Profitability of Bioethanol Production: The Case of Ethiopia

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Abstract

This research investigates the profitability of bioethanol production in Africa, taking Ethiopia as a case in point, and suggests an oil price threshold beyond which biofuels may be profitable. Specifically, the study analyzes the viability of producing bioethanol from molasses in the context of Ethiopia, using data from a biofuels investment survey by EEPFE/EDRI in 2010. We draw on investment theory as our underlying conceptual framework and we employ unit cost analysis for our empirical analysis. Findings reveal that bioethanol production (from molasses) in Africa/Ethiopia can be quite viable and the biofuels industry can be viewed as a way out of poverty. This is a case study involving a few observations because of the small size of the universe of producers studied, hence the need for further analysis as the sector expands.

Key words: profitability; bioethanol; oil price threshold; Ethiopia; Africa
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1. Introduction

The scarcity and rising prices of fossil fuels, together with apprehension about the environmental harm created by them, have resulted in increasing efforts to search for alternative energy sources, particularly emphasising on biofuels[5]. However, many uncertainties about the future of biofuels remain, including competition from unconventional fossil fuel alternatives and concerns about environmental tradeoffs. Moreover, the volatility of world fuel prices leads to variability of prices of both biofuel and feedstocks. Uncertainties in prices in turn influence the viability of biofuels investments. Therefore, the key questions are: Can biofuels be profitably produced in Africa/Ethiopia? What is the oil price threshold beyond which biofuels production, be it for import substitution or export promotion, becomes viable and profitable? The main objective of this study is, therefore, to investigate the profitability of bioethanol investment, taking Ethiopia as a case study. Specifically, this study attempts to:

(i) analyze the viability of bioethanol production and
(ii) suggest an oil price threshold beyond which bioethanol production may be profitable.

Findings reveal that bioethanol production (from molasses) in Ethiopia/Africa can be very viable and the biofuels industry can be viewed as a way out of poverty. Although most of the companies registered had the intention of pursuing large-scale commercial development, especially those companies registered for the cultivation of energy crops for biodiesel production, only very few of them are in operation. Moreover, at present only two of the sugar factories, Finchaa and Metehara, are producing bioethanol. This posed a data limitation to our study.

Ethiopia is viewed as one of the most suitable nations in Africa for tapping renewable sources of energy because of its location. This is the case not only

[5] 'Biofuels' are liquid fuels produced from biomass (MoME 2007). The two most important biofueles are ethanol (i.e., bioethanol) and biodiesel. 'Bioethanol' is manufactured from microbial conversion of biomass materials through fermentation and contains 35 percent oxygen while 'biodiesel' is oil extracted from oil seeds by mechanical crushing or solvent extraction.

for its own economy, but also for export to economies in the region, such as Kenya, Djibouti and Sudan. The country has also been looking at enhancing its energy capacity, especially over the past two decades (Gebreegziabher and Mekonnen 2011). The government's biofuel strategy to encourage domestic biofuels production, with an objective of reducing the dependence on high-cost fossil oil, is also a manifestation of this endeavor (MoME 2007). Ethiopia is a country with a total land mass of 1.2 million km^2 and is said to have an estimated potential area of about 25 million hectares of land suitable for production of biodiesel feedstock (Gebremeskel and Tesfaye 2008). Given rising world prices of fossil oil, the biofuels industry has developed a very significant national presence. Accordingly, there are biofuels investment activities in different regions of Ethiopia with a focus on bioethanol and biodiesel production. Besides, Ethiopia embarked on a 5% blend of bioethanol in transport fuel in 2008, which was raised to 10% a few years later. Although the Climate Resilient Green Economy (CRGE) strategy of Ethiopia envisages a 5% biodiesel blending in transport fuel by 2030 (FDRE 2011), biodiesel blending in transport fuel has not yet started in Ethiopia. As part of the planned large-scale expansion in the sugar industry that is incorporated in Ethiopia's first national Growth and Transformation Plan (GTP I), the country also aims to produce 181,604 cubic meters of bioethanol from sugar byproducts (from molasses) toward the end of the GTP I period 2010/11-2014/15 (MoFED 2010). In addition, constructing bioethanol plants in conjunction with existing and upcoming sugar factories underway was also envisaged, though, as of now, this has not materialized particularly because the planned ten new sugar plants under construction are not yet operational due to various factors.

Nevertheless, the opportunities created and challenges posed by increased production of biofuels have been a subject of considerable policy debate (Searchinger *et al.* 2008; Azar 2011) and the debate is still on-going. Though many countries engage in biofuels production to diversify energy sources, reduce GHG emissions, and/or reduce dependency on imported fossil fuels, the profitability of biofuels production has been less explored. Furthermore, review of available literature reveals the following outstanding issues. First, it is important to note that different countries pursue different feedstock-biofuels (bioenergy) pathways and the viability of biofuels is heavily determined by the type of pathway pursued to produce bioethanol and biodiesel. Institutional arrangements make a difference for viability; a biofuels business or venture can be plantation-based, i.e., capital-intensive agriculture involving mechanization, on the one hand, or out-grower schemes[6] which is more labor intensive, on the other. Other factors that matter include capital cost, firm size, choice of processing technology, and industrial organization issues. Quintero *et al*. (2012) suggest that involving smallholders in the supply chain can, under some conditions, be competitive with liquid biofuel production systems that are purely operating on a large scale. Some argue that, despite the statistical significance of an average cost-size relationship, the average capital cost for a plant of a given size at a particular location is still highly variable due to costs associated with unique circumstances, possibly water availability, utility access and environmental compliance (Gallaghera *et al*. 2005). Moreover, the labor cost or wages, productivity, energy and transport costs, types and price of feedstocks, etc. also influence viability. Volatility of world fuel prices also leads to variability of prices of both biofuel and feedstocks. Uncertainties in prices in turn influence viability of biofuels investments. Therefore, it is natural to ask: “Will it be economically feasible to produce biofuels or bioethanol, for that matter?”

This paper comes out of broader research projects on “impacts and profitability of biofuels in Ethiopia” that looked into the various dimensions of the biofuels debate. Gebreegziabher *et al.* (2013) examine the distributive (welfare) effects and food security implications of biofuels investment in Ethiopia. Ferede *et al.* (2013) look at biofuels, economic growth, and the external sector in Ethiopia. This paper contributes to the existing but very limited literature on the viability of bioethanol production. Specifically, it broadens our understanding of whether and how bioethanol production can be economically viable and internationally competitive by providing insights from a country-specific case study. The paper indicates an oil price threshold beyond which bioethanol can be profitable in this context.

[6] An ‘out-growers scheme’ is a contract farming arrangement in which a firm enters into a binding agreement with individuals or groups of farmers to grow a certain crop and through which the firm ensures its supply of agricultural products or feedstock (Felgenhauer and Wolter, 2008)

The rest of the paper is organized as follows: In the next section, we review the related literature. Section 3 provides the conceptual framework whereas Section 4 presents the empirical approach employed, including the data and study considerations as well as the study context. Section 5 presents results and discussion, while Section 6 concludes and draws implications for policy.

2. Literature Review

An increasing number of developing countries have initiated biofuel production to meet domestic market and international demand. Reasons for engaging in biofuels production include diversifying energy sources, alleviating dependence on imported fossil energy, and reducing greenhouse gas (GHG) emissions (OECD-FAO 2008; Elbehri *et al.* 2009). Increases in fossil fuel prices create the potential for profitable biofuels industries in developing countries; this has been accompanied by the development of new technologies for using biomass for biofuels (Slater 2007). Biofuels are said to have a lower environmental footprint than fossil fuels because their use is expected to release fewer greenhouse gases into the atmosphere, although that contention is debatable. It is important to note that developing countries pursue different feedstock-biofuel (bioenergy) pathways and that the net effect of biofuels on the environment is heavily determined by the type of pathway used to produce ethanol and biodiesel (Mortimer *et al*. 2008; Zah *et al*. 2007).

Azam *et al*. (2005) assess the prospects and potential of fatty acid methyl esters of some non-traditional seed oils for use as biodiesel in India. They concluded that these selected plants have great potential for biodiesel. Based on a review of the literature, Barnwal and Sharma (2005) also assess prospects of biodiesel production from vegetable oils in India. Their economic feasibility analysis shows that the biodiesel obtained from non-edible oils is cheaper than that from edible oils. James and Swinton (2009) find that the break-even biomass prices and yields provide benchmarks for evaluating the profitability potential of converting current cropland to bioenergy crops, especially when adapted to individual grower conditions.

Quintero *et al*. (2012) analyzed social and techno-economical aspects of biodiesel production in Peru. In their work, the costs of biodiesel production from oil palm and jatropha were analyzed under different scenarios. Total production costs for oil palm biodiesel production ranged between 0.23 and 0.31USD/L, while jatropha biodiesel production costs were between 0.84 and 0.87 USD/L. These production costs are analyzed and compared to biodiesel ex-factory prices and diesel fuel production cost factors. Their results suggest that involving smallholders in the supply chain can, under some conditions, be competitive with liquid biofuel production systems that are purely large scale. Felix *et al*. (2010) identified the scenarios that best match Tanzanian conditions: ethanol from sugar-cane juice, with feedstock being supplied from a combination of out-growers (smallholder farmers) and commercial estates; ethanol from molasses; ethanol production from cassava, with feedstock supplied from small-scale cassava producers; and biodiesel from jatropha, with feedstock supplied by out-growers (small-scale farmers). They also find that production of biodiesel from palm oil is not economically viable and places too much risk on oil palm use for food and, hence, is not recommended for Tanzania.

Janaun and Ellis (2010) highlight some of the perspectives for the biodiesel industry to thrive as an alternative fuel, while also discussing the benefits and limitations of biodiesel. The benefits include the improvement of the conversion technology to achieve a sustainable process at a cheaper cost, environmentally benign and cleaner emissions, diversification of products derived from glycerol, and policy and government incentives. They also provide an overview of ways to make the production process more economical by developing high conversion and low-cost catalysts from renewable sources, and utilizing waste oil as feedstock. Moreover, they emphasized the need for public education and awareness for the use and benefits of biodiesel, while promoting policies that will not only promote the industry, but also promote effective land management.

Gallaghera *et al*. (2005) analyzed the relationship between plant size and capital cost in the dry mill ethanol industry. Their estimates suggest that capital costs typically increase less than proportionately to plant size/capacity in the dry mill ethanol industry because the estimated power factor is 0.836. However, capital costs increase more rapidly for ethanol than for a typical processing enterprise when judged by the average 0.6 factor, which is taken as a rule. Some estimates also suggest a phase of decreasing unit costs followed by a phase of increasing costs. They note that dry mills could be somewhat larger than the current industry standard, unless other unlikely factors limit capacity expansion. Their analysis also suggests that the average capital cost for a plant of a given size at a particular location is still highly variable due to costs associated with unique circumstances, possibly water availability, utility access and environmental compliance, despite the statistical significance of an average cost-size relationship. Rosa (2009) analyzed the dimension and profitability of the integrated biodiesel chain with different organizations as well as their effectiveness in different industrial organization contests in the EU. She suggested that the optimal size of plants with a higher level of exploitation of their capacity within an integrated organization is an important part of the cost-reducing process.

Jumbe *et al*. (2009) emphasized that national governments in sub-Saharan Africa should develop appropriate strategies and regulatory frameworks to harness the potential economic opportunities from the development of biofuels. At the same time, they stressed the importance of protecting the environment and rural communities. Rural communities are at risk from adverse effects if land is alienated from mainstream agriculture toward the growing of energy crops for biofuels at the expense of traditional food crops.

Janssen and Rutz (2011) suggested the following so that sustainability requirements will not impose unjustifiable burdens on biofuels producers or block development opportunities in developing countries. First, harmonization is urgently needed in order to avoid trade distortions and barriers or exclusion of developing countries from the emerging trade in biofuels due to the large number of existing initiatives on certification schemes. Second, a practicable and worldwide accepted sustainability program is needed in order to avoid the negative impact of biofuel production. Third, more research is needed on various aspects of the impact of biofuel production. Finally, close cooperation is needed between stakeholders and policy-makers from Latin America, Europe, the US, Asia and Africa to ensure that future sustainability schemes are implemented for the benefit of countries producing and importing biofuels.

3. Conceptual Framework

The two approaches employed in the biofuels industry are farm budget **approach** (James and Swinton 2009) and investment theory or investment analysis approach (Rosa 2009). The farm budget approach provides details of the revenue and cost structure of the biofuels industry. It involves a break-even analysis of yields and prices. That is, it involves determining either break-even prices, given yield, or break-even yield, given prices. By doing so, the economic viability of biofuels production can be assessed.

The investment analysis approach takes a long-term perspective, i.e., a longer time horizon. Specifically, it involves a more detailed valuation and analysis of future streams of costs and benefits of biofuels ventures, including assessing associated risks arising due to changes in prices, technology, etc. Competitiveness and viability of the biofuels industry are largely determined by fossil oil and biofuels prices in the international market. That is, at what cost a unit (a liter) of bioethanol or biodiesel can be produced is important. Therefore, in our case, we applied investment theory or analysis framework (Dixit and Pindyck 1994).

Consider a bioethanol firm (processing plant) that operates independently from the farm unit to maximize profit obtained from the difference between flows of cash of revenues and costs. Hence, the gross margin[7] for the firm can be specified as (Rosa 2009):

$$\pi = MtQgt - CpQgt = (Mt - Cp)Qgt; \qquad \textbf{(1)}$$

for $Mt = coPot + cpPgt - Pgt$; $Rt = coPot + cpPpt$

where Mt is a composite market price for processing one unit of feedstock, say, molasses; Qgt is the quantity of feedstock; Cp is operation cost; co is the seed/oil conversion coefficient; cp is the conversion coefficient oil/cake; $coPot$ and $cpPgt$, respectively, are price equivalents of oil and panel revenues per

[7] 'Gross margin' is the difference between a firm's total revenue and its cost of goods sold (COGS). It is a firm's profit before operating expenses, interest payments and taxes. It is also known as gross profit.

unit of feedstock (molasses) processed, and *Pgt* is the cost of the feedstock at time *t*.

Note that a firm (investor) seeks to maximize the discounted value of the future cash flow minus the current cash outlay for the physical capital of the plant ($K(Qc_t)$). Hence, a 'capitalized profits' form of the expected present value with anticipation of the rate of price increase net of cost of processing plant *K* is given by:

$$VAN^e_t = \Sigma^N_{i=1}(RN^e_t/(1+r^*)^i) - K. \qquad \textbf{(2)}$$

The VAN must be considered as a rent to be capitalized, obtained from a plant of appropriate size with respect to the supply of feedstock. Hence,

$$VAN^e_t = \pi^e_t / r^* \, Kf(Qgt) \qquad \textbf{(3)}$$

where the term π^e_t is the expected net future income discounted at rate *r*; the superscript *e* is the expectation about a future event and the subscript *t* identifies the reference period; r^* is the real discount rate, and K*f(Qgt)* is the capital function of the firm (processing plant), which is *a non-linear U*-shaped function of the quantity of feedstock processed (returns to scale).

Note that r^* is an adjusted real interest rate that takes into account all possible changes in future prospects (price changes) and incorporates the risk implied in the realization of future profits. Hence,

$$r^* = r - \alpha + \varphi\rho\sigma \qquad \textbf{(4)}$$

where α is the anticipated growth rate (varying between 0 and 1) in product price; φ, ρ, σ, respectively, represent the risky prospects of the market price; the correlation between bioethanol profit and the market portfolio; and the standard deviation of % change in bioethanol processing price.

The first order condition from Equation (3) (the expected present value criterion) provides a rule for optimal capital growth. According to Tobin's *q*, the capacity (K) should increase until the capitalized value of the marginal investment is equal to the purchase cost.

Alternatively, marginal profitability can be decomposed to obtain the usual competitive pricing rule as:

$$Mt = Cp + \frac{\partial K}{\partial Qgt} \quad \textbf{(5)}$$

This equation [Equation (5)] says that price (MR) equals the marginal production cost that includes the operating cost component and the capital cost component.

4. Emprical Approach, Data and Context

In this section, we present the approach we employed in the study. Note that we consider bioethanol in the analysis. Molasses is used as feedstock for bioethanol production in Ethiopia; the Finchaa and Metehara sugar factories are currently producing bioethanol. The conceptual framework and empirical procedure outlined in this paper apply to these biofuels and feedstocks. In what follows, we discuss the empirical approach, data and study considerations, and the study context.

4.1 Empirical approach

The optimality condition holds when price (i.e., marginal revenue (MR)) equals the marginal production cost (MC) that includes the operating cost component and the capital cost component for a biofuel venture to be economically viable. Therefore, we consider unit cost analyses that capture both the operating cost and the capital cost components for empirical calculations of viability of bioethanol production, as well as for international comparison.

4.2 Data and study considerations

The decision to produce biofuels depends on considerations of a host of factors, including institutional arrangement (biofuels business model), choice

of processing technology (capital cost and firm size), labor cost or wages, productivity, energy and transport costs, and types and prices of feedstocks.
Two sets of data sources are used for this study. These are survey data and estimates, which are discussed below in that order.

(i) Survey data (cross-sectional) is obtained from a biofuels investment survey in Ethiopia conducted by Environmental Economics Policy Forum for Ethiopia (EEPFE) at the Ethiopian Development Research Institute (EDRI) in 2010. A structured questionnaire was developed to collect the relevant data. The instrument covered questions related to: time elapsed in the investment process from application and registration through to land acquisition; feedstock production and utilization, including purchase price of feedstock offered to out-growers, labor/capital inputs to feedstock production and related expenses; investment in plants and equipment and plant capacity; biofuels (bioethanol and biodiesel) extraction (processing) and sales; and an assessment of environmental and social issues. A list of over 45 companies registered for biofuels investment was obtained from the Ethiopian Investment Agency. Then, about 15 biofuels companies, including two NGOs involved in biofuels and actually operating in the field, were approached to fill out the structured questionnaire. There were six non-responses. Besides its use in calculating the input-output coefficients, the survey also helped to characterize the biofuels industry (sector) in Ethiopia.
ii) A four-year (2007 to 2010) detailed breakdown of bioethanol production costs was also obtained through the survey from the Finchaa Sugar Factory. This data is used for the unit cost analysis of bioethanol production in Ethiopia. Data on production costs as well as sales prices were also obtained for the years 2011 and 2012 from Finchaa and Metehara Sugar Factories. Moreover, additional information was obtained from the Ethiopian Sugar Corporation.

4.3 Study context

The potential for producing fuel alcohol from molasses and other raw materials, including trees such as eucalyptus, is quite large in Ethiopia. In fact, if considered seriously, production of bioethanol from biomass is considered to have a double dividend, i.e., solving the fuel problem and fighting deforestation (Bayissa 2002). The country is also said to have high potential for biodiesel production (Gebremeskel and Tesfaye 2008). The current biofuel development strategy of the country emphasizes the production of bioethanol from sugar beet, sugar cane, sweet sorghum and others, and that of biodiesel from jatropha, castor bean plants, and palm (MoME 2007).

Previously, there was only one biofuel factory in Ethiopia, a power alcohol plant that has been producing bioethanol as a byproduct at Finchaa Sugar Factory. Finchaa has a distillery (an ethanol plant) annexed to its sugar mill with a capacity of 12 million liters/year. The plant was commissioned in 1998 and produces ethanol from sugar cane molasses, a byproduct of the sugar mill; it had a stock of about four million liters of bioethanol at the end of December 2001 (Bayissa 2002). However, although the government had issued a directive allowing Finchaa to produce and sell fuel alcohol to oil companies, who would in turn blend it with gasoline and distribute it to motorists, it could not sell its fuel alcohol on the market at that time. The major reasons for the refusal of the oil companies appeared to be the need for rehabilitating the existing old fuel stations and lack of interest in investing in a fuel sales operation that gives them little profit. This was also viewed as a lack of understanding and absence of commitment to alleviate one of the major problems of the country.

However, the interest in biofuels development has been revitalized with the recent hike in oil prices. Several local and international private and public biofuels companies (developers) have registered in the country since 2006. For example, by 2010 there were more than 82 registered biofuel investors (see Table A1 in the appendices), most of whom were registered for the cultivation of energy crops for biodiesel production. In this regard, jatropha, castor seed, and oil palm are crops/plants mainly grown as feedstocks for biodiesel production. Plants like *Argemone mexicana* and *Croton macrostachyus* are also being promoted and tested in some parts of Ethiopia (Keriko 2007). In the case of bioethanol, however, there are only a few developers in the country, most of which are publicly owned sugar factories that intend to produce bioethanol as a byproduct of sugar production. Reports also indicate that about 1.5 to 2 million hectares of land have already been offered for biofuels investment (ABN 2007; Lashitew 2008; Lakew and Shiferaw 2008; Beyene 2011). In the case of the companies registered for the cultivation of energy crops for biodiesel production, most of them had the intention of going for large-scale commercial development. However, very few of them are in operation. At present only two of the sugar factories, Finchaa and Metehara, are producing bioethanol. The rest are at the pre-implementation stage, either retrofitting existing factories for ethanol development, or at the very early stage of land cultivation for planting sugar cane.

Biofuels development in Ethiopia is unique in two important respects. Firstly, the biofuels sector is characterized by a diversity of biofuels feedstock crops (jatropha, castor bean, sugar cane, and palm oil, including indigenous trees). Second-generation biofuels, i.e., molasses, which are byproducts, are used for bioethanol production, whereas jatropha, castor bean and palm are used for biodiesel production. There are also intercropping options with other crops in the case of castor beans. Secondly, the biofuels business model in Ethiopia includes a mix of plantations, out-growers schemes, and community development models. For example, REST in Tigrai and ORDA in the Amhara region are involved in biofuels under a community development model.

Table A2 provides an overview of the characteristics of this sector in Ethiopia from the survey results.

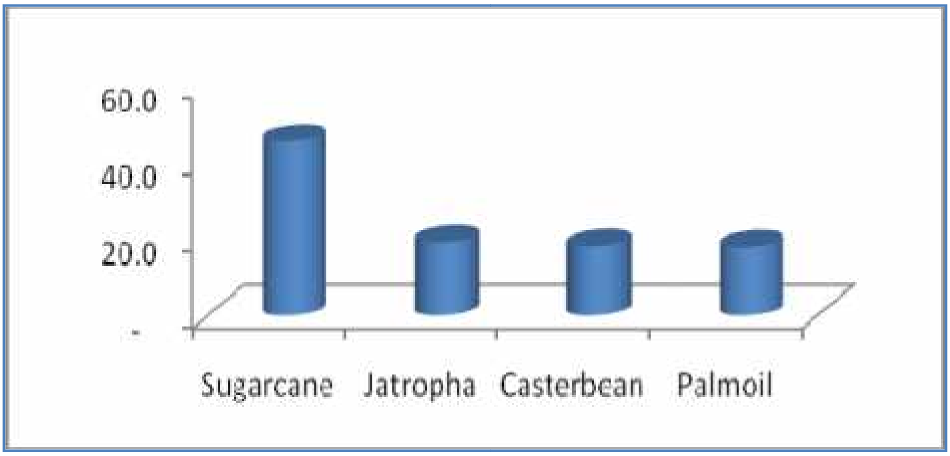
As for production characteristics, while large scale sugar cane is mainly plantation-based, jatropha and castor bean production activities are undertaken by a combination of plantation-based and smallholder-production-growers schemes. Table 1 provides biofuels production characteristics. According to a recent biofuels investment survey, sugar cane accounted for a larger share of the total land allocated to biofuel crops (Figure 1). However, it is important to note that a small proportion of the total land allotted to biofuels production was utilized in 2007. For instance, while a fifth of the total land allocated for biofuels is utilized in castor bean, the figures for jatropha and palm oil are very small, i.e., 1.5% and 0.8%, respectively, in 2009 (Figure 2). A little more than half of the total land allotted to sugar cane has been utilized over the same period.

Table 1: Biofuel Production Characteristics/Technical Coefficients

	Sugar cane and ethanol	Jatropha/castor bean diesel
Land employed (ha)	11,248.00	3,284.00
Biofuel crop production (tons)	569,168.00	200.00
Farm workers employed (in number)	5,365.00	4,384.00
Land yield	50.60	0.06
Farm labour yield	106.09	0.05
Land per capita	2.10	0.75
Capital per hectare	16.46	0.00
Labour-capital ratio	0.029	0.00
Biofuel produced (liters)	5,323,866.05	2,880.69
Processing workers employed	27	0.00
Feedstock yield (L/ton)	9.35	14.40
Processing labour yield	197,180.22	

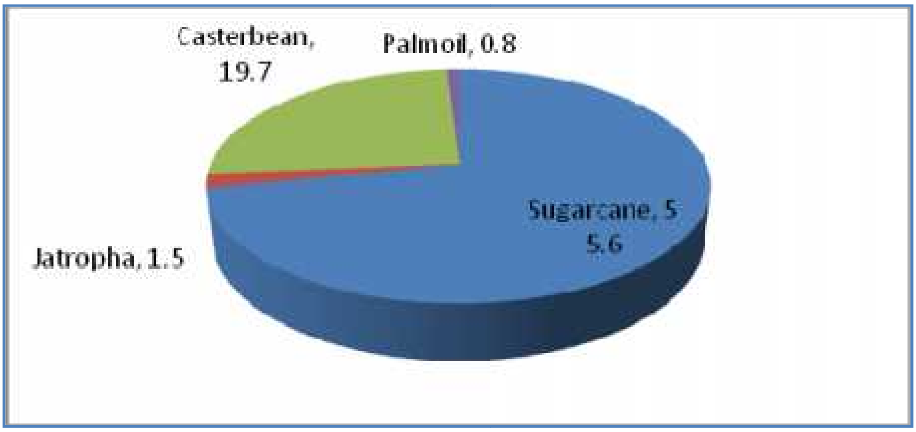
Source: Biofuel investment survey, 2010.

Figure 1: Share in Total Biofuel Crop Land, by Biofuel Crop Type (%)



Source: Biofuel investment survey, 2010.

Figure 2: Ratio of Utilized Land to Total Land Allocated to Each Biofuel Crop (%)



Source: Biofuel investment survey, 2010.

5. Results and Discussion

As previously noted, this paper focuses on analyzing the viability of biofuels, specifically bioethanol production, taking Ethiopia as a case in point. The viability analysis of bioethanol production is carried out based on a detailed breakdown of four years (2007 to 2010) of bioethanol production cost data obtained from Finchaa Sugar Factory. The results are shown in Table 2. Note that the discussion of results is based on a four-year average. As can be seen from the table, feedstock, supplies and other costs constitute important cost components in the context of Ethiopia. The results also suggest that bioethanol can be produced in Ethiopia with the cost of ETB 3.19/gallon or ETB 0.84/liter at the factory gate. Moreover, the unit sales price of molasses bioethanol is analyzed based on a four-year average (see Table 3). The results suggest that the unit sales price of molasses bioethanol at the factory gate in Ethiopia is ETB 3.23/gallon. Considering an exchange rate of ETB 13.5/US$ during August 2010, i.e., during the survey period, this is equivalent to a unit production cost of US$ 0.24/gallon and a sales price of US$ 0.29/gallon or US$ 0.08/liter. Production costs, as well as sales prices at the factory gate for the years 2011 and 2012, also obtained from the Finchaa and Metehara sugar factories, are used to enrich our analysis. As can be seen from Table 4, the unit production costs at the factory ranged between ETB 2.73 and ETB 4.70 per liter. The unit sales prices also ranged between ETB 3.00 and ETB 8.90 per liter. The data also suggest that the sales prices sufficiently cover production costs.

Table 2: Analysis of Molasses Bioethanol Production Costs

Item	Cost (ETB)
Feedstock (molasses)	0.69
Machinery, plant, power	0.35
Supplies	0.68
Labour	0.39
Others	1.07
Total cost (ETB/gallon)	3.18
Total cost (ETB/L)	0.84

Source: Authors' own analysis based on four years of data from Finchaa Sugar Factory.

Table 3: Sales Prices of Molasses Bioethanol in Ethiopia at Factory Gate in 2010

Item	
Unit sales price (ETB/gallon)	3.23
Exchange rate (August, 2010) ETB/US$	13.5
Unit sales price (US$/gallon)	0.29
Liters/gallon	3.785
Unit sales price (US$/L)	**0.08**

Source: Authors own analysis based on data from Biofuels Investment Survey 2010.

Table 4: Production Cost and Sales Price at Factory Gate of Bioethanol 2011 and 2012

Item	2011		2012	
	Finchaa	Metehara	Finchaa	Metehara
Production cost (ETB/L)	2.73	3.00	3.35	4.70
Sales price (ETB/L)	3.00	8.90	7.51	7.43

Source: Ethiopian Sugar Corporation, Annual Plan 2012/13.

In Ethiopia fuel imports account for a significant share of the country's total import bill. For example, between 1991/92 and 2011/12 fuel imports accounted for 28.5% of the total import bill and, on average, about half of the total value of exports and 3.1% of GDP (Ferede *et al*. 2013). Obviously, this puts pressure on the country's balance of payments. Hence, as articulated in the country's Biofuels Development and Utilization Strategy (MoME, 2007), biofuels development has a significant bearing as one of the key strategies for substituting imported fuel. Some official reports also indicate that, by blending more than 38.2 million liters of bioethanol with gasoline, the country has been able to save 30.9 million US dollars on oil imports since 2008 (Biofuelsdigest 2013).

It would be of interest to provide an international perspective in order to visualize the viability and international competitiveness of Ethiopia's engagement in bioethanol production. The world ethanol price increased by 32% to $2.18 per gallon in 2010, after declining by 5.3% in 2009, partly due to a decline in ethanol exports from Brazil. Then, ethanol prices dropped in 2011. Though regional market conditions varied, world ethanol prices declined early in 2012 (OECD 2013). In general, the fluctuation in ethanol price is largely driven by what is happening in Brazil and the US, but also by changes in world oil price. For example, in the United States, with the higher probability of the drought occurring, ethanol prices began to rebound in late 2012, driving up feedstock prices. In Brazil, improved supplies due to an improved sugar cane crop in the second half of 2012 pulled down domestic ethanol prices. As a net effect of all the various underlying factors, the world price of ethanol is expected to increase by 8% in real terms over the next decade between 2012 and 2022, slightly more than the 7% increase in oil prices expected during this period, before starting to increase over the first part of the projection period.

Therefore, if ethanol price is projected to vary, say, between $1.5 and $2.5 per gallon in the next decade (FAPRI 2008; 2011), then, with the unit production cost equivalent to US$ 0.24/gallon, one can visualize that bioethanol production (from molasses) in Ethiopia is indeed viable and competitive internationally.

Over the past few years, ethanol markets have been strongly influenced by the level of crude oil prices. Therefore, uncertainties in the fossil energy sector are directly translated into uncertainties in the ethanol and agricultural sectors.

This is also due to the fact that ethanol production is expected to represent a sizeable part of the demand for agricultural feedstock (OECD/FAO 2013). Moreover, the sector is also vulnerable to perturbations in agricultural production caused by unfavourable climatic or weather conditions. It could be envisaged that all these uncertainties will have a bearing on the bioethanol production of the country.

6. Conclusions and Implications

Doing viability analysis and determining the oil price threshold beyond which biofuels can be profitable is useful to guide policy. The main objective of this study was to investigate the profitability of biofuel investment in Ethiopia. Specifically, the purposes of this study were to analyze the viability of investment in bioethanol production and to determine the oil price threshold beyond which biofethanol production may be profitable, taking Ethiopia as a case in point.

The following conclusions can be drawn from the analysis in this paper:
i) Bioethanol production (from molasses) in Ethiopia is quite viable.
ii) Bioethanol development can have a significant bearing as one of the key strategies for substituting imported fossil fuels.

Interestingly, there are complementary local innovations going on in the biofuels sector, including the invention of biodiesel and bioethanol stoves, processors/distilleries, and biogas-driven vehicles. All these suggest that the sector requires policy attention and could possibly be one avenue to reducing poverty and enhancing growth. However, we also found that the sector suffers from a lack of appropriate institutional setup in terms of better regulatory framework and follow-up, particularly at the regional level. Therefore, better regulatory framework and follow-up is called for.

This is a case study involving very few observations because of the small size of the universe of producers in question. Hence, further analysis is called for as the sector expands. In general, the biofuels industry in Ethiopia can be viewed as a possible pathway out of poverty (Gebreegziabher *et al*. 2013). However, a lot remains to be done to harnessing the country’s potential, especially as it relates to bioethanol development.

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Appendices

Table A1: Number, Type and Regional Distribution of Biofuels Developers in Ethiopia

Region	Type*	
	Biodiesel	**Bioethanol**
Benishangul Gumuz	4(3)	
Amhara	7(5)	1
Oromia	16(3)	4(1)
SNNP	21(3)	
Gambela	4	
Afar		1
Total	52	6

* Numbers in () indicate projects that have started operation.

Source: Lakew and Shiferaw (2008)

Table A2: Overview of Characteristics of the Biofuels Sector in Ethiopia

Indicator	Number / description
No. of firms/companies	>15 (incl. NGOs)
No. of firms already at production stage	2
No. of firms that started export	1
No. of firms at production test stage	2
Total investment (capital)	Multimillion >1.3 b ETB (>0.1 billion USD)
Investment (type)	Largely foreign but also domestic
Land (000' ha)	>308 (currently operating); >101 (additional)
Year in operation	Since 2005
Installed plant capacity	492 to 28,800 liters/day
Employment opportunities.	>17,714 (Temp), >236 (Perm)
Crop types	Sugar cane, jatropha, castor bean, palm oil
Technology	Plantation, out-growers, and community development
Regions	All regions, Oromiya, SNNPR, Amhara, etc

Source: Results of the Biofuels Investment Survey 2010.