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A model of state and federal biofuel policy: Feasibility assessment of the California Low Carbon Fuel Standard

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HIGHLIGHTS

- A mathematical model of the US biofuel market/policy is developed.
- Compliance with California biofuel policy requires rapid deployment of clean diesel fuels.
- Refiners in California should have banked more credits in early years of the low carbon fuel standard.
- There are indirect price impacts between state and federal level fuel credit markets.

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ABSTRACT

Biofuel policy is under near constant review at both the federal and state level. For example, as part of on-going implementation of the California Low Carbon Fuel Standard (LCFS), the California Air Resources Board has recently designed and is implementing a new cost containment mechanism as part of the compliance credit market embedded within the LCFS. This mechanism was born out of concerns that there may be a shortage of LCFS credits, which could lead to an unpredictable rise in the credit price. In general, it is important to develop appropriate mathematical tools with which to estimate the impact of policy changes on biofuel markets. Motivated by the need for such analyses, a novel regional market model is developed that quantifies several categories of impacts across different regional markets. These market impacts include policy-specific effects of California's LCFS as well as the federal level Renewable Fuel Standard (RFS). Several scenarios are developed to highlight issues of long term LCFS feasibility; in particular, this work highlights the role that biodiesel/renewable diesel might need to play in order for the goals of the LCFS to be met. We find that biodiesel blending will need to increase dramatically within a short period of time (i.e., by 2016 all diesel fuel would need to be 20% blends) in order to generate enough LCFS credits. Additionally, this model highlights the indirect market linkages between the LCFS/RFS credit markets; certain biofuels can register under both programs and generate both credits. As a result, if attempts in the US Congressional to fully repeal the RFS are successful, it is possible that the LCFS credit price could increase more than 50%. Symmetrically, it is also true that if the LCFS program were eliminated, certain RFS credit markets would also be impacted, but to a lesser extent.

1. Introduction

1.1. Problem statement

Understanding how biofuels are produced and consumed in the transportation fuel market is challenging for three fundamental reasons. First, there is little demand for pure biofuels in transportation applications. This is because there are very few vehicles in the United States fleet that can burn high percentage blends of biofuel. For 2014, the Energy Information Administration (EIA) estimates that 6% of the light truck and car market can consume ethanol in blends up to 85% (E85), but only a smaller proportion of these vehicles actually burn E85 due to fuel availability issues [1]. B100 (100% biodiesel) can, theoretically be burned in many diesel engines on the road today, but engine manufacturers often only warranty engines up to B20 (20% biodiesel, 80% petroleum diesel) [2].

As a consequence, the second challenge is that biofuel must compete on a cost basis with many other liquid fuels that are mixed together to create a final transportation fuel. Fuel blenders

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are those entities in the supply chain that mix final transportation fuels (i.e., gasoline and diesel); their final products must meet relevant ASTM standards as well as fuel quality standards enforced by the Environmental Protection Agency (EPA) [3]. Other than these constraints, the fuel blender has discretion in how to blend the final product. This puts biofuel producers in direct economic competition with market entities that rely entirely on fossil fuel feedstocks (crude oil refiners, natural gas liquid producers, and other chemical manufacturers).

Third, there are many policies at the state and federal levels that encourage the production/consumption of biofuels. However, variations and inconsistencies among these policies creates a complex system of market distortions with unintended consequences [4]. Beyond the special tax treatment and minimum blending requirements that biofuels receive, policy makers are working to incentivize the consumption of biofuel with lower lifecycle greenhouse gas (GHG) emissions. Examples of these policies are the national Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard (LCFS) [5–7]. More recently, Oregon has introduced regulations to establish their own Clean Fuel Standard [8]. Despite the fact that California and Oregon share a border, there are serious inconsistencies in the two program's carbon accounting; furthermore, carbon credits generated within each program cannot be traded between the two states. The state of Washington is also considering developing a LCFS of its own, but at the time of writing only a basic framework/feasibility study had been released by Governor Inslee [9]. Despite these differences, the model formulation presented here is general enough to allow for the inclusion of other states' LCFS policies. Regulating lifecycle GHG emissions poses some unique challenges and results in market distortions since the carbon emissions are a function of all upstream processing rather than a pure intrinsic property of the biofuel [10,11].

As a result of the interwoven network of policies and markets, it can be difficult for policy makers to understand the impacts of potential policy changes; it can also be difficult for obligated parties (e.g., fuel suppliers) to untangle a least-cost compliance strategy.

This work focuses on presenting the rationale and mathematical structure of a model of the US biofuel market with state-level policy detail. The formulation is designed to be computationally efficient and is motivated by a desire to inform federal and state regulators of the impacts of their decisions on market behavior. This model also includes policy details of the RFS and the embedded renewable identification number (RIN) compliance credit markets as well as California's LCFS credit market. Previous models that have not include all pertinent details of RIN markets or have been developed within a framework that does not explicitly consider the behaviors of all the various liquid fuel market players [12–15]. The proposed model includes all immediately relevant sub-mandates (biomass-based diesel, advanced, and renewable) as well as potentially strategic details of RIN/LCFS credit banking. The model structure is general enough to allow for additional policies to be considered; for example, future work could include influences of the California cap and trade system (AB32) [16].[2]

This paper is motivated by the need to develop a concise mathematical representation of the biofuel market, including state and federal level policies. Others have modeled the biofuel market before, but a single model that includes the LCFS, RFS, along with a state-level description of the US has not been proposed in literature [17–19]. Beyond the need to develop the mathematical model, this paper is motivated by two primary research questions:

[2] Beginning on January 1, 2015 the suppliers of gasoline blendstocks and diesel fuel oils in California will have a compliance obligation for all GHG emissions that would result from combustion of all such fuels (17 California Code of Regulations §95852).

(1) Is the LCFS, as current written, feasible? If not, what might need to change in the biofuel marketplace to ensure feasibility? and
(2) How do the RFS and LCFS policies impact each other?

Specifically, we are interested in how might RIN and LCFS credit prices influence each other in the event that either of the policies be eliminated. These two policies have not been controversy-free, many proposals for their elimination being promoted at the state and federal levels. This analysis would help highlight any unintended consequences should any of these proposals get implemented.

In the rest of Section 1 contains a discussion of state level biofuel policy, including the CA LCFS. Additional policy background, including challenges faced by regulators in charge of implementing the Renewable Fuel Standard program are included in a detailed Appendix B. The appendix also briefly describes the programmatic requirements associated with the RFS. Section 2 is devoted to documenting, in detail, the model structure, solution methodology as well as underlying assumptions and data sources. Specific model parameters are also tabulated in an Appendix D. Section 3 develops scenarios that will help to answer key questions posed in the previous paragraph regarding the feasibility of the LCFS; results from these scenarios will be discussed in Section 4. Section 5 will conclude with policy implications and suggestions for further research.

1.2. State-level policy and the California Low Carbon Fuel Standard (LCFS)

State-level fuel tax policies vary widely throughout the US. For example as of July 1, 2014, the state of New York taxes gasoline at a rate of 50.5 cents/gallon while Alaska only taxes gasoline at 18.4 cents/gallon [20,21]. At the time of writing there were no state-level tax credits that were available for biofuels (although should they become available, their effect would be easy to account for in our modeling framework).

Of particular note with regard to state biofuel policy is the California LCFS. California fuel consumption represents approximately 11% of all gasoline and 8% of all diesel fuel in the US; California is thus the largest state consumer of transportation fuels in the US. An often-touted policy outcome of low carbon fuel standards is to stimulate investment in second- or third-generation fuel production facilities; it is necessary that the market be large enough to spark the interest in these capital-intensive projects. Therefore, encouraging California to adopt a LCFS was a strategic decision for proponents of biofuel consumption.

As mentioned above, the LCFS program regulates an average carbon intensity of the fuel produced in/imported to California. Therefore, the regulated parties under the LCFS are all fuel producers. To track the average carbon intensity of fuels in California, the state uses a credit/deficit accounting system. LCFS credits (units: metric ton of emissions reduced) are generated when a fuel producer/(importer) produces/(imports) a fuel that is below the carbon intensity listed in the regulation, while deficits (in metric tons) are generated when a fuel is produced/(imported) that has a higher carbon intensity. LCFS credit prices are typically reported in units of $/metric ton. This structure implies that a carbon-intensive biofuel producer can generate deficits and would therefore be responsible for acquiring credits to offset those deficits. This behavior does happen, but deficits generated by biofuel producers are small compared to those generated by oil refiners. So for modeling purposes, we assume that oil refiners and importers of petroleum blendstocks are the only entities that generate deficits.

The performance-based LCFS policy structure allows for a wide variety of other compliance pathways to exist, and in theory,