Economy-wide Implications from U.S. Bioenergy Expansion

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Abstract

The Energy Independence and Security Act of 2007 (EISA) sets a goal for 36 billion gallons of biofuels available by 2022 according to the Renewable Fuels Standard (RFS). The mandate is accompanied by tax credits. The paper assesses long-term economic impacts from meeting the RFS using an economywide model. Benefits in U.S. household welfare outweigh costs of the tax credits because of the gains from reduced fuel prices and terms of trade. Impacts are conditioned by long-run price projections for ethanol and petroleum oil.

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I. Introduction

The EISA sets an ambitious goal to use 36 billion gallons of biofuels by 2022 according to the RFS mandate. Of this amount, 15 billion gallons will come from corn ethanol and 21 billion gallons from non-conventional sources. The RFS is accompanied by tax credits which are subject to change. Tax credits are used as production incentives for different types of ethanol made from corn starch and cellulosic material.[1] There are arguments for and against the use of tax credits. Generally, tax credits are considered as welfare-reducing instruments similar to subsidies. However, tax credits could be rationalized for improving energy security and reducing greenhouse gas emissions as they can correct for market failures (Tyner 2007). Furthermore, tax incentives for an infant industry such as cellulosic ethanol might be justified where there are dynamic learning costs (Sheldon and Roberts, 2007). It is estimated that tax credits could cost taxpayers nearly $28.7 billion annually by 2022 (de Gorter and Just, 2009). It has also been recommended that the tax credit for corn ethanol be reassessed because it may not be needed for a mature industry with established technology (GAO, 2009).

By replacing crude petroleum with domestic biofuels it can provide substantial cost-savings to the U.S. economy (Dixon, Osborne, and Rimmer, 2007). According to recent long-term projections made by the Department of Energy (DOE, 2009), the price of petroleum-based gasoline is likely to increase relative to the cost of producing ethanol. If this projection holds it could make substituting lower cost biofuels for imported petroleum-based fuels beneficial. Consequently, long-term economic benefits could offset the cost of tax credits if ethanol has a long-term cost advantage over petroleum-based gasoline.

[1] Currently, corn ethanol receives a tax credit of 45 cents per gallon in the form of a blender's credit and a $1.01 per gallon tax credit is available for cellulosic ethanol.

In this paper, we determine the impacts on U.S. household consumption and GDP of meeting the RFS using an economy-wide model. Under alternative scenarios for tax credits and crude petroleum prices we find that benefits to the households could outweigh the costs of tax credits. Furthermore, the United States by reducing its demand for imported petroleum by 2022 could be in a position to improve its terms of trade and generate additional benefits for the U.S. economy. However, U.S. GDP is likely to be reduced from meeting the RFS, if tax credits are retained. There is considerable uncertainty in how the rest of the world might respond to a reduction in U.S. demand for petroleum oil in the long-term. Given the uncertainty in the price responsiveness in the rest of the world for petroleum oil we perform sensitivity analysis.

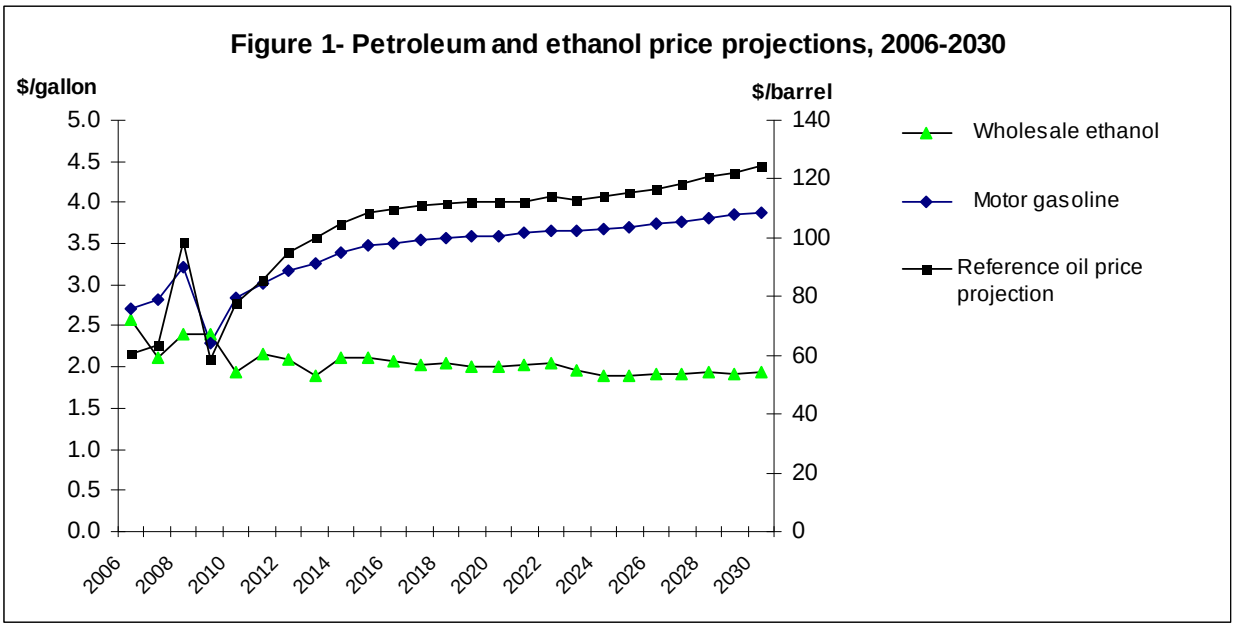
II. Methodology and assumptions

To assess the impacts of meeting the RFS we use a computable general equilibrium (CGE) model for the United States (USAGE model).[2] The theoretical foundation of the model is described in Dixon and Rimmer (2002). A version of the model we use has been enhanced to accommodate new industries and policies related to bioenergy (Winston 2009). The model is extended to include individual industries for corn-based ethanol, cellulosic ethanol, and other advanced biofuels. In doing so this allows for differences in tax credit treatment applied to each ethanol category in meeting the RFS while accounting for technological advances.

One of the challenges in assessing the impacts of meeting the RFS is determining the long-run cost for the ethanol industry.[3] Long-term price projections allow us to gauge technological change and costs. We adopt a price target for ethanol of $2 per gallon using

[2] USAGE is a 535-industry model developed by the Centre of Policy Studies, Monash University, in collaboration with the U.S. International Trade Commission and the U.S. Department of Agriculture.
[3] The conventional approach for projecting technological change in the USAGE framework is to extrapolate from historical trends.

projections made by the Department of Energy for the year 2022 (fig. 1).[4] Technological change is expected to drive down future production costs for conventional and advanced biofuels. The price of crude oil is expected to rise over the next decade, reaching $115 per barrel in real terms by 2022. The price of gasoline is expected to rise with the price of oil reaching $3.70 per gallon in 2022. Given these price projections ethanol would be more competitive than petroleum-based gasoline. However, there is considerable uncertainty in long-term projections of petroleum oil prices.[5] Given this uncertainty, we adopt a low price projection for crude petroleum of $80 per barrel and a high price of $115 per barrel.[6]

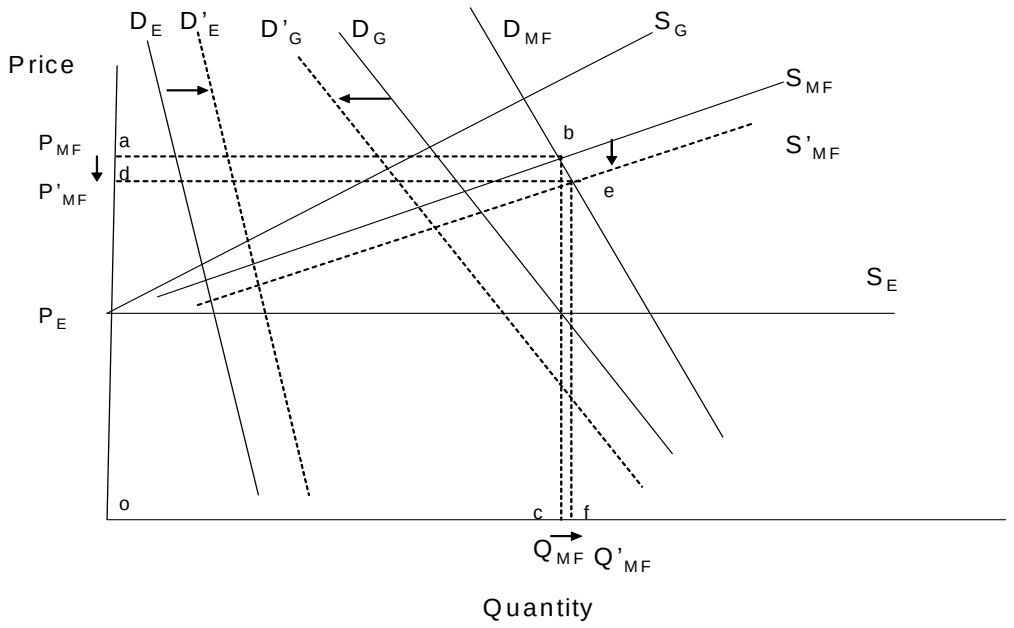


How fuel prices change in meeting the RFS can have important implications for economy-wide benefits. The price of motor fuels depends on supply assumptions for ethanol

[4] The price of ethanol is expected to remain slightly above $2 per gallon but is projected to fall below this price after 2022.
[5] According to the Department of Energy's alternative price projections for petroleum the price of crude oil could vary $47 per barrel to nearly $200 per barrel in 2030.
[6] At $80 dollars per barrel it would make ethanol at $2 per gallon equally competitive with petroleum oil.

and gasoline.[7] We assume by adopting the DOE price projection that ethanol's supply is perfectly elastic. Furthermore a greater proportion of ethanol would be produced from advanced cellulosic sources where the marginal cost is likely to fall due to technological advances. We assume the cost of gasoline falls with a lower quantity supplied. Under these long-run conditions, the price of motor fuels would fall in meeting the RFS (as illustrated in figure 2.)

Figure 2-Impact on motor fuels from meeting RFS



The price of ethanol remains constant at P_E as the RFS mandate shifts the demand curve for ethanol from D_E to D'_E (fig. 2). Ethanol displaces gasoline, thereby reducing gasoline demand. This demand change for gasoline is denoted as a shift from D_G to D'_G. The supply of

[7] In the USAGE model, motor fuels is an aggregate of petroleum gasoline, E10, and E85.

gasoline is dependent on the supply of crude petroleum. The United States, the largest importer of crude petroleum, faces an upward sloping supply curve for petroleum oil. Given that the supply curve for U.S. gasoline is upward sloping $S_{G,}$ the price of gasoline falls with reduced demand. Motor fuels costs would fall as a result of using lower cost inputs, gasoline and ethanol. The reduction in the cost of gasoline would allow the motor fuels industry to sell a greater quantity at the same price as shown by a downward shift in the supply of motor fuels from S_{MF} to $S'_{MF.}$ In this case, the equilibrium quantity supplied and demanded for motor fuels increases from Q_{MF} to $Q'_{MF,}$ as the price of motor fuels falls from P_{MF} to $P'_{MF.}$ The total expenditures on motor fuels shown as area *abco* is reduced to area *defo*. The reduction in the amount of gasoline consumed would be less than the amount displaced by ethanol given that the quantity of motor fuels increases. The more that motor fuels increases from the price drop, the more petroleum gasoline is consumed.

To assess how meeting the RFS would affect the overall U.S. economy in 2022, we first simulate a reference scenario where the RFS is not imposed. The reference scenario is constructed by assuming that the U.S. economy is likely to resume growth at a similar pace prior to the 2008-2009 global economic slowdown. U.S. GDP in the reference scenario expands by 2.9 percent per year lead by export growth of 5.5 percent and real investment growing by 3.2 percent.[8] With regard to ethanol production it is assumed in the reference scenario that 8 billion gallons of conventional corn ethanol would be produced annually through 2022.

Our policy scenario is implemented by imposing the RFS guidelines on the U.S. economy. An additional 7 billion gallons of corn ethanol and 21 billion gallons of non-

[8] Private consumption in our reference case grows by 2.86 per year and public consumption grows by 1.85 percent.

conventional ethanol are produced to meet the annual mandate in 2022.[9] By comparing the results in this simulation with those of the reference scenario, we can deduce the impact of fulfilling the RFS on the U.S. economy in 2022. We assume that when tax credits are removed the industry producing advanced ethanol becomes more efficient and that ethanol could be still be produced at $2 per gallon without tax credits.

III. Results

Table 1 provides impacts on the U.S. economy under alternative crude petroleum prices and options of retaining or removing tax credits for meeting the RFS. Household consumption would increase even with tax credits retained in meeting the RFS. Private consumption gains would range from $14.6 billion in the low-oil price scenario with tax credits to $33 billion in the high-oil price scenario with elimination of tax credits. However, GDP could fall when tax credits are retained under both oil price scenarios. Tax credits place a greater burden on the U.S. economy from foregone revenues. Cost-savings are generated with substituting ethanol for petroleum gasoline as long as ethanol remains competitive with petroleum-based gasoline. This occurs because the supply of ethanol is assumed perfectly elastic and its price remains constant at $2 per gallon according to DOE's projections.

The higher the price of crude oil the greater the benefit the RFS as more expensive petroleum imports are replaced using the same domestic cost of resources. Without elimination of tax credits under the high-oil price case, benefits to the private household would be greater ($25.3 billion) than when tax credits are eliminated under the low-price scenario ($22.3 billion).

[9] Non-conventional sources includes16 billion gallons of cellulosic ethanol and 5 billion gallons from other

By eliminating tax credits GDP would increase by $5.4 billion and $8.7 billion under the low-oil price and high-oil price scenarios, respectively.

Table 1- Impacts on expenditure components of GDP in meeting the RFS in 2022

			With tax credits		Without tax credits	
	2005 base	Reference 2022	Low oil price	High oil price	Low oil price	High oil price
	$ billions		change from reference year $ billions			
Private consumption	8,649	13,973	14.6	25.3	22.3	33.1
Public consumption	1,974	2,695	2.8	4.9	4.3	6.4
Investment	2,187	3,721	6.2	8.3	6.1	8.2
Exports	1,341	3,330	-30.6	-36.8	-32.0	-38.3
Imports	2,064	4,199	-0.9	5.6	-2.5	4.0
GDP	12,086	19,439	-3.7	-0.5	5.4	8.7

Source: USAGE model simulation

Both real wages and household disposable income would rise from meeting the RFS under all scenarios (table 2). The higher the initial petroleum oil price the greater the increase in real wages and household income. Substituting ethanol for gasoline would reduce the demand for crude petroleum. Being the largest importer, the reduction in U.S. demand for oil improves U.S. terms of trade providing additional benefit. Reducing the price for petroleum would allow higher household consumption. With reduced imports of petroleum oil, fewer exports would be needed to pay the import bill. This would result in reduced demand for foreign currency implying appreciation of the dollar in meeting the RFS and is further strengthened with the elimination of tax credits. The export volume would fall about 1 percent with raising export prices. Higher export prices and reduced import prices provide a terms-of-trade gain for the United States (table 2).

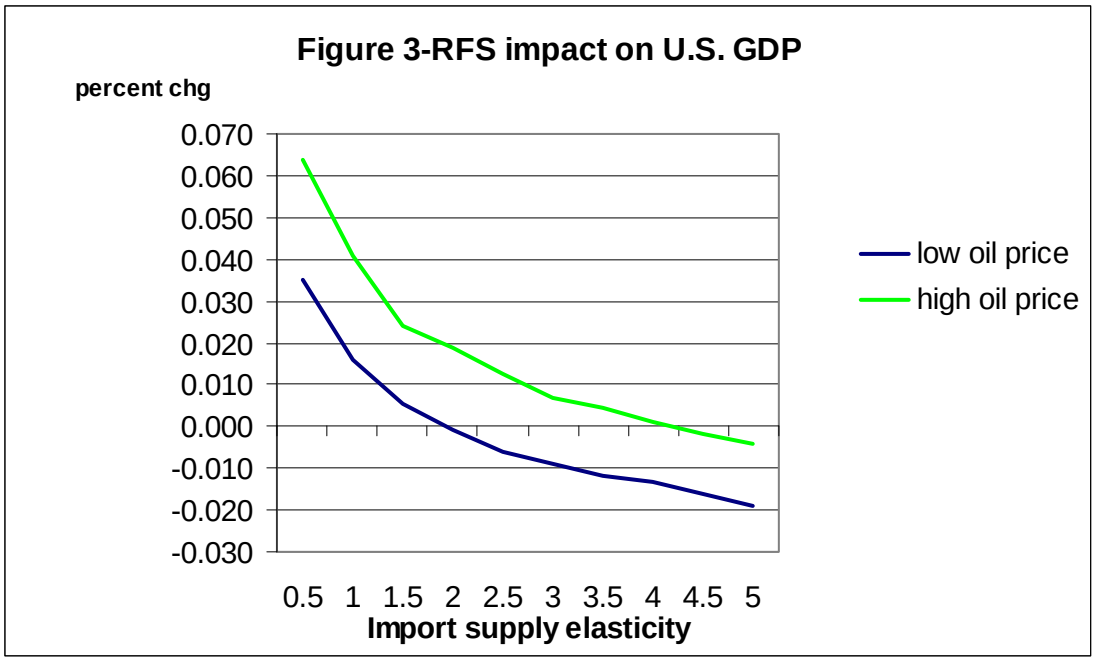
advanced biofuels.

Table 2-Macroeconomic impacts from meeting the RFS in 2022

	With tax credits		Without tax credits	
	Low oil price	High oil price	Low oil price	High oil price
	percent change			
Household disposable income	0.10	0.18	0.16	0.23
Real wages for consumers	0.40	0.54	0.41	0.55
Real appreciation	0.90	1.30	0.94	1.35
Terms of trade	0.79	1.11	0.80	1.13
Export price index	0.09	0.09	0.07	0.07
Import price index	-0.68	-0.99	-0.72	-1.03
Import volume	-0.02	0.13	-0.06	0.10
Export volume	-0.92	-1.11	-0.96	-1.15
Revenue from all indirect taxes	-2.61	-2.64	-1.78	-1.89
Technology contribution (to GDP growth)	0.25	0.25	0.27	0.28

Source:USAGE model simulation

The exact magnitude of the price reduction in petroleum oil is not certain because it depends on the price responsiveness of petroleum oil in the rest of the world. In the USAGE model the import supply elasticity governs the import responsiveness in the rest of the world.[10] However, there is considerable uncertainty in how the rest of the world might respond to a reduction in U.S. demand for petroleum oil in the long-term. Much of the uncertainty has to do with OPEC's supply response and with China and India's demand response to a given reduction in the U.S. demand for petroleum oil. The more responsive import supply, the less crude oil prices would fall. The smaller the decline in the oil price, the less benefit would accrue to the U.S. household. Under a wide range of import supply elasticities (0.5-5.5), we find that household consumption and the terms of trade would remain favorable for the United States. However, U.S. GDP would change from positive to negative over this range of elasticities (fig 3). Under the high-oil price case, GDP would turn positive using an elasticity value of less than 4.5.



With an import supply elasticity of 5, the price of petroleum oil would fall by 4 percent and motor fuels output would increase by 2.5 percent. With a less elastic import supply, the price of crude oil would fall more encouraging greater imports and increasing motor fuels output. The price of crude oil would fall by nearly 8 percent with an import supply elasticity of 2, raising motor fuels output by 3.2 percent.

Table 3. Impact of RFS on motor fuels output and petroleum prices

Import supply elasticity	Motor fuels output	Gasoline price percent change	Crude oil price
2.0	3.2	-9.8	-7.6
2.5	3.0	-9.0	-6.6
3.0	2.9	-8.3	-6.1
3.5	2.8	-7.9	-5.4
4.0	2.8	-7.6	-5.2
4.5	2.7	-7.2	-4.7
5.0	2.5	-6.9	-4.0
5.5	2.5	-6.8	-3.7

Source: USAGE model simulation

[10] The import supply elasticity in the USAGE model is set at 5 for crude oil.

With a less responsive import supply the price of crude oil would fall more providing greater benefit to the U.S. economy. However, a drawback of reduced petroleum prices is a smaller decline in imports of petroleum oil and a greater use of motor fuels. In this case, increased energy independency could be compromised by the reduction of petroleum prices.

IV. Conclusions

This paper finds that the economy-wide benefits of meeting the RFS measured as household consumption gains outweigh costs associated with the tax credits currently accompanying the RFS mandate. This outcome is conditioned by long-run supply projections for ethanol with lower costs through technological progress. However, U.S. GDP is likely to fall when the RFS is accompanied by tax credits. The elimination of tax credits would provide benefits for the U.S. economy by expanding household consumption and increasing GDP. The more competitive that ethanol is relative to petroleum fuels, the more that GDP is enhanced.

A key factor raising U.S. household consumption is the positive effect of reduced petroleum oil prices. However, the size of the gain is likely to depend on the price responsiveness of petroleum oil in the rest of the world (or import supply elasticity). The lower the oil price the effectiveness of displacing petroleum-based motor fuels is weakened in meeting the RFS. Lower motor fuel prices are likely to encourage the use of petroleum-based fuels. Household consumption gains do not accurately capture benefits of achieving energy independence since lower oil prices increase the consumption of petroleum motor fuels. Measures to discourage petroleum use along with incentives to encourage biofuel use would serve the goal of improving energy independence.

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