Aggregate Economic Implications of National Cellulosic Biofuel Goals[1]

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Estimates of the domestic and international economic impacts potentially resulting from the U.S. cellulosic biofuel mandates reflected in the Renewable Fuel Standard (RFS) are presented in this briefing paper.

Four-biofuel combinations of grain ethanol (1st generation) and cellulosic ethanol (2nd generation biofuel) were considered. These were designated as 0+16 (zero grain ethanol and 16 billion gallons of cellulosic ethanol annually), 16+16, 0+20, and 16+20. These four biofuel scenarios were evaluated assuming that no Conservation Reserve Program (CRP) acres return to crop production. A sensitivity analysis of the potential of additional land currently under CRP returning to crop production and reducing competition with existing cropland was also considered.

Estimated economic impacts for these four scenarios are compared against the baseline of no biofuels production. The AGSIM econometric-simulation model served as the basis for the analysis to capture cropping patterns, social welfare, and trade implications (Taylor and Taylor 2011; Taylor 1993).

A dedicated cellulosic feedstock production was assumed to compete for agricultural cropland, affecting the production of conventional grain and other major field crops. For all cases, switchgrass (SG) serves as a proxy for the cellulosic feedstock to meet the RFS. A biomass yield of 2.69 T/ac and an ethanol conversion rate of 96.5 gallons/T of biomass were assumed.

Table 1 is a presentation of the estimated effects of the biofuel scenarios on crop acreages. While total acreage in agriculture (including biofuels production) increased, major field crop acreages declined because they were displaced in large part by the dedicated biomass crop.

Table 1. Estimated change in crop acreages for biofuel scenarios assuming no change in CRP acreage compared to a baseline of zero Biofuel production (million acres)

Scenario[a]	Dedicated SG	Corn	Soybeans	Wheat	Cotton	Hay
0 + 16	61.7	-11.8	-17.2	-10.0	-1.5	-5.3
16 + 16	61.7	-4.7	-16.3	-11.2	-1.5	-5.6
0 + 20	77.1	-14.7	-21.1	-12.0	-1.8	-6.6
16 + 20	77.1	-6.4	-19.9	-13.6	-1.8	-6.9

[a] The first number indicates the level of grain ethanol production, and the second number the level of cellulosic ethanol production (billions of gallons annually)

[1] This briefing paper is a summary of research reported in the dissertation by Dr. Naveen C. Adusumilli (2012).

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Crop price increases that are expected as a result of the biofuel mandate are substantial across all scenarios, as shown in Table 2.

Table 2. Effect on major field crop prices (percent change (increase) compared to the baseline of zero biofuel production)

	Crop				
Scenario	**Corn**	**Soybeans**	**Wheat**	**Cotton**	**Hay**
0+16	21%	12%	30%	21%	18%
16+16	41%	23%	39%	21%	19%
0+20	28%	16%	40%	28%	22%
16+20	52%	28%	50%	27%	24%

Aggregate economic effects (Table 3) indicate a significant loss in economic well-being in the food and agricultural sector due to high commodity prices and subsidy for cellulosic conversion of biomass. For the 0+16 scenario, $15.7 billion of increase in net farm income is more than offset by a loss in consumer surplus of $7.5 billion combined with taxpayers' $16.1 billion expense for cellulosic ethanol subsidies, resulting in a negative net economic surplus for society of $7.9 billion. More substantial losses in total economic surplus impact are evident for the other three scenarios.

The U.S. trade balance, a measure of net exports, decreased compared to the baseline conditions due to reduced supplies of major crops and increased domestic demand from the biofuel sector (Table 3). The results from the current analysis add to conclusions of Taylor and Lacewell (2009), who reported that crop prices increased, and total economic surplus decreased, because of production of first-generation biofuels. The current analysis of a combination of first and second-generation biofuels identified a similar effect.

Table 3. Change in aggregate economic measures of well-being compared to the economic measures of zero biofuel production

	Net Farm Income	**Food Consumer Well-Being (consumer surplus)**	**Federal Taxpayer Expense for Cellulosic Ethanol Subsidy**	**Total Economic Surplus Impact (not considering energy)**	**Trade Balance**
Scenario	Billion dollars annually				
0+16	$15.7	-$7.5	$16.1	**-$7.9**	-$2.3
16+16	$43.1	-$42.8	$16.1	**-$15.8**	-$5.5
0+20	$19.9	-$17.5	$20.2	**-$17.8**	-$2.7
16+20	$49.7	-$55.9	$20.2	**-$26.4**	-$5.9

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All of the above results suggest that the present biofuel policies are associated with large costs to consumers in terms of increased food prices accompanied by a substantial burden on taxpayers to support the biofuel incentive. Alternatively, agricultural producers benefit substantially as evidenced by the increases in net farm income. It is crucial to note, however, that the economic surplus impacts identified above do not include possibly positive effects to consumers via expanded fuel production. Moreover, the net income effects associated with SG production are not accounted for in the estimation of the welfare impacts. Availability of data on SG yields and associated prices would improve the current version of the AGSIM model and the associated resulting impact estimates.

Sensitivity analyses assuming CRP grassland acres returning to crop production identify interesting insights on aggregate economic implications. Table 4 includes the results of the sensitivity analysis for alternative levels of CRP land assumed returning to production, that are compared against the economic effects of 16+16 with no CRP biofuel scenario. The results from these sensitivity analyses indicate that the net economic surplus increased by $6.6 billion as a result of addition of 28 million acres of CRP land to crop production. However, the economic surplus still represents a loss by $9.2 billion annually (-$15.8 + $6.6 = -$9.2; the -$15.8 is the economic surplus of 16+16 scenario presented in Table 3), when compared to the no biofuels scenario. The decrease is a result of higher crop prices that result from shifting land away from traditional crops to biofuel crops. These results are contrary to Tonya Vinas' (of Lean and Green News) claim, *"Cellulosic ethanol is more economically and environmentally sustainable because it is not tied to price-sensitive food crops such as corn and soybeans."* Although return of CRP land to production would soften the effects of biofuel mandates on food consumers, the potential erosion and sedimentation effects of crop production on marginal lands can exacerbate the impact of biofuels production.

Table 4. Economic effects of CRP land returning to crop production compared to no change in current CRP Acreage with the 16+16 Scenario

CRP Land Assumed to Return to Production (million acres)	Net Farm Income	Consumer Surplus	Biofuel Subsidies	Total Economic Surplus	Trade Balance
	Change from 16+16, no CRP Scenario (Billion Dollars annually)				
7	-$2.9	$4.8	-	**$2.0**	$0.2
14	-5.7	$10.9	-	**$5.2**	$0.4
28	-11.2	$17.8	-	**$6.6**	$1.0

Higher biomass yields result in fewer biomass acres required to meet the cellulosic mandate (Table 5). As a consequence, there is less pressure on acreage for traditional crops, a similar intuition of having additional land by allowing CRP grassland to return to crop production. The evaluation of aggregate economic impacts using higher biomass yields produced decreases in expected crop prices, increases in fertilizer prices, a decrease in net farm income, an increase in consumer surplus, an increase in total surplus, and an increase in trade balance. The results support claims of Taylor and Lacewell (2009) that dedicated bioenergy crops compete with food crops for land and other production inputs, thereby impacting food and input prices. In addition, there are potential environmental impacts of production of dedicated biomass crops on marginal lands (Adusumilli 2012), which are not incorporated into the total surplus estimation.

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Table 5. Change in crop acreage and prices with higher biomass yields (relative to scenario 16+16, no change in CRP)

SG Yield (T/ac)	Crop Acreage					Crop Prices				
	Corn	Soybean	Wheat	Cotton	Hay	Corn $/bu	Soybean $/bu	Wheat $/bu	Cotton $/lb	Hay $/ton
	Percent Change from 16+16, no CRP Scenario									
5.0	10.4%	11.4%	10.4%	6.9%	4.4%	-10.6%	-6.9%	-12.1%	-8.6%	-6.8%
7.0	12.6%	12.3%	14.0%	8.9%	5.9%	-14.7%	-8.9%	-15.6%	-11.1%	-9.1%

Limitations

The results of this study are obviously influenced by a number of factors and assumptions, but they also provide significant insights into the likely impacts of cellulosic biofuels on the agricultural and food economy. Some of the limitations of this study are important to consider for further improving the analysis. Limitations include:

- It is assumed that the biomass is a dedicated cellulosic crop and that it competes directly with existing cropland, while there are other sources of cellulosic feedstocks such as timber and hay that could be considered.
- Fertilizer requirements for the biomass crop considered in the analysis are not expressed on a regional yield basis, but instead are modeled on a national basis. Moreover, fertilizer use is relative to the biomass crop yields. Higher yield levels require higher applications that can affect both fertilizer prices and overall welfare.
- The data on biomass crops relative to conversion to fuel are premature. A consistent, science-based estimate on specific biomass-type conversion coefficients would be useful in providing better estimates of the aggregate welfare impacts.
- The model does not capture the effect of future developments or technology changes in both the U.S and the rest of the world that could affect the U.S food sector.
- The current analysis does not explicitly model livestock supply and demand, primarily due to lack of livestock inventory data at the regional level. Although the demand and supply equations of livestock are implicit in the feed demand equations, it is a challenge to appropriately separate consumer surplus effects.
- Net farm income associated with the biomass production is not accounted for in the economic impacts estimation, mainly due to unavailability of data on national SG yields, prices, and costs. Availability of such data would help to identify a better estimate of the total economic surplus implications.
- Externalities related to impacts on natural resources such as irrigation use, water quality, and soil erosion because of production on marginal lands are not included.
- Net energy balances associated with the different scenarios are not calculated, but it is important to have insight on energy in versus energy out. Such a physical measure is frequently reported in literature. Although such a standard is lacking in providing a comprehensive overall net value of alternative scenarios compared to economic assessments, inclusion of energy balance statistics would provide for identifying a relatively comprehensive conclusion.
- Extending the prior limitation, the value of having mobile fuels may override many of the impacts described in this study. The issues of form and place are not considered. However, it is important to

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consider the potential of an alternative fuel not only from an energy perspective, but also from an economic perspective. Often times, however, economic approaches are distorted by government intervention through subsidies, and tariffs. Potential benefits of an increase in mobile fuels with a lower per gallon price were not included in the analysis, but are deemed worthy of being included in future research.

Summary

While the production of biomass for ethanol is touted as a future energy solution, there are unexpected consequences of bioenergy policy that are often apparently ignored in the policy process. Results presented in this paper represent a robust set of expected shifts and economic impacts, suggesting a need for policy makers to be deliberate before acting. Considerations of multiple alternative energy sources to achieve a sustainable energy goal and identification of environmental tradeoffs are warranted. Reductions in food consumer surplus emerge because of price increases for commodities. Higher food prices resulting from biofuel mandates impact lower income society more severely than others. Thus, there is a need to identify and consider those sectors most impacted by energy and other policy decisions, and to carefully weigh economic and environmental tradeoffs.

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