DEPARTMENT OF FOREST ECONOMICS

UNIVERSITY OF HELSINKI

ANALYSIS OF CHINA'S PRIMARY WOOD PRODUCTS MARKET
- SAWNWOOD AND PLYWOOD

THESIS FOR MASTER'S DEGREE IN FOREST PRODUCTS MARKETING

MINLI WAN

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Helsinki, 30th March 2009

Minli Wan
China’s primary wood processing industry and wood consuming sectors have experienced rapid growth in recent years. Industries like sawnwood and plywood have developed very quickly. The purpose of this study is to: 1) provide an overview of the demand, supply, imports and exports of raw wood and primary wood products in the China market between 1993 and 2007; 2) present quantitative estimates of the relative importance of factors influencing the demand, supply and exports of Chinese plywood; 3) draw conclusions about China's potentials and challenges for foreign enterprises, including Finnish companies. The information, analyses and findings presented in this study can give a reference for wood processing companies, especially for sawnwood and plywood firms, and governmental agencies in China. In addition, this study provides a basis for further study and research.

Even though much information has been published in China, academic research in the Chinese woodworking market is scarce, and especially, time-series data is missing and unreliable. The present study tries to fill this gap. It is based on secondary data collected from various sources, including literatures, journals, magazines, consulting reports, industry analysis, news, and so on. The annual time-series data obtained for variables in models are mainly gathered from original official Chinese sources.

The study increases the information and understanding on the Chinese wood products markets by using descriptive and explanatory methods to analyze the data for background information, markets and empirical modeling. By employing econometric models, based on the elasticity estimates, Chinese plywood demand seems to be income elastic but price inelastic, Chinese plywood supply would be highly elastic with raw material price but scale inelastic, and Chinese plywood exports appear to be highly income elastic.
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ACRONYMS AND ABBREVIATIONS (In Alphabetical Order)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>%</td>
<td>Percent</td>
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<tr>
<td>ADF</td>
<td>Augmented Dickey-Fuller</td>
</tr>
<tr>
<td>BG</td>
<td>Breach-Godfrey</td>
</tr>
<tr>
<td>CAF</td>
<td>Chinese Academy of Forestry</td>
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<tr>
<td>CIFOR</td>
<td>Centre for International Forestry Research</td>
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<td>CINTRAFORE</td>
<td>Centre for International Trade in Forest Products</td>
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<tr>
<td>cm</td>
<td>Centimetre</td>
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<tr>
<td>CNY</td>
<td>China Yuan, Chinese currency (equivalent to RMB)</td>
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<td>CPC</td>
<td>Communist Party of China</td>
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<td>DW</td>
<td>Durbin-Watson</td>
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<td>ECM</td>
<td>Error Correction Model</td>
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<td>ECT</td>
<td>Error Correction Term</td>
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<td>e.g.</td>
<td>For example</td>
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<td>et al.</td>
<td>et alii, meaning &quot;and others&quot;</td>
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<td>etc.</td>
<td>And so on</td>
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<td>EU</td>
<td>European Union</td>
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<td>EWP</td>
<td>Engineered Wood Product</td>
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<td>EWPs</td>
<td>Engineered Wood Products</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>FAOSTAT</td>
<td>FAO Statistical Databases</td>
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<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
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<tr>
<td>FGHY</td>
<td>Fast-Growing and High-Yielding</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>ha</td>
<td>Hectare</td>
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<tr>
<td>HDF</td>
<td>High-Density Fibreboard</td>
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<td>HQ</td>
<td>Harvest Quota</td>
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<tr>
<td>HQS</td>
<td>Harvest Quota System</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>IEM</td>
<td>Information Environment Model</td>
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<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>Inc.</td>
<td>Incorporation</td>
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<tr>
<td>ISBN</td>
<td>International Standard Book Number</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<td>ITTO</td>
<td>International Tropical Timber Organization</td>
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<td>JB</td>
<td>Jarque-Bera</td>
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<tr>
<td>JV</td>
<td>Joint Venture</td>
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<tr>
<td>JVs</td>
<td>Joint Ventures</td>
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<tr>
<td>km</td>
<td>Kilometer</td>
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<tr>
<td>LM</td>
<td>Lagrange Multiplier</td>
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<tr>
<td>Ltd.</td>
<td>Limited</td>
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<tr>
<td>m²</td>
<td>Square meter</td>
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<tr>
<td>m³</td>
<td>Cubic meter</td>
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<tr>
<td>MDF</td>
<td>Medium-Density Fibreboard</td>
</tr>
<tr>
<td>mu</td>
<td>0.15 hectare</td>
</tr>
<tr>
<td>NA</td>
<td>Not Available</td>
</tr>
<tr>
<td>NBER</td>
<td>National Bureau of Economic Research</td>
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<td>NBS</td>
<td>National Bureau of Statistics</td>
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<tr>
<td>NFPP</td>
<td>National Forest Protection Program</td>
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<td>NHRP</td>
<td>National Housing Reform Program</td>
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<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<td>p. / pp.</td>
<td>Page(s)</td>
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<tr>
<td>PEST</td>
<td>Political, Economic, Social and Technological (factors)</td>
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<tr>
<td>PPP</td>
<td>Purchasing Power Parity</td>
</tr>
<tr>
<td>P.R.C.</td>
<td>People's Republic of China</td>
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<tr>
<td>R²</td>
<td>R-square</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>RFE</td>
<td>Russian Far East</td>
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<tr>
<td>RMB</td>
<td>Renminbi, Chinese currency (equivalent to CNY)</td>
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<td>RWE</td>
<td>Roundwood Equivalent</td>
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<tr>
<td>SEA</td>
<td>Southeast Asia</td>
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<tr>
<td>SFA</td>
<td>State of Forestry Administration</td>
</tr>
<tr>
<td>SLEPT</td>
<td>Social, Legal, Economic, Political and Technological (factors)</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities and Threats</td>
</tr>
<tr>
<td>Tons</td>
<td>Refers to metric tons unless indicated differently</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>UNECE</td>
<td>United Nations Economic Commission for Europe</td>
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<tr>
<td>US / U.S.</td>
<td>United States</td>
</tr>
<tr>
<td>USD / US$</td>
<td>US Dollar</td>
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<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
</tr>
<tr>
<td>VAT</td>
<td>Value-Added Tax</td>
</tr>
<tr>
<td>WBP</td>
<td>Wood-Based panel</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wide Fund for Nature</td>
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<tr>
<td>yr</td>
<td>Year</td>
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1 BACKGROUND OF THE STUDY

1.1 China as a Major Player in the Global Forest Products Market

China's unprecedented economic growth over the past three decades has resulted in strong demand for a wide variety of commodities, including forest products (primary and secondary processed wood products, pulp and paper). The country's flourishing economy, huge population, growing construction activity and housing reform have driven a dramatic increase in China's consumption of wood and wood products for infrastructure development, building construction, interiors and furniture manufacturing. Currently, China is a major player in the global forest products markets, both as a producer and consumer.

However, with 18.21% forest cover (Jiang, 2007), China is a country deficient in forest resources; and since 1998, the Chinese government has implemented the National Forest Protection Program (NFPP) to restrict the domestic timber harvest. This has fuelled a massive increase in China's imports of forest products. Among a variety of wood products, unprocessed logs (used for domestic wood processing industries) and sawnwood (used for furniture making and the construction industry) make up the bulk of China's imports of wood products. With China's policies on providing incentives for forestry development and a growing demand for low-cost furniture, plywood, wood moldings and flooring particularly in the developed world, many companies have been investing in large-scale plantations and wood processing industries in China in recent years. China has become the world’s wood workshop and has exported high-quality and price-competitive value-added wood products, primarily furniture and then plywood (Lu, 2004). At present, China is the largest exporter of wooden furniture (49% of global exports) and plywood (30% of global exports) in the world (China Wood Products Prices, 2007). The growth in China's production and the competitiveness of its exports in the world market are actually based on its low labour costs. This trend indicates that China mainly imports raw materials, while manufactures and exports finished wood products. During the latest years, China has been
an increasingly important player in the world timber trade. In terms of trade value, China has changed from a net importer into a net exporter of wood products. The US is still the largest importer of Chinese wood products. From 1997 to 2006, both EU and US imports of Chinese manufactured wood products had grown almost 10 fold; whereas, Japan's imports had only increased 180%. These increases were driven by the large demand for plywood and furniture. Over the same period, the exports to other countries, including the United Arab Emirates, Saudi Arabia and Russia, had increased 18 fold. These countries are fast becoming an important market for China. (Canby et al., 2008, p. 2).

Expectations for China's continued strong economic growth suggest that the demand for wood products will continue to grow in the next decade. However, the procurement of raw materials is a big challenge facing the domestic wood processing industry in China. Especially, Russia's accelerated log export tariffs have had a great impact on China's wood products industry - they have considerably increased the cost of logs. In order to meet Chinese domestic and export-oriented demand for wood products, huge amount of raw materials must be either produced domestically or imported from other countries. Thus, China will have to find new sources for logs or consider importing marginally processed wood (sawnwood) rather than logs in the future. Moreover, wood substitute products, including non-wood material (bamboo and straw) and recycling urban waste wood, would become a passive choice for the China market.

1.2 Finland's Presence and Opportunities in the Chinese Forest Products Market

Finland is a country with large forest resources. Accounting for one-fifth of Finland's exports, the Finnish forest industry has developed very well. In Finland, there are two of the world’s largest forest products companies – the Stora Enso Group (Stora Enso) and UPM-Kymmene Corporation (UPM) - and one of Europe's largest forest industry enterprises - the Metsäliitto Group (Metsäliitto). As part of the Metsäliitto's core business, Finnforest has been the biggest wood products industry corporation in Europe. Finnish
companies have been very active in the Chinese paper products market; the three players - UPM, Stora Enso and Metso Paper (one of Metso Corporation's business areas) - have dominated the Chinese pulp and paper industry. UPM's Changshu Mill is China's largest producer of uncoated fine paper. Stora Enso built one of the China's largest coated fine paper mills in the 1990s and set up a joint venture (JV) with Shandong Huatai Paper to produce super-calendared magazine paper in 2006, and now, the company is busy with securing fiber supply by expanding its 60,000 hectares of plantations in southern China. Metso Paper is a leading supplier of paper machinery in China and its completely automated pulp and paper production processes has been a huge marketing edge in China. Additionally, it has a JV company Valmet-Xi'an Paper Machinery Company Limited that specializes in mid-size paper and board machines. (Tan, 2007). In the Chinese wood products market, Finnish companies initiated its export efforts to China in the mid-1990s: UPM and Finnforest opened their sales offices in Shanghai, while Stora Enso opened its sales office in Hong Kong. However, Finnish exports of wood products to China remained very limited: only 31,000 m$^3$ of sawnwood and 4,000 m$^3$ of plywood were exported to China in 2007 (Finnish Statistical Yearbook of Forestry 2008, p. 347). By contrast, Metso Corporation's another business area - Metso Mineral - has been delivering advanced machines and equipments to the Chinese construction, housing and infrastructure market.

China's expanding demand for wood products attracts forest enterprises to export to or invest in China - there will be a need for more wood raw materials and plantations to meet the increasing domestic and global demand for wood products. RISI, the leading information provider for the global forest products industry, forecasted that China's demand for of sawnwood would be over 40 million m$^3$ in 2020 (Food and Agriculture Organization of the United Nations (Food and Agriculture Organization of the United Nations (FAO), 2006); and China's ability to increase its exports of value-added wood products, such as plywood and wooden furniture, is also expected to improve. Nevertheless, the raw material availability is a limit for the development of China's wood products industry. All these will open up new opportunities and present market potentials for Finnish forest industry
companies. For instance, China possesses considerable potentials for establishing new plantations to increase its industrial roundwood supply and therefore to support the domestic manufacturing and exports of forest products; additionally, China would be a promising potential export destination for Finnish sawnwood and a market for introducing advanced production facilities and technical equipments of Finnish forest industry. Yet, the competition in the Chinese wood products market is strong, as the US and Russia are two biggest competitors in China and they have long been actively investing there.

1.3 Motivations for the Study

As one of the fastest growing market in the world, China has become increasingly important in the global trade. The country's dynamic economic growth and huge market potentials proves that China's forest products market will continue to grow in the long term and China has possibilities to expand its wood products industry, but the procurement of wood raw materials is a challenge facing China’s wood products industry. Through describing the operating environment in the Chinese wood products market, analysing the trend of demand, supply, imports and exports of wood and primary wood products in China, and examining the effects of factors on demand (consumption), supply (production) and exports of Chinese plywood, one motivation for this study is to better understand the factors influencing the demand and supply of Chinese wood and wood products, the impacts of China's wood products market on the global forest sector, and the opportunities and challenges presenting for foreign forest industry companies, including Finnish forest industry companies.

In addition, although much information has been published in China, academic research in the Chinese woodworking market is scarce, and especially, time-series data is missing and unreliable. So, another motivation for the study is trying to fill this gap for some small part. Much attention has been paid to searching for time-series data and assessing the uncertainties of the data.
Earlier, there were a number of researches conducted in China: one of the studies analyzing and modelling Chinese forest products market concerns the demand for paper and paperboard in mainland China (Li et al., 2006), another relates to the demand and supply of plywood in Taiwan (Wang & Wu, 2000). In the present study, the similar methodology is used to investigate the influencing factors affecting the demand, supply and exports of the plywood in the Mainland China market.

2 PURPOSE AND IMPLEMENTATION OF THE STUDY

2.1 Purpose of the Study

Based on a large collection and creation of data, the purpose of the study is to: 1) provide an overview of the demand, supply, imports and exports of wood and primary wood products in the China market between 1993 and 2007; 2) present quantitative estimates of the relative importance of factors influencing the demand, supply and exports of Chinese plywood; 3) draw a conclusion about China's potentials and challenges for foreign enterprises, including Finnish companies. To achieve the purpose of the study, data from various official governmental reports and industry trade sources are summarized, and theoretical models are empirically estimated.

Due to the limitations of time and space, the study mainly focuses on describing and analyzing the three most important wood products in China - logs, sawnwood and plywood. Since plywood is the most important primary wood product in China in terms of its consumption, production and exports, the study concentrates on modelling plywood.

Based on the purpose of the study, the following five research questions are answered:

1) What factors affect China's demand and supply of wood and wood products?
2) What are the general trends in the demand, supply, imports and exports of logs, sawnwood and plywood in the China market, respectively?
3) What are China’s impacts on the global forest products markets?
4) How large could be the preliminary price and income elasticities of demand, supply and exports of Chinese plywood?
5) What opportunities and challenges does the Chinese wood products market present for foreign forest industry companies and investors?

2.2 Implementation of the Study

As presented in Figure 2-1, the idea of implementation of the study follows the purpose of the study. Apart from descriptive analysis, the study includes explanatory analysis that aims to gain a more in-depth view of the topic. Based on the results of analyses, the study draws a conclusion.

Figure 2-1. The Idea of Implementation of the Study
The study is carried out through the following four steps:

1. Problem definition: The basis of the study is formed by problem definition. The first part of the thesis includes problem analysis and purpose definition. The specific questions presented in the purpose of the study will be answered in the summary and conclusion part of the thesis, so the problem setting will be acknowledged through the whole study.

2. Theoretical background and framework: A framework is formed to operationalize the theoretical background, which is based on literatures and articles. The framework also guides the empirical implementation of the study and shows the connections between the theories and the empirical part of the study.

3. Data collection and analysis: A wide array of data is collected from different sources. Data analysis will be done with the method that is best suitable for the purpose and the data of the study. Because of the nature of the study, data will be analyzed by using both descriptive analysis and statistical methods.

4. Results, summary, conclusion and discussion: The results will be demonstrated and summary and conclusion will be made on the basis of the results. At this stage of the research, the study will return to the practical level and follow the problem recognition and purpose of the study.

3 THEORETICAL BACKGROUND AND FRAMEWORK OF THE STUDY

3.1 Theoretical Background of the Study

3.1.1 The Information Environment Model and PEST Analysis

The market and marketing environment of Chinese wood products is described analyzed by using Juslin's (2002) Information Environment Model (IEM). According to the IEM,
information environment is divided into Macro Environment and Micro Environment. The Macro Environment contains the categories of demand, supply and other macro environment. The "Other Macro Environment" category contains those factors traditionally considered in a PEST (political, economic, social and technological factors) analysis (Juslin and Hansen, 2002, p. 186). The Micro Environment contains information about the behaviour of customers, competitors and distribution system. When describing the Chinese wood products market, the study mainly focuses on the "Macro Environment" part.

When analyzing the macro-environment, it is important to identify the factors that might in turn affect a number of vital variables that are likely to influence the organization’s demand and supply levels and its costs (Kotter and Schlesinger, 1991; Johnson and Scholes, 1993). A number of checklists have been developed as ways of cataloguing the vast number of possible issues that might affect an industry. The PEST analysis is one of them and it is only a framework that categorizes environmental influences as political, economic, social and technological forces. This analysis examines the impact of each of these factors (and their interplay with each other) on the business. It is a useful strategic tool for understanding market growth or decline, business position, potential and direction for operations. The use of PEST analysis can be effective for business and strategic planning, marketing planning, business and product development and research reports. The results can then be used to take advantage of opportunities and to make contingency plans for threats when preparing business and strategic plans (Byars, 1991; Cooper, 2000). PEST also ensures that company’s performance is aligned positively with the powerful forces of change that are affecting business environment (Porter, 1985).

In conducting PEST analysis, each PEST factor needs to be considered as they all play a part in determining the overall business environment. Some examples are as follows:

- Political factors include tax policy, employment laws, consumer protection, environmental regulations, industry-specific regulations, competitive regulations,
trade restrictions and tariffs, inter-country relationships, political trends and stability, governmental leadership and government structures;

- Economic factors include economic growth trends, interest rates, exchange rates and inflation rates, government spending levels, disposable income, consumer purchasing power, development on foreign trade and foreign investments;
- Social factors include demographics (age, gender, race, family size, etc.), population growth, education, lifestyle changes, fads, diversity, immigration, health, living standards, housing trends, fashion, attitudes to work, leisure activities, occupations, and earning capacity;
- Technological factors include technology incentives and the rate of technological change, rates of obsolescence, manufacturing advances, information technology (IT), inventions, research and development (R&D), energy uses/sources/fuels, recycling, and ecological and environmental factors that determine barriers to entry, minimum efficient production level and influence outsourcing decisions.

The PEST factors combined with external micro-environmental factors can be classified as opportunities and threats in a SWOT (strengths, weaknesses, opportunities and threats) analysis. PEST alongside SWOT and SLEPT (social, legal, economic, political and technological factors) can be used as a basis for the analysis of business and environmental factors (Cameron, 2008).

3.1.2 Theoretical and Empirical Models

This study applies econometric method in analyzing the data and modeling the markets. Econometrics concerns statistical estimation of relationships suggested by economic theory. The theory of demand and supply is one of the fundamental theories of economics. It is the foundation, where many other more elaborate economic models and theories are based. It is also a tool to explain the workings of a market economy, as demand and supply are key elements affecting resource allocation. By definition, demand is the amount of product that a buyer is willing and able to buy at a specified price, while supply is the amount of product that a producer is willing and able to sell at a specified price. The supply and demand
model shows the relationships between a product’s accessibility and the interest shown in it. Economic theory is based on developing supply and demand models and then factoring in whatever elements might cause disruption to their smooth flow (International Society for Complexity, Information and Design). Based on the economic equation: \( Q_t = Q_s - Q_d \)
where \( Q \) represents quantity, \( Q_s \) represents the quantity supplied and \( Q_d \) represent the quantity demanded, export or excess supply will be yielded if \( Q_t \) is positive, while import or excess demand will be yielded if \( Q_t \) is negative (Agricultural Economics, 2006).

### 3.1.2.1 Chinese Plywood Demand Model

In the time-series model, income and price elasticities of demand for plywood are estimated by using yearly data from China over the period 1993-2007. The estimable relationships are based on the previous research on forest products market modelling. Demand for forest industry products are modelled as consumer demand (Buongiorno, 1979) and most often as derived demand (Chou and Buongiorno, 1982; Buongiorno, 1996; Chas-Amil and Buongiorno, 2000; Buongiorno et al. 2003; Hetemäki et al., 2004; Hänninen et al., 2007).

When specifying variables here, consumer demand is described as consumption series. Therefore, the first equation used in this study is the classic double-logarithmic formula (Buongiorno, 1979):

\[
\ln Q_{ijt} = a_j + b_j \ln Y_{it} + c_j \ln P_{ijt} + u_{ijt} \tag{3.1}
\]

where \( Q_{ijt} \) is the consumption of product \( j \) in country \( i \) in year \( t \); \( Y_{it} \) is the consumer income in country \( i \) in year \( t \); \( P_{ijt} \) is the price of product \( j \) in country \( i \) in year \( t \); \( u_{ijt} \) is an error term; the coefficient \( a_j \) is the constant term, \( b_j \) is the income elasticity and \( c_j \) is the price elasticity.

The model is static since time does not appear explicitly in the formulation (Labys, 1973). In the present case, Chinese apparent consumption of plywood can be explained by the Chinese consumer income and the real price of plywood in China. Due to the fact that there are no exact data available at the annual level over the study period, data existing for China’s real gross domestic product (GDP) and the real export price of Chinese plywood
are used as rough proxies for them. China’s GDP and the export price of Chinese plywood were originally in nominal US dollars, but they are converted in real ones by the GDP deflator for China, with 2004 as the base year. Consequently, the empirical equation of plywood consumption corresponding to equation (3.1), after logarithm transformation of the variables used, can be expressed as

\[ LACP_t = a + bLGDPR_t + cLEPR_t + u_t \]  

(3.2)

where \( LACP \) is the Chinese apparent consumption of plywood, \( LGDPR \) is China’s real GDP and \( LEPR \) is the real export price of Chinese plywood. The signs under the coefficients denote prior signs of the estimated coefficients. Based on economic theory, it is assumed that an increase in Chinese consumer income affects positively Chinese plywood consumption, while an increase in the price of Chinese plywood decreases its consumption.

### 3.1.2.2 Chinese Plywood Supply Model

In the time-series model, scale and price elasticities of plywood supply are estimated by using annual data from China over the period 1993-2007. In its simple form, the supply of a commodity (here it refers to plywood) can be presented as a function of its price (Koutsoyiannis, 1977). In addition, it is assumed that plywood supply depends on the end-use sector activity, product price and raw material price. When specifying variables here, commodity supply is described as production series. We assume that the most important end-use sector of plywood is wooden furniture industry, plywood price stands for the product price and log price represents the raw material cost in the supply function.

\[ R_t = f (Y_t, PP_t, PL_t) \]  

(3.3)

where \( R_t \) is the production of plywood, \( Y_t \) is wooden furniture output, \( PP_t \) is plywood price and \( PL_t \) is log price. As it is shown, Chinese production of plywood can be explained by the output of wooden furniture, the real price of plywood and the real price of logs in China. Since there are no exact data available over the study period, data existing for the real export price of Chinese plywood and the real import price of Chinese logs are used as
rough proxies for the real prices of plywood and logs in China, respectively. The import prices of Chinese logs were originally in nominal US dollars, but they are converted in real ones by the GDP deflator for China, with 2004 as the base year. Consequently, the empirical equation of plywood production, after logarithm transformation of the variables used, can be expressed as

\[
LQP_t = a + bLWFQ_t + cLEPR_t + dLIPR_t + u_t
\]  

(3.4)

where \( LQP \) is the production volume of Chinese plywood; \( LWFQ \) is the production volume of Chinese wooden furniture; \( LEPR \) is the real export price of Chinese plywood; \( LIPR \) is the real import price of Chinese logs; \( u_t \) is an error term; the coefficient \( a \) is the constant term, \( b \) is the scale elasticity, \( c \) and \( d \) are the price elasticities. The signs under the coefficients denote prior signs of the estimated coefficients. Based on economic theory, it is assumed that increases in domestic production of Chinese wooden furniture and the price of Chinese plywood affect the domestic production of Chinese plywood positively, whereas, an increase in the price of Chinese logs decreases the Chinese plywood production.

### 3.1.2.3 Chinese Plywood Export Model

When modeling exports of forest products, the Armington (1969) export demand theory is often applied. As the US is the largest importer of Chinese plywood products, it is assumed that the US represents China’s export markets. So, following the Armington (1969) export demand theory, the exports of Chinese plywood can be explained by the US consumer income and the real export price of Chinese plywood to the US. Because there are no exact data available over the study period, data existing for the US real GDP (in 2005 prices, see U.S. Department of Labor, 2008) and the real export price of Chinese plywood are used as rough proxies for them. As a result, the empirical equation of plywood exports can be presented in the following logarithmic form:

\[
LEP_t = a + bLUS_t + cLEPR_t + u_t
\]  

(3.5)
where \( LEP \) is the export volume of Chinese plywood, \( LUS \) is the US real GDP and \( LEPR \) is the real export price of Chinese plywood. The signs under the coefficients denote prior signs of the estimated coefficients. Based on economic theory, it is assumed that an increase in the importing market's consumer income (the US consumer income) affects positively the exports of Chinese plywood to the US, while an increase in the export price of Chinese plywood to the US decreases its exports.

### 3.2 Theoretical Frame of Reference and Its Operationalization

#### 3.2.1 Theoretical Framework of the Study

The purpose of the framework is to serve as a guide for the empirical research, which refers to the statistical part of the study. By using econometric models, statistical analysis is conducted to examine the factors that affect the demand, supply and trade of Chinese plywood.

---

**Figure 3-1. Framework of the Study**

![Diagram of the Framework of the Study]

- **Demand**
  - (Domestic consumption: - consumer income
  - product price)

- **Supply**
  - (Domestic production: - end use sector activity
  - product price
  - raw material price)

- **Trade**
  - (Exports: - consumer income in target market
  - export price to target market)

(Imports / Exports = Excess demand / Excess supply)
3.2.2 Operationalization of the Framework

The framework of the study plays an important role in furthering its operationalization, which is carried out in three stages with three models. These models are developed for Chinese plywood, with the aim to discover the relationships between dependent variables and independent variables of each one. The first model - Chinese plywood demand model - indicates that domestic consumption is explained and affected by domestic consumer income and plywood price; the second model - Chinese plywood supply model - indicates that domestic production is explained and affected by the end-use sector activity, plywood price and log price; the third model - Chinese plywood export model - indicates that exports are explained and affected by the consumer income and Chinese plywood price in the target market.

4 DATA AND DATA ANALYSIS OF THE STUDY

4.1 Data of the Study

The study is entirely based on secondary data, which are collected from various sources, including literatures, journals, magazines, consulting reports, industry analysis, news, etc. As for the annual time-series data obtained for variables in models, they are mainly gathered from original official Chinese sources, for instance, China Statistical Yearbook, China Customs Statistics, the State Forestry Administration of China (SFA) and the National Bureau of Statistics (NBS) of China. Moreover, international sources, such as the World Bank Development Indicator Database and the US Bureau of Labour Statistics are applied. These data are used for market analysis, model estimation and hypothesis testing. All data sources are presented in the appendices.
During the course of data collection, it is detected that data varies much depending on different sources. An especially noteworthy problem is that large differences exist between FAO Statistical Databases (FAOSTAT) and original Chinese sources while collecting the statistical data for logs, sawnwood and plywood. So many efforts have been put into collecting data as accurately and reliably as possible. And in this case, the original Chinese sources shall prevail as they are mainly from publications by governmental organisations, research institutes and industry related sources.

4.2 Data Analysis of the Study

Interpretation of the data calls for a variety of analysis techniques. The data for background information and markets is analyzed with descriptive method, and the data for empirical modeling is analyzed by using EViews statistical software. Through examining how changes in one or more variables would affect another variable, regression models are used to analyze the relationships between dependent variables and independent variable for each statistical model. Variables that are used to explain another variable are called explanatory variables or independent variables, while the variable that is explained is called the response variable or dependent variable. In regression, response variables are always regarded as random variables and explanatory variables are regarded as non-random. In order to use the model for statistical inference, such as testing hypotheses about the model or using it to make predictions on the response variable for new values of the explanatory variables, it is useful to know the distribution of the response variable. A general regression model consists of a function describing how the response variable is related to explanatory variable(s), and a term that models the random variation in the response variable. The most common function in regression is a straight line. Such models are called linear regression models, which are used for studying a straight-line relationship between a random response variable and non-random explanatory variables (Larsen, 2008). The present study is concerned with linear regression models.
In searching for a better understanding of the forces influencing the demand and supply of forest products, forest economists have long relied on empirical models. According to the type of data they use, these models can be divided into two broad categories: time-series model and cross-section model. The first model records yearly, quarterly or monthly variations in variables relevant to the country or region of interest, while in the second model, observations relate generally to different countries observed at a specific point in time. Both types of analysis have their drawbacks. In pure time-series analysis, observations over long time periods are difficult to obtain and there is often little variability in the data. Furthermore, during periods of consistent economic growth, high collinearity among explanatory variables is unavoidable, which lead to difficulties in accurately estimating structural coefficients. As for pure cross-section analysis, though it increases the variability in the observations, it is questionable whether variations across countries are relevant to explaining changes over time. In order to provide a database with a large number of observations and great inherent variability, time-series and cross-section observations could be combined. Pooled time-series and cross-section data have been used in estimating income and price elasticities of demand for forest products (Buongiorno, 1979). In this study, time-series analysis is used for estimating demand and supply functions parameters.

The objects and methods of analysis are presented in Table 4-1. The demand, supply and trade of Chinese primary wood products are described by using descriptive analysis method, which includes graphs, charts, tables and numbers. Other macro environment is analyzed by using the PEST analysis. While, the three models are analyzed by using regression analysis method, including Breusch-Godfrey (BG) serial correlation Lagrange Multiplier (LM) test, Jarque-Bera (JB) test, heteroskedasticity test and Augmented Dickey-Fuller (ADF) unit root test.
Table 4-1. Objects and Methods of Analysis

<table>
<thead>
<tr>
<th>Object of Analysis</th>
<th>Method of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for Chinese wood and primary wood products</td>
<td>Descriptive analysis (graphs, charts, tables, numbers, etc.)</td>
</tr>
<tr>
<td>Supply of Chinese wood and primary wood products</td>
<td>Descriptive analysis (graphs, charts, tables, numbers, etc.)</td>
</tr>
<tr>
<td>Trade of Chinese wood and primary wood products</td>
<td>Descriptive analysis (graphs, charts, tables, numbers, etc.)</td>
</tr>
<tr>
<td>Other macro environment</td>
<td>PEST (political, economic, social and technological factors) analysis</td>
</tr>
<tr>
<td>Chinese plywood demand model</td>
<td>Regression analysis (BG serial correlation LM test, JB test, heteroskedasticity test and ADF unit root test)</td>
</tr>
<tr>
<td>Chinese plywood supply model</td>
<td>Regression analysis (BG serial correlation LM test, JB test, heteroskedasticity test and ADF unit root test)</td>
</tr>
<tr>
<td>Chinese plywood export model</td>
<td>Regression analysis (BG serial correlation LM test, JB test, heteroskedasticity test and ADF unit root test)</td>
</tr>
</tbody>
</table>

BG serial correlation LM test is a test for autocorrelation in the residuals from a regression analysis and it is more general than the standard Durbin-Watson (DW) statistic. There is serial correlation (i.e., autocorrelation) when either the dependent variable or the residual show correlation with its values in past periods (Mittelhammer et al., 2000, p. 548). This is a problem because standard errors (even heteroskedastic robust) are not consistent, affecting statistical inferences (i.e., hypothesis testing). The null hypothesis of the LM test in this case is that there is no serial correlation up to lag order to 1 (Studenmund, 2006). The Obs* R-squared ($R^2$) statistic is the BG LM test statistic, which is computed as the number of observations times and the $R^2$ from the test regression (Mittelhammer et al., 2000, p. 548). The LM test statistic is asymptotically distributed as a $\chi^2$ with $p$ degrees of freedom ($p$ is equal to 1 in this case). If the $p$-value of F-statistic, denoted Prob (F-statistic), is less than the significance level we are testing, say 0.05, the null hypothesis of no serial correlation should be rejected (Dahiya, 2008).

Histogram-Normality test is used to determine whether the residuals from a linear regression model are normally distributed or not, by comparing a histogram of the residuals to a normal probability curve. The JB test is a goodness-of-fit measure of departure from normality (Jarque and Bera, 1980). If the $p$-value of the JB test statistic is greater than the 5% level of significance, the residuals are normally distributed.
Heteroskedasticity means that the variance of residuals is not constant; heteroskedasticity test is a test for heteroskedasticity in the residuals from a regression analysis (Engle, 1982). The null hypothesis of this test is that there is no heteroskedasticity (i.e., variance of residuals are constant) up to order 1. If the p-value of F-statistic is less than the significance level we are testing, say 0.05, the null hypothesis of no heteroskedasticity should be rejected; otherwise, the null hypothesis should be accepted.

ADF unit root test (Dickey and Fuller, 1979) is used to test the residuals for stationarity. A unit root means that the observed time series is not stationary. If a unit root is not present, the residuals are stationary and the variables are cointegrated. If the variables in the regression model are not stationary, the standard assumptions for asymptotic analysis will not be valid (Beachill, 2009). In autoregressive time-series models, the presence of unit root causes a violation of the assumptions of classical linear regressions (Annen, 2008). When non-stationary time series are used in a regression model, one may obtain apparently significant relationships from unrelated variables. This phenomenon is called spurious regression (Cizek et al., 2005). Because of the potential for spurious regression, it is not valid to perform OLS regression with non-stationary variables. Thus, we need to test whether a relationship exists between variables that are non-stationary. And testing for cointegration involves testing the residuals from an OLS regression for stationarity (Beachill, 2009). The unit root property of the residuals is tested by employing the ADF statistics. The test for a unit root is based on the t-statistic on the coefficient of the lagged dependent variable and the null hypothesis of ADF unit root test is that dependent variable has a unit root (Lamarche, 2008). If t-statistic is greater than the critical value at 5% level (in absolute value), the null hypothesis of a unit root is rejected. In other words, the dependent variable is a stationary series.
5 RESULTS OF THE STUDY

5.1 Descriptive Analysis of Markets

5.1.1 Operating Environment in China

5.1.1.1 Economic Environment

With a population of over 1.3 billion people and a geographic area of 9.6 million square kilometres, China is the world's third largest country. Since the adoption of the policy of market-oriented reform and opening up in 1978, China's economy has shown a sustained and rapid growth. Figure 5-1, which is made based on the data extracted from Table A1 in Appendix I, shows China's GDP and its year-on-year growth rate from 1993 to 2007. Over this period, the GDP increased more than sevenfold from US$ 0.44 trillion to US$ 3.57, and 2007 was the fifth consecutive year for China to achieve double-digit GDP growth since 2003.

Figure 5-1. China's GDP and Its Year-on-Year Growth Rate, 1993-2007
Economic development is the basis on which foreign trade grows, while the growing foreign trade constitutes a major element in promoting economic development. The transition from a centrally planned economy to a market-oriented system has led to a substantial relaxation over the controls of foreign goods, and has thus triggered the rapid expansion of China's foreign trade and investment inflows (Adhikari and Yang, 2002). To respond to the globalization trend of world economy and participate in international competition and cooperation, in the 1990s, the Chinese government took a series of steps to promote its trade liberalization, under which large amounts of foreign investments have been introduced into China. Since 1993, China has been the largest foreign investment absorber among developing countries (People's Daily Online, 2008). Its foreign direct investment (FDI) inflows increased sharply, from US$ 28 billion in 1993 (Whalley and Xin, 2006) to US$ 83.5 in 2007 (Diao, 2008). Paralleling with the dramatic increase in FDI inflows, China's foreign trade also achieved an impressive growth, especially after the entry into the World Trade Organisation (WTO). Between 2001 and 2007, China’s total import and export value increased from US$ 509.8 billion (Urbach Hacker Young International Ltd., 2008) to US$ 2,173.8 billion (National Bureau of Statistics of China, 2008), China’s trade surplus increased from US$ 25.4 billion to US$ 262.2 billion, and China grew from the sixth ranking of global trade (People's Daily Online, 2002) to the second ranking in 2007 (The Rank of...2007, 2008). Due to the present global economic downturn, however, there has been a slide in international demand. This has slowed China's export growth, therefore its trade surplus has declined sharply and investment growth has slowed down. China's economy grew at a lower rate of 10% this year and may slow further in 2009. Yet, it will still rank the world's fastest growing economies over this period (Ding, 2008).

The booming economy has brought about a remarkable enhancement in China's overall national strength and a great improvement in people’s living standards, and has therefore resulted in a dramatic increase in the consumption of wood products. Along with the strong demand for wood used in interior housing decoration and furnishing as well as low-cost processed wood products from the US, Europe and Japan, China has become one of the
world's largest users of timber and wood products. With the accelerated process of economic globalization and free trade, the world timber supply and international trade have increased steadily. Although the timber supply from natural forests has decreased, timber supply from plantation has increased rapidly, so the total amount of timber supply is expected to increase gradually. Global timber yield increased from 3.29 billion m$^3$ in 1999 to 3.34 billion m$^3$ in 2003, up by 1.51%. On the other hand, the gross global forest product's trade has markedly increased 17.05% between 1998 and 2003. Of this, gross imports increased by 18.64% and gross exports increased by 15.41%. In 2004, the total value for forest product imports and exports in China exceed US$ 35 billion. China exported US$ 16.3 billion and imported US$ 18.7 billion of forest products, accounting for 2.75% and 3.3% of the nation's total exports and imports, respectively. In addition, the structure of imports and exports has been improved greatly - China imports mainly wood raw materials and exports value-added and labour-intensive products, such as plywood, furniture and wooden flooring. Forest products trade has contributed significantly to forestry development and economic growth in China.

5.1.1.2 Political Environment

China is a country with a highly centralized political system (one-party system) and an increasingly decentralized economic system (socialist market economy). Although there has been a considerable reform of China's economic model, the political system remains the same - the Communist Party of China (CPC) still reigns supreme, dominates the entire political apparatus, makes all major policy decisions and controls the government at all levels of hierarchy. State-level bureaus and agencies play an important and evolving role in administering and enforcing China's growing body of commercial and industrial law, along with its regulations on imports and exports, financial matters, intellectual property, environmental protection, etc. In general, there are two key trends in economic decision-making: 1) at central government level, the main tendency is a gradual withdrawal by the state from direct control of business to free business activity; 2) there is a growing willingness by central government to devolve executive powers down the administrative
chain, granting ever-greater powers to local authorities. The effect of this process is to increase the market opportunities and lighten the bureaucratic burden on foreign businesses. However, foreign investors are still confronted with an overwhelming array of officials and agencies to work through, and they have to deal with representatives from administrative hierarchy (Chinese Information Centre Co-Operative Ltd.).

Over the last two decades, the Chinese government has implemented active forest policies to promote wood industry development. Past policies have focused on protecting domestic natural forest resources and emphasizing the development and utilization of plantation resources as raw materials for China's wood processing industries. To conserve natural forests, the logging ban has been imposed under NFPP and timber harvest has been regulated by the annual Harvest Quota System (HQS), which is set by SFA every five years. Comparing with the 10th Five-Year Plan (2001-2005), China's annual Harvest Quota (HQ) in the 11th Five-Year Plan (2006-2010) has been increased by 25 million m\(^3\) to 248 million m\(^3\). This change reflects the increased availability of forest plantation resources for timber production, and future HQs will allocate more volume to plantations. Another change is the recent relaxation of the application of HQs. It will increase forest owners' interest in forestry and their flexibility in reacting market condition, and will thus increase timber production from domestic forest plantations (Zhang et al., 2007a). Besides wood production, China has implemented the policies to develop wood processing industries. In order to develop large-scale paper enterprises that have their own supplies of forest resources and use advanced technology and equipment, in 2004, the government started the Forest-Paper Integrated Programme by integrating sector development policies between the forestry and paper production sectors. To facilitate forest products trade, China has reformed its foreign trade qualifications from the permit scheme to the registration scheme, and the government has also provided many preferential tax policies. In order to encourage imports of raw materials and exports of value-added products, the processing trade preference program allows duty-free and VAT-free treatment for imported materials that are processed and re-exported as value-added products. In 1999, the government reduced the tariff rates for
industrial roundwood, sawnwood and wood pulp to zero; after joining the WTO, the
government has kept its promises by reducing import tariffs on 249 forest products, gradually
abolishing non-tariff measures and opening its wood market to the world; in 2003, the
average tariff for timber, paper and paper products was only 7%; in 2005, the furniture import
tariff was reduced to zero (Jiang, 2007). Owing to the increasing demand of domestic
producers for wood resources, the government has eliminated the value-added tax (VAT)
rebate for exported wood raw materials and primary processed wood products such as logs
and wood chips. While, exporters of wooden furniture and plywood are still entitled to the
VAT rebate. (Zhang et al., 2007a).

To further develop the forest industry and promote forest product trade, except that the
Chinese government encourages and supports all forms of investment such as
wholly-owned investment, joint ventures (JVs), stock holding, contracting, or leasing in the
fields of afforestation, seedling production, timber processing, integrated paper production,
forest machinery manufacturing, Chinese forest enterprises have also begun to invest in
other countries and establish JVs (these investments include mainly timber harvest and
wood processing), including New Zealand, Canada, Malaysia, Russia, Brazil, and Gabon.
Moreover, the government provides preferential policies in equipment import and tax
reductions, such as exemptions from the tariffs on imported equipment for production and
from business income taxes in the first two years and a further reduction by half of business
income taxes over the following three years for corporations (Jiang, 2007). With increased
wood demand in China and expanded international trade in forest products, China's forest
products sector will further promote reforms, open up the forest sector and expand
international trade. (Zhang et al., 2007a).

However, as a general governance problem, corruption is widespread in China. Bureaucrats
are the source of corruption and bribery is the main accusation of corruption against China's
senior officials. The main reason to breed corruption and the abuse of power by local
officials is because under China's one-party system, there are not independent channels and
judicial institutions to monitor and check the behaviour of local officials (Minzner, 2007). Previous economic reform of the state sector in China consisted of privatisation, while the current reform consists of changing the performance of remaining large state-owned institutions, which are controlled and operated by bureaucrats who could profit from their economic power through corruption (Pei, 2006). Reducing the size of the government sector is a basic solution to the corruption problem in China, while attention should be paid in the privatization process that involves corruption (Chow, 2005). In the forest sector, illegal logging is linked to corruption and criminal cartels. It is a major contributor to corruption at the highest levels of government and throughout the bureaucracy. Most logs imported into China are effectively stolen, with no payment of government, royalties to exporting nations or environmental control over harvest operations. The illegal timber trade drives forest degradation and deforestation in supplying countries, so there is an urgent need for Chinese wood products companies to fight against illegal logging and corruption. (China’s Wood Industry…Countries, 2008). In response to global concern, China has committed to combat illegal logging by signing a series of regional and global agreements that include a set of criteria and indicators for forest conservation and sustainable management. The Chinese government is also a party to the International Tropical Timber Agreement, an agreement negotiated under the United Nations Conference on Trade and Development, which promotes timber trade and the improved management of forests.

5.1.1.3 Social-Demographic Environment

The socio-demographic factors that affect the demand for wood products include household income, population growth, demographic trends, age, urbanization and income disparity between urban and rural areas.

Household income

As the economy continues to develop, per capita income of the Chinese will increase. According to the Development and Research Centre of the State Council of China, it is predicted that China's GDP will double between 2010 and 2020, at an annual growth rate of
nearly 7.2%, to reach US$ 6.6 trillion in 2020. With this assumption, per capita GDP will reach USD 4490, which is similar to that of upper-middle-income countries (Zhang et al., 2007a). This will promote the rapid development of China's furniture, interior decoration, flooring and wood-based panel (WBP) industries.

Population growth

Because of China's population control policy (one-child policy) is enforced more strictly in urban, so when rural areas take on certain traits of the more urbanized regions, families there are also shrinking, slowing China's population growth. Currently, China's total fertility rate is 1.77, while the necessary total fertility rate for a stable population is 2.1 (Rosenberg, 2008). The sharp decline in Chinese fertility and slow population growth may have a positive effect on the environment, but because fertility has fallen just when economic growth is rising, this downward trend will affect the consumption of wood products in the long term.

Demographic trends

Demographic trends and consumer preference will influence the housing sector. As family planning is implemented, the recent population is partly owing to longer life expectancy in the country, which indicates that society is ageing. As the population grows older, savings in the banking sector will decrease because more people will consume without producing. This may affect the amount of savings in the banking sector that can be invested in the construction and housing sectors. In addition, the younger generation tends to consume more than its parents' generation, and it will also encourage a shift from saving to consumption.

Age

As the most populous country in the world, China's demographic profile is ideally suited to economic expansion. Seven out of ten Chinese are aged between 16 and 64, and the average age is 34. Chinese labour force of more than 800 million is over double that of the US and
the EU combined (Tulloch, 2008). It is forecast that China will overtake the US to become the world's largest manufacturer in 2009 (Simpkins, 2008). The supply of labour drives China's economic ascent. Hundreds of millions of people have been lifted out of poverty, and a burgeoning middle class of between 100 and 150 million people has made China one of the most attractive markets worldwide (Tulloch, 2008).

*Urbanization*

Progressing urbanization is another important factor that affects the demand for wood products. China's economic reforms strengthened regional differences by propelling a traditional agrarian economy towards mechanization and industrialization. This has prompted large rural-to-urban migration. Along with economic growth, urbanization has been progressing at a rapid rate: the urban population rose from 26% in 1990 to 43% in 2005, and this trend is expected to reach 58% to 60% of the total in 2020. Government policies to relax regulations on migration will encourage urbanization. The progress of urbanization will continue to affect new housing construction in urban areas, maintaining the strong demand for wood products in urban areas. On the other hand, the demand for wood products in rural areas as the population in those areas will decrease. Investment in infrastructure development by the public sector will shift to the areas left behind. While, the government has started to promote infrastructure and market development at sub-country levels in recent years. Growing sub-country areas will provide further opportunities for construction development and thus enhance the pace of urbanization in what are at present rural areas. (Zhang et al., 2007a).

*Income Disparity between urban and rural areas*

Although people's living standards have improved a lot, per capita GDP in China remains very low because of large population and income disparity. Social development is plagued by problems of inadequate social spending, inflation and urban bias. Moreover, the economic reforms have brought enormous challenges, including growing social and economic inequality, environmental damage and labour migration. The income disparity in
China is between different segments of the population, particularly between the rich in the eastern and southern coasts and in large inland cities and the poor in interior western provinces. The growing disparity between urban and rural incomes, income gaps between the wealthy coastal regions and the poor interior, a large floating population of itinerant workers, mounting unemployment created as state-owned enterprises (SOEs) restructure and downsize, and official corruption will lead to political instability, and will thus affect economic growth adversely (Executive Report on Strategies in China, 2007). So, tackling the expanding disparity between rural and urban areas has become one of the priority policy targets for achieving sustainable and balanced development of the country. The government has taken measures to raise rural income. For example, in order to help the poor in the western region to improve their economic conditions, the Chinese government has adopted a Western Development Strategy to develop the eleven provinces in the Western region. These policy changes will lead to the increased demand for wood products in rural markets.

5.1.1.4 Technical Environment

Although China started a strive for using wood efficiently and developing wood processing industry in the 1950s, the wood processing industry grew slowly before 1979 because of political reasons, limited forest resources and backward technology (Zhang et al., 2007b). Since the implementation of reform and opening policy, China has experienced rapid social and economic development - the construction and interior decorating industries, especially in the interior decoration of home and public construction sectors, have shown significant expansion (Jiang, 2007). The construction industry, furniture industry and paper industry have consumed the most industrial roundwood and contributed greatly to the dramatic increase in wood consumption. While, the domestic wood supply is unable to meet the increasing demand and the outlook for future wood supply remains bleak. However, through the adjustment of wood supply and demand via policy, economic and legal means, there is a potential to reduce the demand for wood, to narrow the gap and to achieve a balance between wood supply and demand. This will thus need to improve production
technology, to innovate processing technology, to enhance compatibility with international
standards, markets and products, and to improve the capacity. (Jiang, 2007).

Currently, there are 200,000 wood processing enterprises nationwide. Of these, 80% are
private- or community-owned. The majority of the enterprises are primary manufacturers,
secondary processing capacity is limited. Since those enterprises still use unsophisticated
technologies and they are poorly equipped, the efficiency of wood utilization is very low.
Thus, management capacities and product quality need to be improved. Under the
framework of sustainable development, during the 11th five-year plan period (2007-2012),
the management and utilization of forest resources must be energy-efficient and
environment-friendly. Therefore, research and technical innovations will be a priority to
develop key technical solutions to supporting the sustainable development of wood
products. (Jiang, 2007).

Relying on research and technical innovations, there are three technical solutions for wood
products development in China. The first is to fully promote efficient management of
user-specific resources for individual forest products industries- Improvement in
economically important end-use wood characteristics will lead to efficient wood processing
and manufacturing of value-added wood products. At present, advanced and intensive
forest management has greatly increased growth rate and has thus reduced the rotation age.
However, the quality of wood obtained from fast-growing and short-rotation plantations
cannot meet end-use requirements for downstream industries yet. Therefore, additional
integrated research should be undertaken to ensure that necessary technologies in tree
breeding, intensive silviculture and timber quality. Continued technology development and
innovation will allow for the shortening of the plantation cycle and the simultaneous
production of high-quality plantation-grown timber. The production of fast-growing and
high-quality plantation-grown timber will reduce pressure on wood supply and demand in
China and contribute to the sustainable development of forestry and the forest products
industry in China. The second solution is to fully promote value-added manufacturing and
diversifying forest products. Through research and technical innovation in the wood processing sector, timber can be processed into a series of primary and secondary products that will improve the utilization of wood and ease the pressure on wood supply. Technical innovations can also improve the quality, performance, and reliability of wood products. In China, technological advances have led to more efficient utilization of wood resources and the development of value-added products, but the percentage of treated timber is lower than the world average because of a lack of practical technologies. Hence, China should increase wood-treatment facilities to process more treated wood for outdoor application, and develop highly effective and low-toxicity preservatives to meet environmental requirements. The third solution is to improve utilization efficiency of wood resources. Currently, the wood utilization rate in China is far behind that in development countries - the utilization rate of timber in China is 63%, while in some developed counties the rate is around 90% (China: Short Supply…System, 2008). The key to improving the utilization rate is to adopt multidimensional processing technologies and extend the industrial chain to achieve the highest wood utilization rate and maximum value possible. China has developed and imported some advanced wood processing equipment and technologies that will contribute to advanced wood processing and comprehensive wood utilization. To develop an energy-efficient strategy, China should make full use of potential fibre resources and develop wood- and wood substitute products to reduce the consumption of forest resources. Moreover, new wood-saving technologies, new techniques and new products should be developed. (Jiang, 2007).

5.1.1.5 Cultural Environment

China has attracted large amounts of foreign investments since it opened economy for foreign businesses. To succeed in doing business in China, foreign investors should understand the Chinese business environment; get familiar with the local business culture, etiquette, style and practices.
China has a different culture from the western countries. According to Chinese social and cultural values, people always integrate both personal and work matters when carrying out business. To survive in the China market, one must have a good relationship network. The Chinese term "Guanxi" refers to any kind of relationships - either personally or bureaucratically. It is a deep-seated concept lying at the core of Chinese society and plays a key role in business life. Before setting on a deal, the Chinese often make efforts in socializing their partners and customers to build good relationships with each other. In order to run businesses in China more smoothly, foreign investors should also cultivate close personal ties with Chinese business associated and gain the trust of Chinese people.

Because of the bureaucratic system, the China government plays a crucial role in business by influencing market movement and administering foreign investments. So, in addition to keep close relationships with business partners, foreign investors should establish close relationships with governments. While dealing with governments and authorities, understanding and patience are of importance in investors' business ventures in China. Understanding the way in which Chinese bureaucracy work is a prerequisite. To obtain the requisite approvals, investors should understand the process of approval and authorization, and understand where the authority is vested - either at central, provincial or municipal levels. Moreover, great patience is required to build up the necessary level of trust, especially when investors are trying to acquire a substantial interest in a state-controlled industry. As the country has traditionally been run on a hierarchical and bureaucratic structure and Chinese organization are only dominated by a few key decision-makers at the top, the pace of decision-making is particularly slow. However, a strong government relationship can reduce unnecessary procedures and delays, expedite paperwork and achieve local authorization. For the investors who newly enter China, they might not have a good network in China and therefore meet lots of bureaucratic problems. Approaching someone who is familiar with the Chinese market and the Chinese culture would help foreign investors know the tactics to handle the local problems. Hence, partnering up with a local individual or organization will allow foreign companies to gain an easier way to a
network. After all, the locals are familiar with the procedures and would be in a better situation to negotiate matters with other domestic companies and governmental officials.

In addition, localization is an important strategy for many foreign investors and it has led to their business success in China. In recent years, there has been an apparent move for foreign paper manufacturers to invest building factories in China. Both UPM and Stora Enso have built up their factories in China. The localization of overseas material manufacturers has consolidated their production and business cases in China, gradually making the local market internationalized.

Moreover, foreign investors should pay attention to the increasingly strong competition from local companies. They should pay attention to not only their competitors of the same level but also smaller local enterprises that are gradually expanding. Actually, when foreign investors enter into China, domestic industries benefit as well - through working with foreign companies, they can increase technical skills and marketing tactics; with lower labour costs, they are able to produce higher quality products at a lower price so as to gain more market share. To efficiently market their products to the China market, foreign investors should find local partners to cooperate.

5.1.2 China's Forest Resources and Raw Materials Demand, Supply and Trade

5.1.2.1 China's Forest Resources

China is a large country with vast forest resources, possessing the fifth largest forest area and the sixth largest forest stock in the world. According to the sixth national-wide forestry resources inventory (1999-2003) by the SFA, China has 175 million hectares (ha) of forests. For the purposes of both industrial production and environmental protection, China has pursued an extensive forest plantation programme. With 53 million ha, China has the largest plantation resources in the world, and 24 million ha are considered to be available for industrial purposes. Oak, Masson pine (Pinus Massoniana), Chinese fir (Cunninghamia...
Lanceolata), Birch and Larch are the dominant species of China's forest. New plantations consist of poplar and eucalyptus species, and the plantation area is expected to continue to increase (Jiang, 2007).

All land in China is owned by the state or by collectives (a form of indirect state ownership): 42% of the forests are state-owned, while the balance is collective-owned. About 34% of collective-owned forestland is allocated to individual households. So, there are three main groups of entities - state, collective and private forest farms. For forests that the state does not manage directly, collective farms and private enterprises can lease the land for forest product. The lease terms are typically 40 years (Butterworth and Zhang, 2005).

China's forest resources are located in three main areas: Northeast China and Inner Mongolia, Southwest China and ten provinces in Southern China. The Northeast and Southwest contain most of the remaining natural forest and they are almost all managed by state-owned forest enterprises, while the majority of plantations, which are primarily run by collectives, are located in the south (Zhu et al., 2004). However, China is a relatively forest-poor country given its large land area and huge population. The forest area per capita is only 0.132 ha, less than one-fourth of the world's average. The forest quality is poor - average stocking volume per ha is 84.73 m$^3$, only 84.86% of the world average; average forest stand diameter is only 13.8 cm; and single species forest dominates China's forests. In addition, the average annual excess logging in China is 75.54 million m$^3$ (Butterworth and Zhang, 2005).

5.1.2.2 Demand, Supply and Trade of Wood Raw Materials in China

Industrial roundwood includes all wood extracted from forests for purposes other than fuel use. It is categorized as logs (sawlogs and veneer logs), pulpwood and other industrial roundwood (poles, pilings, pit props, etc.). As raw materials, logs are used for the production of sawnwood, plywood and other WBPs (Mäki-Simola and Panagopoulos,
The majority of tropical hardwood logs are used to produce plywood, while most softwood logs are sawn into sawnwood for use as construction sawnwood (South Korean Markets for...Products, 1994). By comparison, pulpwod is wood in the rough other than logs, for the manufacture of pulp, particleboard and fibreboard. (Mäki-Simola and Panagopoulos, 2005).

**Demand for Logs**

The demand and consumption of wood raw materials in China has increased rapidly in line with continuous and rapid growth of its economic gross (GDP growth), huge population, increasing construction activities, urbanization, housing reform, lowered tariffs on wood product imports, the recognition of global processing center and the expansion of export trade. Of these, housing and infrastructure construction comprises the bulk of demand for industrial roundwood in China (Zhu et al., 2004). However, after a decade of rapid expansion, the infrastructure boom cooled due to more restrictive loan policies promoted by the Chinese central bank combined with reduced foreign investments caused by the Asian Economic Crisis of the late 1990s. To compensate for the slowing infrastructure construction, the residential housing construction sector in China has been increasing. This growth has been stimulated by the National Housing Reform Program (NHRP), which seeks to transfer state-owned residential housing to private ownership (Cohen et al., 2002, p. 20). Thus, the largest quantity of wood products is used for residential housing construction and/or interior remodelling and commercial construction. New residential construction in China exceeds 700 million m$^2$ annually; commercial construction, which is already booming, has increased with the arrival of the 2008 Olympics and is expected to still increase in advance of the 2010 World Expo (Bloodgood et al., 2006). Other industrial uses for wood include furniture, papermaking, shipbuilding, railways, etc.

In general, wood is used in housing construction in two major ways: 1) as a structural building material in construction for concrete forming as well as joists, beams and rafters in rural housing and 2) as interior decoration such as flooring, moulding and wall panels as
well as windows and doors in urban buildings. As most urban dwellings in China are built by using block and concrete methods, the housing industry consumes an estimated 0.025 to 0.045 m$^3$ of wood per m$^2$ of floor area in urban areas but a higher ratio of 0.04 to 0.06 m$^3$ per m$^2$ in rural area. Interior design adds an estimated 0.025 m$^3$ per m$^2$ to total wood use in housing. Under the NHRP, China plans to double the average living space per unit of housing: from 8 m$^2$ in 1998 to 15-18 m$^2$ by 2010. In addition, the reform seeks to privatise much of the urban real estate. These reforms, coupled with a strong economy, urbanization and increasing population have driven massive growth in residential housing construction and related demand for wood as a building material. The rising number of new housing starts has also increased the demand for wood products for furniture, interior decoration, and flooring and WBPs (Zhu et al., 2004), and has thus increased the demand for large-diameter and high-quality timber. Evaluated from the perspective of log diameter, the demand for large/middle-diameter logs occupies 75% of the volume demand, but the demand for smaller diameter logs represents the remaining 25% (Wang, 2002).

**Supply of Logs**

China was the largest producer of roundwood and the second largest producer of industrial roundwood in the world. However, the majority of harvested volumes (65%) are used for heating and cooking, with only 34% used for industrial purposes (Cohen et al., 2002, p. 13). From 1975 to 1995, China's timber production increased significantly (Cohen et al., 2002, p. 14). Nevertheless, owing to the devastating flood of 1998, the Chinese government implemented the NFPP. As a result, the production of logs began to decline. In order to increase timber production and supplement domestic log supplies, China has launched the fast-growing and high-yielding (FGHY) Plantation Project since 2001. Hence, China's log production started to increase again in 2003 and peaked at 64.92 million m$^3$ in 2007 (see the following Figure 5-2 and Table B1 in Appendix II). The successful cultivation of fast-growing plantations provides volumes of core raw material for the plywood industry. However, China is still facing significant shortages in log supply: the domestic logs
available are far from satisfying the increasing industrial demand in either quantity or quality.

**Figure 5-2. China's Production and Imports of Logs, 1993-2007**

![Graph showing production and imports of logs from 1993 to 2007.](image)

**Trade of Logs**

China’s growing demand for and falling domestic supply of timber have led to a dramatic increase in log imports, which has especially accelerated after the NFPP is fully implemented. Especially, China is in great need of high-qualified imported wood to release the expanded demand for finished products. Prior to 1998, China's domestic timber resource was dominated by large-diameter timber; subsequent to the NFPP, domestic supply of such timber has been limited. The existing commercial plantations are not well aligned with China's growing regional markets, and the rate of adoption of new technology to utilize small-diameter timber from plantations has been slow (Bloodgood et al., 2006). It suggests that large-diameter and high-quality logs cannot be sourced domestically yet. Owing to China's structural shortage of wood, Chinese firms have to depend on the imports currently and would continue to import large amounts of wood in the coming years (Butterworth and Zhang, 2005).
China is the world’s largest timber importing country. Of the total timber imports, log represents the sharpest increase - since 2002, China has been the world's largest importer of both hardwood and softwood logs (Flynn, 2008). According to the statistics from China Customs, in 2007, China imported 37.09 million m$^3$ of logs valued at USD 5350.61 million, up 15.36% and 36.17% respectively over 2006 (Guo, 2008), increased by 9.7 times and 10.7 times respectively compared to 1993. Among the total imported logs, softwoods are imported in greater quantities than hardwoods. Actually, the imports of softwood logs have exceeded that of hardwood logs since 2001. From 1993 to 2007, the share of softwood in China's total log imports had increased sharply, increasing from 45.5% to 62.6%. This increase was mainly due to government emphasis on capital construction projects. Over the same period, the imports of hardwood logs had also grown quickly, although not as dramatically as that of softwood logs (Flynn, 2008). Russia was the largest log supplier to China, with 25.40 million m$^3$ accounting for 68.5% of total log imports in 2007 (China Reports...2007, 2008). Over the past five years, Russia has dominated China's softwood log import market, occupying more than 90% of imports (Flynn, 2008). New Zealand follows (New Zealand Trade and Enterprise, 2006. p. 9). Hardwood logs are mainly imported from Southeast Asia (SEA) including Papua New Guinea (PNG), Malaysia and Myanmar, and Africa such as Gabon and Solomon Islands (China Reports...2007, 2008). In the past few years, Russia had also increased its share of China's hardwood log imports - from 10% in 2001 to more than 31% in 2007 (Flynn, 2008). Because wood resource in China is very deficient and Chinese processing technology is comparatively behind other countries, log exports in China, on the other hand, has always been limited and insignificant.

Because of the substantial increase in the domestic wood consumption, restricted harvest from natural forests and FGHY forests represent only a small portion of its forest resources. China still heavily relies on imported wood to satisfy its demand - about 50% of China's demand for sawlogs is met through log imports (Flynn, 2008). While, the country's entrance into the WTO has led to the changes in its forest products policies, including the efforts to encourage foreign businessmen to participate directly in the management of Chinese wood
market, 'zero-tariff' on logs and a reduction in woody products' tariff to 5-7% (Wang, 2002).

China-Russia Timber Trade

When the Soviet Union collapsed in 1991, the Russian government scrambled to sell off its natural resources. Huge areas of Russian frontier forests in Siberia and the Russian Far East were opened for clear-cutting. The opportunity was partly exploited by the Chinese and SEA forest conglomerates to source cheaper timber to meet China’s future need for wood. Between 1996 and 2007, the volume of Russian timber imported by China soared from 0.53 million m$^3$ to 25.40 million m$^3$. Russian logs imported by China were mainly softwoods. According to China’s Customs Statistics, in the softwood category, the imports of Scots Pine and Korean Pine were top of the list, accounting for 57.3%, of Larch and White Pine were 22% and 20.7%, respectively. The hardwood species were more diverse, while Oak and Ash were the main species, accounting for 18% and 16% of the total hardwood imports (International Tropical Timber Organization (ITTO), 2005).

To boost the country's domestic wood processing industry and promote national development, the Russian government increased the export tariff on coniferous logs to 20% (at least 10 Euros per m$^3$) starting in July 2007 and 25% (at least 15 Euros per m$^3$) in April 2008 (Muran et al., 2007). Due to the global financial crisis, reduction of oil prices, as well as pressure from Scandinavian powers that depend on Russian logs, Russia announced that the planned 80% tax on log exports that had been scheduled to start on January 1, 2009 has been postponed by 9 to 12 months (International Forest Industries, 2008). Since Russia accounts for 40% of the world's exports of softwood logs, it is expected to have a major structural change in global wood markets. Russia's accelerated log export tariff has considerably increased the cost of logs and caused great concern in countries that import large volumes of Russian logs (Castaño, 2007). Prices of Russian softwood logs imported into China had already been increasing sharply in the years leading up to the latest Russian log tariff push. Between June 2003 to June 2007 (the month before the latest increase in Russia's log export tariff), average prices for Russian softwood logs imported into China
increased to 72% in USD. The main reason was the increased production (logging) and transport costs in Russia due to higher fuel oil and labor costs, greater transport distances and road building costs and an appreciation of the Russian Ruble over this time. Following the increase in Russia's log export tariff from a minimum of USD 6.3 to USD 15.70 per m$^3$ in July 2007, by January 2008 average prices had increased another 16% over June levels. China's domestic log prices are broadly in line with the imported saw log prices trend (Flynn, 2008). As shown by Figure 5-3 and Table B1 in Appendix II, China's import price of logs in 2007 was USD144.26 per m$^3$, up 18.04% over 2006.

Russia's considerable log export tariff increases could be a critical force for change to Asia's current log trade dynamics and will result in some dramatic shifts in the form of wood imports in China. The partners of China's timber imports might be changed, and New Zealand, Canada, Europe as well as other countries would become new import suppliers of logs and sawn timber. Nevertheless, China's options in substituting softwood log imports from Russia with other sources, including Australia, Canada, New Zealand and the US, are very limited (Flynn, 2008). Concerning the hardwood logs, since 2000, the export of tropical industrial logs has shown a declining trend and tropical timber exports of ITTO
production countries has reduced. The world’s forest resources are limited. Thus, growth in China's log imports is anticipated to remain positive but at a slower rate in coming years (The Approaches for…Timber, 2007). Due to the limit of Chinese national production and the uncertainty of imported logs' quality, the substitute, non-wood material would become a passive choice for the market (Wang, 2002). Therefore, China will have to solve the timber supply-demand imbalance by itself.

5.1.3 Demand, Supply and Trade of Primary Wood Products in China

5.1.3.1 Demand, Supply and Trade of Sawnwood in China

Demand for Sawnwood

Sawnwood (lumber), veneer and WBP products are the intermediate products resulting from the primary manufacturing of logs. Sawnwood is also divided into two categories, namely, hardwoods and softwoods. Hardwoods come from deciduous trees and they are used mainly in interior decorating, wood flooring, pallets, paneling, furniture, cabinets and moulding. Whereas, softwoods come from conifers and they are used mostly as structural elements in residential and commercial construction. Accordingly, demand for both hardwood and softwood sawnwood are closely linked to housing and construction. Moreover, other important end uses for hardwood sawnwood include shipping pallets, millwork, architectural woodworking and railroad crossties. (U.S. International Trade Commission, 2006).

Housing market is not only driven by short-term economic cycles, but also influenced by long-term trends in the number of homebuyers and interest rates. In addition, local climate, cultural and political factors may affect the demand for the use of building materials. There is a strong cultural preference for masonry construction in China - most urban buildings are concrete and brick. In 2005, only 300 wood-frame houses were constructed in China out of 24 million mostly masonry housing starts (Bloodgood, 2006, p. 4-16). Due to the limited domestic timber supply, sawnwood production in China has remained relatively low in the
past 15 years. As a major wood-saving policy, wood for structure uses in urban construction has been strictly limited and prohibited by the government. This discouragement policy on the use of wood-frame housing made China's demand for softwood sawnwood relatively low (U.S. International Trade Commission, 2006). Instead, wood is used for concrete forms, windows, doors, joists, beams and rafters as well as for interior decorations, such as kitchen cabinets, flooring, molding and wall panels (Zhu et al., 2004, p. 17; Sun et al., 2005b, p. 11).

Although the Chinese government encourages the use of non-wood materials in construction, the high demand for wood in the housing sector makes construction the largest wood consumer among all industries. The government's aim to improve Chinese living conditions by building affordable apartments will increase wood consumption in the sector. China's soaring economic growth has caused a surge in the construction of housing, luxury hotels and office spaces. Increased living standards and the emergence of a wealthy class of consumers have translated into an increased demand for high-quality wood for home and office decoration and furnishing (Sun et al., 2005b, p. 11). As an incentive to build and repair, privatization of the housing market has stimulated the demand for larger and higher quality homes with better amenities. And new construction is expected to drive steadily the increasing demand for hardwood used for many products inside the home (U.S. International Trade Commission, 2006). According to China's Building Decoration Association, China's interior decoration market will grow at a rate of 20% annually over the next few coming years (Sun et al., 2005b, p. 11).

**Supply of Sawnwood**

According to 2007 Statistical Report of the National Forestry Analysis, China's sawnwood in 2007 reached 28.29 million m³, 3.42 million m³ more than in 2006 (up 13.78% over 2006). Figure 5-4 presents the trend of log and sawnwood production from 1993 to 2007.
In the early 1980s, Southern China had a cutting boom when farmers got forests from villages or towns for management by contract. Regulations for harvesting were ignored and cutting for cash became popular for farmers. As a result, the production of sawnwood increased during that period. As the Forest Law was enacted in 1985 followed by a system of timber harvesting quotas enacted in 1986, and a tight national finance policy was implemented at the end of the 1980s to calm down the over-heated economy and to control the double-digit inflation index, sawnwood production had started to decrease since 1986. While, at the beginning of the 1990s, the macroeconomics control loosened and the production of sawnwood increased again. In 1996, China raised the value-added tax from 13% to 17%, which made sawnwood production unprofitable, so sawnwood decreased its production again (Zhang et al., 2007a). With the implementation of the NFPP in 1998, Chinese domestic annual production of sawnwood continued to decline. But unlike log production, sawnwood production began to recover in 2000 and started to increase in 2001 because of the increase in imports of logs, especially the growing availability of imported Russian logs, and also the growth in demand for construction, furniture-manufacturing and interior decoration (U.S. International Trade Commission, 2006).
Trade of Sawnwood

The growth in the architecture industry and furniture manufacturing industry has promoted the development of the sawnwood and WBP industries. However, the shortage of large-diameter and good-quality roundwood made China have to import some high-quality sawnwood for interior decoration and furniture production. According to the statistics for 2007, sawnwood was the second main imported timber product in China, with 6.49 million m$^3$ of import volume and USD1.76 million of import value (see Table B2 in Appendix II). Russian and the US were still two of the traditional main suppliers of softwoods, accounting for 24.2% and 16.4% of China's sawnwood imports, respectively. Other major suppliers were Canada, Malaysia, Brazil, Myanmar, Indonesia and New Zealand (China Reports…2007, 2008).

Figure 5-5. China's Production and Imports of Sawnwood, 1993-2007

In comparison with logs, the growth trend of sawnwood imports is similar to that of logs; but China's log imports had grown much more than sawnwood imports since 1998 (see Figure 5-6). This was a result of China's intention to capture the value-added by primary manufacturing of the logs. It indicates that China is shifting towards importing unprocessed
Among the imported sawnwood, although hardwoods are still the major species, its imports have stagnated in the last few years. Simultaneously, the imports of softwood sawnwood have grown very fast. It is because the Chinese government has started to emphasize on the infrastructure development again. In 2007, hardwood sawnwood accounted for 56.79% of total sawnwood imports, down 6.91% from 2006; while softwoods accounted for 43.21%, up 33.01% over 2006. Of total sawnwood imports, China's imports of softwood sawnwood from Russia had grown rapidly, with an increase of more than 1 million m$^3$ from 2003 to 2007 and a 40% increase in volume in 2007 alone. Due to the impending Russian log export tariffs, China will see a significant decline in softwood log imports in the next couple of years. While, the Russian government's policies aimed at encouraging the development of its own wood processing industry may contribute to the growth of its sawnwood export to China. It will be primarily rough sawn, green sawnwood, produced in small mills relocated across the border into Russia, as well as produced by some of the large sawnwood producers already operating in Siberia. Some small, inexpensive sawmills...
installed by Chinese companies to process hardwood logs and the same pattern will likely be
followed by numerous companies trying to avoid paying the Russian log export tariff on softwood logs. At the same time, importing sawnwood in place of logs will reduce transportation costs. This might shift to sawnwood imports and it will happen quite rapidly. The processing of logs into sawnwood in Russia will mean a decline in available sawm mill residues in China and it will result in other industry dislocations. Anyway, since most efforts to increase plantation forest yields in China have focused on fast-growing hardwoods and alternative sources of softwood logs in the Pacific Rim basin are still limited, Russia will continue to dominate China's softwood markets for many years to come (Flynn, 2008). Meanwhile, Canadian sawnwood exports to China will also climb rapidly.

In contrast to logs, China’s imports of softwood sawnwood from Russia have increased rapidly (Flynn, 2002), but the imports of hardwood species from Russia have decreased. China will try to offset some of this decline with domestic stock, and consequently, there would be a major expansion of domestic timber harvest in China, with most of the increase coming from fast-growing hardwood plantations. Chinese wood products manufacturers are expected to seek new suppliers of hardwood sawnwood, especially in Eastern Europe. On the other hand, China’s sawnwood was mainly exported to Japan, Korea and the US through such ports as Dalian, Qingdao and Nanjing (China Reports…2007, 2008). Because of the scarcity of forest resources, the central government strictly controlled sawnwood exports. For example, in the 1980s, only tens of thousands of cubic meters of sawnwood were exported annually. But since 1990, China’s sawnwood exports had increased due to higher international sawnwood prices. Comparing the figures of 2006 and 2007, sawnwood exports were 745,700 million m³ and valued at USD 389 million in 2007, down 7.5% and up 10.2% respectively from 2006. The reason for this was because most sawnwood had to meet the needs for domestic consumption for housing and construction and also for producing furniture to export. Even though, China's exports of sawnwood had increased 140% from 1993 to 2007. It reflects that China has gradually shifted from a net import country to an exporting country of sawnwood.
Regarding the import price, as presented in Figure 5-8, the price trend of imported logs and imported sawnwood were similar over the period from 2002 to 2006. While in 2007, the import price of China's logs continued to increase, but that of sawnwood decreased.

**Figure 5-8. China's Import Price of Logs and Sawnwood, 1993-2007**
5.1.3.2 Demand, Supply and Trade of Plywood in China

Demand for Plywood

As the technology and materials for surfacing improved, end-uses of WBPs increased dramatically in the 1990s. In a variety of end-use applications, plywood has traditionally been the most consumed WBP type in Asia (Pöyry Forest Industry, 2005).

Housing reform has pushed the residential construction boom in the south and east coastal regions of China. Wood and wood products, especially those made from hardwood species, are the preferred material for interior decoration. Hardwood plywood, which is used as wood floors moulding, wall panels, doors, window and kitchen cabinets, is in high demand by new house owners in urban areas. While, since the western region is less developed than the coastal region, based on government strategy, infrastructure will be emphasized with residential construction lagging by several years. So the demand for wood products as construction material is higher than that for interior wood products, i.e., the demand for hardwood plywood in Western China is higher than that for softwood plywood. However, the west region is expected to grow at a fast pace in a short period of time. This could result in the housing boom following infrastructure development in a few years. Due to a lower population density and a lack of existing infrastructure for sing-family house construction, there may be a great opportunity to promote platform-frame construction in the west (Cohen and Lee, 2000, p. 42).

Supply of Plywood

Rapid economic growth and strong timber demand have led to wide expansion of wood processing industries in China. Since the 1980s, the Chinese government has encouraged both domestic and foreign companies, especially private ones, to invest in forest industries through preferential taxation and land-tenure policies. Many international companies have invested in forest industries and plantation in China. As a result, China's WBP industry has grown very fast (Lu, 2004). China is the largest producer and the second largest consumer of WBP in the world (Pöyry Forest Industry, 2005; Sun et al., 2005a, p. 5).
Among the three panel products of plywood, fibreboard and particleboard, plywood is the most important and promising WBP product in China in terms of pace of development, growth of production and exports. Reviewing the history, the production of China's plywood was on a low level, many domestic plywood manufacturers were small-scale state-enterprise plants with lagged technology and equipment. Since the 1980s, with the arrival of numerous foreign enterprises and the creation of JVs, especially with China's entrance to the WTO, inflows of FDI have increased spectacularly. The high costs of local labour, land and raw materials and the limited domestic markets have encouraged plywood enterprises in Taiwan, Hong Kong, Singapore and other countries to invest in and relocate to China. Advanced processing plants have been established to take advantage of China's highly educable, low-cost workforce, abundant and competitively priced commercial land and a huge domestic consumer market. The introduction of modern equipment, good quality control, rapid development of the adhesives industry and constant improvements in technology have made Chinese plywood meet international market quality standards and Chinese plywood industry grow very fast. According to the statistics of the SFA, the production of plywood increased from 2.13 million m$^3$ in 1993 to and 35.62 million m$^3$ in 2007 (see Table B3 in Appendix II), almost 16 times. In recent years, China’s plywood production has grown stably. In 2003, China exceeded the US to become the world’s largest plywood producer. This rapid development coincided with the fast development of China's fast-growing forests, especially the poplar base (Sun et al., 2005b, p. 8). Yet, the increasing production of plywood necessitates greater veneer log imports - a trend is evident that Chinese plywood manufacturers have begun to use imported pine and birch logs for the core of plywood, although fast-growing plantations have secured abundant material resources for plywood production.

**Trade of Plywood**

In the 1980s, China began to import plywood. From 1993 to 2007, China’s plywood trade developed at a frantic pace. Figure 5-9 shows that 1998 is a watershed for China's imports of logs and plywood. Triggered by the logging ban and a reduction to zero of log import
tariffs, a slow decline in log imports had suddenly became a rapid escalation since 1998. Prior to 1998, plywood dominated tropical timber imports, the low-cost plywood from Indonesia and Malaysia had seriously undermined the competitive position of Chinese manufacturers - many mills were forced to cut production, sack workers and even close down. Thus, Chinese authorities had to remove log import tariffs and crack down on plywood smuggling. With no tariffs on logs, local manufacturers used imported logs to not only fill a gap in log supplies, but also started to export large quantities of cheap plywood (Adams and Ma, 2002).

![Graph showing China's Imports of Logs and Plywood, 1993-2007](image)

Figure 5-9. China's Imports of Logs and Plywood, 1993-2007

Figure 5-10 demonstrates the trends in the trade of China’s plywood: plywood imports plunged from 2.23 million m$^3$ in 1993 to only 306,600 m$^3$ in 2007 (see Table B3 in Appendix II). Imported plywood in 2007 mainly came from Indonesia and Malaysia, accounting for 45.8% and 32.7% of China's plywood imports, down 37.8% and 13.8% respectively from 2006 (China Reports…2007, 2008). Due to the price competitiveness of plywood production as a labour-intensive industry, China's plywood exports had a dynamic growth - soared from 94,000 m$^3$ in 1993 to 8.78 million m$^3$ in 2007 (see Table B3 in...
Appendix II). In 2001, China's plywood exports exceeded its imports for the first time, and since then, China has become a net plywood exporter primarily targeting the US, the Japanese and the UK markets (China Reports…2007, 2008). By contrast, the import volume has been insignificant and declining in the latest years.

**Figure 5-10. China's Production and Trade of Plywood, 1993-2007**

Figure 5-11 presents the trend of the import and export price of China’s plywood from 1993 to 2007. As it is seen, the export price of China's plywood had continued to increase since 2002.
5.1.4 Overview of Sawmills and Plywood Mills Industry in China

The wood-processing industry referred here is the primary conversion industry, including sawnwood and wood chips, plywood, fiberboard, particleboard and other WBP sectors. China's wood-processing sectors vary enormously in sophistication. Pit sawyers operate alongside computer-controlled sawmills; family-operated plywood mills using dried veneers coexist with modern particleboard and medium-density fiberboard (MDF) or high-density fiberboard (HDF) plants (Sun et al., 2005b, p. 6).

5.1.4.1 Sawmills

China's sawnwood sector has been experiencing dynamic changes. Traditionally, sawmills were located in forest-rich regions (i.e., in the northeast state-owned forest regions and southern collective forest regions). Official 2002 data shows that the total sawnwood production from these regions accounted for over 90% of national total. Most of the large sawmills were state-owned. Those enterprises were generally equipped with low-tech
machinery and had limited capital investment. That is why they were unable to produce high-value sawnwood and veneer (The American Forest & Paper Association, 2004). After the implementation of the logging ban, however, almost all state-owned sawmills were closed due to a lack of resources. Currently, many large sawmills are operating far below their capacity. Meanwhile, numerous small family-owned sawmills or small sawnwood-processing facilities have emerged, scattered near timber market places. According to the Chinese Academy of Forestry (CAF), there were 10,350 sawmills in China, only 350 of which were considered large with an annual capacity of 30,000 m³ or more. Since most sawmills and plywood mills are privately owned and small in scale, it is believed that these figures underestimate the actual ones (Sun et al., 2005b, p. 7).

In the past 15 years, sawnwood production in China has been relatively low and the scale of the operations has been small (Sun et al., 2005b, p. 7). However, the number of sawmills in China is huge and growing. China has been modernizing its huge sawmill industry in the Northeast and exporting sawnwood to Japan, Taiwan and other Asia-Pacific countries. By taking the form of JVs or direct investment into a firm, some Chinese companies have moved beyond merely trading to investing directly in foreign countries’ logging operations in other countries, like in the Russian Far East (RFE) regions (Gordon, 2001).

Since China has the lowest cost sawmills in the world, where workers only earn on average about USD 200 per month, it makes significant gains for China's sawnwood industry. When Chinese sawmills ramp up, it may be difficult for the mills that produce commodity sawnwood in other parts of the world to compete on price, especially in China's own domestic market (U.S. West…Industry, 2005).

5.1.4.2 Plywood Mills

Since the 1980s, the Chinese government has encouraged investment in the WBP industry, which results in a rapid increase in the WBP products. The major WBP products in China are plywood, particleboard and fibreboard (Sun et al., 2005b, p. 7). Among these three
products, plywood has maintained the leading position for a long time. The raw materials used for manufacturing plywood consists of domestic poplar logs from plantations, imported logs and veneers from countries such as Russia (mainly Birch, Basswood, Oak and Larch), Africa (mainly Okoume, Meranti and Bintangor), Burma, North America, and New Zealand (China International Plywood Trade Fair, 2008).

Due to the domestic plywood industry boom, China has become the world's largest producer and exporter of plywood since 2003 (Ma, 2008). Panel production is often labour-intensive and most mills use machines made in China. Yet, even small-scale mills can produce high-value products for export.

**Industry Structure of China's Plywood**

There are three industry segments in China: small size, medium size and large size. China's plywood industry is highly fragmented, with thousands of privately owned enterprises ranging from small-scale companies to relatively large manufacturers (U.S. International Trade Commission, 2008, p. 4-1). It consists of a small number of medium- and large-sized entities and a large number of small-sized industries. Small- and medium-sized companies play an important role in China's plywood industry (Rutten and Hock, 2004, p. 23).

It is estimated that there are over 5,000 small-sized plywood mills of in China. Much of the plywood production is from small-sized mills concentrated in eastern and southern coastal provinces, including Zhejiang, Jiangsu, Fujian and Guangdong, as well as Shandong and Hebei provinces in northern China, which are mainly used for furniture, non-structural building material and inner decoration industry (China Plywood…Conference, 2006). Among those 5,000 mills, more than 2,000 are concentrated in the city of Linyi in Shandong Province, with a total production capacity of 3.5 million m$^3$, another 2,000 mills are in the city of Pizhou in Jiangsu Province and 1,000 more are in Hebei Province. Other small-sized mills are spread around the country, mainly close to the areas with large poplar plantations. Most of them are just family firms: some have up to 20 employees and several
have coalesced into larger companies. The majority of these mills specialize in either peeling logs or gluing the veneers together to produce plywood. Many of the mills that peel logs deliver their veneer to the medium-sized plywood mills, and some of the gluing plants buy higher quality veneers from traders or larger plywood plants to produce higher quality products. The quality of production of the small-sized industry is sometimes rather good - industry sources estimated that in 2002 exports from this group reached over 600,000 m$^3$, accounting for one third of China’s plywood exports (Rutten and Hock, 2004, p. 25).

Medium-sized mills account for 30% of plywood capacity in China. Rather than peeling their own logs, these mills tend to buy veneer from large mills or small mills; they may also import veneer. Such mills are concentrated in the city of Jiaxing in Zhejiang Province, with some 200 mills operate. About 100 other medium-sized mills operate in other parts of the country, and many of them are concentrated in Nanhui City in Hainan Province. These mills include a number of JVs. In order to take advantage of lower labour and land costs, plywood companies from Taiwan, Hong Kong and Singapore have moved their facilities to mainland China recently. A number of these companies export Combi or 100% tropical hardwood plywood (Rutten and Hock, 2004, p. 25).

Large plywood mills account for less than 10% of total capacity. When plywood production took off in China in the late 1980s, state entities set up many large-scale plywood mills. Most of these went out of business because they were unable to compete against the small- and medium-sized mills that started up in the early 1990s. However, new large-scale plywood mills were built in the second-half of the 1990s, including a number of large JVs. Nowadays, some of them can produce more than 100,000 m$^3$ of plywood a year. These large and integrated plants buy logs, peel them and manufacture plywood. They export a considerable part of their production. (Rutten and Hock, 2004, p. 26).
Production Centers of China's Plywood

There are four plywood-manufacturing bases in China, namely, Pizhou in Jiangsu Province, Jiashan in Zhejiang Province, Linyi in Shandong Province and Zhengding in Hebei Province. All plywood mills in these bases are privately owned and have experienced rapid growth in the past several years. Most of them are small family operations (Sun et al., 2005b, p. 8). The biggest competitive advantage these mills have is the low price of their products owing to the abundance of local, fast-growing poplar.

Plywood Industry in Pizhou

Pizhou in Jiangsu Province is one of the most important plywood production and export centres in China. It is regarded as the "City of Plywood". With a total plywood production capacity of 8 million m$^3$, about 3,000 mills are engaged in plywood production or raw material supply in Pizhou, over 10 million m$^3$ of domestic poplar plantation logs and almost 3 million m$^3$ of imported logs and veneer are consumed annually. Reportedly, 335 mills produce finished plywood, while the remainder are engaged in veneer production for both plywood and engineered wood flooring. Of the 335 mills, 48 have the production capacity exceeding 50,000 m$^3$ per year, while two producers (Fuhua and Fuxiang Wood) have an annual production capacity over 100,000 m$^3$ (U.S. International Trade Commission, 2008). In addition, about 60% of the larger scale plywood manufacturers have achieved certifications such as ISO9000, ISO14000 and/or CE marking (a mandatory European marking for certain product groups to indicate conformity with the essential health and safety requirements set out in European Directives). The products produced in Pizhou include different kinds of plywood, such as multi-layer plywood, film-faced plywood, fancy plywood, and value-added products like container flooring, engineered flooring with multi-layer plywood as substrate, and special sized multi-layer plywood. Table B8 in Appendix II lists five key plywood manufacturers in the Pizhou area. (China International Plywood Trade Fair, 2008).
Pizhou plays a key role in China's growth as the world's largest exporter of plywood, as over 35% of plywood manufacturers in this area export their production. In 2006, Pizhou County ranked first among all Chinese counties in plywood exports, reaching 3.2 million m³ and representing about 40% of total Chinese plywood exports. Export markets for Pizhou's manufacturers are quite diverse, but they are still dominated by the demand from North America and Europe. Recently, as the US market demand slows, exports have expanded rapidly into the Middle East, Japan and Korea. (China International Plywood Trade Fair, 2008).

**Plywood Industry in Jiashan**

In late years, the timber industries in Zhejiang Province have developed quickly. A number of contributing factors can be identified: skilled labor, good geographical location, good ports and transport infrastructure, access to resources and nearby markets, the adoption of modern management and technology (Adams and Ma, 2002). The plywood sector, centered in Jiashan County, has boomed in recent years and become the county’s pillar industry. Jiashan has been the largest plywood production base in East China. More than 320 plywood mills and processing and accessory enterprises form a complete industrial chain from logs to end products, with a total annual output value of 8.5 billion yuan, accounting for one third of the domestic market share. Currently, 9 wood enterprises have won independent export entitlements, allowing high-quality plywood and furniture to enter the markets of more than ten countries and regions, including the US, Japan and SEA. The export value in 2004 reached USD 113 million, 7.5 times that of 1999 (Zhang et al., 2007a). However, for the mills in Jiashan, exports can be difficult because poplar plantations are quite far and thus core material is relatively expensive, most rely for their core materials on relatively affordable logs imported from Australasia and, to some extent, SEA. Some specialize in producing blockboard or laminating plywood rather than plywood (Rutten and Hock, 2004, p. 26).
5.2 Statistical Modeling

5.2.1 Time Series Properties of Variables

A time series is a collection of observations of well-defined data items obtained through repeated measurements over a period of time (Australian Bureau of Statistics, 2008). Before the models are formed and estimated, it is necessary to analyse the time series properties of the data, e.g., stationary and normality. Appendix III describes some of these properties: Figures A1-A8 show the movements of the logarithmic transformations of the level series and their respective first differences over time, with correlograms up to 12 lags; the following Table 5-1 provides statistics for the JB normality tests and Table 5-2 shows the results for the ADF unit root tests, which indicate whether one should use differenced series or cointegration specifications instead of models in levels.

Table 5-1 shows that all p-values from the JB tests are greater than the 0.05 level of significance. So all series are normally distributed from 1993 to 2007.

Table 5-1. Normality Tests (Jarque-Bera) for Logarithmic Transformations of the Levels Series, 1993-2007

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normality</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>LACP, apparent consumption of Chinese plywood</td>
<td>0.78 [0.68]</td>
<td>0.13</td>
<td>1.92</td>
</tr>
<tr>
<td>LEP, export volume of Chinese plywood</td>
<td>1.24 [0.54]</td>
<td>0.16</td>
<td>1.63</td>
</tr>
<tr>
<td>LEPR, real export price of Chinese plywood</td>
<td>1.22 [0.54]</td>
<td>0.67</td>
<td>3.37</td>
</tr>
<tr>
<td>LGDPR, China's real GDP</td>
<td>0.64 [0.73]</td>
<td>0.31</td>
<td>2.21</td>
</tr>
<tr>
<td>LIPR, real import price of Chinese logs</td>
<td>0.74 [0.69]</td>
<td>0.31</td>
<td>2.12</td>
</tr>
<tr>
<td>LQP, production volume of Chinese plywood</td>
<td>0.59 [0.74]</td>
<td>-0.15</td>
<td>2.08</td>
</tr>
<tr>
<td>LUS, the U.S. real GDP</td>
<td>0.99 [0.61]</td>
<td>-0.28</td>
<td>1.87</td>
</tr>
<tr>
<td>LWFQ, production volume of Chinese wooden furniture</td>
<td>2.91 [0.23]</td>
<td>1.07</td>
<td>3.22</td>
</tr>
</tbody>
</table>

Note: 1) Jarque–Bera (JB) refers to test for normality and $H_0$ means that variable is distributed normally; 2) figures in the brackets are p-values; 3) the sample period is 1993 - 2007.
Table 5-2. ADF Unit Root Tests for the Variables in Levels and First Differences, 1993-2007

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag, determination</th>
<th>t-ADF</th>
<th>Significance level</th>
<th>Decision I(0) or I(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Levels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LACP</td>
<td>L=3, Trend and intercept</td>
<td>-3.49</td>
<td>*</td>
<td>I(1)</td>
</tr>
<tr>
<td>LEP</td>
<td>L=3, Trend and intercept</td>
<td>-3.85</td>
<td>**</td>
<td>I(0)</td>
</tr>
<tr>
<td>LEPR</td>
<td>L=3, Trend and intercept</td>
<td>-0.34</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td>LGDPR</td>
<td>L=3, Trend and intercept</td>
<td>-0.49</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td>LIPR</td>
<td>L=3, Trend and intercept</td>
<td>-0.45</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td>LQP</td>
<td>L=3, Trend and intercept</td>
<td>-3.93</td>
<td>**</td>
<td>I(0)</td>
</tr>
<tr>
<td>LUS</td>
<td>L=3, Trend and intercept</td>
<td>-1.95</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td>LWFQ</td>
<td>L=3, Trend and intercept</td>
<td>-3.90</td>
<td>**</td>
<td>I(0)</td>
</tr>
<tr>
<td><strong>1st differences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>∆LACP</td>
<td>L=3, None</td>
<td>-4.80</td>
<td>***</td>
<td>I(0)</td>
</tr>
<tr>
<td>∆LEPR</td>
<td>L=3, None</td>
<td>-3.51</td>
<td>***</td>
<td>I(0)</td>
</tr>
<tr>
<td>∆LGDPR</td>
<td>L=3, None</td>
<td>0.95</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td>∆LIPR</td>
<td>L=3, None</td>
<td>-3.02</td>
<td>***</td>
<td>I(0)</td>
</tr>
<tr>
<td>∆LUS</td>
<td>L=3, None</td>
<td>-1.23</td>
<td></td>
<td>I(1)</td>
</tr>
<tr>
<td><strong>2nd differences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>∆²LGDPR</td>
<td>L=3, None</td>
<td>-1.82</td>
<td>*</td>
<td>I(1)</td>
</tr>
<tr>
<td>∆²LUS</td>
<td>L=3, None</td>
<td>-3.55</td>
<td>***</td>
<td>I(0)</td>
</tr>
</tbody>
</table>

Note: 1) ∆ denotes the first difference and ∆² denotes the second difference of the variable; 2) *, ** and *** denote the 0.10, 0.05 and 0.01 levels of significance, respectively; 3) I(0) denotes a stationary series and I(1) denotes a non-stationary series.

5.2.1.1 Chinese Plywood Demand Model

Figure A1 indicates that statistical modelling of the Chinese plywood demand series is challenging, as there appears to be local trends in the series. Figures A1, A3 and A4 show all the series with their respective correlograms for the demand model. The correlograms indicate that the series of the apparent consumption of Chinese plywood (LACP) and the real price of Chinese plywood (LEPR) are both non-stationary in levels, but seem to be stationary in their first differences; whereas, the series of China's real GDP (LGDPR) appears to be non-stationary not only in levels, but also in the first difference.
Table 5-1 gives the results for its JB normality test for the time series. It indicates that there are no signs for excess skewness or kurtosis of the data, the series in the Chinese plywood demand model appear to be normally distributed. Table 5-2 shows the unit root test results for \textit{LACP}, \textit{LEPR} and \textit{LGDPR}: the series \textit{LACP} and \textit{LEPR} are both non-stationary in levels, but become stationary in the first differences; by contrast, the series \textit{LGDPR} is non-stationary not only in levels, but also after the second differencing.

5.2.1.2 Chinese Plywood Supply Model

Moving to the Chinese plywood supply model, Figure A6 indicates that there also appears to be local trends in the plywood supply series. Figures A3, A5, A6 and A8 show all the series with their respective correlograms for this model. The correlograms indicate that the series of Chinese plywood production (\textit{LQP}), Chinese wooden furniture production (\textit{LWFQ}), real price of Chinese plywood (\textit{LEPR}) and real price of Chinese logs (\textit{LIPR}) are all non-stationary in levels, but seem to be stationary in their first differences.

Table 5-1 indicates that there are no signs for excess skewness or kurtosis of the data, the series in the Chinese plywood supply model appear to be normally distributed. According to the results of the ADF unit root tests (see Table 5-2), the series \textit{LQP} and \textit{LWFQ} are stationary in levels, the series \textit{LEPR} and \textit{LIPR} are non-stationary in levels but seem to be stationary in the first differences.

5.2.1.3 Chinese Plywood Export Model

Figure A2 indicates that there appears to be local trends in the Chinese plywood export series. Figures A2, A3 and A7 show all the series with their respective correlograms for the export model. The correlograms indicate that the series of Chinese plywood export (\textit{LEP}) and the real price of Chinese plywood (\textit{LEPR}) are both non-stationary in levels, but seem to be stationary in their first differences; whereas, the series of the US real GDP (\textit{LUS}) seems to be non-stationary in both levels and the first difference, but becomes stationary in the second difference.
Table 5-1 indicates that there are no signs for excess skewness or kurtosis of the data, the series in the Chinese plywood export model appear to be normally distributed. Based on the results of the ADF unit root tests (see Table 5-2), the series LEPR is stationary but LEPR and LUS are non-stationary in levels. Anyway, LEPR is stationary in the first difference. Yet, LUS seems to be non-stationary even after the second differencing.

5.2.2 Results for Chinese Plywood Demand Model

5.2.2.1 Level Model

The equation (3.2) indicates a simple linear regression model with LACP (the apparent consumption of Chinese plywood) as the dependent variable, LGDPR (Chinese consumer income) and LEPR (the real price of Chinese plywood) as the explanatory variables. This static demand equation is estimated by the method of ordinary least squares (OLS). As a time series model, the period from 1993 to 2007 is taken into consideration, and thus 15 observations are included. The output file of results is presented in Appendix IVA.

The estimated coefficients for this model using logarithmic variables are shown below with t-values in parentheses (see Appendix IVA Model I):

\[
LACP_t = 3.13 + 1.11LGDPR_t - 0.33LEPR_t + u_t \tag{5.1}
\]

(1.14) (6.77) (-1.00)

As we can see, the coefficients on both LGDPR and LEPR have the expected signs. Since the coefficient on LGDPR is 1.11 > 1 but on LEPR is - 0.33 (in absolute value) < 1, Chinese plywood demand appears to be income elastic but price inelastic. This result can also be verified from the p-values of t-statistics. The plywood demand appears to be highly dependent on income (LGDPR), with the significance level of 1% (p-value = 0.00 < 0.01). Since this value is computed as the tail probability for a two-tail test of the null hypothesis that the coefficient is zero, the null hypothesis is rejected. Whereas, price effect (LEPR) on
Chinese plywood demand is not significant, with the p-value of 0.34 (> 0.10), so the null hypothesis cannot be rejected.

The model has a good fit, as it explains 85% of the variance of the plywood demand series (i.e., adjusted R-squared = 0.85). As a widely used method of testing for autocorrelation, the DW statistic indicates no serial autocorrelation, with the value of 2.04. Testing the significance of a model is equivalent to testing whether any of the explanatory variables influences the dependent variable. The F-stat and Prob (F-stat) test the overall significance of the regression model. Specifically, they test the null hypothesis that all of the regression coefficients are equal to zero. Since the F-statistic has a p-value of 0.00, the coefficients are significant.

Because the p-values from the BG serial correlation LM test, JB test and heteroskedasticity test are all greater than 0.05, the model has no problem with serial correlation, non-normality and heteroskedasticity in the residual series. As shown in Appendix IVA Model I, the result of unit root test shows that t-statistic (-3.68) is greater than the critical value at the 1% (-2.74), 5% (-1.97) and 10% level (-1.60), so the null hypothesis is rejected and there is no unit root in residual series. Hence, the residuals are stationary and we can assume that the three variables are cointegrated.

5.2.2.2 Error Correction Model

Given the result that the plywood consumption, the consumer income factor and the plywood price factor are cointegrated, a long-run equilibrium relationship exists among these three variables: $LACP$, $LGDPR$ and $LEPR$. Thus, the residuals from the equilibrium regression equation (5.1) can be used to estimate the Error Correction Model (ECM) to determine the short-run dynamics. The short-run ECM is obtained by regressing the first difference of the regressors and regressands with an additional variable - the lagged Error Correction Term (ECT) (i.e., the residual estimated from the cointegrating regression equation 5.1). It combines both the long-run, cointegrating relationship between the levels variables and the
short-run relationship between the first differences of the variables, and at the same time, avoids the spurious regression problem.

Since the ECM specifies the first difference in the dependent variable as a function of this error lagged one period, in contrast to the previous model, this one is rewritten as:

\[ \Delta LACP_t = a + b \Delta LGDPR_t + c \Delta LEPR_t + d \text{ECT}_{(t-1)} + \varepsilon_t \]  \hspace{1cm} (5.2)

where \( \Delta LACP \) is the first difference of the apparent consumption of Chinese plywood, \( \Delta LGDPR \) is the first difference of China's real GDP and \( \Delta LEPR \) is the first difference of the real price of Chinese plywood; the coefficient \( a \) is the constant term, \( b \) and \( c \) are respectively the income and price elasticities, \( d \) is the coefficient for ECT and \( \varepsilon \) is the error term. The signs under the coefficients denote a priori signs of the estimated coefficients. The estimated coefficients for this model are shown below with t-values in parentheses (see Appendix IVA Model II):

\[ \Delta LACP_t = -0.20 + 2.93 \Delta LGDPR_t - 0.52 \Delta LEPR_t - 0.99 \text{ECT}_{(t-1)} \]  \hspace{1cm} (5.3)

\[ (-1.02) \hspace{1cm} (1.80) \hspace{1cm} (-0.75) \hspace{1cm} (-2.73) \]

As shown above, the coefficients on both \( \Delta LGDPR \) and \( \Delta LEPR \) have the expected signs. The coefficient on the lagged ECT measures the speed of adjustment of the dependent variable to its long-run value. This value obtained from the ECM system is -0.99, meaning that Chinese plywood consumption adjusts on over 99% over one year.

In contrast with the level model, the adjusted R\(^2\) in the ECM is quite low, which is 0.53. The F-statistic has a p-value of 0.01, indicating all of the regression coefficients are significant. The DW statistic is 1.87, showing that the null hypothesis of no autocorrelation is accepted. Since the p-values from the BG serial correlation LM test, JB test and heteroskedasticity test are all greater than 0.05, there do not appear to be any problems with autocorrelation, normality and heteroskedasticity in the residual series. Concerning the stationarity of the residuals in the ECM system, because t-statistic (-3.25) is greater than the
critical value at the 1% (-2.75), 5% (-1.97) and 10% level (-1.60), there is no unit root in residual series and thus the residuals are stationary, denoted by I(0).

5.2.3 Results for Chinese Plywood Supply Model

5.2.3.1 Level Model

The equation (3.4) indicates a simple linear regression model with $LQP$ (the production volume of Chinese plywood) as the dependent variable, $LWFQ$ (the production volume of Chinese wooden furniture), $LEPR$ (the real price of Chinese plywood) and $LIPR$ (the real price of Chinese logs) as the explanatory variables. This static demand equation is estimated by the method of OLS. In the model, the period from 1993 to 2007 is taken into consideration, and thus 15 observations are included. Since the program used shows a wrong sign of the coefficient on $LEPR$, which is against what we would expect from economic theory, the output file of results will exclude this factor.

The estimated coefficients for this model are shown below with t-values in parentheses (see Appendix IVB Model I):

$$LQP_t = 11.23 + 0.72LWFQ_t - 1.67LIPR_t + u_t$$

(5.4) $(3.18)$ $(3.90)$ $(-3.35)$

As presented above, the coefficients on both $LWFQ$ and $LIPR$ have the expected signs. Since the coefficient on $LWFQ$ is $0.72 < 1$, Chinese plywood supply seems to be scale inelastic; because the coefficient on $LIPR$ is $-1.67$ (in absolute value) $> 1$, the production of Chinese plywood appears to be highly elastic with respect to raw material price (i.e., log price). However, based on the p-values of t-statistics, China’s plywood supply would be highly dependent on the production of wooden furniture and the price of logs, with the significance level of 1% (their p-values are 0.00 and 0.01, respectively). So the null hypothesis of a zero coefficient is rejected.
This model has a good fit, since it explains 79% of the variance of the plywood supply series (i.e., adjusted $R^2 = 0.79$). The DW statistic indicates no serial correlation, with the p-value of 2.25. The F-statistic shows that all of the regression coefficients are significant, with the p-value of 0.00. Since the p-values from the BG serial correlation LM test, JB test and heteroskedasticity test are all greater than 0.05, the model does not suffer from serial correlation, non-normality and heteroskedasticity in the residual series. Based on the result of unit root test, t-stat (-4.14) is greater than the critical value at the 1% (-2.74), 5% (-1.97) and 10% level (-1.60), so there is no unit root in residual series, the residuals are stationary and we can assume that the three variables are cointegrated.

### 5.2.3.2 Error Correction Model

Given the result that the plywood production, the wooden furniture production factor and the log price factor are cointegrated, a long-run equilibrium relationship exists among these three variables: $LQP$, $LWFQ$ and $LIPR$. Thus, the residuals from the equilibrium regression equation (5.4) can be used to estimate the ECM to determine the short-run dynamics.

Since the ECM model specifies the first difference in the dependent variable as a function of this error lagged one period, this model is rewritten as:

$$\Delta LQP_t = a + b\Delta LWFQ_t + c\Delta LIPR_t + dECT_{(t-1)} + \varepsilon_t$$

where $\Delta LQP$ is the first difference of Chinese plywood production, $\Delta LWFQ$ is the first difference of Chinese wooden furniture production, $\Delta LIPR$ is the first difference of the real price of Chinese logs, the coefficient $a$ is a constant term, $b$ and $c$ are respectively the scale and price elasticities, $d$ is the coefficient for ECT and $\varepsilon$ is the error term. The signs under the coefficients denote a priori signs of the estimated coefficients.
The estimated coefficients for this model are shown below with t-values in parentheses (see Appendix IVB Model II):

$$\Delta LQP_t = 0.15 + 0.40 \Delta LWFQ_t + 0.94 \Delta LIPR_t - 0.92^* ECT_{(t-1)}$$  \hspace{2cm} (5.6)

\hspace{2cm} (1.92) \hspace{2cm} (1.92) \hspace{2cm} (1.51) \hspace{2cm} (-4.50)

As shown above, the coefficients on $\Delta LWFQ$ and on the lagged ECT have the expected signs. The coefficient on $\Delta LIPR$ has the positive sign that is against what we would expect from economic theory, but the effect in the short term may differ from the long-term relation, as economic theory concerns long-term equilibrium. The coefficient on the lagged ECT indicates that Chinese plywood production adjusts on over 92% over one year.

Comparing with the level model, the adjusted $R^2$ in the ECM is a bit low, which is 0.63. The F-statistic shows that all of the regression coefficients are significant, with the p-value of 0.00. The DW statistic indicates no serial correlation, with the p-value of 2.04. Since the p-values from the BG serial correlation LM test, JB test and heteroskedasticity test are all greater than 0.05, there do not seem to be any problems with autocorrelation, normality and heteroskedasticity in the residual series. Based on the result of unit root test, t-stat (-3.60) is greater than the critical value at the 1% (-2.75), 5% (-1.97) and 10% level (-1.60), so there is no unit root in residual series and the residuals are stationary, denoted by I(0).

5.2.4 Results for Chinese Plywood Export Model

5.2.4.1 Level Model

The equation (3.5) indicates a simple linear regression model with $LEP$ (the exports of Chinese plywood) as the dependent variable, $LUS$ (the US consumer income) and $LEPR$ (the real export price of Chinese plywood to the US) as the explanatory variables. This static demand equation is estimated by the method of OLS. In this model, the period from 1993 to 2007 is taken into consideration, and thus 15 observations are included. Since the
program used shows a wrong sign of the coefficient on \( LEPR \), which is against what we would expect from economic theory, the output file of results will exclude this factor.

The estimated coefficients for this model are shown below with t-values in parentheses (see Appendix IVC Model I):

\[
LEP_t = -175.91 + 17.13LUS_t + u_t
\]  
\[
(5.7)
\]

\[
(-11.60) \quad (12.04)
\]

As presented above, the coefficient on \( LUS \) has the expected signs. Since it is 17.31 > 1, Chinese plywood exports appear to be highly income elastic. And the p-value of t-statistics also shows that Chinese plywood exports appear to be highly dependent on the US consumer income, with the significance level of 1%, for its p-values are 0.00. Hence, the null hypothesis of a zero coefficient is rejected.

The model has a good fit, as it explains 91% of the variance of the plywood export series (i.e., \( R^2 = 0.91 \)). The F-statistic shows that all of the regression coefficients are significant, with the p-value of 0.00. The DW statistic indicates serial correlation problems. Since the p-values from the BG serial correlation LM test, JB test and heteroskedasticity test are all greater than 0.05, the model does not suffer from serial correlation, non-normality and heteroskedasticity in the residual series. Based on the result of unit root test, t-stat (-2.27) is greater than the critical value at the 5% (-1.97) and 10% level (-1.60), so there is no unit root in residual series, the residuals are stationary and we can assume that these two variables are cointegrated.

**5.2.4.2 Error Correction Model**

Given the result that Chinese plywood exports and the US consumer income are cointegrated, a long-run equilibrium relationship exists between these two variables: \( LEP \) and \( LUS \). Thus, the residuals from the equilibrium regression equation (5.7) can be used to estimate the ECM to determine the short-run dynamics.
Since the ECM model specifies the first difference in the dependent variable as a function of this error lagged one period, this model is rewritten as:

\[ \Delta LEP_t = a + b \Delta LUS_t + cECT_{(t-1)} + \varepsilon_t \]  

(5.8)

where \( \Delta LEP \) is the first difference of Chinese plywood exports, \( \Delta LUS \) is the first difference of the US GDP, the coefficient \( a \) is a constant term, \( b \) is the income elasticity, \( c \) is the coefficient for ECT and \( \varepsilon \) is the error term. The signs under the coefficients denote a prior signs of the estimated coefficients.

The estimated coefficients for this model are shown below with t-values in parentheses (see Appendix IVC Model II):

\[ \Delta LEP_t = 0.22 + 4.82 \Delta LUS_t - 0.50*ECT_{(t-1)} \]  

(5.9)

(0.88)   (0.43)   (-2.08)

As shown above, the coefficients on \( \Delta LUS \) and on the lagged ECT have the expected signs. The coefficient on the lagged ECT indicates that Chinese plywood exports adjust on more than 50% over one year. So, it takes two years for the total adjustment.

Comparing with the level model, the adjusted \( R^2 \) in the ECM is very low, which is 0.15. The F-statistic shows that all of the regression coefficients are not significant, with the p-value of 0.16 (> 0.05). The DW statistic indicates no serial correlation, with the p-value of 2.52. The p-values from the BG serial correlation LM test and heteroskedasticity test are both greater than 0.05, there do not appear to be any problems with autocorrelation and heteroskedasticity in the residual series. Whereas, the p-value from the JB test is 0.01, less than 0.05, indicating the residuals are not normally distributed. Based on the result of unit root test, t-stat (-4.51) is greater than the critical value at the 1% (-2.75), 5% (-1.97) and 10% level (-1.60), so there is no unit root in residual series and the residuals are stationary, denoted by I(0). Finally, we can conclude that the results of this model are not satisfactory. Actually, there are problems already in the level specification.
6. SUMMARY, CONCLUSION AND DISCUSSION

6.1 Summary of the Results

China's rapid economic growth and huge population have resulted in the growing domestic demand for wood products, China's low labour costs have led to the growing international demand for Chinese manufactured wood products. While, these demands have outpaced the supply of domestic wood resources. As a result, China's wood processing industry relies heavily on imported raw materials, which are processed into finished products to either consume in the domestic market or export to overseas destinations.

The increasing competition from China in international wood products markets stresses the importance to study the Chinese market. Understanding the demand and supply of a particular industry is important for policy makers and for the industry stakeholders; and as an emerging international market, China is also of especial interest to foreign producers and investors who are ready to tap into the Chinese market.

There were only a few previous studies on China's forest products markets. For example, Wang and Wu (2000) investigated the influential factors affecting the demand and supply of plywood in Taiwan, Li et al. (2006) investigated the demand pattern for paper and paperboard products in China, and Zhang et al. (2007a) examined the development of China's wood processing industry. Yet, there is a lack of studies on analysis of China’s primary wood products market. So, a major purpose of the study is to describe and analyze China's demand, supply, imports and exports of primary wood products, focusing on sawnwood and plywood. As the raw material for sawnwood and plywood industries and their dependence on imported logs, logs are also included in the analysis. Since plywood is the most important primary wood products in China and China's exports of plywood play a key role in global trade, another purpose of the study is to estimate the factors affecting the demand, supply and exports of plywood.
In accompanying these purposes, both descriptive analysis and explanatory analysis are carried out in the study: background information and markets are analyzed with the descriptive method, while the data for empirical modelling is analyzed with the statistical method. Since data from different sources vary a lot, many efforts have been made to obtain more accurate and more reliable data. The annual data from 1993 to 2007 used for the analyses are mainly gathered from original official Chinese sources, such as China Statistical Yearbook, China Customs Statistics, the State Forestry Administration of China and the National Bureau of Statistics of China. In addition, international sources, such as the World Bank Development Indicator Database and the US Bureau of Labour Statistics are applied.

Descriptive analysis focuses on three research questions: the factors affecting China's demand and supply of wood and wood products, the general trends in China's demand, supply and trade of logs, sawnwood and plywood, and China's impacts on the global forest products markets. Answering the first question, major factors affecting China's demand for wood (here it refers to logs) and wood products include population, income, prices of the products themselves and substitute products (non-wood products), consumer preferences, housing reform and investments in public construction. As mentioned earlier, China's big population spurs consumer demand for wood products, but the slow population growth resulted from the country's population policy would affect China's consumption of wood products in the long run; rising income driven by robust GDP growth has raised China's emerging middle class' spending on wooden furniture and interior wood products; housing reform, coupled with growing consumer affluence, has generated a boom in repair and remodelling and has thus stimulated people's per capita demand for wood products; in addition, recent rapid growth of the public construction sector has had a significant impact on the consumption of wood products. As for wood raw materials, apart from population and income, forest policies and biological factors in relation to climate change may affect their supply. Increasing population density increases the pressure to convert forestland into other uses; higher income tends to result in higher demand for environmental services from
forests (Food and Agriculture Organization of the United Nations (FAO), 1999), which is likely to put pressure on forest resources. China's policies on conservation of national forest resources and the development of forest plantations would affect wood supply. Global climate change may significantly influence forest productivity and security of wood supply.

With regard to the second question, the domestic log supply has failed to keep up with the growing log demand because of a combination of factors: China's limited per capita forest resources, government decision to protect forests, the spectacular increase in domestic consumption of wood products and export demand for China's low-cost wood products. Although the Chinese government has invested heavily in plantation projects to increase forest resources, China is still facing significant shortages in domestic log production. This has fuelled the rapid rise in China's log imports. With the continuing demand for Chinese manufactured wood products, the demand for both home-grown and imported logs is expected to grow. But limited supplies and rising prices of logs will mitigate further increase in the demand for logs (White et al., 2006). For example, Russian rising export tariffs on raw wood has considerably reduced China's import demand for logs. It is therefore anticipated that the growth of log imports will remain at a slower rate in the coming years.

As to sawnwood, China's major end use sectors are packaging, construction, furniture and decoration. The Chinese government has been undertaking initiatives to increase housing and building. Chinese housing reform that aims to achieve the privatisation of public housing has stimulated the demand for affordable, energy-efficient and quality homes with better amenities, and new construction is expected to drive steadily increasing demand for hardwood used for interiors. Reviewing the history, China's sawmilling industry has undergone transitions since 1998. The impact of the logging ban has made China face significant shortages in domestically produced sawlogs and rely heavily imported sawlogs for the production of domestic sawnwood. With the implementation of the NFPP in 1998, Chinese domestic annual production of sawnwood declined sharply. But because of the
increase in log imports, especially the growing availability of imported Russian logs, and the growth in the demand for construction, furniture-manufacturing and interior decoration, sawnwood production began to recover in 2000. (U.S. International Trade Commission, 2006). Despite the dramatic increase in Russian log export tariffs, Russia's policies on encouraging the development of its own wood processing industry may contribute to the growth of its sawnwood exports in the near future. Besides Russia, China imported sawnwood mainly from the US, Canada, Thailand, Malaysia, Brazil and Chile in 2008. Owing to the insufficiency of forest resources, the Chinese government had strictly controlled sawnwood exports before 1990; but then China’s sawnwood exports started to increase because of higher sawnwood international prices; for the past few years, the exports have dropped again due to the expansion of domestic demand and the adjustment in China's trade policy. In 2008, only a small portion of sawnwood was exported to the US and South Korea (China's Wood Imports...2008, 2008). Fuelled by rapid economic growth, improved living standards, lifestyle changes, expansion of the furniture and interior decoration industries and developments in the construction industry, China's plywood industry has grown dramatically. China is the largest manufacturer and exporter of plywood in the world. From 1993 to 2007, China's plywood trade had developed at a frantic pace. However, affected by a fall in the US exports, China's plywood exports fell markedly in the first three quarters of 2008: down 13% by volume from the same period in 2007. The US, the United Arab Emirates, Japan, the UK, Saudi Arabia and South Korea were the top destination countries. Meanwhile, the plywood imports continued to decrease - down 1.8% in volume from the same period in 2007, and they were mainly sourced from Indonesia and Malaysia (China's Wood Imports...2008, 2008). As Chinese plywood industry relies heavily on imported logs, the future development of Chinese plywood exports also depends on the availability of the imported logs for production.

Concerning the third question, the factors impacting the global forest products markets include: China's imports of logs and timber, China's position in the global commodity chain and the structural change in China's imports of wood products. China is the largest importer
of tropical timber in the world, with sources predominantly coming from countries in SEA and the Pacific Region (Stark and Cheung, 2006). According to recent estimates, at least 80% of Chinese timber imports from Brazil, Cambodia, Cameroon, Congo-Brazzaville, Equatorial Guinea, Gabon, Indonesia, Myanmar, Papua New Guinea, and the Solomon Islands are illegal, with 50-60% for Malaysia and Russia (Laurance and Sills, 2008). China's large imports of illegally harvested logs and illegally sourced timber have caused forest degradation and deforestation in supplying countries, undermined global efforts to promote sustainable forest management, eroded public confidence in the international trade of legally harvested and traded wood. As the world wood workshop situated in the middle of a global commodity chain, China's wood processing industry has become increasingly vulnerable to the problems associated with the supply of raw materials, to changing buyer preference and trade regulations. Those major purchasing markets (the US, Japan and the EU) have become more social and environmentally sensitive, especially to the issue of illegal logging. While, taking advantage of low production costs, China has changed the nature of its wood products imports - instead of importing large amounts of value-added products (e.g., plywood) in the late 1990s, the country now plays a key role in the global trade by importing large quantities of logs or barely processed wood products (e.g., sawnwood) and re-manufacturing them into value-added wood products (e.g., plywood and wooden furniture) for export. This has had a serious impact on plywood and wooden furniture manufacturers globally, who have not only lost their share of Chinese markets, but have also been out-competed in other markets by cheaper Chinese value-added products.

By employing econometric models, explanatory analysis focuses on the research question about the elasticities of demand, supply and exports of Chinese plywood, which are estimated by using annual data over the period 1993-2007. The short-term and long-term elasticities obtained from the empirical models provide useful information about the relative importance of income and price factors influencing the demand, supply and export of plywood in China. Based on the results, Chinese plywood demand appears to be income elastic but price inelastic in the long term, indicating that the growth in Chinese plywood
demand had been due to the growth in Chinese consumer income (i.e., China's GDP), while the price increases had only a small negative effect on the plywood demand. Low price elasticity reflects the fact that the use of plywood in Chinese construction, wooden furniture or other end uses is relatively small. If a commodity is used in small quantities in the consumer economy, price may not play such an important role in its use. In terms of Chinese plywood supply, it seems that the production of plywood is highly elastic with respect to raw material price (i.e., log price) but scale inelastic, suggesting that the plywood supply is highly dependent on log price but the end-use sector activity (i.e., the production of wooden furniture) does not have a significant effect on the plywood supply. One explanation for the inelasticity of the end-use sector activity is that there may be errors or inaccuracies in data variables. The reason why the variable does not describe the end use of plywood well enough could be: 1) it is used in some other industries or purposes or 2) the data are erroneous or inaccurate. In our case, a probable explanation is the data are not so accurate. In addition, Chinese plywood exports appear to be highly income elastic, meaning to be highly dependent on the importing market's consumer income (i.e., the US consumer income).

6.2 Conclusion

The dramatic rise of China's wood products industry and its strong impacts on the world markets present a number of opportunities and challenges for the forest products companies and investors outside China, including Finnish forest industry companies. In terms of opportunities, five major issues can be pointed out. First, China has a large consumer base. China's massive population and spectacular economic growth have brought about the country's rising consumer demand for higher quality housing and better furniture. The market for logs, sawnwood, plywood, wooden furniture and other wood products has been and will continue to expand. This provides international suppliers with a large consumer base and an opportunity to enter the China market. Major Finnish forest industry companies, like Stora Enso and UPM, have already led the way and built a strong customer base in
China by establishing pulp and paper businesses. Their previous performance and achievements would provide a solid foundation for further developing their wood products business in China. Second, China's relatively limited wood resources present an opportunity for imported raw materials to support Chinese-based wood processing industry. Forestry companies with the sources, skills and logistics to supply cost-competitive raw materials into China have significant opportunities in this market. Third, China offers a huge opportunity for imported processed wood products. China's entry into the WTO has led to a wave of economic and trade liberalization in China, involving substantial reductions of its tariffs and non-tariff trade barriers. It creates many export opportunities for foreign wood products industries. For instance, China's continued dependence on imported sawnwood provides an opportunity for Finnish sawnwood exporters. As China continues to expand its new commercial and residential construction, its demand for cost-effective wood building products such as flooring, structural panels and load bearing applications drives the consumption of engineered wood products (EWPs). This could open up new opportunities for Finnish wood processing industry. Fourth, China's commitments in carrying out reforms to comply with the WTO, together with its comparative advantage of low production costs, large domestic market, abundant labour and ability to quickly expand production capacity have enabled it to be a magnet for FDIs. China has emerged as the most competitive manufacturing platform in the world. This is an important motive for those Finnish investors who possess advanced production facilities, modern production equipments and technical know-how to make manufacturing investments in China. Fifth, in order to attract foreign investment and create a favorable operating environment for overseas investors, the Chinese government has provided a number of preferential policies for foreign-invested enterprises. Regulations for foreign investments in China are generally favorable for the forest products industry.

In addition to the opportunities, China's wood products market also presents five main challenges for foreign investors. First, China's domestic wood supply is increasing at a slower pace than its wood products demand and exports surge. The shortage of wood raw
materials and rising raw material costs is a growing problem in China, so productivity is a key to improve the overall competitiveness of Chinese forest products industry. Chinese can offset the rising raw material costs either by using more domestic plantation species at lower costs or by incorporating more technology to engineer products and to lower raw material input costs (Taylor, 2005). The second challenge is the rising unit costs of production in the long term. As the economy grows and the manufacturing industries expand, costs of raw materials, energy, oil transportation and labour for wood processing will increase (Jaakko Pöyry Consulting, 2006). Currently, China's plywood can compete well in the international market due to low production costs, but this advantage is being weakened or may be lost because of the increasing costs of oil that is affecting energy costs in production also land transportation and shipping costs (Global Wood Trade Network, 2005). The third challenge is the competition from non-wood building and construction products as well as the increased competition from international suppliers who enter the Chinese market. Fourth, the global economic slowdown has had an impact on China's economy, reflecting the slowdown of China's external trade, domestic consumption and foreign investment. The slowdown in the US and Europe has caused the decline of the US housing market and the European construction market, and has thus influenced Chinese wood product exporters. The drop in global consumer demand has led to a wave of factory closures and layoffs, and has therefore made large numbers of migrant workers lose their jobs, especially in China's export-driven southeast. This has consequently widened the income gap between urban and rural areas in China and greatly affected the domestic consumption of wood products. In addition, as the global downturn slowed capital flows, it is estimated that FDI in China will shrink. Fifth, China is a big country with different culture from western countries; bureaucracy and corruption are two governance problems. Bureaucracy makes the application process for new investments in China rather complicated and corruption in log trade enables illegal logging. Because of China's different business practices and strategies, fully understanding the local culture, social and economic background is a preliminary requirement for doing business in China; and developing business in China is a long process.
6.3 Discussion

By using both descriptive and explanatory research methods, this study produces the information and increases the understanding on the Chinese forest products markets, which were analyzed and modelled in a few earlier studies. Although there is much information on the Chinese markets, reliable historical time-series data are difficult to acquire. This may be one reason why quite a few models were developed before.

In the present study, three models (Chinese plywood demand, supply and export models) are developed. Regarding the demand model, in the previous studies, for example, Li et al. (2006) reported that the domestic demand elasticity of China's paper and paperboard with respect to GDP was 1.01, Buongiorno (1979) estimated the long-term income elasticity for plywood by using panel data from 43 countries was 0.95. Both of the income elasticities were close to 1, and in many other studies on forest products' demand, the income elasticities have also been close to unitary. By comparison, in the present study, the income elasticity for China's plywood is 1.11, which is close to 1 as well. It suggests that as the Chinese economy continues to grow, the demand for domestic plywood will grow at the same rate. Concerning the supply model, we can compare the results from Wang and Wu's study in 2000 and the current study. Wang and Wu (2000) estimated the domestic supply elasticity of Taiwan's plywood with respect to the product price (plywood price), the raw material price (import price of hardwood logs) and the end-use sector activity (area of domestic house building) were 1.75, -1.02 and 0.31, respectively. By comparison, the results of the present study demonstrate that the domestic supply elasticity of China's plywood in relation to the raw material price (import price of logs) and the end-use sector activity (production of domestic wooden furniture) are -1.67 and 0.72, respectively. It seems that the price elasticity for Taiwan's plywood supply in relation to the raw material price was unitary, indicating that as the price of imported hardwood logs increased, the supply of plywood in Taiwan would decrease at the same rate. The change in the price of imported logs in the present study has a larger effect on the supply of plywood in China. Nevertheless, the scale elasticity of plywood supply in China shows a result more in line
with the previous studies of forest products than the one in Taiwan, although they both reveal scale inelasticity. It should be noted that, owing to data and modelling technical limitations, in the course of modelling the supply and export of Chinese plywood, the analyses show the wrong sign of the coefficient on the plywood price, which is against economic theory.

Due to limited time and space, only preliminary models with a relatively small sample size (containing 15 observations) for Chinese plywood were possible to produce. The difficulty in obtaining accurate data for the study might have been the reason why some models could not give very satisfactory results. Even though, we hope that the present results from the descriptive analysis and statistical models are useful references for wood processing companies, especially for sawnwood and plywood firms, and governmental agencies in China. In order to achieve more satisfactory results, future research should focus on obtaining a larger sample size and making efforts to gather more accurate data. However, the findings of this study can be used in a range of applied works for further research area, and there is an evident need for further analyses, models and synthesis.
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APPENDIX I: China's GDP and Its Annual Growth Rate

Table A1. China’s Nominal GDP and Its Year-on-Year Growth Rate, 1993-2007

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</thead>
<tbody>
<tr>
<td>GDP (Billion USD)</td>
<td>440.5</td>
<td>559.2</td>
<td>728.0</td>
<td>856.1</td>
<td>952.7</td>
<td>1019.5</td>
<td>1083.3</td>
<td>1198.5</td>
<td>1324.8</td>
<td>1453.8</td>
<td>1641.0</td>
<td>1900.0</td>
<td>2227.4</td>
<td>2688.1</td>
<td>3570.0</td>
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<tr>
<td>GDP (Trillion USD)</td>
<td>0.44</td>
<td>0.56</td>
<td>0.73</td>
<td>0.86</td>
<td>0.95</td>
<td>1.02</td>
<td>1.08</td>
<td>1.20</td>
<td>1.32</td>
<td>1.45</td>
<td>1.64</td>
<td>1.98</td>
<td>2.33</td>
<td>2.67</td>
<td>3.57</td>
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</tbody>
</table>

Sources: **GDP**


2004: China Revises Figures…Growth, 2006;

2005: Zhu, 2007;


2007: China Revises upward… 11.9 Per Cent, 2008

Year-on-year growth rate


2005: Zhu, 2007;

2006: Reuters, 2008;

2007: China Revises upward… 11.9 Per Cent, 2008
APPENDIX II: China's Production and Trade of Logs, Sawnwood and Plywood

Table B1. China's Production and Trade of Logs (including both softwood and hardwood logs), 1993-2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Volume (1000 m$^3$)</th>
<th>Import Volume (1000 m$^3$)</th>
<th>Import Value (1000 US$)</th>
<th>Import Price (US$/m$^3$)</th>
<th>Export Volume (1000 m$^3$)</th>
<th>Export Value (1000 US$)</th>
<th>Export Price (US$/m$^3$)</th>
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<tr>
<td>1993</td>
<td>58,610</td>
<td>3,459</td>
<td>132.72</td>
<td>154</td>
<td>459.43</td>
<td>475.78</td>
<td>496.54</td>
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<tr>
<td>1994</td>
<td>60,100</td>
<td>3,335</td>
<td>129.06</td>
<td>91</td>
<td>465.48</td>
<td>485.40</td>
<td>496.54</td>
</tr>
<tr>
<td>1995</td>
<td>62,470</td>
<td>2,583</td>
<td>142.64</td>
<td>97</td>
<td>496.54</td>
<td>465.48</td>
<td>496.54</td>
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<tr>
<td>1996</td>
<td>60,730</td>
<td>3,185</td>
<td>143.71</td>
<td>64</td>
<td>390.25</td>
<td>297.14</td>
<td>313.04</td>
</tr>
<tr>
<td>1997</td>
<td>59,350</td>
<td>4,462</td>
<td>124.21</td>
<td>63</td>
<td>347.86</td>
<td>301.04</td>
<td>313.04</td>
</tr>
<tr>
<td>1998</td>
<td>55,560</td>
<td>4,823</td>
<td>123.19</td>
<td>32</td>
<td>297.14</td>
<td>297.14</td>
<td>313.04</td>
</tr>
<tr>
<td>1999</td>
<td>48,487</td>
<td>10,136</td>
<td>121.63</td>
<td>23</td>
<td>27</td>
<td>27</td>
<td>313.04</td>
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<tr>
<td>2000</td>
<td>43,957</td>
<td>1,248,832</td>
<td>100.45</td>
<td>27</td>
<td>18</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>2001</td>
<td>41,970</td>
<td>1,665,840</td>
<td>87.88</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2002</td>
<td>41,270</td>
<td>2,138,415</td>
<td>96.16</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>2003</td>
<td>43,200</td>
<td>2,447,940</td>
<td>106.58</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>2004</td>
<td>47,120</td>
<td>2,797,100</td>
<td>110.46</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2005</td>
<td>50,230</td>
<td>3,244,000</td>
<td>122.21</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2006</td>
<td>61,120</td>
<td>3,929,266</td>
<td>144.26</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2007</td>
<td>64,921</td>
<td>5,350,610</td>
<td>8.70%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: NA = Not Available

Sources: **Production volume**

*1993-2006*: Lu, 2007;


**Import volume and import value**


*2005*: China's Imports…2005, 2006;


**Export volume and export value**

Table B2. China's Production and Trade of Sawnwood (including both softwood and hardwood sawnwood), 1993-2007

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Volume (1000 m³)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>14,010</td>
<td>12,943</td>
<td>41,638</td>
<td>24,424</td>
<td>20,124</td>
<td>17,876</td>
<td>15,859</td>
<td>6,944</td>
<td>7,638</td>
<td>8,516</td>
<td>11,269</td>
<td>15,325</td>
<td>17,902</td>
<td>24,865</td>
<td>28,291</td>
<td>1,02</td>
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<tr>
<td>1994</td>
<td>1,413</td>
<td>935</td>
<td>863</td>
<td>938</td>
<td>1,331</td>
<td>1,690</td>
<td>2,756</td>
<td>3,614</td>
<td>4,034</td>
<td>5,396</td>
<td>5,998</td>
<td>6,052</td>
<td>5,973</td>
<td>6,068</td>
<td>6,491</td>
<td>3,6</td>
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<tr>
<td><strong>Import Volume (1000 m³)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>1993</td>
<td>153,075</td>
<td>145,615</td>
<td>149,133</td>
<td>180,087</td>
<td>268,110</td>
<td>348,260</td>
<td>361,938</td>
<td>982,031</td>
<td>988,518</td>
<td>1,139,000</td>
<td>1,357,000</td>
<td>1,827,006</td>
<td>1,688,513</td>
<td>1,761,978</td>
<td>10,5</td>
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<td><strong>Import Value (1000 US$)</strong></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>1993</td>
<td>108,32</td>
<td>155,76</td>
<td>172,81</td>
<td>191,89</td>
<td>201,36</td>
<td>206,03</td>
<td>240,15</td>
<td>271,75</td>
<td>245,04</td>
<td>214,79</td>
<td>228,19</td>
<td>252,44</td>
<td>278,27</td>
<td>271,47</td>
<td>1,5</td>
<td></td>
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<tr>
<td>1994</td>
<td>313</td>
<td>366</td>
<td>409</td>
<td>384</td>
<td>390</td>
<td>258</td>
<td>355</td>
<td>414</td>
<td>450</td>
<td>431</td>
<td>543</td>
<td>496</td>
<td>673</td>
<td>804</td>
<td>748</td>
<td>1,4</td>
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<tr>
<td><strong>Export Volume (1000 m³)</strong></td>
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</tr>
<tr>
<td>1993</td>
<td>424,90</td>
<td>446,14</td>
<td>476,10</td>
<td>505,33</td>
<td>497,49</td>
<td>445,53</td>
<td>383,06</td>
<td>432,36</td>
<td>437,71</td>
<td>441,04</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>439,29</td>
<td>520,40</td>
<td>22,5 %</td>
</tr>
</tbody>
</table>

Note: NA = Not Available

Sources:

**Production volume**


*2004*: Jiangxi Province Forestry Bureau, 2005;

*2005-2006*: China State Forestry Administration (SFA), 2007;


**Import volume**


*2002*: Cheng et al., 2003;

*2003*: Lu, 2007;
2004: Cheng et al., 2004;
2005-2006: Qin, 2007b;

**Import value**

2002: Cheng et al., 2003;
2003-2004: Cheng et al., 2004;
2005-2006: Qin, 2007b;

**Export volume**

2002: Cheng et al., 2003;
2003: Abstract of...2004, 2004;
2004: Yu, 2005;
2005: Slowdown Growth...2005, 2006;

**Export value**

2002: Cheng et al., 2003;
Table B3. China's Production and Trade of Plywood (including both softwood and hardwood plywood), 1993-2007

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Volume</strong> (1000 m³)</td>
<td>2,125</td>
<td>2,606</td>
<td>7,593</td>
<td>4,903</td>
<td>7,585</td>
<td>4,465</td>
<td>7,276</td>
<td>9,925</td>
<td>9,045</td>
<td>11,352</td>
<td>21,024</td>
<td>20,986</td>
<td>25,150</td>
<td>27,288</td>
<td>35,616</td>
</tr>
<tr>
<td><strong>Import Volume</strong> (1000 m³)</td>
<td>2,229</td>
<td>2,109</td>
<td>2,083</td>
<td>1,775</td>
<td>1,488</td>
<td>1,691</td>
<td>1,042</td>
<td>1,002</td>
<td>651</td>
<td>636</td>
<td>798</td>
<td>799</td>
<td>589</td>
<td>413</td>
<td>306</td>
</tr>
<tr>
<td><strong>Import Value</strong> (1000 US$)</td>
<td>762,163</td>
<td>816,257</td>
<td>773,676</td>
<td>643,835</td>
<td>605,462</td>
<td>543,617</td>
<td>415,837</td>
<td>436,784</td>
<td>254,445</td>
<td>259,720</td>
<td>347,960</td>
<td>347,470</td>
<td>278,292</td>
<td>197,361</td>
<td>170,000</td>
</tr>
<tr>
<td><strong>Export Volume</strong> (1000 m³)</td>
<td>94</td>
<td>103</td>
<td>129</td>
<td>177</td>
<td>438</td>
<td>177</td>
<td>423</td>
<td>687</td>
<td>965</td>
<td>1,793</td>
<td>2,041</td>
<td>4,306</td>
<td>5,584</td>
<td>8,304</td>
<td>6,782</td>
</tr>
<tr>
<td><strong>Export Value</strong> (1000 US$)</td>
<td>33,539</td>
<td>31,635</td>
<td>39,088</td>
<td>62,286</td>
<td>151,509</td>
<td>64,960</td>
<td>123,648</td>
<td>188,958</td>
<td>242,272</td>
<td>436,990</td>
<td>495,750</td>
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<td>1,836,000</td>
<td>2,910,000</td>
<td>3,580,000</td>
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</table>

Sources:

**Production volume**

*1993*: Sun, 1996;


*2003*: Qin, 2004;

*2004-2006*: China's Production...Years, 2008;

*2007*: China's Imports...Drop, 2008.

**Import volume**


*2002-2003*: Lu, 2007;

*2004-2006*: China's Production...Years, 2008;


**Import value**


*2002-2004*: Qin, 2005;
2005-2006: Qin, 2007b;

**Export volume**

2002-2003: Lu, 2007;
2004-2006: China's Production…Years, 2008;

**Export value**

2002-2004: Qin, 2005;
2006: Qin, 2007a;
Table B4. China’s Imports of Sawnwood (including both softwood and hardwood sawnwood) by Main Country of Origin, 2007

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume ('000 cu.m)</th>
<th>Proportion (%)</th>
<th>Increase over 2006 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia</td>
<td>1 585</td>
<td>24.2</td>
<td>35</td>
</tr>
<tr>
<td>USA</td>
<td>1 073</td>
<td>16.4</td>
<td>5</td>
</tr>
<tr>
<td>Canada</td>
<td>675</td>
<td>10.3</td>
<td>69.6</td>
</tr>
<tr>
<td>Malaysia</td>
<td>310</td>
<td>4.7</td>
<td>-17.6</td>
</tr>
<tr>
<td>Brazil</td>
<td>279</td>
<td>4.3</td>
<td>-18.2</td>
</tr>
<tr>
<td>Myanmar</td>
<td>260</td>
<td>4</td>
<td>46.1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>258</td>
<td>3.9</td>
<td>-42.7</td>
</tr>
<tr>
<td>New Zealand</td>
<td>252</td>
<td>3.8</td>
<td>-10.3</td>
</tr>
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</table>


Table B5. China’s Exports of Sawnwood (including both softwood and hardwood sawnwood) by Main Country / Region of Destination, 2007

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume ('000 cu.m)</th>
<th>Proportion (%)</th>
<th>Value (USD '000)</th>
<th>Increase over 2006 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>402.6</td>
<td>53.9</td>
<td>223 396</td>
<td>57.3</td>
</tr>
<tr>
<td>Korea</td>
<td>86.3</td>
<td>11.5</td>
<td>32 953</td>
<td>8.5</td>
</tr>
<tr>
<td>USA</td>
<td>65.1</td>
<td>8.7</td>
<td>29 751</td>
<td>7.6</td>
</tr>
<tr>
<td>Taiwan (PRC)</td>
<td>32.2</td>
<td>4.3</td>
<td>11 567</td>
<td>3</td>
</tr>
<tr>
<td>Vietnam</td>
<td>30.9</td>
<td>4.1</td>
<td>11 238</td>
<td>2.9</td>
</tr>
</tbody>
</table>


Table B6. China’s Imports of Plywood (including both softwood and hardwood plywood) by Main Country of Origin, 2007

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume ('000 cu.m)</th>
<th>Proportion (%)</th>
<th>Value (USD '000)</th>
<th>Increase over 2006 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1 997</td>
<td>22.7</td>
<td>974 662</td>
<td>27.2</td>
</tr>
<tr>
<td>Japan</td>
<td>701</td>
<td>8</td>
<td>247 317</td>
<td>6.9</td>
</tr>
<tr>
<td>UK</td>
<td>486</td>
<td>5.5</td>
<td>181 449</td>
<td>5.1</td>
</tr>
<tr>
<td>UAE</td>
<td>387</td>
<td>4.4</td>
<td>127 696</td>
<td>3.6</td>
</tr>
<tr>
<td>Taiwan (PRC)</td>
<td>387</td>
<td>4.4</td>
<td>101 285</td>
<td>2.8</td>
</tr>
<tr>
<td>Germany</td>
<td>277</td>
<td>3.2</td>
<td>118 878</td>
<td>3.3</td>
</tr>
<tr>
<td>Hong Kong, SAR</td>
<td>258</td>
<td>2.9</td>
<td>64 603</td>
<td>1.8</td>
</tr>
<tr>
<td>Egypt</td>
<td>230</td>
<td>2.6</td>
<td>73 538</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Table B7. China’s Exports of Plywood (including both softwood and hardwood plywood) by Main Country / Region of Destination, 2007

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume ('000 cu.m)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>254.9</td>
<td>11.2</td>
</tr>
<tr>
<td>USA</td>
<td>219.1</td>
<td>9.6</td>
</tr>
<tr>
<td>UAE</td>
<td>171.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Korea</td>
<td>169.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Yemen</td>
<td>147.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Canada</td>
<td>133.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Russia</td>
<td>123.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Syria</td>
<td>121.3</td>
<td>5.3</td>
</tr>
</tbody>
</table>


Table B8. Five Key Plywood (including both softwood and hardwood plywood) Manufacturers in Pizhou Area

<table>
<thead>
<tr>
<th>Company name</th>
<th>Products</th>
<th>Annual production capacity</th>
<th>Certificates</th>
<th>Export markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterling Pacific (Xuzhou Shenghe) Wood Products Co., Ltd.</td>
<td>Plywood (fancy and film-faced) Multi-layer engineered flooring</td>
<td>120 000 (cu.m)</td>
<td>ISO9001-2000, CCE, ISO14001</td>
<td>Europe, U.S., etc.</td>
</tr>
<tr>
<td></td>
<td>Multi-layer engineered flooring</td>
<td>1 000 000 (sq.m)</td>
<td>ISO9001</td>
<td></td>
</tr>
<tr>
<td>Xuzhou Fuxiang Wood Company Ltd. (Meilinsen)</td>
<td>Plywood (general, film-faced, wire mesh, birch face/back, MDO and HDO) Multi-layer engineered flooring LVL products</td>
<td>160 000 (cu.m)</td>
<td>CE (EN-13986), ISO9001 and ISO14000</td>
<td>Europe, Middle East and North America</td>
</tr>
<tr>
<td></td>
<td>Multi-layer engineered flooring</td>
<td>18 000 000 (sq.m)</td>
<td>ISO9001</td>
<td></td>
</tr>
<tr>
<td>Xuzhou Qingshan Wood Co., Ltd.</td>
<td>Plywood (general, fancy and film-faced) Container flooring</td>
<td>100 000 (cu.m)</td>
<td>CE, ISO9001:2000 and ISO14000</td>
<td>Southeast Asia, Middle East, Europe, U.S.</td>
</tr>
<tr>
<td>Xuzhou Xinxin Timber Co., Ltd.</td>
<td>Plywood (high-grade, fancy) Floor and concrete forming</td>
<td>8 000 (cu.m)</td>
<td>CE, ISO9001</td>
<td>U.S., Europe and Middle East</td>
</tr>
<tr>
<td>Xuzhou Zhongyuan Wood Co., Ltd. (JV)</td>
<td>UV and colored UV plywood, maple, red oak, cherry, birch, poplar and combined plywood with E1, E2, WBP and MEL glue</td>
<td>80 000 (cu.m)</td>
<td>CE, ISO9001 and ISO14001</td>
<td>U.S. and Europe</td>
</tr>
</tbody>
</table>

Source: China International Plywood Trade Fair, 2008.
APPENDIX III: Time Series Properties of the Data

Figure A1. LACP and the First Difference (DLACP) with the Respective Correlograms

![Graph showing LACP and DLACP with correlograms]
Figure A2. LEP and the First Difference (DLEP) with the Respective Correlograms
Figure A3. LEPR and the First Difference (DLEPR) with the Respective Correlograms
Figure A4. LGDPR and the First Difference (DLGDPR) with the Respective Correlograms
Figure A5. LIPR and the First Difference (DLIPR) with the Respective Correlograms
Figure A6. LQP and the First Difference (DLQP) with the Respective Correlograms
Figure A7. LUS and the First Difference (DLUS) with the Respective Correlograms
Figure A8. LWFQ and the First Difference (DLWFQ) with the Respective Correlograms
APPENDIX IV: Models for Chinese Plywood

APPENDIX IVA: Chinese Plywood Demand Model

Model I: Level Model

Dependent Variable: LACP
Method: Least Squares
Date: 12/01/08 Time: 16:31
Sample (adjusted): 1993 2007
Included observations: 15 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>3.13</td>
<td>2.75</td>
<td>1.14</td>
<td>0.28</td>
</tr>
<tr>
<td>LGDPR</td>
<td>1.11</td>
<td>0.16</td>
<td>6.77</td>
<td>0.00</td>
</tr>
<tr>
<td>LEPR</td>
<td>-0.33</td>
<td>0.32</td>
<td>-1.00</td>
<td>0.34</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.87</td>
<td></td>
<td>Mean dependent var</td>
<td>9.24</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.85</td>
<td>S.D. dependent var</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.22</td>
<td>Akaike info criterion</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.60</td>
<td>Schwarz criterion</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>2.85</td>
<td>Hannan-Quinn criterion</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>39.59</td>
<td>Durbin-Watson stat</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Breusch-Godfrey Serial Correlation LM Test:
F-statistic 0.10 Prob. F(2,10) 0.96
Obs*R-squared 0.47 Prob. Chi-Square(2) 0.93

Histogram-Normality Test:
Jarque-Bera 0.54 Probability 0.76

Heteroskedasticity Test: ARCH
F-statistic 0.45 Prob. F(1,12) 0.51
Obs*R-squared 0.51 Prob. Chi-Square(1) 0.47

T-ADF (ADF Unit Root Test on RESID06):
Augmented Dickey-Fuller test statistic -3.68 Decision: I(0) or I(1)
1% level -2.74 I(0)
5% level -1.97
10% level -1.60

Note: 1) ARCH stands for Autoregressive Conditional Heteroskedasticity; 2) I(0) refers to stationary time series, I(1) refers to time series that become stationary at the first difference.
### Model II: Error Correction Model

Dependent Variable: D(LACP)  
Method: Least Squares  
Date: 12/05/08  Time: 11:42  
Sample (adjusted): 1994 2007  
Included observations: 14 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.20</td>
<td>0.20</td>
<td>-1.02</td>
<td>0.33</td>
</tr>
<tr>
<td>D(LGDPR)</td>
<td>2.93</td>
<td>1.62</td>
<td>1.80</td>
<td>0.10</td>
</tr>
<tr>
<td>D(LEPR)</td>
<td>-0.52</td>
<td>0.69</td>
<td>-0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>RESID06(-1)</td>
<td>-0.99</td>
<td>0.36</td>
<td>-2.73</td>
<td>0.02</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.64</td>
<td></td>
<td></td>
<td>0.13</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.53</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.23</td>
<td></td>
<td></td>
<td>0.12</td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.52</td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>3.17</td>
<td></td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>F-statistic</td>
<td>5.86</td>
<td></td>
<td></td>
<td>1.87</td>
</tr>
<tr>
<td>Prob(F-statistic)</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Breusch-Godfrey Serial Correlation LM Test:  |
| F-statistic    | 0.21        | Prob. F(2,10) | 0.82 |
| Obs*R-squared  | 0.69        | Prob. Chi-Square(2) | 0.71 |

| Histogram-Normality Test:  |
| Jarque-Bera | 1.02 | Probability | 0.60 |

| Heteroskedasticity Test: ARCH  |
| F-statistic    | 0.80        | Prob. F(1,12) | 0.39 |
| Obs*R-squared  | 0.88        | Prob. Chi-Square(1) | 0.35 |

| T-ADF (ADF Unit Root Test on RESID07):  |
| Augmented Dickey-Fuller test statistic | -3.25 | | I(0) |
| Test critical values  |
| 1% level | -2.75 |
| 5% level | -1.97 |
| 10% level | -1.60 |
APPENDIX IVB: Chinese Plywood Supply Model

Model I: Level Model

Dependent Variable: LQP
Method: Least Squares
Date: 12/08/08   Time: 14:04
Sample (adjusted): 1993 2007
Included observations: 15 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>11.23</td>
<td>3.53</td>
<td>3.18</td>
<td>0.01</td>
</tr>
<tr>
<td>LWFQ</td>
<td>0.72</td>
<td>0.19</td>
<td>3.90</td>
<td>0.00</td>
</tr>
<tr>
<td>LIPR</td>
<td>-1.67</td>
<td>0.50</td>
<td>-3.35</td>
<td>0.01</td>
</tr>
</tbody>
</table>

R-squared Mean dependent var 9.17
Adjusted R-squared S.D. dependent var 0.85
S.E. of regression Akaike info criterion 1.16
Sum squared resid Schwarz criterion 1.30
Log likelihood Hannan-Quinn criter. 1.15
F-statistic Durbin-Watson stat 2.25
Prob(F-statistic) 0.00

Breusch-Godfrey Serial Correlation LM Test:
F-statistic 1.41 Prob. F(2,10) 0.30
Obs*R-squared 4.80 Prob. Chi-Square(2) 0.19

Histogram-Normality Test:
Jarque-Bera 1.10 Probability 0.58

Heteroskedasticity Test: ARCH
F-statistic 0.54 Prob. F(1,12) 0.48
Obs*R-squared 0.60 Prob. Chi-Square(1) 0.44

T-ADF (ADF Unit Root Test on RESID01):
Augmented Dickey-Fuller test statistic -4.14 Decision: I(0) or I(1)
Test critical values
- 1% level -2.74
- 5% level -1.97
- 10% level -1.60
Model II: Error Correction Model

Dependent Variable: D(LQP)
Method: Least Squares
Date: 12/08/08 Time: 14:11
Sample (adjusted): 1994 2007
Included observations: 14 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.15</td>
<td>0.08</td>
<td>1.92</td>
<td>0.08</td>
</tr>
<tr>
<td>D(LWFQ)</td>
<td>0.40</td>
<td>0.21</td>
<td>1.92</td>
<td>0.08</td>
</tr>
<tr>
<td>D(LIPR)</td>
<td>0.94</td>
<td>0.62</td>
<td>1.51</td>
<td>0.16</td>
</tr>
<tr>
<td>RESID01(-1)</td>
<td>-0.92</td>
<td>0.21</td>
<td>-4.50</td>
<td>0.00</td>
</tr>
</tbody>
</table>

R-squared 0.72
Adjusted R-squared 0.63
S.E. of regression 0.25
Sum squared resid 0.61
Log likelihood 2.08
F-statistic 8.51
Prob(F-statistic) 0.00

Breusch-Godfrey Serial Correlation LM Test:
F-statistic 0.46
Obs*R-squared 1.45

Histogram-Normality Test:
Jarque-Bera 0.22

Heteroskedasticity Test: ARCH
F-statistic 1.07
Obs*R-squared 1.16

T-ADF (ADF Unit Root Test on RESID02):
Augmented Dickey-Fuller test statistic -3.60
Test critical values
1% level -2.75
5% level -1.97
10% level -1.60
Decision: I(0) or I(1) I(0)
APPENDIX IVC: Chinese Plywood Export Model

**Model I: Level Model**

Dependent Variable: LEP  
Method: Least Squares  
Date: 12/05/08   Time: 14:03  
Sample (adjusted): 1993 2007  
Included observations: 15 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-175.91</td>
<td>15.16</td>
<td>-11.60</td>
<td>0.00</td>
</tr>
<tr>
<td>LUS</td>
<td>17.31</td>
<td>1.44</td>
<td>12.04</td>
<td>0.00</td>
</tr>
</tbody>
</table>

R-squared: 0.92  
Adjusted R-squared: 0.91

<table>
<thead>
<tr>
<th>Summary Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean dependent var</td>
</tr>
<tr>
<td>S.D. dependent var</td>
</tr>
<tr>
<td>Akaike info criterion</td>
</tr>
<tr>
<td>Schwarz criterion</td>
</tr>
<tr>
<td>Hannan-Quinn criter.</td>
</tr>
<tr>
<td>Durbin-Watson stat</td>
</tr>
</tbody>
</table>

**Breusch-Godfrey Serial Correlation LM Test:**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
<td>1.41</td>
<td>0.30</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>4.45</td>
<td>0.22</td>
</tr>
</tbody>
</table>

**Histogram-Normality Test:**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarque-Bera</td>
<td>3.04</td>
<td>0.22</td>
</tr>
</tbody>
</table>

**Heteroskedasticity Test: ARCH**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
<td>1.98</td>
<td>0.18</td>
</tr>
<tr>
<td>Obs*R-squared</td>
<td>1.98</td>
<td>0.16</td>
</tr>
</tbody>
</table>

**T-ADF (ADF Unit Root Test on RESID03):**

<table>
<thead>
<tr>
<th>Test</th>
<th>t-Statistic</th>
<th>Decision: I(0) or I(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Augmented Dickey-Fuller test statistic</td>
<td>-2.27</td>
<td>I(0)</td>
</tr>
<tr>
<td>Test critical values</td>
<td>1% level</td>
<td>-2.74</td>
</tr>
<tr>
<td></td>
<td>5% level</td>
<td>-1.97</td>
</tr>
<tr>
<td></td>
<td>10% level</td>
<td>-1.60</td>
</tr>
</tbody>
</table>
Model II: Error Correction Model

Dependent Variable: D(LEP)
Method: Least Squares
Date: 12/05/08   Time: 14:09
Sample (adjusted): 1994 2007
Included observations: 14 after adjustments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.22</td>
<td>0.25</td>
<td>0.88</td>
<td>0.40</td>
</tr>
<tr>
<td>D(LUS)</td>
<td>4.82</td>
<td>11.20</td>
<td>0.43</td>
<td>0.68</td>
</tr>
<tr>
<td>RESID03(-1)</td>
<td>-0.50</td>
<td>0.24</td>
<td>-2.08</td>
<td>0.06</td>
</tr>
</tbody>
</table>

R-squared       0.28
Adjusted R-squared 0.15
S.E. of regression 0.41
Sum squared resid 1.88
Log likelihood   -5.81
F-statistic      2.18
Prob(F-statistic) 0.16

Breusch-Godfrey Serial Correlation LM Test:
F-statistic      1.28
Obs*R-squared    3.09

Histogram-Normality Test:
Jarque-Bera      10.06

Heteroskedasticity Test: ARCH
F-statistic      0.05
Obs*R-squared    0.06

T-ADF (ADF Unit Root Test on RESID04):
Augmented Dickey-Fuller test statistic -4.51
1% level 2.75
5% level -1.97
10% level -1.60
Decision: I(0) or I(1)