THE IMPACT OF THE BIOMASS CROP ASSISTANCE PROGRAM ON THE FOREST PRODUCT MARKET: AN APPLICATION OF THE GLOBAL FOREST PRODUCT MODEL

By

WEI JIANG

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

UNIVERSITY OF FLORIDA

2012

To Mom and Dad, your encouragement is my eternal drive to progress.

献给老爸老妈，你们的鼓励是我一生进步的动力

ACKNOWLEDGMENTS

I thank my parents for instilling discipline in me and making me who I am today.

I thank my supervisor Dr. Douglas R. Carter. He had a lot of things to handle but still set aside some time for this work. It's my great honor to work with him and I am thankful for his willingness to accept me as his graduate student. I also acknowledge Dr. Damian C. Adams and Dr. Zhifeng Gao who are the members of my committee. They contribute a lot in my research.

My heartfelt appreciation goes to Dr. Marian Marinescu. Without him, I cannot chase my dream for being in the United States. I also extend my thanks to Charles Nettleman who provides me with the fresh views of life and expert opinions on academic research. Besides, I appreciate the help from Xi Liang who always blames me but is always concerned about me.

I am thankful to College of Agricultural and Life Science and Department of Forest Resources and Conservation for providing me with assistantship to support me to complete my thesis and study at University of Florida.

Ultimately, I must thank to my boyfriend, Jiang Jin. Without him, hardly can I finish my thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

THE IMPACT OF THE BIOMASS CROP ASSISTANCE PROGRAM ON THE FOREST PRODUCT MARKET: AN APPLICATION OF THE GLOBAL FOREST PRODUCT MODEL

By

Wei Jiang

August 2012

Chair: Douglas R. Carter
Major: Forest Resources and Conservation

With the concerns over energy security and greenhouse gas emission, the United States is the leading country in producing bioenergy. Although the government has instituted various policies concentrating on bioenergy, the policies addressing the plantation of woody biomass are few.

Considering this deficiency, the Biomass Crop Assistance Program (BCAP) emerged in 2008 with the purpose of planting energy crops. However, its effects on forest product market, environmental sustainability and welfare economics are suffering attacks from the congress. This study aims at quantifying its effects on these three aspects by applying Global Forest Product Model (GFPM).

Three scenarios were designed to simulate payments in BCAP. In the first scenario, the matching payments were simulated by adjusting the manufacturing cost of fuelwood and particleboard. In the second scenario, the establishment payments were simulated by adjusting the supply rate of industrial roundwood. The third scenario employed the annual payments by linking the supply change rate with soil rental rate.

The increasing productions from the establishment payments and the annual payments for fuelwood and industrial roundwood are the main findings. A decrease could be found in particleboard under the matching payments, while modest increases happen in woodpulp and paper under the establishment payments and annual payments. Few changes were found in forest area but a slight decrease happens in forest stock under the establishment payment. All of three payments will lead to decreases in domestic producer surplus and consumer surplus but the exporters of woodpulp and paper are the biggest winners in this program.

CHAPTER 1
INTRODUCTION

Background

World energy markets are in transition and a general consensus has emerged that biomass energy could expand in the next decades (Ince, 2011). At present, biomass energy accounts for 10 % of primary energy consumed globally, which is more than the produced from all other renewable and nuclear power combined and, among those, woody sources account for 87% of all biomass used globally for energy (FAO, 2009).

The share of utilization of biomass varies across the countries or regions generally correlated with the level economic development and industrialization (FAO, 2009). In developing countries, biomass is a primary energy source for home heating and electricity but its share in energy structure is declining because of the strong demand arising in fossil fuel. For the developed countries, growing concerns about climate change and energy security are the basic drives for increasing utilization of biomass energy.

As the largest gasoline consumer, the United States imports half of its consumption from foreign countries. The biggest industry consuming petroleum is transportation, which digests 71% of petroleum product (Figure 1-1). As a consequence, it also becomes a big producer for the greenhouse gas, which contributes to 34% of carbon dioxide emissions (EIA, 2010a). The newly released Annual Energy Outlook 2012 projects that “delivered fossil energy consumption in the transportation sector will grow from 27.6 quadrillion British Thermal Unit (BTU) in 2010 to 28.8 quadrillion BTU in 2035”. Electricity is another producer for greenhouse gas. Though only consuming about 1% of petroleum (Figure 1-1), the electricity industry deploys about 92% of coal

(Figure 1-1), which is regarded as another main source generating carbon dioxide. In 2009, electricity emitted 41% of the carbon dioxide from fossil fuel combustion (Hodges, 2011), which is more than that from transportation. Therefore, how to decrease the energy consumption and how to reduce the carbon dioxide from these two industries are the top two priorities for policy makers.

Two types of renewable energy are prominent in relieving the concerns over transportation and electricity: biofuel and biopower. Estimated by the International Energy Agency, biofuel has the potential to meet more than a quarter of demand for transportation fuels by 2050 for the United States. With the technology of combined heat and power (CHP) by substituting parts of coals by woody biomass, biopower is also effective in reducing the emission of carbon dioxide. Both of biofuel and biopower are generated from biomass. What is biomass? What is the current status of biomass in the United States? And how much biomass could be supplied to produce biofuel and bioenergy? The answers would be found in the next section with the special attention on woody biomass.

The Supply of Woody Biomass in the United States

In 2009, renewable energy accounted for 8 percent of the U.S. energy consumption or 7.745 quadrillion BTU (EIA, 2010c). Among renewable energy market, biomass accounts for 53% of the total renewable energy consumption market (Figure 1-2) and the trend is expected to continue in the next two decades with the U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) requirements that 30 % of current the U.S. petroleum consumption be replaced with biofuel by 2030 (Perlack et al., 2005).

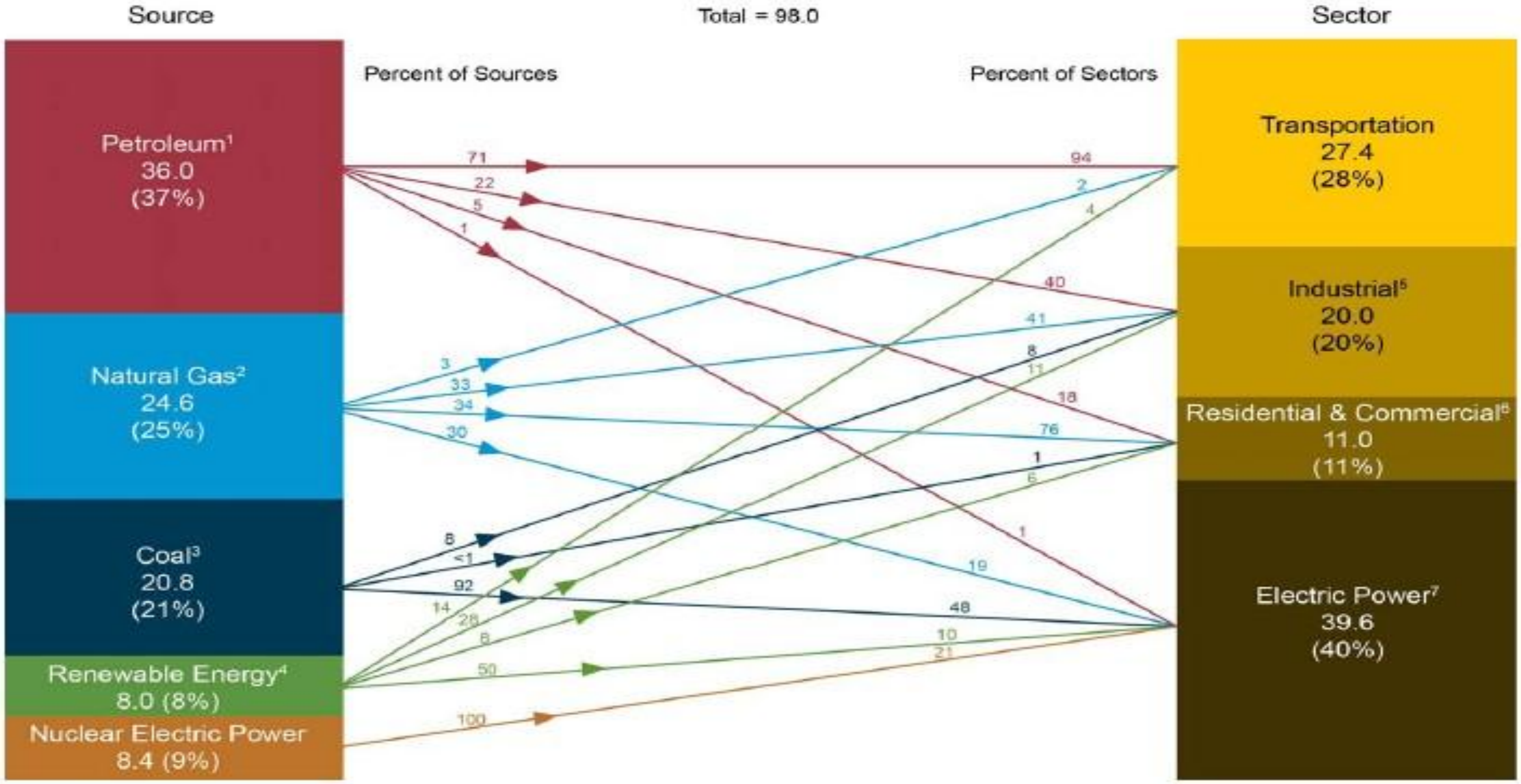


Figure 1-1. Primary Energy Consumption by Source and Sector, 2010. [Source: U.S. Energy Information Administration,Annual Energy Review 2010, http://www.eia.gov/totalenergy/data/annual/pecss_diagram.cfm]

Biomass is the organic material made from plants and animals and most of them are from forestry (woody) and agriculture (Figure 1-3):

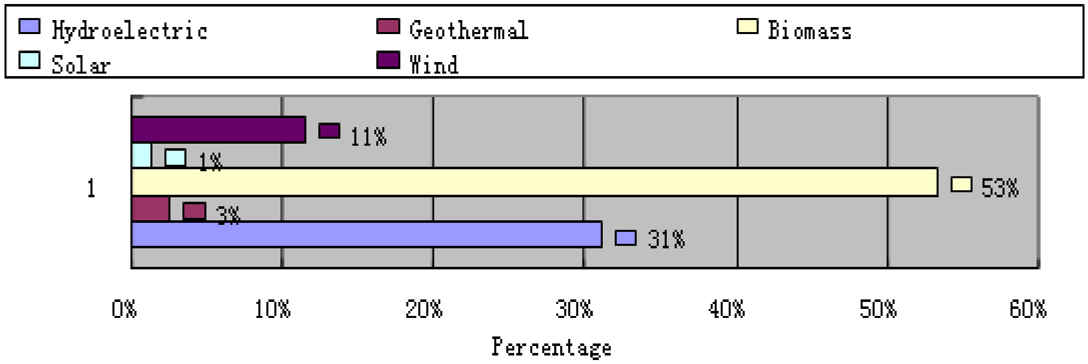


Figure 1-2. The share of renewable energy in the energy consumption in the United States. [Data source: the environmental information agency, 2011, Renewable Energy Production and Consumption by Primary Energy Source, 1949-2010.]

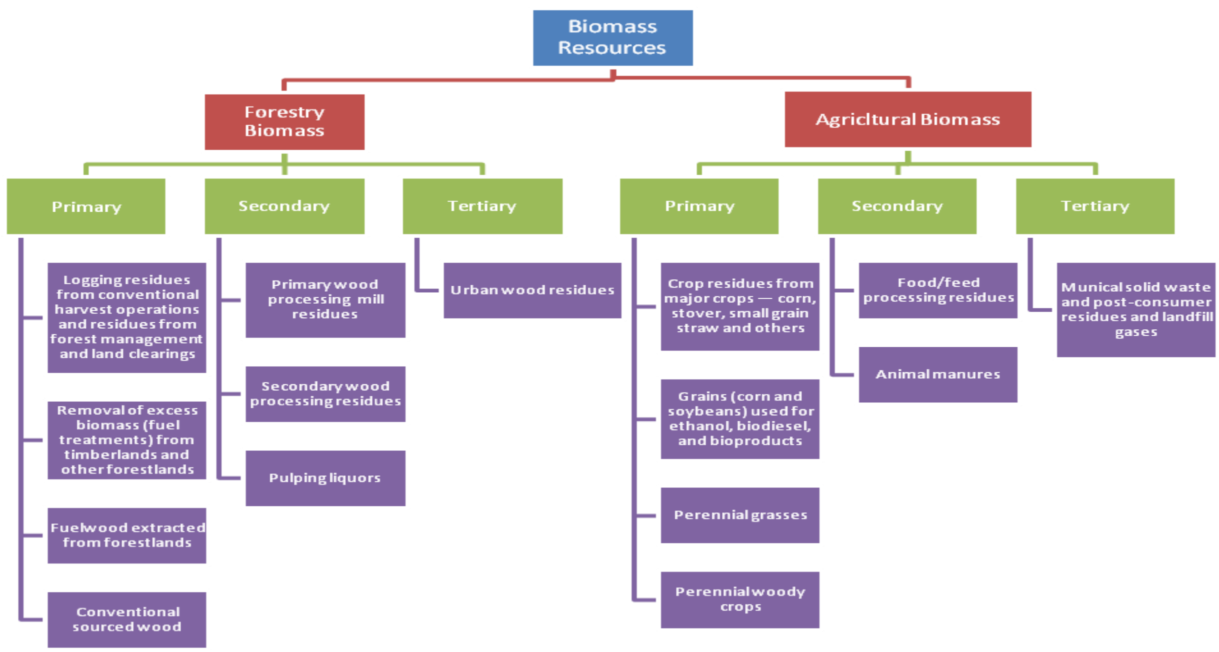


Figure 1-3. Sources of biomass. [Adaptive based on the U.S. Department of Energy, 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p]

Biomass energy has certain advantages over other renewable energies. For example, biomass is stored energy. It can be drawn on at any time, unlike daily or seasonally intermittent solar, wind, wave and small hydro sources whose contributions are all constrained by the high costs of energy storage (FAO, 2009). Biomass energy systems can produce energy in several different carriers at the same facility or implementation platform, thereby enhancing economic feasibility and reducing the environmental impact (FAO, 2009). Typically, the utilizations of woody biomass mainly concentrate on two aspects:

- Solid Bioenergy --- biopower for electricity generating by combustion or gasification processes, co-firing along with coal, or for CHP system in industrial facilities; highly compact wood pellet used for heating purpose (Aguilar and Saunders, 2011).
- Liquid Bioenergy --- biofuel (bioethanol, biomethanol and biodiesel), which can be blended with conventional transportation fuels and bioproduct (Alavalapati, 2009).

Based on the utilizations, woody biomass could be divided into two categories (Table 1-1).

From Table 1-2, we are able to conclude that woody biomass was categorized into second-generation biomass to generate second-generation biofuel in the long-term period. Especially for Short Rotation Wood Crop (SRWC), it is able to meet all the requirements from biofuel, biopower and bioproduct. Therefore, developing the woody biomass seems to be promising with a long-term perspective. Currently, in the United States, the supply of wood feedback for bioenergy is from the following resources (Perlack et al., 2005):

- The recovered residues generated by traditional logging activities and residues generated from forest cultural operations or clearing of timberlands.

Table 1-1. Classification of biomass based on technology

		Liquid Bioenergy					Solid Bioenergy		
Feedback		First generation fuels			Second generation fuels		Biopower		Bioproduct
		Ethanol	Biodiesel	Methane	Cellulosic Ethanol	Thermos Fuels	Stand along	Co-firing	
Second generation(short-term)									
Forest	Logging residues				X	X	X	X	X
Biomass	Fuel treatment				X	X	X	X	X
	Conventional wood				X	X	X	X	X
Urban woody	Primary wood product				X	X	X	X	
waste and	Secondary mill-				X	X	X	X	
landfills	residues		X		X	X	X	X	
	Municipal solid -waste						X	X	
	Construction-								
	demolition wood								
	landfills		X		X				
Second generation (long-term)									
Herbaceous	Switch grass				X	X	X	X	X
energy	Miscanthus				X	X	X	X	
crops	Reed canary grass				X	X	X	X	
	Sweet sorghum								
	Alfalfa				X	X	X	X	
Short rotation	Willow				X	X	X	X	X
woody crops	Hybrid poplar				X	X	X	X	X
	Cottonwood pines				X	X	X	X	X
	Sycamore pines				X	X	X	X	X
	Eucalyptus				X	X	X	X	X

Source: adaptive based on the U.S.Department of Energy, Biomass Research and Development Board, 2008. Increasing feedstock production for biofuels: economic drivers, environmental implications, and the role of research.

.

- The recovered residues generated from fuel treatment operations on timberland and other forestland.
- The direct conversion of round wood to energy (fuelwood) in the residential, commercial, and electric utility sectors.
- Forest products industry residues and urban wood residues.
- Forest growth and increase in the demand for forest products.

The estimated supply of woody biomass totally is 368 million dry tons annually (Perlack et al., 2005). Among these resources, the residues from primary logging, thinning or processing treatment currently take the larger share to produce bioenergy with the supply amount of 243 million dry tons, while the fuelwood and other forest growth (SRWC) with long-term perspective combined only occupy a small amount of 124 million dry tons.

Why the supply for those dedicated energy crops is small? The concerns over market price and risks existing in biomass markets are the main reasons. In the woody biomass market, the price should be higher fairly to compete with woodpulp and paper purchasing price for raw materials and also be lower enough to compete with other fossil fuel to generate energy. These two constrains make the price of woody biomass instable and exacerbate the market risks for farmers and landowners. In addition to this, numerous public policies aiming at subsidizing bioenergy instead of biomass also distort the new market mechanism.

Therefore, this research picks up Biomass Crops Assistance Program (BCAP) as the research target to examine its effects on traditional forest product. Compared with other policies, BCAP is standing out with several features:

- The payments are directly issued to biomass instead of bioenergy.

- It is the program that aims to encourage the plantation of the long-term energy crops.
- It initially puts two types of payments for short-term residues and long-term energy crops into one program.
- It focuses on subsidizing transport and harvest cost of eligible materials, which are regarded as the big two obstacles hindering the development of biomass (Becker, 2009).

Therefore, a detailed introduction for BCAP is needed.

Biomass Assistance Program

BCAP was authorized by the Food, Conservation, and Energy Act of 2008 to provide financial assistance to owners and operators of agricultural and non-industrial private forest landowners who wish to establish, produce, and deliver biomass feedstock (BCAP, 2011). It was fully implemented as of October 27, 2010 and administered by USDA through the Commodity Credit Corporation (CCC) and the Farm Service Agency (FSA). Funding is currently authorized through September 30, 2012. The cap for fiscal year 2010 is $512 million and for 2011 is $432 million (10/1/10 – 9/30/11) and meanwhile no limit for fiscal year 2012 (10/1/11 – 9/30/12). BCAP is comprised of two unique subparts and can be thought of as “two programs in one”.

The matching payments: they intended to assist agricultural and forest land owners and operators with the collection, harvest, storage, and transportation (CHST) of eligible materials for use in a biomass conversion facility. The matching payments are authorized to be made at a rate of $1 for each $1 per dry ton paid by a Qualified Biomass Conversion Facility (QBCF) for the sale and delivery of eligible materials. Payments are capped at $45 per dry ton. These payments are made directly to eligible material owners. Payments are authorized to be made for a 2-year period, beginning on the date the first payment is issued to the eligible material owner(BCAP, 2011).

The establishment payments and the annual payments: they intended to support the establishment and production of eligible crops for conversion to bioenergy in selecting BCAP project areas. The establishment payments cover up to 75% of the actual or average cost (whichever is lower) of establishing an eligible perennial crop (either woody or non-woody). The annual payments intended to offset the lost opportunity costs associated with cultivating a biomass crop as opposed to a traditional crop. Payments will be similar to Conservation Reserve Program (CRP) payments and it will be “based on all or a percentage of: a weighted average soil rental rate for cropland. The time period for the annual payments would be up to 5 years for annual and perennial non-woody crops and up to 15 years for perennial woody crops.

Several requirements for eligible materials and eligible area need to be noticed. In the matching payments, the requirements for eligible materials could be summarized into the Table 1-2.

From Table 1-2, we could find that most of the eligible materials are residues including logging residues, thinning residues as well as processing residues. As a result, the matching payments are regarded as the part addressing the utilization of short-term residues. The rules for eligible area in the matching payments are not strict.

Regard the establishment payments and the annual payments, the requirements for eligible materials are not strict. Any organic matter that is available on a renewable or recurring basis from non-federal land could be qualified as eligible materials. However, the rules for eligible area is relatively strict compared with the matching payments. The area should be agricultural land and nonindustrial private forest land. Land that is native sod or simultaneously enrolled in the: Conservation Reserve

Program (CRP); Wetlands Reserve Program; Grassland Reserve Program are not included.

Table 1-2. Qualified eligible materials for the matching payments

Eligible Material	If collected or harvested directly from the land before transport and delivery to the biomass conversion facility	If collected or harvested by separation from a higher value product collected or harvested directly from the land	
		before transport and delivery to the biomass conversion facility	after transport and delivery to the biomass conversion facility
Forest thinning	Y	Y	N
Post-disaster debris	Y	Y	N
Hardwood chips	Y	Y	N
Softwood chips	Y	Y	N
Cutoffs	Y	Y	N
Bark	Y	Y	N
Trees and shrubs without timber lumber or wood pulp value	Y	Y	N
Trees and shrubs with timber, lumber or wood pulp value	Y non-federal land	N	N

Source: the U.S. Department of Agriculture/ Farm Service Agency, BCAP, 2011. The biomass crop assistance program (BCAP) – Final Rule Provision.

On June 11, 2009, the first phase of the BCAP as authorized by the 2008 Farm Bill was implemented through the publication of a Notice of Funding Availability (NOFA). This NOFA provided the matching payments for the collection, harvest, storage and transportation (CHST) of biomass material to approved energy conversion facilities. On October 27, 2010, a final rule was published implementing all phases of BCAP including financial assistance for the establishment and maintenance of crops for bioenergy production as well as the CHST payments previously funded through the NOFA (BCAP, 2011).

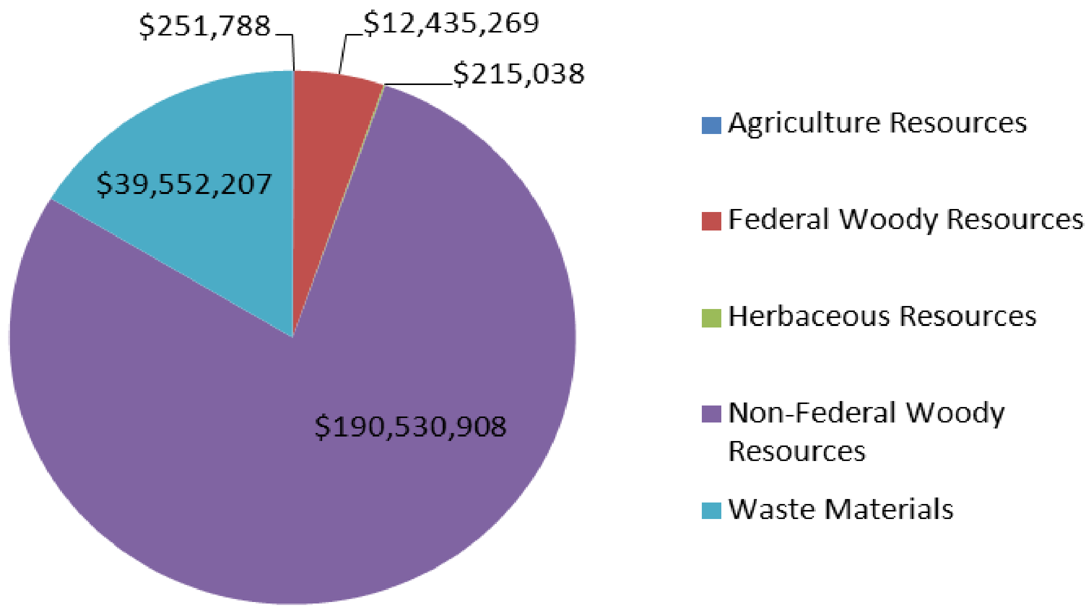


Figure 1-4. The distribution of the matching payments among biomass resources in 2010. [Data source: the U.S. Department of Agriculture/ Farm Service Agency, BCAP, 2010, Report of BCAP CHST payments by biomass type.]

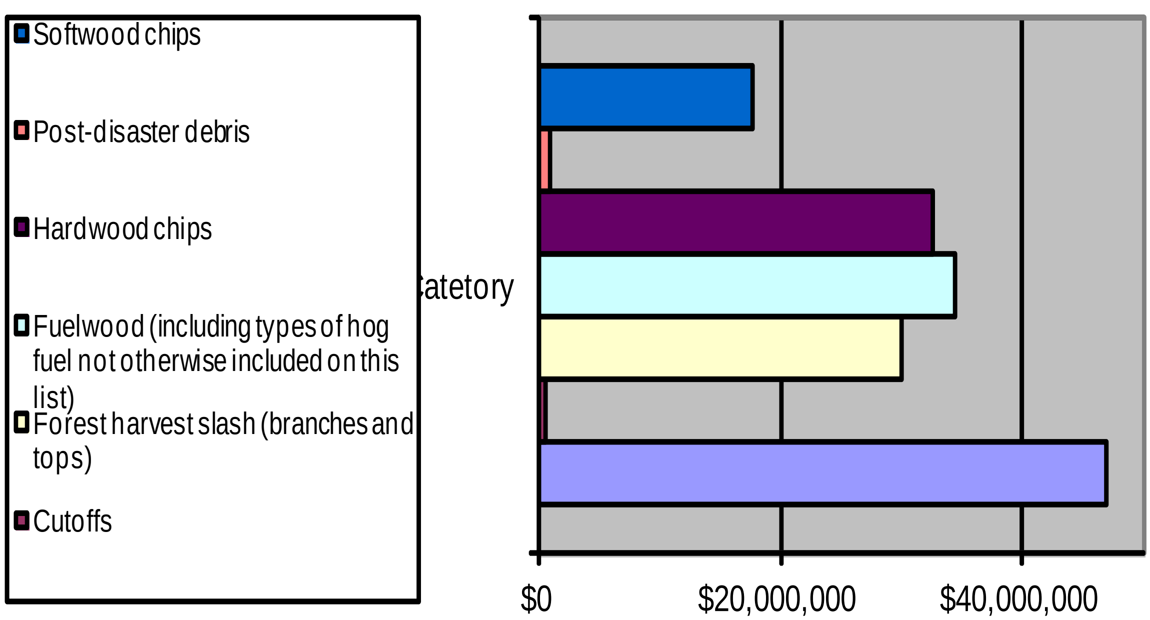


Figure 1-5. The distribution of the matching payments among woody biomass in 2010.[Data source: the U.S. Department of Agriculture/ Farm Service Agency, BCAP, 2010, Report of BCAP CHST payments by biomass type.]

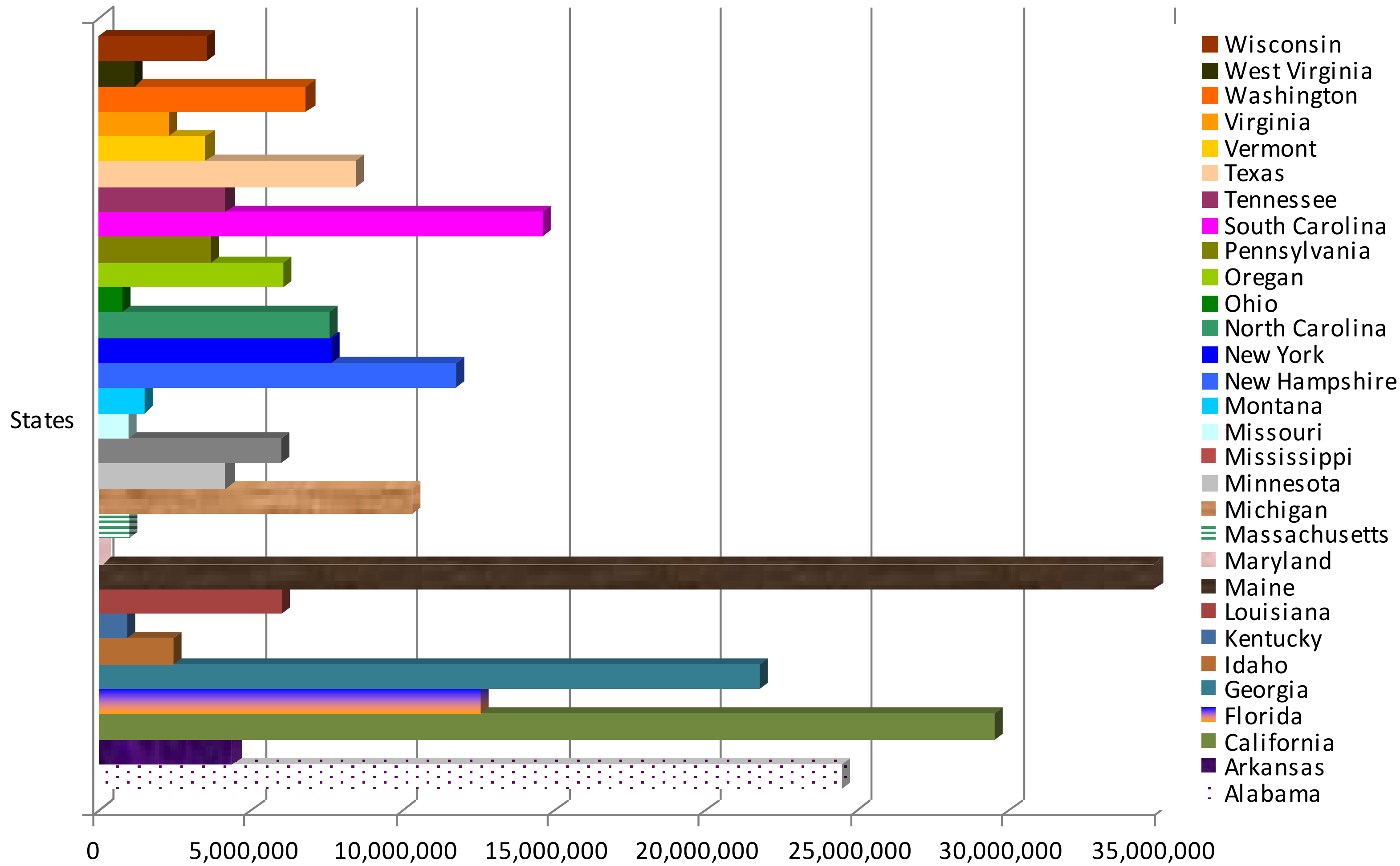


Figure 1-6. The state matching payments reimbursement in 2010. [Data source: the U.S. Department of Agriculture/ Farm Service Agency, BCAP, 2010, Summary Report of BCAP CHST payments.]

Based on one-year statistics (Figure 1-4 and Figure 1-5), we could clearly determine that the majority of BCAP subsidies are distributed to woody biomass and among woody biomass, fuelwood and chips combined occupy a very important position in the matching payments. In 2010, 30 states (Figure 1-6) had jointed in this program and the expense for BCAP from each state is not small. It seems that BCAP would attract more participants with further implementation. However, initial implementing the matching payments raised questions and concerns about the BCAP program as a whole which subsequently brought attention to other aspects of the BCAP program. These questions are:

- Competition with traditional forest product: given the large production capacity of forests product, the forest industry still holds an important position in the United States. In 2009, the industrial roundwood produced and exported from the United States occupy 20.7% in the world market and the share for woodpulp is even higher, reaching to 35% (Oel, 2010). However, after USDA's 2009 notice on the matching payments, pulp and paper manufacturing and nursery industries that use industrial roundwood noticed an increase in price for their raw materials. This increase was linked, by some, to the BCAP payments which offered a federal payment match for the same materials (Stubbs, 2010).

- Sustainability: although biomass was considered as a tool to protect environment, negative impacts on the forest system such as wildlife habitat destruction, soil erosion and deforestation would still happen (Buongiorno et al., 2011). BCAP has a dual purpose on establishing new dedicated biomass crops for bioenergy production (annual and the establishment payments) and increasing the collection of existed and underutilized biomass for bioenergy production (the matching payments). The latter purpose for biomass removal in areas where it is possible but not currently profitable is a key factor for the forestry recovery.

- Efficiency: BCAP initially picked up the concept encouraging the plantation of energy crop for bioenergy production. However, a new market might weak the substituted market such as pulp industry. Whether this program could finally enhance the welfare economics in the whole forestry industry in the United States is still a misery.

Since BCAP was only implemented completely for one year and data correlated to the problems mentioned above is not consistent, this research aiming to quantifying the

BCAP’s effects on these three problems will be conducted based on numerous assumption with an application of Global Forest Product Model (GFPM).

CHAPTER 2
LITERATURE REVIEW

The future of bioenergy and wood energy development is largely dependent on the effectiveness of policies and the consistency with which they are implemented. Therefore, an overview for the public policies is the first step to research.

Overview Policies Supporting Woody Biomass in the United States

The classification of public polices with respect to woody biomass could be viewed from different perspectives. Here, we adopted the classification from Aguilar (2011) that the policies from 1970 to 2009 are discussed under two categories: biopower and vehicle liquid fuels, which are compiled with the two utilizations of woody biomass.

Aguilar and Saunders (2011) pointed out that fiscal incentives are the most popular policy instruments in favoring biopower market. Tax credits were regarded as the top frequently-used financial tool. For example, the federal renewable electricity production tax credit (PTC) was a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to the unrelated person during the taxable year (DSIRE, 2009). Originally enacted in 1992, the PTC had been renewed and expanded numerous times. The extension from closed-loop biomass to open-loop biomass began to include forest-related resources such as mill and harvesting residues, pre-commercial thinning, slash, brush and solid wood waste materials used to power electricity plants (e.g. waste pallets, crates, manufacturing and construction wood wastes and landscape or right-of-way tree trimmings).

As the subsequent policy to PTC, Business Energy Investment Tax Credit (ITC) allowed taxpayers eligible for PTC to take the federal ITC to receive a grant from the U.S. Treasury Department instead of taking the PTC for new installation. For biopower, it typically concentrated on CHP technology requiring that CHP plant might get 10% of credits of the total expenditures without maximum limit stated. Although there was a requirement for the capacity of CHP system, it did not apply to the systems using biomass for at least 90% of the system's energy source.

State governments also focus on activating local biopower market by issuing public policies. The Renewable Portfolio Standard (RPS) is the most commonly adopted. It is a state policy that requires electricity providers to obtain a minimum percentage of their power from renewable energy resources by a certain date. As of March 2009, RPS requirements or goals had been established in 33 states plus the District of Columbia (EPA, 2009). Becker (2008) summarized detailed policies supporting biomass for each state by using Database of State Incentives for Renewable Energy (DSIRE) and the Reuters Find Law search engine. Tax incentives were also widely adopted in state RPS. For example, in Florida, the renewable energy production tax credit was equal to $0.01/kWh of electricity produced and sold by the taxpayer to an unrelated party during a given tax year (Becker and Lee, 2008). The Minnesota Power Grant Program offered grants up to $50,000 to its commercial, industrial, and agricultural customers who use innovative technologies, improve manufacturing processes, undertake renewable electric energy projects or who need project design assistance. Eligible projects include renewable energy products, new electro-technologies that lower energy costs per unit of production in a manufacturing process, innovative technologies that are new and underutilized in the regional marketplace, and the inclusion of energy-efficient options in the design phase of a project (Becker and Lee, 2008).

Detailed policy summary for liquid vehicle fuel is providing by Guo and Sun (2007). After viewing policies from 1970s, they concluded that financial incentives were also the main method subsidizing biofuel. Most of subsidies were awarded to the first-generation biofuel. Much success of the corn-ethanol industry in the United States could be attributed to governmental incentive polices starting in the 1970s (Duffield and Collins, 2006). One of the earliest energy statutes was the Energy Tax Act of 1978. It initially exempted the federal gasoline excise tax of $0.40 per gallon through 1984 on gasoline blended with at least 10% ethanol produced from biomass.

In recent years, increasing federal policies have addressed the utilization of forest biomass for biofuel production. First of all, the Biomass Research and Development Act of 2000 (Title III of the Agricultural Risk Protection Act) addresses the utilization of trees, wood, wood wastes and residues as feedstock for bioproducts. The grants are awarded to improve cellulosic biomass conversion, biomass technologies to biobased fuel and product. The Farm Security and Rural Investment Act, commonly referred to as the Farm Bill, was first developed in the 1920s and had been reviewed approximately every six years. The 2002 Farm Bill included an energy title for the first time in history (Nazzar, 2005). It establishes bio-refinery grants to assist the emerging technologies for the use of biomass, including lingo-cellulosic biomass to diversify markets for agricultural and forestry products.

The Energy Policy Act of 2005 reflected the energy policy of increasing and diversifying domestic energy production (Nazzar, 2005; Duffield and Collins, 2006). It established various programs to foster research and development of woody biomass conversion technologies and biofuel production. In particular, it included stipulations specific to forest biomass utilization to prevent hazardous fires, reduce disease and insect infestation, and restore forest health. The Energy Independence and Security Act of 2007 further the emphasis on bioenergy. Section 202 creates the Renewable Fuel Standard (RFS) calling for transportation fuel sold or introduced into commerce in the United States, on an annual average basis, containing at least the applicable volume of renewable fuel, advanced bio-fuel, cellulosic bio-fuel, and biomass-based diesel.

BCAP was authorized by the Food, Conservation, and Energy Act of 2008 to provide financial assistance to owners and operators of agricultural and non-industrial private forest landowners who wish to establish, produce, and deliver biomass feedstock. BCAP provided (a) the matching payments for no more than two years to eligible material owners, at a rate of 1$ for each 1$ paid by a qualified biomass conversion facility up to $45 per moisture-free metric ton of delivered biomass to produce heat, power, biobased products, or advanced bio-fuels; (b) the establishment payments up to 75 percent of the cost of establishing a bio-energy perennial crop and (c) and up to 15 years of the annual payments for woody crops.

There is no doubt that government is actively participating in the bioenergy market with various polices. However, with respect to the big two problems associated with woody biomass –transport cost (Aguilar and Saunders, 2011, Becker and Lee, 2011, Perlack, 2005) and competition for raw materials with traditional forest product, there are few policies aiming on emphasizing them solely. Except BCAP, there were only two state-level policies for subsidizing transportation cost. The Oregon RFS provides a $9 per green ton income tax credit for the removal and use for energy of biomass directly from the forest. The Arizona Healthy Forest Enterprise Incentives Program was to offset the high cost of transportation due to distant processing facilities (Becker and Lee, 2011). To address the competition for raw materials between forest product and bioenergy market, there are no specific policies. Even in BCAP, only some words are found that the products with a higher market value could not be qualified as eligible material but did not explain the standard to justify the higher market value. Therefore, the research is needed to examine the effect of the federal program aiming at subsidizing transport cost and addressing the competition between forest product market and bioenergy market.

Overview Economic Analysis for Biomass Policies

The economic analysis for woody biomass production is extensive. Most of these studies are concentrating on the analysis of production cost with consideration of feedback, technology and miscellaneous other procurement, transaction as well as opportunity costs. However, the economic studies on policy-driven supply change and projection for woody biomass market are limited. Therefore, we first introduce a study in Norway with the projection of woody biomass supply.

Trogmbor and Bolkesjo (2007) applied NTMII, a model belonging to the same class of models as the GFPM, the European Forest Institute- Global Trade Model (EFI-GTM) and NTM, to simulated three policies in Northway: subsidies reducing 50% of the investment costs of district heating installations; deposit grant for replacing of oil burners with burners based on bioenergy with the accordance to 50% subsidies; feed-in supporting energy production in district heating based on bioenergy. Four alternative scenarios were designed so as to simulate these polices and firewood, chips and pellets were regarded as the representatives of woody biomass. The results provide us with medium-term projections for bioenergy use in Norway.

Abt (2010) conducted research measuring the competition between woody biomass and traditional forest product market. A higher demand for woody residuals or pulpwood driven by RPS in North Carolina was added to the existing forest product demand with Sub Regional Timber Supply Model (SRTS). The results indicated that logging residue alone could not meet the bioenergy demand required in RPS and pulpwood should be used as an option. Thus, there was an increase in price as well as removals of pulpwood and displacement of traditional product would also be intensified.

A relatively completed examination of the state RPS policy is conducted by Hodges (2010). In their reports, three programs including Renewable Electricity Standard, renewable electricity production tax credit and biomass feedstock subsidy (BCAP) were simulated by Computable General Equilibrium (CGE) model, Input-Output analysis and Social Accounting Matrices (I-O/SAM). Accordingly; three scenarios were deigned to finish the simulation: the modifications of Leontief coefficient for the intermediate inputs in CGE model, the negative excise tax rate for electric power and a negative sales tax on purchases of biomass by the electric power sector from the forestry sector in the CGE. The results indicated that various polices and incentives for bioenergy development would bring a relatively small increase in Gross Domestic Product (GDP), overall employment and state government revenues of Florida with a modest decrease of fossil fuels imports. However, the forest product manufacturing sector would be adversely affected by competition for wood resources resulting in higher prices for material inputs.

In summary, the economic analysis implied that the higher demand driven by public policies might have a negative effect on forest product market from the biopower market perspectives.

Beach and McCarl (2010) utilized the Forest and Agricultural Sector Optimization Model (FASOM) to simulate the economic effect of EISA in biofuel market. In this study, milling residues and logging residues were regarded as the input source to generate biofuel and the results indicated the prices for hardwood as well as softwood would rise up under the control case and it also might decrease the competitiveness of forest product for the United States.

Wu (2011) in her dissertation wrote that, based on the analysis of EISA with Agricultural Policy Simulation Model (POLYSIS) and SRTS, the softwood pulpwood inventory and price were more sensitive than other forest products to changes in biofuel production, which means that a small increase in biofuel production would induce a bigger change of pulpwood price and that delaying meeting mandated biofuel targets to future years could maintain a sustainable pulpwood forest inventory. These researches implied that the competition for raw materials also existed in the biofuel market.

Since policies aiming to subsidize transport cost are few, there are few economic analyses about transport cost. Becker (2009) simulated two transportation incentives: the transportation costs of waiving a federal excise tax of $0.2 gallon and a subsidy in which each ton of woody biomass collected from a qualifying source and transported to a bioenergy or biofuel facility is eligible for an offset payment to the contractor. He pointed out that the transport of raw material was the single greatest cost. Transportation subsidies would have to be substantial to result in a significant change.

The offsets achieved through the new federal BCAP, which offers a dollar-for-dollar transportation cost share up to $45/dry ton, is notable.

Based on the literatures discussed above, we could find that the competition for raw materials between forest product and bioenergy market is existing in both biopower market and biofuel market. However, most of these researches only examined the short-term supply change of woody biomass to meet the extra demand for raw materials driven by public policy. It means that these studies regarded most of residues (logging residues, thinning residues, milling residues and other wastes) as the materials to receive subsides but ignore the long-term woody biomass such as the plantation of SRWC. If the extra supply was achieved, the competition for raw material is still existed or not?

In addition, transportation cost is a big concern in the development of biomass. A substantial subsidy for it is required. BCAP is outstanding in favoring transport cost. Whether it worsens the competition or not? The subsidy for transport cost is effective? We need to measure its effects in details.

Furthermore, policy simulation for current bioenergy market is typically divided into two steps: first, identifying the subsidies for biopower or biofuel; then, based on a series of assumptions, transfer these subsides to the input sources—woody biomass. The transferring might complicate the simulation process and might result in inaccurate results. A call for examining direct subsidy for woody biomass is emerging. BCAP, as a federal program awarding direct subsidies for woody biomass and focusing on transport cost, naturally is picked up as the research target.

Overview of the Applications of GFPM

The Global Forest Products Model (GFPM) is an economic model of production, consumption, and trade in forest products at the global level. It uses historical information and exogenous assumptions in a market equilibrium model to produce forecasts of global forest products market developments to 2060. The history of this model could be dated back to the development of PAPYRUS model for U.S. pulp and paper industry (Buongiorno and Gilless, 1983). The PAPYRUS was built with a general structure and software to model any economic sector with spatial and dynamic elements, the Price Endogenous Linear Programming System (PELPS). The PELPS software became PELPS II Plus and PELPS III. The latest version, PELPS IV, forms the structure of the GFPM.

The first connection between GFPM and energy happened after energy crisis. Buongiorno and Chang (1986) tested if there had been systematic changes in the income and price elasticity of demand for forest products after the first oil embargo of 1973. Though this research mainly focused on price change for forest product, it was a good try to link demand change from energy to forest resources.

Raunikar and Buongiorno (2010) examined the competition between high demand for bioenergy set Intergovernmental Panel on Climate Change (IPCC) and future demand for timber and forestry by manipulating GFPM. In this paper, they took two scenarios designed by IPCC as research objectives. Via modifying GFPM by an assumption that the industrial wood would be converted into fuelwood when the prices of these two products are equal, they demonstrated that fuelwood would increase by 5.4 percent from 2006 to 2060 and, on the contrary, industrial wood production will be affected negatively. In addition, Buongiorno and Raunikar (2011) also measured the consequences for the global forest sector of doubling the rate of growth of bioenergy demand relative to a base scenario, keeping other drivers constant with GFPM.

A more detailed model USFPM/GFPM was introduced by Ince and Kramp (2011). It provided a detailed picture of the U.S. regional timber supply and wood residue markets. Scenarios were designed with USFPM/GFPM ranging from baseline of 48% increase to 173% increase in annual consumption of fuelwood for energy from 2006 to 2030 in the United States, while consumption of fuelwood in other countries was assumed to increase by around 65% in aggregate.

Except energy market, traditionally, GFPM was widely adopted in analyzing the change driven by policy in forest product market. Zhu and Buongiorno (2001) applied GFPM to assess the impact of the U.S. paper-recycling policies and pointed out further paper recycling in the United States would affect the pulp and paper markets in other countries. Buongiorno (2003) also applied GFPM to present a simulation of the impact of the U.S. timber harvest policies on Pacific Rim timber markets and forest resources. Economic change and trade change could also be simulated with GFPM by linking the change with forest product market. Whiteman (2000) manipulated GFPM with Food and Agriculture Organization(FAO) predicted data for GDP and population in New Zealand to finish a prediction for forest product existing in GFPM with respect to demand, supply in New Zealand.

Compared with the sub regional model such as SRTS and NTM II, GFPM is more suitable for the federal program analysis. Compared with the general equilibrium model like CGE and agricultural-forestry combination model POLYSIS, GFPM could conduct detailed analysis for the competition between traditional forest product and bioenergy market. Furthermore, the GFPM also includes the variables of forest area and forest stocks, which are generally accepted as the index measuring environmental sustainability .Therefore, a completed introduction of GFPM is needed.

CHAPTER 3
METHODOLOGY

Model Instruction

BCAP effects are modeled using GFPM-Global Forest Product Model. GFPM is an economic model of global production, consumption and trade of forest products (Buongiorno et al., 2003). GFPM 2010 has data and parameters to produce and forecasts of forest resources and markets for 180 countries, and 14 forest product (commodity) categories, from 2006 to 2060 (Buongiorno et al., 2010).

For each product in each country in each year, consumption, production, export, import, manufacturing cost, price and value-added could be calculated based on the input data for six variables and equations listed below. For dynamic changes, part of parameters in six variables could be adjusted exogenously with the aim to simulate policy.

Country Classification

GFPM includes 180 countries (Table A-2) and it could be divided into 7 regions: Africa, South America, North/Central America, Asia, Oceania, Europe and Former USSR. In this research, the United States is the focus since BCAP is the U.S. policy instead of an international policy. Also, we concentrate on the North America, which might be influenced by the U.S. policy.

Commodity Coverage

There are 14 forestry commodities: fuelwood and charcoal, industrial roundwood, other industrial roundwood, sawn wood, veneer and plywood, particleboard, fiberboard mechanical wood pulp, chemical and semi-chemical wood pulp, other fiber pulp, waste paper, newsprint, printing and writing paper, other paper and paperboard. The production transformation could be concluded as Figure 3-1.

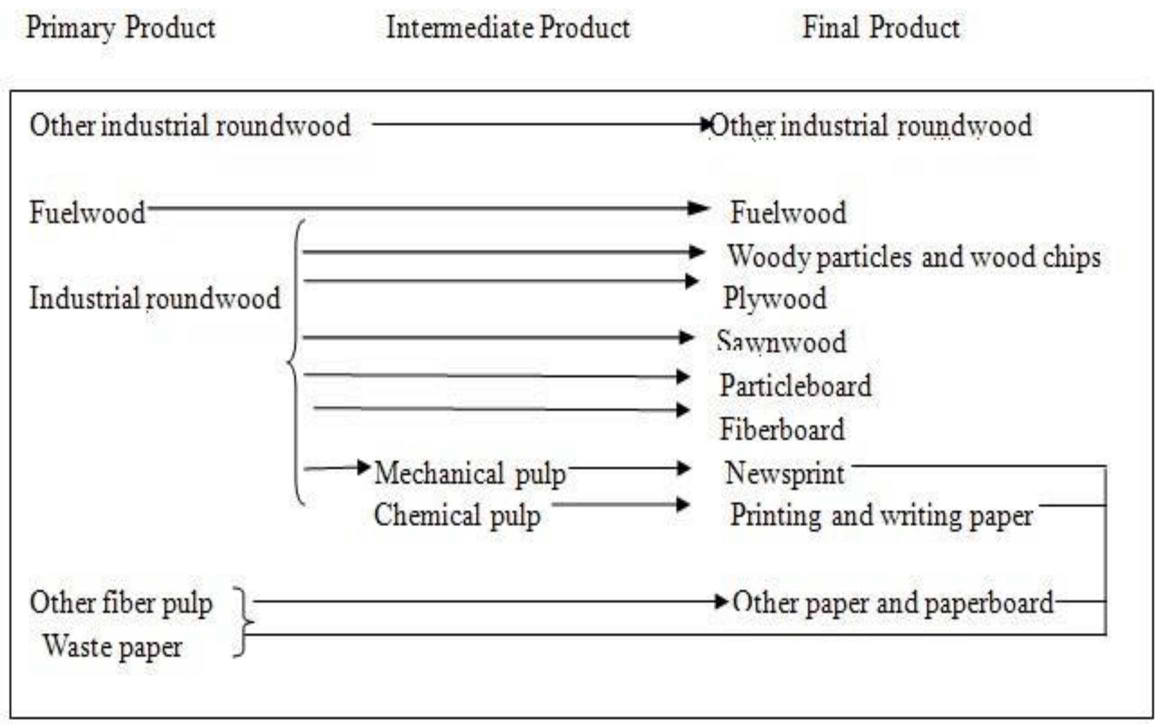


Figure 3-1. Forest product transformation in GFPM. [Source: Raunikar, R., Buongiorno, J., Turner, J.A., Zhu, S., 2010. Global outlook for wood and forests with the bioenergy demand implied by scenarios of the Intergovernmental Panel on Climate Change. Forest Policy and Economics 12, 48-56]

In this research, three products in GFPM are picked up as subsidized targets: fuelwood, chips and industrial roundwood, and three final products are targeted as the competitors being examined the BCAP influences on their productions: particleboard, woodpulp and paper.

Fuelwood and chips combined take half of subsidies from the matching payments for woody biomass (Figure 1-4 and Figure 1-5). Therefore, these two products are the subsidized products for the matching payments, which aim to deduce the costs of collecting, harvesting, storage and transportation of woody biomass. We transform these payments to a decrease in manufacturing costs. We will introduce how to adjust the parameters in GFPM for these two products in the next parts. Regard chips, since it is not listed separately in GFPM, we classify it into the industrial roundwood, which is also fitting in the definition set by FAO: the industrial roundwood included saw logs or veneer logs, pulpwood, other industrial roundwood and, also chips and particles and wood residues. The final product, particleboard, is the competitor for raw materials in the matching payments since it greatly depends on the chip. A change in manufacturing cost of chips will influence the production of particleboard.

In the establishment payments and the annual payments, industrial roundwood is picked up to receive the subsidies. The change in industrial roundwood is from the extra plantation of short-rotation wood crops (SRWC). In the United States, SRWC are regarded as the promising energy crops to meet future demand for bioenergy with its quick-growing and high-yield advantages. Rotation lengths for SRWC range from about 6 to 12 years, although they can be shorter (3 years, e.g., Adegbidi et al., 2001) if the material is sold for bioenergy feedstock or longer (up to 15 years, e.g., Stanton et al., 2002) if sold for sawntimber. As we see, from the last citation, SRWC could be used to produce not only bioenergy but also sawntimber. Besides, woodpulp and paper's production also highly depend on SRWC. Therefore, if BCAP subsidies are attributed to SRWC, in another word, to industrial roundwood in GFPM, there must have a change in productions of woodpulp and paper since, industrial roundwood is the main raw material to produce other forest final products (Figure 3-1).

We link the establishment payments and the annual payments to the price elasticity for industrial roundwood in GFPM so as to calculate the supply expand rate. We will introduce the parameters in details in the next section and Chapter 5.

Six Exogenous Variables

Primary Product Supply

In GFPM, supply was divided into two parts: supply for primary product and recycled product and supply for end product and intermediate product. The former is represented in econometric equation, which could be adjusted exogenously, and the latter is presented in input-output (I-O) coefficient, which was calculated based on previous studies and research. Generally, the change in supply for primary product and recycled product is determined by price, forest resource inventory and other variables influencing the supply (Binkely and Dykstra, 1987). We are able to express it in Cobb-Douglas productions function, which is static equation for each product in one year (Buongiorno et al., 2003):

$$S_{ik} = S_{ik}^{*}\left(\frac{P_{ik}}{P_{ik,-1}}\right)^{\lambda_{ik}} \qquad [3\text{-}1]$$

Where: i j = country, k = product, S* = current supply at last period's price, and λ = price elasticity of supply. For the dynamic change, S* depends on last period's supply, and on exogenous or endogenous supply shifters (Equation 3-2), which could be adjusted based on the policy. In the base year, S* is equal to the base-year supply, and $P_{ik,-1}$ is equal to the observed base year price.

Shifts of supply: the wood supply (fuelwood, industrial round wood, or other industrial round wood) can be shifted exogenously.

$$S^{*} = S_{-1}(1 + \beta_I g_I + \beta_{y'} g_{y'}) \qquad [3\text{-}2]$$

Where: g_I = adjustable supply change rate, $g_{y'}$ = periodic rate of change of GDP per capita, and β = elasticity. The variable driving supply change is g_I , which is adjustable based on policy requirements (Buongiorno et al., 2003).

Total wood drain from the forest:

$$S_i = (S_{ir} + S_{in} + \theta_i S_{if})\mu_I \qquad [3\text{-}3]$$

Where: r = industrial roundwood, n = other industrial roundwood, f = fuelwood, 0≤ θ≤1 = fraction of fuelwood that comes from the forest and μ≥1 = ratio of drain to harvest(Buongiorno et al., 2003).

End Product Demand

In GFPM, demand also was divided into 2 parts: demand for end product, intermediate product and recycled product. The former is presented by the econometric equation, and the latter is expressed by an I-O coefficient. Generally speaking, demand for each end product is decided by real GDP and price of that product (Buongiorno and Chang, 1986). We transformed it into the equation, which is the static equation for each product in one year:

$$D_{ik} = D_{ik}^{*}\left(\frac{p_{ik}}{p_{ik-1}}\right)^{\delta_{IK}} \qquad [3\text{-}4]$$

Where: D* = current demand at last period’s price, P-1 = last period’s price, and δ= price elasticity of demand. For dynamic change, D* depends on last period’s demand, and the growth of GDP in the country (Equation 3-5), which is adjustable based on the policy. In the base year, D* is equal to the observed base year consumption, and $P_{ik,-1}$ is equal to the observed base-year price.

Shifts of Demand:

$$D^* = D_{-1}(1+\alpha_y g_y + \alpha_0) \qquad [3\text{-}5]$$

Where g_y = GDP periodic growth rate, α_y = elasticity with respect to GDP and α_0 =periodic trend. As the changeable rate, g_y could be adjusted exogenously. The parameters driving the demand change is from GDP with the assumption that higher GDP growth will lead to a higher consumption of forest product (Buongiorno et al., 2003).

Manufacture Capacity

In this part, manufacture is divided into 2 parts: I-O coefficient and manufacture cost. GFPM simulates the process of transforming raw materials into final product and intermediate product (Buongiorno, 2003). This process is represented by I-O coefficient (Table A-6). Each product in each country is expressed by one matrix and reflects technology level. Using data from 1992 to 2006, I-O coefficients are estimated by minimizing the deviation of calculated from observed production for all products, given a priori bounds on the I-O coefficients. The manufacturing cost is the marginal cost of the inputs not recognized explicitly by the model (labor, energy, capital, etc.). We could express it in the static equation for each product in one year:

$$m = m_{ik}^*\left(\frac{Y_{ik}}{Y_{ik,-1}}\right)^{s_{ik}} \qquad [3\text{-}6]$$

Where: m* = current manufacturing cost, s= elasticity of manufacturing cost with respect to output and Y=the amount of output. For dynamic change, m* depends on last period’s manufacturing cost (Equation 3-7), and on the exogenous rate of change of manufacturing cost. In the base year, m* is equal to the observed base-year manufacturing cost and $Y_{ik,-1}$ is equal to the observed base-year quantity manufactured.

The manufacturing cost function shifts exogenously over time:

$$m^{*} = m_{-1}(1+g_{m}) \tag{3-7}$$

Where g_m = the exogenous change rate in manufacturing cost.

In this research, forest resources, recycle and transportation were not closely linked to the research aims. There is only a brief introduction for these three variables.

Forest Resource

This section contains data for forest area, forest resource stock and GDP per capita which are related to production, consumption and other parts closely.

Recycle

The wastepaper recovery rate is the ratio of wastepaper production in the current year to last year's paper consumption. It tied closely to last year's consumption and recycled policy in each country. The change in wastepaper recycle rate is projected by GFPM (Buongiorno et al., 2003).

Transport

This part includes: quantity of international trade, trade tariff (export and import tariff), freight cost and trade inertia. Among them, we need to explain freight cost and trade inertia. Regarding freight cost, generally, we could obtain it from the difference between world export and import unit value from product. It keeps constant in the projection period. Trade inertia plays a restriction condition in the model. Trade (export and import) could not exceed its lower bound and upper bound). The transport cost per unit of volume for commodity k from country i to country j is given by:

$$c_{ijk} = c^*_{ijk}(\frac{T_{ijk}}{T_{ijk,-1}})^{\tau_{ijk}}$$ [3-8]

Where: c*=current transport cost at last period's trade, and T=elasticity of transport cost with respect to trade. As shown in the next section, c* depends on last period's transport cost, and on the exogenous changes of freight rates and taxes (Buongiorno et al., 2003). In the base year, c* is computed as:

$$c_{ijk} = f_{ijk} + t^X_{jk}\left(P_{ik,-1}\right) + t^I_{jk}\left(f_{ijk} + P_{ik,-1}\right),$$ [3-9]

Where: c = transport cost per unit of volume, f = freight cost per unit of volume, t^X =export tax, t^I = import ad-valorem tariff, and $P_{ik,-1}$ is equal to the observed base-year world export price (Buongiorno et al., 2003).

Objective Function

The objective for the model is to maximize welfare, which means to maximize consumer surplus and producer surplus which means the valued of end product minus the cost of raw material, the cost of transforming raw materials into the end product and cost of transport. We could specify the objective function as:

$$MaxZ = \sum_i \sum_k \int_0^{D_K} P_{ik}(D_{ik})dD_{ik} - \sum_i \sum_k \int_0^{s_K} P_{ik}(S_{ik})dS_{ik} - \sum_i \sum_k Y_{ik} m_{ik} - \sum_i \sum_j \sum_k c_{ijk} t_{ijk}$$ [3-10]

Where: z= consumer surplus and producer surplus, i j =country, k=product, p=price in US dollar of the constant value in the given year, Y= production quantity, m=manufacture cost efficient, c=transport cost and t= transport quantity (Buongiorno et al., 2003).

The first term could be explained as the consumer surplus which is the area under the demand curve and the last three terms could be explained as producer surplus which is the area under supply curve.

Constraint Function

The constraint condition could be summarized by this equation:

$$\sum_{j} T_{jik} + S_{ik} + Y_{ik} - D_{ik} - \sum_{n} a_{ikn} Y_{in} - \sum_{j} T_{ijk} = 0 \qquad [3\text{-}11]$$

Where: T= import/export, S=domestic supply, Y=manufacture quantity and D= domestic demand. The subscripts have the same meaning with objective function. The coefficient a_{ikn} indicates how much of product k is used to make product n in country i and it represents the technology level in that country. Constraint equation means domestic production with the consideration of import and manufacture quantity should equal to domestic demand plus export and manufacture needed for other products. With objective equation and constraint condition, after inputting data for 6 parts discussed above, we could get equilibrium price, production, demand, trade and transport quantity (Buongiorno et al., 2003).

CHAPTER 4
SCENARIO DESIGNED

In order to explore the impacts of BCAP on forest products market, several scenarios are designed to simulate its effect. As described in methodology framework, the supply and manufacturing cost for forest product in GFPM could be adjusted exogenously. Four scenarios are designed to simulate the three payments in BCAP, which are the baseline scenario, matching payments scenario, the establish payment scenario and the annual payments scenario.

Baseline Scenario

In the baseline scenario, there is no change in the exogenous variable. The change rate is as set in GFPM 2010 by the author.

The Matching Payments

Based on the rules in BCAP, the matching payments (CHST) are authorized at a rate of $1 for each $1 per dry ton paid by a qualified biomass conversion facility for the sale and delivery of “eligible materials”. Payments are capped at $45 per dry ton. The payments are made directly to eligible landowners or farmers for 2 year period, beginning on the date the first payment is issued to the eligible owners. For research aim, we manually extend the eligible period to 15 years as of the establishment payments and the annual payments.

Scenario description: 100 percent deduction in manufacture cost of fuelwood and chips are simulated. In GFPM, the manufacture costs are costs not computed endogenously by the GFPM such as labor, capital, energy and other non-wood or fiber input. Therefore, the matching payments should be transformed into a decrease in manufacture cost for fuelwood and an increase in that of particleboard, which uses the chips as the raw materials. The maximum amount in this payment is $45/ MT. We need to transform this amount as the exogenous change rate in manufacturing cost required in GFPM.

- Firstly, unify the units based on the requirements in FAO: using a factor of 6.0 to convert from weight (MT) to solid volume units (CUM). $45/ MT---- $45/6= $7.5/CUM.

- Identify the manufacture cost for fuelwood: in GFPM, the manufacturing cost of fuelwood is zero in its database, which might ignore the lost opportunity to do more productive or important work such as generating bioenergy. Therefore, in this study we exert the base year market price for fuelwood as the manufacturing cost which is $50/CUM.

- For the base year 2006, fuelwood production is 44.7 million CUM (FAO 2006). The manufacturing cost is 50/CUM. We assume that the manufacturing cost did not change until the year 2010, the beginning of BCAP.

- Based on the estimation made by Perlack (2005), the national annual supply for fuelwood is 51 million dry ton (the sum of currently used and potentially used) which is transferred into cubic meter is 8.5 million CUM. We assume that all the supply were eligible in the BCAP program to receive the matching payments. Therefore, the manufacturing cost for this new part is 50-7.5=42.5/CUM, and the matching payments for fuelwood are $63.75 million.

- The new manufacturing cost, taking the consideration of the amount of fuelwood used to produce bioenergy, is: {8,500,000*42.5+ (44,701,000-8,500,000)*50}/44,701,000=48.57/CUM.

- The change rate for the fuelwood is :(48.57-50)/50=-0.0286.

- We also apply the same method to the woodchips. Since there is no separately list for woodchips and wood particles in the GFPM, we assume that there was an increase in the manufacturing cost for the particleboard, which depends on the woodchips and wood particles intensely.

- Perlack (2005) estimated that, in 2006, harvest residues amount to about 64 million dry tons of cut or killed materials left on harvest site. We assume all this 64 million dry tons could be qualified as eligible material. Transforming the amount into cubic meters is 10.6 million CUM. The total production of particleboard from the supply of chips is 11.16 million CUM calculated by the I-O coefficient in GFPM (Table A-6). In 2006, the supply for particleboard was 21.98 million CUM. The matching payments for particleboard are 79.5 million.

- The manufacturing cost of particleboard is $108.5241/cum in base year.

- Therefore, the rate should be (10.6*(108.5241+7.5) +11.38*108.5241)/21.98=112.141.
- Therefore, there is an increase of manufacturing cost for particleboard with the rate of (112.141-108.5241)/108.5241=0.0333.

The Establishment Payments

Based on the rules in BCAP: the establishment payments are authorized to cover up to 75% of the “actual or average cost (whichever is lower)” of establishing an eligible perennial crop (either woody or non-woody).In order to simplify the simulation procedure, we assume that the establishment payments were based on the average cost of the national average level.

Scenario description: the aim of the establishment payments is to encourage the plantation of dedicated energy crops. Currently, in the United States, energy wood mainly means SRWC (White, 2010). Generally, willow, poplar, cottonwood, sycamore, and southern pine are widely planted across the nation to be used as SRWC. We do not specify the species but just assign the SRWC as the eligible materials to receive the establishment payments. In addition to the potential use for biopower and biofuel, SRWC can also be used to produce woodpulp, paper and sawnwood (Stanton et al., 2002). Therefore, we classify the SRWC into the category of industrial roundwood in the GFPM, which extend its supply from the extra plantation of SRWC.

Currently, in the United States, the average production cost for SWRC is 39-58 dollars/ acre (Tharakan et al., 2005; Eaton, 2007) and general yield for SRWC using contemporary planting stock under current management systems ranges from 5 to 12 dry tons per acre per year of woody material (Adegbidi et al., 2001; BRDB, 2008; Volk et al., 2006).

- Assume the national average establishment cost was (39+58)/2=$48.5/acre and the average harvest tons was (5+12)/2=$8.5ton/acre. Therefore the production cost would be 48.5/8.5=$5.7059/ton.

- Transfer the production cost into CUM. It is 5.7059/6=$0.951/CUM.

- Getting the subsidy from the government, the new establishment cost is 0.951*0.25=$0.2377/CUM.

- The establishment payments are (0.951-0.2377)*(23.8/6)*15=$42.44million.

- We assume that the ratio of establishment cost and price did not change. The ratio of establishment cost and price in the base year 2006 is 0.951/50=0.01902.

- Therefore, the newer price should be 0.2377/0.01902=$12.49737.

- The price change is $50-$12.49737=$37.50263. The price elasticity is 0.64(Table A-4).

- The supply change should be 0.64* (37.50263/50)=0.48.

The Annual Payments

Based on the rules in BCAP, the annual payments are intended to offset the lost opportunity costs associated with cultivating a biomass crop as opposed to a traditional crop. The payments will be similar to CRP payments based on all or a percentage of a weighted average soil rental rate for cropland.

In order to calculate the revenue used for the annual payments, the first step is to identify the area that is suitable for planting SRWC. The number of acres currently planted in SRWC is not definitively known (Tuskan, 1998). Ince (2009) estimated that less than 0.1% of the privately owned agriculture and forest land is currently dedicated to SRWC poplar plantations. Zalesny (2008) citing the work of Eaton (2007) reports approximately 132,000 acres of hybrid poplar currently planted in the United States. Hybrid poplar is planted on approximately 50,000 acres in the Pacific Northwest—for pulpwood and sawntimber production—(Stanton et al., 2002) and on about 6,000 acres in Minnesota for both pulpwood and energy production. Short-rotation woody crops have also been planted in the South (Tuskan, 1998) and the Northeast (including willow for bioelectricity production) (Adegbidi et al., 2001).

We adopt the estimation for eligible area from Alig (2000) with the consideration of budget, transformation from cropland to forest land and BCAP main function—encourage the extra plantation for dedicated energy crop. Alig et al. (2000) pointed out that about 2.8 million acres of cropland was suitable for planting SRWC, mostly in the Corn Belt, Lake States, and South Central states. General yield figures for SRWC using contemporary planting stock under current management systems range from 5 to 12 dry tons per acre per year of woody material (Adegbidi et al., 2001; BRDB, 2008; Volk et al., 2006).

Scenario description: based on the rules in BCAP, the rate for the annual payments is closely attached to another program Conservative Reserve Program (CRP). Therefore, the rate we used is based on the CRP data got from USDA in 2009(USDA, 2009):

- Soil Rental Rate (national average):$51.52/acre. Base year market price for fuelwood: $50/CUM.
- Therefore, in GFPM, we adopted the average harvest level mentioned in the establishment payments. For one year, the total yield of SRWC is 2.8* 8.5=23.8/million dry tons. Total expense for the annual payments is 2.8*51.52=144.26 million dollars.
- Average dry ton subsidy: 144.26/23.8=6.06/dry ton, which is transformed into cubic meters: 6.06/6=$1.01/CUM.
- Here, since the annual payments were directly linked to the opportunity cost of fuelwood, which was reflected in the market price, we assume the subsidy would influence its market price The price change would be(based on the base year market price) 1.01/50=0.02. The supply price elasticity is 0.64(Table A-4).
- Therefore the supply change rate would be 0.02*0.64=0.0128.

CHAPTER 5
RESULT

For each scenario, a set of results are generated to examine the BCAP impacts on forest products, forest area and welfare economics. We pay attention to five products as stated in chapter 2. They are two main input raw materials: fuelwood and industrial roundwood, which are subsidies by the matching payments and the establishment payments as well as the annual payments separately. Besides, there are also three closely related forest products: particleboard, woodpulp and paper, which are picked up as the competitors to biomass market.

We will demonstrate production change, price change and welfare economics change for each product from these three scenarios.

The Matching Payments

Production and Price Change for Fuelwood

Traditionally, North America was not the main producer of fuelwood compared with Africa and South Africa. Therefore, few changes happen in the North America (Figure 6-1). Specifically, there has been no change in fuelwood production in the United States under the matching payments, and Canada's production of fuelwood will decrease by -0.1% by the year 2025. While Africa seems to face a relatively modest increase, its percentage change rate is still around 0.1%. In summary, the change in the production of fuelwood under the matching payments is not significant. In BCAP, the maximum cap of $45 for the matching payments is not enough to influence the total production of fuelwood. Naturally, the fuelwood price in the United States did not change either.

Production and Price Change for Industrial Roundwood and Particleboard

Compared with fuelwood, the change in the industrial roundwood is relatively significant in the United States (Figure 6-2). From 2010 to 2025, there is a continuous decrease in the production of industrial roundwood. The decreasing rate is from -1.7% to -3.0%. Higher manufacturing cost for particleboard is the main reason for the reduction in industrial roundwood. The increase in manufacturing cost reduces the production of particleboard, which decreases the production of industrial roundwood indirectly.

For the particleboard, we could see that the decreasing rate is even higher compared with industrial roundwood but the absolute amount is smaller (Figure 6-2 and Table 6-1). The decreasing rate begins from -19.3% in 2015 to -44.2% in 2025 and the absolute amount decreases from 5.41 million CUM to 14.68 million CUM. The matching payments will encourage more chips to be used as bioenergy instead of traditional particleboard.

Companying with the changes of production, prices for industrial roundwood and particleboard also vary (Figure 6-3 and Table 6-2).We find that the price of particleboard increases faster in both percentage value and absolute value. Higher manufacturing cost is the direct drive to the raising price. The increasing rate for manufacturing cost is only 3.3% annually but the particleboard price will increase 14% annually. We conclude that the matching payments will force the competition between particleboard and bioenergy based on the projection of particleboard’s higher market price and lower production. While there is a decrease in the production of industrial roundwood, its price does not increase but decrease. The main reason is the other products such as sawntimber and wood panel (Figure 3-1) also decrease their productions. Therefore, the demand for industrial roundwood is relatively lower. In addition, higher import for particleboard from foreign countries also lowers its dependence on industrial roundwood. As a consequence, the price for industrial roundwood did not increase.

For the rest of world, as the second largest producer of industrial roundwood, Europe experiences a slightly increase in industrial roundwood production with an annual average increasing rate of 0.2% and the absolute increasing amount is around 1.018 million CUM. Also, in the particleboard market, Europe also faces increasing production with the annual increasing rate of 1.9% and the absolute amount of 794 thousand CUM. Asia follows the Europe's step with an annual increasing rate of 2.6% and absolute amount of 556 thousand CUM. These two producers of particleboard grasp the chance to expand their exports to the United States, which directly drives the expansion of domestic particleboard production.

For the world prices for industrial roundwood and particleboard, both of them experience the increasing tendencies but not too much. The higher price for particleboard in the United States stimulates its world price to increase.

Welfare Economics Change Under the Matching Payments for the United States

As mentioned in chapter 3, the objective function in GFPM is to maximize the consumer surplus and producer surplus, which also take the consideration of net trade change (Equation 3-11) (Buongiorno et al., 2003). Naturally, the standard measuring welfare economics in the United States is the changes of consumer surplus and producer surplus as well as net trade for the whole forestry industry. From Figure 6-4, we could see there is an increase in the welfare economics in the forestry industry in the United States. The increasing rate expands from 1.1% to 2.5% at the end of year 2025. The absolute value in 2015 is reaching to 678.5 million dollars. However, this value does not include government cost, which is 716.25 million based on the calculation in chapter 3. Compared with total gains from the matching payments, there is a net dead loss for the whole welfare economics.

From the producer aspect, the winner is the particleboard. Higher market price deduces a higher producer surplus. However, the increasing prices do not cover the loss from decreasing productions of other forest products. Therefore, the whole producer surplus is negative.

From the consumer surplus, the biggest loser is also from particleboard. Higher manufacturing cost drives the market price to rise, which decreases the consumer surplus. However, by importing cheap particleboard, the loss might be lessened to consumers but the whole consumer surplus is still negative.

From the net trade aspect, the winner is the importer of particleboard. Since its price is higher than the world price, particleboard is highly imported from Europe and Asia. The average importing rate is reaching to 120%. However, for the rest of forest products, the net trade value declines.

The Establishment Payments

Production and Price Change for Fuelwood

Under this scenario, we are able to see the fuelwood production experiences a sharp increase in the United States (Figure 6-5). From the beginning of BCAP, the fuelwood production increases with a rapid rate, and at the end of the year 2025, the rate has reached to 15.4%. The absolute increase also reaches to 7.97 million CUM. Why the fuelwood production increases so fast under this scenario?

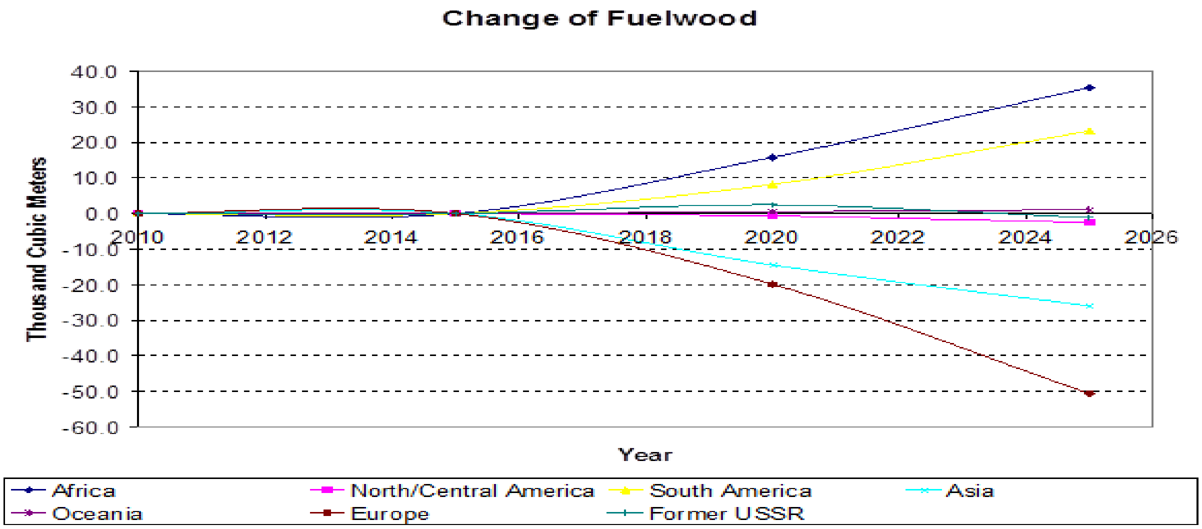


Figure 6-1. The change of fuelwood under the matching payments.

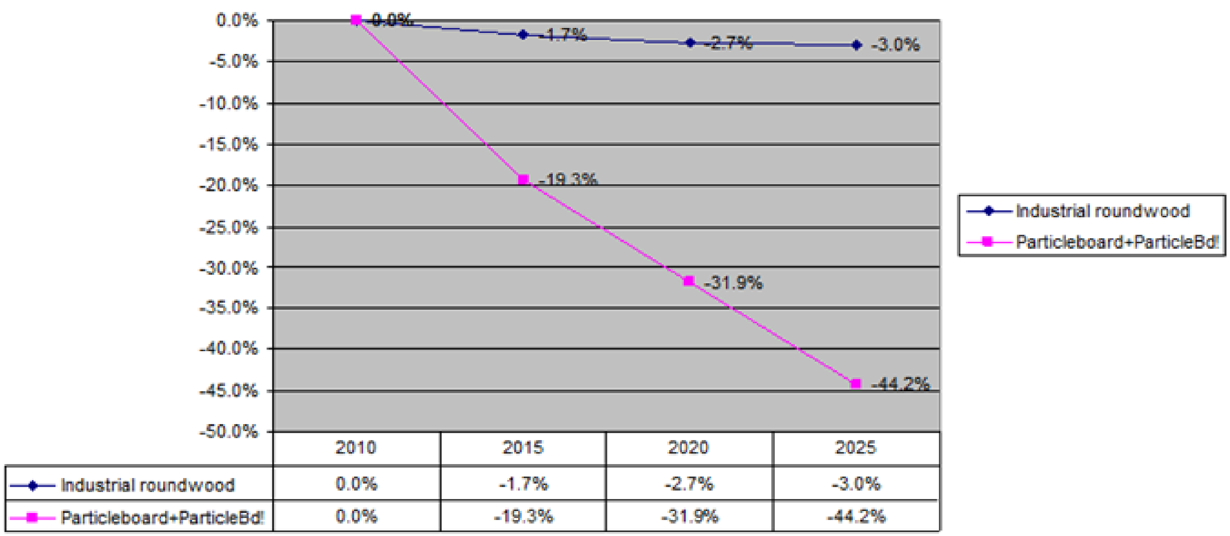
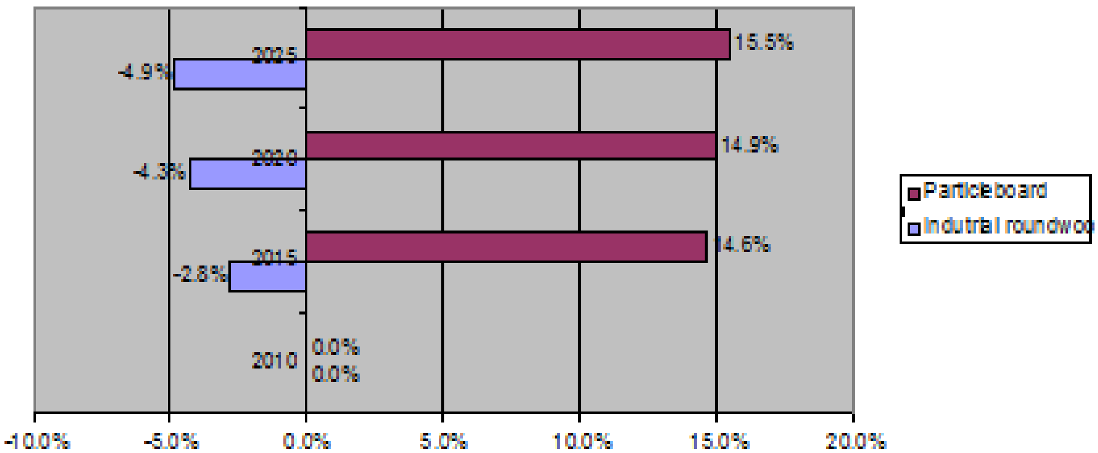


Figure 6-2. The production changes of industrial roundwood and particle.

Table 6-1. The absolute change in production for industrial roundwood in the United States under the matching payments

Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	-7396.3	-11663.7	-13014.5	-32074.5	-5345.8
Particleboard	0.0	-5451.6	-9818.0	-14683.3	-29952.9	-4992.2

Unit: thousand CUM



	2010	2015	2020	2025
Particleboard	0.0%	14.6%	14.9%	15.5%
Industrial roundwood	0.0%	-2.8%	-4.3%	-4.9%

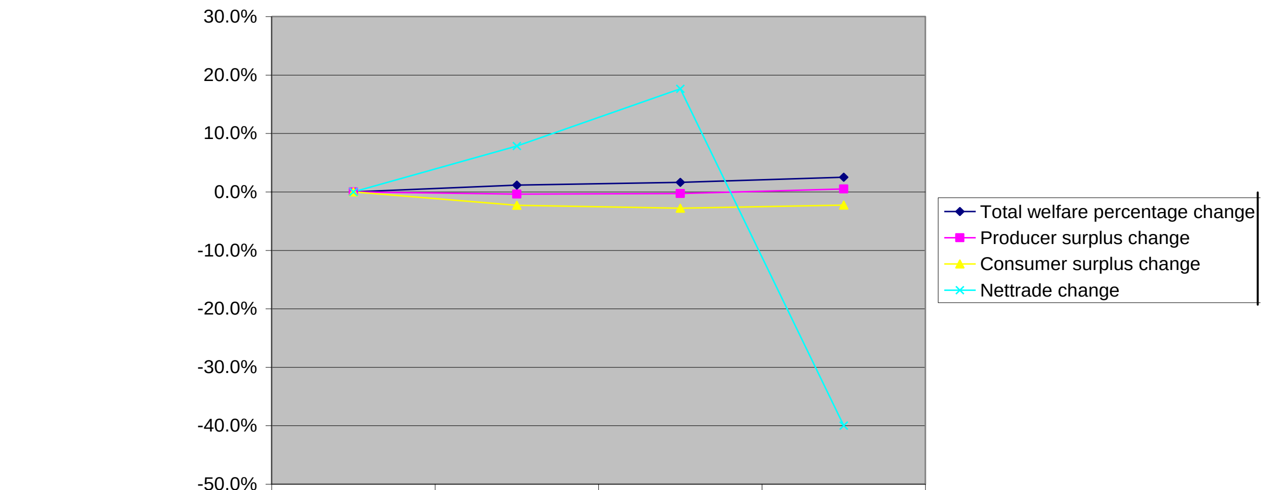
Figure 6-3. The percentage changes in prices of particleboard and industrial roundwood under the matching payments.

Table 6-2. The absolute price change of particleboard and industrial roundwood under the matching payments

Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	-2.1	-3.1	-3.4	-8.6	-1.4
Particleboard	0.0	35.4	35.0	35.0	105.4	17.6

Unit: US dollar

In GFPM, the I-O coefficient between industrial roundwood and fuelwood is 1(Table A-6), which means inputting one unit industrial roundwood will produce 1 unit fuelwood. The establishment payments attribute to the industrial roundwood and there is an increase in its production. Naturally, the fuelwood production will rise as well. Compared with the increasing rate of industrial roundwood, the fuelwood increasing rate is not faster. Higher production does not bring a lower price for fuelwood. The consumption for fuelwood increases as well with almost the same rate.



	2010	2015	2020	2025
Total welfare percentage change	0.0%	1.1%	1.6%	2.5%
Producer surplus change	0.0%	-0.4%	-0.3%	0.5%
Consumer surplus change	0.0%	-2.3%	-2.8%	-2.3%
Nettrade change	0.0%	7.8%	17.6%	-40.0%

Figure 6-4. The percentage change of welfare economics under the matching payments.

Table 6-3. The absolute added value for the United States under the matching payments.

Year	2010	2015	2020	2025	Total	Average
Total value	0.0	678473.1	868596.3	1172949.3	2720018.6	544003.7

Unit: thousand dollars

Therefore, the price for fuelwood does not change too much with only an absolute amount of 0.1 dollars at the end of year 2025.

North America also experiences a similar tendency. From the beginning of BCAP 2010, there is an increase in the production of fuelwood and the increase lasts until 2015 with a rate of 5.4% annually and then a further increase emerges from 2015 to 2025. The rate is reaching to 16% at the end of 2025. For the rest of the world, the changes in fuelwood production and price are still insignificant. However, as the main player in fuelwood production, Africa undergoes an absolute increase with the amount of 22.5 thousand CUM.

Production and Price Change for Industrial Roundwood, Woodpulp and Paper

Under the establishment payments, industrial roundwood was picked as the representative to receive subsidies. Woodpulp and paper were targeted as the competitors being examined BCAP's effects on their productions.

From the Figure 6-6 and Table 6-4, we could conclude that all of industrial roundwood and woodpulp as well as paper increase sharply compared with the matching payments. Industrial roundwood begins to expand its production from 2010 with a rapid rate of 142.3%, and then a relatively modest increasing rate of 49.4% is found since 2020. Woodpulp and paper also follows the increasing tendency with the rates around 10% and 8%.

Compared with the matching payments, the establishment payments are larger and its effects on industrial roundwood production are more significant. However, we could find that, after experiences a strong increase, it will take a modest increase. The reason is the price of industrial roundwood continues to fall (Figure 6-7). Woodpulp's and paper's prices also follow the same decreasing tendency. Unlike fuelwood, these three products' consumptions do not catch up their supplies. As a consequence, the prices will decline.

In summary, the establishment payments could strongly simulate the supply of industrial roundwood to rise up but the prices will go through the decreasing tendency. Compared with woodpulp and paper, fewer fuelwood are transformed from industrial roundwood because its price is still lower than those of woodpulp and paper.

For the rest of the world, as the second largest pulpwood and paper producer, Europe will experience a strong decrease in the productions of woodpulp and paper. The deduction rates are projected to be -2.8% and -0.9%. Another producer of woodpulp and paper, Canada, will also face a decrease in its productions with the decreasing rates of -1.0% and -1.6%.

Welfare Economics Change Under the Establishment Payments in the United States

From the Figure 6-8, we could find that there is an increase in the total welfare economics in the forestry industry in the United States. The increasing rate is 13% from the beginning of BCAP. Taking into the consideration of government budget for the establishment payments 44.8 million dollars, the total gain is far more than the government payments.

However, we could also find that both producer surplus and consumer surplus decrease, while the net trade value increase rapidly. The increasing net trade is the main reason for the increase in the welfare economics.

From the producer aspect, the biggest loser is the industrial roundwood producer. Due to the establishment payments, the price of industrial roundwood falls down too much, which directly decrease the producer surplus. The next two losers are woodpulp and paper, whose prices fall down as well with the rates of -17% and -3.8%.

From the consumer aspect, the biggest loser is from paper. Due to the lower price of paper, its export increase proportionally, Therefore, the extra benefit from the establishment payments is transferred to the foreign consumers and the domestic consumer surplus decrease.

From the net trade aspect, the biggest winner is the paper exporter. The United State is originally the big country in exporting paper and woodpulp. Lower domestic price directly stimulates the strong export for paper with an amazing rate of 92%.

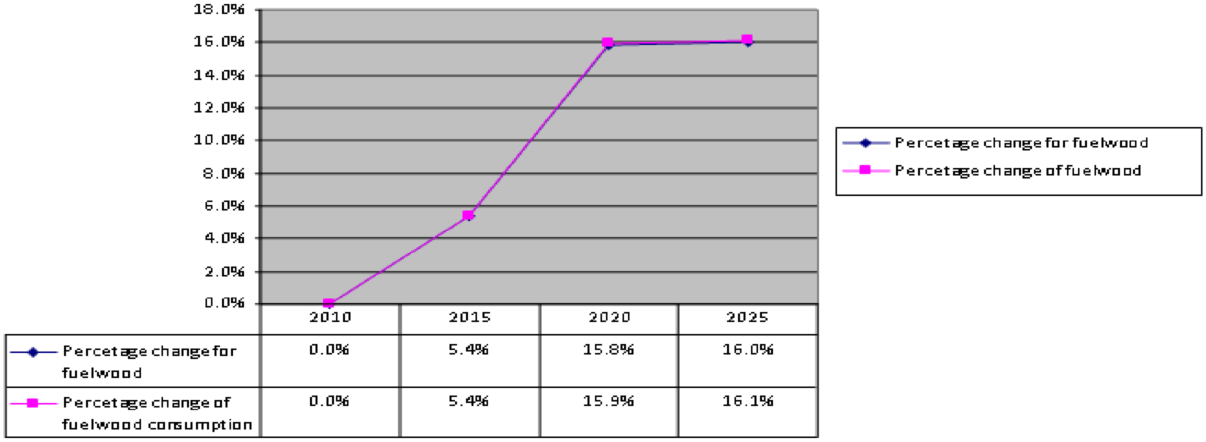


Figure 6-5. The percentage change of fuelwood production and consumption under the establishment payments.

Figure 6-6. The percentage change in production of industrial roundwood, woodpulp and paper under the establishment payments.

Table 6-4. The absolute change in production of industrial roundwood, woodpulp and paper under the establishment payments

Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	612961.4	214328.7	214871.1	1042161.2	173693.5
Woodpulp	0.0	5698.7	9009.6	12389.1	27097.4	4516.2
Paper	0.0	5981.1	8436.3	10864.8	25282.2	4213.7

Unit: thousand CUMs/tons

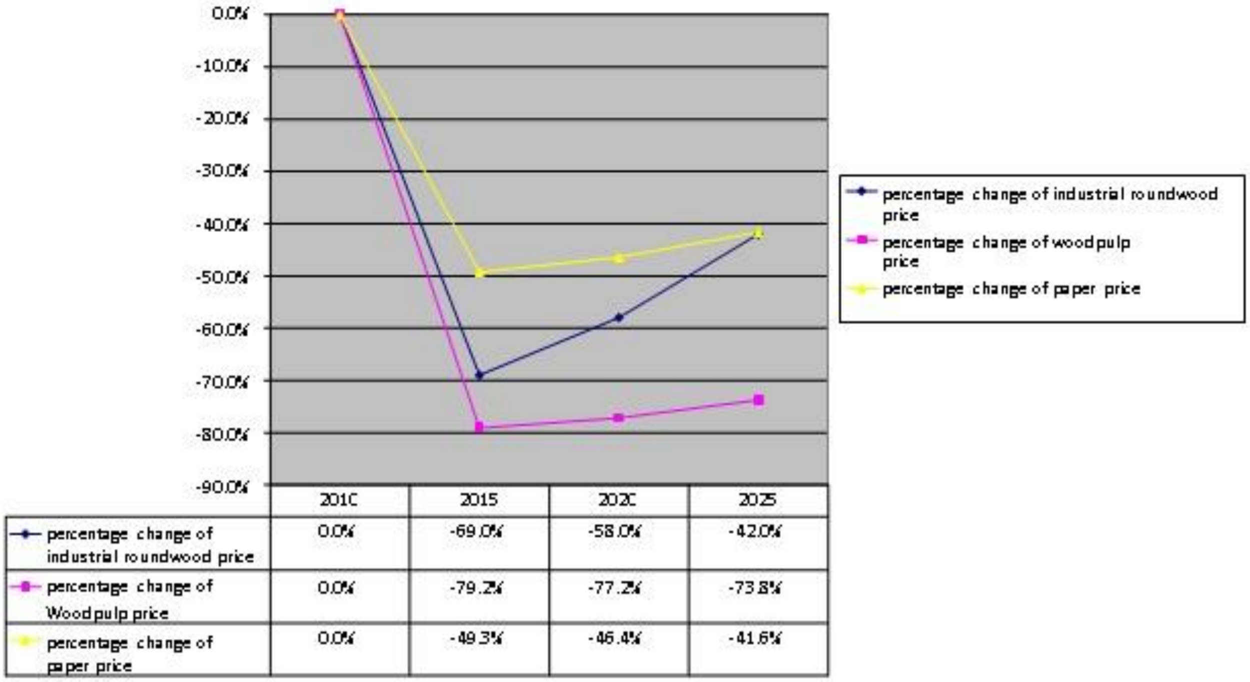


Figure 6-7. The percentage change in price of industrial roundwood, woodpulp and paper under the establishment payments.

Table 6-5. The absolute change in prices of industrial roundwood, woodpulp and paper under the establishment payments

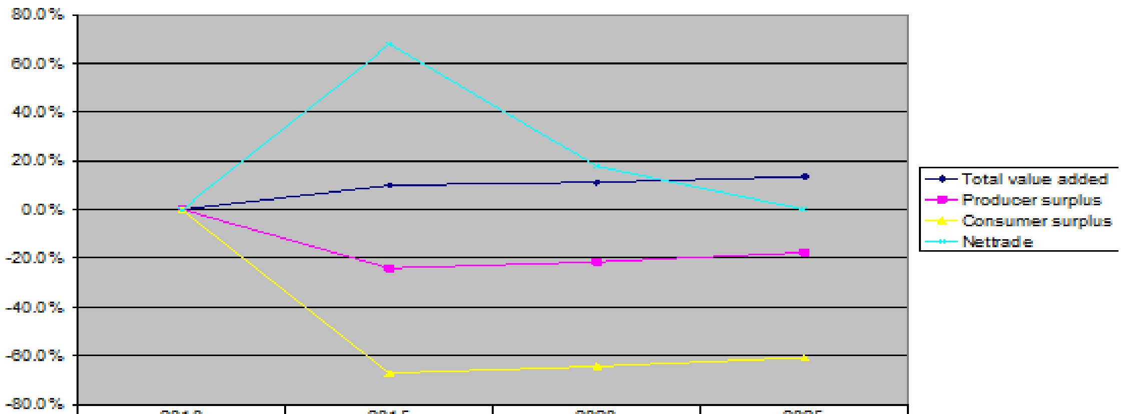
Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	-74.5	-72.8	-70.1	-217.4	-54.4
Woodpulp	0.0	-391.3	-372.4	-346.0	-1109.7	-277.4
Paper	0.0	-376.3	-342.0	-296.5	-1014.8	-203.0

Unit: US dollar

Table 6-6. The absolute added value in the United States under the establishment payments

Year	2010	2015	2020	2035	Total	Average
Value Added	0.0	5915848.0	5904760.7	6318487.6	18139096.2	3627819.2

Unit: thousand dollars



	2010	2015	2020	2025
Total value added	0.0%	10.0%	11.2%	13.4%
Producer surplus	0.0%	-24.1%	-21.5%	-17.7%
Consumer surplus	0.0%	-67.1%	-64.4%	-60.8%
Nettrade	0.0%	67.8%	17.7%	0.0%

Figure 6-8. The percentage change of welfare economics in the United States under the establishment payments.

The Annual Payments

Production and Price Change for Fuelwood

For the change of fuelwood production with the annual payments, the total percentage change is not significant. The absolute change for fuelwood in world market is decreasing around 2.2 thousand CUM, a relatively small change. In the United States, there is an annual increasing 0.1% of production for fuelwood until the ending projection, while there is annual decrease 0.3% of fuelwood production in Canada. Therefore, the curve for North America is a reverse V shape (Figure 6-9). Compared with the establishment payments, the annual payments is not higher enough to encourage more industrial roundwood to be transformed to fuelwood. Also, although the price for fuelwood is projected to increase to $55.6 per unit, it is still lower than woodpulp and paper, which are projected to undergo a decreasing tendency. Therefore, this low price of fuelwood is not enough to attract more dedicated energy crops from the traditional woodpulp and paper industry.

Production and Price Change for Industrial Roundwood, Woodpulp and Paper

From the Figure 6-10 and Table 6-7, we could find that all of industrial roundwood, woodpulp and paper will increase their productions under the annual payments. However, we firstly find that there are decreases from the year 2010 to the year 2015, and then an increase is followed by the year 2025. When we check the price change (Figure 6-11), we find that the price change tendency is opposite to the production change. The reason is that the annual payments, unlike the establishment payments, are issued annually, which means that the landowners or farmers could not get relatively large subsidy at the beginning of the BCAP and that it might not be enough to enhance the producers' willingness to plant SRWC. However, the cumulative effects will come into play at the end of BCAP with the increasing productions. As a result, the production changes will witness an increase at the end of BCAP.

For the rest of the world, Europe and Canada are projected to face the decreases in the production of woodpulp and paper. Comparatively speaking, the negative impacts on those two countries are smaller than the establishment payments'. Europe will meet -0.2% of the decreases in pulpwood and -0.1% in paper industry. Canada will not suffer the loss in pulpwood and undertake around -0.1% loss in paper.

In summary, the changes caused by the annual payments for the rest of world are not significant. However, in the United States, the subsidies for opportunity cost are ineffective at the initial time due to small amount but function well at the end of the program.

Welfare Economics Change Under the Annual Payments in the United States

From Figure 6-12 and Table 6-9, while there is an increase in the percentage change in the year 2020 and 2025 for the total welfare economics, the total absolute value will decrease, which means that a loss is founded in the welfare economics. We could find enhanced trade value is the main reason driving the welfare economics to rise. Regarding domestic producer and consumer, both of them suffer the loss from the annual payments.

From the supply aspects, the biggest loser is the industrial roundwood producer. Due to the annual payments, the price of industrial roundwood falls with an annual rate of -1.1%, which directly decreases the producer surplus. The next two losers are woodpulp and paper, whose prices decline as well with the rates of -0.3% and -0.1%.

From the consumer aspect, the biggest loser is pulpwood, which undertakes around -0.5% of the losses caused by the annual payments. Similar to the establishment payments, most benefits from lower price brought by BCAP were transferred to foreign consumer via export.

From the trade aspect, the winners are still from woodpulp and paper exporter. Just like the establishment payments, lower domestic prices enhance the competitiveness for these two products and speed up their exports.

In summary, except the matching payments, the establishment payments and the annual payments are effective in enhancing the production of fuelwood, which verifies the statement that establishment cost and annual revenue are the big two concerns.

Compared with the annual payments, the establishment cost is more effective in raising willingness to plant energy crops. For the matching payments, the cap for $45/dry ton is not enough to decrease the manufacturing cost of fuelwood so as to boost the fuelwood production.

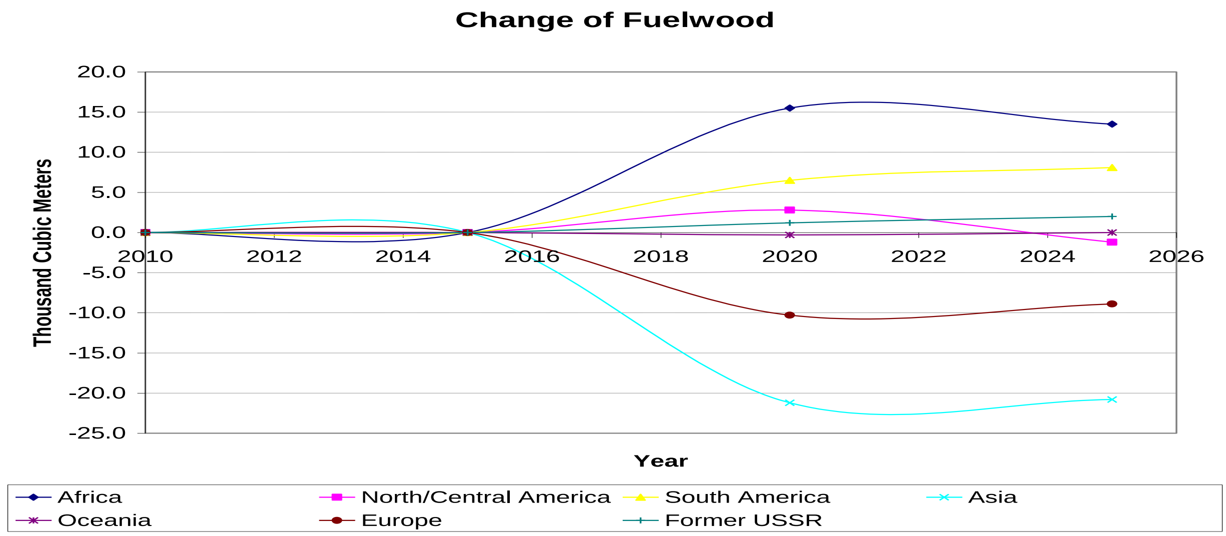
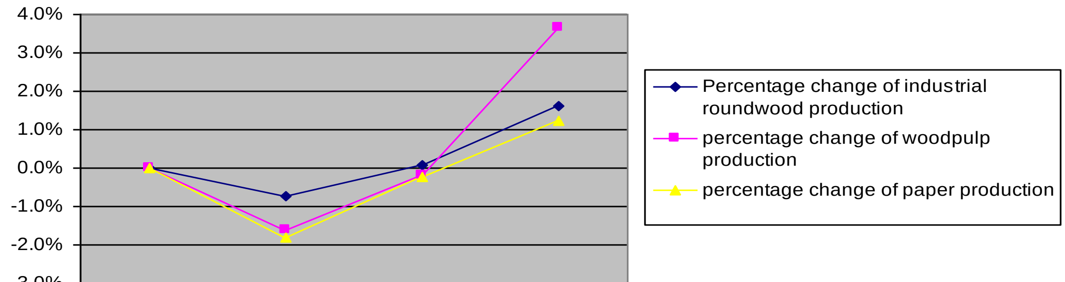


Figure 6-9. The production change of fuelwood under the annual payments



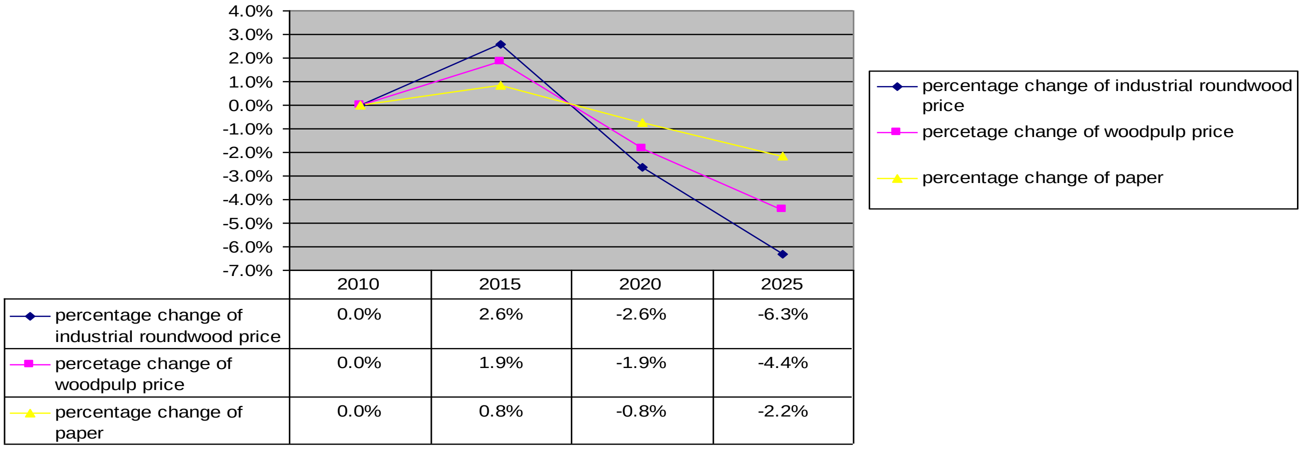
	2010	2015	2020	2025
Percentage change of industrial roundwood production	0.0%	-0.7%	0.1%	1.6%
percentage change of woodpulp production	0.0%	-1.6%	-0.2%	3.7%
percentage change of paper production	0.0%	-1.8%	-0.2%	1.2%

Figure 6-10. The percentage change of industrial roundwood, woodpulp and paper under the annual payments.

Table 6-7. The absolute change in production of industrial roundwood, woodpulp and paper in the United States under the annual payments

Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	-3185.2	306.7	7022.4	4143.9	1036.0
Woodpulp	0.0	-819.6	-87.9	1825.7	918.2	229.6
Paper	0.0	-1673.7	-219.2	1260.4	-632.5	-158.1

Unit: thousand CUM/ ton



	2010	2015	2020	2025
percentage change of industrial roundwood price	0.0%	2.6%	-2.6%	-6.3%
percetage change of woodpulp price	0.0%	1.9%	-1.9%	-4.4%
percentage change of paper	0.0%	0.8%	-0.8%	-2.2%

Figure 6-11. The percentage change in prices of industrial roundwood, woodpulp and paper under the annual payments.

Table 6-8. The absolute change in prices of industrial roundwood, woodpulp and paper under the annual payments

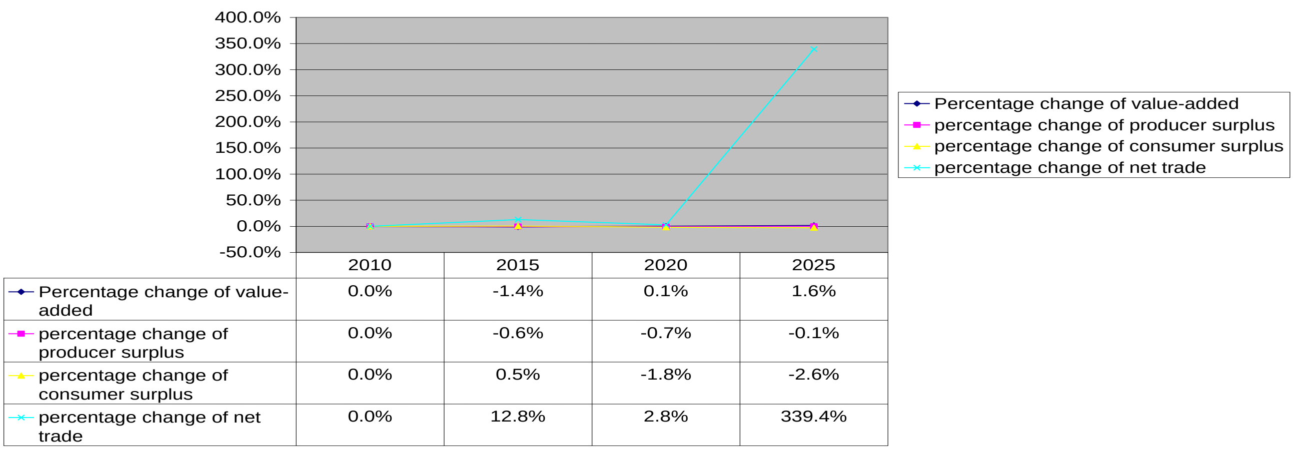
Year	2010	2015	2020	2025	Total	Average
Industrial roundwood	0.0	1.9	-1.9	-4.4	-4.4	-0.9
Woodpulp	0.0	9.2	-9.0	-20.7	-20.5	-4.1
Paper	0.0	6.3	-5.6	-15.5	-14.8	-3.0

Unit: US dollar

Table 6-9. The absolute change in added value under the annual payments

Year	2010	2015	2020	2025	Total	Average
Value-Added	0.0	-814347.5	37343.3	760473.8	-16530.4	-3306.1

Unite: thousand dollars



	2010	2015	2020	2025
Percentage change of value-added	0.0%	-1.4%	0.1%	1.6%
percentage change of producer surplus	0.0%	-0.6%	-0.7%	-0.1%
percentage change of consumer surplus	0.0%	0.5%	-1.8%	-2.6%
percentage change of net trade	0.0%	12.8%	2.8%	339.4%

Figure 6-12. The percentage change in welfare economics under the annual payments.

With respect to competition between bioenergy and traditional forest product, products such as particleboard, which intensively used woodchips and other residues, suffer a lot in the matching payments due to a higher input price. Products with higher market value such as paper and pulpwood do get an enhancement in production. Farmers and landowners would like to sell the product to pulp and paper industries instead of bioenergy companies who will pay for less money for the raw materials.

For the welfare economics analysis, we find that the matching payments and the establishment payments did increase the valued increases. However, the estimated valued did not include the considerations of government cost. When we take it into calculation, the added valued become negative in the matching payments, while the net gain in the establishment payments is still positive. For all of the payments, the domestic producers and consumers suffer the loss caused by the BCAP. Lower prices for industrial roundwood, woodpulp and paper directly reduce the profit for producers and increase the profit for exporter, which makes the exporter become the biggest winner in this program and decreases the domestic consumer’s benefits.

Effects on Forest Area and Forest Stock

The change for forest area is little. As estimated by Perlack (2005), current exploration for woody biomass is far less than the potential storage in the forest system. Therefore, these three payments with limited funding could not make the forest area change.

However, forest stock from the establishment payments will decrease under the establishment payments with an annual rate of -3.7%. For the matching payments and the annual payments, few changes are found. From the analysis above, we find that, compared with the other two payments, the establishment payments would augment the supply of industrial roundwood and fuelwood. The basic raw materials are directly extracted from forestry. Therefore, the forest stock will decrease in the United States.

CHAPTER 7
DISCUSSION AND CONCLUSION

Discussion

BCAP will stimulate the production of fuelwood and industrial roundwood under the establishment payments and the annual payments. Besides, BCAP emphasizes the development of wood biomass market should be with a minimum cost for environment. Otherwise, for the whole forestry industry, BCAP might lead to a net loss for domestic producers and consumers surplus. In this game, the biggest winner is the exporters of woodpulp and paper.

However, there are some doubts emerge on the collapse of producer surplus and consumer surplus in the forestry industry. Most of them are concentrating on the ignorance of environmental benefit brought by woody biomass such as reducing carbon dioxide emission. However, how to quantity the benefits are still a problem needed further exploration. In addition, one of the recorded impacts of BCAP is to create blue, white and green-color jobs (BCAP Fact Sheet, 2010). With a forestry partial equilibrium model, it is impossible to examine the BCAP's effects in a general equilibrium framework. From these two aspects, the welfare economics estimated in this research is not completed.

In GFPM, there is no final product directly related to bioenergy such as bioelectricity or biodiesel. Therefore, the amount of subsidized products is based on previous research, which might overestimate the amount of qualified materials in this program. A call to construct the bioenergy part in GFPM is needed to further explore.

Furthermore, lack of examination of land transfer is another shortcoming for this research. In GFPM, there is no specific part related to land use. The land qualified in this program is estimated from the Alig (2000), which might exaggerate the effect of BCAP on welfare economics. A detailed examination on land is needed.

Conclusion

This study aims to examine the effects of Biomass Crop Assistances Program on traditional forest product market, forest stock, forest area and the whole welfare economics.

Three scenarios were designed to simulate the three payments in BCAP. One is with 100% subsidy on fuelwood and chips based on the regulation listed in BCAP: FSA will provide the matching payments at the rate of $1 for each $1 per dry ton paid by the qualified biomass conversion facility to the eligible material owner for delivery of eligible material that qualify for payment to the facility in an amount not to exceed $45 per dry ton. Alternately, the second scenario is about the establishment payments: cover up to 75% of the actual or average cost (whichever is lower) of establishing an eligible perennial crop (either woody or non-woody) pursuant to a BCAP contract. Comparatively, the third scenarios is designed to simulate the annual payments that offset the lost opportunity costs associated with cultivating a biomass crop as opposed to a traditional crop. Payments will be similar to CRP payments and it will be “based on all or a percentage of: a weighted average soil rental rate for cropland. The time period for the annual payments would be up to 5 years for annual and perennial non-woody crops and up to 15 years for perennial woody crops (BCAP, 2010).

The main findings concern the increasing production of fuelwood, industrial roundwood, particleboard, woodpulp and paper under the establishment payments and the annual payments. Few changes were found in forest stock and forest area with prerequisite in BCAP to stimulate sustainable development of woody biomass.

However, when examined the welfare economics in forestry sector, the competition between woody biomass and traditional forest product emerges as a problem. Except the establishment payments, the traditional forest product market will experience a decline which is outweighed the gains with the consideration of government cost. Exporters for woodpulp and paper are the biggest winners in this game, while domestic producers and consumers for industrial roundwood will embrace the loss.

This study has shortcomings that are a source for future work: the incomplete examination for this program, lack of studies for land, and the absence of constructing the final product for bioenergy in GFPM.

APPENDIX
PARAMETERS USED IN GFPM

Table A-1. Commodity codes in GFPM

Code	Commodities	Units
80	Fuelwood and charcoal	$10^3 m^3$
81	Industrial roundwood	$10^3 m^3$
82	Other industrial roundwood	$10^3 m^3$
83	Sawnwood	$10^3 m^3$
84	Veneer and plywood	$10^3 m^3$
85	Particleboard	$10^3 m^3$
86	Fiberboard	$10^3 m^3$
87	Mechanical wood pulp	10^3 t
88	Chemical and semi-chemical wood pulp	10^3 t
89	Other fiber pulp	10^3 t
90	Waste paper	10^3 t
91	Newsprint	10^3 t
92	Printing and writing paper	10^3 t
93	Other paper and paperboard	10^3 t

Source: Buongiorno, J., 2012. Using the Global Forest Products Model (GFPM version 2012). Staff paper series #74.

Table A-2. Country codes in GFPM

Code	Country	Code	Country	Code	Country	Code	Country
	AFRICA		N/C AMERICA		ASIA		EUROPE
A0	Algeria	F0	Bahamas	I5	Afghanistan	N5	Albania
A1	Angola	F1	Barbados	I6	Bahrain	N6	Austria
A2	Benin	F2	Belize	I7	Bangladesh	N7	Belgium
A3	Botswana	F3	Canada	I8	Bhutan	N8	Bosnia and Herzegovina
A4	Burkina Faso	F4	Cayman Islands	I9	Brunei Darussalam	N9	Bulgaria
A5	Burundi	F5	Costa Rica	J0	Cambodia	O0	Croatia
A6	Cameroon	F6	Cuba	J1	China	O1	Czech
A7	Cape Verde	F7	Dominica	J2	Cyprus	O2	Denmark
A8	Central	F8	Dominican Republic	J3	Hong Kong	O3	Finland
A9	Chad	F9	El Salvador	J4	India	O4	France
B0	Congo,	G0	Guatemala	J5	Indonesia	O5	Germany
B1	Côte d'Ivoire	G1	Haiti	J6	Iran, Islamic Rep of	O6	Greece
B2	Djibouti	G2	Honduras	J7	Iraq	O7	Hungary
B3	Egypt	G3	Jamaica	J8	Israel	O8	Iceland
B4	Equatorial Guinea	G4	Martinique	J9	Japan	O9	Ireland
B5	Ethiopia	G5	Mexico	K0	Jordan	P0	Italy
B6	Gabon	G6	Netherlands Antilles	K1	Korea, Dem People's Rep	P1	Macedonia, The Fmr Yug
B7	Gambia	G7	Nicaragua	K2	Korea,	P2	Malta
B8	Ghana	G8	Panama	K3	Kuwait	P3	Netherlands
B9	Guinea	G9	Saint Vincent/Grenadines	K4	Laos	P4	Norway
C0	Guinea-Bissau	H0	Trinidad and Tobago	K5	Lebanon	P5	Poland
C1	Kenya	H1	United States of America	K6	Macau	P6	Portugal
C2	Lesotho		SOUTH AMERICA	K7	Malaysia	P7	Romania
C3	Liberia	H2	Argentina	K8	Mongolia	P8	Slovakia
C4	Libyan Arab	H3	Bolivia	K9	Myanmar	P9	Slovenia
C5	Madagascar	H4	Brazil	L0	Nepal	Q0	Spain
C6	Malawi	H5	Chile	L1	Oman	Q1	Sweden

Table A-2. Continued

Code	Country	Code	Country	Code	Country	Code	Country
C7	Mali	H6	Colombia	L2	Pakistan	Q2	Switzerland
C8	Mauritania	H7	Ecuador	L3	Philippines	Q3	United Kingdom
C9	Mauritius	H8	French Guiana	L4	Qatar	Q4	Serbia and Montenegro
D0	Morocco	H9	Guyana	L5	Saudi Arabia		FORMER USSR
D1	Mozambique	I0	Paraguay	L6	Singapore	Q5	Armenia
D2	Niger	I1	Peru	L7	Sri Lanka	Q6	Azerbaijan, Republic of
D3	Nigeria	I2	Suriname	L8	Syrian Arab Republic	Q7	Belarus
D4	Réunion	I3	Uruguay	L9	Thailand	Q8	Estonia
D5	Rwanda	I4	Venezuela, Boliv Rep of	M0	Turkey	Q9	Georgia
D6	Sao Tome and Principe			M1	United Arab Emirates	R0	Kazakhstan
D7	Senegal			M2	Viet Nam	R1	Kyrgyzstan
D8	Sierra Leone			M3	Yemen	R2	Latvia
D9	Somalia				OCEANIA	R3	Lithuania
E0	South Africa			M4	Australia	R4	Moldova,
E1	Sudan			M5	Cook Islands	R5	Russian Federation
E2	Swaziland			M6	Fiji Islands	R6	Tajikistan
E3	Tanzania, United Rep of			M7	French Polynesia	R7	Turkmenistan
E4	Togo			M8	New Caledonia	R8	Ukraine
E5	Tunisia			M9	New Zealand	R9	Uzbekistan
E6	Uganda			N0	Papua New Guinea		
E7	Congo, Dem			N1	Samoa	ZY	Dummy Region
E8	Zambia			N2	Solomon Islands	ZZ	World
E9	Zimbabwe			N3	Tonga		

Source: Buongiorno, J., 2012. Using the Global Forest Products Model (GFPM version 2012). Staff paper series #74.

Table A-3. GFPM demand table for the United States in base year 2006[1]

A	B	C	D	E	F	G
h1	80	50.00	44740.000	-0.10	0.22	0.00
h1	82	80	9040.000	-0.05	-0.58	0.00
h1	83	259.00	129157.000	-0.10	0.22	1.00
h1	84	437.84	19552.000	-0.29	0.41	1.00
h1	85	258.56	31303.000	-0.29	0.54	1.00
h1	86	356.53	10063.000	-0.46	0.35	1.00
h1	91	587.00	9621.000	-0.25	0.58	1.00
h1	92	908.00	27523.000	-0.37	0.45	1.00
h1	93	805	53176.000	-0.23	0.43	1.00

Data source: FAO(Food and Agricultural Organization), 2006, http://faostat.fao.org/default.aspx?lang=en

---

A: Region number (01 to 99, in ascending order)

B: Commodity number (01 to 99, in ascending order within each region)

C: Base period price in common currency(US dollars/unit)

D: Base period quantity demanded at price(thousand CUM or thousand ton)

E: Price elasticity (<0, enter 0.00 for horizontal demand)

F: Elasticity of demand with respect to the first shift variable (optional, enter 0.00 if omitted)

G: Elasticity of demand with respect to the second shift variable (optional, enter 0.00 if omitted)[1]

Table A-4. GFPM supply table in the United States in base year 2006[2]

A	B	C	D	E	F	G
h1	80	50	44701.000	0.64	1.00	0.00
h1	81	80	405393.000	0.64	1.00	0.00
h1	82	80	9040.000	0.64	1.00	0.00
h1	89	982	245.000	0.75	0.40	0.00
h1	90	123	44401.000	1.00	0.50	0.00

Data source: FAO (Food and Agricultural Organization), 2006, http://faostat.fao.org/default.aspx?lang=en

[2] A: Region number (01 to 99, in ascending order)

B: Commodity number (01 to 99, in ascending order within each region)

C: Base period price in common currency(US dollars/unit)

D: Base period quantity demanded at price(thousand CUM or thousand ton)

E: Price elasticity (<0, enter 0.00 for horizontal demand)

F: Elasticity of demand with respect to the first shift variable (optional, enter 0.00 if omitted)

G: Elasticity of demand with respect to the second shift variable (optional, enter 0.00 if omitted)[2]

Table A-5. GFPM manufacturing cost table for the United States in base year of 2006[3]

A	B	C	D	E	F	G
h1	80	10	1	0.1000	0.000	0.01
h1	83	10	1	136.4729	92613.667	0.10
h1	84	10	1	236.4648	14180.000	0.10
h1	85	10	1	108.5241	21873.000	0.10
h1	86	10	1	229.1648	7540.000	0.10
h1	87	10	1	224.8572	4080.667	0.10
h1	88	10	1	255.0000	45820.667	0.10
h1	91	10	1	253.4447	4885.000	0.10
h1	92	10	1	474.6265	21081.667	0.10
h1	93	10	1	462.2305	57192.667	0.10

Data source: FAO (Food and Agricultural Organization), 2006, http://faostat.fao.org/default.aspx?lang=en

[3] A Region number (01 to 99, in ascending order)

B Commodity (primary) number (01 to 99, in ascending order within each region)

C Process number(01 to 99, in ascending order within each commodity)

D Input mix number(1 to 9, in ascending order with each process)

E Net manufacturing cost in common currency(US dollars))

F Base period manufactured quantity(thousand CUM or thousand ton)

G Output elasticity of manufacturing cost, >=0, enter 0.00 for constant manufacturing cost

Table A- 6. I-O coefficient in GFPM for the United States[4]

A	B	C	D	F	G
h1	81	83	10	1	1.5218988
h1	81	84	10	1	2.5128571
h1	81	85	10	1	1.8557996
h1	81	86	10	1	1.5878571
h1	81	87	10	1	2.1476190
h1	81	88	10	1	3.5000000
h1	87	91	10	1	0.0434920
h1	88	91	10	1	0.4757937
h1	89	91	10	1	0.0000000
h1	90	91	10	1	0.5007143
h1	87	92	10	1	0.1477672
h1	88	92	10	1	0.6695238
h1	89	92	10	1	0.0072890
h1	90	92	10	1	0.0768254
h1	87	93	10	1	0.0135714
h1	88	93	10	1	0.5254861
h1	89	93	10	1	0.0000000
h1	90	93	10	1	0.4579985

Data source: FAO (Food and Agricultural Organization), 2006, http://faostat.fao.org/default.aspx?lang=en

[4] A Region number (01 to 99, in ascending order)

B Input commodity number (01 to 99, in ascending order within each output commodity)

C Output commodity number (01 to 99, in ascending order within each region)

D Process number(01 to 99, in ascending order within each commodity)

F Input mix number(1 to 9, in ascending order with each process)

G Amount of input commodity per unit of output commodity

LIST OF REFERENCES

Abt, R.C., Abt, K.L., Cubbage, F.W., Henderson, J.D., 2010. Effect of policy-based bioenergy demand on southern timber markets: A case study of North Carolina. Biomass Bioenergy 34, 1679-1686.

Adegbidi, H.G., Volk, T.A., White, E.H., Abrahamson, L.P., Briggs, R.D., Bickelhaupt, D.H., 2001. Biomass and nutrient removal by willow clones in experimental bioenergy plantations in New York State. Biomass Bioenergy 20, 399-411.

Aguilar, F.X., Saunders, A.M., 2011. Attitudes toward Policy Instruments Promoting Wood-To-Energy Initiatives in the United States. South. J. Appl. For. 35, 73-79.

Aguilar, F.X., Song, N., Shifley, S., 2011. Review of consumption trends and public policies promoting woody biomass as an energy feedstock in the US. Biomass Bioenergy.

Aguilar, F.X., Saunders, A., 2010. Policy instruments promoting wood-to-energy uses in the continental United States. J. For. 108, 132-140.

Alavalapati, J., Hodges, A., Lal, P., Dwivedi, P., Rahmani, M., Kaufer, L., Matta, J., Susaeta, A., Kukrety, S., Stephens, T., 2009. Bioenergy roadmap for southern United States. Southeast Agriculture and Forestry Energy Resources Alliance (SAFER), Southern Growth Policies Board, North Carolina 130.

Alig, R.J., Adams, D.M., McCarl, B.A., Ince, P.J., 2000. Economic potential of short-rotation woody crops on agricultural land for pulp fiber production in the United States. For. Prod. J. 50, 67-74.

Beach, R.H., McCarl, B.A., 2010. US Agricultural and forestry impacts of the energy independence and security act: FASOM results and model description. Research Triangle Park, NC: RTI International.

Becker, D.R., Lee, C., 2008. State woody biomass utilization policies. University of Minnesota, Dept.of Forest Resources, St.Paul, MN.Staff Paper 199, 183.

Becker, D.R., Moseley, C., Lee, C., 2011. A supply chain analysis framework for assessing state-level forest biomass utilization policies in the United States. Biomass Bioenergy 35, 1429-1439.

Becker, D.R., Larson, D., Lowell, E.C., 2009. Financial considerations of policy options to enhance biomass utilization for reducing wildfire hazards. Forest Policy and Economics 11, 628-635.

BCAP, 2011. The biomass crop assistance program (BCAP) – Final Rule Provision, http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom%26subject=landing%26topic=pfs%26newstype=prfactsheet%26type=detail%26item=pf_20101021_consv_en_bcap.html.

Binkley, C., 1987. Economic models of timber supply. The global forest sector: An analytical perspective, 109-136.

BRDB (Biomass Research and Development Board), 2008. Increasing feedstock production for biofuels: economic drivers, environmental implications, and the role of research. http://www.brdisolutions.com/Site%20Docs/Increasing%20Feedstock_revised.pdf. (last accessed June 30,2012)

Blouin, J., Krull, L., 2009. Bringing it home: A study of the incentives surrounding the repatriation of foreign earnings under the American Jobs Creation Act of 2004. Journal of Accounting Research 47, 1027-1059.

Buchanan, G., 2010. Increasing Feedstock Production for Biofuels: Economic Drivers, Environmental Implications, and the Role of Research, DIANE Publishing, .

Buongiorno, J., 2003. The global forest products model: structure, estimation, and applications, Academic Press,.

Buongiorno, J., 2012. Using the Global Forest Products Model (GFPM version 2012). Staff paper series #74

Buongiorno, J., Chang, H.S., 1986. Effect of the energy crisis on the elasticities of demand for forest products in OECD countries. Can.J.For.Res 16, 968-974.

Buongiorno, J., Gilless, J., 1984. A model of international trade of forest products, with an application to newsprint. J. World Forest Resour. Manage. 1, 65-80.

Buongiorno, J., Gilless, J.K., 1983. Concepts used in a regionalized model of pulp and paper production and trade. Forest sector models.Berkhamsted, England: AB Academic Publishers, 57-90.

Buongiorno, J., Raunikar, R., Zhu, S., 2011. Consequences of increasing bioenergy demand on wood and forests: An application of the Global Forest Products Model. J. For. Econ. 17, 214-229.

Congress, U., 2008. Food, Conservation, and Energy Act of 2008. Washington, DC: Public Law, 110-234.

Cook, J., Beyea, J., 2000. Bioenergy in the United States: progress and possibilities. Biomass Bioenergy 18, 441-455.

DSIRE (Database of State Incentives for Renewable Energy and Efficiency), 2009. Financial incentives for renewable energy, http://www.dsireusa.org/summarytables/finre.cfm; .

Duffield, J.A., Collins, K., 2006. Evolution of renewable energy policy.

EIA (U.S. Energy Information Administration), 2010a. Monthly Energy Review, Table 12.2-12.5, http://c1cleantechnicacom.wpengine.netdnacdn.com/files/2012/06/energy_related_carbon_dioxide_emissions_sector-large.jpg

EIA (U.S. Energy Information Administration), 2010b. Annual Energy Review 2010, http://www.eia.gov/totalenergy/data/annual/pecss_diagram.cfm.

EIA (U.S. Energy Information Administration), 2010c. Renewable Energy Consumption and Electricity Preliminary Statistics 2009,ftp://ftp.eia.doe.gov/renewables/pretrends09.pdf

EIA (U.S. Energy Information Administration), 2012. Annual Energy Outlook 2012, http://205.254.135.7/forecasts/aeo/pdf/0383(2012).pdf.

EPA (U.S. Environmental Protection Agency), 2009. Renewable Portfolio Standards: An Effective Policy to Support Clean Energy Supply. 2009. http://www.epa.gov/chp/state-policy/renewable_fs.html.

Food and Agriculture Organization of the United Nations, 2006. FAOSTA ,http://faostat.fao.org/default.aspx?lang=en.

FAO(Food and Agriculture Organization of the United Nations), 2009. Wood energy, http://www.fao.org/forestry/energy/en/; .

Guo, Z., Sun, C., Grebner, D., 2007. Utilization of forest derived biomass for energy production in the USA: status, challenges, and public policies. International Forestry Review 9, 748-758.

Harris, W.L., Lubben, B., Novak, J.L., Sanders, L.D., 2008. The Food, Conservation, and Energy Act of 2008 Summary and Possible Consequences.

Heinimo, J., Junginger, M., 2009. Production and trading of biomass for energy - An overview of the global status. Biomass Bioenerg. 33, 1310-1320.

Hillring, B., 2006. World trade in forest products and wood fuel. Biomass Bioenerg. 30, 815-825.

Hodges, A.W., Stevens, T.J., Rahmani, M. , 2010. Economic Impacts of Expanded Woody Biomass Utilization on the Bioenergy and Forest Products Industries in Florida, University of Florida, Institute of Food and Agricultural Sciences, Food and Resource Economics Dept., .

Hodges, A.W., Rahmani, M., 2011. Fuel Sources and Carbon Dioxide Emissions by Electric Power Plants in the United States.

Ince, P.J., Kramp, A.D., Skog, K.E., Yoo, D., Sample, V.A., 2011. Modeling future US forest sector market and trade impacts of expansion in wood energy consumption. Journal of Forest Economics.

Ince, P.J., 1998. Long-range outlook for US paper and paperboard demand, technology, and fiber supply-demand equilibria. , 330-343.

Joseph Buongiorno, Shushuai Zhu, Dali Zhang, James Turner, David Tomberlin, 2010. The Global Forest Product, http://forest.wisc.edu/staticsites/buongiorno/book/GFPM.html. 2010.

Jake Eaton, Opportunities for Poplar Bioenergy Farms in North America, http://www.shortrotationcrops.org/pdfs/eaton_jake.pdf. 2007.

Kroeger, T., 2007. Economic Impacts of Live Wild Animal Imports in the United States. Economic impacts of live wild animal imports in the United States.

Larson, E.D., UN-Energy. , 2007. Sustainable bioenergy: A framework for decision makers, UN-Energy, .

Meghan Gordon, IEA says biofuels can displace 27% of transportation fuels by 2050.http://www.platts.com/RSSFeedDetailedNews/RSSFeed/Oil/6017103. 2011.

Nazzaro, R.M. , 2005. Natural resources: federal agencies are engaged in various efforts to promote the utilization of woody biomass, but significant obstacles to its use remain, DIANE Publishing, .

Nerurkar, N., Library of Congress. Congressional Research Service, 2011. US Oil Imports: Context and Considerations.

Oel, P., Hoekstra, A., 2010. The green and blue water footprint of paper products: Methodological considerations and quantification.

Peter J. Ince, Scientific uncertainty about bioenergy from a forestry perspective,http://webcache.googleusercontent.com/search?q=cache:EcLqMGufzcAJ:foragforum.rti.org/documents/2.3_4_Ince%2520slides-Final%2520-%2520GHG%2520Modeling%2520-%2520Shepherdstown%25202009.ppt+&cd=1&hl=en&ct=clnk&gl=us. 2009.

Pimentel, D., Patzek, T.W., 2005. Ethanol production using corn, switchgrass, and wood; biodiesel production using soybean and sunflower. Natural resources research 14, 65-76.

Raunikar, R., Buongiorno, J., Turner, J.A., Zhu, S., 2010. Global outlook for wood and forests with the bioenergy demand implied by scenarios of the Intergovernmental Panel on Climate Change. Forest Policy and Economics 12, 48-56.

Robert D. Perlack, Lynn L. Wright, Anthony F. Turhollow, Robin L. Graham, Bryce J. Stokes, Donald C. Erbach, 2005. Biomass As Feedstock for A Bioenergy And Bioproducts Industry: The Technical Feasibility of A Billion-Ton Annual Supply.

Ronald S. Zalesny Jr., Woody Energy Crop Production,http://www.corrim.org/presentations/video/2008/CORRIM_Workshop/pdf/06_Zalesny.pdf. 2008.

Rossi, F.J., Carter, D.R., Abt, R.C. , 2010. Woody Biomass for Electricity Generation in Florida: Bioeconomic Impacts Under a Proposed Renewable Portfolio Standard (RPS) Mandate: Final Report, Florida Dept. of Agriculture and Consumer Services,

Rummer, B., Prestemon, J., May, D., Miles, P., Vissage, J., McRoberts, R., Liknes, G., Shepperd, W.D., Ferguson, D., Elliot, W., 2003. A strategic assessment of forest biomass and fuel reduction treatments in western states. RMRS GTR 149.

Sedjo, R.A., 2010. The Biomass Crop Assistance Program (BCAP): some implications for the forest industry. Discussion Paper - Resources for the Future (RFF), 15.

Smith, W.B. , 2004. Forest resources of the United States, 2002, US Department of Agriculture, Forest Service, North Central Research Station St. Paul, MN, .

Solar, D., 2009. Incentives for energy efficiency.

Stanton, B., Eaton, J., Johnson, J., Rice, D., Schuette, B., Moser, B., 2002. Hybrid poplar in the Pacific Northwest: the effects of market-driven management. J. For. 100, 28-33.

Stubbs, M., 2010. Biomass crop assistance program (BCAP): Status and issues.

Tharakan, P.J., Volk, T.A., Lindsey, C.A., Abrahamson, L.P., White, E.H., 2005. Evaluating the impact of three incentive programs on the economics of cofiring willow biomass with coal in New York State. Energy Policy 33, 337-347.

Trųmborg, E., Bolkesjų, T.F., Solberg, B., 2007. Impacts of policy means for increased use of forest-based bioenergy in Norway--A spatial partial equilibrium analysis. Energy Policy 35, 5980-5990.

Tuskan, G., 1998. Short-rotation woody crop supply systems in the United States: what do we know and what do we need to know? Biomass Bioenergy 14, 307-315.

USDA (U.S. Department of Agriculture), 2009. CRP enrollment as of September 2009 and October 2009 rental payment. http://www.fsa.usda.gov/Internet/FSA_File/apportstate.pdf.

USDA (U.S. Department of Agriculture), 2010. Report of BCAP CHST payments by biomass type. http://www.fsa.usda.gov/Internet/FSA_File/bcap_chst_component_report.pdf.

USDA (U.S. Department of Agriculture), 2010. Summary Report of BCAP CHST payments. http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap

USDE(U.S. Department of Energy), 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.

Volk, T., Abrahamson, L., Nowak, C., Smart, L., Tharakan, P., White, E., 2006. The development of short-rotation willow in the northeastern United States for bioenergy and bioproducts, agroforestry and phytoremediation. Biomass Bioenergy 30, 715-727.

White, E.M. , 2010. Woody biomass for bioenergy and biofuels in the United States: a briefing paper, DIANE Publishing, .

Whiteman, A., Brown, C., 2000. Modelling global forest products supply and demand: recent results from FAO and their potential implications for New Zealand. New Zealand Journal of Forestry 44, 6-9.

Wu, Y., 2012. An Integrated Multi-Feedstock Modeling Approach towards Assessing Forest Resource Sustainability.

Zhu, S., Buongiorno, J., Brooks, D., 2001. Effects of accelerated tariff liberalization on the forest products sector: a global modeling approach. Forest Policy Econ. 2, 57-78

Zhu, S., Buongiorno, J., Tomberlin, D., Food and Agriculture Organization of the United Nations. , 1998. Global forest products consumption, production, trade and prices: global forest products model projections to 2010, Food and Agriculture Organization of the United Nations, .

BIOGRAPHICAL SKETCH

Wei Jiang is a young lady born and raised in Hebei, the northern province of China. She did her primary, secondary and undergraduate studies in China. She holds a Bachelor of Economics which was obtained from the Beijing Forestry University in 2006. Based on her background, she decided to pursue a Master of Science in Forest Resources and Conservation with a concentration on woody biomass economics.