Sustainability considerations for ethanol production in Uganda

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Overview

Sustainability calls for a balance between the needs of the present and future generations (Brundtland report of 1987). The social, economic, and environmental sustainability dimensions are typically related to biofuels production. From a social and economic perspective, biofuels can potentially create jobs and markets for agricultural commodities, enhancing household income (see Nakamya & Romstad, 2020; Hartley, van Seventer, Tostão, & Arndt, 2019). In this regard, socio-economic equity is promoted as societies become economically independent. However, this may come at the expense of extensive use of scarce resources such as land, for example, in the case of first-generation biofuels (Paschalidou, Tsatiris, & Kitikidou, 2016). This may result in a deterioration of soil quality, affecting both the present and future generations.

From an environmental viewpoint, biofuels contribute to keeping natural resources in balance. For example, in Uganda, ethanol use could substitute for gasoline and slow its oil reserves extraction rate. Displacement of fossil fuels and the sequestration of carbon during feedstock growth contribute to a low-carbon economy. To some extent, this contributes to mitigating environmental degradation and climate change. While this is true, the increased demand for land could cause changes in farming practices, increase the use of fertilizers and other inputs, and induce the use of high carbon stock lands and other land-use change (LUC) effects (Acheampong, Ertem, Kappler, & Neubauer, 2017).

There are vigorous attempts to promote biofuels through policies aligned with the three goals of sustainability. For example, Brazil's biodiesel program provided tax subsidies to producers who purchased a minimum amount of feedstocks from family-owned farms. The producers were also supposed to have agreements with farmers regarding the pricing and delivery of raw materials and provided technical assistance (Rodrigues & Accarini, 2016). Additionally, the certification standards and emissions thresholds in some jurisdictions ensure that biofuels meet a minimum level of emissions reduction. For example, the US 2007 Renewable Fuel Standard (RFS2) requires ethanol from refineries constructed after its enactment to achieve at least 20 % life cycle GHG emissions reduction relative to fossil fuels. This threshold was set at 50 and 60 % for the advanced and cellulosic ethanol, respectively (Environmental Protection Agency (EPA), 2010; Schnepf & Yacobucci, 2010).

The deployment of biofuels largely hinges on the level of investment in the biofuels sector; this is driven by capital availability. Capital could be locally or foreign-sourced, such as foreign direct investment (FDI), which may have a bearing on the socio-economic outcomes. On the one hand, capital from local sources may create competition and crowd out other sectors. On the other hand, FDI plays a role in providing financial and other resources to mainly developing countries whose sectors would have otherwise found it difficult to take off. Nonetheless, the FDI literature has shown that it is not necessarily true that all countries benefit from FDI as the effects may be adverse (Agosin & Machado, 2005; Herzer, 2012).

The majority of studies on the sustainability of biofuels have been specific. For example, some primarily focus on the environmental aspects using Life Cycle Analyses (LCA) (Seabra, Macedo, Chum, Faroni, & Sarto, 2011); Wang, Han, Dunn, Cai, & Elgowainy, 2012: Lewandrowski et al.,2019). Others have concentrated on the socio-economic impacts (Nakamya & Romstad, 2020; Hartley et al., 2019; Portale, 2012). Because of the benefits and trade-offs involved, all the sustainability pillars should be considered in decision-making. A few studies have taken this approach (see Obidzinski, Andriani, Komarudin, & Andrianto, 2012; Thurlow, Branca, Felix, Maltsoglou & Rincón, 2016; Schuenemann, Thurlow & Zeller, 2017). Nonetheless, such studies are still scarce and much less those that examine the implications of capital source in biofuels development. Additionally, GHG emissions quantifications tend to be contextual and dependent on the data, assumptions, and methodology.

This study explores the social, economic, and environmental sustainability of ethanol production in Uganda by specifically assessing: How local and foreign capital may influence the socio-economic benefits of ethanol production. The extent to which ethanol reduces GHG emissions relative to gasoline in Uganda's context.

The originality of this research is the investigation of all three goals of sustainability while considering the source of capital. To my knowledge, this is the first analysis about Uganda. The results shed light on the hotspots along the ethanol supply chain and the necessary safeguards to ensure implementation of sustainable ethanol production and use.

Methods

This study applies a recursive dynamic Computable General Equilibrium Model (CGE) calibrated to the 2016/17 Uganda official social accounting matrix (SAM). This work extends the Partnership for Economic Policy PEP-1-t single-country recursing dynamic CGE model by Decaluwé, Lemelin, Robichaud, and Maisonnave (2013).
The SAM was obtained from the Ministry of Finance, Planning and Economic Development, while data on gasoline imports and prices are from the Ministry of Energy and Mineral Development and the Uganda Bureau of Statistics (UBOS). Ethanol prices were obtained from ethanol processors, and the elasticity parameters and conversion rates are from the literature.

The ethanol sector is modelled as a latent sector (see Taheripour,Levano &Tyner, 2017). It is based on maize, cassava, and sugarcane as the feedstocks. Land and labor are fully employed, grow at constant rates, and are mobile across sectors. The supply of capital is endogenous, and it is determined by the previous period level of investment and stock of capital adjusted for depreciation. The new stock of capital is then allocated across sectors according to their initial share in total capital income and their sectoral profitability rates. Once allocated, it becomes immobile across sectors such that it earns sector-specific rental rates. The savings-investment balances are investment-driven. The nominal exchange rate is set as the model numeraire with real exchange rate adjusting to correct any imbalances on the current account. The ethanol volume adequate for a 10% blending level by the 15th year is simulated by an exogenous gradual increase of capital into the ethanol sector; hence, other incentives to achieve this are implicit.

Emissions are quantitied for all ethanol and gasoline as the comparative fuel. This module is incorporated in the CGE by directly introducing equations for emissions quantification into the model. The system boundary includes feedstock farming, transportation, processing , ethanol distribution, and combustion. It also incorporates direct land use change by assuming that at least one half of the feedstocks will be produced on grassland with carbon stock of 26 - 30t co_2/ha or forest land of 151t co_2/ha. Any displacement of crops is assumed to generate emissions that lies within the two extremes of with and without land use change.

Results

As ethanol production expands, the feedstock sectors draw in more land, capital, and labor. Capital-specific rent increases in majority of the sectors. Land rent and the economywide wage for each labor type increase as well. This negatively affects other competing sectors including the "Cash crops" and "Grain seeds"as the cost of production rises. The increased cost of production causes a reduction in their output. Prices of virtually all commodities, and consequently, the economy's average price level rise. Additionally, the above affected sectors are among the main exporters of cashcrops and grains. As, gasoline imports reduce because it is substituted by ethanol, the exchange rate appreciates. This raises export prices and further exacerbates the negative impacts on output through reduced exports.

The overall growth effects are slightly higher under local capital. It is apparent that local capital generates more household income and welfare benefits. The growth in real GDP is also slightly faster under local capital. In the findings, real GDP at basic price grows at 0.06 % under both scenarios while the income-based (and nominal GDP at market price) increases by 0.78 % under foreign capital and 1.02 % under local capital. The differences could therefore be associated with the slightly higher income under the local capital scenario. On the contrary, agricultural output is slightly higher under foreign capital because only land is reallocated in this case.

Without land use change, emissions reductions relative to gasoline are 61%, 62%, and 95% for maize, cassava, and sugarcane ethanol, respectively. Considering land use change, the reduction is between 0.84% and 8.82% for maize ethanol, 22.69% and 28.15% for cassava ethanol, and 50.42% and 52.10% for sugarcane ethanol. Growing sugarcane on deforested land results an insignificant emissions reduction by sugarcane ethanol of only 7.78%.

Conclusions

Local capital generates more growth effects than foreign capital, with household incomes and real GDP rising faster under the former. Without any land-use change, all ethanol types achieve a significant reduction in GHG emissions. With land use change, maize would not be a suitable feedstock, particularly because of its low yields per hectare considering the emissions released from cleared land. Cassava is a potential candidate because of the relatively higher yields per hectare and almost zero fertilizer application. Sugarcane ethanol, however, could significantly contribute to climate change mitigation as it generates emissions savings ascribed to the near-zero process emissions, carbon sequestration, and the carbon-free surplus electricity from bagasse. Land-use-change and process emissions are significant sources of GHGs; hence, caution should be taken regarding the type of new land that could be brought into use. Despite its small size, the ethanol industry substantially impacts other sectors and the current account. Therefore, prioritizing local investors may avoid profit repatriation and generate more growth.

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