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Economic Impacts of Future Biorefineries in the State of Arkansas : an Input-output Analysis

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Recently, high fuel prices along with environmental and national security concerns have generated considerable interest in green, renewable, domestic sources of fuel. These environmental concerns over the use of fossil fuels, security concerns due to the dependence on foreign oil, and the growing public preference for a cleaner environment are stimulating the demand for renewable energy sources such as woody and non-woody biomass. As a result, efforts to increase the use of biomass as a fuel source are increasing.

In Arkansas, the Potlatch Corporation, a forest products industry based in Lewiston, Idaho, had in the recent past explored the possibility of establishing a fully integrated biorefinery in its Cypress Bend facility. This proposed refinery would have primarily utilized logging residues along with some agricultural residues and dedicated energy crops. This study investigates the economic impacts of such a biorefinery, and other future biorefineries, on the state's economy.

Input-output economics is a method for examining the flow of goods and services among the different sectors of an economy and thereby analyzing the interdependence of these sectors and associated impacts (Phillips 1955). In 1758, Francois Quesnay published his *Tableau Economique*, which stressed the interdependence of economic activities (Phillips 1955). Quesnay's idea of interdependence is widely seen as the precursor to the input-output model developed by Leontief almost two centuries later (Leontief 1947).

As mentioned earlier, input-output analysis is a method of systematically quantifying the interrelationships among the various sectors of a complex economic system (Leontief 1986). This analysis is based on a table that shows the flow of goods and services within an economy. The basic input-output model can be expressed as follows (Pleeter 1980).

$$\sum_{j=1}^{s} X_{ij} + \sum_{k=1}^{t} Y_{ik} + e_i = X_i \qquad (i = 1,2,.....,s)$$

Where,

X_{ij} = Sales of industry i to industry j
Y_{ik} = Sales of industry i to final demand sector k
e_i = Export sales of industry i
X_i = Total sales of industry i
s = number of industries
t = number of final demand sectors.

Since the production functions are assumed to be linear, each input must be purchased in fixed proportions in order to produce a unit of output. This implies that the production functions have fixed coefficients (Pleeter 1980). These coefficients, often known as technical coefficients, represent the amount of input required from each industry to produce a dollar's worth of output from a specific industry (Miernyk 1965). Depending on the nature of the interindustry flow of goods and services, these coefficients may be used to estimate the direct, indirect, or induced impacts of a positive and negative shock to the economy.

The economic simulation program IMPLAN, short for Impact Analysis for Planning, was used in this study. IMPLAN models economic activity through a 509-sector transaction matrix based on the Bureau of Economic Analysis' National Input-Output table (U.S. Department of Commerce, 1984). Social accounts matrix (SAM) multipliers were used for all households in the model construct.

The growth in economic activity was determined for various sectors related to the operation of the proposed biorefinery. These operations included the collection of in-forest residues (IFR), collection of agricultural residues, harvesting of dedicated energy crops, transportation of biomass to the biorefinery, and the processing of the biocrude output. This growth was modeled in IMPLAN and the resulting growth in value-added products (similar to gross state product), employment, and employee wages was determined by industry sectors in the state. The industry aggregation followed that used by Munn and Tilley (2005). Once these changes for different sectors were entered into the IMPLAN model, economic simulations were run in

order to estimate their direct, indirect, and induced impacts.

The direct economic impacts modeled in IMPLAN for the biorefinery are summarized in Table 1. Various operations associated with the biorefinery would require a total of 177 jobs. These 177 direct jobs will contribute to the creation of 480 new jobs state-wide (Table 2). Employee compensation will increase by more then $15 million dollars and the growth in the state's GSP will be nearly $30 million.

The compensation for jobs directly created are likely to have an average wage of nearly $39,000, and the overall average wage for the 480 jobs created throughout the Delta region will be almost $32,000 annually. According to the Arkansas Employment Security Division's 2004 Covered Wages Report (2006), the average annual wages in the Arkansas Delta were $24,827 for all sectors.

These economic impacts will be realized in a wide variety of sectors within the economy. The principal impacts of the proposed biorefinery will be in truck transportation, logging, organic chemical manufacturing, agriculture and forestry support activities, wholesale trade, and food services sectors.

The statewide production of IFR would support 15 biorefineries using 900 dry tons per day of IFR and the corresponding 600 dry tons per day of biomass from other feed stocks. The IMPLAN impacts were simply expanded by a factor of 15 to estimate the potential economic impact from integrated biorefineries across the state. The limit on the number of biorefineries is based entirely on the sustainable quantity of IFR and harvest of non-growing stock trees. Additional biorefineries could be supported entirely from dedicated energy crops, agricultural residues, urban woody debris, and other organic biomass sources.

In addition, to the Cypress Bend paper mill, there are four other paper mills in Arkansas, as well as other facilities producing lumber, plywood, or oriented strand board (OSB) that are large enough to support a biorefinery. Across Arkansas, there are 40 wood using manufacturing sites that require more than 150,000 tons per year of wood fiber (Arkansas Forestry Commission, 2002). These manufacturing facilities would be able to utilize the waste heat from the biorefinery and achieve similar energy production efficiencies and economies of scale as well as having the ability to process large volumes of biomass.

Table 3 shows the direct, indirect, and induced (household) impacts for employment, employee compensation, and value-added products (gross state product) for 15 biorefineries in the state of Arkansas. The growth in GSP is nearly 450 million dollars annually, and employment increases by more than 7000 jobs statewide. Wage structure is identical to the single biorefinery case.

The results from the simulation analysis show that the planned Cypress Bend biorefinery is likely to have significant impacts on the state's economy. Analysis of the available feedstock shows that Arkansas has great potential for developing a bioenergy sector. An additional 14 biorefineries of similar capacity could potentially be supported in the state. Development of such biorefineries would redefine the state's forest products industry as not only the producer of wood and paper products, but also a supplier of energy. Such a transition nationwide would not only reduce energy costs for the forest products industries, but also would be a major step toward reducing the nation's dependence on imported fuel. In addition, replacement of fossil fuels by renewable sources of energy is widely accepted as the best approach to combat global climate change. The proposed biorefinery is a major step in achieving that goal through production of fuels from a renewable and sustainably managed natural resource.

Table 1. Estimated direct employment impacts of the proposed biorefinery in Cypress Bend.

IMPLAN Sector	Sector Name	Employment increases
10	Other crop farming	5
14	Logging	48
142	Petroleum refineries	12
151	Other basic organic chemical processing	25
394	Truck transportation	87
Total		**177**

Table 2. Direct, indirect, induced, and total effects of the proposed biorefinery in Cypress Bend.

	Direct	Indirect	Induced	Total
Employment	177	170.3	132.2	479.5
Employee Compensation	$6,871,901	$5,438,744	$3,008,236	$15,318,911
Value-added	$13,441,586	10,107,890	$6,347,274	$29,896,750

Table 3. Direct, indirect, induced, and total effects of 15 biorefineries of similar capacity in Arkansas.

	Direct	Indirect	Induced	Total
Employment	2655	2554.3	1982.8	7192.2
Employee Compensation	$103,078,510	$81,581,612	$43,123,543	$229,793,664
Value-added	$201,623,787	$151,618,347	$95,209,117	$448,451,257

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