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The Effect of Changing Ethanol Production on the Harvested Area and CO_2 Emissions

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Abstract

In the last decade biofuel production has been increasing dramatically. Recently several countries have introduced mandates and targets for biofuel expansion. This paper revisits the recent developments in biofuel production and its impact on the harvested area and CO_2 emissions for producers and rest of the world. Three defined scenarios suggested in this paper. Scenario I, scenario II and scenario III show 50%, 100% and 150% increasing ethanol production respectively in the world. Our results show that the impact of increasing production of ethanol has different impact for producers and rest of the world. Our different scenarios indicate that the increasing 50% ethanol production wouldn't result the same portion increasing in the amount of harvested area. Moreover, Increasing of ethanol production have significant impact on the CO2 emissions for producers countries and whole world. We have experienced decreasing CO_2 emissions in the producers' countries and

increasing CO_2 emission in the rest of the world.

Keywords : Ethanol production, Global trade analysis project, Harvested area, CO_2 emissions

1. Introduction

The main part of all energy consumed in the world explore from fossil sources such as petroleum, coal and natural gas but these kinds of energy sources are limited and would be finished in future[1–3]. Generally, four main sectors in each country consume energy: industrial, transportation, residential, and commercial sectors. Reducing energy consumption and emissions in all four main sectors are the primary goal of policymakers, particularly in transportation [4–8] and residential [3,9–13] sectors. The burning of fossil fuel is the main contributor of growing the level of CO_2 in the atmosphere[14]. Finding alternative renewable energy sources gained lots of advantages in the social and environmental issues. The biofuels production can help to minimize the fossil fuel burning and CO_2 emission. "First generation" biofuels can offer some CO_2 advantages and resulted improving domestic energy security, while the main concern exist about the obtaining of feedstocks. It can result to increase completion among land use and it changes the land coverage changes[14].

Biofuel production has been attracted issue that follow by the policy makers due to the potential impacts on net greenhouse gas emissions (GHG) benefits and food production[15]. There is large intend given to use of biofuel replace of gasoline among countries. Some countries including United States, Brazil, Europe and China are willing to expand their biofuel markets[16].

Increased production of biomass for energy has the potential to offset substantial use of fossil fuels, while it would be threaten conservation area and decrease food security. The final impact of biomass energy agriculture on climate could be either negative or positive depends on the crop, the technology and difference between the biomass crop and the pre existing vegetation[17].

A main constraint on the capacity to extend biofuel production to reduce the dependence on fossil fuels is likely the limited amount of land that are available for producing energy crops and limitation of instruments for technical supports. Increasing biofuel production raises immediate concerns for countries. These concerns include the threat to nature conservation, the possible increase of carbon emissions, land use changes and lack of water for people[18].

Crops use as feedstocks for biofuel production has created two kind of reactions. Biofuel supporters believe that biofuels can help to mitigate global climate change due to decreasing petroleum-based fuels. On the other hand, some people believe that biofuels has negative effect on the global warming and in fact increasing indirect land use change (iLUC) conclude that this policy is not effective while we consider to the effect of land changing[19].

This paper presents a discussion of current ethanol production and defines three scenarios. In the Scenario I. we assume that if ethanol production was 50% of actual growth from 2001 to 2010 for largest ethanol production regions such as United States, Brazil, EU and china, what was our CO_2 emission and land coverage changes outcome. In scenario II we used the actual growth which was happen in ethanol production in the 2001 to 2010 for these regions and finally in scenario III considered the situation that the growth rate in the chosen years were 150% of actual growth in this regions. These scenarios help us to show that these growths how can affect on the harvested area and CO_2 emissions for producers of ethanol and the rest of the world. This study uses the Global Trade Analysis Project (GTAP) database to analyze the results. Biofuel industry is developing in the production of biofuel in the near future. This increase is driven by internal and external ethanol market demand[20].

The aim of this paper is to compare different scenarios for ethanol production for producer countries and the rest of the world. so that some generalized information can be developed that could help policymakers and other stakeholders in designing a policy framework to producing ethanol. In Section 2 we present production of ethanol in the world and then in section 3 we introduce the model and in section 4 show our findings for harvested area and CO_2 emissions and finally in Section 5 we present the conclusion.

2. Ethanol Production

The worldwide growth in the production of biofuels is recently one of the new topics on the agricultural and food research area[21]. Biofuels production has increased surprisingly since 2001. Fuel ethanol output experienced an increase from 16.9 to 72.0 billion liters from 2001 to 2009. This growing in production has been motivated by governmental interventions. There are strong financial supports are guaranteed for biofuel manufactures in the United States[22].

Table 1. provides detail information about the largest area of fuel ethanol production and rest of the world.

Table 1. 2013 World Fuel Ethanol Production

Continent	Millions of Gallons
United States	13,300
Brazil	6,267
Europe	1,371
China	696
Rest of the world	727

Source: USDA-FAS, World Ethanol and Biofuels Report,

The largest fuel ethanol producers were the United States, Brazil, and the European Union (EU) and China in 2013. In this paper, we use the four largest regions for producing ethanol in the world. We assume that all these regions have potential to increase their ethanol production. So, we define three scenarios for our paper. In the Scenario I. we assume that the ethanol production in these regions increased 50% of actual increase in ethanol production from 2001 to 2010. It shows us if the increasing in ethanol production was less than the actual what was our outcomes for harvested area changes and CO_2 emissions. In scenario II we use the real scenario, which was happen in 2001 to 2010 in the world. This paper use Scenario II As a baseline scenario to compare with two other scenarios. Scenario II demonstrates real situation for increasing the ethanol production for these regions from 2001 to 2010. Scenario III Indicates that if increasing in the ethanol production was higher than that was happen, what was our outcomes for harvested area and CO_2 emissions. For running these scenarios we ignore the effect of increasing in the other regions that was to low.

3. Model

In this paper we employed Global Trade and Analysis Project (GTAP) model and database. The standard GTAP model is a multi-region, multi-sector, computable general equilibrium (CGE) model, with perfect competition and constant returns to scale. This model gives users a wide range of features, including unemployment, tax revenue replacement and fixed trade balance closures [23]. GTAP-E model is a modified version of the standard GTAP model that incorporates energy substitution into the standard database [24].

Most recent GTAP model extension would handle biofuel by products and accurately represent global land use. This modified version, called GTAP-BIO [25]. So, we use the GATP-BIO model to develop our analysis.

4. Findings

The main outcomes that consider in this paper are contained harvested area and CO_2 emissions.

4.1. Harvested Area

Several factors restrict the potential biofuel production in the world. The main factor is a potential reduction of recoverability in harvest areas due to environmental consideration[26]. Increasing of the ethanol production need land to developed. So, in this section we measure the effect of the increasing the ethanol production on the changing harvested area in defined scenarios. Table 2. shows changing in harvested area for three different scenarios.

Table 2. Change in harvested area by different scenarios

Scenario I		**Scenario II**		**Scenario III**	
Products	**Ethanol Producers**	**Products**	**Ethanol Producers**	**Products**	**Ethanol Producers**
1 CrGrains	8.425	1 CrGrains	17.271	1 CrGrains	26.496
2 Oilseeds	-0.678	2 Oilseeds	-1.341	2 Oilseeds	-2.02
3 Sugarcane	-1.609	3 Sugarcane	-3.16	3 Sugarcane	-4.717
4 OthGrains	-4.039	4 OthGrains	-8.17	4 OthGrains	-12.393
5 OthAgri	-0.367	5 OthAgri	-0.714	5 OthAgri	-1.088
Total	1.738	Total	3.896	Total	6.224
Products	**Rest of the world**	**Products**	**Rest of the world**	**Products**	**Rest of the world**
1 CrGrains	8.052	1 CrGrains	17.547	1 CrGrains	28.426
2 Oilseeds	7.007	2 Oilseeds	14.527	2 Oilseeds	22.496
3 Sugarcane	-6.67	3 Sugarcane	-13.7	3 Sugarcane	-20.746
4 OthGrains	1.423	4 OthGrains	2.987	4 OthGrains	4.55
5 OthAgri	-0.982	5 OthAgri	-1.963	5 OthAgri	-2.927
Total	8.836	Total	19.42	Total	31.799

In all defined scenarios, the greatest change would be happen in the cereal grains. Ethanol is currently mainly produced from corn, wheat and sugar cane [27]. In scenario I cereal grains sectors in the harvested area has the main impact on the producing of the ethanol producers. Cereal grains would be increase 8.42% for all producer countries in this area. The main parts of increasing in the cereal grains (85%) resulted from increasing in market price of sluggish endowment. In the case of the sluggish endowment commodities (e.g., land), shocks to the model will introduce differential price changes across sectors. Another parts that caused increasing in cereal grains resulted from supply of sluggish endowment. For other parts also the main factor affect the fluctuation harvested area in the sectors is cereal grains.

After increasing in this sector we observed reduction on the other sectors such as other grains 4.04%, sugarcane 1.61%, oilseeds 0.68% and finally other agriculture 0.37% for ethanol producers.

The rest of the world also experienced changing in their harvested area. Increasing the ethanol production resulted to increase cereal grains 8.05%, oil seeds 7.01% and other grains 1.42% and reduction on the sugarcane 6.67% and other agricultural products 0.98%. The big share of this effect explores from the changing the market price of sluggish endowment and also the rest amount covered by the supply of sluggish endowment.

In all situations, the main part that cause increasing the ethanol production explored from the cereal grains and other grain products for producer countries. The most change in the harvested area for rest of the world resulted to increasing the two parts cereal grains and oil seeds. Our different scenarios show that the increasing 50% ethanol production from scenario I to scenario II wouldn't result the same portion increasing in the amount of harvested area. So, it seems that for increasing 50% in ethanol production we need more than 50% increasing in the harvested area. When we compare scenario II to scenario III we have observed the same result. Table 2. provides more details information about our different scenarios.

4.2. CO_2 Emissions

A main goal to increase production of biofuels is that they can reduce GHG due to their use may result in fewer emissions than fossil fuels would be produces in the same situation[28]. In this section we compare CO_2 emission reduction in the different scenarios.

The CO_2 emission reduction in Scenario I is only happen for the United States and other countries have experienced increasing CO_2 emissions. Contributors of CO_2 emissions contain as carbon dioxide emissions from firms' usage of imports, government consumption of domestic product, government consumption of imports, private consumption of domestic product and private consumption of imports. Table 3 demonstrates the total emission information for different scenarios. (see Figure 1a in the appendix)

Table 3. Percent changes in the total CO_2 emissions

Scenario	Scenario I	Scenario II	Scenario III
CO_2 emission from Ethanol producers	-1.029	-1.887	-2.701
CO_2 emission from rest of the world	0.736	1.313	1.83
Total CO_2 emission	-0.293	-0.574	-0.871

The effect of ethanol production on the CO_2 emissions resulted reduction 1.19% in the United States and increasing in other regions. The most share of CO_2 emission reduction happens to the United States. In scenario I 83% of CO_2 emission reduction resulted from decreasing oil products. For other ethanol producers the main effect on increasing CO_2 emissions resulted from oil sector. For the rest of the world we observed increasing in CO_2 emissions those results depends on the increasing gas sector. In Scenario II results show that the whole portion of the CO_2 emission reduction happens in the United States 2.19%. This amount is about 84% more than scenario I. The main source of this reduction is the same as scenario I and derived from carbon dioxide emissions from private consumption of domestic product.

The main reason for reducing CO_2 emissions explained with the reduction on the fuel products. About 75% percent reduction in the oil products and nearly 16% decrease in the gas products resulted this reduction on the CO_2 emissions.

In the scenario III Increasing 50% production of ethanol compared to scenario I concluded 3.14% CO_2 emission reduction in the United States. The main parts of reduction for this scenario are oil product sector that showed 70% of this reduction.

For all other countries in all scenarios we observed increasing CO_2 emissions that is not significant compare to the United States. In this scenario rest of the world experienced CO_2 emission reduction in the oil part but overall this reduction cannot cover increasing in other parts. (see Figure 2a in the appendix)

5. Conclusion

In the last decade biofuels production has been boosted in the world. The main producers of ethanol limited to the four countries that contains United States, Brazil, EU and china. So, in this paper we made three scenarios and showed that the effect of increasing ethanol production have different effects on the producer countries and rest of the world. Harvested area and CO2 emissions are the main factors that would be changed during these different scenarios. The main result showed that the needed harvested area for increasing 50% on the ethanol production is more than this amount in all scenarios. So, for increasing certain amount of ethanol production we need more harvested area as expected. CO_2 emissions are totally different for producers countries compared to the rest of the world. We showed that increasing ethanol production resulted mainly CO2 emissions for the United States and increasing CO2 emissions for rest of the world. Finally, we observed reduction in the CO_2 emissions for whole economy.

Appendix

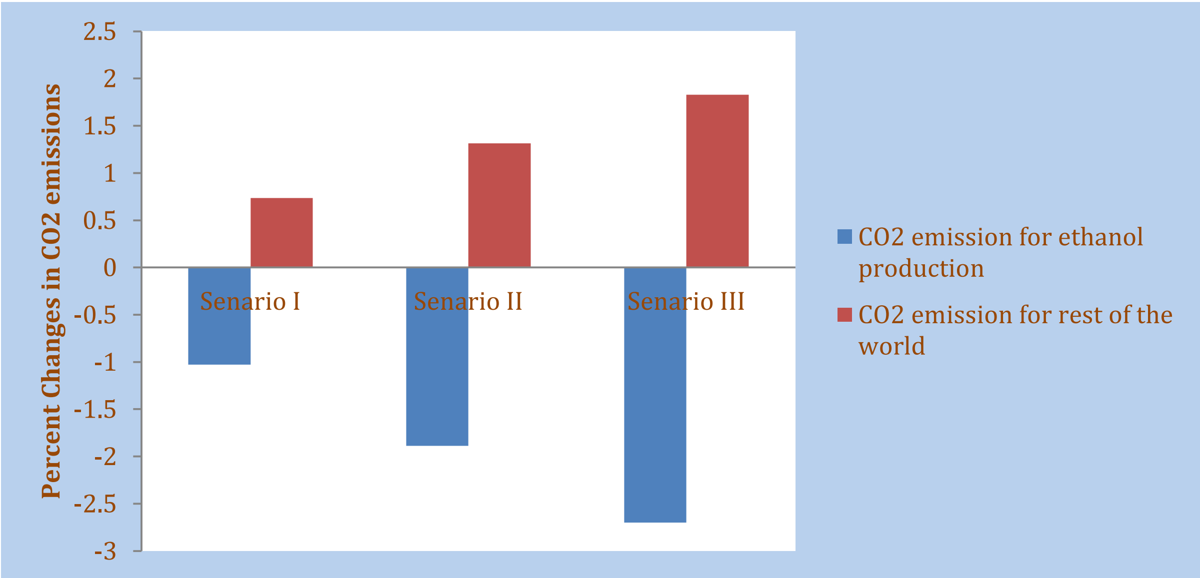

Figure 1a. Percent changes in CO2 emissions by different scenarios

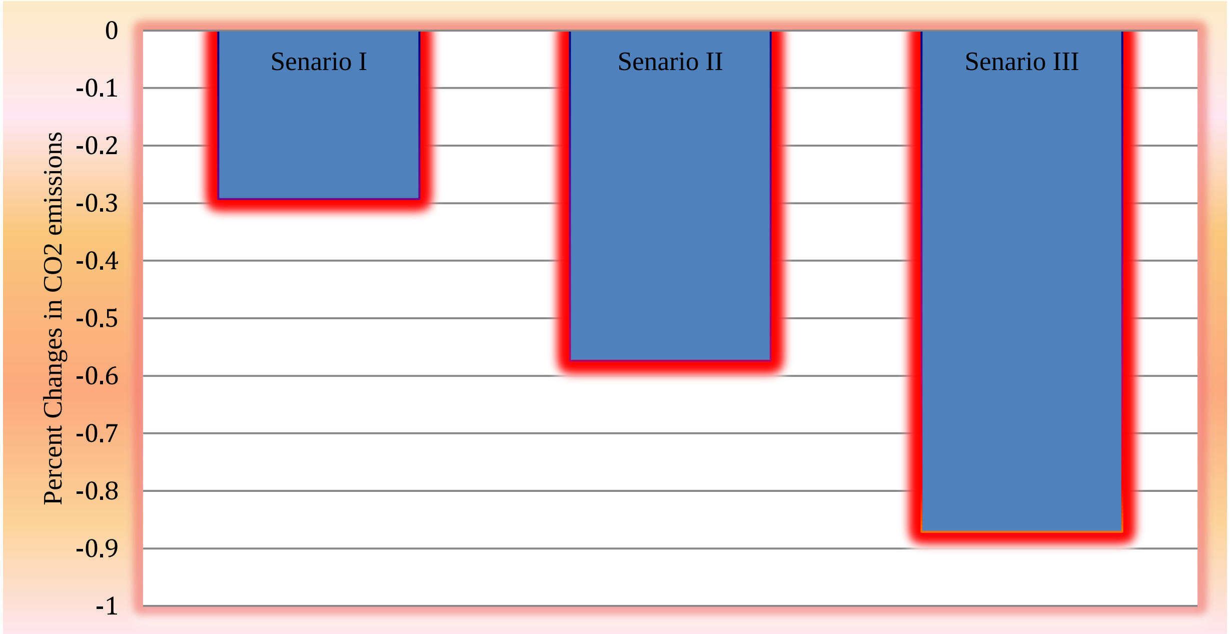

Figure 2a. Percent changes in CO2 emissions for the whole economy

References

[1] Koh MY, Mohd. Ghazi TI. A review of biodiesel production from Jatropha curcas L. oil. Renewable and Sustainable Energy Reviews 2011;15:2240–51.

[2] Javid RJ, Nejat A, Hayhoe K. Selection of CO2 mitigation strategies for road transportation in the United States using a multi-criteria approach. Renewable and Sustainable Energy Reviews 2014;38:960–72.

[3] Salari M, Javid RJ. Residential energy demand in the United States : Analysis using static and dynamic approaches. Energy Policy 2016;98:637–49.

[4] Javid RJ. P16-Greenhouse gas and air pollution emission reduction from incentivized carpooling. Journal of Transport & Health 2016;3:S71.

[5] Javid RJ, Nejat A. A comprehensive model of regional electric vehicle adoption and penetration. Transport Policy 2017:(forthcoming).

[6] Javid RJ, Nejat A, Hayhoe K. Quantifying the environmental impacts of carpooling on HOV lanes in the United States. Transportation Research Part D: Transport and Environment 2017:(forthcoming).

[7] Javid RJ. Online estimation of travel time variability using the integrated traffic incident and weather data. Transportation Research Board 96th Annual Meeting, Washington, DC 2017:(forthcoming).

[8] Javid RJ, Nejat A, Salari M. The environmental impacts of carpooling in the United

States 2016.
[9] Hamilton IG, Steadman PJ, Bruhns H, Summerfield AJ, Lowe R. Energy efficiency in the British housing stock: Energy demand and the homes energy efficiency database. Energy Policy 2013;60:462–80.
[10] Alberini A, Gans W, Velez-Lopez D. Residential consumption of gas and electricity in the U.S. : The role of prices and income. Energy Economics 2011;33:870–81.
[11] López-rodríguez MA, Santiago I, Trillo-montero D, Torriti J, Moreno-munoz A. Analysis and modeling of active occupancy of the residential sector in Spain : An indicator of residential electricity consumption. Energy Policy 2013;62:742–51.
[12] Ueno T, Sano F, Saeki O, Tsuji K. Effectiveness of an energy-consumption information system on energy savings in residential houses based on monitored data. Applied Energy 2006;83:166–83.
[13] Salari M, Javid RJ. Modeling household energy expenditure in the United States. Renewable and Sustainable Energy Reviews 2017:(forthcoming).
[14] Naik SN, Goud V V., Rout PK, Dalai AK. Production of first and second generation biofuels: A comprehensive review. Renewable and Sustainable Energy Reviews 2010;14:578–97.
[15] Ravindranath NH, Sita Lakshmi C, Manuvie R, Balachandra P. Biofuel production and implications for land use, food production and environment in India. Energy Policy 2011;39:5737–45.
[16] Mussatto SI, Dragone G, Guimarães PMR, Silva JP a, Carneiro LM, Roberto IC, et al. Technological trends, global market, and challenges of bio-ethanol production. Biotechnology Advances 2010;28:817–30.
[17] Field CB, Campbell JE, Lobell DB. Biomass energy : the scale of the potential resource. Trends in Ecology & Evolution 2008;23:65–72.
[18] Cai X, Zhang X, Wang D. Land availability for biofuel production. Environmental Science & Technology 2011;45:334–9.
[19] Kim S, Dale BE, Ong RG. An alternative approach to indirect land use change: Allocating greenhouse gas effects among different uses of land. Biomass and Bioenergy 2012;46:447–52.
[20] Lapola DM, Schaldach R, Alcamo J, Bondeau A, Koch J, Koelking C, et al. Indirect land-use changes can overcome carbon savings from biofuels in Brazil. Proceedings of the National Academy of Sciences of the United States of America 2010;107:3388–93.
[21] Banse M, van Meijl H, Tabeau A, Woltjer G, Hellmann F, Verburg PH. Impact of EU

biofuel policies on world agricultural production and land use. Biomass and Bioenergy 2011;35:2385–90.

[22] Sorda G, Banse M, Kemfert C. An overview of biofuel policies across the world. Energy Policy 2010;38:6977–88.

[23] Truong TP. Model with Emission Trading USER ’ S GUIDE The GTAP-E Modules 2007.

[24] Burniaux J-M, Truong T. GTAP-E : An Energy-Environmental Version of the GTAP Model. GTAP Technical Paper No 16 2002.

[25] Birur D, T. H, W. T. Impact of biofuel production on world agriculture markets : A computable general equilibrium analysis. GTAP Working Paper 53 Center for Global Trade Analysis, Prdue University 2008.

[26] Carriquiry M a., Du X, Timilsina GR. Second generation biofuels : Economics and policies. Energy Policy 2011;39:4222–34.

[27] Bondesson P-M, Galbe M, Zacchi G. Ethanol and biogas production after steam pretreatment of corn stover with or without the addition of sulphuric acid. Biotechnology for Biofuels 2013;6:11.

[28] Grafton RQ, Kompas T, Long N Van, To H. US biofuels subsidies and CO2 emissions: An empirical test for a weak and a strong green paradox. Energy Policy 2014;68:550–5.