

Project 001(D) Alternative Jet Fuel Supply Chain Analysis

The Pennsylvania State University

Project Lead Investigator

Saurabh Bansal
Associate Professor of Supply Chain Management
Department of Supply Chain and Information Systems
The Pennsylvania State University
405 Business
University Park, PA 16802
814-863-3727
sub32@psu.edu

University Participants

The Pennsylvania State University (Penn State)

- PI: Saurabh Bansal, Associate Professor of Supply Chain Management
- PI: Lara Fowler, Senior Lecturer, Penn State Law School; Assistant Director, Penn State Institutes of Energy and the Environment
- PI: Ekrem Korkut, Penn State Law School
- FAA Grant Number: 13-C-AJFE-PSU, RISK-INFORMED ALTERNATIVE JET FUEL (AJF)
- Period of Performance: 08/01/17- 01/31/2022

Washington State University (WSU)

- Kristin Brandt, Staff Engineer

University of Tennessee

- Tim Rials, Associate Dean of Agricultural Research
- Burt English, Professor of Agricultural and Resource Economics

Project Funding Level

FAA Funding: \$200,000
Matching, Penn State: \$200,000
Total Funding: \$400,000

Investigation Team

Task 1.3.1 (Bansal; supported by Brandt and English): Risk-reward profit-sharing modeling for first facilities

Task 1.3.2 (Bansal; supported by Brandt and English): Additional quantification of risk and uncertainties in supply chains (foundational part of Task 1.3.1)

Task 1.3.3 (Bansal; supported by Brandt and English): Supply chain risk analysis tools for farmer adoption

Task 1.4.1 (Fowler; supported by Korkut): National survey of current and proposed state and federal programs that monetize ecosystem services

Task 1.4.3 (Fowler; supported by Korkut): Support of stakeholder engagement efforts

Project Overview

This project focuses on developing a qualitative and quantitative understanding of factors that can help establish biofuel supply chains for alternative jet fuels. Although efforts are being made to establish these supply chains, many face challenges due to a lack of clarity regarding the incentives that stakeholders would require to engage in these supply chains and devote their resources to invest in the facilities required for these supply chains. To this end, this project has two goals:

1. Develop pro forma cash flows that represent the financial status of various participants in biofuel supply chains for alternative jet fuels to inform a transparent risk-sharing tool, and
2. Understand the policy landscape in various parts of the United States to encourage alternative jet fuel supply chains and identify additional policy initiatives that may be needed.

Task 1.3.1 – Risk-reward Profit-sharing Modeling for First Facilities

The Pennsylvania State University

Objective

Develop a transparent risk-sharing tool to provide all partners with an understanding of the cash flows and risks faced by all supply chain partners.

Research Approach

We first collected a large number of risk-sharing tools that have been proposed in the supply chain literature. Subsequently, we narrowed this list down to 9-12 mechanisms. We created an Excel-based framework in which the cash flows of all supply chain partners are modeled based on data from the techno-economic analyses developed by WSU. This framework incorporates the risk-sharing mechanisms.

Milestone

We developed Excel models for four realistic configurations by using data from techno-economic analysis models developed by WSU.

Major Accomplishments

We developed an Excel-based framework showing the cash flows of four key stakeholders in alternative jet fuel supply chains: farmers, preprocessors, refineries, and airlines. The framework shows various risk-sharing contracts that each of the stakeholders can extend to others, as well as the financial burden or opportunities associated with these mechanisms. The framework also shows the government's financial burden of supporting these mechanisms. The framework was developed for four levels of refinery capacity. Overall, this framework can be used as a decision support tool by various stakeholders to determine whether to engage in alternative jet biofuel supply chains and negotiate with each other.

Publications

We anticipate publishing a paper based on combined work from last year and the coming year. The paper would make the important point that: no single risk-sharing approach or policy instrument is likely to be sufficient for creating a sustainable supply chain. Rather, a portfolio of instruments is needed. This perspective has not been previously presented in the literature.

Outreach Efforts

Our tool has been presented and discussed at three ASCENT advisory committee meetings.

Awards

None

Student Involvement

None

Plans for Next Period

We intended to conduct laboratory studies with graduate students. However, the behavioral research lab was closed at Penn State due to COVID-19. We will perform these studies when students are back on campus. We can conduct these studies only when students are able to interact with each other in a simulated negotiation environment. We will provide the tool and training on its use to the project sponsor.

Task 1.3.2 – Additional Quantification of Risk and Uncertainties in Supply Chains (Foundational Part of Task 1.3.1)

The Pennsylvania State University

Objective

Develop methods to rely on expert judgments to quantify uncertainties associated with biofuel supply chains.

Research Approach

We developed a new econometric approach to quantify probability distributions of uncertain quantities such as yield or demand when an expert panel provides judgments regarding the most likely values. This approach exploits the well-known theory of generalized least squares in statistics for the context in which historical data are available to calibrate expert judgments or when these data are not available.

Milestones

We have described this method in two manuscripts. In the first manuscript, [*Using Subjective Probability Distributions to Support Supply Chain Decisions for Innovative Agribusiness Products*](#), we developed a two-stage procedure to calibrate expert judgments for the distribution of biofuel uncertainties, such as the uncertain yield of new varieties of oil seeds, demand, or selling price. In the first step of the procedure, we calibrate the expert judgments by using historical data. Specifically, we use prior judgments provided by experts and compare them with actual realizations (such as predicted yield versus actual yield) to determine the frequency with which each expert over- or underestimated the uncertainty, e.g., Expert 1 underestimated the yield 60% of the time, but Expert 2 underestimated the yield 90% of the time. In the second manuscript, [*Optimal Aggregation of Individual Judgmental Forecasts to Support Decision Making in a R&D Program*](#), we use this information to determine the optimal approach for aggregating the experts' judgments to determine the mean and standard deviation of the probability distributions. In this manuscript, we develop a new optimization protocol for determining the optimal acreage for growing specific crops by considering the estimated mean and standard deviation as well as incorporating the variability in these estimates. This manuscript won an award at a professional conference (INFORMS 2021) in November 2021.

Major Accomplishments

Theoretical development and a numerical study have demonstrated the promise of this approach.

Publications

Bansal, S., & Gutierrez, G. J. (2020). Estimating uncertainties using judgmental forecasts with expert heterogeneity. *Operations Research*, 68(2), 363-380. <https://pubsonline.informs.org/doi/abs/10.1287/opre.2019.1938>

The second manuscript has been written and will be submitted for publication during this period.

Outreach Efforts

None

Awards

2021 Decision Analysis Practice Award, INFORMS. November 2021.

Student Involvement

None

Plans for Next Period

The second paper has been submitted to the sponsor for review. It will be submitted for publication during this period.

Task 1.3.3 – Supply Chain Risk Analysis Tools for Farmer Adoption

The Pennsylvania State University

Objectives

Understand farmers' risk preferences over a long duration and how these preferences affect their decisions to grow crops that can support alternative jet fuel supply chains

Research Approach

We surveyed farmers to understand their risk preferences over extended durations. Specifically, we presented farmers with sample yield ranges over extended periods and asked them to estimate the lowest equivalent guaranteed yield that they would be willing to accept given the uncertain yields. We used these responses for statistical analyses.

Milestones

We have completed the survey and have written a manuscript based on the survey.

Major Accomplishments

We compiled data from 43 farmers in central Pennsylvania regarding their preferences given uncertain yields from their land. The results quantify the loss of value that farmers attribute to an uncertain yield. Results are reported for both 1-year and 10-year horizons. For the 10-year horizon, we also report results for an initial yield build-up, which often arises with most biofuel crops. The key takeaways from this study are as follows: (a) farmer valuations of a new crop decrease acutely as the uncertainty in yield increases and (b) the initial build-up period of low yields can be a large deterrent that inhibits farmers from adopting new crops for the purpose of supporting biofuels.

Publications

A paper detailing this work has been written and provided to the sponsor.

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

The results in the first version of the paper revealed something interesting: when faced with uncertain yields, say from x to y , farmers were willing to swap their output for a consistent output at levels that were lower than x . This finding was initially surprising. However, the research team has recently found prior research in economics documenting similar behavior. More data collection will reinforce these findings. We plan on collecting additional data from another 50 farmers during the spring of 2021.

Task 1.4.1 – National Survey of Current and Proposed State and Federal Programs that Monetize Ecosystem Services

The Pennsylvania State University

Objective

Conduct a survey and summarize current and proposed state and federal programs to monetize ecosystem services.

Research Approach

This task builds on and continues the work performed under ASCENT Project 01, Task 8.1, which focused on the biomass and water quality benefits to the Chesapeake Bay watershed. In previous years, we examined the biofuel law and policy landscape of the Pacific Northwest and Southeast regions, as well as the state of Hawaii. This year, we have focused on federal biofuel law and policy and how it has been affected by international drivers.

Milestones

Our research has previously been circulated in three region-specific white papers. In addition, we developed a federal-level white paper to the list of tasks, which was subsequently turned into a published paper (see below).

Copies of these documents are available online:

- Western U.S. policy paper (with a focus on Washington state, last updated in 2019):
<https://pennstateoffice365.sharepoint.com/:w:/s/Biomasslawandpolicy/EVLle-CR5aBCjIYCrXhY3RqB7WqGPAaqjFEkl8b5JDvWEq?e=ZAGT1V>
- Southeast policy paper (with a focus on Tennessee):
https://pennstateoffice365.sharepoint.com/:w:/s/Biomasslawandpolicy/EVvAOEktS9xFlmBgVksIEM8B_OvGngJ_l6oMRqojDcNy7A?e=OVg7FF
- Hawaii policy paper:
https://pennstateoffice365.sharepoint.com/:w:/s/Biomasslawandpolicy/EXmtXyHdCgdAs56DdQvIbq0B0SxOPIAhdplwjlLbMdax_Q?e=m6bYJb
- Federal-level white paper:
<https://pennstateoffice365.sharepoint.com/:w:/s/Biomasslawandpolicy/EUauzGRg2adBgUHildnKjqcB6Yg9ppAsP3ga0mYghB6AEA?e=6xiT9K>

Major Accomplishments

In addition to developing the white papers described above, we adapted the federal-level white paper for publication (see below). We also presented our work as a poster during the Penn State Energy Days, provided updates during bi-weekly ASCENT 01 team meetings, and provided a briefing and poster during the ASCENT fall meeting. Additionally, PI Lara Fowler is involved in another USDA National Institute of Food and Agriculture (NIFA-funded project entitled "Consortium for Cultivating Human and Naturally Regenerative Enterprises" (USDA-NIFA Sustainable Agricultural Systems Award 2020-68012-31824), dubbed the "C-CHANGE" project. She has built upon her work in this ASCENT project to link to the regenerative agriculture work being pursued in C-CHANGE, including providing a briefing on 2nd generation biofuel law and policy.

In September 2021, both Lara Fowler and Ekrem Korkut participated in the September 16, 2021 SAF Grand Challenge Roadmap Workshop with the sustainable aviation fuel research community.

Publications

Our federal-level white paper has been submitted and published in a special edition of *Frontiers in Energy*:

Korkut, E. & Fowler, L. B. (2021). Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States." *Frontiers in Energy Research*, 732.
<https://www.frontiersin.org/articles/10.3389/fenrg.2021.750514/full>

Outreach Efforts

Posters

- Fowler, L. B., & Korkut, E. (2020, September). Biofuel law & policy: Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States. Poster presented at the ASCENT Annual Meeting.
- Fowler, L. B., & Korkut, E. (2021, May). Regulatory and policy analysis of production, development and use of sustainable aviation fuels in the United States. Poster presented at the Penn State Energy Days.
<https://iee.psu.edu/events/energy-days/posters>



Presentations

- Fowler, L. B. (2020, December). U.S. biofuel law and policy: A quick overview on U.S. law and policy affecting second generation biofuels." Paper presented at the USDA NIFA C-CHANGE.
- Fowler, L. B., Korkut, E. (2021, June). National and regional law and policy drivers for alternative jet fuel. Paper presented at the ASCENT 01 team meeting.
- Fowler, L. B., & Lewis, K. (2021, October). Sustainable aviation fuel development: Law, policy and the blender's tax credit." Paper presented at the ASCENT Annual Meeting.

Awards

None

Student Involvement

Ekrem Korkut graduated from the Penn State School of International Affairs in May 2021 and transitioned to working as a postdoctoral associate on this project (50% of his time, with the other 50% funded by another project).

Plans for Next Period

As noted above, we will continue adapting the existing white papers for publication, with the next step being a focus again on regional efforts. In addition, we are working on law and policy research questions identified by other ASCENT team members, including how landfill regulations shape opportunities in Hawaii and other related topics. As needed, we will provide support to working groups under the SAF Grand Challenge.

Task 1.4.3 – Help Support Stakeholder Engagement Efforts

The Pennsylvania State University

Objective

Facilitate dialogue among producers, industry, government, and other affected stakeholders.

Research Approach

Our work under this objective has focused on stakeholder engagement and facilitation of effective dialogue to help bridge gaps between producers, industry, government, and other affected stakeholders. This role supports the needs of other team members.

Milestone

These efforts have supported stakeholder engagement efforts led by other teams, including but not limited to the regional partners identified in ASCENT Project 01, Tasks 3.1, 3.2, and 3.3.

Major Accomplishments

This set of tasks has been more limited, with no major accomplishments to date. We have continued to participate in discussions and calls related to potential stakeholder engagement needs.

Publications

None

Outreach Efforts

None

Awards

None

Student Involvement

None





Plans for Next Period

Future work under this objective will include presenting to the project partners on facilitation skills and tactics. Additional support for regional projects will be offered as needed for facilitation and stakeholder engagement sessions as the regional projects move to the deployment stage. As needed, we will provide support to working groups under the SAF Grand Challenge.