Analyzing the Impact of Intermodal Facilities to the 
Design of Supply Chains for Biorefineries


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Project Objectives
The main purpose of this project is to analyze the impact of intermodal facilities in the design of supply chains for biofuel production facilities. This objective will be attained by pursuing two specific aims: (a) Build mathematical models that will be used to design the in-bound and out-bound supply chain of a biorefinery. This model will take as an input (i) location of existing intermodal facilities and their capacity; (ii) the geographical distribution of biomass feedstock and demand for biofuels, feedstock production yield, and (iii) production, transportation and inventory costs. (b) Compare supply chain designs that take advantage of intermodal facilities with the ones that do not. The comparison of alternative designs will be performed with respect to logistics costs and supply uncertainties. The performance of each design will be tested in a number of scenarios. We anticipate that locating a production plant close to an intermodal facility, allow for economical in-bound and out-bound transportation options and reduce the risk of biomass supply. We will demonstrate the implications of this research using a case study that concentrates in the state of Mississippi. Note that a biorefinery can use corn, or cellulosic biomass to produce ethanol. We plan to investigate the impact of an intermodal facility on both biorefinery types.

Project Abstract
Bioenergy has been recognized as one of the future power sources in the USA that will reduce the nation’s dependency on petroleum, thereby having a positive impact on the economy, environment, and society. Based on a study by Oak Ridge National Laboratories, the production of renewable energy is expected to increase from 2.3 bgy
(billion gallons per year) in 2003 to 7.5 bgy by year 2012. However, fear of unreliable feedstock costs and supply has been a major barrier for the start-up of biofuel production facilities.

It is estimated that 20-40% of the cost of ethanol (which is a biofuel) is due to biomass supply; and about 90% of the costs of delivering biomass are logistics related costs. In addition, the pipeline system that is in place for petroleum cannot be used to distribute ethanol. Currently, about 70% of ethanol produced is being shipped in containers using rail and truck. Ethanol producers in the Midwest are using containers to ship overseas DDGS (Distiller’s Dried Grains with Solubles), a byproduct of ethanol. DDGS is very popular in Asia as livestock and poultry feed. In summary, since logistics (transportation) related costs are a large component of the final product costs, they should be considered when making biorefinery location decisions.

The supply of biomass feedstock (such as corn) is subject to uncertainties like weather conditions, insect disease, or farmers planting plans for the season. In addition, farmers can decide not to produce corn if they identify better alternative uses of their land. As a rule of thumb, a biorefinery should be located within 50 miles of its supply points. However, considering the high level of uncertainty, alternative options for assuring a steady flow of biomass supply should be considered. Locating a facility close to an intermodal facility allows for economical transportation options to replenish the inventories.

The research in this proposal is motivated by two recent events in Mississippi: (i) the first and only ethanol production plant is located near the port of Vicksburg; (ii) in 2007, the number of acres of land planted with corn tripled. The Vicksburg’s plant by locating near to the port is addressing the two major issues investors are facing: transportation costs and supply uncertainties. In case of supply shortage from the delta region, the plant can get shipments from the Midwest using intermodal transportation (water and truck) which is an economical transportation option.

The Vicksburg plant will consume about 1/6th of the corn produced in Mississippi in 2007. To make use of the increased supply of corn and make use of cellulosic biomass that is abounding in the state, we anticipate that other plants will open in the near future. Therefore, identifying potential locations for such plants; and designing (i) low risk; (ii) cost efficient in-bound and out-bound distribution chains; is very important. We anticipate that providing investors with well designed supply chains will attract them to Mississippi. This in turn will positively impact the economy of the state and open new jobs for rural Mississippians.

Literature Review:
The literature related to in-bound supply-chain designs for biofuel production facilities (and agro-based businesses in general) is scarce. On the other side, a number of models and best practices are available for other industries, such as the personal computer industry, or retail industry. These models, while provide some insights and serve as a starting point for designing in-bound supply chains for biorefineries, do not directly
Biomass feedstock has certain characteristics that distinguish it from industrial products, such as: (a) the supply of biomass feedstock is seasonal and its yield depends on weather conditions, insect populations, plant disease, etc. An additional source of uncertainty is the price of biomass feedstock. Price of biomass feedstock (such as price of corn) is influenced not only by demand and supply, but also by government policies and international trade. These uncertainties are critical for the profitability and even the survival of biorefineries; (b) biomass supply is constrained by land availability; (c) biomass has high transactions costs because of the large number of suppliers, the assortment of produce, traditional administrative systems, and less than sophisticated buying offices; (b) biomass looses dry matter with time; (e) biomass has high logistics costs that include: the cost of physical distribution, packaging at the point of harvest, and repackaging at the point of shipment, at the distribution center, and at the point of sale location.

The current literature provides models that: estimate the cost of collecting, handling and hauling biomass to biorefineries [Error! Reference source not found.]; compare different modes of delivering biomass [Error! Reference source not found.]; and identify supply-chain options for biobased businesses [Error! Reference source not found.]. These articles do not take an integrated systems approach to this problem, and do not consider the impact of costs, and supply uncertainty on location decisions. Furthermore, there are no articles that consider the impact of intermodal facilities in reducing logistics costs and reducing the risks associated with supply uncertainties. For these reasons, we believe that there is gap in the existing literature that needs to be filled.

**Intermodal Orientation of the Project**
Modes of transportation affected are: railroad, in-land waterways, and truck. This research will contribute to distribution system design for freight transportation.

**Task Description**
**Task 1: Data collection:** The data needed to complete this project will come from three major sources. The first source is the National Agricultural Statistics Service (NASS) [4]. NASS is provided by United States Department of Agriculture (USDA). NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. NASS publishes the following data related to corn and other crops: harvested area, production yield, total production, planting and harvesting periods, crop price during the current harvesting period, historical crop prices, number of farms, etc. This information is given at the county and state level.

The second source of data is research articles that provide forecasts about ethanol production from 2006 until 2012 (in billion of gallons) [5]; biomass transportation costs [5, Error! Reference source not found., 6]; biomass to ethanol conversion rates [Error! Reference source not found.], etc.

The final source of data is companies that provide intermodal services, and companies that produce biofuels. Among others, we plan to interview with Miller Transporters, a company that provides intermodal services across the U.S. Their corporate office is located in Jackson, MS. We plan also to interview with officials of the Port of Vicksburg.
We plan to interview with officials of Ergon, the company that owns the ethanol production plant in Vicksburg.

Task 2: Model development and validation: In a previous project, the PI has developed a mathematical model that can be used to build the in-bound part of the supply chain of a biorefinery. These models will be extended to capture: (a) the impact of an intermodal facility to the cost and uncertainty of biomass supply, (b) the impact of an intermodal facility to the out-bound supply chain design.

Task 3: Develop a solution approach: Supply chain problems are usually modeled as mixed integer programming problems. Commercial packages, such as CPLEX, can be used to solve the model. However, depending on the problem’s size and complexity, CPLEX may fail. In this case, heuristic algorithms will be designed to generate good quality solutions.

Task 4: Analyze the results, draw conclusions and prepare the final report.

Technology Transfer
The PI plans to present the findings of this research in national and international professional conferences, as well as in meetings with business development officials and local businesses. For example, the PI attends regularly the IIE (Institute of Industrial Engineers) Annual Meeting and INFORMS (Institute for Operations Research and Management Science) Annual Meeting. These are two potential conferences where the PI plans to present the findings of this research.

The PI has a record of refereed journal publications in the area of supply chain and logistics. Some of the potential journals where she plans to publish the results of this research are the Journal of Supply Chain Management, International Journal of Logistics Management, Transportation Science, Computers and Industrial Engineers.

The PI has discussed the research plan of this project with Mr. Sumesh Arora, the Director of Strategic Biomass Initiative (SBI), at Mississippi Technology Alliances (MTA). MTA is a non-profit organization whose mission is to drive innovation and technology-based economic development for the state of Mississippi. The purpose of SBI is to strengthen targeted biomass research and development among Mississippi universities and the private sector to break down the hurdles to commercializing renewable energy resources. Mr. Arora is very supportive of this research and believes that it is of benefit to the state (see the attached letter of support).

The PI has also discussed the research plan of this project with Mr. Skip Scaggs, the Manager of Business Development at East Mississippi Business Development Corporation. Mr. Scaggs is very encouraging of this research. He made suggestions and gave insights about the impact that an intermodal facility has on the in-bound and out-bound logistics operations of a biorefinery. His suggestions were considered in the process of putting together this proposal. Mr. Scaggs has offered his support in setting
contacts with the petroleum distribution manager of Ergon, and in identifying companies that provide intermodal shipments in the state.

**Benefits of Project**
The testing grounds for the research proposed here will be the state of Mississippi. The economy of Mississippi relies mainly on agriculture. The results of this study have the potential of creating substantial economic value for the state.

The proposed research has the potential of creating substantial economic value for farmers and biorefineries. In particular, this research is in accord with nationwide efforts aimed at developing sustainable and renewable sources of energy. This effort is a reflection of the rising awareness of the consequences of climate change; the desire to improve energy sustainability; and the need to create new jobs in rural areas.