Applied Energy 104 (2013) 466–474

Contents lists available at SciVerse ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Impact assessment of global and national biofuels developments on agriculture in Pakistan

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HIGHLIGHTS

- Three scenarios of increased biofuels use are modeled using GTAP model.
- Impact on prices, production, and trade of agricultural commodities for Pakistan are presented.
- Expansion in biofuels will increase prices of most of agricultural commodities in Pakistan.
- Production of feedstock crops (especially sugarcane) will increase considerably.
- Overall trade balance for agricultural commodities will worsen due to Pakistan's biofuels program.

ARTICLE INFO

Article history:
Received 24 April 2012
Received in revised form 17 November 2012
Accepted 20 November 2012

Keywords:
Biofuels
Impact
Agriculture
Pakistan

ABSTRACT

This research uses GTAP model to assess the expected future effects of national and global biofuels policies on agriculture markets and food prices in Pakistan. Our results show that by 2020, global mandates on biofuels will significantly affect the prices, production and trade of major feedstock crops such as sugarcane, maize, soybean and rapeseed, especially in the USA, Brazil and EU. Global biofuels developments are projected to increase the prices of maize, rapeseed, soybean, and sugarcane in Pakistan. Pakistan will benefit from improved trade balance in agriculture under the global-only scenario. Under Pakistan plus three-producer's biofuels scenario, the price and production of sugarcane in Pakistan will increase substantially. Under this scenario, the country will face considerable loss in agricultural trade. Consequently, food-security of net-buyers may be threatened. The income of feedstock farmers will increase. Higher crude oil prices will strongly influence commodity markets via increased production of biofuels and agricultural production costs.

1. Introduction

Biofuel is a type of fuel whose energy is derived from biological carbon fixation. Biofuels include fuels derived from biomass conversion, as well as solid biomass, liquid fuels and various biogases [1]. Production of liquid biofuels has increased five-fold over the last two decades due to policy interventions and changing relative energy prices [2]. The increasing production of biofuels is triggered mainly to gain energy security by decreasing dependence on import of fast-depleting fossil fuels and saving considerable amounts of foreign exchange; to mitigate the global warming emissions by reducing the use of fossil fuels; and to improve the agricultural development by offering better prices and new jobs [3].

While many developed and few developing countries are setting up ambitious targets to achieve their national biofuels mandates, the effectiveness of biofuels to produce the desired results is strongly debated in recent literature. There are studies suggesting that rather than decreasing carbon dioxide and other greenhouse gas emissions, biofuels actually increase them [4,5]. More important are the spillover negative effects on food security of millions of poor in developing countries, who depend on cereals as their major food intake. Many researchers have found a positive relationship between the increased food cost and the recent surge in demand to use crops as fuel [6–9].

Other factors have also impinged on food supplies and prices, however, most experts see the biofuels demand as a substantial contributor, and one that exacerbates any other factor on food costs. With 800 million people at risk for hunger and malnutrition, the consequences are far more severe in developing nations than they are in developed nations. [10] World Bank President Robert Zoellick has acknowledged that "biofuels is no doubt a significant contributor" to high food costs, adding that "it is clearly the case that programs in Europe and the United States that have increased

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http://dx.doi.org/10.1016/j.apenergy.2012.11.047

biofuel production have contributed to the added demand for food". Moreover, this is occurring only when a small fraction of biofuels mandates have been realised. The US is only one-quarter of the way toward the 36 billion gallon requirement by 2022 included in latest big energy bill. The European Union also has plans to increase its biodiesel use, though it is now reconsidering this policy.

On the other hand, surplus-subsidised production has been creating unbalances in global agricultural markets, depressing international prices and dislocating agricultural production in low-income countries [11]. The incomes of farm households, frequently one of the poorest groups in low-income countries, may be increased by higher commodity prices [12]. This makes the trade-off between fuel and food a complex policy issue that needs very careful research encompassing all the related factors and stakeholders. Only a comprehensive study would provide a guideline on how the world (and individual countries) should proceed with their biofuel plans.

We hypothesise that Pakistan' agriculture-based economy can also experience ripple effects of increased demand of agriculture products by biofuels from national and international markets. It should be noted that Pakistan's economy has been growing at a steady rate during last 20 years. This growth has resulted in remarkable increase in energy demand, thus putting huge pressure on country's limited energy resources [13]. To cope with increasing energy demand, Pakistan is also starting a biofuels blending program. The government has approved a policy to achieve a minimum of 5% by volume share of biodiesel in the total petroleum diesel consumption by 2015. And gradually take it to 10% by 2025 [14]. Whether Pakistan can achieve the targeted objectives of the biofuels policy, i.e. reducing dependence on imported fossil fuels and environmental improvements is open to question. There are even more crucial issues related to the expansion of biofuels like: what would be the choice of feedstock (oilseeds crops for biodiesel or sugarcane for ethanol)? How would the increased demand affect production and prices of feedstock crops and other related agricultural commodities? To answer above questions a serious economic analysis is needed.

Many studies have analysed the impacts of biofuels developments on emerging and transition economies, e.g. [15,16]. Yet no such effort has been made for Pakistan. This is the first quantitative study to understand the effects of national and global biofuels developments on agriculture and the rest of economy in Pakistan. We aim to assess the direction and magnitude of impact of expected growth in biofuels-related demand for agricultural products on agricultural production, trade and food prices. In relation to Pakistan this is carried out through quantitative assessment of different market scenarios based on the use of GTAP model. The results would help to shape future policies on choosing the best available options, which ensure economical and socially sustainable development of biofuels in the country.

The paper is divided into five sections. Following the introduction, Section 2 outlines the model, data and methods used in the study. Section 3 elaborates the scenarios used to assess the impacts of biofuels development on Pakistan. Section 4 presents the effects of these scenarios. In Section 5 the paper concludes with some brief remarks.

2. Data, model and scenarios

This study covers only first generation ethanol produced from maize (ethanol1), sugarcane, and sugar beet (ethanol2); and biodiesel produced from oilseeds crops like soybean, rapeseed, and sunflower (biodiesel). Our model is based on the data in 2004, so we would focus on the biofuels production and trade trends in that year. Here, the US is the largest producer of ethanol (in terms of value) valuing at US$ 5974.2 million (Table 1). Brazil, with US$ 3669.9 million, is the second biggest producer of ethanol in the world. Brazil is also the single largest producer of ethanol from sugarcane. Other major producers of ethanol are China, India, Russia, EU27, South Africa, and Canada. European Union (EU27) is the world's top biodiesel producer at US$ 992 million, mostly from rapeseed. In 2004, USA is the only other biodiesel producers with sizable production at US$ 46 million.

Pakistan, the focus of this study, produced about 33 million gallons of ethanol worth over US$ 55 million in 2004. Almost all of this ethanol was produced from molasses, which in turn is a by-product of sugar production from sugarcane and is synthesised in the distilleries attached with sugar mills.

In 2004, Pakistan exported US$ 37 million worth of ethanol, mostly to EU countries. Notice that in our model we assumed no international trade in biodiesel, given that there are only few countries producing biodiesel, which is assumed to be domestically consumed.

Moreover, we have used GTAP model to perform recursive-dynamic simulations. In these simulations, the total time, 2006–2020, is divided into three parts. The multi-period simulation results are computed one-period-at-a-time, using the data from the previous period as base data for the next period. This in turn is done by dividing the shocks into appropriate sub-shocks for each period. Such a method has been popularly adopted by many other studies, e.g. [17,18].

Production structure of biofuels is very important for the forecasting model. For each type of biofuel, specific plant-level cost-of-production-models were used. Our analysis for ethanol1 is based on the work by Tiffany and Eidman [19]. Information from [20–22] was used for ethanol2. For biodiesel, information from [23] was used.

We used GTAP, a multi-region, multi-sector, computable general equilibrium model, with perfect competition and constant returns to scale, to capture the implications of expected biofuels developments both on national and international levels. The GTAP model is a comparative static model providing powerful insights into the underlying data and mechanisms of economic change resulting from the development of biofuels and other trade policy changes. For this study, we extended the latest GTAP model and database (version 7) to include biofuels sector for Pakistan,

Table 1
Biofuels production by type in 2004 (US$ millions).[a]

	Countries	Ethanol1[b]	Ethanol2[c]	Biodiesel	Total
1	Australia	0	55.8	2.6	58.4
2	China	1629.2	0	2.6	1631.8
3	Japan	1.5	0	0	1.5
4	Korea	1.5	0	2.6	4.1
5	Indonesia	0	74.4	0	74.4
6	Malaysia	1.0	0	0	1.0
7	Philippines	0	37.2	0	37.2
8	India	0	780.8	0	780.8
9	Pakistan	0	55.8	0	55.8
10	Canada	103.1	0	5.2	108.3
11	USA	5974.2	0	46.6	6020.8
12	Argentina	0	71.0	5.2	76.2
13	Brazil	0	3669.9	0	6741.4
14	EU27	305.9	0	992.0	1297.9
15	South Africa	0	185.9	0	185.9
16	Russia	334.6	0	0	334.6
17	ROW	655.7	682.8	53.3	1675.7
	Total	9004.6	5613.4	1110.1	19225.8

Source: assimilated by author from various sources such as: IEA, RFA outlook reports, and GAIN reports by USDA.

[a] Using 2004 price US$ 1.69/gallon.

[b] Produced from maize as feedstock.

[c] Sugarcane feedstock.