GLOBAL LEGALITY REQUIREMENTS AND CHAIN OF CUSTODY CERTIFICATION: POTENTIAL IMPACTS OF RECENT CHANGES ON CHINA'S WOOD PRODUCTS INDUSTRY

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Abstract

Many initiatives have been designed to reduce illegal logging and to legitimize the associated forest products trade. The latest governmental initiatives include the United States Lacey Act Amendment (US LAA) and the European Union Timber Regulation (EU TR). A key non-governmental initiative is Chain of Custody (CoC) certification. Since China is a very large importer of primary wood products and a major exporter of value-added wood products, it is critical to understand the impacts of these initiatives on China.

The study aims to analyze the potential impacts of the US LAA, the EU TR, and CoC certification on China's wood products industry at two levels. First, at the individual producer level, 107 export-oriented Chinese wooden furniture manufacturers were randomly selected to investigate their perceptions of and responses to these initiatives. Guided by an integrated innovation-adoption model, the study identified the factors that affect a firm's legal compliance and its propensity to adopt CoC certification. Second, at the wood products industry level, the potential longer-term impacts of the US LAA and the EU TR on China's wood products industry were estimated using the International Forest and Forest Products (IFFP) trade model.

There were several key results. First, at the individual producer level, multiple linear regression identified factors that were statistically significant in determining a firm's willingness to comply with legality requirements. They included the natural logarithm of firm size, the natural logarithm of export proportion, the interaction between opportunity and: client pressure, the natural logarithm of export experience and the natural logarithm of export proportion. Second, at the individual producer level, binary logistic regression suggested that client pressure, firm size, and the expectation of general benefits were statistically significant in determining a firm's decision to adopt CoC certification. Third, at the wood products industry level, the IFFP results indicated that these governmental initiatives in the US/EU might decrease the production and net export of China's plywood, veneer sheet, and fibreboard. The results also indicated an increase in China's sawnwood and particleboard production, and a decrease in their net imports.

Preface

The author of this thesis, Yu Huang, was responsible for the research design, data collection, data analyses, and thesis writing.

Chapter 2 and Chapter 3 were based on a survey conducted in China in 2011 which was approved by the Behavioural Research Ethics Board (BREB) of the University of British Columbia (UBC).The Certificate Number is H10-02656.

The thesis contains three chapters (Chapter 2, 3, and 4) that are being prepared for three publications.

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List of Abbreviations

BREB	Behavioural Research Ethics Board
CGEMs	Computable General Equilibrium Models
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNFA	China National Furniture Association
CoC	Chain of Custody
CS	Compliance Standard
CSER	Corporate Social and Environmental Responsibility
DDR	Due Diligence Regulation
EFI-GTM	European Forest Institute Global Trade Model
EMS	Environmental Management System
EU	European Union
FARM	Future Agricultural Resources Model
FLEGT	Forest Law Enforcement, Governance, and Trade
FM	Forest Management
FSC	Forest Stewardship Council
GFPM	Global Forest Products Model
GTAP	Global Trade Assessment Project
GTM	Global Trade Model
IBM	International Business Machine
IFFP	International Forest and Forest Products Model
ISO	International Standardization Organization
ITTO	International Tropical Timber Organization
LAA	Lacey Act Amendment 2008
MI	Management Improvement
MLE	Maximum Likelihood Estimation
MP	Market Performance

NFCP	Natural Forest Conservation Program
NGOs	Non-Governmental Organizations
OR	Odds Ratio
PEFC	Program for the Endorsement of Forest Certification
PEMs	Partial Equilibrium Models
PR	Public Relations
ROW	Rest of the World
RPP	Responsible Purchasing Policy
SCM	Supply Chain Management
SFA	State Forest Administration
SFM	Sustainable Forest Management
SFI	Sustainable Forestry Initiatives
SMEs	Small and Medium Enterprises
SPSS	Statistical Product and Service Solutions
	(It is formerly known as Statistical Package for the Social Sciences)
SOS2	Special Ordered Sets of type Two
TAMM	Timber Assessment Market Model
TFAP	Tropical Forest Action Plan
TR	Timber Regulation
UBC	University of British Columbia
UN	United Nations
US	United States
VIF	Variance Inflation Factor
VPAs	Voluntary Partnership Agreements
WTO	World Trade Organization

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1 Introduction

Forests, which cover approximately 30% of the world's land surface, play a pivotal role in shaping and sustaining both the global environment and human society (Clawson 1979; Pearce 2001; Elands et al. 2004; Innes and Hickey 2006; Streck and Scholz 2006; Miller 2007). However, the world's forests are under enormous pressures and are being converted to agricultural lands, human settlements, or heavily degraded lands (Reiners et al. 1994; Fearnside 2000; Rudel et al. 2005; Shearman et al. 2009; Klenk et al. 2012). It is estimated that around 13 million ha were deforested between 2000 and 2010, a slight drop from 16 million ha between 1990 and 2000 (Food and Agriculture Organization 2010). Deforestation, which essentially leads to land conversion, continues to be a problem.

Forestland conversion is often unplanned and most of the actions leading to conversion are generally considered to be illegal (Lawson and MacFaul 2010). One of the critical illegal activities is illegal logging which is a widespread issue in many countries. It has led to serious environmental, economic, and social problems (Richards et al. 2003; Tacconi 2007; Gutierrez-Velez and MacDicken 2008; Li et al. 2008). Examples of environmental problems include deforestation and forest degradation, biodiversity loss, carbon loss, soil erosion, landslides, water loss, and floods. Examples of economic problems include wood products price distortion, negative influence on the competitiveness of legitimate producers, trade distortion, and government revenue loss. Examples of social problems include threats to the livelihood of local communities, social conflicts with logging companies, crime, and threats to human rights.

Various governmental and non-governmental initiatives have been designed to deal with illegal logging. These initiatives may have impacts on both the individual firms and the whole wood products industry. Using an innovation-adoption model and the perfect competition theory as the theoretical foundation, this study aims to analyze the potential impacts of some of the initiatives at both the individual producer level and the industry level. The United States Lacey Act Amendment 2008 (US LAA), the European Union Timber Regulation (EU TR), and the

Chain of Custody (CoC) certification are the studied initiatives. China, a major processor of wood products, is the studied country. The study can help China's wood products firms and the industry to grow sustainably. The study can also help us to understand the effectiveness of the studied initiatives in combating illegal logging and associated trade.

The following sections of this chapter continues with an introduction of illegal logging and the studied initiatives to combat illegal logging (i.e. the US LAA, the EU TR and CoC certification), followed by an overview of China's wood products industry and a review of the research theoretical background. The chapter concludes with the central research question, objectives, the thesis framework, and research methods.

1.1 Illegal logging

1.1.1 Definition of illegal logging and legality

There is no universal consensus on the definition of illegal logging (Hansen and Treue 2008; Dieter 2009). In its narrowest sense, illegal logging is: "*harvesting activities which do not conform to national or sub-national laws and regulations*" (Smith et al. 2003). This includes: (1) harvesting without license; and (2) harvesting exceeding license in terms of region, volume or species (Casson and Obidzinski 2002). According to the narrowest definition, world's production of illegal industrial roundwood was estimated to be 139 million m^3 in 2005, accounting for about 8% of total (Turner et al. 2007; Indufor 2008).

A broader definition of illegal logging is: "*the harvest, transportation, purchase and sale of wood and wood products in violation of national or sub-national laws and regulations*" (Brack 2003; 2007a). It involves a wide range of non-compliance with laws and regulations along the supply chain of forest products (Turner et al. 2008). Therefore, the narrowest definition of illegal logging refers to illegal activities that occur at harvest sites, while the broader definition refers to illegal activities occurring along the supply chain.

The lack of a consensus on the definition of illegal logging has made the estimation of the extent of illegal logging very difficult and inconsistent between different definitions (Hansen and Treue 2008). Lawson and MacFaul (2010) found very different estimations of illegal logging rate

when applying different definitions. For example, if illegal logging was defined as logging exceeding licensed volume, the illegal logging rate was estimated to be about 35% in Brazilian Amazon region. However, Chatham House experts, when surveyed, suggested the average illegal logging rate was about 75% in Brazilian Amazon region (Lawson and MacFaul 2010). This was because no definition of illegal logging was given to the experts in the survey, and therefore they estimated the illegal logging rate according to different definitions.

Correspondingly, the definition of legality is complex. In practice, it often involves assessing evidence of non-compliance with key national laws and regulations and is used as a short-term measure, with the goal of improving legality definition over time (Tacconi et al. 2004; Fripp 2006; Attah et al. 2009).

Verification of legality has faced many difficulties. First, legality requirements may be not consistent or universally accepted. What is legal in country A may be unacceptable in country B and illegal in country C. Second, legality requirements are often not consistent (sometimes contradicting) between national or regional levels. Third, the scope of legality is not defined universally. For example, it is not clear that to what extent should financial, economic, environmental, and social legislation and court decisions be included. Fourth, in some places, legal framework could promote forest conversion or practices that violate indigenous people's rights or are unsustainable practices according to certification rules (Chatham House 2007; Clark 2007).

1.1.2 Causes of illegal logging

Many proximate or institutional and socio-economic factors are perceived as causes of illegal logging. They include: political power of timber companies, overcapacity of the timber industry, unclear and unstable ownership rights, insufficient budgetary resources, failures of law, weak law enforcement, incompetent and inconsistent government policies, insufficient knowledge and inadequate knowledge management, lack of transparency, and corruption among forest staff (Palmer 2001; Richards et al. 2003; Smith et al. 2003; Bouriaud 2005; Fripp 2006; Tacconi 2007; Hansen and Treue 2008; Alemaqi and Kozak 2010; Miller 2011).

Others suggest that these factors can be re-categorized into three underlying factors: economic rent seeking, population growth, and/or poverty reduction (Hansen and Treue 2008; Klenk et al. 2012). Since many developing countries have rent-seekers, high population growth and many poor people, most of them are considered of high or at least moderate risk (Indufor 2008; Lawson and MacFaul 2010). The low risk countries/regions, whose illegal logging (narrowest definition) rate is no more than 10%, include 27 European Union countries (EU), Norway, Switzerland, the United States (US), Canada, Japan, Australia, New Zealand, and South Africa. The remainder are considered high (illegal logging rate is more than 20%) or moderate risk (illegal logging rate is in the range of 10%-20%) countries/regions (Turner et al. 2007; Indufor 2008).

1.1.3 Illegal wood and wood products trade

Although most illegal logs are consumed domestically, substantial quantities do enter the international market (Li et al. 2008; Lawson and MacFaul 2010). Illegal roundwood was estimated to account for 12%-17% of world's total roundwood exports by volume in 2002 (Seneca Creek Associates 2004). Most wood products produced with illegal logs from countries such as Papua New Guinea, Malaysia, Indonesia and Myanmar have been processed in other countries such as China, India, and Vietnam. The finished or semi-finished products are then frequently exported to major consumer markets in the developed countries/regions such as the US, the EU, Japan and Australia (Cashore et al. 2006; Dieter 2009).

1.1.4 International efforts to combat illegal logging

To combat illegal logging, various governmental and non-governmental initiatives have been developed in producer, processor and consumer countries (Fripp 2006). In the 1980s, the Tropical Forest Action Plan (TFAP) was developed to promote and improve sustainable forest management through a regulatory approach. The TFAP soon came to be viewed as a failure because it was not curbing deforestation and, instead, was perceived as a way of opening up new areas for logging (Bowles et al. 1998). Another three efforts to address forest problems through public policy and intergovernmental processes also failed. First, the International Tropical

Timber Organization (ITTO) that was formed to improve forest management practices in the tropics was unable to achieve the goal (Gale 1998). Second, the talks at the United Nations Conference on Environment and Development on a global forest convention were collapsed (Humphreys 1996; Bernstein and Cashore 2004). Third, tropical timber boycott campaigns, which created incentives for governments in the South to convert "unproductive" forest land to other uses, has gained growing concern over the potentially perverse effects (Cashore et al. 2004). Due to all these failures, in the 1990s, the focus shifted to market-based mechanisms, with non-state market driven forest certification as the key example. At the same time, many countries also used log export restrictions to control illegal exports (Resosudarmo and Yusuf 2006).

More recently, many new governmental and non-governmental initiatives have been developed. In the public sector, examples of governmental initiatives include:

- Supply-side laws and regulations (e.g. log export restrictions, such as log export ban, tax, and quota);
- Demand-side laws and regulations (e.g. the US LAA and the EU TR);
- Action plans (e.g. the Tropical Forest Action Plan (TFAP) and European Union Forest Law Enforcement, Governance, and Trade (EU FLEGT) Action Plan);
- International agreements (e.g. EU FLEGT Voluntary Partnership Agreements (VPAs)); and
- Public procurement policies in consumer countries (e.g. Japan and the EU government) (Chatham House, 2009; Moiseyev et al., 2010).

Examples of non-governmental initiatives include:

- Non-state market driven forest certification (e.g. Forest Management (FM) certification or Sustainable Forest Management (SFM) certification, and Chain of Custody (CoC) certification);
- Big retailers' responsible purchasing policies; and
- Corporate responses to campaigns of Non-Governmental Organizations (NGOs) (Fripp 2006).

In this study, governmental initiatives, such as the demand-side new laws and regulations, specifically the US LAA and the EU TR, are the main focus since they are mandatory and affect a broad range of participants in the world's forest sector.

Detailed analyses of the US LAA and the EU TR will be in Chapter 2 and Chapter 4. Since non-state market driven forest certification is seen as an evidence of legality, and US LAA and EU TR are likely a stepping-stone for it in wood products industry, non-state market driven certification, especially CoC certification, will also be studied in more detail in Chapter 3.

1.2 The US LAA and the EU TR

Until recently, no consumer country had legislation in place to prohibit the import or sale of illegal-sourced wood products (Lawson and MacFaul 2010). Without such legislations, it is very difficult for consumer country authorities to prevent the entering and selling of illegal-sourced wood products. Although other actions can help, this legislative gap is now being addressed so that consumer countries can deal with illegal logging problem better. The US and the EU are the leaders in using such measures.

1.2.1 The US LAA

The Lacey Act is a law with a long history. It is a conservation law in the US, which has been effective since 1900 and prohibits trade in wildlife, fish, and plants that have been illegally taken, transported or sold (Fowler et al. 2007; Saltzman 2010; Woloson et al. 2011). The law has been amended several times. On May 22nd 2008, the US Lacy Act was amended to protect a broader range of plants and plant products, which is the US LAA. According to the US LAA, it is unlawful to import, export, transport, sell, receive and purchase in interstate or foreign commerce any plant (including trees) taken or traded in violation of the laws of the US, a US state, or relevant foreign laws (Tanczos 2011; Cashore and Stone 2012; The US Fish and Wildlife Service 2012). Operators need to exercise due diligence/due care and provide a basic declaration specifying various details of the imported wood or plant-related products (e.g. scientific name, country of origin, etc). The Amendment has been implemented phase by phase,

covering from primary to final wood products (Table 1.1). The wooden furniture was included in Phase Ⅳ (The US Department of Agriculture 2012). The concept of "due care" is assessed during any prosecution to determine degree of penalty (Saltzman 2010). The level of penalty can be steep, with jail time, forfeiture of goods, or fines depending on degree to which company knew or should have known that it was handling illegal products (The US Fish and Wildlife Service 2012).

Table 1.1 The four phases of the US LAA

Phase	Starting Time	Declaration Requirements for Plants and Plant Products
Phase Ⅰ	December 15th, 2008	The range of affected products was not clearly stated
Phase Ⅱ	April 1st, 2009	Wood and articles of wood, including fuel wood, wood in the rough, poles, piles, stakes, railway or tramway sleepers, wood sawn or chipped lengthwise, sheeting for veneering, wood continuously shaped, tools, tool handles, broom handles, and builders' joinery and carpentry of wood
Phase Ⅲ	October 1st, 2009	Wood and articles of wood, including wood charcoal, plywood, veneer panels, wooden frames, tableware and kitchenware of wood, wood marquetry, caskets, statuettes; Plus goods in Phase Ⅱ
Phase Ⅳ	April 1st, 2010	Other articles of wood, umbrellas, walking sticks, whips, riding crops, hand tools, pianos and other musical instruments, arms and ammunition, **wooden furniture**, toys, games, sporting equipments, works of art; Plus goods in Phase Ⅱ and Ⅲ

Source: http://www.usda.gov/

For many years, the Lacey Act has been considered a useful tool in preventing illegal fish and wildlife harvest and trade (Anderson 1995; Indufor 2008; Fairbrother 2009). Some firms have already been punished due to non-compliance with the US LAA. The first investigation for potential prosecution under the US LAA was on Gibson Guitar in 2009 for ebony wood likely sourced illegally from Madagascar and rosewood and ebony likely sourced illegally from India (Innes 2010; Saltzman 2010). Gibson Guitar has previously been recognized for its recognition of the problems associated with illegal logging, and has been sourcing mahogany from legal, certified sources in Honduras and Guatemala (Rainforest Alliance 2010). The US Fish and Wildlife Service had to demonstrate that illegalities have occurred (Innes 2010). The second

investigation on Gibson Guitar was in 2011. In August 2012, Gibson Guitar agreed to pay a penalty amount of $300,000 and a community service payment of $50,000 to the National Fish and Wildlife Foundation, implement a compliance program designed to strengthen its compliance controls and procedures, and withdraw its claims to the wood seized in the course of the criminal investigation, including Madagascar ebony from shipments with a total invoice value of $261,844 (The US Department of Justice 2012). The first ticket was given to a wooden baby furniture firm (Style Craft Furniture Co. Ltd.) in Shanghai, China for smuggling cribs containing internationally protected ramin wood. It received a $40,000 penalty because of violating the US LAA (The US Department of Justice 2009).

1.2.2 The EU TR

The EU has developed the EU FLEGT Action Plan to combat illegal logging and associated trade. Since 2005, EU FLEGT Action Plan has been focusing on developing bilateral negotiations with timber exporting countries, known as VPAs (Cashore and Stone 2012). The EU FLEGT VPAs aim to guarantee that the wood exported to the EU is from legal sources and to support partner countries in improving their own regulation and governance of the sector (Beeko and Arts 2010). Technical details of legal verification such as a mutual definition of legality and the development of a secure licensing system are included in the EU FLEGT VPAs (Beeko and Arts 2010). As of October 2012, there were six countries developing the systems agreed under a VPA (i.e. Cameroon, Central African Republic, Ghana, Indonesia, Liberia, and Republic of Congo) and six countries that were negotiating with the EU (i.e. Democratic Republic of Congo, Gabon, Guyana, Honduras, Malaysia, and Vietnam). Furthermore, there were many other countries from Africa (e.g. Côte d'Ivoire, Sierra Leone), Asia (e.g. Cambodia, Laos, Myanmar, Papua New Guinea, the Solomon Islands and Thailand), and Central and South America (e.g. Bolivia, Colombia, Ecuador, Guatemala, Peru) that have expressed interest in VPAs (European Forest Institute 2012).

Although the EU FLEGT VPAs are believed to be useful in controlling illegal wood products shipping from the VPA countries to the EU, it cannot prevent illegal wood products,

either produced in non-VPA countries or produced in VPA countries and shipped to the EU through non-VPA countries, entering the EU. Therefore, inspired by the US LAA and its ability to cover all countries simultaneously, the EU parliament took the additional step in early July 2010 to require that importers not covered by VPAs also avoid importing illegal timber by demonstrating "due diligence" and proposed as the Due Diligence Regulation (DDR). In October 2010, the DDR was re-named as the EU TR and passed (European Forest Institute 2012). It prohibits the sale of timber logged illegally under the rules of the country of origin and requires companies to use a "due diligence" system which ensures that the timber they sell in the EU was harvested legally. This regulation will take effect on March 3rd 2013.

1.2.3 Comparison of the US LAA and the EU TR

The US LAA and the EU TR are similar in several ways. First, the concept of "due care" requires operators in the wood products supply chain to meet varying environmental and socially responsible requirements. Second, the illegality of wood in the law/regulation is defined in relation to the laws of the country where the timber was harvested. Third, certificates, such as CoC certification, are good evidence of legality and sustainability (Butler and Grant 2011).

Although the EU TR and the US LAA are similar, they have some differences. Most important of all, they are different approaches. The US LAA is a fact based statute, rather than a document-based statute (Wolosin et al. 2011). Moreover, it has no standards for due care. Therefore, documentation, such as CoC certificates and legality verification certificates, is not a sufficient guarantee of legality under the US LAA. For example, Gibson Guitar has a CoC certificate issued by the Forest Stewardship Council (FSC), and has been subject to annual inspections by the FSC. However, it was still investigated by the US Fish and Wildlife Service (Innes 2010). The EU TR is a system-based statute, which has due diligence system for the operators to follow. Under this system, the measures the companies must take are outlined (Saltzman 2010). FLEGT and CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) licenses are adequate proof of legality (European Forest Institute 2012). For individual operators, the main difference caused by the different approaches

is the process the trader is required to follow (Butler and Grant 2011). Under the US LAA, individual company needs to exercise due diligence and provides a basic declaration, while under the EU TR, individual company is provided with a due diligence system and a process to follow. Table 1.2 compares the two initiatives.

Table 1.2 Comparison of the US LAA and the EU TR

Items	The US LAA	The EU TR
Enactment	2008	2013
Approach	Fact-based	System-based
Target	Overall prohibition for any US company or individual in the timber supply chain to import, export, transport, sell, receive, acquire or purchase illegal timber and timber products	Prohibition to place illegal timber and timber products on the EU market
Requirements	Operators need to exercise due diligence and provide a basic declaration.	Operators need to implement a due diligence system including information access, risk assessment and mitigation.
Certification	Certification and verification are not required. Certificates are not considered proof of legality, but can be good assistance.	FLEGT and CITES license are adequate proof of legality. Certificates are good evidence of legality and sustainability.
Penalties	Civil and criminal penalties, including jail time, forfeiture of goods, or fines, depending on degree to which company knew and good value	Member states are required to impose penalties, which are "effective, proportionate and dissuasive".

1.2.4 Potential Impacts of the US LAA and the EU TR

Enforcement of the US LAA and the EU TR might have significant positive impacts. The policy makers in the US and the EU expect that such initiatives would reverse the negative economic, environmental and social effects of illegal logging. For the US and the EU, preventing illegal plant and plant products (including wood products) from reaching their markets through the enforcement of the US LAA and the EU TR would protect their ecosystems against plant invasions (Fowler et al. 2007), protect their legitimate producers (Cashore and Stone 2012), and increase their wood products prices (Tanczos 2011). For countries which export wood products to the US and the EU, the US LAA and the EU TR are expected to decrease their harvest level of illegal logs (Wolosin et al. 2011). The US and the EU import significant amount of wood products from the high or moderate risk countries in which illegal logging or processing of

illegal-sourced wood products happens in a larger scale and extent than other countries (Lawson and MacFaul 2010). The implementation of the US and the EU thus are expected to reduce illegal logging in these high or moderate risk countries (Cashore and Stone 2012). In addition, such regulations also encourage wider compliance with local laws and regulations, especially land tenure laws, in countries which export to the US and the EU (Wolosin et al. 2011).

Despite the potential positive impacts on both the US/EU and other countries, the US LAA and the EU TR also have brought about widespread concerns (Tanczos 2011). First, the Importers of the US and the EU have pointed out that there are ambiguities in the declaration requirements and the extent to which the provisions would be enforced (Saltzman 2010). Second, it is also worried that such laws and regulations would impose substantial costs in terms of trade distortion, while proving to have little or no effects in reducing illegal logging (Melnitzer 2010). The industry importers of the US and the EU are anxious that these initiatives may have a devastating effect on imports and their manufacturers that rely on these imports, therefore they may harm the legitimate commerce instead of protect it (The Animal and Plant Health Inspection Service 2009). Third, for the exporters in countries which export to the US and the EU, their export cost may increase substantially and the trade volume may decrease if export costs surges, as certain portion of firms may stop or reduce export wood products of suspicious origins to the US due to fearing of being caught (Han and Cao 2009; Sun and Canby 2010). Malicious reports from competitor might make life difficult for their firms (Li et al. 2010).

However, both the positive and the negative impacts mentioned above have not been tested. This is because the US LAA and the EU TR are newly emerging. The full and effective implementations of these laws and regulations still need time. In addition, the wood products firms and the whole industry also need time to learn and comply. Hence, the economic, environmental and social impacts are still uncertain and can be only measured after several years. Nevertheless, at this time of point, it is still useful and interesting to estimate the potential impacts of these initiatives using feasible methods. For China's wood products industry, which is in a very important position in the world's wood products sector, this would be extremely important, as it could contribute to the decision making process of China's wood products firms

and other stakeholders. This thesis thus evaluates their potential impacts on the attitudes and behaviours of Chinese wooden furniture firms (Chapter 2), as well as their longer-term impacts on China's wood products industry (Chapter 4).

1.3 Non-state market driven forest certification

1.3.1 Types of forest certification

Forest certification emerged in the mid-1990s as a non-state market driven incentive to improve forest management (Cashore et al. 2006). It is perceived as the best example of a voluntary governance structure for addressing environmental spillovers (Cashore et al. 2005) and is considered an addition to the command and control method of governance (Cashore and Vertinsky 2000; Abbott and Snidal 2003).

There are many international and national forest certification schemes, among which the Program for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC) are the most widely implemented (Aguilar and Vlosky 2007). Both PEFC and FSC contain two parts: Forest Management (FM) certification (or Sustainable Forest Management (SFM) certification) and chain of custody (CoC) certification. FM/SFM certification focuses on whether forest resources and forest lands are managed sustainably to meet the social, economic, ecological, cultural and spiritual needs of present and future generations by providing for their multiple and complementary functions and uses (Overdevest 2010). CoC is the custodial sequence that occurs as ownership of wood supply is transferred from one custodian to another along the supply chain (Wingate and McFarlane 2005). Hence, CoC certification has the objective to ensure that the wood products purchased can be accurately tracked back to its source, which in turn ensures that they really come from an environmentally certified source (Nor Suryani et al. 2011; Cashore and Stone 2012).

1.3.2 Distribution of forest certification

Forest certification has experienced phenomenal growth (Ratnasingam et al. 2008; Chen et al. 2011a, 2011b). Worldwide, as of the end of 2011, more than 245.1 million ha and 147.8

million ha forest had been certified by PEFC and FSC, accounting for over 6.1% and 3.7% of global forest area, respectively (Table 1.3). About 93.6% and 64.1% of PEFC and FSC certified forests were in low risk regions, respectively. Over eight thousand and 20 thousand companies had gained CoC certification under PEFC and FSC, respectively. Around 94.2% and 76.6% of PEFC and FSC CoC certificates were in low risk regions, respectively.

Table 1.3 PEFC and FSC certification statistics as of December 31, 2011

Country/Region		PEFC*		FSC▲	
		Area (ha)	CoC certificates	Area (ha)	CoC certificates
Low risk regions	USA	35,275,332	354	13,693,832	3,714
	Canada	111,955,420	183	46,255,553	1,016
	EU-27	62,731,845	7,236	26,441,693	9,905
	Norway	91,15,902	32	138,753	31
	Switzerland	206,083	54	516,614	492
	Australia	10,069,605	201	622,447	253
	New Zealand	0	19	1,510,122	142
	Japan	0	210	3,872,725	1,130
	South Africa	0	1	1,675,321	84
	Total	229,354,187	8,290	94,727,060	16,767
High or moderate risk regions	China	0	155	2,659,240	1,827
	Russia	3	2	29,332,208	128
	Papua New Guinea	0	0	32,610	3
	Malaysia	4,646,068	171	501,751	132
	Other	0	179	20,578,935	3,022
	Total	3,232,654	507	53,104,744	5,112
World total		245,124,936	8,797	147,831,804	21,879
Percentage of world forest		6.1%	-	3.7%	-

Data source: *PEFC 2012 ▲FSC 2012

Forest certification is still at a very early stage in China (Bowers et al. 2012). The total area of forestland certified under the FSC standard was about 2.7 million ha as of the end of 2011, accounting for only about 1.3% of its total forest area (Table 1.3). Although a national certification standard was adopted in 2007, it has not yet been implemented and is currently undergoing review for PEFC endorsement. Certified forests of China's main non-coniferous log suppliers, such as Papua New Guinea and Malaysia, also account for a very limited proportion of total certified forest (Table 1.3). Hence, the supply of certified logs for China is constrained (Ganguly and Eastin 2011). Besides, companies gained CoC certification under FSC and PEFC

constitute only a small proportion (less than 4%) of all wood manufacturing firms in China (PEFC 2012; FSC 2012).

1.3.3 CoC certification

CoC certification is being employed by wood products manufacturers to enhance their supply chain management and ensure legality and sustainability (Cashore et al. 2004; Cashore et al. 2006; Ratnasingam et al. 2008).There are three types of CoC certification labels: pure, mixed, and recycled (PEFC 2012; FSC 2012). Pure label means that a wood product comes from 100% certified forests; mixed label means that a wood product is made of a combination of certified fibre and/or recycled fibre mixed with controlled fibre. The recycled label means that a wood product is made of 100% recycled fibre (FSC 2012). The controlled label means that the fibre is not certified, but it satisfies certain FSC or PEFC standards, including legality. Therefore, CoC-certified wood products do not necessarily originate from certified forests.

Many studies have researched CoC certification and found that it has various benefits. These benefits include easier market access, increased market share, more customers, increased product prices, improved relationships with governments and non-governmental organizations, and improved efficiency (Upton and Bass 1996; Viana et al. 1996; Dykstra et al. 2002; Vidal et al. 2005; Ratnasingam et al. 2008; Chen et al. 2011b).

Although CoC certification has proven benefits, these benefits are not sufficient to drive many firms to obtain certification (Ratnasingam et al. 2008). The direct and indirect monetary cost may outweigh the benefits (Tikina et al. 2008). Revenues from the price premiums of certified wood products are uncertain, which could also lead to lack of interest in CoC certification (Sedjo and Swallow 1999; Wilson et al. 2001; Vlosky et al. 2003; Anderson and Hansen 2004; Kozak et al. 2004). In addition to economic consideration of benefits/revenues and costs, other factors/barriers may affect a firm's decision to obtain CoC certification. Previous studies show that potential barriers include organizational structures and behaviour, operating environment, and external pressures (Oliver 1991; Vertinsky and Zietsma 1998; Cashore and Vertinsky 2000; Chen et al. 2011b).

Although the benefits and barriers of CoC certification are well identified, most of the previous studies on this issue are qualitative studies (Ratnasingam et al. 2008; Vlosky et al. 2009; Chen et al. 2011a, 2011b). Only a few studies have done quantitative analyses in explaining what drives a firm to gain forest certification. Tikina et al. (2008) used a logistic regression model and found that market pressure, land ownership pattern and water-body abundance were the three key factors that influence certification decision in the US Pacific Northwest. They did not differentiate CoC certification and FM certification, as well as the operator types (public agencies, forest industry and non-industrial private forest owners). Seol (2011) also utilized logistic regression models and found that company size and years in business were statistically significant in determining a firm's CoC certification status in China. There was also no distinguish of operator types. This study aims to fill in the gap through assessing the factors that affect the adoption of CoC certification among China's wooden furniture firms.

1.3.4 Legal and certified wood products

The relationship of legal and certified wood products is that certified wood products can be perceived as legal wood products that satisfy various sustainable requirements besides legality. Therefore, legality is taken as a minimum requirement for certified wood products. Verification of legality of logs and wood products are not sufficient in assuring sustainable management (Cerutti et al. 2011).

Forest certification is believed to have the potential to address certain environmental or social spillovers, such as weak forest legal frameworks, or inadequately implemented ones, that allow the unsustainable (though legal) use of forests (van Kooten et al. 2005; Auld et al. 2008). Evidences of such corrective potential have recently been documented in many regions. In Latin America, logging companies had to comply with government laws that were otherwise largely unenforced in order to be certified (Espach 2006). In the Asia-Pacific region, regional codes of practices based on the rules of certification were developed and promoted by national governments (Durst et al. 2006). In Africa, annual allowance cut was less when FSC rules were requested than that when only obeying to the legal harvesting rules (Cerutti et al. 2011).

The definition of legality in forest certification is slightly wider than governmental legality requirements. Hence, certification schemes (national or international) can actually provide adequate proof of legality (Brack 2007b, 2007c), although they may not be recognized by the US LAA or the EU TR. For example, the definition of legality in FLEGT VPA is determined according to the VPA countries, and it is likely to include rules, such as: (1) logging by holder of legal harvest rights; (2) compliance with regulations on permitted harvest levels, environmental and labor regulations; (3) payments of timber royalties and other fees; (4) respect for others' legal tenure rights. In forest certification, the definition of legality covers a wider range of requirements. It requires the forest company to ensure compliance with national legal requirements including forest management, environment, labor and welfare, health and safety, and other parties' tenure and land rights (Brack 2007c).

However, the standards of forest certification are believed to be hard to reach for the majority of the wood products operators, especially for those in developing countries and small and medium enterprises (SMEs). The emerging governmental regulations, such as the US LAA and the EU TR, thus try to protect the forest resources through enforcing the minimum requirement, which is legality. As stated, certification schemes can provide adequate proof of legality. Although the US LAA and the EU TR do not require certification and verification, certification will help demonstrate to the government and the customers that the timber is legally harvested. Therefore, legality requirements from consumer countries are likely a stepping-stone to certification.

1.4 China's wood products industry

China is a very important player in global wood products trade. It is now one of the world's largest importers of primary wood products (Ganguly and Eastin 2011). In 2010, China's industrial roundwood harvest and sawnwood production accounted for only 6.2% and 8.6% of world's total production by volume, while its industrial roundwood and sawnwood imports accounted for 28.2% and 11.5% of world's total imports by volume, respectively (FAOSTAT 2012). China is one of the world's largest exporters of value added wood products (Ganguly and

Eastin 2011). Its plywood production and exports in 2010 accounted for 55.5% and 25.8% of world's total by volume, respectively. Therefore, economic globalization has driven China's wood products industry into a significant position in the global wood products sector (Katsigris et al. 2004; Sun et al. 2004; White et al. 2006; Démurger et al. 2009). Although China's wood products industry has been experiencing fast and steady development in recent decades, it is also confronting a growing number of challenges, especially the limitation of domestic log supply and the using of suspicious raw materials.

1.4.1 China's domestic log supply

China's forest resources have increased in area, standing stock volume and forest coverage, growing from 121.9 million ha, 9.5 billion m^3 and12.7% in the first national forest inventory survey (1973-1976) to 195.5 million ha, 14.9 billion m^3 and 20.4% in the seventh national forest inventory survey (2004-2008), respectively (Table 1.4) (State Forest Administration 2012). However, China's domestic log supply is still limited and cannot meet the increasing industrial demand (Bull and Nilsson 2004).

Table 1.4 China's national forest inventory surveys

Inventory survey	Year	Forest area (million ha)	Standing stock volume (billion m^3)	Forest coverage (%)
1st	1973-1976	121.9	9.5	12.7
2nd	1977-1981	115.3	9.0	12.0
3rd	1984-1988	124.7	9.1	13.0
4th	1989-1993	133.7	10.1	13.9
5th	1994-1998	158.9	11.3	16.6
6th	1999-2003	174.9	13.6	18.2
7th	2004-2008	195.5	14.9	20.4

Data Source: State Forest Administration (SFA) 2012

China's domestic log supply is constrained by several factors. First, its total available forest resources are limited. According to the seventh survey, its forest area per capita was 0.1 ha and standing stock volume per capita was 10.2 m^3, accounting for less than 25% and 15% of the world's average level, respectively. Its forest coverage was only 2/3 of the world's average level (SFA 2012). The shortage is mainly caused by the conversion of forest land to agricultural land

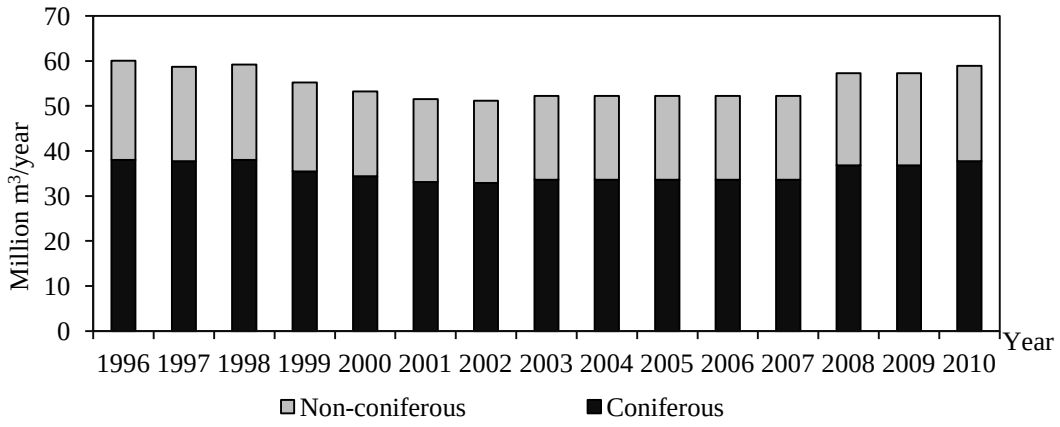
to meet the growing food demand of a rising population and low land productivity in some regions. Second, the age structure of the forest is unfavorable. A prolonged period of over-harvesting has led to young and middle-aged forests representing nearly 70% of the total forest area, while mature and over-mature forests are either scarce or have low accessibility (Démurger et al. 2009). Third, its forest resources are of low productivity. According to the seventh survey, its average stock volume was 85.9 m^3 per ha, accounting for only 78% of the world's average level (SFA 2012).

Log supply is further limited by China's new forest policies, shifting from resource exploitation to resource protection (Démurger et al. 2009). One main program in the policy shift is the Natural Forest Conservation Program (NFCP), announced in October 1997 and implemented in December 2000. NFCP bans any further logging of natural forests in the upper and middle reaches of the watersheds of major rivers such as the Yangtze and Yellow rivers (Uchida et al. 2005). According to the seventh survey, China's natural forest area was 119.7 million ha, accounting for over 61.2% of its total forest area. The volume of standing stock in natural forest was 11.4 billion m^3, accounting for over 76.5% of its total standing stock volume. NFCP has reduced log supply from China's natural forest (Cao et al. 2010). Annual timber harvest from natural forest in the program area was reduced from 32.1 million m^3 in 1997 to 14.8 million m^3 in 2009 (SFA 2012).

Although the planted forest has been increasing, from 53.3 million ha in the sixth survey (1999-2003) to 61.7 million ha in the seventh survey, it cannot fully offset the harvest reduction in natural forest. The productivity of the planted forest is very low. Its standing stock volume in the seventh survey was only 2.0 billion m^3, leading to only 49.0 m^3 per ha average standing stock volume (SFA 2012). Therefore, both the NFCP and the low productivity of planted forest limit China's wood supply (Bull and Nilsson 2004). China's total sawlog and veneer log harvest had been trending downward after the implementation of NFCP, declined from 58.7 million m^3 in 1997 to 51.2 million m^3 in 2002 (Figure 1.1). However, due to the recent increase of forest cover, mainly in plantations, sawlog and veneer log harvest increased to 58.9 million m^3 in 2010. The composition of harvested logs was stable, with coniferous logs accounting for around 64.3% of

total harvests each year.

Figure 1.1 China's sawlog and veneer log harvest

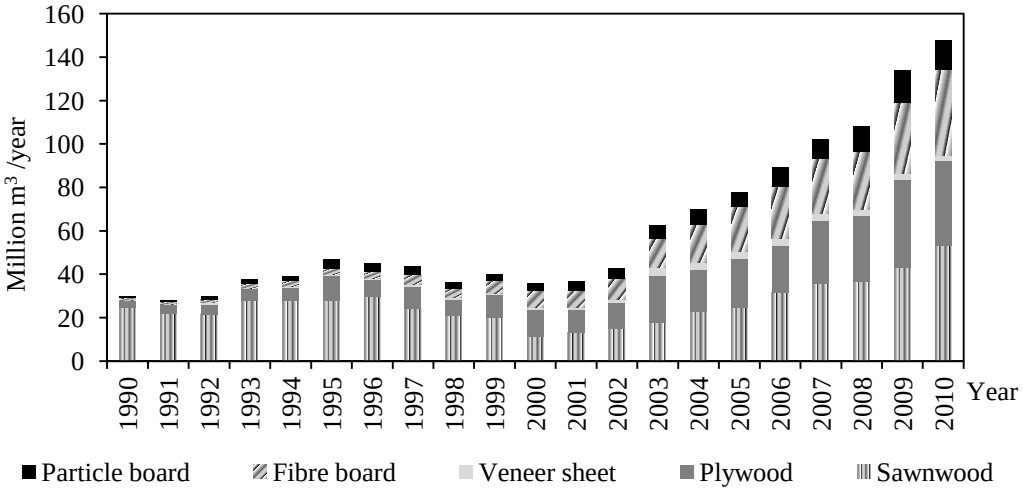


Data Source: FAOSTAT 2012

Bull and Nelson (2004) estimated that China was severely over-harvesting and had substantial illegal logging problem. However, others have pointed out that China's domestic harvested log has been considered low-risk, as timber legality is ensured by four licenses in China: certificates of forest tenure, logging licenses, transport licenses, and processing licenses (Sun and Canby 2010).

At the same time, China's flourishing economy during the reform period has led to a surge in demand for forest products (Figure 1.2). The domestic consumption of forest products has been increasing due to construction boom and rising demand for value added products, such as wooden furniture, wood flooring, paper and paperboard (Démurger et al. 2009). In addition, the wood products processing industry is export-oriented, growing very fast to supply the international wood products market. Exports of value added wood materials in the form of wooden furniture, wood flooring, and plywood are rising (FAOSTAT 2012). Increasing domestic and international demand, combined with limited domestic log supply, makes China's wood products industry rely on imports of primary wood products, including sawlog and veneer log, sawn wood, veneer sheet, particleboard, and fibreboard.

Figure 1.2 China's wood products consumption

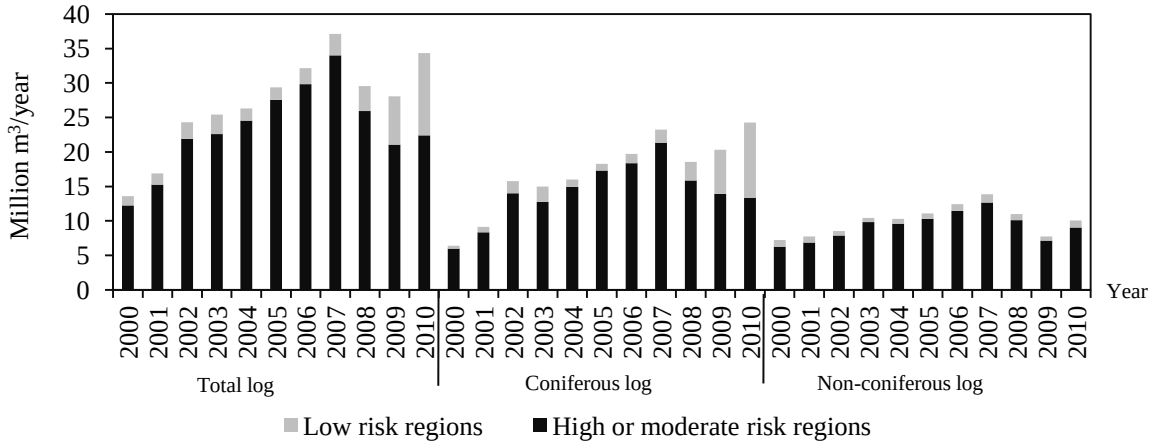


Data Source: FAOSTAT 2012

1.4.2 China's imports of primary wood products

China's sawlog and veneer log imports almost tripled in the past decade, increasing from 13.6 million m^3 in 2000 to 34.3 million m^3 in 2010, reaching at a peak of 37.1 million m^3 in 2007 (Figure 1.3). The main suppliers of coniferous sawlog and veneer logs included Russia, New Zealand, the US, Australia and Canada, with Russia occupying the top spot and accounting for 54.2%-93.9% of Chinese coniferous sawlog and veneer log annual imports during 2000-2010. Main non-coniferous log suppliers to China included Russia, Papua New Guinea, Malaysia, Gabon, Solomon Islands, Myanmar, Equatorial Guinea, Congo, Indonesia, Cameroon, Mozambique, the EU, and the US, with annual imports from high or moderate risk countries/regions accounting for 87.0%-94.4% during 2000-2010. Annual imports from high or moderate risk countries/regions accounted for 65.2%-93.9% of total sawlog and veneer log imports during 2000-2010.

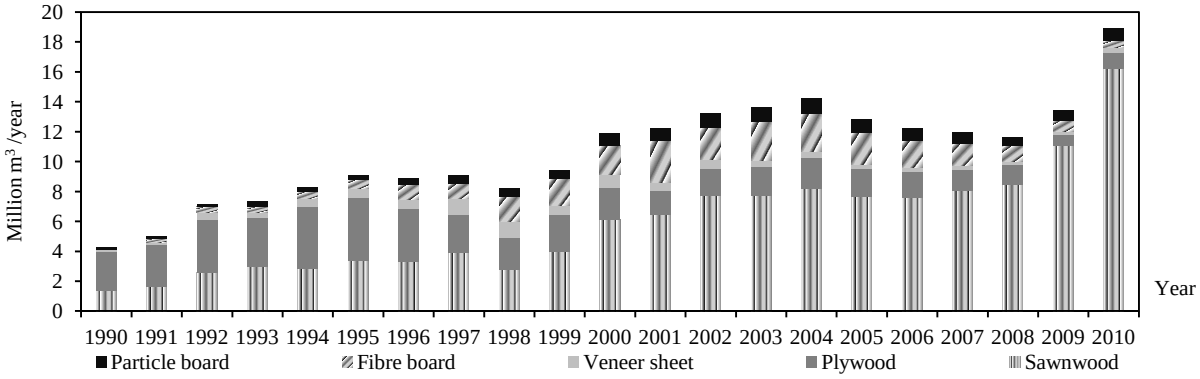
Figure 1.3 China's sawlog and veneer log import



Data Source: United Nation (UN) Comtrade 2012

China's imports of intermediate wood products, especially sawn wood, also exhibited strong growth. Sawn wood imports jumped from about 5.4 million m^3 in 2000 to about 16.2 million m^3 in 2010 (Figure 1.4). The main suppliers of coniferous sawn wood were Russia, Chile, Argentina, Brazil, Myanmar, Indonesia, Canada, the US, the EU, New Zealand, and Australia, with imports from high or moderate risk countries accounting for 49.0%-75.3% during 2000-2010. Its main suppliers of non-coniferous sawn wood were Thailand, Malaysia, Indonesia, Brazil, Russia, Philippines, Cameroon, Gabon, Myanmar, the EU, the US, and Canada, with imports from high or moderate risk countries accounting for 66.2%-83.0% during 2000-2010.

Figure 1.4 China's imports of intermediate wood products



Data Source: FAOSTAT 2012

China has been harshly criticized for irresponsible procurement practices of using illegal-sourced primary wood products (Katsigris et al. 2004; Sun et al. 2004; Lang and Chan

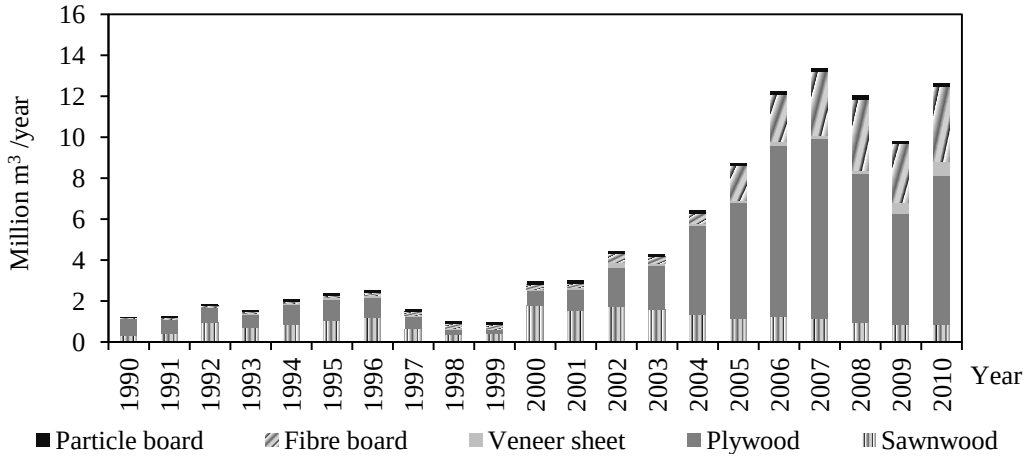
2006; Ganguly and Eastin 2011). The amount and share of illegal-sourced wood products between China and its suppliers can be assessed using the method of trade data discrepancies. For example, illegal exports of logs and sawnwood from Indonesia to China were estimated to be 1.6 and 1.7 million m^3 in 2004, respectively, down to 0.2 and 0.4 million m^3 in 2008 (Lawson and MacFaul 2010). Although China's import of illegal-sourced wood have declined largely due to the reduced supply of illegal logs from Indonesia and Myanmar, China remains the largest importer of illegal logs in volume and illegal logs are estimated to account for about 20% of its overall imports in 2008 (Lawson and MacFaul 2010)

These primary wood products were further processed into value-added wood products that were exported to various countries, mainly in the form of wooden furniture and plywood.

1.4.3 China's exports of value-added wood products

Exports of China's value-added wood products, especially plywood and wooden furniture, have been increasing. China has been the leading plywood producer and exporter since 2005 (Tian et al. 2008). Plywood production increased from 10.8 million m^3 in 2000 to 45.3 million m^3 in 2010. Plywood exports grew from 1.4 million m^3 in 2000 to 7.3 million m^3 in 2010, reaching at a peak of 10.2 million m^3 in 2007 (Figure 1.5). Exports to the US, the EU and Japan grew from 15.8% of total plywood exports in 2000 to around 67.9% in 2009.

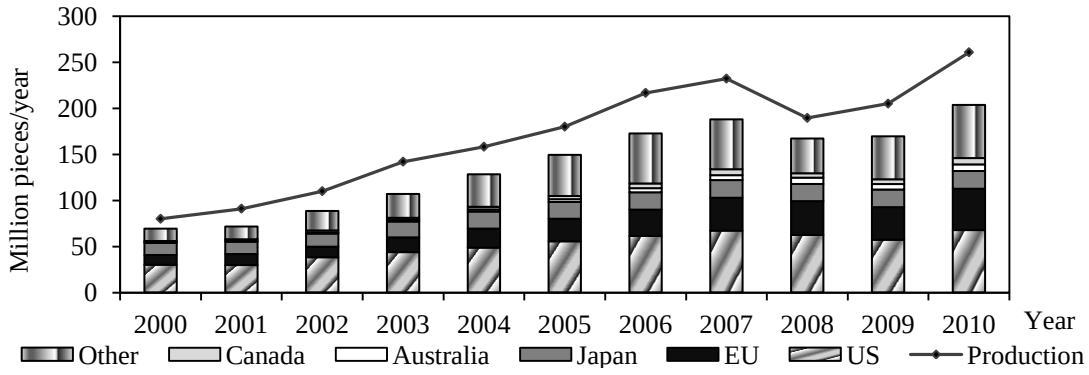
Figure 1.5 China's exports of intermediate wood products



Data Source: FAOSTAT 2012

The wooden furniture industry is the largest subsector of China's wood products industry and has grown almost threefold between 2000 and 2010 (Figure 1.6). China's wooden furniture production increased from about 80.0 million pieces in 2000 to 260.7 million pieces in 2010. Wooden furniture exports grew from 69.2 million pieces in 2000 to more than 203.5 million pieces in 2010. Most of them (65.6% to 78.7%) were exported to the US, the EU, Japan and Australia where initiatives to combat illegal logging are becoming more rigorous (Sun and Canby 2010). China has been the leading wooden furniture exporter since 2005, overtaking the traditional European manufacturers, Germany and Italy (Ganguly and Eastin 2011).

Figure 1.6 China's wooden furniture production and export

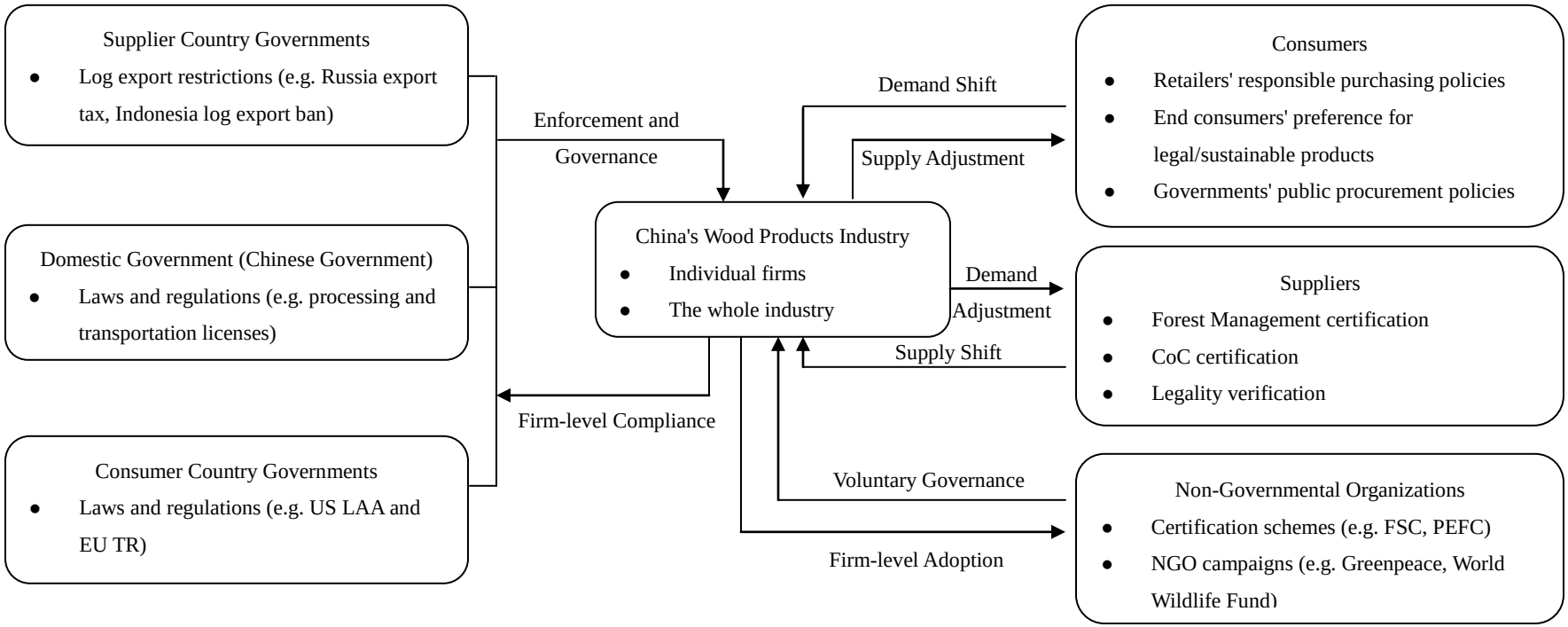


Data Source: UN Comtrade 2012; China National Furniture Association (CNFA) 2012

Illegal wood products from high or moderate risk regions are transferred to and consumed in major markets where strict policies are now implemented to prevent illegal-sourced wood products. The exports of plywood and wooden furniture manufactured from illegal-sourced tropical primary wood products from China to the EU were estimated at 30% of the total (Turner et al. 2007).

As one of the leading exporters of many wood products, China's wood products industry has been placed into a difficult position due to the emerging global governmental and non-governmental initiatives to combat illegal logging. Figure 1.7 summarizes major governmental and non-governmental initiatives that have direct influence on China's wood products industry.

Figure 1.7 Initiatives to combat illegal logging and responses of China's wood products industry



These initiatives exert influence on both individual wood products firms and the wood products industry as a whole. Understanding the impacts of global initiatives to combat illegal logging on China's wood products industry is important. It could help to understand the effectiveness of these initiatives in achieving its goal of reducing illegal logging and associated wood products trade. It could also help the industry to secure a sustainable future while maintaining a rapid economic growth. The industry needs to develop new business strategies by embracing the environmental paradigm to achieve both economic and sustainable development (Cao and Hansen 2006), such as complying with new laws/regulations and adopting of voluntary schemes.

The impacts of global initiatives to combat illegal logging on China's wood products industry will depend on how individual firms and the industry respond to these initiatives. Therefore, it is necessary to study both the firm-level responses and the industry-level responses. This thesis will focus on their responses to two new governmental initiatives (i.e. the US LAA and the EU TR) and one non-governmental initiative (i.e. CoC certification). One major aspect of firm-level responses to laws/regulations is a firm's legal compliance. While for firm-level responses to non-state market driven forest certification, such as CoC certification, a very important part is a firm's adoption of voluntary governance schemes. The US LAA, the EU TR, and CoC certification will all be viewed as innovations in the wood products sector. An integrated innovation-adoption model will be used as the theoretical guide for the firm-level analysis. In-depth understanding of firm-level responses to these initiatives will enable us to analyze potential industry-level responses, especially making reliable assumptions to model and forecast potential longer-term economic impacts on the industry. The perfect competition theory was used as a theoretical guide for the industry-level analysis.

1.5 Theoretical background

An innovation is an idea, practice, or object that an individual person or organization perceives as new (Rogers 1995). Economic research has identified innovation as a key engine for economic growth, competitiveness and employment (Schumpeter 1934; Stone et al. 2011). This

is not only relevant to high-tech industries but to all sectors and economies, including forestry and rural areas (Rametsteiner and Weiss 2006a, 2006b).

Alternative frameworks for innovation lead to differing types of innovation based on the objectives and approaches inherent in the framework. According to the classification of innovation in the public sector, innovation in the forest sector at the government level can be classified into legislative innovation, enforcement/implementing innovation, and administrative innovation (Australian National Audit Office 2009). At the firm level, innovation types include product (good or service) innovation, process innovation, positioning innovation, and paradigm innovation (Tidd and Bessant 2011). Innovations in the public sector can lead to innovations in the private sector. The emerging legality requirements, such as the US LAA and the EU TR, are legislative innovation in the public sector, while CoC certification is an example of process innovation in the private sector.

In this thesis, the theoretical foundation at the firm level is an integrated innovation-adoption model that builds on several social-psychological theories, including the innovation-diffusion theory, the elaboration likelihood model and theory of planned behaviour. The integrated innovation-adoption model is used to explain a firm's attitudes, decision and behaviour towards two legislative innovations in combating illegal logging (i.e. the US LAA and the EU TR) and one process innovation (i.e. CoC certification) at the firm level. At the broader industry level, the perfect competition theory was used as a theoretical guide to analyze the impacts of the two legislative innovations on China's wood products industry.

1.5.1 Innovation-diffusion theory

Researchers have traditionally conceptualized the adoption decision process by examining distinguishing characteristics of adopters and non-adopters and opinion leaders, perceptions of the attributes of the innovations, rates of adoption and diffusion, and the channels of communication during the various stages of the adoption decision process (Marra et al. 2003).

Understanding how innovations are adopted (or rejected) in any particular industry or group is important. Rogers' innovation-diffusion theory is one of the major theories. This concept

centers on the linear adoption process, which has five stages (Rogers 1995):

1. Knowledge (gathering knowledge about the innovation);
2. Persuasion (evaluating the innovation and forming attitudes towards the innovation);
3. Decision (deciding to adopt or reject);
4. Implementation (adopting or rejecting); and
5. Confirmation (continuing to adopt/reject or not).

Rogers (1995) separates the participants in the innovation adoption process into five adopter classes: innovators, early adopters, early majority, late majority, and laggards. These classes reflect how quickly or slowly a person or business owner would adopt and implement an innovation, with innovators being the quickest and laggards being the slowest.

Innovation-diffusion theory has been widely used in different areas. There are some studies on innovation in forest industries (Hansen 2010; Nybakk et al. 2011), which have focused on the forest products (Globerman et al. 1998; Anderson 2006; Bull and Ferguson 2006; Kubeczko et al. 2006; Albert 2007; Hansen 2010; Stone et al. 2011), forest landowners (Šálka et al. 2006; Rasamoelina et al. 2010), and forest policy (Rametsteiner and Weiss 2006a, 2006b).

1.5.2 The elaboration likelihood model

The elaboration likelihood model explains the processing of information that may lead to behavioural change of an individual or a decision-maker of a firm (Petty et al. 1983; Petty and Cacioppo 1986). In this model, elaboration refers to the degree of cognitive effort one puts forth concerning a target object's attributes, merits, and drawbacks (Petty et al. 1997).

A firm's information about the innovation comes from three sources: internal information sources (e.g. employees and the decision maker himself/herself), business to business information sources (e.g. other forest owners/managers, clients, and consumers), and institutional level information sources (e.g. universities, research institutions, technical conferences, consultants, seminars, courses, excursions, technical journals, various media, and forest administration). The information is then processed either through the central information processing route or the peripheral information processing route. In the former route, the decision

maker carefully and actively evaluates information regarding a decision, object, or event. While in the latter route, the decision maker conducts minimal cognitive efforts. The latter route is activated by simple cues or cognitive heuristics such as the presence of an expert source, the inclusion of statistics in a message, or the length of an argument (Chaiken 1980; Chaiken et al. 1989; Krosnick and Petty 1995; Street et al. 2001). It is believed that information processed through the central cognitive processing route is more likely to result in an enduring behaviour than information processed through the peripheral route (Petty et al. 1997). Usually, the central cognitive processing route will lead to a higher awareness level of an issue (more knowledge) as the organization and the decision maker are taking active effort to learn.

The elaboration likelihood model indicates two sets of factors that influence the information processing route: motivation factors and ability factors (Chaiken 1980; Chaiken et al. 1989; Krosnick and Petty 1995; Street et al. 2001). For the decision maker of a firm, motivation can be affected by his/her values/beliefs and the firm's organizational culture. Information closely aligned with an individual's motivations is more likely to be processed along a central route (Petty et al. 1997). Ability consists of two dimensions: the cognitive capacity of the decision-maker (e.g. education level, and age) and the relative conduciveness of the situation for the expenditure of cognitive effort directed at the attitude object (e.g. firm size, ownership structure, and resources) (Street et al. 2001).

In summary, the elaboration likelihood model indicates that for a decision maker of a firm to engage in purposeful and issue-relevant thinking he or she must have sufficient motivation and ability to do so. This explains why different decision makers from different firms have different awareness levels for a given issue. In this thesis, the elaboration likelihood model is integrated into the knowledge stage of the innovation-diffusion theory.

1.5.3 Theory of planned behaviour

In the theory of planned behaviour, the intention to perform the behaviour in question is the immediate antecedent of overt behaviour. It explains behavioural adoption using three factors: subjective norms, attitudes and perceived behavioural control (Ajzen 1991). This theory can be

applied to explain both personal and firm behaviour of innovation adoption.

At the firm level, subjective norms include a firm's values/beliefs, goals, and perceived expectations of relevant others. A firm's values, beliefs, and goals are related to its organizational culture which is the collective behaviour of humans that are part of an organization and includes a common set of norms, values, beliefs, and goals (Morgan 1998; Haslam 2004; Schein 2010). Organizational goals refer to a set of requirements or constraints, such as profit, which has only an indirect relation to the motives of the decision makers within the organization (Simon 1964). Perceived expectation of relevant others is related to social norms, which prescribe the appropriate way to behave in a given context. It is the social pressures put on a firm to perform (or not perform) the behaviours in question.

At the firm level, attitudes are understood as a rational-choice-based evaluation of the consequences of behaviour, including economic, social and environmental consequences, as well as an estimate of the likelihood of these outcomes. A firm's perceived behavioural control is determined by its organizational characteristics, mainly including various resources (human resources, natural resources, and capital resources), technology, products, ownership structure, business duration, management/operation level, raw material sources, and final markets. It is believed that behaviours not depending on the organizational characteristics are easier to adopt (Haslam 2004; Schein 2010).

According to this theory, behaviours are more likely to be adopted if a firm has favorable attitudes toward behavioural outcomes, if external pressures and other social expectations reinforce adopting the behaviour, and if individuals feel they have control over the situation so that behavioural changes in which they engage are likely to have the intended effect. In this thesis, the theory of planned behaviour theory on the organizational level is integrated into the persuasion stage of the innovation-diffusion theory.

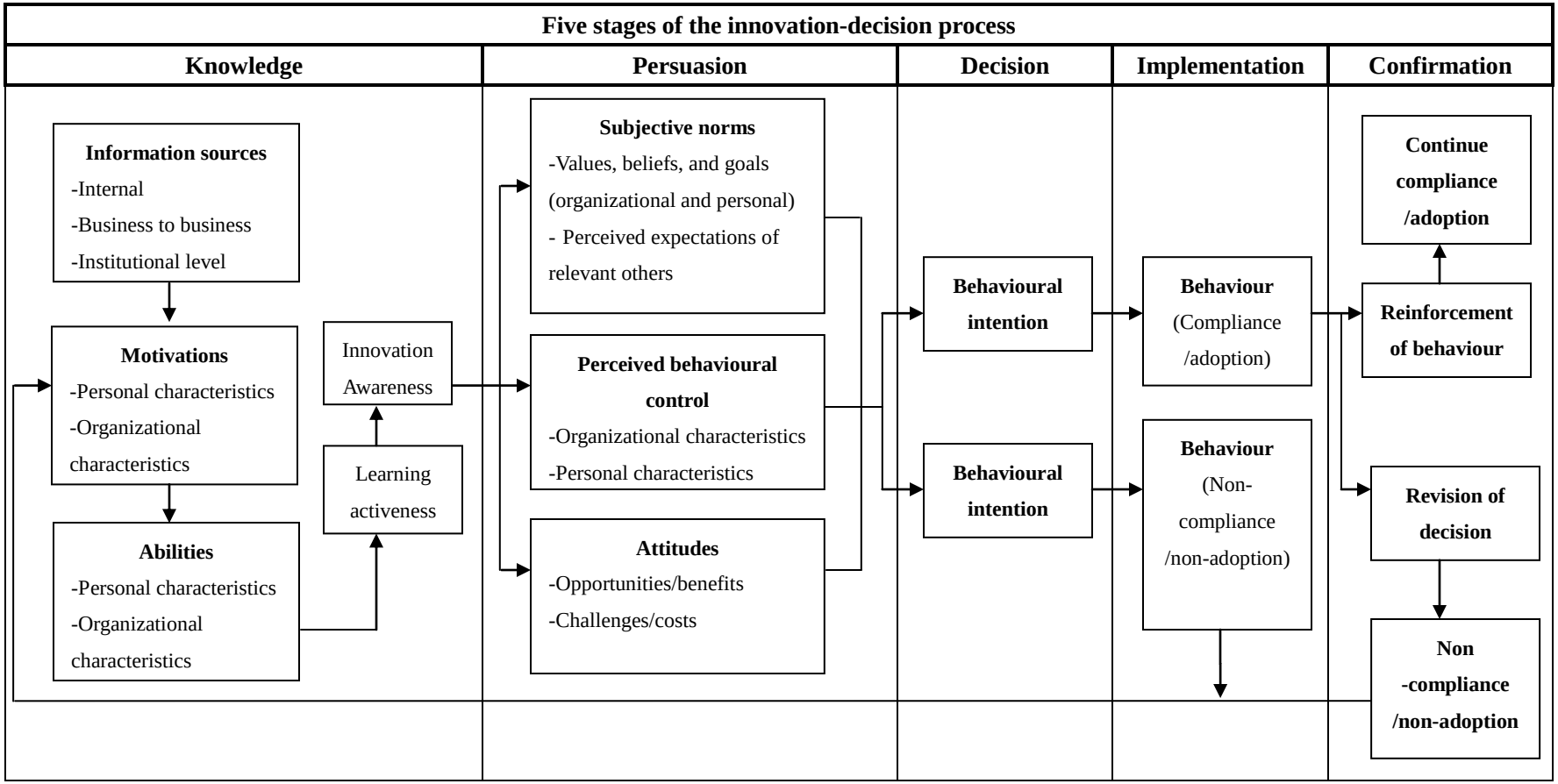
The elaboration likelihood model and theory of planned behaviour indicate that a firm's decision making process is based on bounded rationality. Bounded rationality is the idea that rationality of a firm is limited by the information they have, the cognitive limitations of decision makers, and the finite amount of time they have to make a decision (Simon 1955, 1990, 1991). It

complements rationality as optimization, which views decision-making as a fully rational process of finding an optimal choice given the information available. Because decision-makers lack the ability and resources to arrive at the optimal solution, they instead apply their rationality only after having greatly simplified the choices available (Gigerenzer and Selten 2002). Thus, the decision-maker seeks a satisfactory solution rather than the optimal one.

1.5.4 Integrated innovation-adoption model

This thesis employs an integrated innovation-adoption model, which uses the innovation-diffusion theory as a basis and integrates the elaboration likelihood model and the theory of planned behaviour, to analyze the legal compliance with the US LAA and the EU TR and the adoption of CoC certification. The integrated innovation-adoption model was adapted from Rasamoelina et al. (2010) who used a similar model to analyze the adoption of woodland management practices by private forest owners in Virginia. The elaboration likelihood model was integrated into the knowledge stage to analyze the processing of information and the formation of new knowledge. The theory of planned behaviour was incorporated into the persuasion stage to analyze how a final decision was made based on various factors. Figure 1.8 summarizes the key characteristics and stages of the integrated innovation-adoption model.

Figure 1.8 The integrated innovation-adoption model



Note: This model is adapted from Rasamoelina et al. (2010).

At the knowledge stage, learning activeness refers to a firm's activeness in learning environment-related issues. It reflects a firm's information processing route. Innovation awareness refers to the results of the learning process of the knowledge stage, which is a firm's awareness of the innovation (e.g. the US LAA, the EU TR, and CoC certification). The elaboration likelihood model was simplified in the analysis of this thesis, using only learning activeness to analyze the processing of information and the formation of new knowledge.

At the persuasion stage, given the knowledge of the innovation (processed information), the decision-making of a firm with bounded rationality is determined by subjective norms, attitudes, and perceived behavioural control (Ajzen 1991). Subjective norms include organizational/personal values, beliefs, goals, and perceived expectations of relevant others. Regarding the US LAA, the EU TR, and CoC certification, subjective norms can be interpreted as a firm's values/beliefs towards environmental protection/corporate social and environmental responsibility, a firm's goals in the market, pressure from clients, customers, social association, and forest administration. Attitudes include a firm's evaluation of the challenges and opportunities (or costs and benefits) of the US LAA, EU TR, and CoC certification. Perceived behavioural control is determined by the characteristics of a firm and its decision maker. According to this theory, behaviours are more likely to be adopted if a firm has favorable attitudes toward behavioural outcomes, if external pressures and other social expectations reinforce adopting the behaviour, and if individuals feel they have control over the situation so that behavioural changes in which they engage are likely to have the intended effect (Ajzen 1991).

At the decision stage, the decision maker makes a decision (behavioural intention) about how to response to the innovations (i.e. the US LAA, the EU TR, and CoC certification) based on the estimation of the persuasion stage, which directly leads to the behaviour of the implementation stage (i.e. legal compliance/non-compliance, CoC certification adoption/non-adoption). After a period of the implementation, a firm gains new information and knowledge from the implementation feedbacks and then go to the final confirmation stage, at which the decision maker seeks reinforcement of the compliance/adoption or

non-compliance/non-adoption if exposed to conflicting message about the previous decision. At the confirmation stage, a decision maker seeks to avoid a state of dissonance or to reduce it if it occurs.

1.5.5 Perfect competition theory

At the industry level, industry organization economic theories generally follow the industry structure-firm behaviour-industry performance approach and assume that industry structure (e.g. perfect/almost perfect competition, monopoly and oligopoly) determines firm behaviour (e.g. new product development, innovation, and pricing), which then determines industry/economic performance (Bain 1968; Porter 1998; Conner 1991).

The industry-level analysis in this thesis uses the perfect competition theory (Aumann 1966; Alchian and Demsetz 1972; Alchian 1982; Makowski and Ostroy 2011). The wood products industry is assumed to be perfect competition with the following specific features: (1) the market consists of a large number of buyers and sellers that are small relative to the size of the overall market; (2) the sellers in one sector of the wood products market offer reasonably homogenous or similar products (e.g. sellers in plywood sector offers homogenous plywood); (3) firms can freely enter or exit the market; (4) the combination of input to produce certain output is known; (5) the marginal contribution of each input can be easily computed; (6) all parties have perfect and complete information; and, (7) labour and capital is completely mobile and divisible among firms in one country (Conner 1991).

As multiple wood products were analyzed, substitution between raw and processed wood products was one of the major concerns. Substitute goods are goods which, as a result of changed conditions, may replace each other in consumption (Nicholson and Snyder 2011). A substitute good, in contrast to a complementary good, is a good with a positive cross elasticity of demand. This means a good's demand is increased when the price of another good is increased. Conversely, the demand for a good is decreased when the price of another good is decreased. In this analysis, substitution between products contained two parts: (1) substitution between different raw and processed wood products (e.g. legal and illegal logs); (2) substitution between

products from different countries (e.g. logs from China and logs from the USA). Substitutes were assumed to have a constant marginal rate of substitution. The second feature of the perfect competition market indicates that certain type of wood products manufactured in different countries (e.g. plywood manufactured in China and US) are assumed to be of perfect substitution.

1.6 Research question, objectives, framework and methods

The central research question of this thesis is: How would China's wood products industry, particularly the wooden furniture industry, be influenced by the US LAA, the EU TR and CoC certification? I addressed the question by exploring three research objectives:

Objective 1: Identify factors that determine a firm's legal compliance with the US LAA and the EU TR;

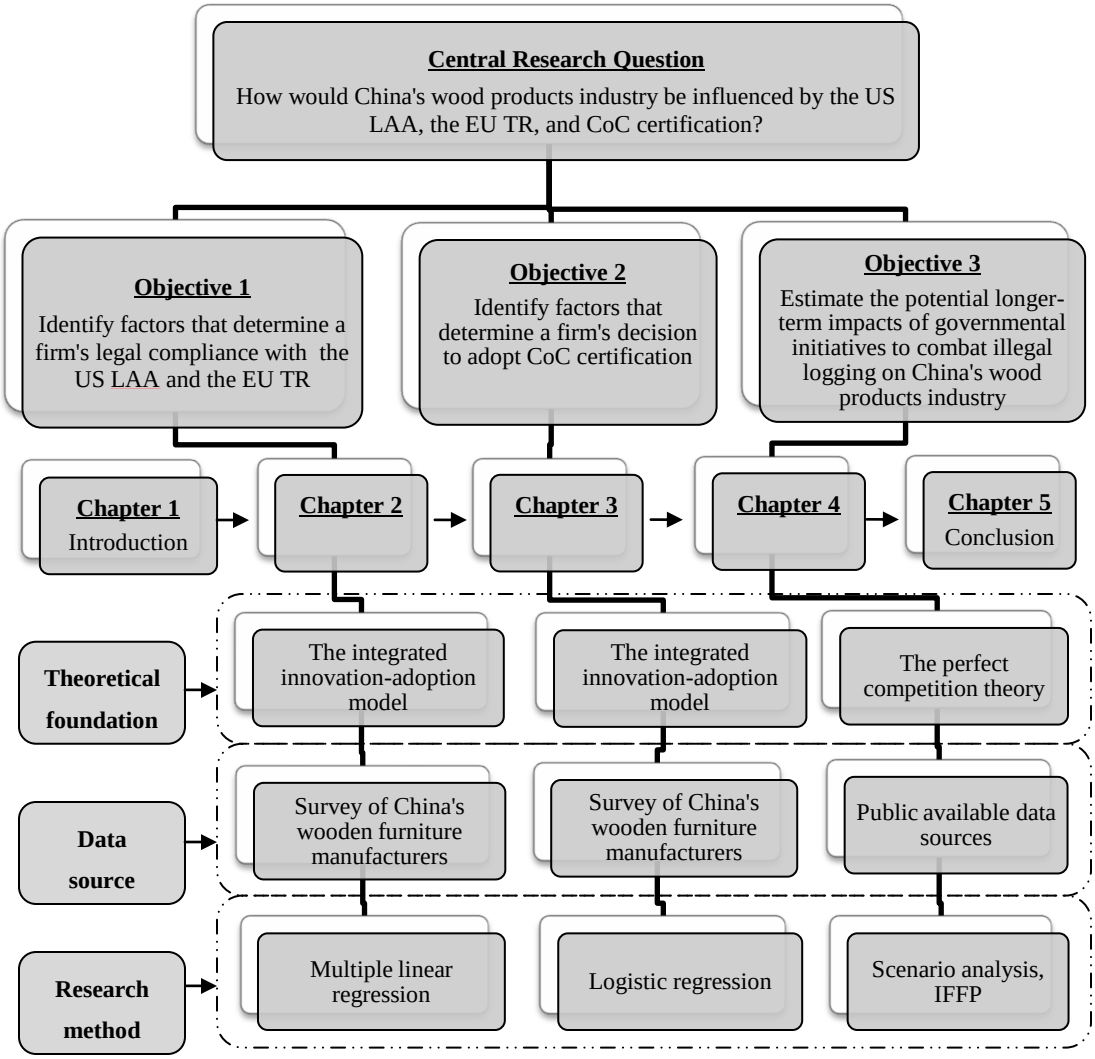
Objective 2: Identify factors that determine a firm's decision to adopt CoC certification; and

Objective 3: Estimate the potential longer-term impacts of governmental initiatives to combat illegal logging in the US the EU on China's wood products industry.

The first two objectives addressed the central research question at the firm level. I surveyed 107 randomly selected export-oriented wooden furniture manufacturers in China to investigate their perceptions of and responses to these initiatives and used the integrated innovation-adoption model as a guide. The wooden furniture sector was chosen as it is the largest sub-sector of China's wood products industry.

The third objective addressed the central research question at the industry level. I used the International Forest and Forest Products (IFFP) model to examine the potential longer term impacts on the wood products sector based on the perfect competition theory. Figure 1.9 is a summary of the research framework for this thesis. The central research question is broken down into three key research objectives and each of these objectives is addressed in a separate chapter (Chapter 2, 3 & 4) within the thesis.

Figure 1.9 A research framework to study the impacts of recent forest policy changes on China's wood products industry



Objective 1: Identify factors that determine a firm's legal compliance with the US LAA and the EU TR.

When facing global legality requirements, wood products manufacturers can either try to take advantage of new opportunities to gain greater market share, or possibly watch their existing markets dwindle, or shift to domestic market and other overseas markets where legality requirements are not in place. Companies that are more aware of the policies and understand them better are assumed to be more prepared and are more likely to develop an appropriate response. It was reported that, when the US LAA was implemented, the Chinese wooden

furniture firms did not pay enough attention and suffered losses; they were reported even less familiar with EU-FLEGT related initiatives (EU Green Barriers Shock the Furniture Industry 2009). For example, a Chinese wooden baby furniture company (Style Craft Furniture Co. Ltd.) was sentenced to a $40,000 fine and three-year probation due to smuggling internationally protected wood, ramin (The US Department of Justice 2009). In-depth research to evaluate a firm's legal compliance with the US LAA and the EU TR and factors that correlate to the compliance are needed to understand a firm's behaviour towards global legality requirements. In my study, I conducted interviews with China's wooden furniture manufacturers, which are in the largest sub-sector and a well-defined export sector of China's wood products industry, to fill some of the gap in knowledge. Guided by the integrated innovation-adoption model, multiple linear regression was conducted to identify factors that determine a firm's willingness to comply with the US LAA and the EU TR.

Objective 2: Identify factors that determine a firm's decision to adopt CoC certification.

Wood products manufacturers are increasing adopting CoC certification to improve their supply chain management and ensure legality and sustainability (Ratnasingam et al. 2008). While much have been written about forest certification in developed countries (Cashore et al. 2003; Ozanne and Vlosky 2003; Archer et al. 2005; Vidal et al. 2005; Owari et al. 2006; Jayasinghe et al. 2007; Owari and Sawanobori 2007; Baker 2009; Vlosky et al. 2009; Chen et al. 2011b; Montague 2011), there has been little examination of CoC certification in China. Further, as the wooden furniture industry is the largest sub-sector within the wood products sector of China, an evaluation of wooden furniture manufacturers' attitudes and behaviours towards CoC certification was necessary. Therefore, in the study I conducted interviews to assess the current awareness levels of CoC certification among wooden furniture producers and their perceptions of cost, benefits, effectiveness and barriers. The integrated innovation-adoption model was again used as a theoretical guide for the analysis. Binary logistic regression was conducted to identify factors that determine a firm's decision to adopt CoC certification.

Objective 3: Estimate the potential longer-term impacts of governmental initiatives to combat illegal logging on China's wood products industry.

Earlier studies have addressed the economic impacts of illegal logging by comparing two alternatives-the present situation versus the end of illegal logging (Northway and Bull 2006; Turner et al. 2007; Li et al. 2008). Only a few studies focus on the impacts of alternative policy initiatives that aim to combat illegal logging (Ottitsch et al. 2005; Moiseyev et al. 2010). The potential impacts of the US LAA and the EU TR on China's wood products industry have never been forecasted. Forecasting the potential impacts of these policies on China's wood products industry can help us to evaluate the effectiveness of these policies in combating illegal logging and associated trade, understand the potential challenges and benefits of these policies for China, and enable China's industry to make corresponding efforts to take advantage and minimize risk. This research will address the last research objective through scenario analyses using IFFP. Three research hypotheses will be tested.

In conclusion, this study aims to answer the central research question at both the individual producer level and the wood products industry level. At the individual producer level, I will sample and survey wooden furniture manufacturers in China to investigate their perceptions of and responses to three innovations: the US LAA, the EU TR, and CoC certification. The integrated innovation-adoption model will be used as a guide to analyze factors that affect their extent of compliance with the US LAA and the EU TR, and their adoption of CoC certification. At the wood products industry level, I will use the International Forest and Forest Products (IFFP) model which is based on the perfect competition theory to examine the potential longer-term impacts of the US LAA and the EU TR on China's wood products industry.

Following this introductory chapter, Chapter 2, Chapter 3, and Chapter 4 are the research chapters addressing each of the thesis objectives. Chapter 2 evaluates factors that correlate to a firm's extent of compliance with the US LAA and the EU TR. Chapter 3 identifies key factors which affect a firm's decision to adopt CoC certification.Chapter 4 evaluates the potential longer-term impacts of the US LAA and the EU TR on China's wood products industry. Chapter 5 presents the contribution of the study, the key findings, potential application, limitations, and future research possibilities.

2 Compliance with the US Lacey Act Amendment and the EU Timber Regulation: Perspectives of China's Export-Oriented Wooden Furniture Manufacturers

2.1 Introduction

Traditional environmental resource management policies are mostly supply-side policies, which were designed to internalize the environmental externalities by changing the marginal cost function (Caviglia-Harris et al. 2003). Recently, demand-side policies are often preferred to achieve long-term sustainability (Edler and Georghiou 2007). To combat illegal logging, they are increasingly used since numerous supply-side policies did not have the intended effect (Lawson and McFaul 2010; McDermott et al. 2010; White 2010; Dauvergne and Lister 2011).

Recent demand-side policies in the forest sector include the US Lacey Act Amendment 2008 (the US LAA) and the EU Timber Regulation (the EU TR). Before the implementation of the US LAA, all initiatives intended to combat illegal logging were either voluntary or a constraint on domestic operators (Chatham House 2009). Now compliance with the US LAA is mandatory and compliance with the EU TR will be mandatory soon. These legislations constrain/will constrain all wood products operators that are doing business in/with the US/EU. In other words, we are seeing two major demand-side shifts: from domestic to international markets and from voluntary action to governmental regulations (Caviglia-Harris et al. 2003; Dauvergne and Lister 2011).

Numerous popular reports have explained the contents of the US LAA and the EU TR. They suggested strategies for operators to respond (Gregg and Porges 2008); analyzed potential economic, environmental and social effects (Brack 2007b; Roda et al. 2007; Betser and Oliver 2009; Environmental Investigation Agency 2009; Roberts 2011); compared the US LAA and the EU TR (Butler and Grant 2011); and discussed how to use certification schemes to mitigate risk of market loss (ClientEarth 2011a, 2011b). However, because the US LAA and the EU TR are quite new, only a few peer-reviewed papers have been published (Meyer 2008; Moiseyev et al.

2010; Saltzman 2010; Tanczos 2011; Cashore and Stone 2012) and they focus on the major consumer countries in North American and Europe. In-depth studies to assess how these demand-side policies can affect supply-side countries exporting to the US and the EU are needed.

Among all the countries exporting to the US and the EU, China merits special attention since it has emerged as a critical player in global wood products trade. Currently, China is the largest importer of logs and lumber and the largest exporter of value added wood products in the world (Ganguly and Eastin 2011). The wooden furniture industry is the largest subsector of China's wood products industry. It has grown almost threefold between 2000 and 2010. In 2010, China's wooden furniture production was 260.7 million pieces of which 203.5 million pieces were exported (CNFA 2012). Over 70% of China's exported wooden furniture is sold to major consumer markets where initiatives to combat illegal logging are rigorous, such as the US, the EU, and Australia (UN Comtrade 2012). Since 2005, China has overtaken the traditional European manufacturers, Germany and Italy, as the leading wooden furniture exporter (Ganguly and Eastin 2011). However, this dominance could be curtailed by global regulatory initiatives to combat illegal logging (Canby 2010).

As indicated, there is very little research about the manufacturers' perceptions of and responses to global legality requirements. In this study, I surveyed China's export-oriented wood furniture manufacturers to investigate their perceptions of and responses to the US LAA and EU TR. I assessed the legal compliance of China's wooden furniture manufactures with these laws/regulations. Factors that affect a firm's legal compliance were analyzed using multiple linear regressions.

2.2 Theoretical framework

The integrated innovation-adoption theoretical model was used as the theoretical foundation of the analysis. In this analysis, the US LAA and the EU TR are viewed as legislative innovations at the government level in the forest sector which can lead to various process innovations of a firm. This model was adapted from Rasamoelina et al. (2010) who used a

similar model to analyze the adoption of woodland management practices by private forest owners in Virginia. Please see section 1.5.4 for detailed information about the integrated innovation-adoption model.

2.3 Methods

2.3.1 Data collection

Interviews were conducted to gain insights into the views and attitudes of China's wooden furniture manufacturers towards the US LAA and the EU TR from June to November 2011.

Sample frame: A sample frame of China's wooden furniture manufacturers that export products to the US and/or the EU was produced from three sources. The first source was the business directory for China's import and export furniture manufacturers (ASKCI 2011). The directory had 13300 import and export furniture manufacturers. Information about their address, contacts, main products and export destinations were listed. All wooden furniture manufacturers that exported to the US and/or the EU were selected from the directory. This gave us 1803 firms. The second source was the FSC certificate database. There were 341 CoC-certified wooden furniture manufacturers in China as of May 2011 (FSC 2011). The 341 firms were double-checked in the 1803 firms selected in the first step and 280 firms which were included in the 1803 firms were included in the sample frame. The third source was the PEFC CoC certificate holder information. There were three PEFC-CoC-certified wooden furniture manufacturers in China as of May 2011 (PEFC 2011). They were all included in the 1803 firms and therefore were included in the sample frame. Hence, the sample frame included 1803 firms (1520 non-CoC-certified firms and 283 CoC-certified firms). Stratified random sampling was used to select 800 non-CoC-certified firms and 200 CoC-certified firms to send the interview materials.

First-stage interview (pre-test): Interview questions were pre-tested to examine the validity of the questions from June to August 2011. I randomly selected 100 non-CoC certified firms from the 800 non-CoC certified firms and 35 CoC-certified firms from the 200 CoC-certified firms. The original invitation letter was sent to the senior manager or owner of

each of the 135 firms to explain the research purpose and inquire their participating willingness. Materials sent together with the original invitation letter included the interview questions, a brief introduction of the US LAA, the EU TR, and CoC certification, and a consent form based on ethics policies of the Behavioural Research Ethics Board (BREB) of the University of British Columbia (UBC) that outlined the rights of the participants. Twenty firms (17 non-CoC-certified firms and 3 CoC certified firms) which responded actively were interviewed face-to-face and therefore the response rate for the pre-test was about 14.8%. The interviewer asked the interviewees whether they understood the questions, whether they were able to answer the questions, and how the questions could be improved. It turned out that some questions needed to be expressed clearer and some questions needed to be deleted, as they were difficult for the respondents to answer due to business secrets and/or complexity.

The interview questions were re-designed according to the pre-test interviews. The 20 firms involved in the pre-test were re-interviewed through telephone with the new questions. This time, they were proved fully feasible.

Second-stage interview: After the pre-test, the rest 865 from the 1000 firms were interviewed. A new invitation letter was sent to the senior manager or owner of each firm to explain the research purpose and inquire their participating willingness. Materials sent together with the new invitation letter included the new interview questions, a brief introduction of the US LAA, the EU TR, and CoC certification, and a consent form based on UBC BREB ethics policies that outlined the rights of the participants. At the time of the survey, the US LAA had only been implemented for approximately three years in the wood products sector, and around one year specifically in the wooden furniture sector, the respondents were still at the stage of collecting information (knowledge stage). Therefore, a brief introduction of the US LAA and the EU TR could help the respondents to gain more information and estimate the perceived expectations of relevant others, perceived behavioural control, opportunities, and challenges at the persuasion stage, and anticipate potential responses of the decision stage. At last, 61 non-CoC-certified firms and 26 CoC certified firms responded. They were interviewed from September to November 2011. Therefore, from a total of 1,000 firms approached in the two

stages, 107 volunteered to participate, giving us a response rate of 10.7%. Based on previous studies, the response rates for wood products industrial studies ranged from 10% to 30% (Vlosky and Ozanne 1998; Vidal et al. 2005; Yuan and Eastin 2007; Chen et al. 2011b; Seol 2011). Overall, the response rate for this study was considered adequate given the total firms approached. A thank-you letter was sent to each interviewee after the interview.

Interview questions: The interview script was developed in Chinese and then translated in English to communicate with the research committee and several experts from NGOs before the pre-test. The interview questions were revised based on the comments obtained. The revised interview questions were then translated back into Chinese and then re-translated into English in order to assure the accuracy of the translation. The same procedure was used for the pre-test.

The interview script contained open-ended and semi-structured questions. The open-ended questions were used to ask respondents about firm profiles (from question 1-1 to question 2-6, and question 4-1 in Appendix A). Respondents were asked to grade their level of understanding about the US LAA and the EU TR using a five-point Likert-type scale with 1=understand nothing to 5=understand fully (question 3-1 in Appendix A). Attitudinal questions were posed as a set of statements to which respondent firms were asked to rank their level of agreement using a five-point Likert scale with 1=strongly agree to 5=strongly disagree (question 3-2 in Appendix A). Semi-structured questions were used to ask firms' attitudes towards the expected impacts of the regulations and their responses (question 3-3 and question 3-4 in Appendix A). Respondents were also asked to report the pressures they received from associations and clients to satisfy legality and sustainability using Likert-type scales (question 4-8 and 4-9 in Appendix A). Likert scale or Likert-type scale was treated as interval in nature (Likert 1932; Norman 2010). The answers about the expected impacts of regulations on costs, prices and volumes were treated as interval. Answers regarding the responses to legality requirements were treated as nominal/binary. Please see Appendix A for detailed interview questions.

Test of interview bias: Non-response bias was examined using two-tailed t-tests. Late-respondents are theorized to have some similarities with non-respondents (Groves 2006). The answers of the early respondents and the late respondents for two selected questions

(question 3-1 and question 4-2 in Appendix A, question 3-1 contained two sub-questions) were compared. Those who responded to the invitation letter within two weeks were perceived as early respondents and those who responded after two weeks were perceived as late respondents. There were 46 early respondents and 61 late respondents. The results showed no statistical significance (α=0.05) between the answers to both questions (degree of freedom=105; P=0.415 and 0.407 for question 3-1; P=0.344 for question 4-2). Thus, there is no indication of non-response bias, and the results can be considered representative of the population.

A total of 60 face-to-face interviews and 47 telephone interviews were conducted. To test potential bias based on methods of data collection, two-tailed t-tests were run between different interview approaches using one interview question (question 3-1 in Appendix A). The results did not reveal any significant difference (α=0.05) in answers collected between telephone interview and face-to-face interview (degree of freedom=105; P=0.400 and 0.430 for question 3-1).

2.3.2 Data analysis

The survey data were coded, entered and then analyzed using the International Business Machine Statistical Product and Service Solutions Statistics 20.0 (IBM SPSS Statistics 20.0, hereafter SPSS).

Legal compliance: The variable "legal compliance" was used in this analysis to denote a firm's willingness to comply with the US LAA and the EU TR within five years. Table 2.1 shows the estimation of the compliance standards (CS). Ten standards were developed based on the US due care requirements (The US Fish and Wildlife Service 2012), the EU due diligence system (European Commission 2012), and the SmartWood Generic Standard for Verification of Legal Compliance (Rainforest Alliance 2012) to estimate a firm's willingness to comply with the US LAA and the EU TR. CS1 is the pre-condition standard for a firm which means that the firm has to continue to export to the US/EU market. CS2-CS8 are specific measures a firm shall take to comply with the US LAA and the EU TR. CS2-CS5 are standards about legal trade and indicate that a firm shall demonstrates compliance with all local, national, and binding international laws and regulations relating to the processing, transportation and trade of forest products. All firms

were assumed to comply with CS2-CS5. CS6-CS8 are standards regarding the origin tracing along the supply chain. CS9 and CS10 are general practices a firm shall take.

Table 2.1 Estimation of a firm's legal compliance with the US LAA and the EU TR

Compliance Standard	Estimation Score
CS1. Companies shall stay in the US/EU market within the next 5 years.	0: For firms which have exited or plan to exit within five years. 10: For firms which will not exit within five years.
CS2. Compliance with the applicable provisions and requirements of CITES (the Convention on International Trade in Endangered Species of Wilde Fauna and Flora) shall be demonstrated.	10: For all surveyed firms
CS3. Evidence of compliance with requirements in relation to the transportation of forest products shall be demonstrated.	10: For all surveyed firms.
CS4. Timber processing facilities shall hold the appropriate licenses and comply with required laws and regulations.	10: For all surveyed firms.
CS5. Exportation shall meet any nationally defined restrictions or limitations.	10: For all surveyed firms.
CS6. Company shall verify the validity of the supplier's certificate or claim and verify that material purchased and received is consistent with the claim category specified.	10: For firms which (1) have/plan to have CoC certification within five years; or (2) require/plan to require suppliers to provide proof of legality/ sustainability; or (3) use/plan to use contract conditions to ensure suppliers' compliance; or (4) plan to purchase more from certified suppliers. 0: For firms which get 0 score for CS1 and all other firms
CS7. Company shall develop and implement procedures for addressing non-conformances.	10: For firms which (1) have/plan to have CoC certification within five years; or (2) shift or plan to shift raw and processed material import from high/moderate risk regions to low risk regions; or (3) reduce or plan to reduce the procuring sources to less countries and less species. 0: For firms which get 0 score for CS1 and all other firms
CS8. Company shall cooperate more closely with the US/EU clients about documentation.	0: For firms which have no such plan or get 0 score for CS1 10: For all other firms.
CS9. Company shall enhance firms' awareness of environmental and social responsibilities.	0: For firms which have no such plan or get 0 score for CS1 10: For all other firms.
CS10. Company shall enhance or establish firm's supply chain management system	0: For firms which have no such plan or get 0 score for CS1 10: For all other firms.

For each standard, firms which satisfied the requirement got a score of 10 and firms which did not got scored 0. The total score a firm received was used as the estimation of a firm's willingness to comply with the US LAA and the EU TR. Firms which satisfy all 10 standards

would get a full compliance score (100). Firms which have exited or plan to exit the US/EU market within five years would be viewed as the lowest compliance and would get only 40 (CS2-CS5) as they would avoid to do CS6-10 to comply with the US LAA and the EU TR through exiting the US/EU market.

Multiple linear regressions: Multiple linear regressions were run to model the relationship between legal compliance and the variables identified at the persuasion stage according to theory of planned behaviour, using Ordinary Least Square (OLS) method. Variables identified at the knowledge stage, such as learning activeness and legality awareness, were not analyzed because these variables assessed participants' status prior to the survey. Materials sent to the participants prior to the interview, especially the introduction of the US LAA, the EU TR, and CoC certification, might change their learning activeness and legality awareness. The values of the variables identified at the persuasion stage, especially participants' attitudes towards challenges and opportunities, assessed participants' perceptions after they read the materials and involved in the survey.

Ten variables were identified at the persuasion stage, including two variables about subjective norms (i.e. firm goal and client pressure), and six variables about perceived behavioural control (i.e. firm size, export experience, export proportion, import proportion, certified proportion, and wood proportion), and two variables about a firm's attitudes (i.e. opportunity and export barrier) (Table 2.2).

Table 2.2 Descriptive statistics of the variables

Variable	Characteristics	Question	Range	Mean	Standard Error
Subjective norms					
Firm goal	Binary (1=yes, 0=no)	1-6	0/1	-	-
Client pressure	Interval (Likert-type scale)	4-8	1-5	2.9	1.0
Perceived behavioural control					
Firm size	Continuous (employee number)	1-2	10-3300	594.0	710.3
Export experience	Continuous (number of export years)	1-4	1-52	12.6	5.9
Export proportion	Continuous (percent of sales value, %)	1-5	1-100	54.7	34.8
Import proportion	Continuous (percent of input value, %)	2-1	0-100	21.8	20.2
Certified proportion	Continuous (percent of input value, %)	2-4	0-15	5.5	3.7
Wood proportion	Continuous (percent of sales value, %)	1-3	20-100	79.8	24.9
Attitudes on opportunities and challenges					
Opportunity	Interval (Likert scale)	3-2	1-5	2.5	0.9
Challenge	Interval (Likert scale)	3-2	1-5	2.7	1.0
Dependent variable					
Legal compliance	Interval	3-4	40-100	87.4	15.6

"Firm goal" denotes whether environmental protection or CSER is included in the firm's values, beliefs, or goals. "Client pressure" refers to the pressures a firm gained from its client n to satisfy legality and sustainability. "Opportunity" was the perceived opportunity that would bring by the legality requirements to a firm. It is estimated with the Likert scale, using answer gained from the respondents' attitude toward the statement "legality requirements will create new wood products export opportunities". "Challenge" was the perceived extent of the legality requirements to be trade barriers. It is also estimated with the Likert scale, using answer gained from the respondents' attitude toward the statement "legality requirements are green trade barriers for wood products export".

Scatter plot of legal compliance versus each variable was used to determine whether to make transformation of the independent variable or not. Natural logarithms were applied to four variables (i.e. firm size, export experience, export proportion, and wood proportion). In order to test the moderator effects of variables about subjective norms and perceived behavioural control, interactions between each of these variables (or their natural logarithms) and each of the two attitudes variables were also included in the full regression model.

Backward stepwise method was employed to select independent variables. It began with a

full model consisting of 26 variables (six variables in their original forms, four variables in the forms of natural logarithms, and 16 interactions). Variables were sequentially dropped from the model until all the variables left in the model were significant (α=0.05), given the other variables that were in the equation. The reduced model contained five variables.

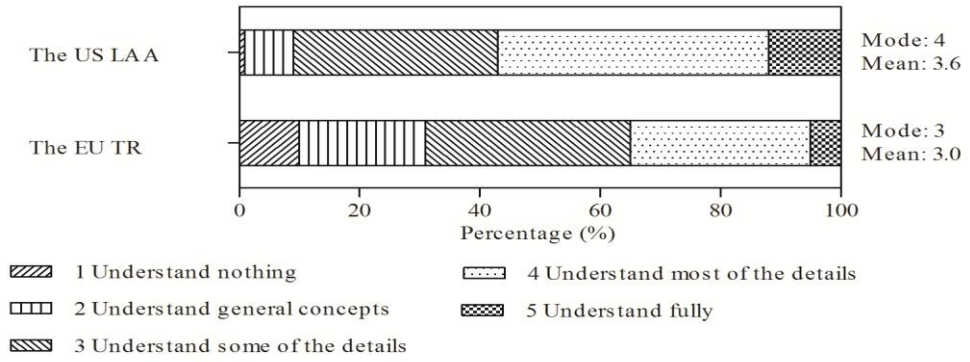
2.4 Results and discussion

2.4.1 Knowledge stage: information process and awareness

A key factor for innovation activities is processing information on potential innovations. Participants were asked to estimate the effort required to obtain information about environment-related issues and then their awareness of the US LAA and the EU TR using a five-point Likert/Likert-type scale scales (question 3-1 and question 3-2 in Appendix A).

The survey results showed that the majority (73.8%) of the respondents were active in learning environment-related issues, including the US LAA and the EU TR. This meant that firms which indicated "strongly agree" or "somewhat agree" with the statement that the company has been taking active effort to learn environment-related issues. The result meant that most firms processed information through the central cognitive processing route (Petty 1983). Figure 2.1 indicates that the awareness level for the US LAA and the EU TR prior to the survey reported by the majority of the participants was 4 ("understand most of the details") and 3 ("understand some of the details"), respectively.

Figure 2.1 Awareness of legality requirements



Overall, participants had a better understanding of the US LAA than that of the EU TR.

This is logical since the EU TR emerged only in 2010 and the US LAA emerged in 2008, with the former having a mean of 3.6 and the latter having a mean of 3. For the US LAA, firms' awareness level increased within about three years in China, from almost no understanding when the law was just implemented in 2008 to an average of 3.6 after three years when the survey was conducted. Therefore, it is expected that a similar increase will be observed for firms' awareness level of the EU TR after it becomes effective in 2013. The current awareness level for legality requirements is still less than 4 (understanding most of the details). As the US and the EU are major consumer countries of China's wooden furniture, lower awareness of LRs in these markets would prohibit the access of export-oriented wooden furniture firms to these markets.

2.4.2 Persuasion stage: fitted model

The multiple linear regressions modeled the decision making process at the persuasion stage. The backward stepwise method stopped at step 22nd because all variables left in the reduced model were significant (α=0.05). Table 2.3 shows the multiple linear regression results. Five variables were left in the reduced model. They were: the natural logarithm of firm size, the natural logarithm of export proportion, the interaction between opportunity and client pressure, the interaction between opportunity and the natural logarithm of export experience, and the interaction between opportunity and the natural logarithm of export proportion.

Table 2.3 Multiple linear regression results

Variable	Coefficient	Standard Error	t	Significance	Variance Inflation Factor	95% Confidence Interval for Coefficient	
						Lower	Upper
Constant	28.481	8.738	3.259	0.000		11.147	45.816
LN (firm size) (LNFS)	3.671	1.066	3.444	0.001	1.381	1.556	5.785
LN (export proportion)(LNEP)	12.116	2.065	5.868	0.000	2.944	8.020	16.211
Opportunity*client pressure (OP*CP)	1.389	0.448	3.097	0.003	1.962	0.499	2.279
Opportunity* LN (export experience) (OP*LNEE)	2.659	1.141	2.331	0.022	5.448	0.396	4.921
Opportunity*LN (export proportion) (OP*LNEP)	-3.591	0.828	-4.336	0.000	9.400	-5.233	-1.948

The final form of the multiple regression model was:

$$LC = 28.481 + 3.671LNFS + 12.116LNEP + 1.389OP * CP + 2.659OP * LNEE - 3.591OP * LNEP$$

where the dependent variable LC was "legal compliance"; LNFS was the natural logarithm of

"firm size"; OP was "opportunity"; and LNEE was the natural logarithm of "export experience".

For the final model, the presence of multicollinearity was evaluated using Variance Inflation Factors (VIF). The VIF values of the variables were all less than 10, indicating no multicollinearity was present in the data (Table 2.3). Residual plots in the SPSS outputs were used to check the assumptions of: linear relationship (i.e. the relationship between the independent variables and dependent variable is linear), equal variance (i.e. the variance of the values of the dependent variable must the same for every combination of the values of the independent variables), and independence (i.e. each observation must be independent of all other observations). The residual plots showed that all these assumptions were met. The normality plot of the SPSS outputs were used to check the normality assumption of the linear regression and it revealed that the assumption was met.

For the final model, all the tests indicated a good model fit. First, F-test was employed to test the model significance. The F value was 14.162 and $p=0.000<\alpha=0.05$ (Table 2.4). Therefore, the assumption that the model was insignificant was rejected. The model had a reasonable fit. Second, R Square (0.412) and adjusted R Square (0.383) were acceptable for cross-section data, which also indicated a good model fit. Third, the t test for each parameter rejected the null hypothesis that $\beta_i=0$ (i=0,1, 2, 3, 4, 5). Therefore, the parameters for the intercept and slopes were all statistically significant (Table 2.3), which also indicated that the model provided a reasonable fit.

Table 2.4 Analysis of Variance (ANOVA)

Source	Degree of freedom	Sum of Squares	Mean Squares	F	Significance
Regression	5	10661.144	2132.229	14.162	0.000
Residual	101	15206.146	150.556		
Total	106	25867.290			

2.4.3 Persuasion stage: subjective norms

In the theory of planned behaviour, subjective norms refer to the strength of normative beliefs and the motivation to comply with these beliefs (Ajzen 1991; Kaiser et al. 2005). In this analysis, "firm goal" and one external pressure (i.e. "client pressure") were employed as the

indicators of a firm's subjective norms. The multiple linear regression results suggested that each of the two variables about subjective norms (i.e. "firm goal" and "client pressure") alone were not statistically significant in determining a firm's willingness to comply with legality requirements. However, the interaction between "client pressure" and "opportunity" was significant, indicating that "client pressure" was a significant moderator. There were two possible reasons for the insignificance of "firm goal". First, most of China's wooden furniture firms had low environmental consciousness and CSER was excluded from their values/beliefs/goals (Guerin 2009). The survey results showed that only about 28.0% of the respondents had included some kind of concern about environmental protection or CSER in their firms' values/beliefs/goals. Second, the use of a firm's goal as the only indicator for its values/beliefs/goals might miss important information. In fact, values, beliefs, and goals of a firm are very different concepts and can be measured using different indicators (Haslam 2004). A hierarchical structure is assumed among the concepts in organizational culture that the effect of values/beliefs on decision making and behaviour is mediated via goals through pro-environmental social norms (Nilsson et al. 2004). As long as the assumption is not true for the surveyed firms, the ignorance of values and beliefs might be a problem.

2.4.4 Persuasion stage: perceived behavioural control

In the theory of planned behaviour, a perceived behavioural control refers to the decision maker's perception of a firm's control over the situation. It is determined by a firm's organizational characteristics and the decision maker's characteristics (Ajzen 1991). In this analysis, six variables about a firm's organizational characteristics were used to represent a firm's perceived behavioural control.

The natural logarithm of "firm size" was statistically significant in determining a firm's "legal compliance" (Table 2.3). Larger firms were more likely to have a higher willingness to comply, given other variables. Of the 107 firms, 8.4% were large-sized firms (employee number >2000); 47.7% were medium-sized firms (employee number in the range of 300-2000); and 43.9% were small-sized firms (employee number<300), which is close to the current

distribution pattern of wood products manufacturers in China, with more than 96% being considered SMEs (ASKCI 2012). Previous studies found that a firm's size had effects on its attitudes and behaviours towards environmental issues (Christmann and Taylor 2001; Vernon et al. 2003; Simpson et al. 2004). "Firm size" is a good indicator of a firm's general organizational characteristics, including financial strength, management and technology levels (Chan et al. 1985; Hall 1987; Wagner 1995; Beck et al. 2005; Damanpour 2010). The SMEs were often described as "hard to reach" and lagging in terms of "green business" due to resource poverty and a lack of management capability. This absence of resources then translates into an unwillingness and/or inability to commit to environmental improvements in any systematic and ongoing fashion (Cassells and Lewis 2011).

"Export experience" alone was not statistically significant. However, the interaction between the natural logarithm of "export experience" and "opportunity" was statistically significant, indicating that "export experience" was a significant moderator (Table 2.3). Firms with more export experience were more likely to have a higher willingness to comply, given all other variables. The number of years that a firm had been exporting was used to indicate a firm's export experience. The firms surveyed reported an average of 12.6 years of export experience, with the oldest firm having 52 years' export experience and the youngest having only one year's export experience. Foreign markets are often seen as more complex than domestic markets, requiring more objective information to reduce risk and uncertainty (Hart et al. 1994). Greater experience results in greater involvement and more knowledge (Diamantopoulos et al. 1990), and thus positive relationship with export propensity and intensity (Cavusgil 1982; Ibeh 2003; Suárez-Ortega and Álamo-Vera 2005; Nazar and Saleem 2011). Hence, firms with more export experience may have more knowledge to deal with legality requirements, and thus are more likely to have a higher legal compliance. It should be noted that export experience was measured in terms of the number of years the companies had been exporting in this analysis. However, the number of regions covered by exports also contributes to the accumulation of export experience (Hart et al. 1994). The ignorance of such information may have limited the results.

The natural logarithm of "export proportion" and its interaction with "opportunity" were

also statistically significant (Table 2.3). The firms with an export proportion of less than 50% (54 firms) and no less than 50% (53 firms) took almost equal share. About 70.1% targeted both domestic and export markets, while the rest targeted only export markets, with the US and/or the EU being major destinations. Previous studies found that more export-oriented companies (firms with higher export proportion) had stronger awareness and uptake for social and environmental responsibilities (Vogel 2005; Blowfield 2007). Therefore, the intuition was that firms with higher export proportion would be more aware of legality requirements and thus had a higher legal compliance than firms with lower export proportion would. The results of this study revealed that the influence of "export proportion" was more complex as the interaction between its natural logarithm and "opportunity" is also significant and the sign was negative. Given all other variables, firms with higher export proportion were more likely to comply only when "opportunity" was less than 4 (i.e. firms indicated "strongly agree", "somewhat agree", or "neither agree or disagree" with the statement that "legality requirements will create new wood products export opportunities").When "opportunity was no less than 4 (i.e. firms indicated "somewhat disagree" or "strongly disagree" with the statement that "legality requirements will create new wood products export opportunities"), firms with higher export proportion were less likely to comply."Import proportion", "certified proportion" and "wood proportion" were statistically insignificant in determining a firm's willingness to comply. Firms that bought raw materials from both oversea markets (mainly Russia and Southeast Asia) and domestic markets accounted for 70.1% of the respondents and the rest bought materials only in domestic market. About 64.5% of the respondents could list at least some of the countries of origin for imported wood materials while the rest did not know or were unwilling to reveal the origins of the raw wood materials at all. Of the firms surveyed, about 47.7% produced only wooden furniture, while the rest produced many other products, including other wood products and non-wooden furniture products.

The characteristics of decision makers may also be important determinants of a firm's perceived behavioural control (Ajzen 1991; Kaiser et al. 2005; Rasamoelina et al. 2010), such as a decision maker's age and education level. These variables were not considered in this analysis

and this is a limitation of the study.

2.4.5 Persuasion stage: attitudes towards opportunities and challenges

In the theory of planned behaviour, attitude is understood to be a rational-choice-based evaluation of the consequences of a behaviour, as well as an estimation of the likelihood of these outcomes (Kaiser et al. 2005). In this analysis, a firm's attitudes toward the US LAA and the EU TR were classified into two categories: opportunities which may lead to economic, social and environmental benefits, and challenges which may lead to negative impacts (increased costs).

Opportunities: Participants were asked about their opinions on the opportunities regarding legality requirements using five-point Likert scale (question 3-2 in Appendix A). They were also asked to estimate whether legality requirements would lead to specific benefits for their firms.

Although "opportunity" alone was statistically insignificant, its interactions with "client pressure", the natural logarithm of "export experience", and the natural logarithm of "export proportion" were statistically significant. Of the 107 participants, 49.5% expressed their attitudes as "strongly agree" or "somewhat agree" to the statement that legality requirements will create new wood product export opportunities (Figure 2.2).

Figure 2.2 Attitudes towards the opportunities and challenges of legality requirements

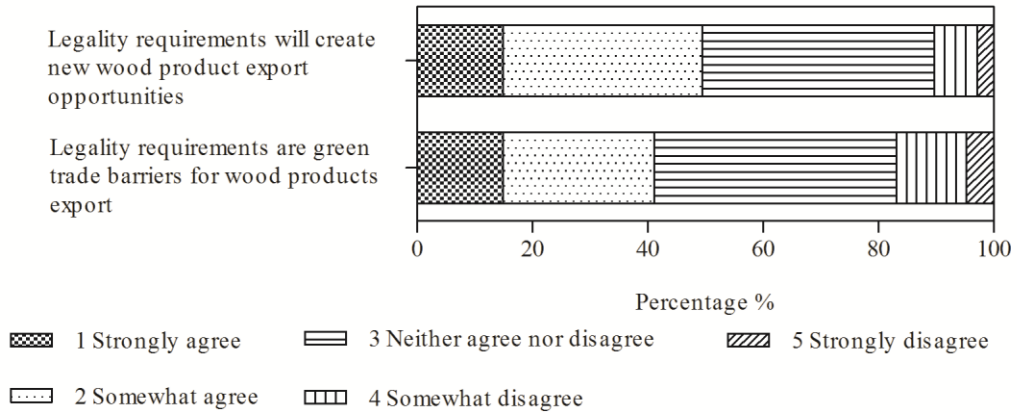
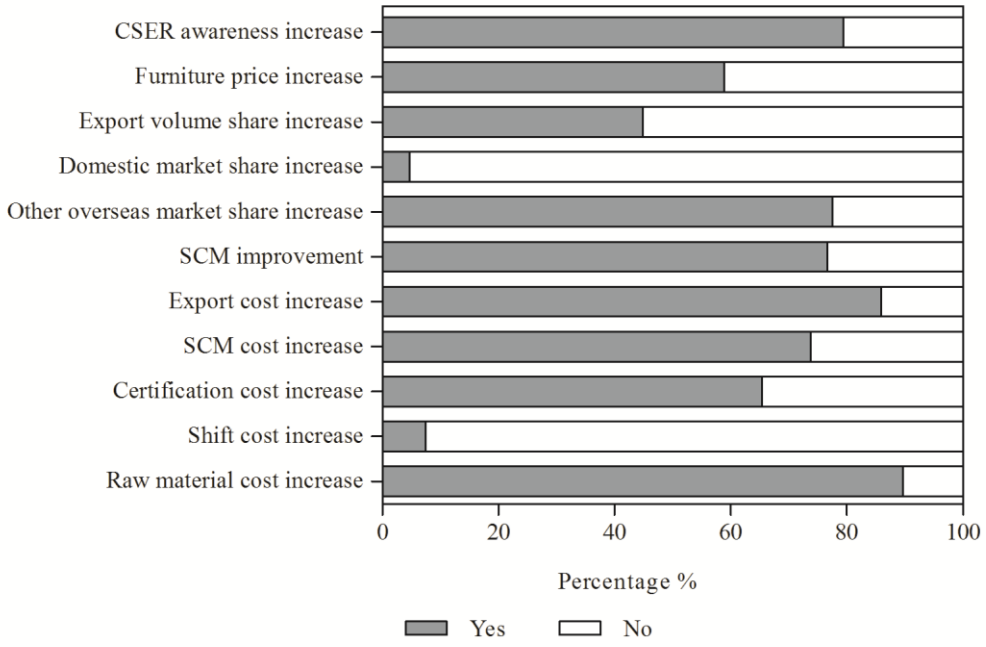


Figure 2.3 summarizes the anticipated impacts of specific opportunities that the legality requirements might provide included the improvement of CSER awareness, the increase of furniture price and export volume share, the motivation to invest and gain more market share in

domestic market and other overseas market, and the improvement of SCM (Figure 2.4).

Figure 2.3 Anticipated impacts



Challenges: Participants were asked about their opinions on whether legality requirements were trade barriers using five-point Likert scale (question 3-2 in Appendix A). The results showed that "barrier" were statistically insignificant in determining a firm's willingness to comply. This indicated that a firm's opinions towards whether legality requirements are green trade barriers for wood products export might not affect their compliance with legality requirements, although 41.1% of the participants expressed their opinions as "strongly agree" or "somewhat agree" (Figure 2.2). These firms wondered if these legality requirements constitute non-tariff trade barriers according to the World Trade Organization (WTO). In fact, concerns have been raised about whether legality requirements are trade barriers and compatible with the rules of the WTO (Simberloff 2006; Smith et al. 2008; Brack 2009; Asche and Smith 2010).

However, it is less likely for manufacturers in producer and processing countries, including China, to use WTO rules to argue, which is a broad concern for developing countries who sell natural resources products to developed countries, such as fishery products (Potts and Haward 2007; Perez-Ramirez et al. 2012), energy products (Rao and Patil 2011), and many eco-labeled

products (Clemenz 2010). This is because measures to protect environment distort trade and raise concerns regarding potential violation of the WTO rules and the rights of its members, they are allowed if they do not lead to unjustifiable or arbitrary discrimination of specific countries.

Specific challenges that might be caused by the legality requirements had be put forward, including certification cost increase, export cost increase, SCM cost increase, shift cost increase, and raw material cost increase (Figure 2.3). "Certification cost increase" referred to the increase of direct cost led by adopting certification (e.g. preparation for audits, certification expenses, and yearly monitoring audits). "Shift cost increase" referred to the increase of cost of shifting raw and processed materials from high risk to low risk regions, which reflected the transaction cost increase of buying raw and processed wood materials. "Raw material cost increase" reflected the price increase of the raw and processed wood materials. For example, a firm may shift from Papua New Guinea wood to Canadian wood. The switch would require certain time, expenses, and labor cost to seek new supplier, negotiate, and sign new contract, which is the shift cost. Raw material cost thus refers to the price different between the wood of the two countries.

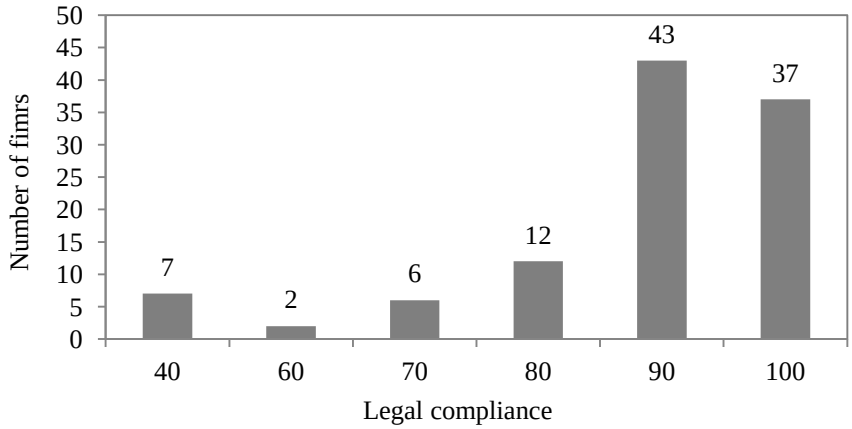
At the end of the persuasion stage, firms with bounded rationality would form a behavioural intention, thus the innovation-decision process would go to the decision stage. In the theory of planned behaviour, the behavioural intention is seen as a function of a firm's subjective norms, perceived behavioural control, and their attitude toward performing a particular act (Ajzen 1991; Kaiser 2005).The intention to perform the behaviour in question is the immediate antecedent of overt behaviour. Followed the decision stage is the implementation stage, and then the confirmation stage (Rogers 1995).

2.4.6 Decision stage, implementation stage, and confirmation stage: legal compliance

Participants were asked to express what measures had they already taken or planned to take to deal with legality requirements (question 3-4 in Appendix A). The answers together with the firms' general information were used to estimate a firm's intentions with respect to legal compliance. Figure 2.4 shows the distribution of legal compliance of the 107 firms surveyed. The scores were in the range of 40 to 100. More than 74.8% of the firms got a score of 90-100,

indicating that the majority of the surveyed firms were willing to take actions to ensure a high compliance with the legality requirements.

Figure 2.4 Distribution of legal compliance



Firms that had the lowest legal compliance were those, which planned to exit from the US and the EU markets and shift to market with no such legality requirements, such as the domestic and other overseas market. Only seven firms indicated that they would exit or had exited, accounting for 6.5% of the total respondents (Figure 2.4). The common characteristics of these firms included: (1) environmental protection or CSER was not embodied in their firm goals; (2) they were all small or medium sized firms (five small and two medium); (3) they all had below average export experience (1-12 years); and (4) they were all non-CoC-certified and non-ISO14001-certified and had no plan to gain certification within five years.

Firms that indicated that they would remain in the US and/or EU market and adapt to meet these new requirements accounted for 93.5% of the respondents. They would take various measures along the supply chain to cope with legality requirements and ensure legal compliance (Table 2.5).

Table 2.5 Responses to legality requirements

Responses	Percentage (%)	
	Yes	No
Quit from US and EU market	6.5	93.5
Shift raw and processed material import from high/moderate to low risk regions	37.4	62.6
Reduce the procuring sources to less countries and less species	42.1	57.9
Require suppliers to provide documentation proof of legality/ sustainability	77.6	22.4
Purchase more from certified suppliers	80.4	19.6
Use contract conditions to ensure suppliers' compliance	94.4	5.6
Enhance a firm's awareness of environmental and social responsibilities	86.9	13.1
Enhance or establish a firm's supply chain management system	76.6	23.4
Enhance the relationship with non-governmental organizations	4.7	95.3
Gain chain of custody certification	65.4	34.6
Cooperate more closely with the overseas clients	57.0	43.0
Keep in the US/EU as well as entering/enhancing domestic market	4.7	95.3
Keep in the US/EU as well as exploring more other overseas markets	77.6	22.4

2.5 Conclusion

Globalization and international trade has increased institutional and customer pressures on firms to comply with various environmental and social requirements. The US LAA and the EU TR increase the pressure for China's wooden furniture firms as they now have to invest more to comply with not only the local government laws and regulations, but also the laws and regulations of their supplier countries and consumer countries.

Firms' awareness of legality requirements was still inadequate. Information about legality requirements should be provided through various information sources and knowledge width and depth should be ensured. Motivations should also be provided for both the decision makers and the employees to learn and efforts should also be made to enhance the firms' ability to learn.

A firm's willingness to comply with the new laws and regulations in the international market is influenced by various factors. The integrated innovation-adoption model utilized in this analysis suggested that the natural logarithm of firm size, the natural logarithm of export proportion, the interaction between opportunity and client pressure, the interaction between opportunity and the natural logarithm of export experience, and the interaction between opportunity and the natural logarithm of export proportion were statistically significant in

determining a firm's willingness to comply at the persuasion stage.

The results suggested SMEs had to take more efforts to reach a higher legal compliance as they usually lack managerial, entrepreneurial, and marketing expertise, and lack capital, investments, and assets, and have limited access to financing, and have difficulties sourcing raw materials (Mead and Liedholm 1998; Aky üz et al. 2006). External supports should be provided for SMEs to deal with legality requirements, such as governmental supported research and development, better policy environment to learn and adopt CSER and development of financial markets.

The perceived opportunities were more important than the perceived challenges in determining a firm's willingness to comply. Legality requirements would lead to various opportunities and challenges. While perceived challenges were all economic costs, perceived opportunities and benefits were mostly not direct and not intermediate financial benefits. The results indicated that the potential long-term benefits were one of the main driving forces of higher legal compliance. Perceived opportunity alone was not statistically significant. Its interactions with one variable about subjective norms (i.e. client pressure), and two variables about a firm's perceived behavioural control (i.e. export experience and export proportion) were statistically significant, indicating significant moderation effects of subjective norms and perceived behavioural control.

A firm's actual compliance with legality requirements may not be consistent with its willingness to comply in a changing business environment and a dynamic decision-making process. Although a firm's willingness to comply was assessed, a firm's actual compliance with legality requirements was unable to be estimated. This is mainly because firms have not had enough time and information to respond to these legality requirements. The US LAA was implemented in 2008 and it has only been effective for wooden furniture since April 2010. The EU TR was still not effective when the survey was conducted. The integrated innovation-adoption model used in this analysis enabled us to identify various factors that affect a firm's willingness to comply at the persuasion stage of the innovation-decision process. However, the behavioural intention was based on very limited knowledge and the estimate

impacts of the legal compliance could be different when they reached the confirmation stage. Therefore, a firm's actual compliance has to be re-assessed at the confirmation stage after several years. Future research can focus on collecting more data to build a regression model to explain a firm's actual compliance in the framework of the integrated innovation-adoption model.

3 Adoption of Chain of Custody Certification: Perspectives of China's Export-Oriented Wooden Furniture Manufacturers

3.1 Introduction

Global markets have become more complex, differentiated and demanding (Morris and Dunne 2004). Consumers are increasingly concerned with environmentally sustainable products (Miles and Covin 2000; Cashore and Stone 2012). Consequently, there is a growing demand for reassurance about the raw materials, origins, and the environmental consequences of the products (Chatham House 2009). This is especially the case with respect to products such as wooden furniture and other value-added wood products that depend heavily on natural forest resources and threaten their sustainability (Morris and Dunne 2004). Firms in the wood products industry have had to take a new role with respect to environmental politics and the business environment has consequently undergone quite significant adaptation. In the wood products sector, such customer demands have lead to the development of the internationally recognized certification schemes, such as the FSC CoC certification and the PEFC CoC certification (Cashore and Vertinsky 2000; Clark and Kozar 2011).

As mentioned in Chapter 1, CoC is the 'custodial sequence' that occurs as ownership of wood supply is transferred from one custodian to another along the supply chain (Wingate and McFarlane 2005). CoC certification in the wood products sector should ensure that the wood products purchased can be traced back to its source in the forest, which in turn should ensure that the wood products really come from an environmentally certified source (Nor Suryani et al. 2011; Cashore and Stone 2012). In the global wooden furniture and related wood products industry, wood products manufacturers are increasing use CoC certification to enhance their supply chain management and ensure legality and sustainability (Cashore et al. 2004; Cashore et al. 2006; Ratnasingam et al. 2008).

Why does a firm adopt CoC certification? Economists have traditionally focused on the costs and benefits of CoC certification. Costs for achieving certification standards, as well as

audits and site visits over the life of the CoC certificate are often viewed as a barrier for companies to become certified (Nor Suryani et al. 2011). The profits of forest products manufacturers often decline due to higher prices paid for certified raw materials and costs to become CoC certified (Schwarzbauer and Rametsteiner 2001). Despite the costs, CoC certification is believed to have various benefits that attract a firm to adopt it. There are three benefits which are mentioned most frequently. First, it allows certified producers and firms to access new niche markets, such as the US and the EU (Chen et al. 2011a, 2011b). Second, it enhances a firm's environmental and ethical image to the public (Seol 2011).

However, cost and benefits are not the only explanation for the adoption of CoC certification. In many cases, stakeholders in both the private and the public sector have had to become the active driver through the value chain of demands (Morris and Dunne 2004). NGOs (e.g. the World Wildlife Fund and Greenpeace), big retailers (e.g. B&Q, Home Depot, Wal-Mart and IKEA), and some public sector (e.g. EU Timber Trade Federation) have been advocating and adopting RPP that require suppliers to be able to document country of origin of timber sources and ensure that the timber is legal as a minimum requirement and sustainable as a higher requirement (Toyne et al. 2002; Institute for Global Environmental Strategies 2007; Newman 2009; Proforest 2010; Sun and Canby 2010; Wal-Mart 2010). Hence, various stakeholders in the wood products sectors are driving the wood products firms to adopt CoC certification through the producer links in the value chain (Kaplinsky et al. 2002).

Wood products firms in developed countries are able to adapt to new market demands by adopting certification schemes such as CoC certification, operating in a highly conscious environmental social milieu, and selling into a domestic market that reinforces environmentalism (Morris and Dunne 2004). However, this may not necessarily be the case with respect to firms further down the value chain operating in developing countries (Durst et al. 2006). Besides cost, benefits, external pressures from the public and private sectors, various other internal and external factors may exist for a wood products firm in developing countries to drive a firm to adopt CoC certification or prevent a firm from adopting it (Seol 2011).

This study of China's wooden furniture manufacturers aims to examine the factors that

affect a firm's decision to adopt CoC certification using the integrated innovation-adoption model and a statistical regression method. This analysis addresses this issue quantitatively and systematically for the first time. The results of this study could help manufacturers make CoC certification decisions based on the alignment of my study results with the characteristics of their firms. The study could also assist certification organizations and governments identify firms that are more likely to seek CoC certification.

3.2 Theoretical framework

The integrated innovation-adoption theoretical model mentioned in section 1.5.4 was again used as the theoretical foundation. In this analysis, CoC certification is viewed as a process innovation for a firm. Please see section 1.5.4 for detailed model information.

3.3 Methods

3.3.1 Data collection

Interviews were conducted to gain insights into the views and attitudes of China's wooden furniture manufacturers towards CoC certification from June to November 2011. Please see Chapter 2 for detailed data collection method.

The interview script contained open-ended and semi-structured questions. Open-ended questions were used to ask respondents about firm profiles (from question 1-1 to question 2-6 in Appendix A), certification status (question 4-1 in Appendix A), and plan of gaining CoC certification (question 4-7 in Appendix A). Respondents were asked to grade their level of understanding about CoC certification using a five-point Likert-type scale, with 1=understand nothing to 5=understand fully (question 4-2 in Appendix A). Then, attitudinal questions were posed as a set of statements to which respondent firms were asked to rank their levels of agreement using five-point Likert-type scale or Likert scale. These semi-structured questions were concerned with CoC certification cost (question 4-3 in Appendix A), a firm's expectations of CoC certification benefits (question 4-4 in Appendix A), CoC certification effectiveness

(question 4-4 and question 4-5 in Appendix A), and CoC certification adoption barriers (question 4-6 in Appendix A). Interviewees also ranked the level of association and client pressures regarding legality and sustainability (question 4-8 and 4-9 in Appendix A), from 1=very low to 5=very high. Please see Appendix A for detailed interview questions. The items listed in question 4-4 and question 4-6 were based on several previous studies (Owari et al. 2006; Owari and Sawanobori 2007; Ratnasingam et al. 2008; Vlosky et al. 2009; Chen et al. 2011a, 2011b) and the pre-test of the survey. Interviewees were free to put up any other items they perceived as being important. Items about benefits and effectiveness were classified into different groups according to their functions. Items about the barriers were grouped according to the sources of the barriers.

3.3.2 Data analysis

Table 3.1 describes the 13 independent variables identified at the persuasion stage, including variables regarding subjective norms, perceived behavioural control, and attitudes.

Table 3.1 Variables used in the analysis

Variable	Characteristics	Question	Range	Mean	Standard Error
Subjective Norms					
Firm goal	Binary (1=yes, 0=no)	1-6	0/1	-	-
Client Pressure	Continuous (Likert-type scale)	4-8	1-5	2.9	1.0
Perceived behavioural control					
Firm size	Continuous (employee number/100)	1-2	0.1-33	5.9	7.1
Export experience	Continuous (number of export years)	1-4	1-52	12.6	5.9
Export proportion	Continuous (percent of sales value, %)	1-5	0-100	54.7	34.8
Import proportion	Continuous (percent of input value, %)	2-1	0-100	21.8	20.2
Certified proportion	Continuous (percent of input value, %)	2-4	0-15	5.5	3.7
Wood proportion	Continuous (percent of sales value, %)	1-5	20-100	79.8	24.9
RPP	Binary (1=yes, 0=no)	2-5	0/1	-	-
ISO 14001	Binary (1=yes, 0=no)	4-1	0/1	-	-
Attitudes on cost and benefit					
Cost assessment	Continuous (Likert-type scale)	4-3	1-5	2.9	1.0
Benefit	Continuous (Likert scale)	4-4	1-5	2.6	1.1
Legality verification	Continuous (Likert scale)	4-4	1-5	2.3	0.9

"RPP" was a binary variable that referred to a firm's possession of responsible purchasing policy (RPP). Respondents were asked to indicate whether their firms have RPP or not. Here, the

so called RPP did not follow the accepted strict definition that "*a complete and effective set of responsible purchasing policy should include detailed rules governing the compliance principles for timber, standards of purchasing, the scope of the policy, the future objective of purchasing, and the actual plan for implementation*" (Liu 2008). This is because only a few wooden furniture firms in China have the strict RPP in place. However, they do have some measures related to RPP in place, therefore, RPP here refers that a firm has certain measures to ensure that wood raw materials purchased are of legal origins. For example, a firm is perceived to have a RPP if it has a list of "approved suppliers" who can supply legal and sustainable timber, uses contract condition to ensure suppliers' compliance, or requires suppliers to provide documentation proof of legality/sustainability before a contract is signed or a purchase order is placed. When a firm has no responsible purchasing policy, RPP=0, which is taken as the reference category in the logistic regression. When a firm has a responsible purchasing policy, RPP=1. "ISO 14001" was also a binary variable which referred to a firm's possession of International Standardization Organization (ISO) 14001 certificate. Other variables on subjective norms and perceived behavioural control were explained in section 2.3.2. "Cost assessment" is a firm's attitudes towards the cost levels of CoC certification. "Benefit" referred to a firm's expectation for the general benefits of CoC certification. "Legality verification" referred to the ability of CoC certification in dealing with legality requirements. The corresponding questions for "benefit" and "legality verification" used Likert scale and lower value represented stronger agreement. In order to make lower value represent weaker agreement, transformations were applied using 6 minus the values of the Likert scale.

Logistic regression was performed to identify factors affecting a firm's CoC certification decision. CoC certification decision was treated as a nominal variable with 1=certified or plan to be certified within five years and 0=non-certified and no plan to be certified within five years. The probability of being CoC certified (hereafter called "certified probability") was the dependent variable. A probability which was greater than the cutoff point of 0.5 indicated that a firm was likely to be certified. Binary logistic regression was conducted using IBM SPSS Statistics 20.0 to assess the probability of being CoC certified in relation to various factors.

The logistic regression models in this analysis were:

$$P(Z) = \frac{e^{Z}}{1 + e^{Z}} \quad [1]$$

$$Z_1 = \beta_0 + \beta_1 X_1 + \cdots + \beta_{13} X_{13} + \varepsilon \quad [2]$$

$$Z_2 = \beta_0 + \beta_1 X_1 + \cdots + \beta_{13} X_{13} + \beta_{14} X_1 \ln X_1 + \cdots + \beta_{23} X_{10} \ln X_{10} + \varepsilon \quad [3]$$

$$Z_3 = \beta_0 + \beta_1 X_1 + \cdots + \beta_{13} X_{13} + \beta_{14} X_1 X_{11} + \cdots + \beta_{33} X_{10} X_{13} + \varepsilon \quad [4]$$

where β_0 was the intercept parameter; β_i (i=1…q) were the slope parameters; X_i, X_j (i, j=1…13) represented the independent variables; and P(Z) was the dependent variable which was the probability of being CoC certified. ε represented the residual. Equation [1] denoted the uniform logistic model and equation [2], [3], and [4] represented three models attempted in this analysis. Equation [2] contained only the 13 independent variables. Equation [3] included the 13 independent variables and the interactions between each of the 10 non-dummy/non-binary variables and its natural logarithm. Equation [4] included the 13 independent variables and the interactions between the three dummy variables (X_{11}, X_{12}, and X_{13}) and other variables.

The linearity of the logit assumption was examined using the Box-Tidwell approach (Hosmer and Lemeshow 2000; Tabachnik and Fidell 2001). A binary logistic regression was run using the model denoted by equation [1] and [3]. The logit assumption would be violated if one or more of the added interactions were statistically significant. Violation of the assumptions would lead to transformation of variables. The results showed that no variables violated the linearity of the logit assumption. All variables were left in their original forms. As normality is not a necessary requirement for logistic regression analysis, it was not tested in this analysis (Tabachnik and Fidell 2001).

Then, another binary logistic regressions was run again using the model represented by equation [1] and [4]. Analysis results showed that the inclusion of interactions led to the absence of a Maximum Likelihood Estimation (MLE). Therefore, models using equations [3] and [4] were all excluded.

A binary logistic regression was run using the model represented by equation [1] and [2]. Multicollinearity, outliers and influential data set problems were first examined. Multicollinearity between variables was checked using the correlation matrix produced in the

SPSS output. Multicollinearity did not present a problem in the analysis because most of the correlations were either no correlation or weak correlation. A dataset whose studentized residual was larger than 2 or smaller than -2 was considered an outlier and was excluded from the analysis (Vittinghoff et al. 2004). Two cases were excluded. Dfbeta value was employed to identify influential observations (Vittinghoff et al. 2004). No influential data set was found.

The backwards likelihood ratio method was used to select independent variables (Austin and Tu 2004). It began with a full model consisting of all the13 candidate variables. Variables were sequentially dropped from the model until the change of the likelihood ratio were not significant (α=0.05), given the other variables that were in the equation. Three variables were left in the final reduced model. Hosmer-Lemeshow test, Cox & Snell R^2 and Nagelkerke R^2 were employed to examine the model significance (Vittinghoff et al. 2004). The Wald Test was used to test parameter significance. The classification table of the SPSS results was used to measure the general model accuracy (Pearce and Ferrier 2000).

The odds ratio (OR) is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. The coefficient of each predictor is the natural logarithm of the OR (Vittinghoff et al. 2004). Therefore, for any one unit increase in one predictor, the OR can be calculated by:

$$OR = e^{\beta_i} = \frac{P_{(Xi+1)}/(1-P_{(Xi+1)})}{P_{Xi}/(1-P_{Xi})} \qquad [5]$$

When there are more than one predictors, the values of other predictors are held fixed. The certified probability can be calculated using the final fitted model if the value of each predictor is known for a firm. If the certified probability of firm A is known, the certified probability of firm B with only one unit increase in one predictor, compared to firm A, can be calculated using the OR and the certified probability of firm A.

3.4 Results and discussion

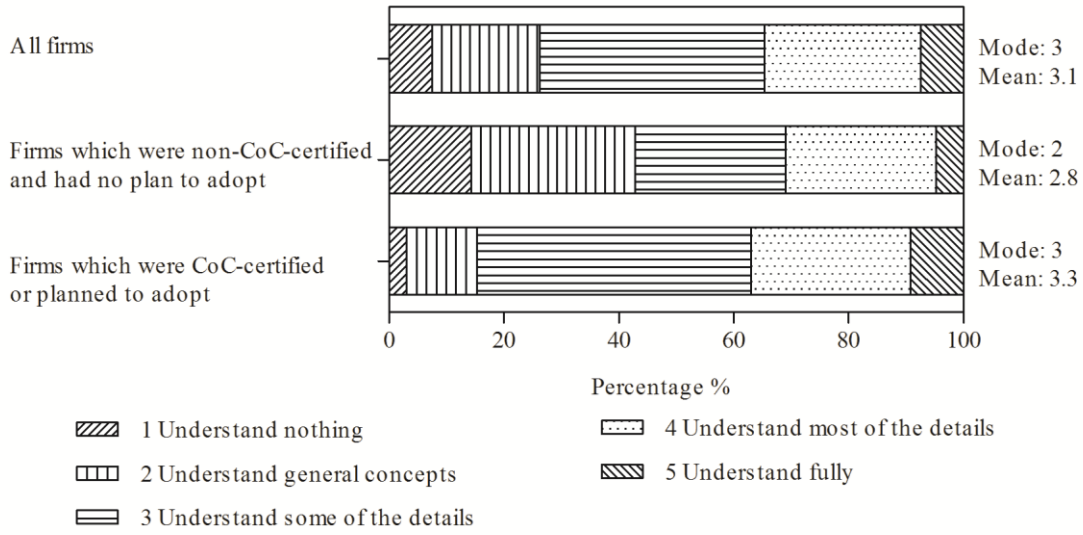
3.4.1 Knowledge stage: information process and awareness

Participants were asked to estimate their efforts to obtain information about environment-related issues and their awareness level of CoC certification using five-point Likert/Likert-type scales (question 3-1 and question 3-2 in Appendix A).

As stated in Chapter 2, the survey results showed that the majority (73.8%) of the respondents were active in learning environment-related issues. This meant that the information was processed through the central cognitive processing route by most firms (Petty et al. 1983).

Of the 107 participants, only 27.1% stated that they understood most of the details of CoC certification and only 7.5% indicated that they had full understanding (Figure 3.1). It is not surprising that manufacturers which were CoC-certified or planned to adopt CoC certification were more aware of CoC certification than manufacturers who were not CoC-certified and had no plan to adopt it (Figure 3.1). This result was consistent with the finding of Chen et al. (2011a) who found that the majority of China's wood products manufacturers had a low awareness level of forest certification, including CoC certification. The awareness level was much lower than those of the developed countries where forest certification was widely recognized and was perceived to be a significant tool in ensuring sustainability along the supply chain (Kozak et al. 2004; Vlosky et al. 2009; Chen et al. 2011b). However, it is similar to the awareness levels of other forested developing countries where CoC certification has low levels of adoption, such as Ghana (Attah et al. 2010, 2011), Malaysia (Ratnasingam et al. 2008) and Indonesia (Durst et al. 2006).

Figure 3.1 Awareness of CoC certification



3.4.2 Persuasion stage: fitted model

The estimation terminated at the 8th iteration because parameter estimates changed by less than 0.001 and the backwards likelihood ratio method stopped at the 11th step because any further drop of the variables left did not improve the model significantly. Of the seven variables used for the analysis, three variables contributed significantly and were left in the final step. They were "client pressure", "firm size", and "benefit" (Table 3.2).

Table 3.2 Binary logistic regression results

Variable	Coefficient	Standard error	Wald	Significance	Odds ratio	95% Confidence interval for odds ratio	
						Lower	Upper
Constant	-16.264	3.541	21.097	0.000	0.000		
Client pressure (CP)	3.282	0.736	19.876	0.000	26.631	6.291	112.726
Firm size (FS)	0.374	0.111	11.357	0.001	1.453	1.169	1.807
Benefit (BE)	2.313	0.677	11.668	0.001	10.106	2.680	38.108

The final form of the logistic regression model was:

$$P = \frac{e^{-16.264+3.282CP+0.374FS+2.313BE}}{1+e^{-16.264+3.282CP+0.374FS+2.313BE}} \qquad [6]$$

where the dependent variable P was "certified probability"; CP was "client pressure"; FS was "firm size"; and BE was "benefit".

For the final model, all the tests indicated a good model fit. First, Hosmer-Lemeshow test was employed (Hosmer and Lemeshow 2000). The Hosmer-Lemeshow Chi-Square was 6.343 and $p=0.609>\alpha=0.05$. Therefore, the assumption that the model was lack of fit was rejected (Tabachnik and Fidell 2001). The model had a reasonable fit. Second, both Cox & Snell R Square (0.627) and Nagelkerke R Square (0.850) were high for logistic regression (Tikina et al. 2008), which also indicated a good model fit. Third, the model classified in 93.5% of the cases correctly, which is 43.5% greater than by chance alone. The misclassification consisted of 9.5% of false positives (commission errors) and 4.6% false negatives (omission errors). Fourth, the Wald test for each parameter rejected the null hypothesis that $\beta_i=0$ (i=0, 1, 2, 3). Therefore, the parameters for the intercept and slopes were all statistically significant (Table 3.2), which also indicated that the model provided a reasonable fit.

3.4.3 Persuasion stage: subjective norms

In this analysis, "firm goal" (whether environmental protection or CSER is included in the firm's values, beliefs, or goals) and one external pressures (i.e. "client pressure") were employed as the indicator of a firm's subjective norms.

Firm goal was not statistically significant in determining a firm's certification decision. There two reasons that might explain. First, most of China's wooden furniture firms had low environmental consciousness and CSER were excluded from their values/beliefs/goals (Guerin 2009). The survey results showed that only about 28.0% of the respondents indicated that their firms had included some kind of concern about environmental protection or CSER in firms' values/beliefs/goals. Second, the use of a firm's goal as the only indicator for a firm's values/beliefs/goals might miss important information. In fact, the values, beliefs, and goals of a firm are very different concepts and can be measured using different indicators (Haslam 2001).

The logistic regression results showed that "client pressure" was statistically significant in determining a firm's certification decision (Table 3.2). The results confirmed the findings of previous studies (Auld et al. 2003; Vidal et al. 2005; Tikina et al. 2008) that factors such as "client pressure" made a statistically significant contribution to certification decisions. If all the

three predictors took values around their mean values (i.e. "client pressure"=3; "firm size"=5.9; and "benefit"=3), certified probability was about 0.939 and the odds was 15.296. If "client pressure" increased one unit (i.e. "client pressure"=4), certified probability increased to 0.998 and the odds increased to 407.320. If "client pressure" decreased one unit (i.e. "client pressure"=2), certified probability decreased to 0.365 and the odds decreased to 0.574. Therefore, the odds ratio was 26.631 (≈407.32/15.296≈15.296/0.574) for each one unit increase of "client pressure" (Table 3.2). The interpretation of odds ratios could provide interesting insights (Vittinghoff et al. 2004; Tikina et al. 2008). The associated 95% confidence intervals of the estimated odds ratio in Table 3.2 for the final model (equation [6]) exclude 1.0, indicating that each of the independent variables was associated with statistically significant increases in "certified possibility" among China's wooden furniture manufacturers.

The results indicated that in an environment where the legality requirements became stricter and clients were more likely to demand sustainable and legal wood products, manufacturers would be more likely to become certified. Regulations in the US and EU (i.e. the US LAA and the EU TR) have made traders and retailers desire certified or verified legal product in order to escape possible prosecution, seizure of products or fines. In the US, more retailers (55%) now consider it "essential" that producers be third party certified–up from 27% in just 2007 (Canby 2010). The survey results showed that about 72.0% of the participants ranked client pressure as being medium to high.

However, this result should also be treated with caution, as a Likert-type scale was used to represent the degree of clients' requesting for legal/sustainable/certified products, which was estimated by the interviewees according their own assessment. Besides, the survey did not distinguish client categories, such as wholesalers, retailers and brokers. Therefore, we could not conclude that the findings applied to all categories.

3.4.4 Persuasion stage: perceived behavioural control

In this analysis, eight variables on a firm's organizational characteristics were used to represent a firm's perceived behavioural control. Among the eight variables, only "firm size" was

statistically significant in determining a firm's CoC certification decision. As stated before, if all the three predictors took values around their mean values (i.e. "client pressure"=3; "firm size"=5.9; and "benefit"=3), certified probability was about 0.939 and the odds was 15.296. If "firm size" increased one unit (i.e. "firm size"=6.9), certified probability increased to 0.957 and the odds increased to 22.234. If "firm size" decreased one unit (i.e. "firm size"=4.9), certified probability decreased to 0.913 and the odds decreased to10.523. Therefore, the odds ratio was 1.453 (=22.234/15.296=15.296/10.523) for each one unit (100 employees) increase of "firm size" (Table 3.2). This result was consistent with the previous finding that larger entities were more likely to obtain certification than smaller entities (Sasser 2003), because larger firms usually have more resources and more advanced management systems which are required by CoC certification than do SMEs (Vernon et al. 2003; Simpson et al. 2004). The reason why only "firm size" showed significance regarding a firm's perceived behavioural control maybe because firm size is a good indicator of a firm's general organizational characteristics, including financial strength, management and technology levels (Chan et al. 1985; Hall 1987; Wagner 1995; Beck et al. 2005; Wagner and Hansen 2005; Damanpour 2010). Although other variables regarding organizational attributes might play a role in influencing a firm's certification decision, their influence is weak as each of them reflects only a small facet of a firm's organizational characteristics. However, if "firm size" was represented using other indicators, such as annual sales value, general assets, and fixed capital, the results might be different.

It should be noted that "RPP" and "ISO 14001" were not statistically significant in determining a firm's CoC certification decision. However, "RPP" was the last variable dropped in the backward likelihood ratio method, indicating that it was important, although not statistically significant. In fact, RPP was perceived to be a good indicator of a firm's social and environmental consciousness (Schlegelmilch et al. 1996; Worthington et al. 2008). The possession of ISO 14001 was also excluded from the final logistic regression model, indicating that it was not statistically significant in determining a firm's CoC certification decision. This might be due to several reasons. First, the current status of ISO 14001 was used. It would be better to include a firm's plan to adopt ISO14001 within five years. Second, some manufacturers

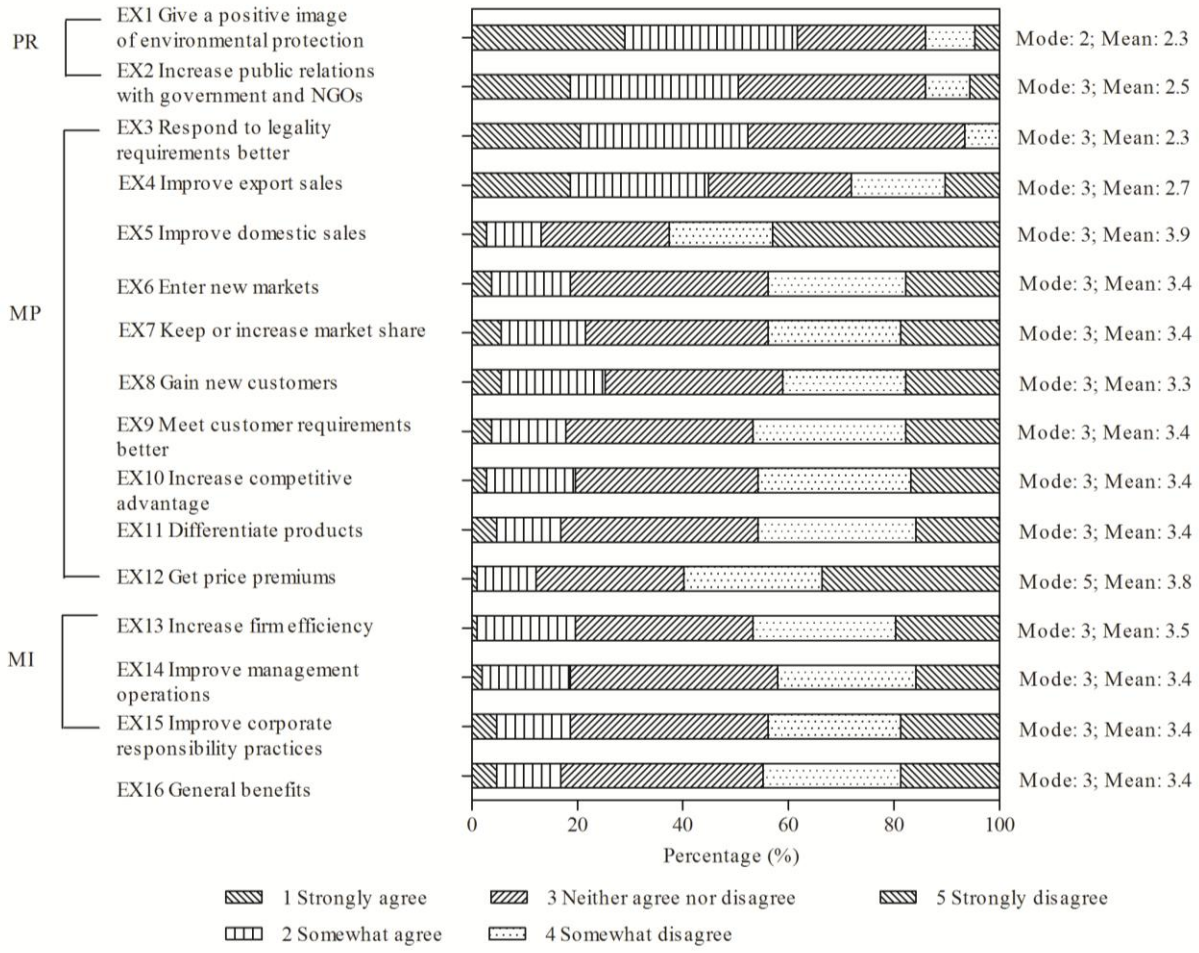
thought that ISO 14001 and CoC were substitutes for each other and thus would not adopt CoC certification after obtaining ISO 14001 certification. This will be discussed further in section 3.4.6.

3.4.5 Persuasion stage: attitudes towards benefits and costs

In this analysis, a firm's attitudes toward CoC certification were classified into two categories: CoC certification benefits and cost. Interviewees were asked to state their levels of agreements with the expected benefits of CoC certification prior to being CoC certified, from 1=strongly agree to 5=strongly disagree. They were also asked to estimate the cost of CoC certification based on their own assessment, from 1=very low to 5=very high.

Expected benefits: The 15 items listed in Figure 3.2 (EX1-EX15) represented a firm's expected benefits of CoC certification and can be classified into three categories: public relations (PR), market performance (MP), and management improvement (MI).

Figure 3.2 Expected benefits of chain of custody certification



Public relations (PR): Among all the potential benefits, respondents ranked the improvement of public relations as the most important benefit. This included "give a firm a positive image of environmental protection" (EX1) and "increase a firm's public relations with government and NGOs" (EX2). Of the 107 participants, approximately 61.7% for EX1 and 50.5% for EX2 chose "strongly agree" or "somewhat agree" (Figure 3.2). Our results were consistent with the findings of previous studies from both developed and developing countries (Owari et al. 2006; Ratnasingam et al. 2008; Chen et al. 2011b). This is because sustainability and corporate environmental and social responsibility is gaining increasing importance amongst the world's more progressive forestry companies and CoC certification plays an important role in demonstrating environmental and social responsibility (Leslie 2004; Ota 2006; Owari et al. 2006; Aguilar and Vlosky 2007; Vidal and Kozak 2008).

Market performance (MP): Ten of the 15 potential benefits could be classified as improvements in market performance that led to direct financial/economic benefits or that help a firm to avoid direct financial/economic loss. "Respond to legality requirements better" (EX3) and "improve export sales" (EX4) were two benefits that received higher expectations, with 49.5% and 44.9% respondents choosing "strongly agree" or "somewhat agree", respectively (Figure 3.2). Although forest certification (including CoC certification) or legality verification are not required by legality requirements, such as the US LAA and the EU TR, and the associated documents are not a guarantee to avoid punishment when illegal-sourced products are found, certification in practice is perceived to be due diligence and a good evidence of legality and sustainability (Butler and Grant 2011). Therefore, most wooden furniture manufacturers perceived "respond to legality requirements better" as an important benefit of CoC certification. This indicated that legality requirements might be a stepping stone for CoC certification. "Improve export sales" was considered to be another important benefit. Previous studies found that CoC certification was more recognized and required in developed countries (Durst et al. 2006; Owari et al. 2006; Chen et al. 2011b). As most of China's wooden furniture products are exported to developed countries where certified wood products are preferred by both public and private sectors, CoC certification may enhance a firm's market access to these countries and thus help to improve export sales.

The other eight benefits in market performance, although less important, included "improve domestic sales " (EX5), "enter new markets" (EX6), "keep or increase market share" (EX7), "gain new customers" (EX8), "meet customer requirements better" (EX9), "increase competitive advantage" (EX10), "differentiate products" (EX11), and "get price premiums" (EX12). Wood products companies tend to view certification as an opportunity to maintain existing markets and/or to expand into more lucrative niche markets (Irvine 2000; Cashore et al. 2005).

It should be noted that "get price premiums" had the least support, with only 12.1% of the interviewees indicated as "strongly agree" or "somewhat agree". The price premium is the difference in price between a certified and an identical non-certified product (Owari and Sawanobori 2007). In fact, there is no consensus on whether significant price premiums for

certified wood products exist in the market place. Some researchers argue that there are no significant price premiums (Owari et al. 2006; Owari and Sawanobori 2007; Chen et al. 2010), and others have found that significant price premiums exist (Kozak et al. 2004; Vlosky et al. 2009). This might be due to the differences of products, location, and respondents among these researches. Evidence has shown that price premiums vary amongst wood products and income level. Higher priced wood products have lower percentage price premiums (Ozanne and Vlosky 1997), which might explain why our study found low expectations for price premium among China's wooden furniture manufacturers.

Management improvement (MI): Benefits of management improvement included: "increase firm efficiency" (EX13), "improve management operations " (EX14), and "improve corporate responsibility practices" (EX15). Overall, the benefits of management improvement received less supports than the benefits of public relations and market performance, with an average of 19.0% of the participants indicated as "strongly agree" or "somewhat agree" (Figure 3.2). While previous studies pointed out that the importance of the potential benefits of CoC certification in improving efficiency due to improved information systems, better inventory control, and more precise and clearer communications along the supply chain (Upton and Bass 1996; Dykstra et al. 2002; Vidal et al. 2005), our study found less support for these potential benefits. Our findings were consistent with the research results of Ratnasingam et al. (2008) and Chen et al. (2011a).

The top four expected benefits were ranked as "give a firm a positive image of environmental protection">"increase a firm's public relations with government and NGOs">"respond to legality requirements better">"improve export sales". And the percent of respondents choosing "strongly agree" and "somewhat agree" for each of the four benefits was in the range of 44.9%-61.7%. For the other 11 items, the share was in the range of 12.1%-25.2%.

General benefits: Respondents were also asked to state their expectation for the general benefits of CoC certification (EX16). Only 4.7% expressed as "strongly agree" and 12.1% as "somewhat agree" (Figure 3.2). In addition, respondents' answers had a mode of 3 and a mean close to 3 for the majority of the expectations, which indicates that most respondents were either neutral or perceiving the benefits to be unimportant. These results suggest that China's wooden

furniture manufacturers do not have high expectations for the general benefits of CoC certification.

"Benefit" was statistically significant in determining a firm's certification decision. As stated before, if all the three predictors took values around their mean values (i.e. "client pressure"=3; "firm size"=5.9; and "benefit"=3), certified probability was about 0.939 and the odds was 15.296. If "benefit" increased one unit (i.e. "benefit"=4), certified probability increased to 0.994 and the odds increased to 154.563. If "benefit" decreased one unit (i.e. "benefit"=2), certified probability decreased to 0.602 and the odds decreased to 1.514. Therefore, the odds ratio was 10.106 (≈154.562/15.296≈15.296/1.514) for each one unit increase of "benefit" (Table 3.2). However, this result should be treated with caution because Likert scale was used to represent the expectation level of CoC certification which was estimated by the interviewees according their own assessments and expectations.

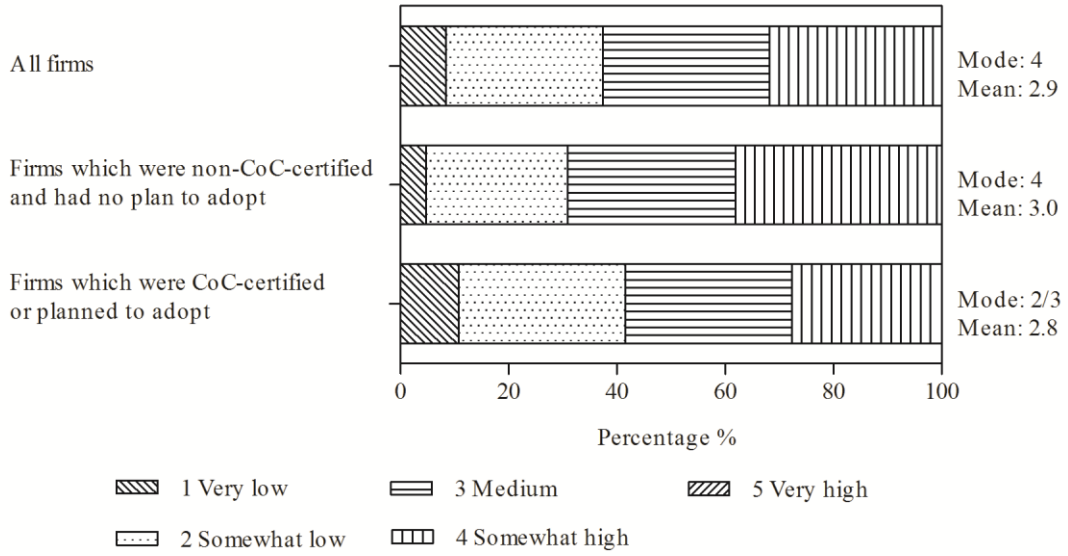
Of the 16 items considered, only "benefit" and "legality verification" were considered in the logistic regression. This is because that the other 14 items all had high correlation with the general benefits, which would lead to multicollinearity in the logistic regression model. In addition, general benefit is a good indicator of all the 15 specific benefits.

"Legality verification" was considered for two reasons: (1) it had weak correlation with general benefits; and (2) we are interested in testing whether the emerging legality requirements would lead to any apparent change in a firm's certification decision. The results showed that it is not statistically significant in the logistic regression. The results suggested that although wood products manufacturers would be more likely to pursue CoC certification under a stricter wood products legality environment (Sun and Canby 2010), it would be statistically insignificant in determining a firm's CoC certification decision. One possible explanation for these results is that these requirements are very new and the awareness of China's wooden furniture manufacturers is inadequate, as indicated in the results presented in Chapter 2. Therefore, the benefits of CoC certification in dealing with legality requirements might not be fully recognized. A second possibility is that the most of the CoC certified firms got their certificate before the emergence of US LAA and EU TR. A third possibility, which is the most plausible, is that the benefits of CoC

certification in dealing with legality requirements have already been reflected in the increase of client pressure.

Assessed cost: It is surprising that no participants stated that CoC certification cost was very high. Only about 31.8% of the respondent indicated that the cost was somewhat high (Figure 3.3). Although there were some differences in cost estimation between firms which were CoC-certified or planned to adopt CoC certification and firms which were non-CoC-certified and had no plan to adopt it, the differences were not statistically significant.

Figure 3.3 Chain of custody certification cost assessment



CoC costs can be classified as direct and indirect costs. The direct costs include activities such as preparation for audits, CoC audits, and yearly monitoring audits. The indirect costs include the costs incurred to improve supply chain management. These costs are considerable if the company is lagging behind required certification standards (Durst et al. 2006). CoC certification cost is influenced by many factors, such as the location of the company, firm size, the quantity of manufacturing facilities, the complexity of the manufacturing procedures, and the annual sales revenue (Vlosky and Ozanne 1998).

Previous studies have pointed out that CoC certification cost is an inhibiting factor for the development of CoC certification in developing countries as the majority of their wood products manufacturers are SMEs (Atyi and Simula 2002; Durst et al. 2006; Ratnasingam et al. 2008). On

the contrary, the results of this study suggest that although CoC cost was somewhat high for around one third of the participants, the majority of the participants perceive the costs to be low to medium, indicating that CoC cost might not be a barrier for the majority of the firms in adopting CoC certification. This will be discussed further in section 3.4.6.

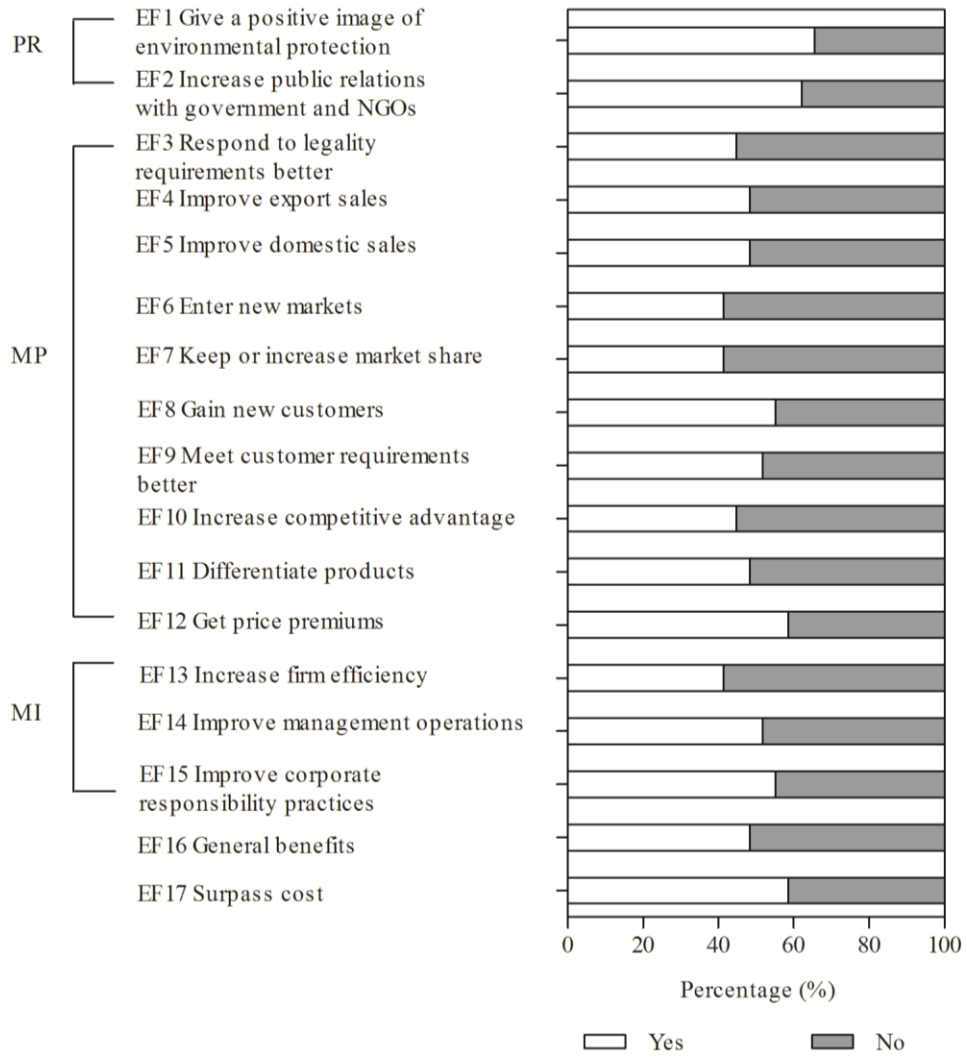
3.4.6 Decision, implementation, and confirmation stage: adoption of CoC certification

Of the 107 respondents, 27.1% were FSC CoC certificate holders, and 33.6% expressed their intention to adopt CoC certification within five years. As CoC certification emerged more than a decade ago and firms which were already CoC certificate holders had adequate information to have an adequate awareness level at the knowledge stage, and were able to reach the confirmation stage to evaluate the effectiveness of CoC certification. Those who did not adopt CoC certification were also able to access the barriers for adopting CoC certification at the confirmation stage.

Effectiveness: Two questions were given to the 29 respondents from CoC certified firms to assess the effectiveness of CoC certification. First, respondents indicated whether CoC certification met their expectations for its benefits after they became certified. Second, respondents assessed whether the general benefits of CoC certification surpassed its cost.

CoC certification was perceived to perform best in improving a firm's public relations, compared to the benefits of improving market performance and management (Figure 3.4). Around 65.5% of the participants indicated that it had met their expectations in giving a firm a positive image of environmental protection (EF1) and 62.1% indicated that it had met their expectations for increasing a firm's public relations with governments and NGOs (EF2). For the reminder of the benefits, respondents expressed that their expectations were met accounting for 41.4%-55.2% the 29 respondents (EF3-EF16). Interestingly, 58.6% of the participants indicated that their price expectations were met (EF12); this is may be due to low initial price premium expectations.

Figure 3.4 Effectiveness of chain of custody certification



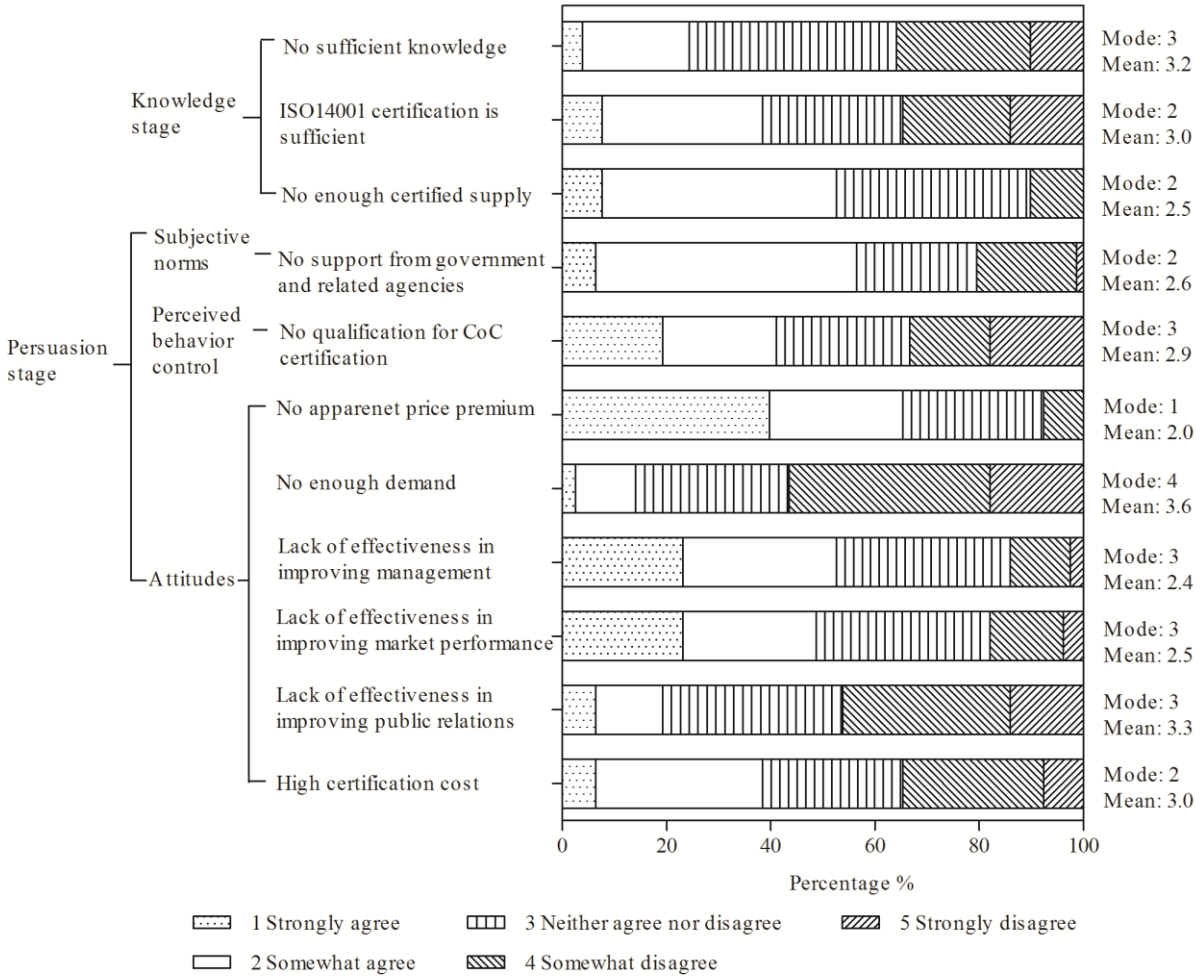
About 48.3% of the interviewees stated that the general benefits were met and 58.6% indicated that the general benefits of CoC certification surpassed its cost. The results suggested that although CoC certification was effective for almost half of the respondents, the other half of the respondents perceived it to be ineffective. Given this and respondents' generally low expectations for its benefits, it is believed that CoC certification have limited effectiveness. According to Durst et al. (2006), many constraints have limited the effectiveness of forest certification (including CoC certification) in developing countries such as China. They include insufficient demand for certified products in global markets, wide gap between management standards and certification requirements, weak ability to formulate appropriate forest sector

policies and ensure their effective implementation, insufficient capacity to develop national certification standards and certification procedures, and high direct and indirect costs.

While the effectiveness of FM certification has been well researched (Hartsfield and Newsom et al. 2006; Tikina and Innes 2008), the effectiveness of CoC certification is less studied. Our study assessed CoC effectiveness at the level of individual manufacturers. Future studies can focus on evaluate its effectiveness at the industrial, national, and international level based on established methods and evaluation frameworks (Young 1994). Various categories of CoC effectiveness need to be analyzed. They include effectiveness in problem solving and goal attainment, behavioural effectiveness (differences in behaviour brought about by a governance system), process effectiveness (adoption of a particular system in an institution or region or country), constitutive effectiveness (the acceptance of a system by social groups and their expenditures related to the operation of the system) and evaluative effectiveness (whether CoC certification is the best/cheapest/ most equitable tool for achieving certain results) (Tikina and Innes 2008).

Barriers: Seventy eight participants from non-CoC certified firms were asked to state their level of agreement for 11 potential barriers for the adoption of CoC certification, with 1=strongly agree to 5=strongly disagree. Of the 11 items listed in Figure 3.5, three items belonged to the knowledge stage and eight items belonged to the persuasion stage.

Figure 3.5 Potential barriers for adopting chain of custody certification



Knowledge stage barriers: Three barriers in the knowledge stage were "no sufficient knowledge", "ISO 14001 certification is sufficient", and "no enough certified supply", with 24.4%, 38.5%, and 52.6% of the participants expressing "strongly agree" or "somewhat agree", respectively. This indicated that some firms had a misunderstanding of ISO 14001 and CoC certification. They thought that ISO 14001 and CoC were substitutes to each other. In fact, FSC, PEFC and national schemes represent very different approaches from ISO 14001. ISO 14001 Environmental Management System (EMS) focuses on management standards. It has no mechanism to address environmental performance and no CoC procedure and labeling system (Forest Movement Europe 1996). ISO 14001 is process-based, while CoC certification is performance-based (Chen et al. 2010). The WTO recognizes ISO 14001 as a standard that

facilitates free trade, while FSC and PEFC can be perceived as a non-tariff trade barrier (Stringer 2006).Misunderstandings of ISO 14001 and CoC certification, together with the perceived knowledge gap, indicated that additional information was stilled needed for the firms at the knowledge stage.

The item "no enough certified supply" was classified in to the knowledge stage. This is because it was, in fact, a problem of misunderstanding or information asymmetry. Previous studies have pointed out that only a small percentage of the potential annual supply of certified logs [logs from forest management (FM) certified forest] are used as inputs of CoC-certified wood products (Werndle et al. 2006; Auld et al. 2008). Most certified logs have been consumed by non-CoC-certified producers and therefore the wood products have no specific reference to the certification status of the inputs. This is largely due to the relatively small number of CoC certificates that have been awarded and a general lack of recognition and differentiation of certified wood products by private end-users (Durst et al. 2006). In addition, controlled and recycled fibres are also accepted in CoC certification. This indicated that while the majority of manufacturers considered inadequate certified inputs as a barrier, certified logs were actually more than adequate to supply the current CoC certificate holders. Two reasons may explain the result that manufacturers perceive supply constraints of certified logs to be a barrier: (1) manufacturers do not understand CoC certification well enough; (2) there is information asymmetry between the certified log suppliers and the manufactures, which makes the manufacturers hard to reach the suppliers.

Persuasion stage barriers: Eight barriers belonged to the persuasion stage, including one barrier regarding subjective norms, one barrier regarding perceived behavioural control, and six barriers regarding a firm's attitudes. About 56.4% of the interviewees stated "strongly agree" or "somewhat agree" with "no support from government and relative agencies" regarding subjective norms. Durst et al. (2006) pointed out that in the forest sector developing countries such as China had ineffective implementation of national forest legislations and policies, inadequate forest law enforcement and governance, uncertain land tenure, conflicting social-economic and extra-sectoral policies, and insufficient capacity to develop national certification standards and

certification procedures. Many participants indicated they would welcome more knowledge communication through activities such as seminars, workshops, lectures and training programs held by governments or other agencies.

There was only one barrier regarding a firm's perceived behavioural control. About 41.0% of the interviewees stated "strongly agree" or "somewhat agree" with "no qualification for CoC certification". This indicated that a firm's existing management was one of the key barriers. Most firms have insufficient financial or human resources to effectively increase their management levels to meet the standards of CoC certification. The results supported the finding of previous studies that organizational structure, behaviour, and operating environment may prevent a firm from adopting CoC certification (Oliver 1991; Vertinsky and Zietsma 1998; Cashore and Vertinsky 2000; Chen et al. 2011b). That is to say, most firms do not have enough perceived behavioural control at the persuasion stage.

There were six barriers regarding a firm's attitudes on the benefits and costs of CoC certification. Lack of price premium was the largest barrier among the 11 items listed in Figure 3.5. Approximately 65.4% of the participants indicated "strongly agree" or "somewhat agree" with "no apparent price premium". This is consistent with their low expectations for the benefits of getting price premium. Only about 14.1% of the respondents stated "strongly agree" or "somewhat agree" with "no enough demand". Although insufficient demand for certified products in global markets was assessed as one of the key constraints for CoC certification in developing countries (Durst et al 2006), it was not a barrier for the majority of respondents. This is because the interviewees are all export-oriented manufacturers, with major markets being the US and the EU where governmental and non-governmental initiatives, such public procurement policies, big retailers' responsible purchasing policies, the US LAA, and the EU TR, are in place and these initiatives prefer certified wood products. This indicates that CoC certification allows a firm to keep market access to the US and the EU, and therefore "no enough demand" was not an important barrier.

In terms of the general effectiveness of CoC certification, "lack of effectiveness in improving public relations" was not perceived as a key barrier, with only 19.2% of the

participants chose "strongly agree" or "somewhat agree". However, as high as 52.6% and 48.7% of the respondents expressed "strongly agree" or "somewhat agree" with "lack of effectiveness in improving management" and "lack of effectiveness in improving market performance". This result supported our survey results in section 3.3.3 that firms had a relatively low expectation for CoC certification's benefits in improving management level and market performance. Corresponding to the results of participants' assessment for CoC certification, cost was stated as a barrier. About 38.5% of the participants indicated "strongly agree" or "somewhat agree" with "high certification cost".

According to the percentage of firms indicated "strongly agree" or "somewhat agree", barriers for a firm to adopt CoC certification ranked as: "no apparent price premium">"no support from government and relative agencies">"no enough certified supply"="lack of effectiveness in improving management">"lack of effectiveness in improving market performance">"no qualification for CoC certification">"ISO 14001 certification is sufficient"="high certification cost">"no sufficient knowledge">"lack of effectiveness in improving public relations">"no enough demand". The percentage for the top four barriers was in the range of 52.6%-65.4%. For the rest seven barriers, it was in the range of 14.1%-48.7%.

3.5 Conclusion

A firm's responses to environmental issues are an important component of global environmental management (Nakamura et al. 2001). Various empirical studies have been conducted on certification adoption behaviour of firms in developed countries, such as the US (Tikina et al. 2008), Japan (Nakamura et al. 2001), Canada (Chen et al. 2011), and Finland (Owari et al. 2006). Despite their importance in the global market, little empirical research exists analyzing China's wooden furniture manufacturers' responses to global environmental issues. In this chapter, we presented empirical estimates of the factors influencing a firm's adoption of CoC certification using an integrated innovation-adoption model and the binary logistic regression method.

The results suggested that despite the high level of activeness of surveyed firms in learning

environment-related issues, the knowledge gap still cannot be ignored. Information inadequacy and asymmetry, together with a firm's limited ability to learn, may have limited the information processing at the knowledge stage. In order to promote CoC certification, NGOs (especially organizations which provide CoC certification, such as PEFC and FSC), governments, industry associations, and environment-concerned clients of China's wooden furniture firms need to help enhance their understanding of the differences between ISO 14001 and CoC certification and improve the information transparency of certified supplies.

At the persuasion stage, the results indicate that the adoption of CoC certification was determined by the joint function of subjective norms (e.g. client pressure), perceived behavioural control (e.g. firm size), and attitudes (e.g. benefits). Although "legality verification" (the benefit of CoC certification in dealing with legality requirements, such as the US LAA and the EU TR), was not statistically significant in modeling a firm's adoption behaviour, "client pressure" was statistically significant and the benefits of CoC certification in dealing with legality requirements might already be represented in the increase of "client pressure". In other words, when the legality requirements are well understood and CoC certification is proven to be an important tool to deal with legality requirements and ensuring market access, the modeling results might be different. It should be noted that SMEs need more support to adopt CoC certification as they usually lack managerial, entrepreneurial, and marketing expertise, and lack capital, investments, and assets, and have limited access to financing, and have difficulties sourcing raw materials (Mead and Liedholm 1998).

It is also noteworthy that cost assessment of CoC certification was statistically insignificant in determining a firm's decision to obtain CoC certification. Previous studies have found that cost and benefits were the key concerns for adopting forest certification (Chen et al. 2011b; Ebeling and Yasue 2009; Gulbrandsen 2004, 2005; Ratnasingam et al. 2008). However, the results suggest that expectations for general benefits were more significant than a firm's cost to make the decision of adopting CoC certification. Currently, the most recognized benefits of CoC certification was the improvement of public relations, while its benefits in improving market performance and firm management are still limited. For a CoC certification system to be widely

adopted, its benefits and effectiveness still need to be more tangible, ensuring that the certified manufacturers receive a price premium and increasing market demand for certified products.

4 Modeling the impacts of the governmental initiatives to combat illegal logging in the US and the EU on China's wood products industry

4.1 Introduction

Illegal logging and its associated international trade have led to various economic problems. The World Bank (2002) estimates that illegal logging reduces government revenues by about 5 billion US dollars a year. Illegal logging has been proven to have adverse effects on global markets. It has led to wood products price distortion, negatively influenced the competitiveness of legitimate producers, distorted trade, and led to a loss of government revenue (Northway and Bull 2006, 2007; Turner et al. 2007; Li et al. 2008).

While the economic impacts of illegal logging have been well documented, the impacts of alternative policy initiatives to combat illegal logging have been less studied. Ottitsch et al. (2005) studied the impacts of trade instruments applied within the FLEGT VPA framework between Russia and the EU, and investigated two policy options. Moiseyev et al. (2010) employed the European Forest Institute Global Trade Model (EFI-GTM) to simulate the impacts of VPAs on global forest sector with four different scenarios. It was found that options similar to the EU Timber Regulation (the EU TR) do not predict the elimination of illegal logging from high risk countries (Moiseyev et al. 2010). Schwarzbauer and Rametsteiner (2001) analyzed the potential impacts of forest certification on forest products markets using a simulation model of the Western European forest sector; and they found that the market impact of a timber supply reduction from certified forests would be more distinct than the impacts of a CoC cost increase.

The potential impacts of the US Lacey Act Amendment (the US LAA) and the EU TR on China's wood products industry have never been forecasted. Forecasting the potential impacts of these policies on China's wood products industry can help us to evaluate the effectiveness of these policies in combating illegal logging and associated trade, understand the potential challenges and benefits of these policies for China, and enable China's industry to make corresponding efforts to take advantage and minimize risks. The main objective of this chapter is

to estimate the potential longer-term impacts of the US LAA and the EU TR on China's wood products industry, using a trade model, the International Forest and Forest Products Model (IFFP).

Trade models are widely used to explore the policy impacts of international forest products markets. These models can be grouped into two types: Computable General Equilibrium Models (CGEMs) and Partial Equilibrium Models (PEMs).

CGEMs emphasize the links between the forest sector and the macro-economy. CGEMs model goods and factors in all sectors and allow for wages, prices and incomes to be determined endogenously (Croppenstedt et al. 2007). There are many CGEMs that can be applied to the forest sector. Examples include the Global Trade Assessment Project (GTAP) model (Hertel 1997; Hertel et al. 2010) and the Future Agricultural Resources Model (FARM) (Darwin et al. 1996). The main merits of CGEMs include: (1) they attempt to describe the entire economic system, capturing not only the direct impact of a policy shock on the relevant market, but also the impact on other areas of the economy and feedback effects from these sectors to the original market (O'Toole and Matthews 2002); and (2) they commonly incorporate Armington Elasticity (Armington, 1969; et Edward and Balistreri, 2003) to distinguish between the roles of imported and domestic goods, which can mitigate the effects of product aggregation.

The main disadvantage of CGEMs is their large data requirement and high degree of complexity (Croppenstedt et al. 2007). Another disadvantage, especially as compared to PEMs, is that following the top-down approach, CGEMs typically lack a detailed bottom-up representation of the production and supply side (Bohringer and Loschel 2006). Finally, the Armington assumption in CGEMs makes them universally sensitive to the pre-defined Armington elasticity rate (Gallaway et al. 2003; McDaniel and Balistreri 2003).

PEMs are the most common approach for forest sector analysis as they can concentrate on the forest sector, using more detailed data (O'Toole and Matthews 2002). The PEMs are based on the work of Samuelson (1952) and Takayama and Judge (1971). Early PEMs in the forest sector include the Global Trade Model (GTM) (Kallio et al. 1987), the EFI-GTM (Kallio et al. 2004), the Timber Assessment Market Model (TAMM) (Adams and Haynes 1980), and the

Global Forest Products Model (GFPM) (Buongiorno et al. 2003 Buongiorno 2011). All of these PEMs use "trade inertia" to mitigate the distorting effects of product aggregation (except TAMM in which product aggregation is articulated as a well-defined problem). Trade inertia implies that the quantity traded of any particular good cannot change from year to year beyond constraints (Kallio et al. 1987). While this technique and the aggregation allow for elegant model outputs, it can lead to non-economic relationships between the projected quantity traded and price (Cardellichio and Adams 1990).

A new PEM is the International Forest and Forest Products Model (IFFP) applied in this project. It is a multi-country, multi-product and multi-process spatial partial equilibrium trade model developed at the UBC (Northway and Bull 2006). It has some advantages over the other models. IFFP is a partial equilibrium model requiring less data and with less complexity than CGEMs. Compared to other PEMs, it can derive the supply of logs through an integrated forest estate model to adequately represent the supply of logs from the forest over time (Northway and Bull 2007). IFFP applies a trade calibration method to mitigate the distortion of data aggregation. The calibration of supply elasticities, demand elasticities, and transport costs can produce model outputs that match real world trade (Northway and Bull 2006).

IFFP has been applied to analyze the impacts of Russian export tariff on China's log harvest volume (Northway and Bull 2006), Indonesia certification choices on China's wood products market (Northway and Bull 2007), and some preliminary analysis of FLEGT-related initiatives on Asian wood products industry (Huang et al. 2010). This study adds to the IFFP application by employing it to forecast the potential impacts of US LAA and EU TR on China's wood products industry.

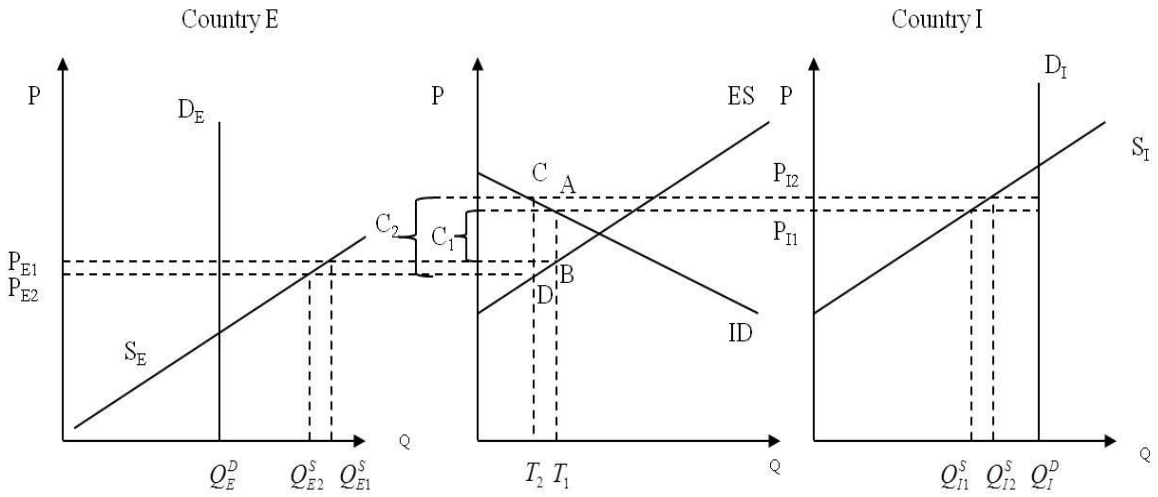
4.2 Theoretical framework and research hypotheses

Three hypotheses are assumed in this analysis.

Hypothesis 4.1: Enforcement of laws/regulations in the US and the EU, which covers only the imported products of the US/EU, will have negative impacts on China's wood products with net exports, leading to decreases in their production and export volume.

Figure 4.1 describes the theory underlying the hypothesis. Demand for a wood product is assumed to be inelastic for a certain year (Buongiorno 1979; Newman 1987; Prestemon and Abt 2002). Country I is the importing country (e.g. the US or the EU), Country E is the exporting country (e.g. China). Initial market equilibrium requires $C_1=P_{I1}-P_{E1}$ according to the law-of-one price, which means that the price difference between Country I and Country E has to be equal to the trade cost C_1 (including transportation cost and other trade costs) (Gregorio 1994; Vercammen 2011). Assume a governmental initiative to combat illegal logging in Country I increases trade cost to C_2. The export volume will decrease from T_1 to T_2. Correspondingly, Country E's production and price decrease from Q_{E1}^S to Q_{E2}^S, from P_{E1} to P_{E2}, respectively.

Figure 4.1 Impacts of trade cost increase



Hypothesis 4.2: Enforcement of laws/regulations in the US and the EU, which covers both the imported and exported products of the US/EU, will have negative impacts on China's wood products with net exports, leading to decreases in their production and export volume. For China's wood products with net imports, the enforcement will lead to increases in their production, and decreases in their import volume.

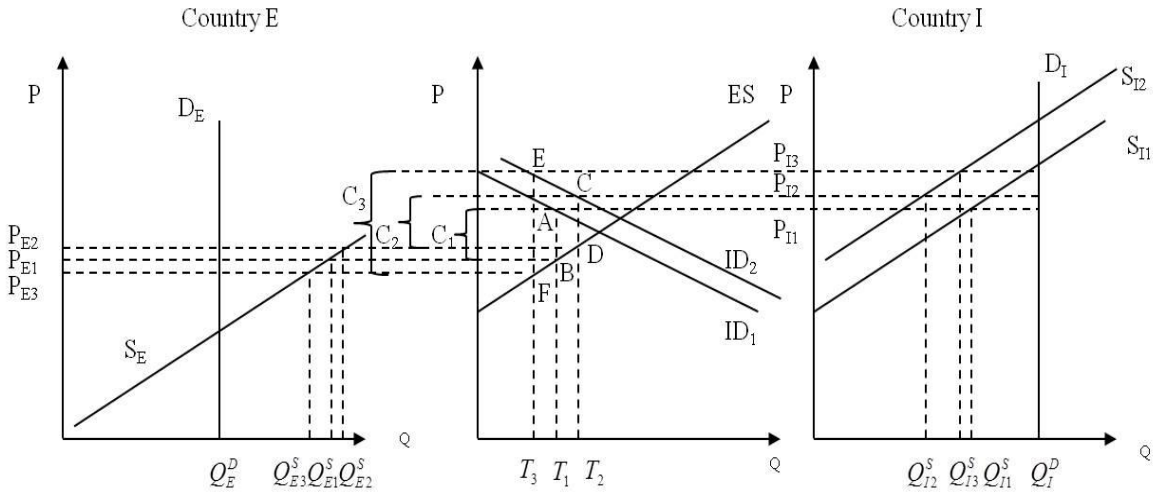
The analysis for wood products with net exports is same with that of Hypothesis 4.1. For wood products with net imports, Figure 4.1 can also be used to explain. The only difference is that Country I now represents China, while Country E represents the US/EU.

Hypothesis 4.3: Enforcement of laws/regulations in the US and the EU, which covers the

domestic, the imported, and the exported products of the US/EU, will have uncertain impacts on China's wood products with net exports. However, the production and price of China's wood products with net imports will increase, and their import volume will decrease.

For China's wood products with net exports, Figure 4.2 can be used to describe the theory underlying the hypothesis by two steps. First, assume that there is a supply shock (e.g. a decrease of illegal log supply) in country I (e.g. the US/EU), leading to a leftward shift of supply curve from S_{I1} to S_{I2} and a rightward shift of import demand curve from ID_1 to ID_2. The exporting country, Country E (e.g. China), has an export supply of ES. Initial market equilibrium before the supply shock requires $C_1=P_{I1}-P_{E1}$ according to law-of-one price. As trade cost stays unchanged, new market equilibrium requires that $C_2=C_1$, therefore, price increases to P_{I2} in Country I and increases to P_{E2} in Country E; production in Country I decreases to Q_{I2}^S and increases to Q_{E2}^S in Country E. In the meantime, trade volume increased from T_1 to T_2.

Figure 4.2 Supply shock in importing country and trade cost increase

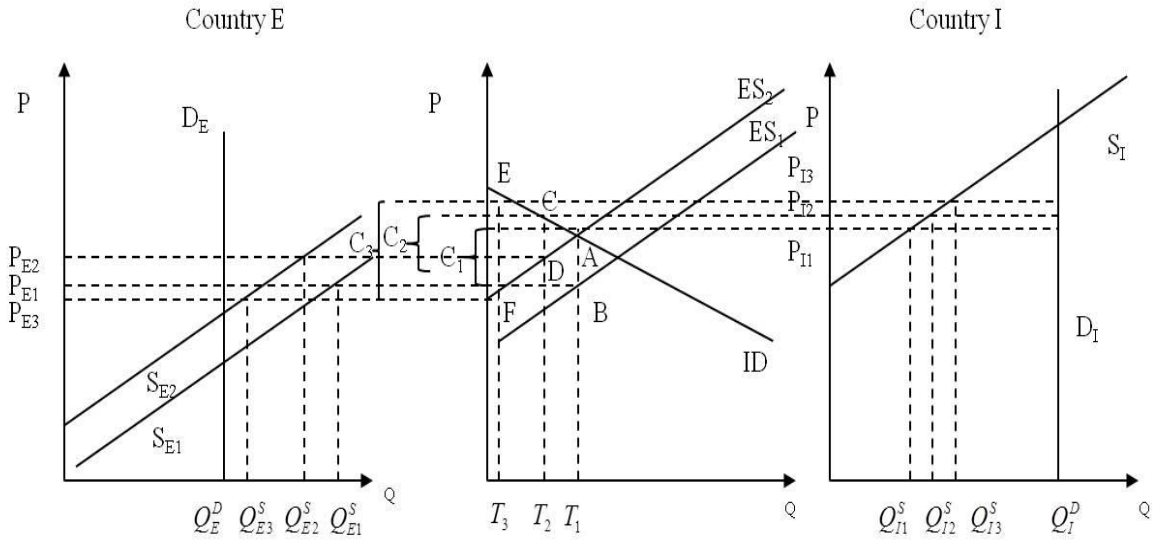


Second, assume that the trade cost to country I increased, leading to an export volume decrease from T_2. When trade cost increase is modest compared to the supply shift, the export volume of new equilibrium (T_3) will be no less than T_1 and in the range of [T_1, T_2); and P_{E3} will be no less than P_{E1} and in the range of [P_{E1}. P_{E2}), and production Q_{E3}^S will be more than Q_{E1}^S. When trade cost increase is large enough compared to the supply shift, T_3 will be less than T_1. Therefore, P_{E3} will be less than P_{E1} and production Q_{E3}^S will be less than Q_{E1}^S. Hence, the

impacts on Country E are uncertain.

For China's wood products with net imports, this hypothesis can also be analyzed in two steps using Figure 4.3. This time, Country I is China. First, the equilibrium after supply shock in Country E will lead to a price increase in Country E from P_{E1} to P_{E2} and a price increase in Country I from P_{I1} to P_{I2}. The trade volume will be decreased from T_1 to T_2. Second, increase in trade cost will cause an import volume decrease from T_2, which means that the import volume of the new equilibrium (T_3) is less than T1. Therefore, price of China (P_{I3}) is more than P_{I1} and production is more than Q_{E1}^{S}.

Figure 4.3 Supply shock in exporting country and trade cost increase



4.3 Methods

4.3.1 Model structures

The basic hypothesis of IFFP is that the forest products market is perfectly competitive and producer and consumer surplus is maximized, utilizing market-clearing prices (Northway and Bull 2006, 2007). The modeling structure is defined through processes and products. Processes consume one or more products while producing one or more products. The supply of primary products is represented through a typical supply curve, relating quantity to price. Each process is represented through a curve relating processed quantity to value-added price.

In this analysis, four regions are analyzed. They are China, US, EU, and the ROW. The analysis of the impacts of legality requirements requires us to disaggregate the primary products. Primary products, sawlogs and veneer logs, are classified into two types: legal and illegal. The two types of sawlogs and veneer logs are then processed into intermediate wood products, including sawnwood, plywood, veneer , fibreboard, and particleboard. As data on the proportion of each intermediate wood product used to produce each final wood product, such as wooden furniture and wood flooring, are unknown, final wood products are not included.

Time is not explicitly dealt with in the model structure, but rather in the definition of products and processes. As time is not explicitly included in the model structure, any desired discounting of future prices must be done explicitly in the appropriate definitions of products and processes. In this analysis, inter-temporal effect of stock is not considered; harvest and products of one year are assumed to be consumed totally. However, products of different years are connected through the assumptions in increases of available log volumes and manufacturing capacity.

Substitution of wood products with other non-wood products is not considered specifically. Demand for wood products is assumed to be inelastic. Illegal logging in this analysis refers to a narrow definition: "*harvesting activities which do not conform to national or sub-national laws and regulations*" (Smith et al., 2003). This includes: (1) harvesting without license; and (2) harvesting exceeding license in terms of region, volume or species (Casson and Obidzinski, 2002). For more details of IFFP model structure, please see Appendix B.

4.3.2 Scenario assumptions

Five scenarios are analyzed using IFFP (Table 4.1). Under the "business as usual" (BAU) scenario, the wood products market is assumed to develop following historical trends and no governmental initiatives to combat illegal logging are enforced in the US/EU during the projection period 2008-2020.

Table 4.1 Policy coverage and cost change of the five scenarios

Scenario	Law/Regulation Coverage	Cost Change of the Covered Products
Business as usual (BAU)	No legality requirements	No change
Import products (IMP)	Products imported by the US/EU	Import cost: 10% increase for legal products 50% increase for illegal products
Import and export products (IEP)	Products imported by the US/EU Products exported by the US/EU	Import cost: Same as IMP Export cost: 10% increase for legal products 50% increase for illegal products
All products weak enforcement (ALW)	Products imported by the US/EU Products exported by the US/EU Domestic products* of the US/EU	Import cost: Same as IMP Export cost: Same as IEP Harvest cost: 50% increase for illegal logs Manufacturing cost: 50% increase for illegal products
All products strong enforcement (ALS)	Products imported by the US/EU Products exported by the US/EU Domestic products of the US/EU	Import cost: Same as IMP Export cost: Same as IEP Harvest cost: 10% increase for legal logs 50% increase for illegal logs Manufacturing cost: 10% increase for legal products 50% increase for illegal products

Note: *Domestic products of the US/EU refer to products produced and consumed in the US/EU

The governmental initiatives of the four law/regulation scenarios in the US/EU (IMP, IEP, ALW, and ALS) cover different products (Table 4.1). For example, under the IMP scenario, only wood products imported by the US/EU are covered. The difference between the ALW scenario and the ALS scenario is that the latter assumes that the domestic legitimate wood products sector of the US/EU also subject to cost increase due to strong enforcement of the law/regulation.

The cost increase of legal products could be caused by the increase in compliance costs such as documentation cost, supply chain management cost, certification cost, cost of exchange rate change, extra delay cost and extra labor cost. Although Indufor (2008) assesses that an EU FLEGT VPA would cost the private sector less than one Euro, which is a minor factor to affect the legal trade, the new laws/regulations, like the US LAA and the EU TR, contain more uncertainties for the manufacturers and, therefore, 10% cost increase is assumed for legal products.

The cost increase of illegal products could mainly be from punishment due to violating the

laws/regulations. According to the US LAA, if an operator knowingly engaged in prohibited conduct, such as trade in illegal-sourced wood or false import declaration, the operator will subject to varying penalties. The penalties can be the forfeiture of goods, criminal felony fine up to twice gain from transaction, or jail time, depending on the degree to which a company knew or should have known that it was handling illegal products (The US Fish and Wildlife Service, 2012). The punishment of the EU TR is assumed similar to that of the US LAA.

4.3.3 Model parameters

Historical data between 2000 and 2010 on production, imports, and exports are obtained from the FAOSTAT and UN Comtrade. Projection time scale is 2008-2020. Parameter values of this analysis are as follows:

Log supply and products demand: Sawlog and veneer log supply and wood product demand for each country/region is assumed to increase at certain rate adjusted from the average historical increase rate (Appendix C1).

Manufacturing efficiency: Manufacturing efficiency is reflected through the conversion ratio of each process (Appendix C2). Efficiency conversion ratio=units of input product/units of output product. The conversion ratios are adjusted from GFPM (Buongiorno et al. 2003; Buongiorno et al. 2011).

Illegal logging rate: The illegal logging rate of each region is adjusted from Indufor (2008), with China and the ROW being 25%, the US being 10%, and the EU-27 being 8%.

Manufacturing capacity: Historical manufacturing capacity is assumed to be 1.2 times of the annual production. Future manufacturing capacity is assumed to increase at a certain rate adjusted from the average historical increase rate of production (Appendix C3).

Manufacturing cost: Manufacturing cost is adjusted from Northway and Bull (2006, 2007) (Appendix C4). For sawlogs and veneer logs, price-bottom is the price below which no product would be available and price-top is the price at which all of the products would be available. For processed products, price-bottom is the value-added price (marginal cost) below which nothing would be processed and price-top is the value-added price at which processing would be at

capacity. Price-bottom of illegal logs and intermediate products is 10% lower than that of legal ones.

Trade cost: Baseline trade cost is adjusted from GFPM (Buongiorno 2011) at the baseline scenario (Appendix C5).

4.3.4 Leakage calculation

Policies intended to conserve forest in one place are likely to stimulate timber harvest, deforestation, or forest degradation elsewhere (Sohngen et al. 1999). This phenomenon is often referred to as "leakage" (Murray et al. 2004), which can significantly undermine the net gain of global forest conservation obtained from implementing forest policies in one country (Mayer et al. 2004). Leakage can be negative (e.g. conservation policy in region A stimulates timber harvest in region B) or positive (e.g. conservation policy in region A decreases timber harvest in region B). Negative leakage is a central concern of trade policies with respect to trade of illegal-sourced wood products. The extent of negative leakage can be used to estimate the effectiveness of forest conservation policies.

Increase in harvest, production or trade measured by lumber units can be used to compute leakage rate (Sohngen et al. 1999; Wear and Murray 2004; Lepp änen et al. 2005; Bolkesj øet al. 2005; Kallio et al. 2006; Gan and McCarl 2007). This analysis estimates the negative leakage within China using the following equation:

$$LR = \frac{\Delta ILA}{\Delta ILB}$$

In equation [1], *LR* is negative leakage rate. When computing the *LR* inside China, $\triangle ILA$ is the increase of illegal harvest/production/trade in one or more wood products sector of China; $\triangle ILB$ is the decrease of illegal harvest/production/trade in the rest of the wood products sector of China. For example, if the illegal production of sawnwood and particleboard increases one m^3 and the illegal production of plywood, veneer sheet and fibreboard decrease two m^3, then *LR*=1/2=50%. When there is no increase of illegal harvest/production/trade, *LR* equals zero. When there is no decrease in illegal production/trade, *LR* reaches infinity. In order to understand the effectiveness of the US LAA and the EU TR in a global context, negative harvest leakage of

the world is also computed. When computing the *LR* of the world, $\triangle ILA$ is the increase of illegal harvest in one or more countries/regions; $\triangle ILB$ is the decrease of illegal harvest in the other countries/regions.

4.4 Results and discussion

4.4.1 China's import and export role

China may still be a net exporter of plywood, veneer sheet and fibreboard in the projected period (Table 4.2) due to increasing demand from overseas market and price competitiveness. Growing population is the key reason leading to increasing global demand for these wood products. China's price competitiveness in these wood products comes from lower manufacturing cost, which is largely due to relatively lower labor cost (Han et al. 2009).

Table 4.2 The import and export role of each country/region during 2008-2020

Country	Sawlog and Veneer log	Sawnwood	Particleboard	Plywood	Veneer sheet	Fibreboard
China	I	I	I	E	E	E
US	E	I	I	I	I	I
EU-27	E	E	E	I	I	E
ROW	E	E	E	I	E	I

Note: E-net exporter; I-net importer.

China may continue to rely on the imports of primary wood products (i.e. sawlog and veneer log, sawnwood, and particleboard) in the projected period (Table 4.2). This is because of two major reasons. First, China has inadequate log supply due to limited forest areas, unfavourable forest age structure, low forestland productivity, and forest resource protection policies (e.g. the Natural Forest Conservation Program (NFCP)) (Bull and Nilsson 2004; Uchida et al. 2005; Démurger et al. 2009; Cao et al. 2010; SFA 2012). Second, China's domestic demand for these products keep growing due to increasing domestic population and surging demand from value-added final wood products, especially wooden furniture.

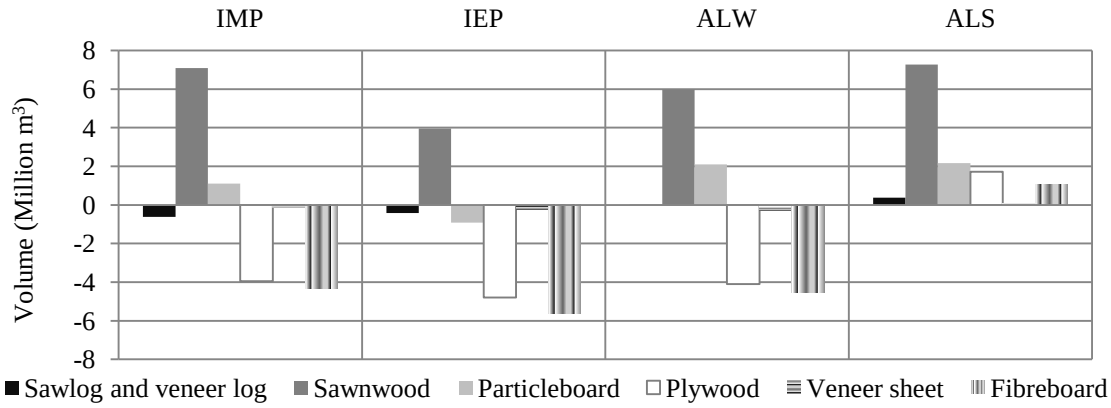
In the following sections, China's wood products sectors with net import, such as sawlog and veneer log, sawnwood, and particleboard sector, are referred as import sectors. While China's wood products sectors with net export, such as plywood, veneer sheet, and fibreboard

sector, are referred as export sectors.

4.4.2 Impacts on China's harvest, production and trade

Figure 4.4 shows the effect that the four law/regulation scenarios could have on sawlog and veneer log harvest and wood products production in China during 2008-2020. As the results are all marginal changes, which account for around 1% of the harvest, production or trade, absolute deviations from the BAU scenario are presented instead of percentage changes. The marginal changes suggest that harvest or production could only be affected a little under the four law/regulation scenarios. This is because harvest or production quantity is very large for each wood product. Therefore, even if the absolute deviations are considerable, the percentage changes could be marginal. For example, sawnwood production under the ALS scenario could increase approximately 7.26 million m^3 from the BAU scenario during the projected period, which only accounts for about 1.4% of the sawnwood production of the BAU scenario.

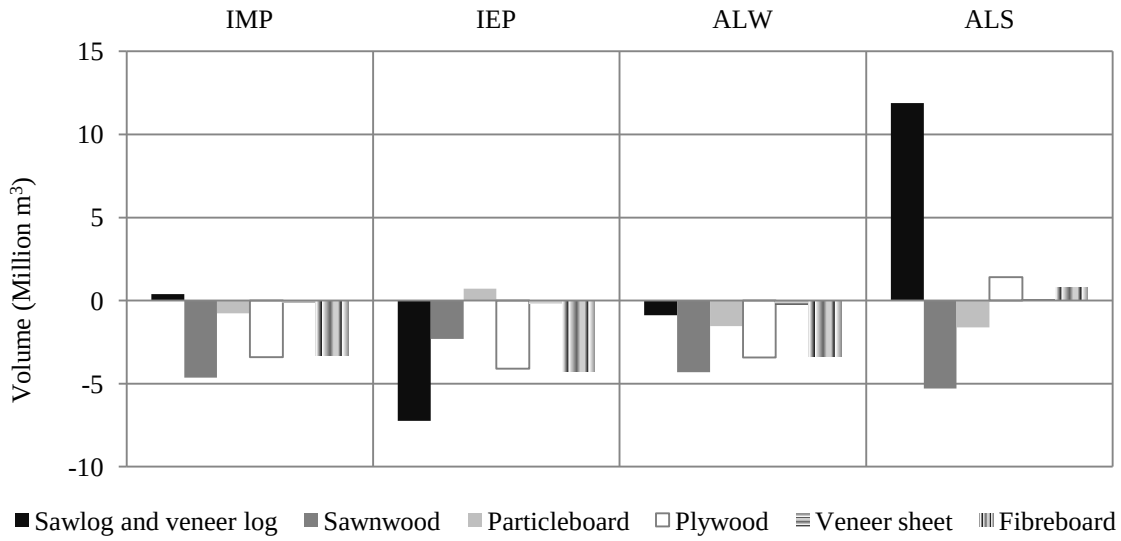
Figure 4.4 Accumulated changes of log harvest and wood products production in China: deviation from the BAU scenario during 2008-2020



IMP scenario: China's wood products export sectors could be affected negatively under the IMP scenario. The results of the IMP scenario in Figure 4.4 reveal that governmental initiatives in the US/EU which covers only the import products of the US/EU could decrease the production of plywood, veneer sheet, and fibreboard, indicating that hypothesis 4.1 is supported. The production decrease may largely reflect in the export decrease (Figure 4.5), mainly to the US/EU. The results are due to the increase of the import cost for importers of the US/EU or the export cost for the exporters of China and the ROW. Initial market equilibrium under the BAU

scenario reaches the situation that the price difference between China and the US/EU equals to the trade cost according to the law-of-one price (Gregorio, 1994; Vercammen 2011). Trade cost increase under the IMP scenario would change the initial equilibrium to a new equilibrium under which the law-of-one price still stands, which leads to the decrease of China's production level and export volume from the BAU scenario.

Figure 4.5 Accumulated changes of China's log import and wood products trade: deviation from the BAU scenario during 2008-2020



Note: For log, sawnwood and particleboard, the changes are net import changes; for plywood, veneer sheet, and fibreboard, the changes are net export changes.

China's wood products import sectors could also be affected under the IMP scenario. Under the IMP scenario, the harvest of China's sawlog and veneer log could decrease from the BAU scenario and the production of China's sawnwood and particleboard could increase from the BAU scenario (Figure 4.4). China's import of sawlog and veneer log could increase from the BAU scenario and the import of sawnwood and particleboard could decrease from the BAU scenario (Figure 4.5). The results are because of the vertical and horizontal linkages of the wood products supply chain. The changes of China's wood products export sectors affects its wood products import sectors. Given that the US/EU could not import plywood and fibreboard from the ROW, which is also a net importer of these products (Table 4.2), the US and the EU have to increase their domestic production to meet their domestic demand, which leads to increased demand for sawlog and veneer log to produce these products. Correspondingly, the price of

sawlog and veneer log could increase, leading to less production of sawnwood and particleboard in the US/EU. Thus, China has to import less sawnwood and particleboard from the EU, import more sawlog and veneer log from the ROW (Figure 4.5), and produce more sawnwood and particleboard (Figure 4.4).

IEP scenario: China's wood products export sectors could also be influenced negatively under the IEP scenario, similar to that of the IMP scenario (Figure4.4; Figure 4.5). However, the impacts on China's wood products import sectors under the IEP scenario may be varied from that under the IMP scenario, except sawnwood sector (Figure4.4; Figure 4.5). Sawlog and veneer log harvest and import could decrease due to the decline in downstream demand of plywood, veneer sheet, and fibreboard. The production of particleboard may decrease, while its import may increase. The complex changes of China's wood products import sectors under the IEP scenario are mainly due to two reasons. First, as just analyzed in the last paragraph, the changes of China's wood products export sectors have effects on its wood products import sectors due to the vertical and horizontal linkages. Second, the expansion of governmental initiatives to include the export wood products in the US could have little impacts on China since the US is a net importer for most of the wood products, except sawlog and veneer log (Table 4.2). Only that of the EU could have impacts on China. The results of the IEP scenario are not all the same with the expectation in Hypothesis 4.2.

ALW scenario: The inclusion of domestic illegal activities in the US/EU, besides their import and export wood products, could bring negative influence on China's wood products export sector and positive influence on China's wood products import sector. Like the IMP and IEP scenario, China's wood products export sectors could also be influenced negatively under the ALW scenario, with both production and export decreasing from the BAU scenario (Figure4.4; Figure 4.5). China's wood products import sector could witness increase in harvest/production and decrease in import of all the three wood products under the ALW scenario, with the harvest/production of sawlog and veneer log, sawnwood, and particleboard increasing from the BAU scenario and their import decreasing from the BAU scenario.

ALS scenario: China's wood products export sectors may be influenced positively when

the law/legislation brings considerable cost to the legitimate operators in the US/EU under the ALS scenario. The production and export of China's wood products export sectors under the ALS scenario could increase. This indicates that the inclusion of the domestic products of the US/EU could lead to more uncertainties for the plywood, veneer sheet, and fibreboard industry in China. Strong enforcement in the domestic industry of the US/EU leads to surges in the prices of the wood products produced in the US/EU. China's wood products, even if they suffer from the increases of trade costs, can still be price-competitive. And therefore, China could export more to the US/EU under the ALS scenario, which in turn may lead to an increase in China's log harvest and import. The impacts on sawnwood and particleboard under the ALS scenario are similar to those under the IMP and ALW scenario, with production increasing and import decreasing from the BAU scenario. The results of the ALW scenario and the ALS scenario support hypothesis 4.3.

4.4.3 Impacts on illegal harvest, production and trade

Governmental initiatives to combat illegal logging in the US/EU may cause negative leakage problems in China that can not be ignored. China's illegal harvest, associated illegal production and trade could decrease from the BAU scenario for most of the products under the IMP, IEP and ALW scenario (Figure 4.6; Figure 4.7). However, the decreases are minor compared to the total illegal harvest, production and trade, accounting for less than 2%. In addition, the production of: illegal-sourced particleboard under the IMP scenario, illegal-sourced sawnwood and particleboard under the ALW scenario, and most of the illegal-sourced wood products (except fibreboard) under the ALS scenario could increase from the BAU scenario (Figure 4.6). Illegal imports of: sawnwood and particle under the IMP and the IEP scenario, sawnwood under the ALW scenario, and sawlog and veneer log under the ALS scenario could also increase from the BAU scenario (Figure4.7). Increases in import of illegal-sourced sawnwood under the IMP scenario could reach as high as 12.0 million m^3 during 2008-2020.

Figure 4.6 Accumulated changes of illegal harvest and associated production in China: deviation from the BAU scenario during 2008-2020

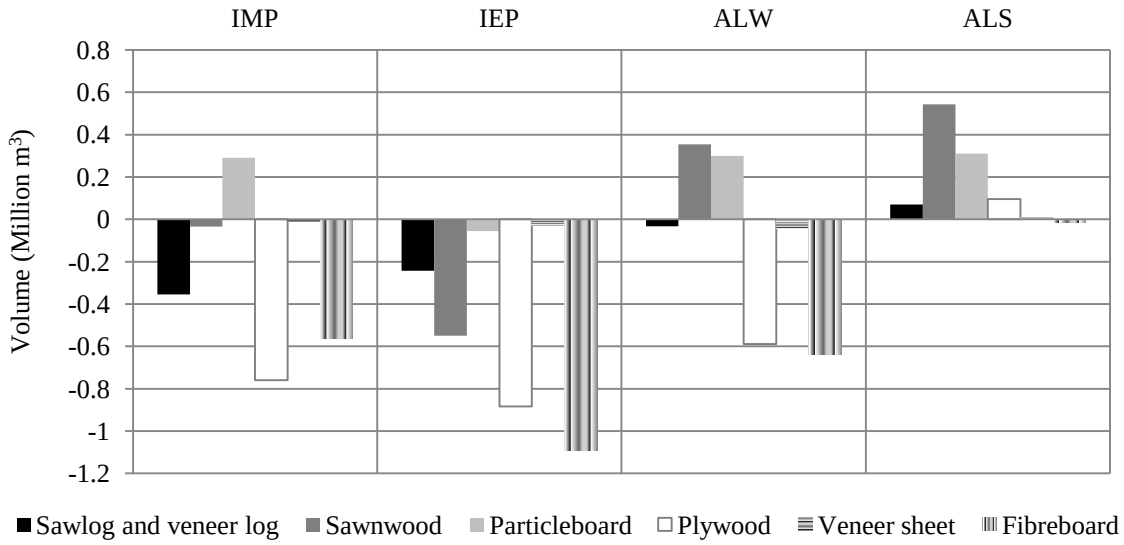
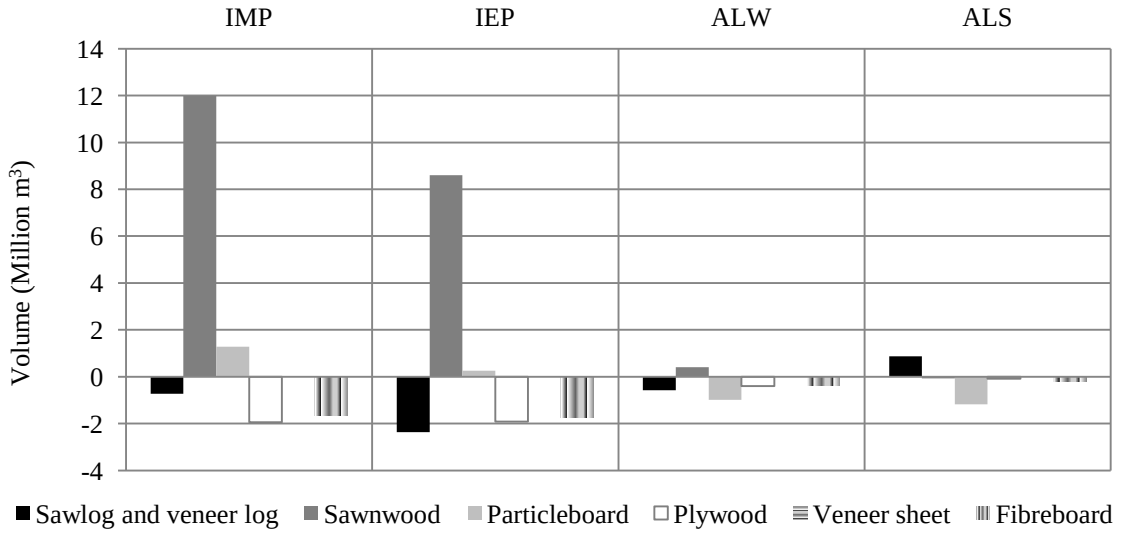


Figure 4.7 Accumulated changes of China's import and export of illegal logs and wood products: deviation from the BAU scenario during 2008-2020



Note: For log, sawnwood and particleboard, the changes are net import changes; for plywood, veneer sheet, and fibreboard, the changes are net export changes.

The law/regulation coverage could affect the effectiveness of the legislative/regulatory instrument in combating illegal logging. Table 4.3 shows the negative leakage rate in China and the world. When assessed by with the negative leakage rate in China's illegal harvest and production or the negative leakage rate in the world's illegal harvest, the law/regulation under the IEP scenario could be the most effective in combat illegal logging, and that under the ALS scenario could be the least effective. When assessed by the negative leakage rate in China's

illegal wood products trade, the law/regulation under the ALW scenario could be the most effective, and that under the IMP scenario could be the least effective.

Table 4.3 Leakage rate of the four policy scenarios

Country/Region, Item	Leakage Rate (%)			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
China, Production	16.8	0	50.2	6627.7
China, Trade	306.5	147.4	17.8	57.0
World, Harvest	15.4	0	16.6	31. 7

The US LAA and the EU TR could be similar to other forest conservation policies in terms of causing negative leakage. Various previous studies have found that the forest management intensity, timber harvest, or wood products production outside the conservation sector may increase due to demand forces (Sohngen et al. 1999; Linden and Uusivuori 2002; Wear and Murray 2004; Lepp änen et al. 2005; Bolkesj øet al. 2005; Kallio et al. 2006; H änninen and Kallio 2007). Although governmental initiative to combat illegal logging in the US/EU could be effective in reducing illegal logging in the world's total log harvest, negative leakage problems may have weaken the effectiveness. Currently, although the US LAA mentions that it is unlawful to import, export, transport, sell, receive and purchase in interstate or foreign commerce any plant (including trees) taken or traded in violation of the laws of the US, a US state, or relevant foreign laws (Tanczos 2011; Cashore and Stone 2012; The US Fish and Wildlife Service 2012), only importers of the US or the exporters of other countries who export to the US are required to make declarations. The EU TR is also likely to be enforced only on its imported wood products. Therefore, the current law/regulation enforcement is similar to the initiatives analyzed in the IMP scenario, indicating that it might not be effective in combat illegal logging due to potential negative leakage.

The negative leakage problem caused by governmental initiative to combat illegal logging in the US/EU could happen in any of the four analyzed countries/regions. This is because the governmental initiatives in the US/EU aim to combat global illegal logging. Therefore, when illegal logging is reduced in one or more countries/regions, it can lead to leakage problem in any other countries/regions. Negative leakage happens in the EU under the IMP scenario. Under the

ALW scenario, negative leakage happens in the ROW. Under the ALS scenario, negative leakage happens in both China and the ROW, with ROW contributing to about 98.2% of the leakage (leakage rate in the ROW is 31.1%=98.2%×31.7%).

4.4.4 Implications

Illegal logging leads to government revenue loss, deforestation and various other economic, environmental, and social problems. It is the source of a substantial amount of wood for local wood products and for export (Li et al. 2008). The governmental initiatives, such as the US LAA and the EU TR, aim to combat illegal logging from the demand-side. It is essential to assess the impacts of these initiatives on China's wood products industry, a very important part of the world wood products trade.

Sensitivity analysis has been conducted to check the effects of changes in harvest cost, manufacturing cost and trade cost due to the governmental initiatives in the US/EU. The analysis is repeated with a set of assumed weaker (+5%) and stronger (-5%) enforcement of laws/regulations for each scenario. For example, two extra scenarios are run for the IMP scenario, with the IMPW scenario using 5% increase for legal products and 45% increase for illegal products, and with the IMPS scenario using15% increase for legal products and 55% increase for illegal products. Sensitivity analysis reveals that the impacts of cost change uncertainties on the harvest, production, trade, and leakage rate are limited, accounting for less than 5% change of the accumulated volume changes.

The impacts of governmental initiatives on China's wood products export sectors could be distinguished from its import sectors. For example, under the IMP scenario, the production and net export of plywood, veneer sheet, and fibreboard could decrease while the production and net import changes of China's sawlog and veneer log, sawnwood, and particleboard are far complex and could, in some instances, increase.

The coverage of the law/regulation could have varied effects on China's wood products industry. The production and net exports of China's wood products export sector could move in the same direction (i.e. decrease) and, in fact, we forecast very similar impacts under the IMP,

IEP, and ALW scenarios. However, the results for these products under the ALS scenario are reversed (i.e. increase) due to the compliance cost surge for legitimate operators in the US/EU. The production and net import changes of China's sawnwood and particleboard under the four law/regulation scenarios, except for particleboard under the IEP scenario, could increase in production and decrease in net imports.

The leakage problem in our analysis is due to product and market substitution. In this analysis, products from different countries are assumed to be perfect substitutes for each other. Therefore, when imports from the US/EU become expensive due to governmental initiatives such as the US LAA and the EU TR, China's imports of sawlog and veneer log, sawnwood and particleboard from the ROW could increase. Similarly, when trade or compliance costs increase for markets in the US/EU, China could export more plywood, veneer sheet and fibreboard to the ROW.

The impacts of the demand-side initiatives discussed in this paper have more uncertainties than supply-side initiatives for three major reasons. First, they may affect all types of wood products in the supply chain and they may influence both the export sectors and the import sectors. Second, the coverage of these demand-side initiatives may vary. It may only apply to selected products imported by the US/EU, or may apply to all products related to the US/EU market. Third, enforcement of the law/regulation may differ. Strong enforcement of these initiatives may lead to more severe punishment and affect legitimate operators more than weak enforcement mechanisms.

Initiatives to combat illegal logging should attempt to minimize the impacts on legitimate operators. If the costs for the legitimate operators surge, legal harvest, production and trade could decrease, and illegal harvest, production and trade could continue or even expand. To avoid the potential harm to legal operators, the government should provide more guidance for them to comply and reduce their compliance cost.

There are some limitations of the study. First, aggregated data are used for EU-27 and the ROW instead of data for each specific country. Second, net import and net export are analyzed instead of import and export since the same type of wood products from different countries are

viewed as perfect substitutes. Third, critical assumptions are made on the: illegal logging rate, manufacturing costs, manufacturing capacity, producing efficiency, rate of increase in supply and demand, and trade costs. Therefore, the modeling results should not be interpreted as the right answers in terms of changes in production level and trade volume, but as explorations of the potential trends in the impacts of the governmental initiatives similar to the US LAA and the EU TR.

4.5 Conclusion

This study assesses the impacts of the US LAA and the EU TR on China's wood products industry using the IFFP trade model. These governmental initiatives will have different impacts on China's wood products industry due to compliance cost increase for legitimate operators and barriers erected for illegal operators.

First, as parts of China's wood products export sectors (i.e. plywood, veneer sheet, and fibreboard) could suffer from shrinkage of production and a reduction in net export under all the scenarios, except for the ALS scenarios, government assistance is needed to decrease the compliance costs. Government could also help enhance the producers' awareness of social and environmental responsibilities, improve their supply chain management, cover all or part of their forest certification cost, and assist their efforts to increase market share in both the domestic market and other overseas markets.

Second, the increase in domestic production and the decrease in net import of sawnwood and particleboard under all four law/regulation scenarios, except for particleboard under the IEP scenario, suggest that the US LAA and the EU TR may provide an opportunity for China to expand its domestic production. More investment capital should be provided for sawnwood and particleboard sector to expand their manufacturing capacity and increase their efficiency.

Third, the leakage problem caused by the governmental initiatives to combat illegal logging is a concern. While illegal-sourced wood and wood products may decrease in China's trade flows to and from the US and the EU, illegal harvest and consumption may increase within China and within other high or moderate risk countries/regions in the ROW. Illegal trade may also increase

between these high or moderate risk countries/regions. Globally, the net environmental effects depend on the countries to which illegal harvest/production and trade shifts. It is expected that if more countries adopt policies similar to the US LAA and the EU TR, including China and countries in the ROW (e.g. Australia, New Zealand, Canada, and Russia), the leakage problem could dissipate.

5 Conclusion

5.1 Research contributions

In the forest products marketing literature, increasingly research has been focussed on the study of illegal logging. However, thus far, limited research has explored the potential impacts of governmental and non-governmental initiatives aiming to combat illegal logging. This is particularly true for transitional economies such as China where manufacturing using potentially illegal wood could be fairly high. Therefore it is important to study the potential impacts of governmental and non-governmental initiatives to combat illegal logging since it could provide useful information to various stakeholders seeking measures to help the firms and the industry take advantage of the new policy measures and also reduce or avoid business and market risks.

In this dissertation, the impacts of the US LAA, the EU TR and CoC certification on China's wood products industry are examined. Chapter 2 evaluates factors that affect legal compliance with the US LAA and the EU TR using a series of interviews and multiple linear regression. Chapter 3 identifies factors affecting the decision of China's wooden furniture manufacturers to adopt CoC certification, again using a series of interviews and logistic regression. Chapter 4, which broadens the analysis to China's wood products sector, forecasts the potential longer-term impacts of the US LAA and the EU TR on China's wood products industry using IFFP.

Chapter 2 and Chapter 3 analyze the impacts at individual producer level and I chose China's wooden furniture sector because it is the largest sub-sector of China's forest products sector and it is a well-defined export sector. Due to the lack of data on final wood products such as wooden furniture, Chapter 4 focuses on intermediate wood products, including sawnwood, plywood, veneer sheet, fibreboard, and particleboard. Thus, the study enables us to have a broader understanding of the impacts of governmental and non-governmental initiatives to combat illegal logging on China's wood products industry.

This study aims to make three major contributions to the state of knowledge of forest

products marketing as summarized below:

Contribution 1: Based on an integrated innovation-adoption model and an assessment framework of legal compliance, this study identified factors that determines a firm's willingness to comply with legality requirements.

Increasing globalization causes concern about environmental impacts. Previous regulatory frameworks for environmental protection do not work effectively in the presence of globalization (Christmann and Taylor 2001). The US LAA and the EU TR were developed to address the illegal logging problem associated with international trade, assuming that as the world's major consumer countries/regions of wood products, the implementation of these initiatives could contribute to the control of illegal logging in producer and processor countries from the demand-side. As China is a major wood products processor country and the wooden furniture industry is its largest sub-sector, the study of the legal compliance of China's wooden furniture manufacturers could provide useful insights in assessing how these laws and regulations might work in a global economy.

According to the findings of Chapter 2, a firm's willingness to comply with legality requirements is determined by the natural logarithm of firm size, the natural logarithm of export proportion, the interaction between opportunity and client pressure, the interaction between opportunity and the natural logarithm of export experience, and the interaction between opportunity and the natural logarithm of export proportion.

Because firms have very different characteristics with regard to knowledge learning, subjective norms, perceived behavioural control, and attitudes towards the US LAA and the EU TR, their willingness to comply could be very different. The variations in country-specific regulatory requirements have increased these differences. Firms that do not have favoured characteristics in dealing with the US LAA and the EU TR would be expected to follow a low compliance extent and shift to markets with lower environmental standards (i.e. lower concern for illegal logging problem), such as the domestic market and other overseas markets. Thus it falls into the well-known pollution heaven hypothesis (Walter 1982) and indicates that firms in a global economy could take advantage of differences between national environmental regulations.

However, our study shows that the majority of the surveyed firms intended to stay in the US and the EU markets and expressed a higher level of willingness to comply. To reach a higher level of legal compliance, our study suggests that firms with certain size, export proportion and export experience should enhance their activeness in learning environment-related issues and their awareness of legality requirements, and explore the potential market opportunities accompanying legal compliance. If they aware that higher legal compliance could bring various benefits, especially the increase of CSER awareness and the improvement of SCM, they may be more willing to embrace environmental protection. In fact, through complying with the US LAA and the EU TR, firms could develop superior environmental management capacities and technologies, which would improve their international competitiveness as similar regulations are expected to be raised in many other international markets.

Contribution 2: Based on an integrated innovation-adoption model and a logistic regression, this study developed a model which identified statistically significant factors that can predict a firm's decision to adopt CoC certification.

Firms' responses to environmental issues are an important component of global environmental management. While overseas governmental laws and regulations, such as the US LAA and the EU TR, force firms to adopt different legal compliance, voluntary governance schemes such as CoC certification provide another choice for firms to enhance self-regulation. Current and future adoption levels suggest that approximately 61.7% of the surveyed wooden furniture firms, which are all export-oriented firms, might be CoC certified by the year 2016.

An important question to consider is what factors influence a firm's decision to adopt CoC certification. Chapter 3 identified three factors (i.e. client pressure, firm size, and benefits) in the persuasion stage which are statistically significant in determining a firm's decision to adopt CoC certification. The importance of client pressure suggests that the requirement of importers in the overseas market is one of the major forces influencing China's export-oriented wooden furniture firms to adopt CoC certification. In fact, big retailers in the US and the EU have been using responsible purchasing policies to try to ensure product legality and sustainability. The emerging governmental initiatives, such as the US LAA and the EU TR, have increased their use of RPP.

That is to say, although the benefit of CoC certification in meeting legality requirements is not statistically significant in modeling a firm's CoC certification adoption decision, it may have influence through client pressure.

The perceived benefits of CoC certification was another statistically significant factor. The result suggests that although direct benefits, such as price premiums and increased market share, were not perceived as being likely to occur by the respondents, firms are now paying attention to the indirect benefits of certification, especially improvement of public relations and management operations. These indirect benefits may result in an improved competitive advantage and, therefore, increased economic benefits (Miles and Coven 2000; Vidal et al. 2005). That is to say, long-term and indirect benefits can play important role in influencing a firm's decision to adopt CoC certification.

Firm size is also a statistically significant factor. Larger firms usually have more resources and management capacity, facilitating the implementation of CoC certification. This indicates that SMEs may need more support in adopting CoC certification as they usually lack managerial, entrepreneurial and marketing expertise, lack capital, investments and assets, have limited access to financing, and have difficulties sourcing raw materials (Mead and Liedholm 1998).

Contribution 3: Using the IFFP model and data on legal and illegal wood products, this study forecasts the potential longer-term impacts of the governmental initiatives to combat illegal logging in the US/EU on China's wood products industry.

Responses to illegal logging and its associated trade have already been considerable, and have led to important reductions in the extent of the problem (Lawson and MacFaul 2010). Although the US LAA and the EU TR were implemented/ developed very recently, they are already having an impact on the world forest products sector (Lawson and MacFaul 2010).

Chapter 4 presented a forecast of the impacts of governmental initiatives, similar to the US LAA and the EU TR, on China's wood products industry and found that those impacts vary for different categories of wood products under different policy coverage. Production and net exports of China's plywood, veneer sheet, and fibreboard, which are all products with net export, would generally decrease from a baseline scenario. However, if laws and regulations in the

US/EU were to cover domestic production and affect their harvest and manufacturing cost too much, production and net exports of China's plywood, veneer sheet, and fibreboard might increase, driven by an increase in exports to the US/EU. Domestic productions of China's sawnwood and particleboard, which are all products with net imports, would generally increase, while their net imports would decrease. The results suggest that products with net exports and products with net imports would be influenced very differently under different policy coverage. The impacts of laws and regulations, such as the US LAA and the EU TR, on the wood products industry of producer countries and processor countries, such as China, may not be all negative. The results also indicate that demand-side-driven policies, such as the US LAA and the EU TR, could have international economic impacts, as the illegal harvest level of other countries/regions, such as the US, the EU-27, and the ROW, would all change from the baseline scenario.

The results also indicated laws and regulations, such as the US LAA and the EU TR, would be effective in combating illegal logging in the US and the EU, and they would also be effective in reducing China's illegal harvest, production, and trade. However, leakage problem may undermine that effectiveness. This suggests that demand-side-driven measures would also have limits. While illegal harvest in the major consumer countries (e.g. the US and the EU) and the associated trade with their major supplier countries (e.g. China) would be controlled to a certain extent, illegal harvest and trade might increase from the baseline scenario within and among less sensitive markets, including China and the ROW. As production for export to the major countries is increasingly legalized, domestic demand within the less sensitive markets for illegal wood would become relatively more important and domestic consumption within the less sensitive market would also expand as a result of increased population and economic growth, which presents challenges for demand-side policies to be globally effective in combating illegal logging.

Contribution 4: There are several theoretical contributions of the thesis.

First, at the individual producer level, the integrated innovation-adoption model does have the ability to explain a firm's decision process and behaviour. The integrated innovation-adoption model which combined the innovation-diffusion theory (Rogers 1995), the elaboration likelihood

model (Petty 1997), and the theory of planned behaviour (Ajzen 1991) has the ability to explain the decision process and behaviours of a firm very well from the organizational psychology point of view. It can be widely used to analyze the adoption of innovations regarding forest policies/technologies, and other environment and natural resources management.

Second, at the industry level, the IFFP trade model results indicate the analyzing of the impacts of demand-side policies in an open economy should differentiate the products with net imports and net exports. The results show that products with net exports will be influenced differently than products with net imports under different policy scenarios. At the industry level, the hypotheses regarding the policy impacts on wood products with net import and net export were generally supported by the modeling results. Enforcement of laws and regulations in the US/EU, if the domestic harvest and production within the US/EU are not affected, may have negative impacts on China's wood products with net exports, leading to decreases in production and export volume. For China's wood products with net imports, enforcement of laws and regulations in the US/EU may increase their price and production, and decrease their import volume.

Third, also at the industry level, the IFFP trade model indicates that leakage problem due to product substitution between products from different sources and different countries could undermine the effectiveness of the new demand-side policies. While China's wood products net exports to the US/EU would decrease from the baseline scenario due to the laws and regulations, such as the US LAA and the EU TR, its net exports to the ROW would increase from the baseline scenario. Similarly, while China's net imports from the US/EU would decrease from the baseline scenario due to the US LAA and the EU TR, its net imports from the ROW, including net imports of illegal logs, would increase from the baseline scenario.

5.2 Potential applications

Various stakeholders, including wood products industries, governments, researchers and non-government organizations (NGOs), could use the research results of this study.

First, this study points out a need to enhance awareness and understanding of legality

requirements and CoC certification within China's wooden furniture industry. Stakeholders can use the results to provide more public activities such as seminars, workshop, lectures, and training programs.

Second, policy makers should design policies that adapt to firms of different characteristics. This study suggests that China-related environmental policy makers should adopt a broader view to better understand factors that affect the legal compliance of China's wooden furniture manufacturers to legality requirements and factors that determine their CoC certification adoption decision. Firms with different learning activeness, awareness, subjective norms, perceived behavioural control, and attitudes have different decisions and behaviours towards innovations. For example, SMEs tend to be more vulnerable to legality requirements and are less likely to adopt chain of custody certification. More help should be provided to them to improve their management capacity. In addition, this study can also help organizations that promote CoC certification to better define their future clients. The logistic regression model presented in Chapter 3 shows that firms with higher client pressure, larger size, and higher expected CoC benefits are more likely to adopt CoC certification.

Third, stakeholders should consider strategies for the wood products industry to mitigate risk and take advantage of legal timber policies. As China's plywood, veneer sheet, and fibreboard may suffer from lower production and exports, policies should be implemented to help these sub-sectors through the transition, including enhancing their awareness of social and environmental responsibilities, helping them to improve supply chain management, promoting forest certification, and assisting them in exploring domestic and other overseas market. More financial support should be provided for the sawnwood sector to expand their manufacturing capacity and to enhance manufacturing efficiency. The policy environment should also be improved to favour certification or legality verification.

5.3 Limitations

The research findings and conclusions have several major limitations:

First, due to the limitations of sample size, the results of chapter 2 and chapter 3 should be

treated with caution. Only 107 export-oriented wooden furniture manufacturers were interviewed, compared to the nearly 3,000 Chinese wooden furniture manufacturers that export products to the US/EU. The small sample size may possibly cause some bias in terms of representativeness for the entire population, although the sample for this study used was selected through stratified random sampling and was evaluated as having not much variance from the population in terms of the distribution of firm size. Using logistic regression in Chapter 3, the small sample size could lead to estimation bias. A minimum of 10 observations per independent variable have been recommended for logistic regression (Peduzzi et al. 1996; Hsieh et al. 1998; Agresti 2007; Demidenko 2008). The initial full model with seven variables should have at least 70 observations and the final model that had only three independent variables should have at least 30 observations, which all made the sample size of 107 larger than the minimum requirement. However, it may still be a problem as logistic regression tends to systematically overestimate odds ratios or slope coefficients when the sample size is less than 500 (Nemes 2009).

Second, although the integrated innovation-adoption model was used as the theoretical guide, the empirical analysis ignored some variables to simplify the analysis process. Variables at the knowledge stage, such as a firm's learning activeness and innovation awareness, were not considered because they assessed a firm’s corresponding status prior to the survey. At the persuasion stage, a firm's goal was used to represent its values/beliefs/goals, without differentiating them and studying the relationships between them. Also, decision makers' characteristics, such as their education levels and ages, should be considered in a firm's perceived behavioural control.

Third, in Chapter 2, the dependent variable (i.e. legal compliance) is truncated, which should be treated with caution when conducting regression. It falls in the range of 40-100 and most of the values are at the right side. Truncated dependent variable is a common phenomenon in social science and economics. Ordinary Least Square (OLS) regression is used in Chapter 2 to analyze the relationship between the truncated dependent variable and the independent variables. OLS regression will not adjust the estimates of the coefficients to take into account the effect of truncation, and the coefficients may be severely biased. This can be conceptualized as a model

specification error (Heckman 1979). Truncated regression can be used to address the bias.

Fourth, in Chapter 2, it is difficult for a single firm to link the changes of benefits and costs to a specific reason. Many other factors in the trade process might contribute to opportunities and benefits, such as quality and design improvement, demand surge, and management enhancement. Similarly, many other factors in trade process might contribute to the challenges and costs, such as price increase of raw wood materials, increase of labor cost and exchange rate appreciation. Therefore, future studies could focus on more detailed quantitative research on the impacts of global legality requirements on opportunities/benefits and challenges/costs. When reliable data and information are obtained, we would be able to conduct more reliable modeling analysis to assess the impacts of legality requirements on global wood products industry.

Fifth, besides the small sample size, there are several other technical issues with the logistic regression in Chapter 3. Although the backwards likelihood ratio method is a good choice for variable selection in logistic regression, it could result in models that are unstable and not reproducible (Austin and Tu 2004). The independent variables selected are sensitive to random fluctuations in the data. In addition, the relationships between the independent variables were not considered in the logistic regression. That is to say, effects of moderation, mediation, confounding, and suppression were not analyzed, which may have led to the false inclusion and exclusion of certain variables and thus limited the applicability of the model.

Sixth, the results of Chapter 4 results should also be treated with caution. I had to make critical assumptions regarding: illegal logging rate, manufacturing costs, manufacturing capacity, producing efficiency, rate of increase in supply and demand, and trade costs. In addition, I used net import and net export instead of import and export to analyze each of the wood products. Finally, because of the data aggregation challenge of the EU-27 and the ROW, I was not able to analyze China's trade with specific countries in these regions. The modeling results should not be interpreted as the definitive answers, but as an exploration of the potential impacts of governmental initiatives similar to the US LAA and the EU TR.

5.4 Future research

With regard to the research topic, future research can focus on conducting research in the following areas:

Conduct comparative study across wood products sectors, across different stakeholders, and over time. As the survey in this study was conducted only among China's wooden furniture manufacturers, more work is needed to identify ways to involve more stakeholders from various wood products sector in the process. The comparative study would thus enable better policy making. As the US LAA and EU TR are all new regulations, perceptions of them may change over time. A comparative study over time would provide useful information on how organization's attitudes and behaviours change with growing knowledge.

Collect more data to improve the empirical analysis. At the knowledge stage of the integrated model, a firm's learning motivations and abilities should be studied further. At the persuasion stage, a firm's values, beliefs, and goals should also be studied separately. The value-belief-norm theory can thus be integrated into the model to conduct detailed research. Besides, decision makers' characteristics and entrepreneurship can also be studied to represent more comprehensively a firm's perceived behavioural control. When a firm's awareness of the US LAA and the EU TR developed into an adequate stage, we will be able to collect information to conduct multiple regressions to model a firm's legal compliance by including statistically significant factors. For CoC certification, the current logistic regression analysis is limited in the knowledge and persuasion stage. A second round logistic regression analysis could be conducted if more information is collected at the confirmation stage. For example, detailed assessment is needed to estimate CoC effectiveness in terms of problem solving and goal attainment, behavioural effectiveness, process effectiveness, constitutive effectiveness, and evaluative effectiveness.

Collect more data to improve the modeling reliability. Illegal log supply is currently assumed to be a percentage of legal log supply. A better way might be to collect data to develop a separate supply curve for illegal logs. More reliable data are needed to reflect the manufacturing

costs, manufacturing capacity, producing efficiency, log supply change over time, demand change over time, and trade cost. This would enable us to conduct a more reliable modeling.

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Appendices

Appendix A: Interview script

PART Ⅰ BASIC COMPANY INFORMATION

1-1 Company name and contacts

Company name:_____ Company address:_____

Contact person:_____ Position:_____

Telephone:_____ E-mail:_____

Date of interview:_____ Interviewer:_____

1-2 How many employees do you have?_____ employees

1-3 What were the proportions of wood products in total sales value in 2010?

Wooden furniture:_____% Other wood products:_____%

1-4 When did your firm start to export wood products?_____

1-5 What was the percentage of exported wood products in total wood products produced (value) in 2010?_____%

1-6 Is environmental protection or corporate social and environmental responsibility included in your firm goals?_____

PART Ⅱ MATERIAL INPUT

2-1 What was the percentage of imported wood materials in total wood material inputs (value) in 2010?_____%

2-2 Do you import directly from other countries and/or purchase from an agent in China?

_____

2-3 Do you know the sources of the imported wood materials? If yes, please list the country names.

_____

2-4 What was the percentage of certified (FSC, PEFC, and other equivalent certification schemes) wood products input in total wood material inputs (value) in 2010?_____%

2-5 Does your firm have a responsible purchasing policy?_____

2-6 How do you ensure legal and/or sustainable timber is being supplied?

_____

PART Ⅲ AWARENESS OF EMERGING REGULATIONS

3-1 Please indicate the current level of understanding of the following legality requirements:1=understand nothing; 2=understand general concepts; 3=understand some of the details; 4=understand most of the details; 5=understand fully.

US Lacey Act Amendment (2008):_____

EU Timber Regulation:_____

3-2 What is your opinion on the following statements? 1=strongly agree; 2=somewhat agree; 3=neither agree nor disagree; 4=somewhat disagree; 5=strongly disagree.

- The firm is actively gaining information about environment-related issues. _____
- Legality requirements are green trade barriers for wood products export. _____
- Legality requirements will create new wood products export opportunities. _____
- Legality requirements enhance a firm's awareness of social and environmental responsibilities. _____

3-3 What impacts do you expect these legality requirements will have on the following costs/prices/export volume? "-"=decreased; "+"=increased; "0"=unchanged

- Export cost _____
- Supply chain management cost _____
- Certification cost _____
- Cost of shifting raw and processed materials imported from high to low risk regions _____
- Price increase of raw and processed materials _____
- Price of wooden furniture _____
- Export volume share _____
- Other costs/prices (please specify) _____
- Opportunity in domestic market _____
- Opportunity in other overseas market _____
- Improvement of supply chain management _____

3-4 What measures did and will you take to deal with legality requirements in the next 5 years (check all that apply)?

- Quit from the US and the EU market _____
- Shift raw and processed material import from high/moderate to low risk regions _____
- Reduce the procuring sources to less countries and less species _____
- Require suppliers to provide documentation proof of legality/sustainability _____
- Purchase more from certified suppliers _____
- Use contract condition to ensure suppliers' compliance _____
- Enhance a firm's awareness of environmental and social responsibilities _____
- Enhance or establish a firm's supply chain management system _____
- Enhance the relations with non-governmental organizations _____
- Gain chain of custody certification _____
- Cooperate more closely with the overseas clients _____
- Keep in the US/EU markets as well as entering/enhancing the domestic market _____
- Keep in the US/EU market as well as exploring more other overseas markets _____
- Other (Please specify) _____

PART Ⅳ CHAIN OF CUSTODY CERTIFICATION

4-1 Does your firm have the following certification schemes?

Chain of custody (CoC) certification_____ISO 14001 _____

4-2 Please indicate the current level of understanding of CoC certification:1=understand nothing; 2=understand general concepts; 3=understand some of the details; 4=understand most of the details; 5=understand fully._____

4-3 Please grade the cost level of CoC certification: 1=very low; 2=somewhat low; 3=medium; 4=somewhat high; 5=very high._____

4-4 Please indicate your expectations for the potential benefits of CoC certification prior to being CoC certified (1=strongly agree; 2=somewhat agree; 3=neither agree nor disagree; 4=somewhat disagree; 5=strongly disagree). If you already have CoC certification, please indicate whether it is effective in meeting the expectations (Yes/No).

	Expectations	Effectiveness
➢ Give a firm a positive image of environmental protection	_____	_____
➢ Increase a firm's public relations with government and NGOs	_____	_____
➢ Help a firm respond to legality requirements better	_____	_____
➢ Improve export sales	_____	_____
➢ Improve domestic sales	_____	_____
➢ Enter new markets	_____	_____
➢ Keep or increase market share	_____	_____
➢ Gain new customers	_____	_____
➢ Meet customer requirements better	_____	_____
➢ Increase competitive advantage	_____	_____
➢ Differentiate products	_____	_____
➢ Get price premiums	_____	_____
➢ Increase firm efficiency	_____	_____
➢ Improve management operations	_____	_____
➢ Improve corporate responsibility practices	_____	_____
➢ General benefits	_____	_____
➢ Other benefits (please specify)	_____	_____

4-5 If you have CoC certification, does the general benefit obtained overcome the certification cost?_____

4-6 If you do not have CoC certification, what are the potential barriers for you to adopt CoC certification? 1=strongly agree; 2=somewhat agree; 3=neither agree nor disagree; 4=somewhat disagree; 5=strongly disagree.

- ➢ No qualification for CoC certification _____
- ➢ ISO 14001 certification is sufficient _____
- ➢ No sufficient knowledge _____
- ➢ No enough certified supply _____
- ➢ No apparent price premium _____
- ➢ No enough demand _____
- ➢ CoC cost is too high _____
- ➢ Lack of effectiveness in improving management _____
- ➢ Lack of effectiveness in improving a firm's market performance _____

- Lack of effectiveness in improving a firm's public relations _____
- No support from government and relative agencies _____
- Other barriers (please specify) _____

4-7 If you do not have CoC certification, do you plan to get one in the next 5 years? _____

_____

4-8 Do your clients/customers require legality or sustainability? Please indicate the pressure level you receive from your clients/customers to satisfy legality and sustainability. 1=very low; 2=somewhat low; 3=medium; 4=somewhat high; 5=very high._____

Appendix B: IFFP model structure

The International Forest and Forest Products Model (IFFP) originated at the University of British Columbia is a spatial partial equilibrium model of the global forest sector. It is the only forest sector model to derive its supply of logs through an integrated forest estate model. It is flexible to analyze multi-country, multi-products and multi-period problems in the forest sector.

The IFFP is a JAVA program that will: (1) translate text based input files, describing the problem, into a linear-programming formulation; (2) initiate the linear-programming solver; and (3) translate the solution into HTML based output reports.

The modeling structure is defined through processes and products. Processes use-up one or more products while producing one or more products. The supply of primary products is represented through a typical supply curve, relating quantity to price. Each process is represented through a curve relating processed quantity to value-added price.

Time is not explicitly dealt with in the model structure, but rather in the definition of products and processes. Processes are used, where necessary, to link products through time. The model solution is designed to maximize producer and consumer surplus, utilizing market-clearing prices. As time is not explicitly included in the model structure, any desired discounting of future prices must be done explicitly in the appropriate definitions of products and processes.

The objective function and constraints of the model are:

Maximize:

$$W = \sum_a \sum_i \int_0^{D_{ai}} P_{ai}(D_{ai}) dD_{ai} - \sum_a \sum_i \int_0^{S_{ai}} P_{ai}(S_{ai}) dS_{ai} - \sum_a \sum_i \int_0^{YM_{ai}} M_{ai}(YM_{ai}) dYM_{ai} - \sum_a \sum_i \sum_b TC_{aib}\, T_{aib} \quad [1]$$

Subject to:

$$YM_j \leq C_j \quad \forall j \quad [2]$$

$$\sum_{j=1}^{m} YM_j Z_{ij} - S_i \geq 0 \quad \forall i \qquad [3]$$

$$\sum_{j=1}^{m} YM_j \geq D_i \quad \forall i \qquad [4]$$

and C, M, P, S, D, YM, TC, T $\geq$ 0 (i=1…n; j=1…m) [5]

where is W is the total welfare of the forest sector, which is the sum of the producer and consumer surplus; a, b=country; i=product; j= process; P=price; D=final product demand; S=raw material supply; YM=quantity manufactured; M=manufacturing cost; TC=trade cost; T=quantity traded; C_j=maximum capacity of the jth process (j=1…m); Z_{ij} is the quantity of the ith product produced (+) or consumed (-) for each unit of capacity used in the jth process (related to efficiency conversion ratio).

Constraint [2] ensures manufacturing capacity is not exceeded. Constraint [3] ensures that the initial supply of each product is not exceeded and that a material balance is maintained. Constraint [4] ensures that final demand is met. There are several things implicit in this definition. The initial supply of products cannot be used directly to meet final product demand. This is to ensure that the costs of providing primary products are represented. Products are either inputs or outputs in a process, but never both. For most models, most S_i, D_i and Z_{ij} will be 0, resulting in sparse matrices.

This formulation cannot be directly solved with Linear Programming, unless the per-unit processing costs are constant (i.e., M is a simple multiple of YM; P is a simple multiple of D/S). However, more complex relationships can be approximated through the use of Special Ordered Sets of type Two (SOS2) and solved with Mixed Integer Programming. An SOS2 is a set of consecutive decision variables in which only two adjacent variables are allowed to be non-zero. A SOS2 can be used to represent each processes' operating cost (M/P as a series of piece-wise linear functions.

To implement this, we need to expand our constraints to include:

$$1 = \sum_{k=1}^{p} W_{jk} \quad \forall j \qquad [6]$$

$$SOS2(W_{jk}) \quad \forall j \qquad [7]$$

$$A_j = \sum_{k=1}^{p} B_{jk} W_{jk} \quad \forall j \qquad [8]$$

and $B_{jk}, W_{jk} \geq 0$ $(j=1\ldots m; k=1\ldots p)$ [9]

where W_{jk} is the weight of the kth vertex (k=1…m) used in representing a realized capacity in the jth process (j=1…p); B_{jk} is the capacity utilization of the jth process (j=1…p) at the kth vertex (k=1…m). Constraint [6] is part of representing the complex relationship as a series of linear segments. The value of each linear segment is calculated as a weighted sum of adjacent points, where the sum of the weights equals 1. Constraint [7] defines the weights for each line belonging to a Special Ordered Set of size two. Constraint [8] calculates the value of the interpolated line segment.

Appendix C: Parameter value for modeling

Appendix C1 Assumptions on supply and demand

Region	Log supply (%)	Demand (%)				
		Sawnwood	Plywood	Veneer sheet	Fibreboard	Particleboard
China	3	3	5	6	6	5
US	1	-4	-4	-1	1	-3
EU-27	5	-1	2	5	2	2
ROW	5	1	2	2	5	4

Note: All data are adjusted from historical increase rate of 2000-2010 based on FAOSTAT data

Appendix C2 Assumptions on manufacturing efficiency

Region	Efficiency Conversion Ratio				
	Sawnwood	Plywood	Veneer sheet	Fibreboard	Particleboard
China	1.4	1.2	1.3	1.35	1.4
US	1.5	1.4	1.4	1.6	1.5
EU-27	1.3	1.2	1.4	1.4	1.3
ROW	1.45	1.25	1.3	1.5	1.4

Appendix C3 Manufacturing capacity in 2008 and annual increase rate

Region	Sawnwood	Plywood	Veneer sheet	Fibreboard	Particleboard	Increase rate (%)
China	36.11	45.28	3.90	36.38	14.38	10
US	91.09	12.97	0.50	8.30	22.71	5
EU-27	109.46	7.39	1.74	14.20	41.86	5
ROW	262.73	30.31	9.21	31.27	50.46	5

Note: manufacturing capacities are denoted by roundwood equivalent (RWE) volume of input (million m^3/year)

Appendix C4 Manufacturing cost

Region	Log		Sawnwood		Plywood		Veneer sheet		Fibreboard		Particleboard	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
China	45	90	20	40	55	110	55	110	26	52	20	40
US	50	100	25	50	60	120	60	120	27	54	23	46
EU-27	55	110	20	40	60	120	60	120	22	44	20	40
ROW	45	90	20	40	65	130	65	130	30	60	25	50

Note: all units are US dollar/RWE m^3

Appendix C5 Trade cost

	Log	Sawnwood	Plywood	Veneer sheet	Fibreboard	Particleboard
Cost	15	15	20	20	15	10

Note: all units are US dollar/RWE m^3