especially, care, credibility, moral integrity are all important factor to improve trust relationship with farmers. In addition, farmers should be educated. With education, farmers could realize the significance of straw-supply.

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CHAPTER 7: PROPOSED RMB MODEL

7.1 Introduction

In line with the analysis on solving biomass supplying problem in biomass power plant in Northeast China, it is clear to see that understanding risk perceptions and motivation that influence behavior is at the heart of changing stakeholders' behaviors and policy-making. As a new industry (biomass power industry), to achieve cooperation among stakeholders, policy making is significant to guidance stakeholders' behaviors. However, this RMB (Risk perception-Motivation-Behavior change) model does not only focus on policy making, in the long-term, changing stakeholders' behavior is the ultimate goal which is also a sustainable approach for the development of biomass power industry. In the RMB model, there are generally three steps to reach the final goal (behavior change). First, risk perception is the fundamental step to behavior change. Accurately and comprehensive investigate stakeholders' risk perceptions and the causation among risk perception is the most important in mitigating risk perception. Second, through investigation and the results of analysis of risk perceptions, the affecting factors of motivation to change can be clear. In the last step, to change stakeholders' behaviors, the factors that affecting motivation should be changed, such as appropriate policy making, regulations, and cooperated partners' behaviors. To fully understand the RMB model, related literature review is as follow.

7.2 Literature review

7.2.1 Risk perception, Motivation and behavior change

Risk is a complex concept which has received considerable interest from academic (i.e.

Beck, 1992; Hardaker et al., 2004; Botterill and Mazur, 2004). The reaction of individuals to particular risk can vary substantially depending on the type of risk that is present (Beck, 1992). For example, Beck (1992) describes how people react differently towards risk posed by natural disasters when compared to those related to 'manufactured' or 'man-made' risks. Maye et al. (2012) argue that it is difficult to change a person's perception of a risk once a value judgement is made. There are a number of factors which influence perceptions of risk. According to Botterill and Mazur (2004), these include the characteristics of the individual facing the risk, the characteristics of the risk itself, as well as the social and environment context in which the risk is placed. Risk perception is usually influenced by a wide variety of factors, such as personal experience, cultural worldviews (Akerlof et al., 2013), socio-demographics and political ideology (Leiserowitz, 2006), trust (Milfont, 2012), knowledge (Sundblad et al., 2007). There are very few studies on risk perception and motivation. Romy (2008) studied on the influence of motivation and risk perceptions on adoption of conservation practice. The result indicates that a sound understanding of farmers' motivations and risk attitudes is required in regional, industry and environmental context.

Regarding motivation, a growing literature distinguishes extrinsic and intrinsic sources of motivation (Ryan and Deci, 2000). Intrinsic motivation is the tendency to engage in tasks because one finds them interesting, challenging, and comfortable. Extrinsic motivation is the tendency to engage tasks because of task-unrelated factors such as the promise of rewards or punishments. Another extrinsic motivator could be the opportunity to gain social admiration or recognition. Therefore, to identify intrinsic and extrinsic motivation could be useful for behavior change.

Positive response to a particular risk is likely to involve a certain type of behavior and understanding the factors that influencing behavior. Behavior and decision making is often influenced by dynamics and social norms especially when decisions relate to commonly owned resources or community interests such as in the case of climate change, water abstraction or disease prevention, when individuals are unlikely to act unless others do so as well (Pike, 2008). Therefore, to change stakeholders' behavior, mitigation of risk perception is vital.

Although there are literature related to risk perception and motivation and behavior, respectively, there is no research on the causation relationship of risk perception, motivation and behavior change.

7.2.2 Theoretical foundation of RMB model

Countless theories of behavior have been developed to fully understand stakeholders' behavior. Most of them fall within the Theory of Reasoned Action (Fishbein and Ajzen, 1975) and the Theory of Planned Behaviors (Ajzen and Madden, 1986), which discuss the main internal and external influences on behavior.

The theory of Reasoned Action suggests that a person's behavior is determined by his or her intention to perform the behavior and that this intention is, in turn, a function of his or her attitude toward the behavior and his or her subjective norm. The best predictor of behavior is intention. Intention is the cognitive representation of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior, this intention is determined by three things: their attitude toward the specific behavior, their subjective norms and their perceived behavioral control. The theory of planned behavior holds that only specific attitudes towards the behavior in question can be expected to predict that behavior. In addition to measuring attitudes toward the behavior, people's subjective norms also needed to be measured. To predict someone's intentions, knowing these beliefs can be as important as refers to people's perceptions of their ability to perform a given behavior. These predictors lead to intention. The conceptual mode is shown in **Fig. 7.1**.

In addition, the detailed reviews of other models by Jackson (2005) and Darnton et al

(2006) illustrate how easy it can be to get diverted by different approaches that focus on slightly different aspects. Dwyer et al (2007) emphasizes the role of advice, knowledge transfer and communication.

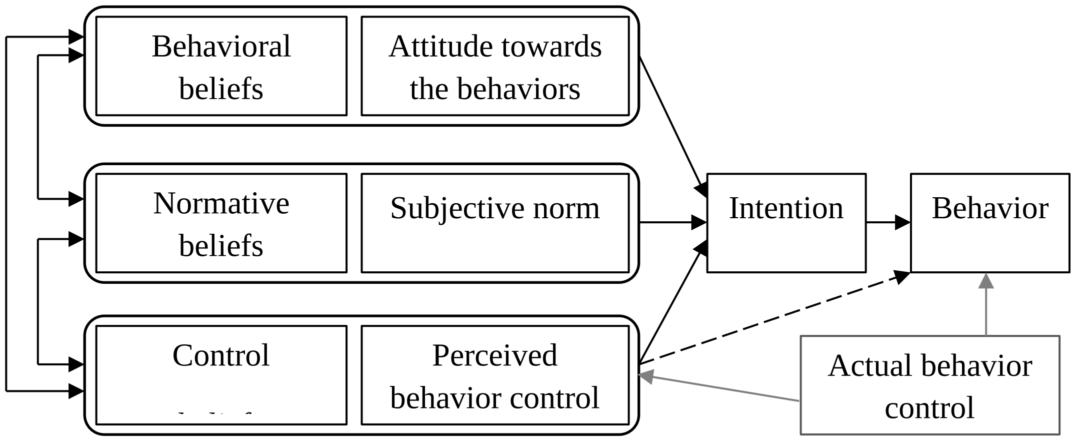

Fig. 7.1 conceptual model

Source: Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, p. 179-211.

As stated before, policy is significant and necessary for a new industry. To explicitly add the policy dimension, a concise behavior approach is contained within "Securing the Future" the UK Sustainable Development Strategy (Defra, 2005). It is argued that for successful and sustainable government intervention needs to be a balanced approach addressing barriers to change through the "4Es", that is, encouraging (incentives and disincentives), enabling (facilitating through addressing infrastructure etc.), engaging (influencing underlying attitudes and motivations) and exemplifying (government taking wider action either on our performance.) Combining the "4Es" and theory of behavior, Pike (2008) proposed a model arguing that in order to fully understand farmers' decisions relating to their practice, it is necessary to explore their underlying attitudes, motivations and objectives. Pike suggests that the intention to undertake a particular behavior is influenced by attitudes, past behaviors, perception of behavior and social factors such as the views of others (**Fig.7.2**). Building on the traditional theory of behavior which identifies attitudes, social factors, past behaviors (internal factor) and external factors (including cost and policy interventions) as being the basic components of behavior. Pike's (2008) model makes an important contribution to the development of behavioral theory as it emphasizes the role of the wider political context and the potential influence of government intervention on individual behaviors.

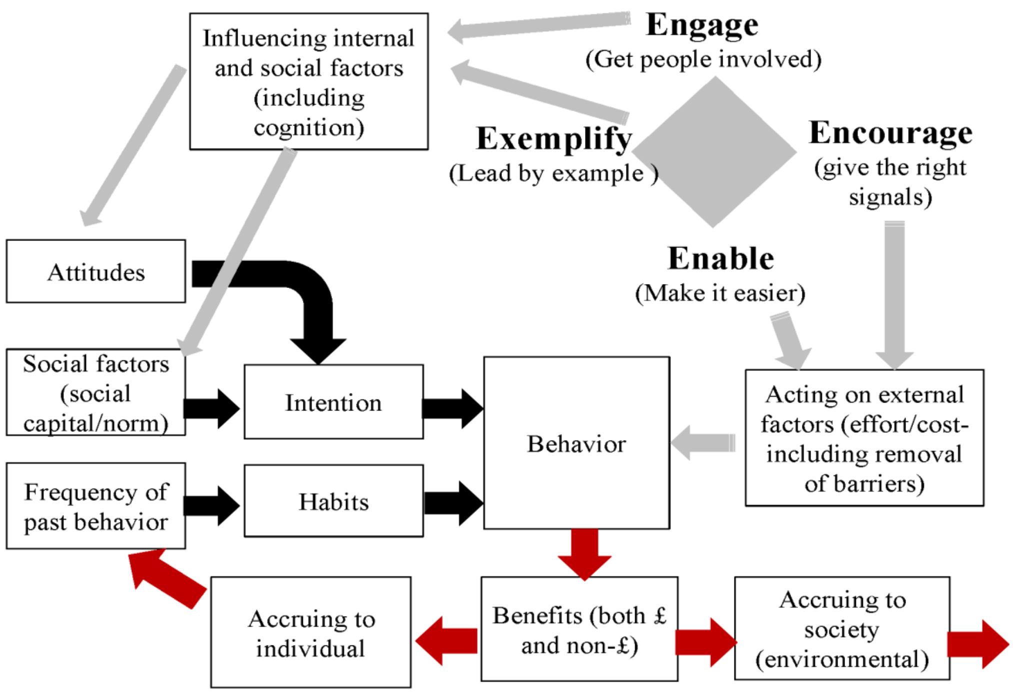

Fig. 7.2 Pike's (2008) integrated approach to influencing farmer behavior

7.3 Proposed conceptual RMB model

Based on the previous model and the analysis of biomass power industry in China, to cooperate stakeholders especially farmers in China, a RMB model is built to highlight the process and the key factors to change farmers' behaviors. The proposed conceptual model is shown in **Fig. 7.3**. In this RMB model, there are generally four steps.

- The first step is to investigate the current situation to find the reasons stakeholders'' unwillingness to cooperative with their partners or organization. Clarifying stakeholders' expectation to their partners and the organization is fundamental to analysis of their risk perceptions. The gap between the reality and stakeholders' expectation could be clear through investigation.

- Based on the investigation data, the second step is to analyze key stakeholders' risk perception and uncertainty. To find the causation relationship between risk perceptions and to assess stakeholders' risk perception are the precondition to choose appropriate approaches to mitigate stakeholders' risk perception.
- Third step is to increase or create motivation to mitigate risk perception. As stated in the literature review, the motivation includes extrinsic and intrinsic motivation. To change from extrinsic motivation to intrinsic motivation, education is a vital role.
- After stakeholder have internal motivation, their behavior can change automatically. The trust relationship, cooperation, long-term relationship and mutual benefit can be realized.

Behavior change can improve the current situation and further mitigate stakeholders' risk perceptions and uncertainty. In this model, risk perception, motivation and behavior change have interactions between each other. High motivation could decrease risk perception. In the contrary, clearly understanding risk perception is the basic to obtain motivation. In terms of behavior change, intrinsic motivation could automatically change stakeholders' behavior. Meanwhile, changed behavior also is one of the sources to enhance the motivation.

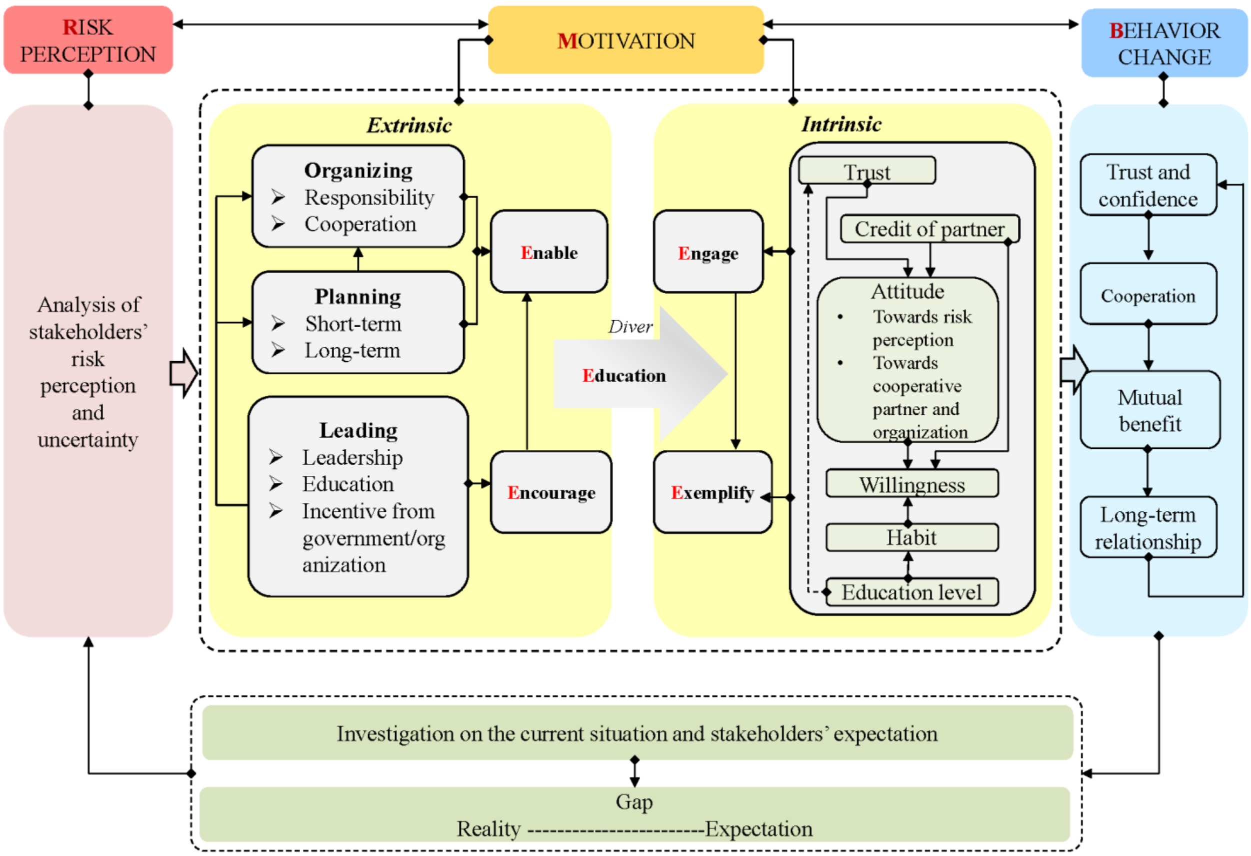

Fig. 7.3 Proposed RMB model

7.4 Discussion of application of RMB model to biomass power industry in Northeast China

New industry development depends on local resources, social, economic, cultural, human, and political factors as well as the coordination of overcoming barriers and disadvantages. In line with the RMB model, the factors which affect the cooperation in the biomass power industry are discussed in the following part.

7.4.1 Farmers' internal and external risk perception affecting factors in supplying straw

In Chapter 4, farmers' risk perceptions, which includes distrust towards middleman, being cheated, outweighing benefit, little profit, farmland damage, middleman's unclean up farmland insufficient labor, insufficient harvest time, smog emission caused by burning crops straw, bad influence of next generation, health problem caused by smog emission and overall risk perception, in supplying straw are stated from investigation. The risk perceptions are affected by political factors, economic factors, trust factors and socio-demographic characteristics. Among them, policy factors and economic factors are external factors while trust factors and socio-demographic characteristics are internal factors, as shown in **Fig. 7.4**. In the developing period of establish cooperation relationship, external factors are even more significant because they have great influential on internal factors before the internal factors become strong. If the external factors have positive affect, the internal factor can expand. On the contrary, if the influence is negative, the internal factors will shrink. In the process of supplying straw, if the process of farmers' supplying straw, it is important to get support from local government's support and obtain their economic benefit from their cooperative partner (middleman). Or it is impossible to build trust. Socio-demographic characteristics, particularly income and education have high impact on farmers' risk perception. Likewise, generally, farmers with high income and education are relatively intelligent people. Without economic insurance, it is hard to make progress in the transaction. Therefore, in the short-term, positive government's policy and economic guarantee is priority in cooperating with farmers. After the trust and farmers' awareness are being fostered and expanded, it is expectable that internal factors could substitute the impact of external factors.

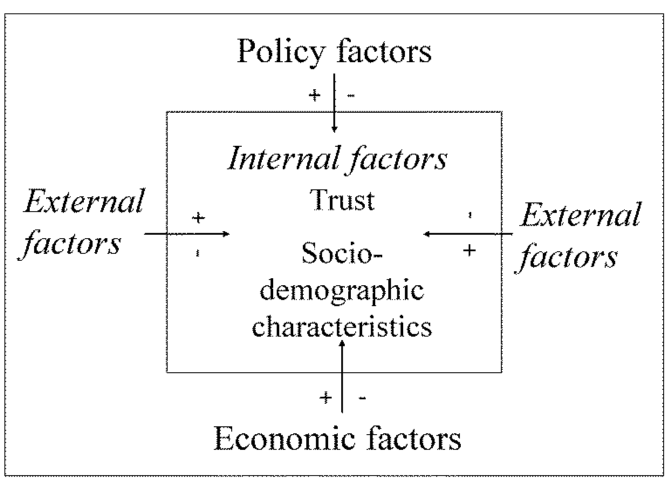

Fig. 7.4 Interaction of internal factors and external factors

Source: author, 2015

7.4.2 Farmers' motivation enhancement in straw supply

As demonstrated in **Fig.7.3**, to enhance the stakeholders' motivation, first to give incentive from outside to push stakeholders' participation is vital. However, to change stakeholders' behavior is the final purpose. In order to achieve the goal, extrinsic motivation should be converted to intrinsic motivation.

7.4.2.1 Extrinsic motivation

In the activity of biomass supplying, encourage (incentive) and enable (make it ease) are the extrinsic motivation. To be specific, to achieve the "2E", leading, planning and organizing are necessary.

(1) Leading

The importance of leading has received great attention both in the field of government and academy. Byrt (1978) defined leadership as "an imprecise, general, emotional, value laden term such as justice, democracy, sin and virtue" (Byrt, 1978). Therefore, leading could be considered as a process, an outcome and as a collection of personal attributes. In this study, leading has two layers of meanings; one is the local government's guidance, another one is middleman's leadership and behavior.

- *Local government's guidance*

  In order to encourage farmers' willingness to supply straw to the biomass power plant, to give knowledge of biomass power generation to the local people is necessary. Knowledge on the process of biomass power generation, the significance of developing biomass power plant, the negative impact of fossil fuel, the adverse impact of burning straw in the open field should be delivered to local farmers. To educate farmers more effectively, organizing a field trip for farmers to visit the biomass power plant is an alternative approach. These education and activities not only could build closer relationship between farmer group and local government, but also could enhance farmers' awareness of significance of straw-supply.

Moreover, to mitigate farmers' economic risk perception, in the short-term, government's incentive to straw-supplier is an effective mean to motivate farmers' willingness to supply straw. In rural China, most people have the characteristic of Chinese Farmerist, which means that only consider their own benefit, stubborn, and reluctant to change. Under this historical characteristic, to change farmers' traditional cogitation of burning straw to modern cogitation of power generation needs local government's efforts and supports.

- *Middleman's leadership and behavior*

In the biomass supply chain, role of middleman is crucial, which connect with the farmers directly. Therefore, the capability and behavior of middleman directly influence farmers' motivation of supply straw and the quantity of biomass for the biomass power plant. To cooperate with farmers, middleman should be generous and considerable towards farmers. Although most farmers have characteristic of farmerist, they also have high personal loyalty and consider about face problem. If farmers consider that middleman could be a valued friend, it would not be a problem to supply straw.

(2) Planning and organizing

In order to facilitate biomass supply chain, both the local government and the biomass power plant including the middleman should make clear plan and put the plan into action. Based on the current situation of supplying straw, short-term and long-term planning should be considered.

- To increase farmers' willingness to cooperate with middleman and the biomass power plant, in the short-term, incentive and education scheme for developing relationship with local farmers is necessary, such as "how to give incentive?", "how to convey the significance of supplying straw?".

- In terms of long-term plan, to obtain farmers' opinions and effectiveness of incentive and education and make further improvement could be the target. In addition, establishment of trust relationship with farmers to get their support would be benefit to local government and farmers, as well as the biomass power plant.

(3) Organizing

- To share responsibility among all stakeholders, such as local government, village committee, middleman and farmers. It is wise to organize all related organizations and people to participate in this activity.
- To reach the goal and the plan, cooperation among the stakeholders and organizations is crucial. To smooth the barriers, as shown in **Fig.7.3**, the important step is to identify stakeholder and organization's risk perception in cooperation with each other.

7.4.2.2 Intrinsic motivation

Extrinsic motivation is power from outside, which is not sustainable. To obtain inside power is the key to keep sustainability. Therefore, intrinsic motivation is considerably important for the sustainability of biomass supply.

From the evidence of supplying biomass in this study, trust has high impact on farmers' participation of supplying straw. As demonstrated shown in **Fig. 7.3**, there are several elements influence intrinsic motivation (engage and exemplify). From the relationship among the elements, trust affects farmers' willingness through attitude. Middleman's behavior (credit of partner) affects both farmers' attitudes and willingness. Farmers' education level has impact on their habit which also influences their willingness. Education level can influence trust level indirectly. In a summary, trust, middleman's behavior, and education level are the key elements influencing engage and exemplify. Therefore, to enhance the intrinsic motivation, in the short-term, middleman's behavior is crucial. In the long-term, building trust and increasing education level are the significant approaches for enhancing farmers' intrinsic motivation in cooperation with middleman.

7.4.2.3 Interaction of extrinsic and intrinsic motivation

As stated before, the sustainable development diamond (4Es) model is developed by Defra, 2005. However, this model emphasizes on the function of government. Based on the 4Es model, to be widely used it in organizations, particularly in rural China; education is included in model, which is called 5Es. Due to situation of supply straw in rural China, both extrinsic and intrinsic motivation should be combined. Education is a crucial role to combine extrinsic and intrinsic motivation. **Fig. 7.5** shows the interactive relations of "5Es".

① Government gives incentive and political support to the local farmers to improve the straw supplying condition. In the biomass power industry, the role of government could not be ignored. Although it is necessary to encourage free market with little intervention of the government, for renewable industry including biomass power industry, government's appropriate intervention is necessary. The role of government's leadership could be emphasized.

② To facilitate the government's incentive and plan, biomass power plant and the middleman should make formal system to realize the plan ultimately. For example, it is recommended to investigate the straw market to make reasonable price and set effective contract with farmers to ensure their benefit.

③ Encourage and enable are both motivation from outside to attract farmers' cooperation. To change extrinsic motivation to intrinsic motivation, education can be the channel. In the short-term, training and educating the knowledge on biomass power generation and the negative impact of burning straw in the open field could enhance farmers' awareness of significance of supplying straw. In the long-term, to enhance education level in rural China should be a strategy of government.

④ After enhancing farmers' awareness, their trust and willingness of supplying straw and cooperation with middleman would increase. It would make them participate in the supplying straw activities automatically.

⑤ With insured benefit and trust and willingness increasing, the straw suppliers demonstrate the advantage of cooperating with middleman, which would attract more farmers to engage this activity.

⑥ In the long-term, with the willingness enhancing, intrinsic motivation will be become stronger, which could gradually substitute the role of government.

From the extrinsic motivation to the intrinsic motivation is top-down support from the government, while the intrinsic motivation expands and substitutes the extrinsic motivation is bottom-up support from farmers. With both combinations, the “5Es” could work effectively.

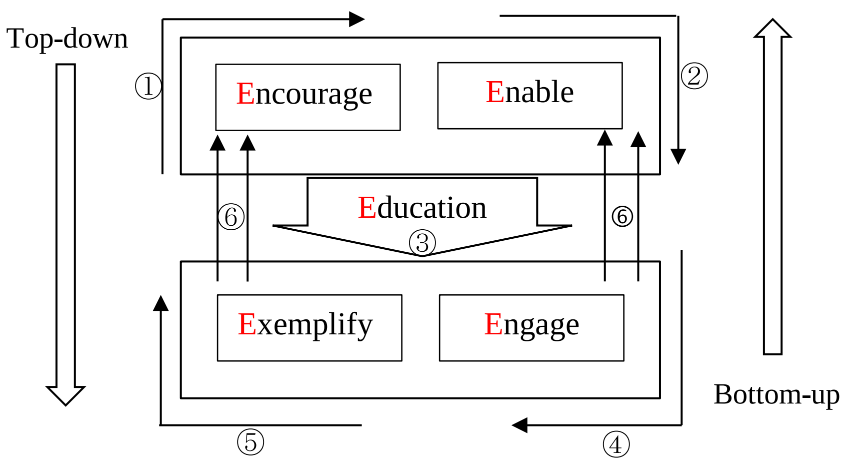

Fig. 7.5 the interactive relations of “5Es”

Source: author, 2015

7.4.3 Behavior change

To change farmers’ behavior, the most difficult barrier is build trust with them. With increasing intrinsic motivation, farmers would be cooperative with middleman and the biomass power plant. The behavior change is gradually and automatically.

7.5 Conclusion

This part of study derived RMB model from the case study of biomass supply chain in Northeast China. There are four steps in this model: first, investigation of the current situation to define stakeholders' dissatisfaction and expectation, which could clarify the gap between the reality and the expectation. Second, to analyze the risk perceptions and uncertainty of stakeholders is the foundation of risk mitigation. Third, giving extrinsic motivation to stakeholders and changing extrinsic motivation to intrinsic motivation are crucial to change behavior. The last step is behavior change which could form with intrinsic motivation increase.

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CHAPTER 8: CONCLUTION AND FUTURE WORK

8.1 Introduction

In a summary, the goal is the study is to solve biomass supply problem from the perspective of mitigating key stakeholders' risk perception. To achieve the goal, there are five parts in this study. First is to analyze the current situation and dilemma in biomass supply chain. Then, after formulating problems in the second part, it is found that farmers' risk perceptions are the crucial cause of insufficient straw supplying. Economic factors and trust factors are the major reasons leading to farmers' risk perception. Therefore, economic incentive strategy was analyzed and proposed based on game theory. However, depending on economic incentive cannot last long. In the long-term, trust between farmers and middleman/biomass power plant should be built. Trust enhancing model was generated in line with the analysis of trust affecting factors. Lastly, an exploratory RMB model was derived from the empirical study expecting to contribute to the biomass power plant industry and other new industry in the future. The following sections introduce detailed conclusions and implication from this study.

8.2 Strategies to mitigating stakeholders' risk perceptions based on the analysis of problem formulation

(1) Building a "farmer-based system

Due to the important role of farmers, a "farmer-based price system" should be promoted to ensure benefits to farmers, which would enhance relations between middleman and farmers as well as enable the whole biomass supply chain to deliver a long-term stable stream of biomass. In order to build "farmer-based system", farmers' benefits should be given high priority in biomass collection system. Building trust with farmers is essential for effectively collecting biomass residues. However, it takes a long time to build trust with farmers. In order to let farmers trust middleman and power plant, the most important step is to give benefit to farmers without cheating. Economic incentive is one of the most important approaches to attract farmers to cooperate with middleman. If government's subsidies transfer partly from power plant to farmers, farmers would have more motivation to cooperate with power plant. Meanwhile, middleman should be the persons who have reputation and trust credibility in local place. Technical service and support from local government, for example, special equipment for quick biomass collection, should be available to assist farmers and agents to attain maximum benefits from the biomass resource utilization business. With the efforts of agent, power plant and local government, increasing number of farmers would prefer to cooperate with agents and power plant. Therefore, in short term, the "farmer-based system" may rely on economy incentive; in long-term, this system will gradually turn to win-win system based on trust.

(2) Achieving agreement between middleman and biomass power plant

Based on studies of the National Bio-Energy power plant, stable and long-term agreement between the middleman and the power plant is critical for ensuring biomass at a reasonable price. An agreement should be signed between middleman and the biomass power plant for the required amount of biomass. For example, the power plant pays 90 percent for the first delivery and the rest during the second delivery. Requirement should be given for the middleman. For example, middleman should have sufficient cash flow to prepay for biomass collection in case emergency happens during crop straw collecting, storage or processing. However, for the power plant, it is also essential to ensure the economic benefit of middleman; otherwise, they will have less motivation to cooperate with the power plant. For example, if middleman achieve the required amount of biomass, it is better for the power plant to give reward to attract middleman. According to the investigation, agents burden substantial amount of risk, they therefore should get equivalent pay back. It seems that more fair profits redistribution system should be built based on risk share.

(3) Establishing policy and regulation framework for biomass supply chain

According to main stakeholders' risk perception, central and local government's policy and regulation is one of effective factors that may improve biomass power plant development. In particular, the biomass power plant's profit relies on the subsidy policy, which means that the profit depends on the amount of subsidy. Nowadays, both central government and local government's policy emphasize the power plant's benefit. However, in the biomass supply chain, middleman and farmers are extremely important. A reliable source of biomass requires long-term guaranteed contracts with biomass suppliers. This was also stressed by middleman and farmers interviewed in this study. Thus, in development of biomass power industry, government should not only consider power plant's profit, but also middleman and farmers' profit. It would be advisable to give incentives to middleman and farmers to encourage them to be cooperators.

8.3 Factors Affecting Farmers' Risk Perceptions of Biomass-Supply and implications for farmers' risk mitigation in biomass-supply

To solve the problem of insufficient biomass supply for biomass power industry, this study conducted a Farmers' Risk perception Of Straw-Supply model (FROSS) by combining and integrating socio-demographic characteristics, policy guidance factors, economic factors and trust factors. The conceptual model was tested empirically on a sample of responses to risk perceptions, by 275 farmers living around a biomass power plant in Northeast China. The model was analyzed comprehensively, as well as vertically (different economic levels of villages) and horizontally (different risk perception dimensions) to determine factors influencing farmers' risk perception of biomass-supply. The results indicate that the full farmers' risk perception of straw-supply model can account for more than 90.9% of the variance in farmers' risk perception of straw supplying. Education level, income, economic factors such as no payment, outweigh benefit, farmland damage cost, and trust factors such as trust of no farmland being damaged, trust of no extra cost caused by unclearing up farmland, trust of no cheating and trust feeling are all significant predictors. Especially, education and income factors can predict 46.7% of farmers' risk perception. The results of vertical analysis show that both economic factors and trust factors are statistically significant. However, policy guidance factors can only predict farmers' risk perception in village with high annual income. Horizontal analysis confirmed by factor analysis that farmers' risk perception can be conceptualized along two dimensions, named: personally and environmentally related risk perception. Based on the study, there are several implications below.

First and foremost, because farmers' risk perceptions of biomass-supply are influenced by socio-demographic characteristics, policy guidance factors, economic factors, as well as trust factors, risk mitigation processes could be effective when not only policy guidance is provided, but also economic loss problems are solved by economic incentives. Then, in the long-term, building trust is vital to solving the biomass-supply problem. Indeed, distrusting factors lead farmers to have lower policy guidance awareness and keep concerning economic factors. For example, through field survey, the authors found that many farmers believe that government would strength punishing rule of burning crop straw in the field instead of giving economic incentive to them regarding the crop straw supply issue. Moreover, farmers keep calculating if risk happens, how much economic loss they may suffer. In addition, the results also show that socio-demographic characteristics are largely various in predicting farmers' risk perceptions; particularly, education and income factors are statistically significant. Enhancing farmers' education levels and increasing income help lower farmers' perceived risk.

However, it takes a long time to increase farmers' education level. In order to mitigate farmers' risk perception, the first step would to make middleman and biomass power plant change their behaviors. Without middleman and biomass power plant's sincere behavior to farmers, farmers would not trust them. Actually, trust is bred from economic factors. If the middleman could ensure that farmers' economic benefit would not be damage in this crop straw collection activity, it is possible for farmers to increase their trust toward middleman.

Second, economic incentive is necessary to motivate farmers to participate in this activity. Here, it is important to note that farmers in different income levels of villages have different risk perception affecting factors. To some extent, the influencing factors have some indirect causal efficacy among the variables. At low income levels, to guarantee farmers' economic benefits (or at least no damage to their economic benefit) is the priority. With economic security, trust feelings, especially to government, can also increase, which can mitigate farmers' risk perceptions. In medium income level villages, economic factors are still important to predict risk perceptions. Therefore, for farmers in low and medium income level villages, economic factors are still dominant.

Third, to increase farmers' awareness of environment, in the long-term, increase education level is significant. In line with the results in this study, in rural China, farmers consider their personal risk instead of the environmental risk. Although economic incentives are necessary in the short-term to guarantee the farmers' benefits, in the long-term, to increase farmers' awareness of the environment is an important task not only for air quality improvement, but also for energy conversion.

8.4 Incentive Effect for China's Straw-based Power Plant Supply Chain under Uncertainty and Risk and economic incentive resources.

As analysis in problem formulation part and farmers' risk perception affecting factors part, currently, economic factors are the most significant in the short-term since farmers are generally considering their personal related risk which are economic factors. Economic incentive is necessary in solving current insufficient biomass problem and in encouraging farmers' engagement in participating selling straw, which are significant for building trust in the future. To give appropriate incentive to farmers, Stackelberg game theory is applied to model biomass supply chain and design incentive scenarios to cooperate stakeholders under risk and uncertainty. The impacts of incentive to the farmer and the middleman were demonstrated. The proposed methodology is illustrated using an empirical case study of China. The results show that with incentive, both the quantity of straw supplied by the farmer and stakeholders' profit will increase. Particularly, incentive to the farmer has remarkable effect. Moreover, perceived risk and uncertainty affects stakeholders' profit dramatically.

To give incentive to farmers, external cost of coal-fire power and biomass power plant are compared to be the resource of farmers' incentive. The results highlight that the external costs of a coal-fired plant are 0.72 US $/kWh, which are extremely higher than that of biomass power plant, 0.00012 US$/kWh. External cost of coal-fired power generation is as much as 90% of the current electricity price generated by coal, while external cost of biomass power plant is 1/1000 of the current electricity price generated by biomass. In addition, for biomass power plant, external cost associated with SO_2, NO_X, and PM are particularly lower than those with coal-fired power plant. Moreover, some estimations of external costs of coal-fired power plants are made with insufficient precision. First, proper metrics have not been developed to represent the impact on water and land which can threaten the living environment in the long run. Second, among pollutants such as fly ash, furnace residue, gangue and contaminated water, there are no international damage cost standards. Third, in the phases of coal mine construction and coal mining, the estimation does not account for recovery and sustainable development costs. Fourth, occupational disease and mortality costs are estimated based on the existing unsound compensation system. With improvement of estimation of external costs of coal-fired power plant, it would be even clearer to identify the significance of development of biomass power plant.

8.5 The significance of role of trust in biomass supply decision-making.

As stated before, in the short-term, economic incentive is necessary to increase farmers' engagement in cooperation with middlemen and biomass power plant. In the long-term, trust is both a bond between farmers and the middlemen and lubricant to decrease conflict in the straw transaction process. In this study, distrust factors are explored in supplying straw. In the relationship of trust, risk perception, lowering transaction cost and engagement, it found that farmers with high level trust have lower risk perception, higher perception of lowering transaction cost and higher engagement. The findings also provide additional insights into the underlying factors affecting risk perception, perception of lowering transaction cost and farmers' engagement. The statistical analysis indicates that demographic characteristics and trust re the major factors that explain high risk perception, low perception of lowering transaction cost and low farmers' engagement in straw-supply. In the trust enhancement model, it is clearly demonstrated that to build trust between middleman and farmers, the middleman should behave well, especially, care, credibility, moral integrity are all important factor to improve trust relationship with farmers. In addition, farmers should be educated. With education, farmers could realize the significance of straw-supply. With these findings, there are several implications bellows:

First, this study suggests that in the biomass power industry, to overcome the difficulty of collecting straw, the middleman's behavior is the utmost in building trust with famers. Our findings suggest that the middleman needs to ensure trust building receives as much attention as economic benefit in the process of communication with farmers. The trust enhancement model specifies those factors of trust that can matter. "General trust", "transparence", "care", and "humble attitude" are the factors that affect risk perceptions, while "general trust", "transparence", "credibility", and "moral integrity" affect the perception of lowering transaction cost. In terms of farmers' engagement, "credibility" and "moral integrity" have high impact. These findings highlight the importance of trust feeling, transparence, credibility and moral integrity.

The second policy recommendation concerns farmers' engagement in crop straw supplying. Because collecting enough quantity of crop straw is critical for the development of biomass power plant. To motivate farmers to participate this activity is the utmost step for the biomass power plant. As the straw collector, the middleman, plays vital role between the biomass power plant and the farmers. To enhance farmers' trust towards the middleman, middleman's behavior change and designing mechanisms to ensure farmers' benefit can be improvement approach. Although an emerging body of the energy literature has suggested that public engagement can foster trust (e.g. Mah et al., 2014; Adams et al.), it is important to note that the engagement cannot be regards as procedural solutions for the distrust (Aegerter and Bucher, 1993). Public engagement may further damage trust in some cases (Mah et al., 2010a). Without the middleman's behavior changing, farmers' engagement may cause even deep distrust leading to less engagement. On the contrary, with solid trust towards middleman, farmers could engage the activity with low risk perception. In this case, the engagement can foster trust. Fostering trust to enhance farmers' engagement can be discussed in the further study.

In this study, we have not ascertained the relationship between risk perception, perception of lowering transaction cost and farmers' engagement, but only focusing on the trust affecting risk perception, perception of lowering transaction cost and farmers' engagement, respectively. By finding the inside relationship among risk perception, perception of lowering transaction cost and farmers' engagement, it would be clear to find the significance of trust in the process of supplying straw.

8.6 Recommendations for future study

(1) In the part of affecting factors of farmers' risk perception, it should be noted that the results of the current study are based on the investigation of farmers' risk perceptions in northeast China. Although in China almost all biomass power plants face the same problem of the lack of raw material, it remains unclear to what extent the results can predict this in other areas or other cultures. The aim of this study was to examine the key impact factors to predict farmers' risk perceptions of the biomass-supply. The list of determinants is based on the literature and investigation, which is certainly not exhaustive. Future research could also constructively build on the current study by further exploring the interrelated nature of policy guidance factors, economic factors, and trust factors.

(2) In the game model part, future research may be conducted in a few directions. First, more sophisticated situations may be considered, such as competition straw among middleman, among biomass power plants. Second, middleman's behaviors change facing straw feedstock companies competing collected straw. The third investigation would consider longer-term contract between the biomass power plant and the middleman, and also between the middleman and the farmer issues, trust issue, and environmental concerns. Then cooperative game model can also be further research to allocate the benefit among stakeholders in the supply chain.

(3) Drawing on the present study, it is worth studying several critical issues related to localization in the future. First, to improve environmental conditions in area where fossil fuel electricity is generated, such as Shanxi Province, Hegang city and Shuang Yashan city in Heilongjiang Province, the full development and utilization of straw residues is significant to replace certain small fossil fuel power plants. Second, farmers' willingness and risk of unwillingness to sell straw and agents' interests should be investigated to build a close co-ordination mechanism among farmers,

agents and power plants. Third, a cooperation mechanism with factories that use crop straw as feedstock is needed to fix a reasonable crop straw price to reduce vicious straw competition and guarantee sufficient crop straw supply. Meanwhile, a construction plan of biomass power plants should be regulated in detail and strictly implemented. These issues are critical for China to design policies to optimize energy structure, utilize agricultural waste and support biomass power development.

(4) Regarding trust part, further development of trust model to facilitate the interaction of stakeholders could be interesting and benefit for cooperation of stakeholders. For the relationship of biomass power plant and the middlemen, to build contract trust is significant to guarantee middlemen's benefit and maintain sustainable straw supplying. To further study the contract trust and goodwill trust is also another approach to identify farmers' trust and set up appropriate regulation to improve trust.

(5) The exploratory RMB model is derived from the case study. To verify whether the exploratory model and strategies in this study would be successfully implemented in other industry. It requires a future empirical study to examine the effectiveness of the model. This study provided hypotheses for further studies.

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APPENDIX

APPENDIX 1: FIELD SURVEYS

1. The first field survey during 18th May – 1st June 2013

1.1 Objectives

- To acknowledge the status of biomass power generation plant in China.
- To acknowledge the situation of biomass power generation plant in Heilongjiang province.
- To identify the key stakeholders in biomass power generation industry.
- To acknowledge the risk and benefit of each stakeholder in the industry

1.2 Survey activities

Investigating location: Wangkui Town in Heilongjang Province

Investigation people: The National Bio-energy Power Plant

Equipment suppliers

Straw suppliers (farmers)

Government officers

The investigation method: Interview

Investigation contents:

- The government policy to biomass power plant.
- The future policy to biomass power plant.
- The reason that the enterprise cannot get profit.
- The situation of the biomass power plant.
- The relationship among stakeholders.
- What each stakeholder can get from the biomass power enterprise now? What do they intend to get in the future?
- What is the risk of each stakeholder?
- What do they intend to do with the risk?

- What is the conflict between stakeholders?
- Clarify the organization structure

2. The second field survey during 18th May – 1st June 2013

2.1 Objectives

- To identify the relationship of the key stakeholders in the biomass supply chain (the biomass power plant, middlemen and farmers).
- To identify the risk perceptions of the three stakeholders
- To explore key barrier of development of biomass power plant.
- To identify the relationship of stakeholders' risk perception in order to dig the root problems.
- To explore the key stakeholder that weakens the supply chain.

2.2 The specific target data

Stakeholder	Expecting data
The local government	The policies and regulations that related biomass power plant.
	The local management regulations regarding biomass power plant.
	The subsidy to biomass power plant.
	Comparing to coal-fired power plant, the advantages of biomass power plant from economic, social and environmental perspectives.
	The problems in developing biomass power plant.
	The restrictive factors in developing biomass power plant in China
Biomass power plant	The basic situation of Wangkui County, Heilongjiang Province.
	The advantages of Wangkui County in developing biomass power plant.
	Risk and benefit in developing biomass power plant
	The benefit conflict among biomass power plant, middlemen and farmers.
	The problems of biomass power plant.
	The restrictive factors in developing biomass power plant in China.
Farmers	The benefit that farmers can obtain from biomass power plant
	The risk that farmers facing related supplying straw
	The reason that farmers don't want to cooperate with biomass power plant.

2.2 Survey activities

Date	Research Activities	Place
Arrival Day 29 July 2013	-	
29 July 2013	Survey	Biomass power plant, local government and villages
1 August 2013	Discussion with Profession in biomass field	Harbin
2 August 2013	Interviewing the local government	Wangkui County
3 August 2013	Interviewing the factory director and middlemen	Wangkui County
4-8 August 2013	Interviewing farmers who supply straw and farmers who don't supply straw	Villages around biomass power plant in Wangkui County
Returning Day 11August	-	-

(1) Interview the key stakeholders in the biomass supply chain, the biomass power plant middleman and farmers.

Fig. A-1.1 Field survey in biomass power plant
Source: Taken by author, (August, 2013)

Fig. A-1.2 Field survey in biomass power plant
Source: Taken by author, (August, 2013)

Fig. A-1.3 Interview with middleman
Source: Taken by author, (August, 2013)

Fig. A-1.4 Interview with local government
Source: Taken by author, (August, 2013)

Fig. A-1.5 Interview with farmers
Source: Taken by author, (August, 2013)

Fig. A-1.6 Interview with farmers
Source: Taken by author, (August, 2013)

3. The second field survey during 24th September – 12nd October 2014

3.1 Objectives

(1) To identify the role of trust in the purchasing crop straw from farmers.

(2) To identify the influence of trust on transaction cost of crop straw.

- The relationship between trust and transaction cost
- How much can trust economize transaction cost
- Which trust criteria influence transaction cost most

(3) To clarify the bargaining process between agents and farmers.

3.2 Survey activities

September 24th ------October 12th	
September 24th	Leaving Kochi
September 25th	Visiting Prof. Zhang Caihong in Beijing Forestry University
September 26th	Visiting Prof. Zhang in Harbin Institute of Technology
September 27th	Visiting seniors
September 28th	Visiting Wangkui County (Talking with Mr. Wang)
September 29th ----October 6th	Interviewing with middleman and farmers
October 7th -----October 10th	Holiday
October 11th	Coming back to Japan

In this field survey, farmers were interviewed and questionnaires were sent.

Fig. A-1.7 harvesting
Source: Taken by author, (August, 2013)

Fig. A-1.8 straw processing
Source: Taken by author, (August, 2013)

Fig. A-1.9 Questionnaire survey
Source: Taken by author, (August, 2013)

Fig. A-1.10 Questionnaire survey
Source: Taken by author, (August, 2013)

Fig. A-1.11 Intermview with farmers
Source: Taken by author, (August, 2013)

Fig. A-1.12 Intermview with farmers
Source: Taken by author, (August, 201

APPENDIX 2: RESULTS OF INTERVIEWS WITH STAKEHOLDERS

2.1 Summary of the results of in-depth interview with the director of **National Bio-energy Power Plant.**

Question	Answer
1. How many staff in the factory?	There are around 1500 staffs in the factory.
2. The average salary for each staff per month?	Averagely, the salary is 2000 yuan per month, which is higher in the other local industry in Wangkui County.
3. The capacity of the boiler?	30 MW.
4. How much straw does the power plant consume annually?	Every year the quantity of straw is around 200,000 ton of processed straw.
5. How much percentage water contain in the collected straw?	Before we purchase processed straw from middlemen, we will test the water contain. Our standard is less than 15% of water contain.
6. How many species straw include in biomass?	There are mainly three kinds of straw, corn straw, soybean straw, and rice straw. But corn straw is the main biomass because Wangkui County mainly produces corn. We also collect tree branches if the raw material is not enough.
7. How much does the biomass power plant pay to the middleman per ton of straw?	Averagely, we pay 280 yuan/ton of straw. However, it also depends on the species of raw material. If the raw material is tree branches or corncob, it would be cheaper.
8. How many electricity does the power plant generate?	Annually, the power plant generates 200,000,000 kwh electricity.
9. What is the price of electricity per kwh selling to the State Grid?	Now the electricity price generated by renewable energy is 0.75 yuan/kwh.
10. What is the price of electricity generated by coal-fired power plant?	It is 0.50 yuan/kwh.
11. How much is the subsidy to the biomass power plant per kwh?	Generally, we have subsidy 0.25 yuan/kwh from the government after we generate electricity. Also we can obtain 26,000,000 yuan from CDM project.
12. How many hours does the biomass	We generate electricity 24 hour every day.

power plant generate electricity?	
13. What is the ideal situation for biomass power plant?	The ideal situation is we could have sufficient qualified raw material.
14. What is the gap between the ideal situation and the current situation?	Now it is hard for us to collect straw. Besides, the price of straw increases every year.
15. Now, whether there are raw material competitors?	Until now, our factory is the biggest straw consumer. Other straw competitors have less ability to compete with us.
16. How does the factory set up relationship with the middleman?	Actually, the factory invest 200,000 to 300,000 yuan to each middleman to support their machines. There are 300 to 400 workers for each middleman.

2.2 Summary of the results of interview with **middlemen**

Question	**Answer Summary**
1. After collecting straw from farmers, what will you with the straw? How much is the cost?	After we collect straw, we process the straw and store it. The labor cost of processing, the oil consuming cost, paling cost and transportation cost are around 230 yuan/ton.
2. How much do you pay for the farmers per ton of straw?	Averagely, the salary is 2000 yuan per month, which is higher in the other local industry in Wangkui County.
3. When do you begin to collect straw from farmers?	We begin to collect straw at the beginning of November. Farmers begin harvest in the middle of October.
4. Do the farmers like to sell their straw?	Not all farmers are willingness to sell straw to us, because their benefit may destroy when middlemen collecting straw, such as destroy their farmland.
5. What kind of risk do you face in collecting straw?	Because we have to store the straw before the factory purchased it. In winter, we have to prevent fires. There are also production safeties such as high-tension line, high place, big machine. People may get injured if they are not careful. In addition, the road condition is not good and the labor cost become higher and higher.
6. Is it easy to collect straw in the farmland?	No. First because of the limited collecting time. Second, the collecting area is so big. Third, some farmers are not cooperative, which cause us difficulty to collect straw and high price.

2.3 Summary of the results of interview with **farmers.**

Question	Answer Summary
1. How much can you get from selling straw to the middleman per ton?	The price is various. a. If the straw is clean without soil and water contain is low, usually the price it 30 yuan/ton. b. If the straw contains soil and water, the price will be lower, around 10 yuan/ton. c. If farmers are not cooperative with the middleman, and middleman really wants to purchase the straw, the price is high, around 40 to 50 yuan/ton. d. If the middleman has good relationship with farmers or they know each other for long time, farmers are willingness to sell their straw with low price or free. e. If middleman would harvest the straw in the farmland by themselves, middleman doesn't need to pay the straw.
2. How do you deal with straw if you don't sell it?	There are many way to deal with the straw a. Usually, in winter, farmers use straw to heat houses. However, in recent years, the farmers' life level becomes higher than before. Many farmers use coal or gas to heat house. More straw is distributed in the farmland. b. If the house-hold has cattle or other livestock, they will use some straw to feed livestock. c. Since the local government has regulation of cleaning up farmland in autumn, usually farmers burn the extra straw in the farmland.
3. Why do you burn the straw in the farmland?	There are several reasons a. There is not insufficient labor to harvest the straw. b. There autumn cleaning up time is limited and farmland is huge. c. It costs labor cost if we hire people to harvest straw and it is not worthy. d. The weather is cold in autumn; it is hard to harvest in the farmland. e. Burning the straw in the farmland is the easiest way to deal with the straw.
4. Do you know the danger of burning straw in the farmland? Have you considered about environmental	The answers are various a. I am sorry I don't know. b. I heard from my son who is study in university, but I don't think it

problem?	is truth. c. I heard from my son who is study in university. However, everyone does the same I just follow.
5. Why don't you sell the straw to the middleman? Not only can get profit, but also can clean the farmland.	a. I don't know the middleman well, if they collect the straw without paying what should I do. b. If the middlemen collect the straw in the farmland be themselves, they may destroy the farmland and it is hard for us to saw in the next year c. The profit of selling the straw is so little that it is not worthy to collect the straw in the farmland and sell it to the middleman. d. Sometimes, the collecting cost is higher than the price that middleman pay to us. e. We don't have enough labor to collect straw.
6. If your relative or friend is a middleman, do you want to sell the straw?	a. Of course, if my relative or friend is a middleman, I just give the straw to them. b. Yes, I don't need to consider ay thing if my relative or friend is a middleman. c. Yes, I can help him collect straw in the farmland if my relative or friend is a middleman.

APPENDIX 3: RESULTS OF STATISTIC ANALYSIS

1.1 Result of hieratical regression analysis

Descriptive Statistics

	Mean	Std. Deviation	N
Risk perception	3.073	.5369	275
Gen	.31	.464	275
real age	51.48	9.465	275
real educarion years	4.43	4.011	275
Inco	4,795.11	2,405.718	275
Policy on economic incentive	2.58	.918	275
Policy on enhancing environmental awareness	2.77	1.046	275
Policy on encouragement in selling straw	2.87	.940	275
Econo_suffer loss	3.00	1.207	275
Econo_Meager profit	3.56	1.120	275
Econo_Farmland damage	3.49	1.151	275
Trust on no farmland damage	3.14	.941	275
Trust on agents' cleaning up farmland	3.24	1.147	275
Trust on no cheating on financial return	3.20	1.271	275
Trust on personal feeling	2.99	1.187	275

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.689[a]	.475	.467	.3919	.475	61.099	4	270	.000
2	.846[b]	.716	.709	.2897	.241	75.695	3	267	.000
3	.929[c]	.864	.859	.2019	.147	95.182	3	264	.000
4	.956[d]	.914	.909	.1615	.050	38.131	4	260	.000

a. Predictors: (Constant), Inco, Gen, real age, real educarion years

b. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness

c. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness, Econo_Meager profit, Econo_Farmland damage, Econo_suffer loss

d. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness, Econo_Meager profit, Econo_Farmland damage, Econo_suffer loss, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Trust on personal feeling

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.527	4	9.382	61.099	.000[b]
	Residual	41.459	270	.154		
	Total	78.985	274			
2	Regression	56.582	7	8.083	96.331	.000[c]
	Residual	22.404	267	.084		
	Total	78.985	274			
3	Regression	68.223	10	6.822	167.344	.000[d]
	Residual	10.763	264	.041		
	Total	78.985	274			
4	Regression	72.202	14	5.157	197.674	.000[e]
	Residual	6.783	260	.026		
	Total	78.985	274			

a. Dependent Variable: Risk perception

b. Predictors: (Constant), Inco, Gen, real age, real educarion years

c. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness

d. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness, Econo_Meager profit, Econo_Farmland damage, Econo_suffer loss

e. Predictors: (Constant), Inco, Gen, real age, real educarion years, Policy on encouragement in selling straw, Policy on economic incentive, Policy on enhancing environmental awareness, Econo_Meager profit, Econo_Farmland damage, Econo_suffer loss, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Trust on personal feeling

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.654	.185		19.767	.000		
	Gen	.061	.051	.053	1.194	.233	.990	1.010
	real age	.001	.003	.010	.192	.848	.748	1.337
	real educarion years	-.054	.007	-.405	-7.353	.000	.642	1.557
	Inco	-8.111E-05	.000	-.363	-6.016	.000	.533	1.877

2	(Constant)	4.453	.147		30.246	.000		
	Gen	-.001	.038	-.001	-.015	.988	.972	1.029
	real age	.001	.002	.015	.401	.689	.745	1.342
	real educarion years	-.024	.006	-.178	-4.072	.000	.559	1.790
	Inco	-3.810E-05	.000	-.171	-3.600	.000	.473	2.116
	Policy on economic incentive	-.136	.024	-.232	-5.722	.000	.647	1.545
	Policy on enhancing environmental awareness	-.166	.022	-.323	-7.450	.000	.564	1.772
	Policy on encouragement in selling straw	-.114	.024	-.200	-4.852	.000	.626	1.597
3	(Constant)	2.642	.149		17.755	.000		
	Gen	.035	.027	.030	1.316	.189	.961	1.041
	real age	-.001	.002	-.017	-.636	.525	.733	1.364
	real educarion years	-.022	.004	-.167	-5.363	.000	.534	1.874
	Inco	-2.424E-05	.000	-.109	-3.249	.001	.462	2.164
	Policy on economic incentive	-.059	.017	-.102	-3.457	.001	.596	1.677
	Policy on enhancing environmental awareness	-.037	.018	-.072	-2.101	.037	.441	2.267
	Policy on encouragement in selling straw	-.029	.017	-.050	-1.660	.098	.571	1.752
	Econo_suffer loss	.176	.017	.396	10.115	.000	.336	2.972
	Econo_Meager profit	.090	.017	.188	5.254	.000	.401	2.493
	Econo_Farmland damage	.049	.018	.104	2.718	.007	.351	2.849
4	(Constant)	3.718	.154		24.209	.000		
	Gen	.018	.022	.016	.857	.392	.954	1.049
	real age	-.002	.001	-.031	-1.435	.153	.730	1.370

real educarion years	-.013	.003	-.099	-3.888	.000	.506	1.976
Inco	-1.835E-05	.000	-.082	-3.005	.003	.441	2.267
Policy on economic incentive	-.027	.014	-.046	-1.911	.057	.560	1.785
Policy on enhancing environmental awareness	-.012	.014	-.023	-.800	.424	.416	2.404
Policy on encouragement in selling straw	.007	.014	.012	.483	.630	.541	1.847
Econo_suffer loss	.075	.016	.168	4.593	.000	.248	4.033
Econo_Meager profit	.054	.014	.113	3.806	.000	.375	2.667
Econo_Farmland damage	.033	.015	.070	2.215	.028	.332	3.010
Trust on no farmland damage	-.059	.018	-.104	-3.221	.001	.318	3.147
Trust on agents' cleaning up farmland	-.035	.014	-.074	-2.449	.015	.358	2.792
Trust on no cheating on financial return	-.071	.013	-.168	-5.362	.000	.336	2.977
Trust on personal feeling	-.113	.016	-.249	-7.090	.000	.267	3.747

a. Dependent Variable: Risk perception

1.2 Results of regression analysis in three different income levels

Descriptive Statistics

Village_level		Mean	Std. Deviation	N
poor	Risk perception	3.548	.2280	92

	Gen	.30	.463	92
	real age	54.38	10.929	92
	real educarion years	.76	1.180	92
	Inco	2,756.03	984.395	92
	Econo_suffer loss	3.97	.818	92
	Econo_Meager profit	4.30	.808	92
	Econo_Farmland damage	4.28	.700	92
	Policy on economic incentive	2.00	.756	92
	Policy on enhancing environmental awareness	2.00	.825	92
	Policy on encouragement in selling straw	2.24	.869	92
	Trust on no farmland damage	2.46	.717	92
	Trust on agents' cleaning up farmland	2.25	.807	92
	Trust on no cheating on financial return	2.16	.816	92
	Trust on personal feeling	2.14	.793	92
medium	Risk perception	3.034	.4731	105
	Gen	.31	.466	105
	real age	51.50	8.758	105
	real educarion years	4.45	2.587	105
	Inco	4,918.79	1,941.269	105
	Econo_suffer loss	2.80	1.130	105
	Econo_Meager profit	3.19	1.029	105

	Econo_Farmland damage	2.97	1.156	105
	Policy on economic incentive	2.56	.733	105
	Policy on enhancing environmental awareness	2.97	.914	105
	Policy on encouragement in selling straw	3.07	.847	105
	Trust on no farmland damage	3.33	.873	105
	Trust on agents' cleaning up farmland	3.44	1.009	105
	Trust on no cheating on financial return	3.43	1.208	105
	Trust on personal feeling	3.04	1.208	105
rich	Risk perception	2.564	.3582	78
	Gen	.32	.470	78
	real age	48.03	7.206	78
	real educarion years	8.73	3.425	78
	Inco	7,033.67	2,072.283	78
	Econo_suffer loss	2.14	.864	78
	Econo_Meager profit	3.18	1.125	78
	Econo_Farmland damage	3.27	1.077	78
	Policy on economic incentive	3.28	.836	78

Policy on enhancing environmental awareness	3.42	.876	78
Policy on encouragement in selling straw	3.33	.733	78
Trust on no farmland damage	3.68	.781	78
Trust on agents' cleaning up farmland	4.15	.685	78
Trust on no cheating on financial return	4.13	.873	78
Trust on personal feeling	3.91	.759	78

Model Summary

Village_level		R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
						R Square Change	F Change	df1	df2	Sig. F Change
poor	1	.937[a]	.879	.857	.0863	.879	39.832	14	77	.000
	2	.937[b]	.879	.858	.0858	.000	.036	1	77	.849
	3	.937[c]	.879	.860	.0853	.000	.063	1	78	.803
	4	.937[d]	.878	.862	.0848	.000	.114	1	79	.737
	5	.937[e]	.878	.862	.0846	-.001	.515	1	80	.475
	6	.935[f]	.875	.861	.0849	-.002	1.619	1	81	.207
	7	.934[g]	.872	.860	.0853	-.003	1.745	1	82	.190
	8	.932[h]	.869	.858	.0858	-.003	2.115	1	83	.150
medium	1	.953[i]	.908	.893	.1547	.908	63.080	14	90	.000
	2	.953[j]	.908	.894	.1538	.000	.002	1	90	.967
	3	.953[k]	.907	.895	.1530	.000	.047	1	91	.829
	4	.953[l]	.907	.896	.1523	.000	.092	1	92	.763
	5	.952[m]	.907	.897	.1516	.000	.172	1	93	.679
	6	.952[n]	.907	.898	.1511	.000	.367	1	94	.546
	7	.952[o]	.906	.899	.1506	.000	.365	1	95	.547
	8	.952[p]	.906	.899	.1502	-.001	.563	1	96	.455
	9	.950[q]	.903	.897	.1515	-.003	2.630	1	97	.108

rich	1	.930[r]	.864	.834	.1460	.864	28.596	14	63	.000
	2	.930[s]	.864	.836	.1449	.000	.004	1	63	.949
	3	.930[t]	.864	.839	.1438	.000	.017	1	64	.896
	4	.929[u]	.864	.841	.1427	.000	.034	1	65	.855
	5	.929[v]	.863	.843	.1419	.000	.228	1	66	.635
	6	.928[w]	.862	.844	.1417	-.002	.800	1	67	.374
	7	.927[x]	.859	.842	.1423	-.003	1.570	1	68	.214
	8	.926[y]	.857	.842	.1422	-.002	.957	1	69	.331

a. Predictors: (Constant), Trust on personal feeling, Inco, Gen, real educarion years, Policy on encouragement in selling straw, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Policy on economic incentive, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

b. Predictors: (Constant), Trust on personal feeling, Inco, Gen, real educarion years, Policy on encouragement in selling straw, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

c. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

d. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

e. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

f. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

g. Predictors: (Constant), Trust on personal feeling, Inco, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

h. Predictors: (Constant), Trust on personal feeling, Inco, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

i. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Inco, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

j. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

k. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

l. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

m. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

n. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

o. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss
p. Predictors: (Constant), Trust on personal feeling, real educarion years, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss
q. Predictors: (Constant), Trust on personal feeling, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss
r. Predictors: (Constant), Trust on personal feeling, real educarion years, Inco, Trust on agents' cleaning up farmland, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage
s. Predictors: (Constant), real educarion years, Inco, Trust on agents' cleaning up farmland, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage
t. Predictors: (Constant), real educarion years, Inco, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage
u. Predictors: (Constant), real educarion years, Inco, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage
v. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage
w. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage
x. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage
y. Predictors: (Constant), real educarion years, Trust on no cheating on financial return, Policy on enhancing environmental awareness, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage

ANOVA[a]

Village_level			Sum of Squares	df	Mean Square	F	Sig.
poor	1	Regression	4.156	14	.297	39.832	.000[b]
		Residual	.574	77	.007		
		Total	4.730	91			
	2	Regression	4.155	13	.320	43.430	.000[c]
		Residual	.574	78	.007		
		Total	4.730	91			
	3	Regression	4.155	12	.346	47.609	.000[d]
		Residual	.575	79	.007		
		Total	4.730	91			
	4	Regression	4.154	11	.378	52.509	.000[e]
		Residual	.575	80	.007		
		Total	4.730	91			
	5	Regression	4.150	10	.415	58.055	.000[f]
		Residual	.579	81	.007		

		Total	4.730	91			
	6	Regression	4.139	9	.460	63.844	.000[g]
		Residual	.591	82	.007		
		Total	4.730	91			
	7	Regression	4.126	8	.516	70.969	.000[h]
		Residual	.603	83	.007		
		Total	4.730	91			
	8	Regression	4.111	7	.587	79.748	.000[i]
		Residual	.619	84	.007		
		Total	4.730	91			
medium	1	Regression	21.124	14	1.509	63.080	.000[j]
		Residual	2.153	90	.024		
		Total	23.277	104			
	2	Regression	21.124	13	1.625	68.685	.000[k]
		Residual	2.153	91	.024		
		Total	23.277	104			
	3	Regression	21.123	12	1.760	75.184	.000[l]
		Residual	2.154	92	.023		
		Total	23.277	104			
	4	Regression	21.121	11	1.920	82.819	.000[m]
		Residual	2.156	93	.023		
		Total	23.277	104			
	5	Regression	21.117	10	2.112	91.894	.000[n]
		Residual	2.160	94	.023		
		Total	23.277	104			
	6	Regression	21.108	9	2.345	102.748	.000[o]
		Residual	2.168	95	.023		
		Total	23.277	104			
	7	Regression	21.100	8	2.637	116.315	.000[p]
		Residual	2.177	96	.023		
		Total	23.277	104			
	8	Regression	21.087	7	3.012	133.453	.000[q]
		Residual	2.190	97	.023		
		Total	23.277	104			
	9	Regression	21.028	6	3.505	152.716	.000[r]
		Residual	2.249	98	.023		
		Total	23.277	104			
rich	1	Regression	8.536	14	.610	28.596	.000[s]
		Residual	1.343	63	.021		
		Total	9.879	77			
	2	Regression	8.536	13	.657	31.283	.000[t]
		Residual	1.343	64	.021		
		Total	9.879	77			
	3	Regression	8.536	12	.711	34.408	.000[u]

	Residual	1.344	65	.021		
	Total	9.879	77			
4	Regression	8.535	11	.776	38.091	.000[v]
	Residual	1.344	66	.020		
	Total	9.879	77			
5	Regression	8.530	10	.853	42.365	.000[w]
	Residual	1.349	67	.020		
	Total	9.879	77			
6	Regression	8.514	9	.946	47.122	.000[x]
	Residual	1.365	68	.020		
	Total	9.879	77			
7	Regression	8.483	8	1.060	52.383	.000[y]
	Residual	1.397	69	.020		
	Total	9.879	77			
8	Regression	8.463	7	1.209	59.767	.000[z]
	Residual	1.416	70	.020		
	Total	9.879	77			

a. Dependent Variable: Risk perception

b. Predictors: (Constant), Trust on personal feeling, Inco, Gen, real educarion years, Policy on encouragement in selling straw, Trust on agents’ cleaning up farmland, Trust on no cheating on financial return, Policy on economic incentive, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

c. Predictors: (Constant), Trust on personal feeling, Inco, Gen, real educarion years, Policy on encouragement in selling straw, Trust on agents’ cleaning up farmland, Trust on no cheating on financial return, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

d. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on agents’ cleaning up farmland, Trust on no cheating on financial return, real age, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

e. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on agents’ cleaning up farmland, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

f. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Policy on encouragement in selling straw, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

g. Predictors: (Constant), Trust on personal feeling, Inco, real educarion years, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

h. Predictors: (Constant), Trust on personal feeling, Inco, Trust on no cheating on financial return, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

i. Predictors: (Constant), Trust on personal feeling, Inco, Econo_Meager profit, Econo_suffer loss, Trust on no farmland damage, Policy on enhancing environmental awareness, Econo_Farmland damage

j. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Inco, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents’ cleaning up farmland, Econo_suffer loss

k. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

l. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, real age, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

m. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, Policy on encouragement in selling straw, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

n. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

o. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Econo_Meager profit, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

p. Predictors: (Constant), Trust on personal feeling, Gen, real educarion years, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

q. Predictors: (Constant), Trust on personal feeling, real educarion years, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

r. Predictors: (Constant), Trust on personal feeling, Trust on no farmland damage, Trust on no cheating on financial return, Econo_Farmland damage, Trust on agents' cleaning up farmland, Econo_suffer loss

s. Predictors: (Constant), Trust on personal feeling, real educarion years, Inco, Trust on agents' cleaning up farmland, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage

t. Predictors: (Constant), real educarion years, Inco, Trust on agents' cleaning up farmland, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage

u. Predictors: (Constant), real educarion years, Inco, Gen, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage

v. Predictors: (Constant), real educarion years, Inco, Policy on encouragement in selling straw, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage

w. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage, Econo_Farmland damage

x. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, real age, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage

y. Predictors: (Constant), real educarion years, Inco, Trust on no cheating on financial return, Policy on enhancing environmental awareness, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage

z. Predictors: (Constant), real educarion years, Trust on no cheating on financial return, Policy on enhancing environmental awareness, Econo_suffer loss, Policy on economic incentive, Econo_Meager profit, Trust on no farmland damage

Coefficients[a]

Village_level			Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
			B	Std. Error	Beta			Tolerance	VIF
poor	1	(Constant)	3.389	.171		19.872	.000		
		Gen	.005	.020	.011	.263	.793	.913	1.096
		real age	.000	.001	-.017	-.319	.751	.578	1.729
		real educarion years	.011	.009	.059	1.244	.217	.690	1.448
		Inco	-2.034E-05	.000	-.088	-1.804	.075	.665	1.504
		Econo_suffer loss	.036	.018	.128	2.030	.046	.394	2.541
		Econo_Meager profit	.056	.019	.199	2.983	.004	.352	2.839
		Econo_Farmland damage	.064	.022	.197	2.852	.006	.330	3.029
		Policy on economic incentive	-.003	.015	-.010	-.191	.849	.628	1.594
		Policy on enhancing environmental awareness	-.020	.018	-.073	-1.108	.271	.359	2.786
		Policy on encouragement in selling straw	-.014	.012	-.054	-1.156	.251	.719	1.391
		Trust on no farmland damage	-.057	.020	-.180	-2.804	.006	.382	2.621
		Trust on agents' cleaning up farmland	-.008	.014	-.030	-.608	.545	.662	1.510
		Trust on no cheating on financial return	-.021	.014	-.074	-1.471	.145	.615	1.627
		Trust on personal feeling	-.071	.018	-.248	-4.050	.000	.420	2.381
	2	(Constant)	3.382	.165		20.501	.000		
		Gen	.005	.020	.010	.250	.803	.918	1.089
		real age	.000	.001	-.018	-.346	.730	.587	1.705

	real educarion years	.011	.009	.058	1.237	.220	.714	1.401
	Inco	-2.058E-05	.000	-.089	-1.849	.068	.674	1.485
	Econo_suffer loss	.036	.018	.129	2.052	.043	.394	2.536
	Econo_Meager profit	.056	.019	.200	3.016	.003	.353	2.830
	Econo_Farmland damage	.065	.022	.200	3.007	.004	.351	2.849
	Policy on enhancing environmental awareness	-.020	.018	-.072	-1.099	.275	.365	2.739
	Policy on encouragement in selling straw	-.015	.012	-.056	-1.215	.228	.741	1.349
	Trust on no farmland damage	-.058	.020	-.181	-2.841	.006	.383	2.609
	Trust on agents' cleaning up farmland	-.008	.014	-.030	-.611	.543	.662	1.510
	Trust on no cheating on financial return	-.021	.014	-.075	-1.485	.142	.615	1.626
	Trust on personal feeling	-.072	.017	-.250	-4.148	.000	.429	2.330
3	(Constant)	3.389	.161		21.008	.000		
	real age	.000	.001	-.017	-.337	.737	.588	1.701
	real educarion years	.011	.009	.057	1.229	.223	.717	1.394
	Inco	-2.052E-05	.000	-.089	-1.855	.067	.674	1.484
	Econo_suffer loss	.035	.017	.127	2.049	.044	.399	2.504
	Econo_Meager profit	.056	.019	.199	3.024	.003	.356	2.808
	Econo_Farmland damage	.065	.022	.200	3.028	.003	.351	2.849
	Policy on enhancing environmental awareness	-.020	.018	-.072	-1.111	.270	.365	2.738

	Policy on encouragement in selling straw	-.015	.012	-.057	-1.247	.216	.746	1.340
	Trust on no farmland damage	-.058	.020	-.183	-2.924	.005	.391	2.556
	Trust on agents' cleaning up farmland	-.009	.014	-.031	-.648	.519	.671	1.490
	Trust on no cheating on financial return	-.021	.014	-.073	-1.476	.144	.621	1.611
	Trust on personal feeling	-.072	.017	-.250	-4.185	.000	.430	2.327
4	(Constant)	3.374	.154		21.931	.000		
	real educarion years	.012	.008	.062	1.403	.164	.789	1.268
	Inco	-1.874E-05	.000	-.081	-1.939	.056	.873	1.146
	Econo_suffer loss	.036	.017	.129	2.090	.040	.401	2.492
	Econo_Meager profit	.055	.018	.196	3.022	.003	.361	2.768
	Econo_Farmland damage	.064	.021	.196	3.040	.003	.366	2.730
	Policy on enhancing environmental awareness	-.021	.018	-.075	-1.177	.243	.373	2.683
	Policy on encouragement in selling straw	-.015	.012	-.057	-1.254	.213	.746	1.340
	Trust on no farmland damage	-.058	.020	-.183	-2.934	.004	.391	2.555
	Trust on agents' cleaning up farmland	-.010	.013	-.034	-.718	.475	.690	1.449
	Trust on no cheating on financial return	-.020	.014	-.071	-1.448	.151	.638	1.568

	Trust on personal feeling	-.072	.017	-.251	-4.219	.000	.430	2.325
5	(Constant)	3.363	.153		22.028	.000		
	real educarion years	.012	.008	.063	1.429	.157	.790	1.266
	Inco	-1.988E-05	.000	-.086	-2.091	.040	.897	1.115
	Econo_suffer loss	.036	.017	.130	2.118	.037	.402	2.490
	Econo_Meager profit	.055	.018	.196	3.026	.003	.361	2.768
	Econo_Farmland damage	.064	.021	.198	3.080	.003	.367	2.726
	Policy on enhancing environmental awareness	-.024	.017	-.087	-1.410	.162	.398	2.510
	Policy on encouragement in selling straw	-.015	.012	-.057	-1.272	.207	.746	1.340
	Trust on no farmland damage	-.060	.020	-.189	-3.078	.003	.400	2.503
	Trust on no cheating on financial return	-.020	.014	-.070	-1.448	.151	.638	1.568
	Trust on personal feeling	-.072	.017	-.251	-4.226	.000	.430	2.325
6	(Constant)	3.340	.152		21.947	.000		
	real educarion years	.011	.008	.058	1.321	.190	.795	1.257
	Inco	-2.055E-05	.000	-.089	-2.157	.034	.899	1.112
	Econo_suffer loss	.035	.017	.125	2.034	.045	.403	2.480
	Econo_Meager profit	.056	.018	.199	3.071	.003	.362	2.763
	Econo_Farmland damage	.066	.021	.204	3.177	.002	.369	2.709
	Policy on enhancing environmental awareness	-.028	.017	-.102	-1.689	.095	.415	2.411

	Trust on no farmland damage	-.061	.020	-.192	-3.110	.003	.400	2.500
	Trust on no cheating on financial return	-.021	.014	-.074	-1.510	.135	.640	1.564
	Trust on personal feeling	-.074	.017	-.256	-4.321	.000	.433	2.311
7	(Constant)	3.297	.149		22.089	.000		
	Inco	-1.800E-05	.000	-.078	-1.920	.058	.938	1.066
	Econo_suffer loss	.038	.017	.136	2.228	.029	.411	2.433
	Econo_Meager profit	.056	.018	.198	3.033	.003	.362	2.762
	Econo_Farmland damage	.071	.021	.217	3.400	.001	.378	2.648
	Policy on enhancing environmental awareness	-.024	.017	-.088	-1.470	.145	.428	2.334
	Trust on no farmland damage	-.063	.020	-.198	-3.205	.002	.402	2.486
	Trust on no cheating on financial return	-.020	.014	-.071	-1.454	.150	.640	1.561
	Trust on personal feeling	-.068	.017	-.237	-4.103	.000	.462	2.165
8	(Constant)	3.287	.150		21.900	.000		
	Inco	-1.890E-05	.000	-.082	-2.007	.048	.942	1.061
	Econo_suffer loss	.043	.017	.154	2.548	.013	.428	2.338
	Econo_Meager profit	.052	.018	.184	2.832	.006	.370	2.703
	Econo_Farmland damage	.070	.021	.215	3.351	.001	.378	2.647
	Policy on enhancing environmental awareness	-.028	.016	-.100	-1.675	.098	.437	2.290
	Trust on no farmland damage	-.069	.019	-.218	-3.584	.001	.422	2.368

		Trust on personal feeling	-.072	.016	-.251	-4.379	.000	.475	2.105
medium	1	(Constant)	3.558	.279		12.768	.000		
		Gen	.027	.035	.027	.784	.435	.866	1.155
		real age	.001	.002	.011	.271	.787	.620	1.612
		real educarion years	.008	.007	.046	1.259	.211	.782	1.279
		Inco	4.049E-07	.000	.002	.042	.967	.648	1.544
		Econo_suffer loss	.074	.027	.177	2.739	.007	.246	4.065
		Econo_Meager profit	.012	.023	.026	.532	.596	.423	2.365
		Econo_Farmland damage	.066	.024	.161	2.764	.007	.302	3.316
		Policy on economic incentive	.005	.024	.007	.203	.840	.753	1.328
		Policy on enhancing environmental awareness	.015	.024	.029	.628	.532	.482	2.074
		Policy on encouragement in selling straw	-.010	.026	-.017	-.375	.708	.487	2.054
		Trust on no farmland damage	-.061	.027	-.113	-2.247	.027	.407	2.455
		Trust on agents' cleaning up farmland	-.078	.029	-.167	-2.746	.007	.277	3.611
		Trust on no cheating on financial return	-.071	.022	-.182	-3.302	.001	.337	2.964
		Trust on personal feeling	-.116	.023	-.297	-5.020	.000	.293	3.416
	2	(Constant)	3.562	.266		13.407	.000		
		Gen	.027	.035	.027	.792	.430	.868	1.152
		real age	.001	.002	.010	.281	.779	.753	1.328
		real educarion years	.008	.007	.046	1.273	.206	.787	1.271
		Econo_suffer loss	.074	.027	.177	2.755	.007	.246	4.060

	Econo_Meager profit	.012	.022	.026	.539	.591	.425	2.352
	Econo_Farmland damage	.066	.024	.161	2.785	.007	.304	3.293
	Policy on economic incentive	.005	.023	.008	.217	.829	.786	1.273
	Policy on enhancing environmental awareness	.015	.023	.029	.632	.529	.494	2.024
	Policy on encouragement in selling straw	-.009	.025	-.017	-.379	.705	.522	1.916
	Trust on no farmland damage	-.061	.027	-.113	-2.260	.026	.407	2.455
	Trust on agents' cleaning up farmland	-.078	.028	-.167	-2.765	.007	.277	3.606
	Trust on no cheating on financial return	-.071	.021	-.182	-3.325	.001	.339	2.951
	Trust on personal feeling	-.117	.023	-.298	-5.070	.000	.295	3.391
3	(Constant)	3.560	.264		13.475	.000		
	Gen	.028	.034	.028	.823	.413	.877	1.140
	real age	.001	.002	.011	.303	.763	.759	1.318
	real educarion years	.008	.007	.046	1.293	.199	.789	1.267
	Econo_suffer loss	.075	.027	.179	2.823	.006	.251	3.989
	Econo_Meager profit	.012	.022	.026	.529	.598	.427	2.341
	Econo_Farmland damage	.066	.023	.162	2.829	.006	.306	3.269
	Policy on enhancing environmental awareness	.016	.023	.030	.680	.498	.508	1.970

	Policy on encouragement in selling straw	-.010	.024	-.018	-.412	.681	.531	1.885
	Trust on no farmland damage	-.060	.026	-.110	-2.285	.025	.431	2.320
	Trust on agents' cleaning up farmland	-.078	.028	-.166	-2.773	.007	.281	3.554
	Trust on no cheating on financial return	-.070	.021	-.179	-3.383	.001	.358	2.795
	Trust on personal feeling	-.117	.023	-.299	-5.167	.000	.300	3.335
4	(Constant)	3.600	.228		15.759	.000		
	Gen	.025	.033	.025	.773	.442	.949	1.054
	real educarion years	.008	.006	.044	1.264	.209	.823	1.216
	Econo_suffer loss	.074	.026	.178	2.822	.006	.252	3.971
	Econo_Meager profit	.012	.022	.026	.546	.587	.428	2.336
	Econo_Farmland damage	.067	.023	.162	2.848	.005	.306	3.268
	Policy on enhancing environmental awareness	.016	.023	.030	.683	.497	.508	1.970
	Policy on encouragement in selling straw	-.010	.024	-.018	-.415	.679	.531	1.885
	Trust on no farmland damage	-.059	.026	-.110	-2.285	.025	.432	2.315
	Trust on agents' cleaning up farmland	-.079	.028	-.168	-2.855	.005	.287	3.488
	Trust on no cheating on financial return	-.071	.020	-.182	-3.506	.001	.369	2.710

	Trust on personal feeling	-.117	.023	-.299	-5.186	.000	.300	3.332
5	(Constant)	3.580	.222		16.097	.000		
	Gen	.026	.033	.025	.782	.436	.949	1.053
	real educarion years	.008	.006	.046	1.360	.177	.847	1.181
	Econo_suffer loss	.076	.026	.182	2.951	.004	.260	3.853
	Econo_Meager profit	.013	.022	.029	.609	.544	.436	2.295
	Econo_Farmland damage	.065	.023	.159	2.830	.006	.312	3.207
	Policy on enhancing environmental awareness	.013	.022	.026	.606	.546	.536	1.865
	Trust on no farmland damage	-.061	.026	-.112	-2.363	.020	.438	2.281
	Trust on agents' cleaning up farmland	-.080	.027	-.171	-2.927	.004	.290	3.450
	Trust on no cheating on financial return	-.072	.020	-.184	-3.568	.001	.372	2.691
	Trust on personal feeling	-.117	.022	-.300	-5.226	.000	.300	3.329
6	(Constant)	3.632	.204		17.775	.000		
	Gen	.025	.033	.024	.763	.448	.951	1.052
	real educarion years	.009	.006	.049	1.465	.146	.864	1.158
	Econo_suffer loss	.076	.026	.181	2.944	.004	.260	3.850
	Econo_Meager profit	.013	.022	.029	.604	.547	.436	2.295
	Econo_Farmland damage	.060	.021	.146	2.824	.006	.367	2.728
	Trust on no farmland damage	-.063	.025	-.116	-2.491	.014	.449	2.228
	Trust on agents' cleaning up farmland	-.076	.026	-.162	-2.876	.005	.310	3.226

	Trust on no cheating on financial return	-.072	.020	-.184	-3.584	.001	.372	2.691
	Trust on personal feeling	-.118	.022	-.302	-5.302	.000	.302	3.311
7	(Constant)	3.684	.185		19.945	.000		
	Gen	.024	.032	.024	.750	.455	.951	1.051
	real educarion years	.010	.006	.053	1.624	.108	.900	1.111
	Econo_suffer loss	.075	.026	.180	2.938	.004	.260	3.847
	Econo_Farmland damage	.064	.020	.157	3.234	.002	.415	2.411
	Trust on no farmland damage	-.066	.025	-.121	-2.629	.010	.460	2.173
	Trust on agents' cleaning up farmland	-.079	.026	-.169	-3.077	.003	.324	3.088
	Trust on no cheating on financial return	-.072	.020	-.185	-3.615	.000	.372	2.689
	Trust on personal feeling	-.120	.022	-.306	-5.412	.000	.305	3.275
8	(Constant)	3.713	.180		20.579	.000		
	real educarion years	.010	.006	.053	1.622	.108	.900	1.111
	Econo_suffer loss	.073	.025	.173	2.868	.005	.265	3.772
	Econo_Farmland damage	.063	.020	.155	3.204	.002	.416	2.404
	Trust on no farmland damage	-.066	.025	-.121	-2.646	.009	.460	2.172
	Trust on agents' cleaning up farmland	-.080	.026	-.170	-3.101	.003	.324	3.087
	Trust on no cheating on financial return	-.075	.020	-.192	-3.820	.000	.384	2.602

		Trust on personal feeling	-.119	.022	-.305	-5.410	.000	.305	3.274
	9	(Constant)	3.713	.182		20.410	.000		
		Econo_suffer loss	.073	.026	.174	2.860	.005	.265	3.771
		Econo_Farmland damage	.065	.020	.159	3.271	.001	.417	2.396
		Trust on no farmland damage	-.061	.025	-.112	-2.441	.016	.468	2.138
		Trust on agents' cleaning up farmland	-.075	.026	-.160	-2.911	.004	.328	3.047
		Trust on no cheating on financial return	-.075	.020	-.193	-3.805	.000	.384	2.602
		Trust on personal feeling	-.118	.022	-.301	-5.299	.000	.306	3.267
rich	1	(Constant)	3.414	.305		11.211	.000		
		Gen	-.007	.039	-.009	-.183	.855	.805	1.243
		real age	-.004	.003	-.073	-1.310	.195	.686	1.458
		real educarion years	-.009	.005	-.089	-1.807	.076	.897	1.115
		Inco	-1.400E-05	.000	-.081	-1.423	.160	.666	1.501
		Econo_suffer loss	.059	.026	.143	2.280	.026	.551	1.814
		Econo_Meager profit	.111	.022	.348	5.035	.000	.452	2.212
		Econo_Farmland damage	.021	.025	.062	.829	.411	.384	2.604
		Policy on economic incentive	-.061	.028	-.142	-2.192	.032	.513	1.950
		Policy on enhancing environmental awareness	-.062	.023	-.152	-2.746	.008	.705	1.418
		Policy on encouragement in selling straw	.010	.027	.021	.384	.702	.729	1.373
		Trust on no farmland damage	-.120	.033	-.261	-3.663	.001	.425	2.354
		Trust on agents' cleaning up farmland	.003	.025	.006	.134	.894	.918	1.089

		Trust on no cheating on financial return	-.059	.024	-.144	-2.458	.017	.633	1.581
		Trust on personal feeling	.002	.034	.005	.065	.949	.409	2.444
	2	(Constant)	3.418	.298		11.472	.000		
		Gen	-.007	.039	-.009	-.181	.857	.807	1.238
		real age	-.004	.003	-.073	-1.323	.190	.698	1.432
		real educarion years	-.009	.005	-.089	-1.820	.073	.897	1.114
		Inco	-1.394E-05	.000	-.081	-1.434	.157	.671	1.489
		Econo_suffer loss	.059	.025	.142	2.371	.021	.596	1.678
		Econo_Meager profit	.110	.021	.346	5.342	.000	.505	1.980
		Econo_Farmland damage	.021	.024	.063	.865	.390	.400	2.501
		Policy on economic incentive	-.060	.027	-.141	-2.265	.027	.547	1.827
		Policy on enhancing environmental awareness	-.062	.022	-.151	-2.796	.007	.725	1.379
		Policy on encouragement in selling straw	.011	.026	.022	.407	.685	.756	1.322
		Trust on no farmland damage	-.119	.032	-.260	-3.743	.000	.440	2.275
		Trust on agents' cleaning up farmland	.003	.025	.006	.132	.896	.920	1.087
		Trust on no cheating on financial return	-.059	.024	-.143	-2.482	.016	.638	1.567
	3	(Constant)	3.429	.283		12.137	.000		
		Gen	-.007	.039	-.009	-.183	.855	.808	1.238
		real age	-.004	.003	-.073	-1.332	.188	.698	1.432
		real educarion years	-.009	.005	-.090	-1.875	.065	.918	1.089
		Inco	-1.381E-05	.000	-.080	-1.438	.155	.678	1.475
		Econo_suffer loss	.059	.025	.142	2.388	.020	.596	1.678
		Econo_Meager profit	.110	.020	.345	5.407	.000	.513	1.950
		Econo_Farmland damage	.021	.024	.064	.901	.371	.409	2.448
		Policy on economic incentive	-.061	.026	-.142	-2.298	.025	.550	1.818

	Policy on enhancing environmental awareness	-.062	.022	-.151	-2.815	.006	.728	1.374
	Policy on encouragement in selling straw	.011	.026	.022	.413	.681	.757	1.322
	Trust on no farmland damage	-.119	.031	-.259	-3.787	.000	.447	2.237
	Trust on no cheating on financial return	-.059	.023	-.143	-2.507	.015	.639	1.565
4	(Constant)	3.432	.280		12.247	.000		
	real age	-.004	.003	-.073	-1.338	.185	.698	1.432
	real educarion years	-.010	.005	-.091	-1.974	.053	.962	1.039
	Inco	-1.403E-05	.000	-.081	-1.484	.143	.689	1.451
	Econo_suffer loss	.059	.024	.143	2.474	.016	.614	1.628
	Econo_Meager profit	.109	.020	.344	5.475	.000	.523	1.912
	Econo_Farmland damage	.021	.023	.062	.890	.377	.418	2.391
	Policy on economic incentive	-.061	.026	-.142	-2.324	.023	.551	1.815
	Policy on enhancing environmental awareness	-.061	.022	-.150	-2.830	.006	.733	1.364
	Policy on encouragement in selling straw	.012	.025	.024	.478	.635	.808	1.238
	Trust on no farmland damage	-.119	.031	-.260	-3.826	.000	.448	2.233
	Trust on no cheating on financial return	-.060	.023	-.145	-2.598	.012	.659	1.518
5	(Constant)	3.446	.277		12.438	.000		
	real age	-.004	.003	-.071	-1.311	.194	.703	1.422
	real educarion years	-.010	.005	-.091	-1.979	.052	.962	1.039
	Inco	-1.364E-05	.000	-.079	-1.456	.150	.694	1.440
	Econo_suffer loss	.059	.024	.142	2.473	.016	.615	1.626
	Econo_Meager profit	.110	.020	.346	5.556	.000	.526	1.902
	Econo_Farmland damage	.021	.023	.062	.894	.374	.418	2.391

	Policy on economic incentive	-.062	.026	-.146	-2.409	.019	.559	1.790
	Policy on enhancing environmental awareness	-.060	.021	-.148	-2.814	.006	.739	1.353
	Trust on no farmland damage	-.114	.029	-.248	-3.935	.000	.513	1.950
	Trust on no cheating on financial return	-.060	.023	-.147	-2.641	.010	.661	1.514
6	(Constant)	3.549	.252		14.107	.000		
	real age	-.003	.003	-.067	-1.253	.214	.707	1.415
	real educarion years	-.009	.005	-.089	-1.947	.056	.964	1.037
	Inco	-1.391E-05	.000	-.080	-1.489	.141	.695	1.439
	Econo_suffer loss	.063	.023	.153	2.714	.008	.641	1.560
	Econo_Meager profit	.114	.019	.359	5.946	.000	.557	1.795
	Policy on economic incentive	-.067	.025	-.157	-2.663	.010	.585	1.710
	Policy on enhancing environmental awareness	-.064	.021	-.156	-3.013	.004	.761	1.314
	Trust on no farmland damage	-.119	.028	-.260	-4.239	.000	.539	1.857
	Trust on no cheating on financial return	-.064	.022	-.157	-2.894	.005	.690	1.449
7	(Constant)	3.360	.202		16.616	.000		
	real educarion years	-.009	.005	-.087	-1.897	.062	.965	1.036
	Inco	-7.859E-06	.000	-.045	-.978	.331	.949	1.054
	Econo_suffer loss	.064	.023	.154	2.722	.008	.641	1.559
	Econo_Meager profit	.114	.019	.358	5.904	.000	.557	1.795
	Policy on economic incentive	-.069	.025	-.161	-2.727	.008	.587	1.705
	Policy on enhancing environmental awareness	-.065	.021	-.160	-3.089	.003	.764	1.308
	Trust on no farmland damage	-.119	.028	-.260	-4.219	.000	.539	1.857

	Trust on no cheating on financial return	-.065	.022	-.159	-2.928	.005	.691	1.447
8	(Constant)	3.297	.192		17.212	.000		
	real educarion years	-.009	.005	-.089	-1.934	.057	.966	1.035
	Econo_suffer loss	.065	.023	.157	2.775	.007	.643	1.555
	Econo_Meager profit	.115	.019	.361	5.959	.000	.558	1.791
	Policy on economic incentive	-.069	.025	-.161	-2.723	.008	.587	1.705
	Policy on enhancing environmental awareness	-.061	.021	-.150	-2.955	.004	.795	1.258
	Trust on no farmland damage	-.121	.028	-.264	-4.291	.000	.541	1.849
	Trust on no cheating on financial return	-.066	.022	-.162	-2.973	.004	.692	1.444

a. Dependent Variable: Risk perception

1.3 Results of factor analysis

Rotated Component Matrix[a]

	Component	
	1	2
1.distrust towards agents	.853	.103
3.suffer loss	.856	-.186
5.Farmland damage	.808	-.131
6.Agents' insufficient cleaning up is not sufficient	.728	-.314
7.insufficent labor	.884	-.082
8.insufficent time	.618	-.163

9.aerosal emission caused by burning crop straw	-.162	.871
10 bad influence of next generation caused by fossil fuel and burning straw	-.099	.886
11health problem caused by aerosal emission	-.120	.919

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2
1	.886	-.464
2	.464	.886

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

1.4 Results of two risk perception aspects

(1) Personal risk

Descriptive Statistics

	Mean	Std. Deviation	N
risk_p_mean	3.049	.6766	275
Gen	.31	.464	275
real age	51.48	9.465	275
real educarion years	4.43	4.011	275
Inco	4,795.11	2,405.718	275
Econo_suffer loss	3.00	1.207	275
Econo_Meager profit	3.56	1.120	275

Econo_Farmland damage	3.49	1.151	275
Policy on economic incentive	2.58	.918	275
Policy on enhancing environmental awareness	2.77	1.046	275
Policy on encouragement in selling straw	2.87	.940	275
Trust on no farmland damage	3.14	.941	275
Trust on agents' cleaning up farmland	3.24	1.147	275
Trust on no cheating on financial return	3.20	1.271	275
Trust on personal feeling	2.99	1.187	275

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.902[a]	.814	.804	.2995	.814	81.319	14	260	.000
2	.902[b]	.814	.805	.2990	.000	.074	1	260	.786
3	.902[c]	.814	.805	.2985	.000	.109	1	261	.742
4	.902[d]	.814	.806	.2982	.000	.465	1	262	.496
5	.902[e]	.813	.806	.2981	-.001	.833	1	263	.362
6	.901[f]	.812	.806	.2983	-.001	1.407	1	264	.237
7	.900[g]	.810	.805	.2990	-.002	2.242	1	265	.136

a. Predictors: (Constant), Trust on personal feeling, Gen, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
b. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
c. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
d. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
e. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
f. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
g. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	102.124	14	7.295	81.319	.000[b]
	Residual	23.323	260	.090		
	Total	125.447	274			
2	Regression	102.118	13	7.855	87.881	.000[c]
	Residual	23.329	261	.089		
	Total	125.447	274			
3	Regression	102.108	12	8.509	95.520	.000[d]
	Residual	23.339	262	.089		
	Total	125.447	274			
4	Regression	102.067	11	9.279	104.374	.000[e]
	Residual	23.381	263	.089		
	Total	125.447	274			
5	Regression	101.993	10	10.199	114.801	.000[f]
	Residual	23.455	264	.089		
	Total	125.447	274			
6	Regression	101.868	9	11.319	127.204	.000[g]
	Residual	23.580	265	.089		
	Total	125.447	274			
7	Regression	101.668	8	12.709	142.161	.000[h]
	Residual	23.779	266	.089		
	Total	125.447	274			

a. Dependent Variable: risk_p_mean

b. Predictors: (Constant), Trust on personal feeling, Gen, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

c. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

d. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

e. Predictors: (Constant), Trust on personal feeling, real age, Policy on economic incentive, real educarion years, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

f. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Econo_Farmland damage, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

g. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Inco, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
h. Predictors: (Constant), Trust on personal feeling, real age, real educarion years, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3.994	.285		14.024	.000					
	Gen	.011	.040	.007	.271	.786	-.005	.017	.007	.954	1.049
	real age	-.005	.002	-.077	-2.456	.015	.250	-.151	-.066	.730	1.370
	real educarion years	-.015	.006	-.091	-2.426	.016	-.581	-.149	-.065	.506	1.976
	Inco	-1.606E-05	.000	-.057	-1.418	.157	-.551	-.088	-.038	.441	2.267
	Econo_suffer loss	.113	.030	.202	3.758	.000	.815	.227	.100	.248	4.033
	Econo_Meager profit	.043	.026	.072	1.647	.101	.669	.102	.044	.375	2.667
	Econo_Farmland damage	.033	.027	.057	1.222	.223	.665	.076	.033	.332	3.010
	Policy on economic incentive	-.024	.026	-.033	-.918	.360	-.584	-.057	-.025	.560	1.785
	Policy on enhancing environmental awareness	.009	.027	.014	.341	.733	-.646	.021	.009	.416	2.404
	Policy on encouragement in selling straw	.017	.026	.023	.635	.526	-.568	.039	.017	.541	1.847
	Trust on no farmland damage	-.046	.034	-.064	-1.341	.181	-.740	-.083	-.036	.318	3.147

	Trust on agents' cleaning up farmland	-.066	.026	-.111	-2.488	.013	-.739	-.152	-.067	.358	2.792
	Trust on no cheating on financial return	-.122	.025	-.229	-4.972	.000	-.796	-.295	-.133	.336	2.977
	Trust on personal feeling	-.132	.030	-.232	-4.476	.000	-.819	-.267	-.120	.267	3.747
2	(Constant)	4.007	.280		14.297	.000					
	real age	-.006	.002	-.077	-2.479	.014	.250	-.152	-.066	.732	1.366
	real educarion years	-.015	.006	-.091	-2.424	.016	-.581	-.148	-.065	.506	1.975
	Inco	-1.584E-05	.000	-.056	-1.405	.161	-.551	-.087	-.038	.443	2.255
	Econo_suffer loss	.112	.030	.200	3.759	.000	.815	.227	.100	.252	3.973
	Econo_Meager profit	.043	.026	.072	1.651	.100	.669	.102	.044	.375	2.667
	Econo_Farmland damage	.033	.027	.057	1.222	.223	.665	.075	.033	.332	3.010
	Policy on economic incentive	-.024	.026	-.033	-.917	.360	-.584	-.057	-.024	.560	1.785
	Policy on enhancing environmental awareness	.009	.027	.014	.330	.742	-.646	.020	.009	.417	2.400
	Policy on encouragement in selling straw	.016	.026	.022	.611	.541	-.568	.038	.016	.547	1.828
	Trust on no farmland damage	-.046	.034	-.064	-1.359	.175	-.740	-.084	-.036	.319	3.138
	Trust on agents' cleaning up farmland	-.066	.026	-.112	-2.509	.013	-.739	-.153	-.067	.359	2.784

	Trust on no cheating on financial return	-.122	.025	-.230	-4.988	.000	-.796	-.295	-.133	.336	2.976
	Trust on personal feeling	-.132	.029	-.232	-4.485	.000	-.819	-.267	-.120	.267	3.747
3	(Constant)	4.029	.271		14.847	.000					
	real age	-.006	.002	-.077	-2.474	.014	.250	-.151	-.066	.733	1.365
	real educarion years	-.015	.006	-.089	-2.408	.017	-.581	-.147	-.064	.522	1.915
	Inco	-1.625E-05	.000	-.058	-1.453	.147	-.551	-.089	-.039	.449	2.227
	Econo_suffer loss	.112	.030	.199	3.754	.000	.815	.226	.100	.252	3.963
	Econo_Meager profit	.043	.026	.071	1.634	.104	.669	.100	.044	.377	2.651
	Econo_Farmland damage	.031	.026	.053	1.180	.239	.665	.073	.031	.351	2.849
	Policy on economic incentive	-.023	.026	-.031	-.888	.375	-.584	-.055	-.024	.567	1.764
	Policy on encouragement in selling straw	.017	.026	.024	.682	.496	-.568	.042	.018	.565	1.771
	Trust on no farmland damage	-.047	.034	-.066	-1.399	.163	-.740	-.086	-.037	.322	3.110
	Trust on agents' cleaning up farmland	-.064	.026	-.109	-2.495	.013	-.739	-.152	-.066	.371	2.693
	Trust on no cheating on financial return	-.122	.024	-.229	-4.985	.000	-.796	-.294	-.133	.338	2.962
	Trust on personal feeling	-.131	.029	-.230	-4.480	.000	-.819	-.267	-.119	.268	3.727
4	(Constant)	4.058	.268		15.148	.000					
	real age	-.005	.002	-.076	-2.459	.015	.250	-.150	-.065	.733	1.363

	real educarion years	-.015	.006	-.089	-2.424	.016	-.581	-.148	-.065	.522	1.914
	Inco	-1.542E-05	.000	-.055	-1.388	.166	-.551	-.085	-.037	.454	2.201
	Econo_suffer loss	.111	.030	.197	3.725	.000	.815	.224	.099	.253	3.950
	Econo_Meager profit	.042	.026	.069	1.603	.110	.669	.098	.043	.378	2.644
	Econo_Farmland damage	.031	.026	.052	1.163	.246	.665	.072	.031	.351	2.846
	Policy on economic incentive	-.024	.026	-.032	-.913	.362	-.584	-.056	-.024	.568	1.762
	Trust on no farmland damage	-.044	.033	-.062	-1.325	.186	-.740	-.081	-.035	.327	3.062
	Trust on agents' cleaning up farmland	-.062	.026	-.105	-2.432	.016	-.739	-.148	-.065	.377	2.652
	Trust on no cheating on financial return	-.121	.024	-.227	-4.960	.000	-.796	-.292	-.132	.339	2.953
	Trust on personal feeling	-.129	.029	-.227	-4.437	.000	-.819	-.264	-.118	.271	3.684
5	(Constant)	4.034	.267		15.136	.000					
	real age	-.006	.002	-.079	-2.559	.011	.250	-.156	-.068	.740	1.351
	real educarion years	-.016	.006	-.094	-2.562	.011	-.581	-.156	-.068	.531	1.883
	Inco	-1.706E-05	.000	-.061	-1.557	.121	-.551	-.095	-.041	.467	2.143
	Econo_suffer loss	.110	.030	.196	3.708	.000	.815	.222	.099	.253	3.949
	Econo_Meager profit	.045	.026	.074	1.718	.087	.669	.105	.046	.383	2.611
	Econo_Farmland damage	.031	.026	.053	1.186	.237	.665	.073	.032	.352	2.845
	Trust on no farmland damage	-.050	.033	-.069	-1.510	.132	-.740	-.093	-.040	.337	2.966

	Trust on agents' cleaning up farmland	-.061	.026	-.104	-2.398	.017	-.739	-.146	-.064	.378	2.647
	Trust on no cheating on financial return	-.123	.024	-.231	-5.080	.000	-.796	-.298	-.135	.342	2.922
	Trust on personal feeling	-.131	.029	-.230	-4.512	.000	-.819	-.268	-.120	.273	3.667
6	(Constant)	4.088	.263		15.559	.000					
	real age	-.006	.002	-.078	-2.509	.013	.250	-.152	-.067	.742	1.348
	real educarion years	-.015	.006	-.088	-2.426	.016	-.581	-.147	-.065	.540	1.851
	Inco	-1.640E-05	.000	-.058	-1.497	.136	-.551	-.092	-.040	.468	2.137
	Econo_suffer loss	.119	.029	.213	4.165	.000	.815	.248	.111	.272	3.675
	Econo_Meager profit	.057	.024	.095	2.420	.016	.669	.147	.064	.461	2.167
	Trust on no farmland damage	-.057	.032	-.080	-1.773	.077	-.740	-.108	-.047	.350	2.855
	Trust on agents' cleaning up farmland	-.061	.026	-.104	-2.406	.017	-.739	-.146	-.064	.378	2.647
	Trust on no cheating on financial return	-.127	.024	-.238	-5.278	.000	-.796	-.308	-.141	.348	2.872
	Trust on personal feeling	-.129	.029	-.227	-4.452	.000	-.819	-.264	-.119	.273	3.656
7	(Constant)	3.985	.254		15.679	.000					
	real age	-.004	.002	-.060	-2.094	.037	.250	-.127	-.056	.864	1.157
	real educarion years	-.018	.006	-.106	-3.114	.002	-.581	-.188	-.083	.611	1.637
	Econo_suffer loss	.123	.029	.219	4.287	.000	.815	.254	.114	.274	3.652

Econo_Meager profit	.056	.024	.093	2.358	.019	.669	.143	.063	.462	2.164
Trust on no farmland damage	-.059	.032	-.082	-1.818	.070	-.740	-.111	-.049	.351	2.852
Trust on agents' cleaning up farmland	-.068	.025	-.116	-2.706	.007	-.739	-.164	-.072	.390	2.565
Trust on no cheating on financial return	-.130	.024	-.245	-5.432	.000	-.796	-.316	-.145	.351	2.846
Trust on personal feeling	-.127	.029	-.223	-4.371	.000	-.819	-.259	-.117	.274	3.647

a. Dependent Variable: risk_p_mean

(2) Environmental risk

Descriptive Statistics

	Mean	Std. Deviation	N
risk_envi_mean	1.936	.5794	275
Gen	.31	.464	275
real age	51.48	9.465	275
real educarion years	4.43	4.011	275
Inco	4,795.11	2,405.718	275
Econo_suffer loss	3.00	1.207	275
Econo_Meager profit	3.56	1.120	275
Econo_Farmland damage	3.49	1.151	275
Policy on economic incentive	2.58	.918	275
Policy on enhancing environmental awareness	2.77	1.046	275
Policy on encouragement in selling straw	2.87	.940	275
Trust on no farmland damage	3.14	.941	275
Trust on agents' cleaning up farmland	3.24	1.147	275
Trust on no cheating on financial return	3.20	1.271	275
Trust on personal feeling	2.99	1.187	275

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.447[a]	.200	.157	.5320	.200	4.643	14	260	.000
2	.447[b]	.200	.160	.5309	.000	.003	1	260	.955
3	.447[c]	.200	.163	.5300	.000	.021	1	261	.884
4	.447[d]	.200	.166	.5290	.000	.025	1	262	.875
5	.447[e]	.200	.169	.5280	.000	.064	1	263	.800
6	.446[f]	.199	.172	.5273	-.001	.234	1	264	.629
7	.442[g]	.196	.171	.5274	-.003	1.130	1	265	.289
8	.436[h]	.190	.169	.5281	-.005	1.712	1	266	.192
9	.431[i]	.186	.168	.5286	-.005	1.512	1	267	.220
10	.427[j]	.183	.168	.5286	-.003	1.009	1	268	.316
11	.418[k]	.175	.162	.5302	-.008	2.653	1	269	.105

a. Predictors: (Constant), Trust on personal feeling, Gen, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
b. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
c. Predictors: (Constant), Trust on personal feeling, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
d. Predictors: (Constant), Trust on personal feeling, Policy on economic incentive, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
e. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
f. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
g. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
h. Predictors: (Constant), Trust on personal feeling, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
i. Predictors: (Constant), Trust on personal feeling, Econo_Farmland damage, Inco, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
j. Predictors: (Constant), Trust on personal feeling, Inco, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
k. Predictors: (Constant), Trust on personal feeling, Inco, Trust on agents' cleaning up farmland, Trust on no farmland damage

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.395	14	1.314	4.643	.000[b]
	Residual	73.576	260	.283		
	Total	91.971	274			
2	Regression	18.394	13	1.415	5.019	.000[c]
	Residual	73.577	261	.282		
	Total	91.971	274			
3	Regression	18.388	12	1.532	5.456	.000[d]
	Residual	73.583	262	.281		
	Total	91.971	274			
4	Regression	18.381	11	1.671	5.972	.000[e]
	Residual	73.590	263	.280		
	Total	91.971	274			
5	Regression	18.363	10	1.836	6.586	.000[f]
	Residual	73.608	264	.279		
	Total	91.971	274			
6	Regression	18.298	9	2.033	7.313	.000[g]
	Residual	73.673	265	.278		
	Total	91.971	274			
7	Regression	17.984	8	2.248	8.082	.000[h]
	Residual	73.987	266	.278		
	Total	91.971	274			
8	Regression	17.508	7	2.501	8.968	.000[i]
	Residual	74.463	267	.279		
	Total	91.971	274			
9	Regression	17.086	6	2.848	10.191	.000[j]
	Residual	74.885	268	.279		
	Total	91.971	274			
10	Regression	16.804	5	3.361	12.027	.000[k]
	Residual	75.167	269	.279		
	Total	91.971	274			
11	Regression	16.063	4	4.016	14.283	.000[l]
	Residual	75.908	270	.281		
	Total	91.971	274			

a. Dependent Variable: risk_envi_mean

b. Predictors: (Constant), Trust on personal feeling, Gen, real age, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

c. Predictors: (Constant), Trust on personal feeling, Gen, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss

d. Predictors: (Constant), Trust on personal feeling, Policy on economic incentive, real educarion years, Policy on encouragement in selling straw, Econo_Farmland

damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
e. Predictors: (Constant), Trust on personal feeling, Policy on economic incentive, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
f. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Econo_Meager profit, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
g. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage, Econo_suffer loss
h. Predictors: (Constant), Trust on personal feeling, real educarion years, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
i. Predictors: (Constant), Trust on personal feeling, Econo_Farmland damage, Inco, Policy on enhancing environmental awareness, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
j. Predictors: (Constant), Trust on personal feeling, Econo_Farmland damage, Inco, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
k. Predictors: (Constant), Trust on personal feeling, Inco, Trust on agents' cleaning up farmland, Trust on no cheating on financial return, Trust on no farmland damage
l. Predictors: (Constant), Trust on personal feeling, Inco, Trust on agents' cleaning up farmland, Trust on no farmland damage

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.011	.506		3.976	.000					
	Gen	.010	.071	.008	.142	.887	.026	.009	.008	.954	1.049
	real age	.000	.004	-.004	-.057	.955	-.183	-.004	-.003	.730	1.370
	real educarion years	.015	.011	.102	1.307	.192	.287	.081	.073	.506	1.976
	Inco	2.978E-05	.000	.124	1.481	.140	.332	.091	.082	.441	2.267
	Econo_suffer loss	-.054	.053	-.113	-1.015	.311	-.337	-.063	-.056	.248	4.033
	Econo_Meager profit	-.023	.047	-.045	-.492	.623	-.273	-.031	-.027	.375	2.667
	Econo_Farmland damage	-.045	.048	-.090	-.938	.349	-.292	-.058	-.052	.332	3.010

	Policy on economic incentive	-.011	.047	-.018	-.237	.812	.233	-.015	-.013	.560	1.785
	Policy on enhancing environmental awareness	-.071	.048	-.128	-1.492	.137	.211	-.092	-.083	.416	2.404
	Policy on encouragement in selling straw	.008	.046	.013	.172	.864	.245	.011	.010	.541	1.847
	Trust on no farmland damage	.091	.061	.148	1.502	.134	.341	.093	.083	.318	3.147
	Trust on agents' cleaning up farmland	.083	.047	.164	1.771	.078	.349	.109	.098	.358	2.792
	Trust on no cheating on financial return	.054	.044	.118	1.232	.219	.332	.076	.068	.336	2.977
	Trust on personal feeling	-.132	.052	-.271	-2.520	.012	.246	-.154	-.140	.267	3.747
2	(Constant)	1.998	.451		4.428	.000					
	Gen	.010	.071	.008	.146	.884	.026	.009	.008	.956	1.046
	real educarion years	.015	.011	.102	1.312	.191	.287	.081	.073	.506	1.974
	Inco	3.021E-05	.000	.125	1.624	.106	.332	.100	.090	.514	1.946
	Econo_suffer loss	-.054	.053	-.113	-1.015	.311	-.337	-.063	-.056	.249	4.019
	Econo_Meager profit	-.023	.047	-.045	-.498	.619	-.273	-.031	-.028	.377	2.656
	Econo_Farmland damage	-.046	.048	-.091	-.944	.346	-.292	-.058	-.052	.333	3.002
	Policy on economic incentive	-.011	.046	-.018	-.244	.807	.233	-.015	-.014	.565	1.770
	Policy on enhancing environmental awareness	-.071	.048	-.128	-1.497	.136	.211	-.092	-.083	.416	2.403
	Policy on encouragement in selling straw	.008	.046	.013	.171	.864	.245	.011	.009	.541	1.847

	Trust on no farmland damage	.091	.060	.148	1.505	.133	.341	.093	.083	.318	3.146
	Trust on agents' cleaning up farmland	.083	.047	.164	1.774	.077	.349	.109	.098	.358	2.791
	Trust on no cheating on financial return	.054	.043	.118	1.239	.216	.332	.076	.069	.337	2.969
	Trust on personal feeling	-.132	.052	-.270	-2.524	.012	.246	-.154	-.140	.267	3.745
3	(Constant)	2.008	.444		4.519	.000					
	real educarion years	.015	.011	.102	1.318	.189	.287	.081	.073	.507	1.973
	Inco	3.048E-05	.000	.127	1.650	.100	.332	.101	.091	.519	1.926
	Econo_suffer loss	-.055	.053	-.115	-1.042	.298	-.337	-.064	-.058	.252	3.962
	Econo_Meager profit	-.023	.047	-.045	-.499	.618	-.273	-.031	-.028	.377	2.656
	Econo_Farmland damage	-.046	.048	-.091	-.947	.344	-.292	-.058	-.052	.333	3.002
	Policy on economic incentive	-.011	.046	-.018	-.245	.807	.233	-.015	-.014	.565	1.770
	Policy on enhancing environmental awareness	-.071	.047	-.129	-1.508	.133	.211	-.093	-.083	.417	2.398
	Policy on encouragement in selling straw	.007	.046	.012	.157	.875	.245	.010	.009	.547	1.827
	Trust on no farmland damage	.091	.060	.147	1.503	.134	.341	.092	.083	.319	3.138
	Trust on agents' cleaning up farmland	.082	.047	.163	1.772	.078	.349	.109	.098	.359	2.783
	Trust on no cheating on financial return	.054	.043	.118	1.239	.216	.332	.076	.068	.337	2.968
	Trust on personal feeling	-.132	.052	-.270	-2.529	.012	.246	-.154	-.140	.267	3.745
4	(Constant)	2.017	.440		4.585	.000					

	real educarion years	.015	.011	.102	1.315	.190	.287	.081	.073	.508	1.968
	Inco	3.085E-05	.000	.128	1.687	.093	.332	.103	.093	.528	1.895
	Econo_suffer loss	-.055	.053	-.115	-1.052	.294	-.337	-.065	-.058	.253	3.954
	Econo_Meager profit	-.023	.046	-.045	-.505	.614	-.273	-.031	-.028	.377	2.653
	Econo_Farmland damage	-.046	.048	-.090	-.947	.345	-.292	-.058	-.052	.333	3.002
	Policy on economic incentive	-.012	.046	-.019	-.253	.800	.233	-.016	-.014	.566	1.765
	Policy on enhancing environmental awareness	-.070	.047	-.127	-1.507	.133	.211	-.093	-.083	.431	2.322
	Trust on no farmland damage	.092	.060	.149	1.542	.124	.341	.095	.085	.325	3.078
	Trust on agents' cleaning up farmland	.083	.046	.165	1.796	.074	.349	.110	.099	.362	2.762
	Trust on no cheating on financial return	.054	.043	.119	1.249	.213	.332	.077	.069	.337	2.964
	Trust on personal feeling	-.131	.052	-.269	-2.530	.012	.246	-.154	-.140	.269	3.714
5	(Constant)	2.004	.436		4.596	.000					
	real educarion years	.014	.011	.100	1.297	.196	.287	.080	.071	.514	1.946
	Inco	3.018E-05	.000	.125	1.671	.096	.332	.102	.092	.539	1.854
	Econo_suffer loss	-.056	.053	-.116	-1.060	.290	-.337	-.065	-.058	.253	3.952
	Econo_Meager profit	-.022	.046	-.043	-.484	.629	-.273	-.030	-.027	.381	2.627
	Econo_Farmland damage	-.046	.048	-.091	-.949	.343	-.292	-.058	-.052	.333	3.001
	Policy on enhancing environmental awareness	-.071	.046	-.129	-1.545	.124	.211	-.095	-.085	.435	2.297
	Trust on no farmland damage	.089	.058	.145	1.524	.129	.341	.093	.084	.336	2.975

	Trust on agents' cleaning up farmland	.084	.046	.166	1.817	.070	.349	.111	.100	.363	2.752
	Trust on no cheating on financial return	.053	.043	.116	1.233	.218	.332	.076	.068	.340	2.940
	Trust on personal feeling	-.132	.052	-.270	-2.553	.011	.246	-.155	-.141	.270	3.702
6	(Constant)	1.919	.399		4.813	.000					
	real educarion years	.014	.011	.098	1.278	.202	.287	.078	.070	.515	1.942
	Inco	3.030E-05	.000	.126	1.681	.094	.332	.103	.092	.539	1.854
	Econo_suffer loss	-.056	.052	-.116	-1.063	.289	-.337	-.065	-.058	.253	3.952
	Econo_Farmland damage	-.054	.044	-.108	-1.227	.221	-.292	-.075	-.067	.390	2.567
	Policy on enhancing environmental awareness	-.069	.046	-.125	-1.508	.133	.211	-.092	-.083	.439	2.276
	Trust on no farmland damage	.094	.058	.153	1.633	.104	.341	.100	.090	.346	2.889
	Trust on agents' cleaning up farmland	.085	.046	.169	1.852	.065	.349	.113	.102	.365	2.743
	Trust on no cheating on financial return	.053	.043	.116	1.226	.221	.332	.075	.067	.340	2.939
	Trust on personal feeling	-.128	.051	-.262	-2.511	.013	.246	-.152	-.138	.278	3.592
7	(Constant)	1.647	.306		5.386	.000					
	real educarion years	.014	.011	.100	1.308	.192	.287	.080	.072	.515	1.941
	Inco	3.185E-05	.000	.132	1.772	.078	.332	.108	.097	.543	1.842
	Econo_Farmland damage	-.067	.043	-.133	-1.558	.120	-.292	-.095	-.086	.418	2.393
	Policy on enhancing environmental awareness	-.066	.046	-.120	-1.446	.149	.211	-.088	-.080	.441	2.268

	Trust on no farmland damage	.105	.057	.171	1.864	.063	.341	.114	.103	.359	2.788
	Trust on agents' cleaning up farmland	.092	.046	.182	2.017	.045	.349	.123	.111	.372	2.690
	Trust on no cheating on financial return	.060	.042	.132	1.421	.157	.332	.087	.078	.350	2.859
	Trust on personal feeling	-.111	.049	-.228	-2.297	.022	.246	-.139	-.126	.306	3.266
8	(Constant)	1.530	.293		5.225	.000					
	Inco	4.070E-05	.000	.169	2.441	.015	.332	.148	.134	.633	1.581
	Econo_Farmland damage	-.056	.042	-.110	-1.322	.187	-.292	-.081	-.073	.435	2.298
	Policy on enhancing environmental awareness	-.056	.045	-.100	-1.230	.220	.211	-.075	-.068	.456	2.195
	Trust on no farmland damage	.108	.057	.176	1.911	.057	.341	.116	.105	.359	2.784
	Trust on agents' cleaning up farmland	.098	.045	.195	2.169	.031	.349	.132	.119	.376	2.659
	Trust on no cheating on financial return	.065	.042	.143	1.544	.124	.332	.094	.085	.353	2.836
	Trust on personal feeling	-.103	.048	-.212	-2.144	.033	.246	-.130	-.118	.311	3.212
9	(Constant)	1.408	.276		5.107	.000					
	Inco	4.126E-05	.000	.171	2.473	.014	.332	.149	.136	.633	1.580
	Econo_Farmland damage	-.040	.040	-.080	-1.005	.316	-.292	-.061	-.055	.476	2.100
	Trust on no farmland damage	.110	.057	.178	1.936	.054	.341	.117	.107	.359	2.783
	Trust on agents' cleaning up farmland	.085	.044	.168	1.929	.055	.349	.117	.106	.399	2.507
	Trust on no cheating on financial return	.059	.042	.130	1.409	.160	.332	.086	.078	.357	2.797

	Trust on personal feeling	-.113	.048	-.232	-2.382	.018	.246	-.144	-.131	.320	3.122
10	(Constant)	1.156	.115		10.039	.000					
	Inco	3.991E-05	.000	.166	2.400	.017	.332	.145	.132	.637	1.570
	Trust on no farmland damage	.131	.053	.212	2.481	.014	.341	.150	.137	.416	2.405
	Trust on agents' cleaning up farmland	.088	.044	.175	2.008	.046	.349	.122	.111	.401	2.494
	Trust on no cheating on financial return	.067	.041	.147	1.629	.105	.332	.099	.090	.371	2.697
	Trust on personal feeling	-.108	.047	-.222	-2.288	.023	.246	-.138	-.126	.324	3.086
11	(Constant)	1.161	.115		10.051	.000					
	Inco	4.490E-05	.000	.186	2.739	.007	.332	.164	.151	.660	1.516
	Trust on no farmland damage	.148	.052	.241	2.875	.004	.341	.172	.159	.435	2.301
	Trust on agents' cleaning up farmland	.102	.043	.202	2.359	.019	.349	.142	.130	.416	2.401
	Trust on personal feeling	-.079	.044	-.163	-1.805	.072	.246	-.109	-.100	.377	2.655

a. Dependent Variable: risk_envi_mean

APPENDIX 4: QUESTIONNAIRE SHEET

Questionnaire Survey for the Study of Stakeholders' Qualitative Risk Assessment
Conducted by Linglng Wang
Graduate School of Engineering, Kochi University of Technology, Japan

5.6 Questionnaire conducted from 29th July to 10th August, 2013

Part 1 <u>Demographic Characteristics.</u>

1.1 Gender__________________________ 1.2 Age_____________________Years old

1.5 Average Income/year_______yuan 1.6 Educational level___________________

Part 2 <u>The basic farmers' attitude toward cooperative with middlemen.</u>

Q1. Are you willing to sell the crop straw to the middleman?

(The level of willingness from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q2. Are you satisfied with the crop straw price?

(The level of satisfaction from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q3. Are you willing to keep long-term relationship corporation with the middleman and sell the crop straw to the agency?

(The level of willingness from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q4. Does the middleman take you trouble during crop straw collection?

(The level of troublesome from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q5. Are you satisfied with policy of prohibiting burning straw in the field?

(The level of satisfaction from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q6. If there is no prohibit burning straw policy, are you willing to sell the crop straw to the agency or burn it?

(1---burning, 2---selling)

1. ☐ 2. ☐

Q7. Are you worried about the air pollution during burning the straw?

(The concerning level of from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

Q8. Is there enough labor for selling crop straw?

(1---enough, 2---not enough)

1. ☐ 2. ☐

Q9. Are you satisfied with the crop straw collection time?

(The level of satisfaction from 1 to 4)

1. ☐ 2. ☐ 3. ☐ 4. ☐

5.7 Questionnaire conducted from 24th September to 20th October, 2014

Part I Demographic Characteristics.

1. Gender__________________________

2 Age_____________________Years old

3. Average Income/year_______yuan

4. Educational level___________________

Part II Risk perception

Section 1 *Farmers' risk perception.*

1.1 *Risk perception of distrust towards agents*

- I would not cooperate with agent mainly because I don't trust agent.

___ Strongly disagree
___ Disagree
___ Agree
___ Strongly agree

1.2 *Risk perception of being cheated*

- How risky do you think you would be arrears of payment or out of pay?

___ Very low
___ Low
___ High
___ Very high

1.3 *Risk perception of outweigh benefit*

- I am afraid that the straw harvesting cost is higher than straw selling price.

___ Strongly disagree
___ Disagree
___ Agree
___ Strongly agree

1.4 *Risk perception of little profit*

- I would like to burn straw in open field instead of selling to agent because the payment is so little that it is not worthy to sell.

___ Strongly disagree
___ Disagree
___ Agree
___ Strongly agree

1.5 Risk perception of farmland damage

- It is risky that agent's collecting straw would bring damage to the farmland?

___ Strongly disagree ___ Disagree
___ Agree ___ Strongly agree

1.6 *Risk perception of agents' cleanup is not sufficient*

- I would like agents to collect crop straw in my farmland if they will not damage the land.

___ Strongly disagree ___ Disagree
___ Agree ___ Strongly agree

1.7 *Risk perception of insufficient labor in harvesting straw*

- I don't have enough labor to harvest crop straw.

___ Strongly disagree ___ Disagree
___ Agree ___ Strongly agree

1.8 *Risk perception of insufficient time.*

- It really take time to harvest crop straw and I cannot finish harvesting in regulated time.

___ Strongly disagree ___ Disagree
___ Agree ___ Strongly agree

1.9 *Risk perception of air deterioration caused by burning crop straw*

- I would not burning crop straw in the farmland if I know it can cause air pollution.

___ Strongly disagree ___ Disagree
___ Agree ___ Strongly agree

Section 2 ***<u>Farmers' understanding on the impact of economic factors</u>***

2.1 How much possibility do you think you will suffer loss (middleman collect straw without payment)?

___ Very low ___ Low
___ Medium ___ High

___ Very high

2.2 How much possibility do you think you will overweigh benefit?

___ Very low
___ Low
___ Medium
___ High
___ Very high

2.3 How much possibility do you think the straw price cannot cover risky of farmland damage?

___ Very low
___ Low
___ Medium
___ High
___ Very high

Section 3 *<u>Farmers' understanding on the impact of policy factors</u>*

3.1 How much possibility you would more likely to sell crop straw to agents and power plant if selling crop straw can be supported by government scheme concretely, such as economic incentive?

___ Very low
___ Low
___ Medium
___ High
___ Very high

3.2 The local government didn't inform us that burning straw are bad to environment?

___ Very low
___ Low
___ Medium
___ High
___ Very high

3.3 If government highly enhances the negative impact of burning straw, how much probability of not burning straw in the open field?

___ Very low
___ Low
___ Medium
___ High
___ Very high

3.4 How much is impact of the government' encouragement (the significance of crop straw to generate energy) in selling crop straw?

___ Very low
___ Low
___ Medium
___ High
___ Very high

Section 4 ***Farmers' understanding on the impact of trust factors***

4.1 I can trust agent that they will not destroy my farmland during straw collection?

___ Strongly disagree
___ Disagree
___ Neither disagree nor agree
___ Agree
___ Strongly agree

4.2 I can trust on agent that they can clean up the farmland and I don't have to do cleanup again which increase your cost?

___ Strongly disagree
___ Disagree
___ Neither disagree nor agree
___ Agree
___ Strongly agree

4.3 I trust agent that I will not face being cheated after selling crop straw?

___ Strongly disagree
___ Disagree
___ Neither disagree nor agree
___ Agree
___ Strongly agree

4.4 How much trust feeling do you have towards agent?

___ Very low
___ Low
___ Medium
___ High
___ Very high

Part III Trust

1. *Trust relationship*

- Can you trust middleman?

___ Cannot be trusted
___ Have little trust with agent
___ Sometimes can be trusted
___ Most time can be trusted
___ Totally can be trusted

2. *Distrust in motives*

- The middleman is an integrity person and reliable to trade with. (Moral integrity)

___ Strongly disagree
___ Disagree
___ Neither disagree nor agree
___ Agree
___ Strongly agree

- The middleman considers my situation and feeling, and tries to consider things in my position. (Care)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

- The middleman treated me as fair as the other households. (Equal treatment)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

- The middleman have good attitude when trade with me. (Humble attitude)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

3. *Distrust in transparency*

- The middleman's crop straw purchasing price from other households is transparent to me. (Transparence)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

- Based on experience, I can rely on my middleman with complete confidence to keep their promises to me. (Credibility)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

4. *Distrust in competency*

- The middleman has the ability to deal with conflict with a modest approach. (Competence of handling conflict)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

- The middleman has the ability to help others. (Competence of helping others)

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree

___ Strongly agree

5 *Guanxi*

- I would like to trade with middleman with I have guanxi with him.

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

6 *Transaction cost*

- I would like to lower the crop straw to the cost of harvesting straw.

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

7 *Long-term relationship*

- I have known my middleman for a long time. If I cheat my agent, I will lose my reputation immediately.

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

- I would like to use contract to keep long-term relationship /trust with middleman. (Contract trust).

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

- I would like to keep long-term relationship /trust with middleman just because I feel he is kind. (Goodwill trust).

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

- I would like to keep long-term relationship /trust with middleman because with time passes, I know him well (Knowledge trust).

  ___ Strongly disagree ___ Disagree
  ___ Neither disagree nor agree ___ Agree
  ___ Strongly agree

8 *Public engagement*

- Are you willingness to participate in crop straw supply?

___ Yes ___ No
___ Considering

- 2. I would like to sell crop straw to agent.

___ Strongly disagree ___ Disagree
___ Neither disagree nor agree ___ Agree
___ Strongly agree

Thank you very much

LISTS OF PUBLICATION

1. International journals

Lingling Wang, Tsunemi Watanabe and Zhiwei Xu. Stakeholders' Risk Perception of Sustainable Biomass Power Plant Development---A Case Study of Wangkui County, China. Internet Journal of the International Symposium on Social Management Systems. *Journal of Society for Social Management Systems*. **2013**; ID. SSMS-1056, (Sydney, Australia, December 2013) Peer Reviewed.

Lingling Wang, Tsunemi Watanabe and Zhiwei Xu. Monetization of External Costs of Coal-fired Power Plant and Biomass Power Plant Based on Life Cycle Analysis---A Comparative Case Study in Northeast China. *Energies*. **2015**; 8(2): 1440-1467. (ISSN: 1996-1073) (Impact Factor: 2.072) doi: 10.3390/en8021440 (*SCI*, *EI* and *Scopus*)

Lingling Wang, Tsunemi Watanabe. Exploring Factors Affecting Farmers' Risk Perceptions of Biomass-Supply: A Case Study in the National Bioenergy Industry Area of China, *Risk Analysis*. (Under review)

2 Conferences and peer-reviewed journals

Lingling Wang, Tsunemi Watanabe. Current Situation and Existing Problems of Biomass Energy Industry in Rural China, *ISFT* 2013; Jul. 25th --30th, Shenyang, China. (Oral presentation)

Lingling Wang, Tsunemi Watanabe. Building Stakeholder Relationship in Biomass Energy Industry in Rural China, EASEC13, September 11st—13rd ,2013, Sapporo, Japan. (Oral presentation)

Lingling Wang, Tsunemi Watanabe. Stakeholders' Risk Perception of Sustainable Biomass Power Plant Development---A Case Study of Wangkui County, China, the 9th International Symposium for Social Management Systems, Dec. 2nd –4th , 2013, Sydney, Australia. (Oral presentation)

Lingling Wang, Tsunemi Watanabe. Analysis of Analysis of Policies in Biomass Power Industry in China, *ISFT* 2015; Jul. 24th --28th, Kunming, China. (Oral presentation)