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Multi-objective regulations on transportation fuels: Comparing renewable fuel mandates and emission standards

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ABSTRACT

We compare two types of fuel market regulations — a renewable fuel mandate and a fuel emission standard — that could be employed to simultaneously achieve multiple outcomes such as reduction in fuel prices, fuel imports and greenhouse gas (GHG) emissions. We compare these two types of regulations in a global context taking into account heterogeneity in carbon content of both fossil fuels and renewable fuels. We find that although neither the ethanol mandate nor the emission standard is certain to reduce emissions relative to a business-as-usual baseline, at any given level of biofuel consumption in the policy region, a mandate, relative to an emission standard, results in higher GHG emissions, smaller expenditure on fuel imports, lower price of ethanol-blended gasoline and higher domestic fuel market surplus. This result holds over a wide range of values of model parameters. We also discuss the implications of this result to a regulation such as the US Renewable Fuel Standard given recent developments within the US such as increase in shale and tight oil production and large increase in average vehicle fuel economy of the automotive fleet.

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1. Introduction

Governments all over the world have enacted policies in support of alternatives to crude oil (see Martinot and Sawin, 2009 for a list of countries). These policies aim to simultaneously reduce petroleum imports, help the rural economy, support domestic infant industries, and reduce greenhouse gas (GHG) emissions (CARB, 2009; CBO, 2010; Sobrino and Monroy, 2009). One popular regulation is a biofuel mandate, which specifies either a target quantity of biofuel (as in the United States (US) with the Renewable Fuel Standard[1] (RFS)) or a target market share for biofuel (as in the case of several European countries). An alternative type of regulation is an emission intensity standard, which specifies an upper limit on the average GHG intensity of fuel(s). Examples include the California Low Carbon Fuel Standard[2] (LCFS) and the European Union's Fuel Quality Directive.[3] The two types of regulation can be considered equivalent when there is only one type of fossil fuel and one alternative fuel and each has a fixed GHG intensity. Otherwise, the two regulations present different trade-offs between different potential policy objectives. In this paper we show how the two policies differ when they apply only to a portion of the global market for affected fuels. The political economic literature suggests that public policies are selected based on multiple performance measures (see Rausser et al., 2011). We therefore analyze alternative fuel policies based on their ability to influence multiple objectives as opposed to a single criterion such as efficiency or cost-effectiveness. We compare the two different approaches — a biofuel share mandate (SM) and a fuel-emission intensity standard (ES) to each other and also to a third policy that targets

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[1] http://www.epa.gov/otaq/fuels/renewablefuels/.

[2] http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

[3] http://ec.europa.eu/environment/air/transport/fuel.htm.

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emissions but also affects energy prices and energy imports, namely, a fuel carbon tax (CT). Our objective is to illustrate the differences between these policies with respect to different outcome variables that are invariant to both parametric uncertainty and policy stringency. Our modeling effort is not aimed at predicting the absolute impact of biofuels or any given policy.

This paper contributes to an expanding literature on the economics of biofuel policies, only a small sample of which we summarize. One set of papers develops simple analytical models to illustrate stylized facts about the net economic benefits or the cost-effectiveness of GHG emission reduction under different biofuel policies. One insight from this literature is that biofuel mandates lead to larger net social benefit when implemented in conjunction with a GHG tax rather than with a biofuel subsidy (de Gorter and Just, 2009; Khanna et al., 2008; Lapan and Moschini, 2009). Another message is that the currently commercial biofuels are not cost-effective for GHG mitigation (Creyts, 2010; Holland et al., 2009; Jaeger and Egelkraut, 2011) regardless of the policies used. Another set of papers rely on multi-market partial equilibrium and computable general equilibrium models to derive numerical estimates of the impact of biofuel policies on producers and consumers in different markets, the change in total surplus, and balance of trade and emissions (Bento et al., 2011; Cui et al., 2011; Rajagopal et al., 2010; Thompson et al., 2011). This literature suggests that worldwide, biofuel policies benefit food producers and biofuel producers and harm food consumers and suppliers of oil and oil products. Gasoline consumers benefit while consumers of the rest of oil products lose from ethanol policies. This literature demonstrates the multidimensionality of the policy objectives as well as policy tools. Individual studies mostly compare a mandate with a carbon tax or a subsidy, or compare an emission standard to carbon tax. However, the policy choice problem is selection of one or more policies from a set of inefficient policies. We contribute to this literature by emphasizing the differences between volumetric mandates and emission standards based on multiple explicit criteria.

Our work is related to two recent papers that analyze both emission standards and share mandates. Chen and Khanna (2012)—in contrast to most studies—found that either type of regulation reduces GHG emissions relative to a no-policy, business-as-usual scenario. Huang et al. (2013) simulated a policy scenario incorporating both the RFS and the LCFS and concluded that stacking these policies would lead to a greater GHG emission reduction than would occur under either policy alone, and more generally that biofuel policies tend to confer net economic benefits. The findings of both studies are predicated on achieving a level of cellulosic ethanol consumption that meets or exceeds the Energy Security and Independence Act 2010 target of 16 billion gallons of advanced biofuels. However, according to the US Energy Information Administrations Annual Energy Outlook 2014, the quantity of cellulosic biofuels consumed in the US in the year 2040 is predicted to be about 230 million gal, which accounts for less than 2% of the US annual biofuel consumption, while the prediction for first generation biofuels is one of no growth relative to current consumption. We focus on highlighting the differences between alternative policies for the currently mature, first-generation biofuels. Another distinction is that, since we do not model the land or food sectors (unlike Bento et al., 2011; Chen and Khanna, 2012; Huang et al., 2013), we analyze how different policies perform for a given level of domestic biofuel consumption.

Almost all the simulation-based studies mentioned above analyze results from only a few select combinations of values of their model's multiple assumed parameters such as the elasticity of supply and demand for different fuels in different markets, and the emission intensities of the various fuels. An exception is Rajagopal and Plevin (2013) who use a Monte Carlo simulation framework. Their simulations suggested that although either a biofuel mandate or an emission standard could reduce emissions relative to a no-policy baseline, a reduction occurred only within a narrow range of parameters. They focused on fuel rebound effects and GHG emissions. Here we extend their analysis to include economic variables including expenditure on fuel imports and the impact on fuel producers and consumers, and on biofuel suppliers.

2. Model and simulation

2.1. Model

We build on the model described in Rajagopal and Plevin (2013), a schematic diagram which is shown in Fig. 1. For a detailed description refer to the Supporting Information (SI) document. There are two regions — home and rest of the world (ROW), with each region having an open economy and competitive markets. There are two types of crude oil, namely, conventional crude oil and synthetic crude oil derived from Canadian oilsands. The two types of oil are perfect substitutes, but

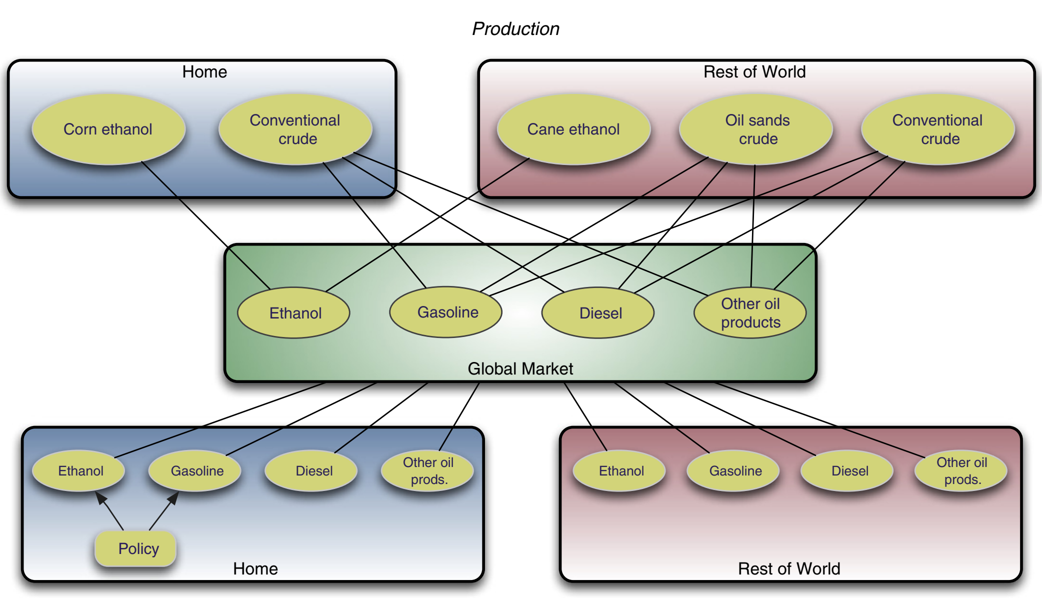

Fig. 1. Schematic diagram of the modeling framework.

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