Assessing Sustainability of Biofuels Production in China

Global production of different types of biofuels for transportation has crossed 35 billion gallons in 2015, and it is expected to reach 62 bg by 2023. International Energy Agency (IEA) estimates that biofuels have the potential to contribute sustainably from their current global share of 3% to about 27% of total transportation liquids by 2050. China being one of the fastest growing economies, is expected be the source of nearly half of the world oil demand growth till 2035 (IEA, 2014). With its policy initiatives on renewable energy for transportation, China is currently the third largest producer of biofuels in the world next only to Brazil and the United States. China produced 340 million gallons of ethanol in 2012. Nearly 20% of gasoline consumed in China is blended with 10% ethanol that utilizes 0.71% of country's total grain production. China has plans to use 1.67 billion gallons of ethanol fuel over the 12th national planning period spanning from 2011 to 2015. China focused on producing ethanol from corn because of surplus production until 2006, and the country felt the need to be energy independent. However food-fuel debate has forced China to seek alternative feedstock to meet its ethanol production goal. The recent focus has been to produce ethanol from nonfood crops such as cassava, sweet sorghum, sweet potato, and 2nd generation feedstocks such as crop residues. The dependency on crop production irrespective of any generations of crops will have significant impact on land and other resources use and greenhouse gas emissions.

The objectives of this study are to assess the impact of China's biofuel goal on (i) food supply and food prices, (ii) land use change and water needs, and (iii) greenhouse gas emissions. To accomplish these objectives, we use a dynamic computable general equilibrium (CGE) model called GDyn-E-BIO model (Birur et al. 2014) developed based on the Global Trade Analysis Project (GTAP) data base which includes explicit agriculture related sectors, first and second generation biofuels. The model includes an aggregated data base that comprise 25 global regions and 45 sectors, focusing on food and fuel sectors most likely to be directly impacted by China's expanded biofuels production.

The GDyn-E-BIO model is a multi-region, multi-sector, recursive dynamic CGE model developed by adapting the GDyn-E-AEZ model (Golub et al., 2012) which comprised comparative static models versions of the GTAP-E (Burniaux and Truong, 2002) and GTAP-BIO (Birur et al. 2008; Taheripour et al. 2010) models and the recursive dynamic GDyn (Ianchovichina and McDougall, 2001). The GDyn (dynamic GTAP) model is a recursive dynamic CGE model where the agents base their decisions on adaptive expectations, with international capital mobility and endogenous capital accumulation. The dynamics in the GDyn model comes from capital accumulation, labor productivity, and other exogenous macro variables such as GDP and population growth. In addition, our baseline (2004 through 2050) includes projections on technological change in agricultural production based on Total Factor Productivity (TFP) growth rates as offered by Ludena et al. (2007) for the crops and livestock sectors.

The land supply structure in the GDyn-E-BIO model follows a 18 Agro-Ecological Zone (AEZ) level nested constant elasticity of transformation (CET) function where the land is first allocated across three cover types (cropland, pastureland, forestland) and in the second tier cropland is allocated across alternate 13 different crops including first and second generation biofuel feedstocks. The detailed incorporation of explicit crops in this CGE model helps in precisely identifying the change in cropping pattern and distribution. Using these results on change in AEZ level change in cropping pattern from the CGE model, we follow Chapagain and Hoekstra (2011) approach to estimate the water footprint (WF) of biofuels production. The water footprint is defined as the total volume of freshwater used to produce the product over the course of its production chain. We further distinguish the sources of water footprint as the green (rainwater), blue (surface and groundwater), and grey (freshwater pollution) water footprints. The WFs for water intensive crops such as sugarcane and rice are significant particularly in China given the recent drought conditions.

Our prospective analyses indicate that it is possible to sustainably meet the stated mandate without substantial impact on food supply or water needs. There will be minimum impact on the gasoline price and world ethanol market from these changes. We assume historical increase in crop productivity and availability of surface and ground water. Our biofuels policy scenarios include ethanol production targets of 1.67 and 3.35 billion gallons in China by 2015 and 2020, respectively. Similarly the biodiesel targets include 0.30 and 0.60 billion gallons in 2015 and 2020, respectively. We conduct sensitivity analysis by changing the biofuel requirements and the resulting effects on the economy. The CGE model allows for import to meet the biofuel needs and also meeting the goal by increased domestic supply. Results obtained are consistent with previous studies which have examined these multiple issues using a piecemeal approach (Cao et al. 2014; Ge et al. 2014; and Koizumi, 2014; Yang et al. 2009).

References

Birur D.K. et al. (July 2014) “Achieving Food vs. Fuel Security – Economywide Implications of India’s “Right to Food Act 2013.” Paper presented at the Agricultural & Applied Economics Association annual meeting, Minneapolis, MN.

Birur, D.K., T.W. Hertel and W.E. Tyner (2008) “Impact of Biofuel Production on World Agricultural Markets: A Computable General Equilibrium Analysis”. GTAP Working Paper No. 53, Center for Global Trade Analysis. Purdue University, West Lafayette, IN.

Chapagain, A.K. and A.Y. Hoekstra (2011) “The Blue, Green and Grey Water Footprint of Rice from Production and Consumption Perspectives.” *Ecological Economics*, (70):749-758.

Golub, A., T.W. Hertel, and S. Rose (2012). “Effects of Environmental and Energy Policies on Long Run Patterns of Land Use.” Presented at the 15th Annual Conference on Global Economic Analysis, Geneva, Switzerland, held during June 27-29, 2012.

Cao, X., Wu, P., Wang, Y., & Zhao, X. (2014). Water Footprint of Grain Product in Irrigated Farmland of China. *Water Resources Management*, *28*(8), 2213-2227.

Ge, Jianping, Yalin Lei, and Suminori Tokunaga. "Non-grain fuel ethanol expansion and its effects on food security: A computable general equilibrium analysis for China." *Energy* 65 (2014): 346-356.

Liu, H., Ren, L., Spiertz, H., Zhu, Y., & Xie, G. H. (2014). An economic analysis of sweet sorghum cultivation for ethanol production in North China. *GCB Bioenergy*.

Koizumi, T. (2014). Biofuels and Food Security in China. In *Biofuels and Food Security* (pp. 31-41). Springer International Publishing.

Yang, H., Zhou, Y., & Liu, J. (2009). Land and water requirements of biofuel and implications for food supply and the environment in China. *Energy Policy*, *37*(5), 1876-1885.

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