Economy-wide implications of biofuel production in Zambia

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Introduction

- Biofuel demand in Southern Africa is expected to increase as countries implement blending mandates to reduce GHG emissions. In 2014, South Africa implemented biofuel blending mandates creating an anchor market for producers in the region. By 2025, South African demand for bioethanol is estimated to reach 1400 million litres.
- Zambia has the potential to become a large supplier of this demand. It's near-central geographical location, suitable climate, abundance in land and (on paper) supportive set of bioenergy incentives provide a strong case for successful biofuel production within the country.
- The establishment of a biofuels sector in Zambia has the potential to promote development and poverty reduction as it introduces new employment opportunities and income streams (FAO, 2013), particularly in the agriculture sector.
- This study assesses the potential economic and welfare impacts of bioethanol production in Zambia such that production satisfies demand from South Africa.
- We consider three potential feedstock crops identified by the government, i.e. sugarcane, cassava; and sweet sorghum.
- Also consider the impact of farm size, land displacement and by-products, specifically cogeneration from sugarcane bagasse.

Potential for biofuels production in Zambia

- Sugarcane and cassava are highlighted as key crops given existing production scales
  - Sugarcane farming is predominantly commercial (60% of total supply) with smallholder farmers participating through outgrower schemes. Farming is irrigation based. Smallholders receive water from estates as part of outgrower services provided.
  - Cassava is a low-input, drought tolerant crop primarily grown by smallholder farmers. It is a rainfed, duo-purpose crop largely used as a staple food (second only to maize). Smaller shares are used as inputs to the manufacturing sector. Excess cassava flour supply in 2015/16 indicates space for bioethanol production.
- Sweet sorghum provides an alternative feedstock crop with large potential
  - Can be grown more than once a year; has low input requirements; is drought-tolerant; and is a duo-purpose crop. Current production is relatively small. New varieties under study at the University of Zambia show potential to substantially reduce the costs of bioethanol production as a result of their high yields (3x).

Methodology

- Dynamic Computable General Equilibrium model for Zambia.
- 2007 Social Accounting Matrix (SAM): 44 industries and commodities; 4 labour groups (by education); 5 rural and urban representative households groups.
- Production factors include capital, labour and in the case of agriculture, land.

Feedstocks Processing

- Bioethanol industry included in SAM using technology vectors
- Capital for commercial and smallholder sugarcane farming; and ethanol processing is assumed to be sourced from international markets → returns to capital (after tax) repatriated using new factor account.
- Non-sugarcane smallholder farmers' receive international donor funding → (after tax) returns transferred in the standard way to domestic households.
- All bioethanol is exported.

- Include the potential for cogeneration from sugarcane waste (i.e. bagasse).
- Assume 70kWh of electricity is produced per MT sugarcane using bagasse (Deepchand, 2005)

Scenarios and Assumptions

	Scenario	Description
1	Sugarcane, status quo	Ethanol production using sugarcane (60% commercial; 40% smallholder)
2	Sugarcane, 20-80	Ethanol production using sugarcane (20% commercial; 80% smallholder)
3	Sugarcane + cogeneration	Ethanol production using sugarcane (status quo) + cogeneration from bagasse
4	Cassava	Ethanol production using smallholder grown fresh root cassava
5	Cassava + Displacement	Ethanol production using smallholder grown fresh root cassava + 50% land displacement
6	Sweet Sorghum	Ethanol production using smallholder grown sweet sorghum

- Aligned with stylised facts for Zambia: Flexible exchange rate; Savings driven investment; No fiscal rule (i.e. government savings is flexible).
- To fully assess the impact, assume labour and land is fully employed and mobile; non-biofuel capital is also fully employed but activity-specific.
- Capital used in the biofuel industry is unemployed and foreign sourced.

Cost of Producing Bioethanol in Zambia

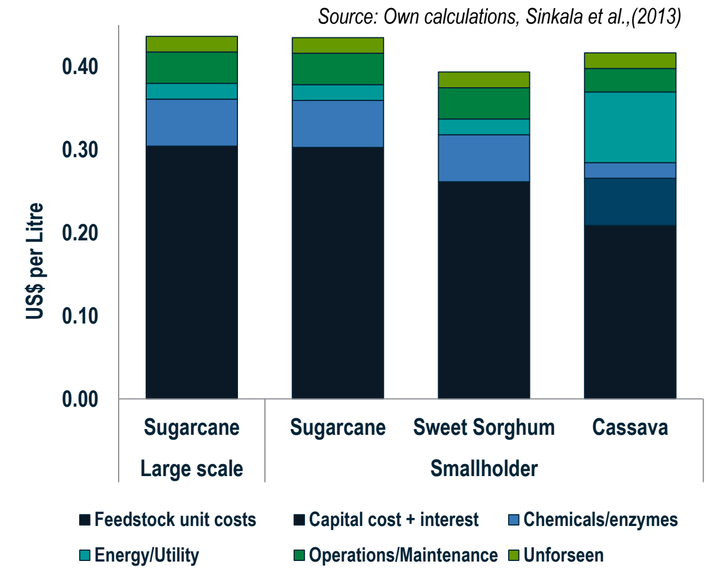
Bioethanol Feedstock Costs (US$ per Hectare)

	Commercial	Smallholder		
	Sugarcane	Sugarcane	Sweet Sorghum	Cassava
Seed	181.6	181.6	7.3	45.0
Chemicals	860.3	749.2	141.3	0.0
Food				3.0
Wood and Paper			8.3	
Business Services	311.3	124.6	30.1	42.2
Financial Services	40.8	45.4		30.0
Trade Services	95.3	37.8		0.0
Transport	116.5	116.5	23.1	40.0
Labour	257.9	460.2	170.8	278.0
Land	95.8	21.9	19.6	123.5
Capital	718.4	200.1	66.0	205.9
Total Cost	2677.9	1937.5	466.6	767.5
MT/Hectare	110	80	35	22
Litres/MT	80	80	167	51
Total Cost /Litre	0.304	0.303	0.261	0.209

Source: Own calculations; Sinkala et al. (2013); Sinkala (2015) & Samboko et al. (2016)

Bioethanol Processing Costs

Source: Own calculations, Sinkala et al.,(2013)

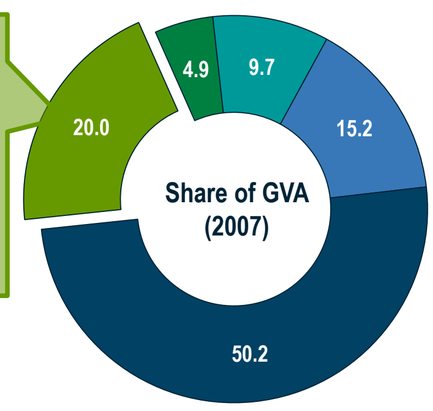


- Feedstock costs sourced from farming budgets; no commercial processing in Zambia → use costs from Sinkala et al. (2013)

Key features of the Zambian economy

Agriculture

- Largest employer (71.3%, largely low skilled); but only 16.3% of wage income
- Net exporter (8.2% of total)
- Domestic demand largely satisfied by local production



- Mining is the main earner of foreign income (71.4% of total exports) followed by manufacturing (10.5%, largely metal products and machinery)
- Returns to land, livestock and foreign transfers are largely paid to rural households; while labour and enterprise income; and government transfers are predominately paid to urban households
- Food consumption makes up the largest share of rural and urban household spending, accounted about 40% of total consumption

Bioethanol production leads to GDP and welfare gains

			Deviation from Baseline growth rate (%-point)					
	Share, 2007 (%)	Baseline growth 2015-25 (%)	Scenario 1 Sugarcane, status-quo	Scenario 2 Sugarcane, 20-80	Scenario 3 Sugarcane + Cogeneration	Scenario 4 Cassava	Scenario 5 Cassava + Displacement	Scenario 6 Sweet Sorghum
Total GDP	100.0	5.1	0.029	0.020	0.058	0.040	0.007	0.018
Agriculture	20.0	4.0	0.173	0.157	0.181	0.237	0.153	0.231
Food crops	10.2	3.1	0.024	0.024	0.020	0.038	-0.101	0.009
Biofuel crops	0.0	0.0	146.985	145.807	146.985	154.103	154.103	154.573
Other agriculture	3.6	4.6	-0.026	-0.037	-0.027	-0.020	-0.125	-0.038
Forestry & Fishing	6.2	4.9	-0.081	-0.092	-0.053	-0.123	-0.133	-0.112
Mining	4.9	3.1	-0.287	-0.311	-0.187	-0.461	-0.445	-0.397
Manufacturing	9.7	5.1	0.098	0.079	0.384	0.181	0.138	0.084
Food processing	5.8	4.8	-0.013	-0.018	-0.017	0.014	-0.037	-0.001
Biofuels processing	0.0	0.0	135.482	132.817	163.638	146.518	146.518	132.642
Other manufacturing	3.9	5.4	-0.029	-0.036	-0.020	-0.050	-0.084	-0.046
Utilities & construction	15.2	6.4	-0.007	-0.014	-0.028	0.021	0.012	-0.027
Services	50.2	5.2	0.004	-0.002	0.003	-0.012	-0.037	-0.020

Source: CGE Model Results

- **Positive impact on average annual real GDP growth and welfare.** Real GDP growth increases due to bioethanol production with both rural and urban household welfare rising. The largest gains are experienced under Cassava.
- **Including cogeneration doubles gains to average annual growth.** The increase in electricity supply lowers electricity prices, raising profitability as well as household purchasing power. In Scenario 3 this also leads to increased capital use.
- **Increased competition for labour results in higher wages.** This negatively impacts sectors with price sensitive demand and constrains the positive impact on growth. These sectors however release resources to be used elsewhere in the economy. Cassava is one sub-sector that benefits from this endogenous shift in resources. This is an important finding given the importance of cassava for food security in Zambia.
- **Export intensive sectors experience the largest declines in activity.** The real exchange rate appreciates to maintain the current account balance, reducing the competitiveness of these sectors.
- **Food prices increase as a result of higher production costs and increased household demand.** Food price increases are larger in the case of cassava and sweet sorghum as they are more labour intensive, causing larger increases in wages. The assumed displacement of land has a particularly negative impact on food prices as food crop production decreases.
- **On aggregate bioethanol production (with no land displacement) does not negatively affect food security**. Urban households do however consume marginally less food, increasing non-food manufacturing consumption.

GDP and welfare impacts increase with the availability of resources

- Ease the constraint on unskilled labour categories → more realistic, accounts for unemployed
- Results in larger GDP gains as average wage increases in the economy is partly offset by the increase in labour supply.
- Relative to the labour constrained scenarios, average annual real GDP growth is about 0.02 percentage points higher. Welfare gains are also larger.
- The direct and indirect impact of the bioethanol industry results in between 16,000 and 60,000 additional jobs. As expected the bulk of jobs are created in the bioethanol industry, although employment in food crop production and services also increase. The bioethanol industry creates between 25,000 and 60,000 new employment opportunities depending on the feedstock crop chosen.

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