THE BIOFUEL DECADE AND THE PETROLEUM REFINING INDUSTRY

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Overview

Energy availability is central to operation and growth of modern society. However, all energy forms are not equivalent in ease of access, reliability and pollutants. The newfound of (unconventional) natural gas, as well as readily available biomass resources, coupled with technological advancements, present these alternatives as viable alternative energy sources. For example, modern biology has expanded the range of commodities that are derived by biological processes to include new sources of energy and fine chemicals. However, assessing the economic and environmental impacts of these alternatives and developing optimal strategies to manage them are major challenges.

In this work, we develop a framework to assess the impact of new biofuels taking into account the multiple products that are produced by the petrochemical system that biofuels and shale gas are likely to replace. For example, the reduced production of gasoline or diesel as they are being replaced by biofuels will also affect the supply and cost of co-products—including kerosene, fuel jets and asphalt, which have significant economic and environmental impacts. By modeling the interaction between these multiple products and their possible substitution patterns, we are able to assess these alternatives true economic net benefits and their broader impacts on green house gas emission (GHG).

Methodology

This work develops methodologies to manage energy resources, and to evaluate and assess the economic opportunities and challenges alternative to fossil fuel entail. It conceptually investigates the dynamics of greenhouse gas emissions, as well as the dynamics of investment of petroleum refineries in new technologies, in response to the introduction and adoption of alternative energy sources such as natural gas and biomass. This work assesses how competition with an incumbent oil industry impacts the evolution and adoption of alternative energy sources, and illustrate how adoption of alternative energy sources impacts countries' energy composition and energy security.

We evaluate empirically the model's theoretical findings. Using EIA data for 2000 to 2012, we document and compute the environmental, as well as economic impact of the introduction of biofuels and shale gas. While in 2000 shale gas provided only 1% of U.S. natural gas production, it supplied more than 20% by 2010 and the U.S. Energy Information Administration predicts that it will reach 46% of U.S. natural gas supply by 2035.

Results

In this work we assess how competition with an incumbent oil industry impacts the evolution and adoption of alternative energy sources, and illustrate how the adoption of alternative energy sources impacts countries energy composition and energy security.

The conceptual framework is used to show that one should be more cautious when calculating greenhouse gases (GHG) emissions from energy consumption. The analysis also shows that capital intensity and the multiproduct production process of the oil industry has important implication to GHG lifecycle analysis of alternative energy sources. The multi-product production structure developed in the paper suggests that when calculating greenhouse gases an indirect co-product effect should be addressed. The analysis shows that the putty-clay structure of the oil industry has important implication regarding lifecycle analysis of GHG and technological innovation. When analyzing the long run investments of the petroleum refining industry, we derive conditions where the petroleum refinery invests in technologies that reduce gasoline and diesel production further than suggested in the short-run. The reduction in fuel produced comes with an increase in production of other petroleum products.

Early calculations suggest that that introduction of biofuels may lead to (indirect) reduction in GHG emissions because of the changes in patterns of use of co-product of fossil fuels replaced by biofuels. The empirical analysis also shows that if indirect effects are considered in biofuel policies, focusing on indirect land use change and ignoring other indirect effects may lead to underestimation of the contribution of biofuels to GHG emissions reductions. Further, calculations suggests that the introduction of alternatives had a significant impact on East Cost refineries, and that the introduction of the alternatives resulted in a substantial decline in oil imports into PADD I and contributed to the US becoming a net exporter of petroleum products.

Conclusions

Our model relies on the putty-clay approach, which assumes in the short-run fixed-proportions of technology and which is frequently used to analyze the impacts of environmental regulations. This framework describes a capital

intensive industry whose technological response is limited in the short-run. Further, regulations of biofuels are based on estimates of the impact of biofuel on greenhouse gas emission. Most of the literature conducting such assessments assumes perfectly competitive fuel markets and ignores the fact that fossil fuels are a result of a multi-product process, whereby gasoline and diesel are derived from crude oil together with other petroleum products. This paper develops an alternative framework, taking into consideration the basic properties of the oil refining business. In particular, the petroleum refining is a putty-clay production process and crude oil is used to produce gasoline and diesel, as well as other petroleum products such as liquid-petroleum-gas and asphalt. These modifications suggest that capital intensity and the multiproduct production process of the oil industry has important implication to GHG lifecycle analysis of alternative energy sources, and that the putty-clay structure of the oil industry impacts the oil industry's abilities to adapt to the introduction of alternatives, and thus impacting the patterns of adoption of alternatives to the petroleum products.