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Research paper

Market impacts of China and India meeting biofuel targets using traditional feedstocks☆

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ABSTRACT

Biofuel production has largely occurred in Brazil, the European Union (EU), and the United States (U.S.), but several other countries have articulated large biofuel targets. Among them, China and India stand out with large populations, with a prominent food versus fuel debate. Recent research has recognized the importance of biofuels in replacing traditional transportation fuels in these two countries; but such work has largely considered unconventional pathways such as lignocellulosic feedstocks. This work takes a more straight-forward approach, using a computable general equilibrium (CGE) model to estimate the market impacts of achieving biofuel targets in 2020. Along with projections in food and fuel demand to 2020, we also consider several options in meeting biofuel targets. China's biofuel policy focuses on ethanol, and the result of meeting a 10 percent ethanol blend target, along with food and feed demand, is an increase in coarse grain production of 19 percent. India's largest potential biofuel component is biodiesel, where reaching a 20 percent target would entail a triple-digit increase in vegetable oil production. Results indicate that these impacts could be somewhat mediated if biofuel trade access is increased; in addition, utilizing stockpiled grain in China, or implementation of an effective waste cooking oil collection-to-biodiesel program in either country could substantially reduce agricultural feedstock requirements.

1. Introduction

Biofuels produced from lignocellulosic feedstocks, i.e., non-food/feed sources, remains the ultimate goal of providing green energy; however, the economic feasibility of large-scale production of such feedstocks remains a significant challenge. In the near future, biofuels produced from feedstocks that compete with other food and feed uses remains the only viable option. Countries have signaled in their intended national determined contributions (INDC) that biofuels are an option to reduce greenhouse gas (GHG) emissions from transportation. However, a collision between the fuel and food/feed demand satisfaction is highly likely for some of the countries of the Paris Agreement.

China and India are two key 'food versus fuel' examples, where ambitious biofuel targets collide with the need to feed over a billion people each. In addition, both countries have rapidly expanding fuel fleets, with projections for transport fuels doubling for India by 2026 [1]. However, biofuel production growth has been slow, both countries have actual biofuel blend rates of less than 2 percent. One reason for the slow growth in biofuel production is that they both have rules to limit competition with food uses. For example, China has removed policy support for grain-based ethanol, mandating that biofuel feedstocks not compete with feedstocks intended for human or animal consumption [2]. India restricts feedstock use for biofuels, such as prohibiting the use of sugar-cane juice for ethanol production. The pledges made by China and India in the Paris Agreement could, however, push them to focus more on biofuel strategies. China [3] notes that they will proactively develop bioenergy. India's INDC [4] notes the national policy on biofuels is a 20 percent blending rate for both biodiesel and ethanol.

Some studies have explored unconventional ways (i.e., lignocellulosic ethanol or feedstocks grown on marginal land) for these countries to meet their targets. Wang and Shi [5] investigate the optimal utilization of marginal land for biofuels in a province in China; Qui et al. [6] provides information on the feasibility and geographical location of lignocellulosic feedstocks in China. For India, Sasmal et al. [7] considered the potential of non-conventional biomass in North-East India; Lavanya et al. [8] conducted a study to identify high yielding castor that could be used for biodiesel. The scope of these newer opportunities to help meet biofuel target of these two countries remains limited, similar to the situation in Brazil, EU and U.S. Moreover, few studies have examined how meeting 2020 targets with unconventional

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and/or traditional feedstocks will impact domestic and global food and feed markets. In addition to the desire to lower GHG emissions, the rules limiting competition between food and fuel uses, and limited infrastructure for lignocellulosic feedstocks raise serious doubts on these countries ability to achieve targets pledged under the Paris agreement.

In this study, we use a computable general equilibrium (CGE) model to analyze each country meeting their biofuel targets, focusing on commodity price impacts for domestic and global consumers, as well as shifts in global trade patterns. An examination of each countries' biofuel production, feedstocks used, and trade provides information on additional options to meet their targets. These are grouped into four categories: reconsidering restrictions on ethanol feedstocks, an expansion of ethanol feedstocks, an expansion of biodiesel feedstocks, and a reduction in trade barriers. The market impacts of each scenario are very large and the size of the adjustments to supply, demand, and prices is well outside the range of the historical data; thus, the focus here is on changes in magnitude across scenarios to help evaluate the feasibility of the adjustments that may be needed to meet the policy targets.

2. Background

With tremendous growth in production, biofuels have become a major source of energy in several countries. Major producers include Brazil, the EU, and U.S., however, each of these regions have reduced their mandates at some point in the last five years [9]. As such, other countries might be good candidates to provide future growth. Because of the amount of transportation fuels they consume, the biofuel targets set out by China and India are two of the more interesting cases. In addition, having the largest and second-largest populations makes the food versus fuel argument a relevant theme in their energy policy.

2.1. China

China is currently the third largest producer of ethanol in the world; in addition, biofuels are a part of China's long run energy plan. However, policies encouraging or mandating the production of biofuels frequently change. In early 2000, China implemented an ethanol program in response to abundant grain supplies [2]. However, the rapid increase in commodity prices (and commodity price volatility) in 2007 and 2011 triggered several changes to the biofuel program. For example, policy now dictates that biofuel production should not use crops intended for human or animal consumption. As part of their 12th Five Year plan (FYP), which ended in 2015, China set a target of producing 4.5 hm3 of ethanol and 1.1 hm3 of biodiesel; however, only the biodiesel target was reached. China's 13th FYP (2016–2021) increases those targets. By 2020, China targets the production of 6.3 hm3 of ethanol and 2.3 hm3 of biodiesel annually. These targets imply a 100 percent expansion of its production capacity of ethanol over the five years and even larger development of biodiesel production [2].

2.1.1. Ethanol

Although China has not met its ethanol production target, production has increased from 1.7 hm3 in 2006 to 3.7 hm3 in 2015 (Fig. 1). There are three avenues through which this expansion took place: (1) more refineries, (2) of these refineries, a number of the new ones were 1.5 generation (non-grain based feedstocks) and 2nd generation (lignocellulosic) technologies which received subsidies, and (3) each refinery increased their operating capacity. The driver of this increased production was increased demand [2]. Ethanol blend targets have increased in 2016, though a national mandate has yet to be implemented. As of 2016, a total of 10 provinces and a number of municipalities use E10 blending zones which is up from 6 provinces since 2015. During late 2015 to the middle of 2016, the largest fuel consumption regions were Guangdong, Jiangsu, and Hainan provinces and Beijing and Tianjin cities [2].

Although China has tried to move away from using feedstocks that could compete for food uses, corn and wheat remain the largest input sources for ethanol (Table 1). Combined, the two feedstocks accounted for 80 percent of ethanol inputs in 2015. The supply of Chinese corn, however, is exposed to a number of regulations and current events. Corn destined for fuel production cannot be grown on arable land; therefore, the corn used in ethanol production has been limited to the harvest from marginal lands within China. In 2014, China began to import ethanol for the first time. Imports were cheaper than domestically produced ethanol in 2015 (470 \$ m^3 versus 620 \$ per m^3). Imported ethanol is primarily used for fuel and is monitored by the government. With the pending increase in domestic demand for ethanol, increased imports may become inevitable [10]. For the work here, we only consider China's use of current, 1st generation feedstocks.

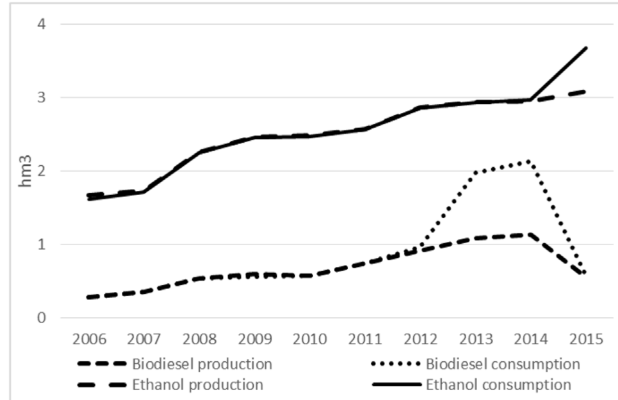

Fig. 1. China biofuel production and consumption.
Source: [2].

2.1.2. Biodiesel

Between 2010 and 2014, Chinese biodiesel production grew around 16 percent spurred by fiscal incentives and the crackdown of the illegal use of waste cooking oil for human consumption. Production reached around 1.1 hm3 in 2014 before it collapsed by more than 50 percent in 2015 (Fig. 1) due to consumer complaints over fuel quality and a decision by oil companies to curtail purchase of used cooking oil [2].

By 2015, nearly all biodiesel was made from waste cooking oil. However, in 2015, the two major Chinese oil companies, Sinopec and CNOOC, stopped buying biodiesel for two reasons: (1) the biodiesel is of poor quality and (2) it has a high cost. Because of the withdrawal of the main consumers of biodiesel, producers of biodiesel have also withdrawn from the marketplace [11]. Capacity is estimated to be at 3.8 hm3; however, the utilization rate is 27 percent due to the lack of large scale collection channels for waste cooking oil. By the end of 2015, there are only 31 biodiesel plants leftover from the peak of 84 in 2008, but more than one third of these 31 producers have either ceased production or operate well under capacity. Part of the difficulty in expanding biodiesel production in China is that state owned oil companies block biodiesel from being sold to most consumers. As a result most biodiesel is sold at private gas stations in small cities or in the country side [2]. Since 2012, China has imported biodiesel to help meet domestic consumption, almost all these imports have been from Indonesia. These imports were substantial in 2013 and 2014 (note the difference in production and consumption in Fig. 1); however, 2015 imports were small. Biodiesel is only approved for fuel use in select cities [2].

2.2. India

The Government of India (GOI) proposes to reduce its dependence on crude oil imports by ten percentage points in several ways: increasing domestic output; promoting energy efficiency and