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The Impact of the Biomass Crop Assistance Program on the United States Forest Products Market: An Application of the Global Forest Products Model

Wei Jiang [1,*], Douglas R. Carter [2], Hanliang Fu [3], Michael G. Jacobson [1], Katherine Y. Zipp [4], Jiang Jin [5] and Long Yang [6]

[1] Department of Ecosystem Science and Management, Penn State University, University Park, PA 16801, USA; mgj2@psu.edu
[2] School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611, USA; drcart@ufl.edu
[3] School of Management, Xi'an University of Architecture and Technology, Xi'an 710055, China; fuhanliang@xauat.edu.cn
[4] Department of Agricultural Economics, Sociology and Education, Penn State University, University Park, PA 16801, USA; kyz1@psu.edu
[5] Department of Civil Engineering, Penn State University, University Park, PA 16801, USA; jjj5395@psu.edu
[6] College of Public Administration, Fujian Agriculture and Forestry University, Fuzhou 350002, China; yanglong@ruc.edu.cn
* Correspondence: wxj126@alumni.psu.edu; Tel.: +1-3528714254

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Abstract: As the largest consumer of petroleum and second highest producer of greenhouse gas emissions, the United States currently is a leading country in bioenergy production driven by a series of policies. One such public program that directly subsidizes biomass feedstock growers is the Biomass Crop Assistance Program (BCAP), which recently received attention for stimulating the development of bioenergy. However, critiques were also raised, concerning the possibility of intensifying the feedstock competition between bioenergy and forest products. This study, therefore, aimed at assessing the effects of BCAP on the forest product markets with the Global Forest Products Model (GFPM). Three alternative scenarios were designed to simulate three payments in BCAP. In the first scenario, the matching payment was simulated by adjusting the manufacturing cost of fuelwood and particleboard. In the second scenario, establishment payment was simulated by adjusting the supply rate of industrial roundwood. In the third scenario, the annual payment was simulated by linking the supply change rate with the soil rental rate for industrial roundwood. We found that, under the matching payment scenario, industrial roundwood and particleboard will experience a sharp decrease in production and an increase in price. For establishment payments, industrial roundwood will experience a continuous increase in production and a decrease in price. For annual payments, the industrial roundwood will experience a V-shape pattern production.

Keywords: BCAP; GFPM; woody biomass; bioenergy

1. Introduction

Forest biomass has recently emerged as an important strategy in addressing energy and environmental needs in the United States. On the one hand, forest biomass has the potential to provide significant amounts of feedstock for bioenergy production, which may help offset desired reductions in fossil fuel use [1]. On the other hand, it can help accomplish desired reductions in hazardous fuels that feed wildfires, and provide a means for creating suitable wildlife habitat or restoring unhealthy forests plagued by insects and disease [2]. As a result, there has been a proliferation of policies seeking to stimulate forest biomass utilization, including tax credits for renewable energy generation, cost-share programs for production equipment purchases, and new contracting rules for raw material procurement [3].

One of the largest programs is the Biomass Crop Assistant Program (BCAP). This program stands out is because: (1) it is the first program aiming directly to assist producers with establishing new dedicated biomass crops for bioenergy production and to cover possible opportunity costs and additional risks associated with turning away from traditional crop production, through multi-year contracts and annual payments; and (2) it aims to assist additional supply challenges, including the collection, harvest, storage and transportation (CHST) of biomass, which is regarded as the biggest cost hurdle in forest biomass supply chain [3].

During 2009–2010, BCAP matching payments totaled $244 million. Around 78% ($190,530,908) of the budget was used for forestry biomass, while agricultural biomass only accounted for 0.13% (Figure 1) [4]. The high allocation to forestry biomass causes concerns regarding possible market competition between this bioenergy program and existing wood industries [4]. In 2010, some wood manufacturing industries that heavily depend on wood residues such as wood shavings, wood chips and sawdust, noticed an increase in price for their raw materials, after the release of the United States Department of Agriculture's announcement of matching payments in 2009. This increase seemed to be linked to the BCAP program [5] since over 80% of matching payment goes for these forest residues (Figure 2). This program created an incentive for biomass owners to sell wood residues to biomass facilities rather than to manufacturers that use the same raw materials for products such as composite panels, particleboard, and fiberboard.

Although manufacturing industries that use wood residue displayed the greatest opposition to BCAP matching payments, those in the lumber industry also questioned the sustainability of this program. They argued that, while biomass was considered a tool to protect the environment, negative impacts on the forest system such as soil erosion and deforestation would still happen [5], as this program may increase the collection of existing and underutilized forestry biomass for bioenergy production, which may disturb the natural forestry self-cycle ecosystem, and may also influence the lumber quality.

There are many arguments about the BCAP in politics and industry, however, few academic studies assess this program. The most related one is by Hodges, et al. (2010) [5], who assessed three public policies (renewable electricity standards, a renewable electricity production tax credit, and BCAP) with a regional Input-Output model and Social Accounting Matrix (I-O/SAM) coupled with a Computable General Equilibrium (CGE) model. He found that the forest product manufacturing sector would be adversely affected due to the competition for wood resources caused by bioenergy demand and high prices for material inputs. Nevertheless, as this study assessed multiple policies, it is hard to differentiate if the competition is mostly caused by BCAP.

Therefore, this research aimed to fill this gap by solely assessing BCAP's effect on forest product markets using the Global Forest Products Model (GFPM). GFPM is an economic model that simulates the production, consumption, and trade in forest products at the global level. Several studies have used GFPM to assess the impact of bioenergy demand on the forestry industry. Raunikar and Buongiorno (2010) [6] applied this model to examine the competition between high demand for bioenergy set by the Intergovernmental Panel on Climate Change (IPCC). They found that there will be a six-times increase in world demand for fuelwood by 2060. The price of fuelwood would rise and converge towards the price of industrial roundwood by about 2025. At the same time, industrial roundwood, which was used in the past to manufacture sawnwood, panels, and pulp, would begin to be used for energy production. In addition, Buongiorno et al. (2011) [7] analyzed the result of doubling the rate of growth of bioenergy demand. They found that the industrial roundwood price would rise nearly 30% and the price of fuelwood would catch up to the price of industrial roundwood. While both studies assumed that all the bioenergy demand would be fulfilled by woody biomass by adjusting the exogenous variables related to demand, this study simulated BCAP's payments by changing the supply variables, as this program directly subsidizes biomass suppliers. The structure of the paper is as follows. Section 2.1 describes more about the BCAP, Section 2.2 discusses the GFPM model and Section 2.3 discusses the results and conclusions.

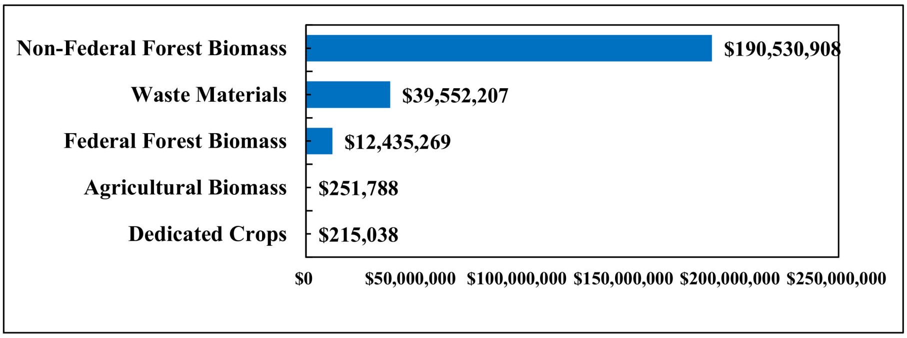

Figure 1. BCAP (Biomass Crop Assistance Program) matching payments allocation among eligible materials during 2009–2010. Data Source: The U.S. Department of Agriculture/Farm Service Agency, BCAP, 2010, Report of BCAP CHST (collection, harvest, storage and transportation) payments by biomass type [8].

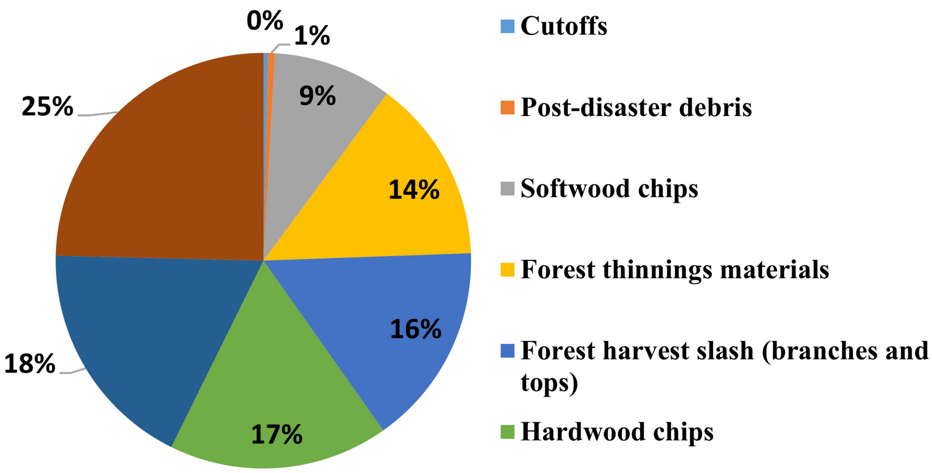

Figure 2. BCAP matching payments allocation among forestry biomass during 2009–2010. Data Source: The U.S. Department of Agriculture/Farm Service Agency, BCAP, 2010, Report of BCAP CHST payments by biomass type [8].

2. Materials and Methods

2.1. Biomass Crop Assistant Program

BCAP was established by the Food, Conservation, and Energy Act of 2008 to provide financial assistance to agricultural and non-industrial private forest landowners who are willing to establish, produce, and deliver bioenergy feedstocks [9]. It was fully implemented on 27 October 2010 and administered by USDA (United States Department of Agriculture) through the Commodity Credit Corporation (CCC) and the Farm Service Agency (FSA) [10].

This program supports three main types of activities. First, it provides funding for agricultural and forest landowners to receive payments for certain eligible material sold to qualified biomass conversion facilities for conversion to bioenergy, bio-based products, or biofuels. These payments are referred to as "matching payments". These payments are intended to help producers with the cost of collection, harvest, storage and transportation (CHST) of certain eligible material [11], as such these payments may incentivize the removal of existing biomass where it might not currently be profitable to do so (e.g., crop residue or forest undergrowth). Through a matching payment, USDA would pay dollar-for-dollar, up to $45 per dry ton (dt) directly to eligible material owners [11,12]. Payments are authorized to be made for a two-year period, beginning on the date the first payment is issued to the eligible material owner [13]. Second, BCAP provides funding 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). Third, BCAP offers the annual payments intended to offset the 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 will be "based on all or a percentage of: a weighted average soil rental rate for cropland" [11]. The period for the annual payments is up to five years for annual and perennial non-woody crops and up to 15 years for perennial woody crops.

The first stage of the BCAP, which only covers the matching payment, was implemented through the publication of a Notice of Funding Availability (NOFA) in June 2009. A final rule implementing all phases of BCAP was released in October 2010 [9].

2.2. The GFPM Model

BCAP effects are modeled by the Global Forest Products Model (GFPM). GFPM is a partial equilibrium economic model of global production, consumption and trade of forest products [14]. GFPM 2010 has data and parameters to produce forecasts of forest resources and markets for 180 countries, and over nine forest products (Figure 3) [6].

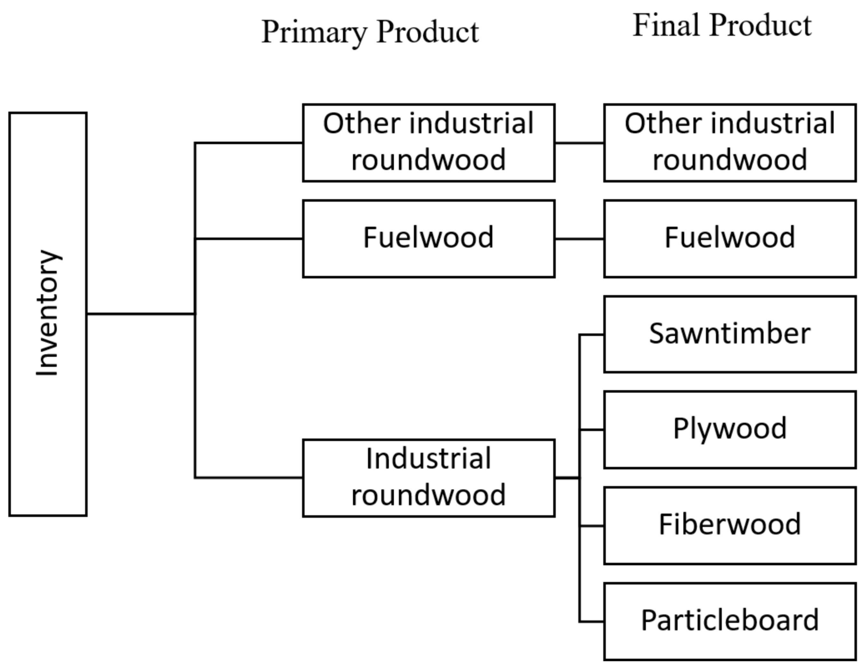

Figure 3. Forest products in GFPM. Adapted from Buongiorno, J., Zhu, S., Zhang, D., Turner, J., and Tomberlin, D. (2003). The global forest products model: structure, estimation, and applications. Elsevier [15].

This model includes four components of forest industry: timber supply, final product demand, intermediate processing, and trade [16]. Equilibrium in each year is computed by maximizing the welfare of the global forest industry (Equation (1)): the difference between product values and production cost as well as transport cost.

$$Max\ Z = \sum_{i}\sum_{k}\int_{0}^{D_p} P_{ip}(D_{ip})dD_{ip} - \sum_{i}\sum_{p}\int_{0}^{S_p} P_{ip}(S)dS_{ip} - \sum_{i}\sum_{p} Q_{ip}m_{ip} - \sum_{i}\sum_{j}\sum_{p} l_{ijp}T_{ijp} \quad (1)$$

where i, j = country, p = product, and P = price in US dollars of the constant value in the given year; D = final product demand; S = raw material supply; Q = production quantity; m = manufacture cost; l = transport cost, including tariff; and T = transport quantity [15].

The equilibrium for each year is obtained by recursive programming [17] with consideration of endogenous and exogenous changes. Endogenous changes include the changes in capacity growth and availability of recycle fibers, which are calculated by the model algorithm. Exogenous changes include economic growth, timber supply, and trade inertia, which are determined by the assumptions in the model. The model parameters are updated with the intervening exogenous changes, and a new objective function is formed leading to a new market-clearing price, consumption levels, and welfare. This procedure is recursively run until the end of the projection.

In this study, we modeled an exogenous change on timber supply to assess the BCAP influence, because the subsidies provided by BCAP directly cover supply cost (production and logistics) for forest landowners. We designed three scenarios to simulate three payments in BCAP: the matching payments scenario, the establish payment scenario and the annual payments scenario.

In the matching payment scenario, we attributed the $45/dry ton of matching payment directly to the reduction of manufacturing cost of fuelwood by adjusting the manufacturing cost rate. The reason we selected the manufacturing cost is that it corresponds to the BCAP's matching payment purpose. The matching payment aims to provide financial support to producers with the logistics cost of collecting, harvesting, storing and transporting eligible biomass to the bioenergy facilities. This cost cannot be computed endogenously in the GFPM model [18]. Therefore, we translated this cost into a reduction of the manufacturing cost of fuelwood. The reason for fuelwood is because the eligible materials receiving BCAP matching payments are the "waste" of forest biomass such as wood residues, small-diameter trees and forest treatment residues, which require at least two procedures to be turned to ethanol [19]. These materials are one of the components making up fuelwood supply in GFPM [20].

In the establishment and annual payment scenarios, we simulated the effects by adjusting the supply rate (g_I) of industrial roundwood in GFPM. This adjustment in the industrial roundwood supply was assumed to be from the extra plantation of short-rotation woody crops (SRWC), which is the main eligible material receiving the establishment and annual payment [19]. In the United States, SRWCs are regarded as promising energy crops to meet future demand for bioenergy due to their quick-growing and high-yield advantages. Rotation lengths for SRWCs range from about 3 to 12 years [21,22], and SRWCs could be sold for either bioenergy feedstock or for industrial roundwood such as sawn timber [23]. Therefore, we selected industrial roundwood as the targeted product to simulate the establishment and annual payment effects.

We set the exogenous shock in 2010 when BCAP was fully implemented. We then assessed the production and price changes for industrial roundwood, particleboard, and the welfare change for 2010–2025, with a timeline corresponding to the BCAP 15-year subsidy timeline [24].

2.3. Scenario Assumptions

The key economic assumptions of three alternative scenarios are summarized in Table 1. The base year was set as 2010, which was calibrated using the FAO and World Bank data for 2006. The base year equilibrium production and price for fuelwood, industrial roundwood and particleboard are summarized in Table 2.

Table 1. Scenarios and key economic assumptions.

	Matching Payment Scenario	Establishment Payment Scenario	Annual Payment Scenario
Adjusted variables	Manufacturing rate	Supply change rate	Supply change rate
Adjusted rates	−2.8%	4.8%	1.28%

Table 2. Base scenario price and production.

	Base-Scenario Price ($/dt)	Base-Scenario Production (1000 dt)
Fuelwood	50	44,701
Industrial roundwood	80	405,393
Particleboard	258.56	31,303

2.3.1. The Matching Payment Scenario

To transform the maximum cap of $45/dt matching payment into a manufacturing rate, we applied the following assumptions:

- The market price of fuelwood in the GFPM base year (2010) were used as the manufacturing cost of fuelwood given the zero-manufacturing cost for fuelwood in GFPM [14], which is $50/dt. The new manufacturing cost after being subsidized by BCAP maximum matching payment is $5/dt.
- The national matching payment was calculated based on Perlack et al. (2005) estimation that 51 million dry tons of fuelwood can be used for bioenergy [25].
- After accounting for the national matching payment, the new manufacturing cost is $48.6/dt, which is the mean of subsidized fuelwood manufacturing cost and the unsubsidized fuelwood manufacturing cost.
- The manufacturing change rate is ($48.6 − $50)/$50 = −2.8%

2.3.2. The Establishment Payment Scenario

To transform the maximum coverage of 75% of the "average cost" of establishing SRWC in the supply rate in GFPM, we adopted the following assumptions:

- The production cost of SRWC was assumed to be $5.7/dt, which was calculated based on the national average establishment cost of $48.5/ac and average yield 8.5 dt/ac. The average national production cost and yield for SRWC was calculated based on the data published by Tharakan et al. (2005) [26], Stanton et al. (2002) [21], Adegbidi et al. (2001) [22], Volk et al. (2006) [23] and Dorr et al. (2008) [24].
- After receiving the establishment payment subsidy, the new marginal production cost is $2.12/dt.
- We assumed the base year ratio (1.9%) of establishment cost and price did not change, which was calculated and validated based on the FAO data for 2006 in this model [20].
- The supply rate was then calculated as 4.8%

2.3.3. The Annual Payment Scenario

The annual payments are intended to offset the opportunity costs associated with cultivating a biomass crop. We adopted the soil rental rate in 2009 from the Conservation Reserve Program (CRP) as the opportunity costs [26]. The supply rate of 1.28% for annual payment was calculated based on the following assumptions:

- The USDA 2009 national soil rental rate of $51.52/acre was used as the opportunity cost.
- We relied on Alig et al. (2000) [27] to calculate the national suitable lands for SRWC, which is 2.8 million acres.
- The average national yield of SRWC is 8.5 dt/ac, which was calculated based on Tharakan et al. (2005) [26], Stanton et al. (2002) [28], Adegbidi et al. (2001) [21], Volk et al. (2006) [22] and Dorr et al. (2008) [23].
- The average soil rental rate is $51.52/8.5 = $6.06/dt, i.e., annual payment received by landowners.
- The supply rate of 1.28% was calculated based on this annual payment and assumed the supply elasticity does not change from the base year (2010).

3. Results and Discussion

For each scenario, we focused on the price and production change of industrial roundwood, as industrial roundwood is the main raw material for other final forest productions (Figure 3). In addition, we assessed the welfare change for the whole forest product industry to examine if BCAP causes welfare loss for the forestry product market. For the matching payment scenario, we also examined the price and production change for particleboard as well as fuelwood to assess if BCAP negatively influences the manufacturing industries that intensively use wood residues.

3.1. The Industrial Roundwood

The implementation of the establishment payment led to the biggest jump in industrial roundwood production. Compared to the base-year scenario, its production expanded at rate of 142.3% in 2015. Under the matching payment scenario, there was a mild decrease in the production of industrial roundwood, with a rate ranging from −1.7% to −3.0% (Figure 4). This decrease was mainly caused by the increased manufacturing cost for particleboard. The increased manufacturing cost caused a reduction in the production of particleboard, which, in turn, decreased the demand for its raw materials: industrial roundwood. Under the annual payment scenario, the industrial roundwood production was V-shaped with a small changing rate. We found that there was a 0.7% decrease in 2015, but a 1.6% increase in 2025. This V-shape change was mainly because the payments are issued annually, implying that forest landowners cannot get a one-time large payment at the beginning of the BCAP to reduce the uncertainty landowners may have on supplying the SRWC [10,23,29]. However, the cumulative effects will come into play at the end of BCAP with increasing production of industrial roundwood.

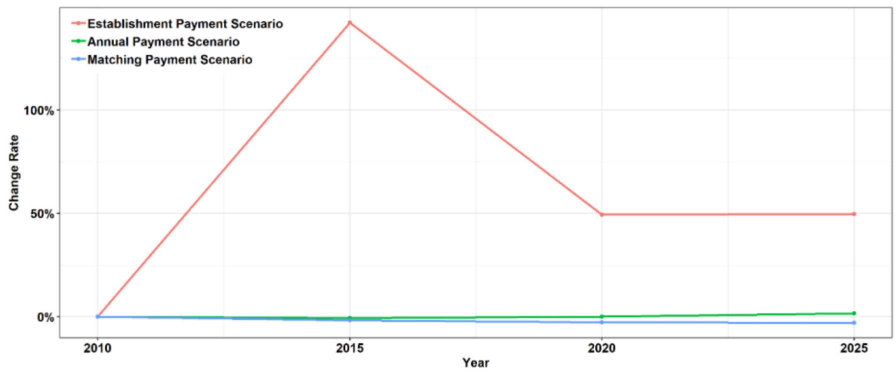

Figure 4. Production change of industrial roundwood.

Given the rapid increase in production under the establishment payment, the price of industrial roundwood decreased greatly, at a rate of −69% in 2015 and −42% in 2025 compared to the base-year scenario (Figure 5). Under the matching payment scenario, the price reduced slightly with a decreasing rate ranging 2.8%–4.9%. We found that both the production and price of industrial roundwood decreased under the matching payment, which was mainly caused by the significant reduction in the particleboard production. The particleboard production reduction led to a weak demand for industrial roundwood, resulting in a decrease in industrial roundwood production. However, the decreasing rate of production could not catch up to the decreasing rate of demand, resulting in a price reduction as well. For the annual payment scenario, the price change was an inverse V-shape, with an increasing rate of 2.6% in 2015 but a decreasing rate of 6.3% at the end of the projection, which corresponds to the production change.

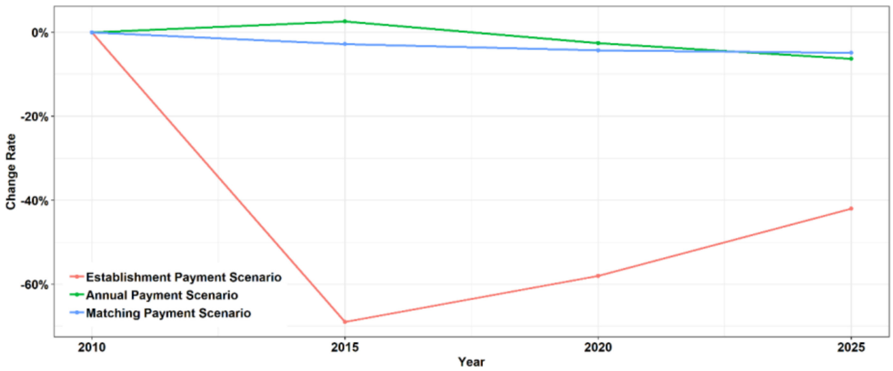

Figure 5. Price change of industrial roundwood.

3.2. *The Particleboard and Fuelwood Price and Production Change under the Matching Payment Scenario*

We examined if the matching payment, which aims to subsidize the logistics cost of CHST forest residues, causes the price of particleboard to increase due to the competition between forestry and bioenergy. Particleboard was selected because it is a representative product intensively using residues as raw materials.

We found that particleboard production was reduced significantly, with a rate of 19.3% in 2015 and 44.2% in 2025 compared to the base-year scenario (Figure 6). The increasing manufacturing cost was the main reason for this significant decrease. The price for particleboard also increased significantly. The price increase reached 15.5% in 2025 for particleboard, which, in turn, influenced the welfare for the particleboard producers and consumers.

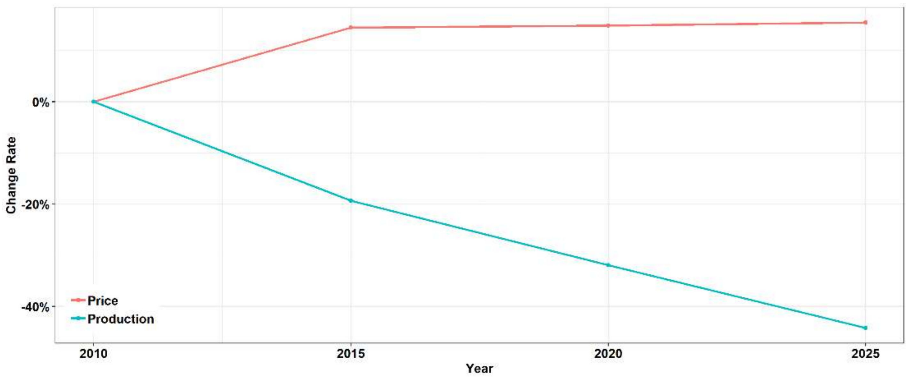

Figure 6. Particleboard price and production change under matching payment scenario.

Under the matching payment scenario, few changes were found in fuelwood production and price. Two reasons may explain this result. First, the maximum cap of $45/dt for the matching payments may not be big enough to influence the production of fuelwood. Second, the US is not the main producer of fuelwood compared to Africa and South Asia [29]. BCAP's small amount of matching payment subsidy cannot change the market price of fuelwood too much.

3.3. *Welfare Changes*

Under the matching payment scenario, there was an increase in the welfare of the forestry industry, ranging from 1.1% to 2.5% at the end of 2025 (Figure 7). The increasing welfare was mainly driven by importing particleboard. As the domestic price increased significantly, US tended to import cheaper particleboard from Europe and Asia, leading to a significant surge in net trade from 2010 to 2020, which drove the total welfare to increase in the forestry industry.

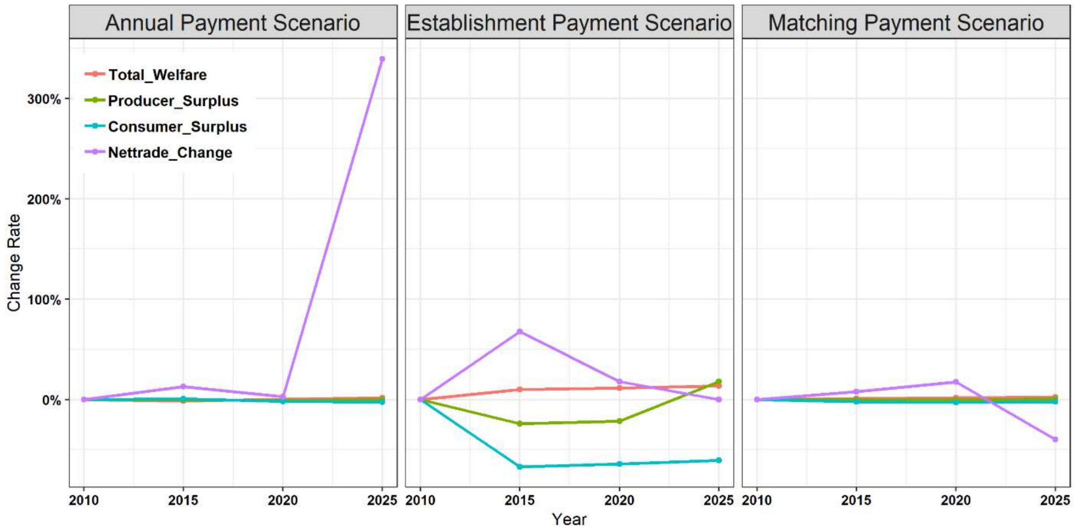

Figure 7. Welfare change under three scenarios.

Similarly, the establishment payment also triggered an increase in the total welfare of the forestry industry (Figure 7) with a rate of 13% in 2010. The main reason for this increase was the increase in net trade, while both producer surplus and consumer surplus decreased [30]. Industrial roundwood producers suffered the biggest loss, due to the decreasing price of industrial roundwood. On the consumer side, paper consumers suffered the biggest loss. As the industrial roundwood supply increased significantly, the supply of paper increased as well, leading to a lower price. Although domestic consumers gained some benefits due to this lower price, international customers took the biggest advantage of these benefits due to the sharp increase in the export of paper. This finding indicates that the possible benefits created by the establishment payments might be shipped to foreign countries through international trade.

Under the annual payment scenario, the welfare change was also an inverse V-shape. From 2011 to 2015, there was a 1.4% decrease in forestry industrial welfare compared to the base-year scenario. However, in 2025, the final welfare increase reached 1.6%. The enhanced trade value was the main reason driving the increase in welfare. Both domestic producers and consumers suffered a loss from the annual payments. On the supply side, the biggest loser was the industrial roundwood producer. Due to the annual payments, the price of industrial roundwood fell at an annual rate of −1.1%, which directly decreased the producer surplus. The next two losers were woodpulp and paper, whose prices declined as well at rates of −0.3% and −0.1%, respectively. On the consumer side, the biggest loser was pulpwood, which suffered around −0.5% losses caused by the annual payments. Similar to the establishment payments, most benefits from the lower price brought by BCAP were transferred to the foreign consumer via export. From the trade aspect, the winners were still from woodpulp and paper exporters. Similar to the establishment payments, lower domestic prices enhanced the competitiveness of these two products and induced exports.

In summary, the establishment and annual payments were both effective in increasing fuelwood and industrial roundwood production, while the matching payment did not cause significant changes in these productions due to its small subsidy cap of $45/dt. However, this small payment did lead to a significant reduction in particleboard supply, because particleboard mainly depends on forest residues as raw materials. This result validates some of the concerns from the wood manufacturing industry that prices for their raw materials may increase [5]. Higher-valued forest products such as woodpulp and paper were modeled as increasing in production because the raw materials such as industrial roundwood would enhance its supply, which may be counterproductive for policies aiming to promote the development of bioenergy. Since the biomass market has not been established, the increased production of industrial roundwood and fuelwood might flow to high-valued forest products instead of being used as the biomass feedstock. However, this model did not examine the quality of the industrial round and fuelwood. The final change on the high-valued forest products markets needs to be further assessed. Compared to the annual payment, the establishment payment was more effective in the expansion of SRWC plantation, as the up to 75% subsidy in the establishment cost of SRWC was more efficient in relieving landowners' uncertainty in planting SRWC.

For the welfare economics analysis, we found that all three payments will increase the total welfare in the forest product industry. This increase was mainly derived from the rise in international trade. Under the matching payment scenario, the biggest winners were importers of particleboard. Under the establishment payment and annual payment, the biggest winners were wood and pulp exporters. The domestic producers and consumers suffered a loss in all three scenarios. This finding implies that the benefits from BCAP may transfer out through international trade and lead to a loss in the domestic forestry industry. In addition, this finding may be counterproductive to policies aiming to promote the development of bioenergy industry for environmental benefits such as reducing carbon sequestration and socioeconomic benefits such as lower forest product prices. One example is the currently rising export of wood pellet to the United Kingdom (UK). The UK power utility companies are using wood pellets imported from the southern region of the United States to generate electricity to meet UK's national energy consumption goal that 15% of energy should be from renewable sources [31]. These wood pellets may have obtained public policy support in the US but were traded to the UK.

There are some limitations in this paper. First, we make several non-conservative assumptions on simulating BCAP's effects on the forestry industry, such as turning the maximum matching payment $45/dt into the model, which might overestimate the effects but these results could be regarded as a sign or guide for public policymakers that the benefits derived from the policies aiming at promoting the development of bioenergy might be transferred to other countries via international trade. Second, there are some doubts emerging on quantifying the welfare change caused by BCAP or any other bioenergy policies. Several studies argue that, although bioenergy policy might cause competition between fuel and forestry, it is important to recognize that this policy may also lead to some environmental benefits such as improved water quality or more diverse wildlife habitat from the supply of bioenergy feedstock such as SRWC [12,32–34]. These environmental benefits are often ignored when calculating the welfare change caused by these policies due to complicated bioenergy conversion process [19,31,35]. Future research should focus on constructing a model to include environmental benefits into a welfare analysis. Third, this analysis mainly focused on the US forestry market but not the whole world market. The reason is that BCAP's effects are relatively small for the rest of the world market due to the small amount of the subsidies and the short time frame of implementation. However, in the US market, it did influence the forestry industry. Therefore, we only assessed its influence in the US market.

4. Conclusions

As one of the programs directly assisting producers with the establishment of new dedicated biomass crops for bioenergy production, BCAP's effects were assessed with GFPM. We designed three alternative scenarios to simulate three payments in BCAP. We found that, under the matching payment scenario, industrial roundwood and particleboard experienced a sharp decrease in production and an increase in price. For establishment payments, industrial roundwood experienced a continuous increase in production and a decrease in price. For annual payments, the industrial roundwood production experienced a V-shape pattern. For the welfare analysis, we found that all three payments increased the total welfare of the forestry industry in the United States. The biggest contributor to the increase in welfare was from international trade. This finding implies that the benefits from this public policy might be transferred out of the country through international trade.

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