Title: AGRICULTURAL PRODUCTIVITY AND CO_2 EMISSIONS DUE TO LAND USE CHANGE IN SUB-SAHARAN AFRICA

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Selected Poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennal Conference, Foz do Iguacu, Brazil, 18-24 August, 2012.

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❖ INTRODUCTION

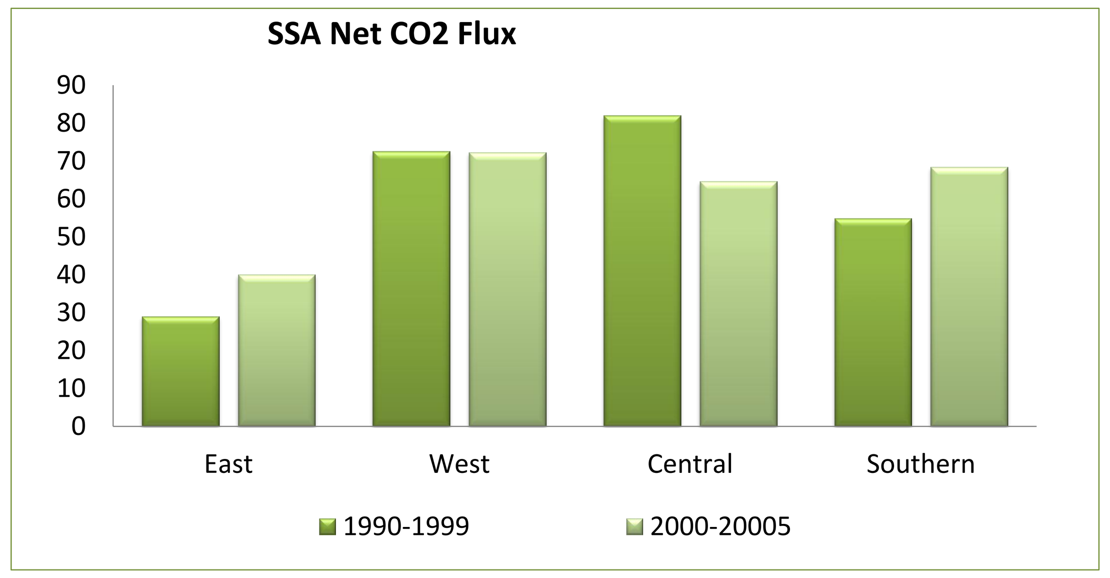
- Agricultural expansion (need for additional cropland) is the main driver of deforestation in Sub-Saharan Africa (SSA).
- There is growing concern to reduce loss in carbon stocks (through greenhouse gas emissions) due to deforestation given that large aboveground stock of carbon are put at risk with deforestation.
- Estimates of agricultural productivity in SSA usually do not account for externalities such as CO_2 emissions due to land clearing.

❖ OBJECTIVES

- Estimate agricultural total factor productivity (TFP) growth rate while ignoring CO_2 and deforestation;
- Modify TFP measurements to include the effects of CO_2 emissions from land use change – two approaches are used:
  - Approach 1: Estimate TFP growth rates while accounting for the joint production of CO_2 due to land clearing (two outputs: aggregate production and CO_2);
  - Approach 2: Estimate TFP growth rates while treating CO_2 as an additional input in the production of "good" output.

❖ DATA

- Outputs: Aggregate agricultural production, and CO_2 emissions from land use change.
- Inputs: fertilizers, livestock, machinery, labor, land, and CO_2 emissions from land clearing.



❖ METHODS

Approach 1: Translog Output distance function

$$-\ln y_{it}^{1} = \alpha_0 + \alpha_1 \ln\left(\frac{y_{it}^{2}}{y_{it}^{1}}\right) + \frac{1}{2}\alpha_{11}\ln\left(\frac{y_{it}^{2}}{y_{it}^{1}}\right)^{2} + \gamma_0 t + \gamma_{y1}\ln\left(\frac{y_{it}^{2}}{y_{it}^{1}}\right)t + \frac{1}{2}\gamma_{11}t^{2} + \sum_{k=1}^{5}\beta_k \ln x_{itk} + \frac{1}{2}\sum_{k=1}^{5}\sum_{l=1}^{5}\beta_{kl}\ln x_{ik}\ln x_{il} + \sum_{k=1}^{5}\varphi_{1k}\ln x_{itk}\ln\left(\frac{y_{it}^{2}}{y_{it}^{1}}\right) + \sum_{k=1}^{5}\gamma_{xk}\ln x_{itk}t + \varepsilon_{it} \qquad i = 1,2,\ldots,41$$

$$\varepsilon_{it} = -u_{it} + v_{it}$$

where y_{it}^{1} is CO_2 emissions from land use change, and y_{it}^{2} is the aggregate agricultural production; x_{kit} is the *k*-th input used by the *i*-th country; *k* and *l* are traditional inputs; *t* is the time trend (t=1,…46); and $\alpha, \beta, \gamma, \varphi$ and ϕ are the parameters to be estimated.

❖ METHODS

Approach 2: Parametric Stochastic Translog Production Frontier

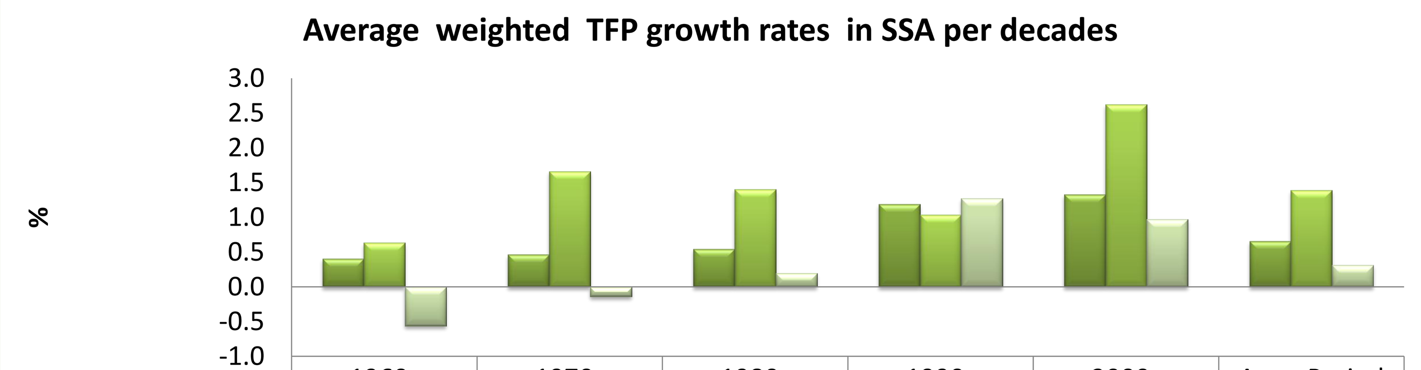
$$\ln Y_{it} = a_0 + \sum_{j=1}^{6} b_j x_{ijt} + \frac{1}{2}\sum_{j=1}^{6} c_{jj}x_{jj}^{2} + \sum_{j=1}^{6}\sum_{k>1}^{6} c_{jk}x_{ijt}x_{ikt} + b_1 t + \frac{1}{2}b_{tt}t^{2} + \sum_{j=1}^{6} b_{jt}x_{ijt}t + \varepsilon_{it}$$

$$i = 1,\ldots,41$$

$$\varepsilon_{it} = -u_{it} + v_{it}$$

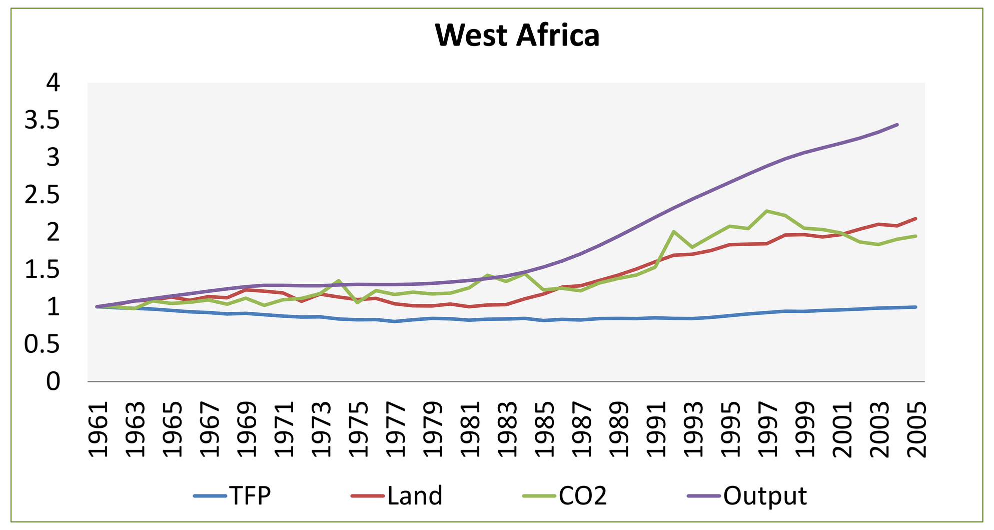
where *j* and *k*=1,…,6 the inputs; Y_{it} is the aggregate agricultural production; t is time (t=1,…45); a, b, c are parameters to be estimated.

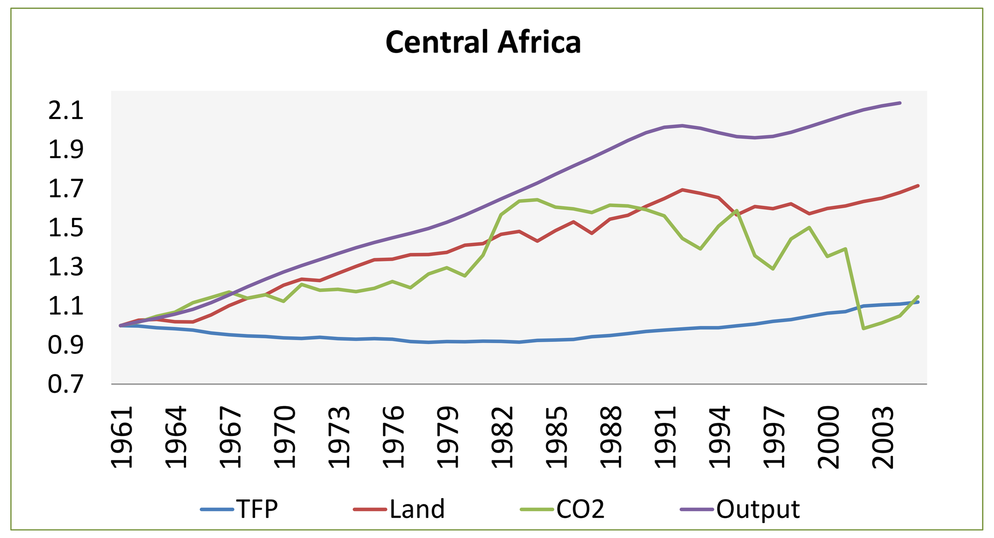
❖ RESULTS

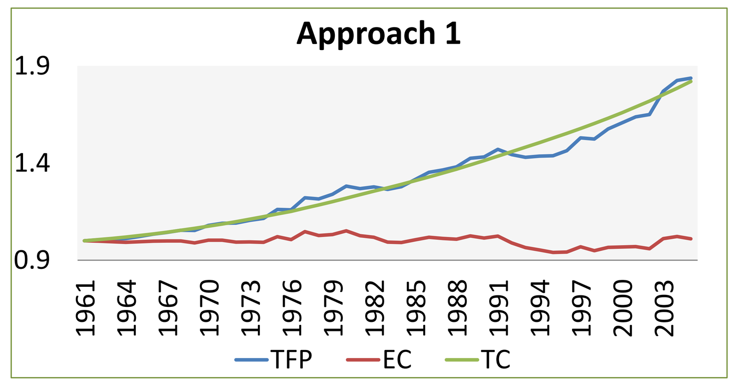


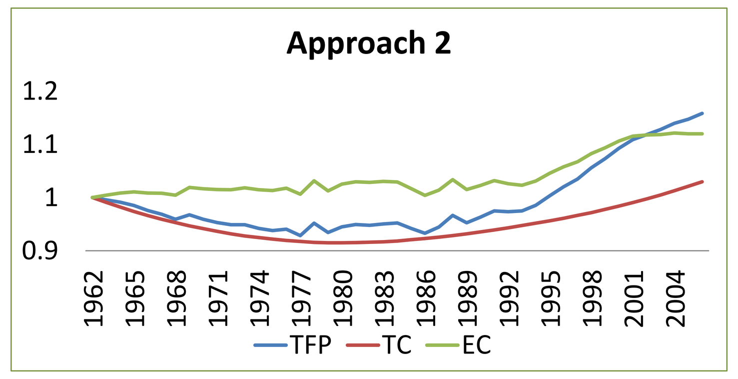
	1960s	1970s	1980s	1990s	2000s	Aver. Period
No CO2 considered	0.41	0.46	0.54	1.19	1.33	0.66
Method 1	0.64	1.66	1.40	1.04	2.62	1.39
Method 2	-0.56	-0.14	0.20	1.27	0.97	0.31

TFP = total factor productivity rate
Weighted by aggregate agricultural production

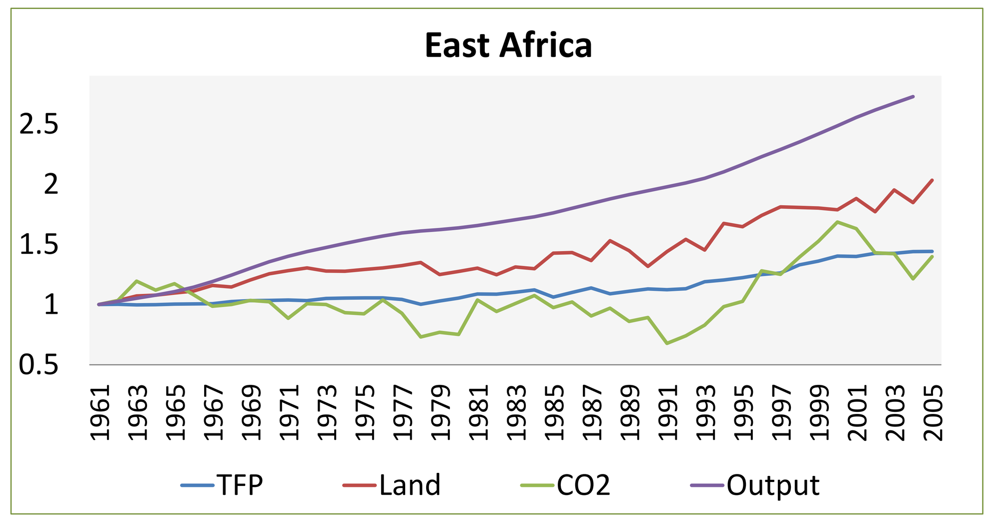


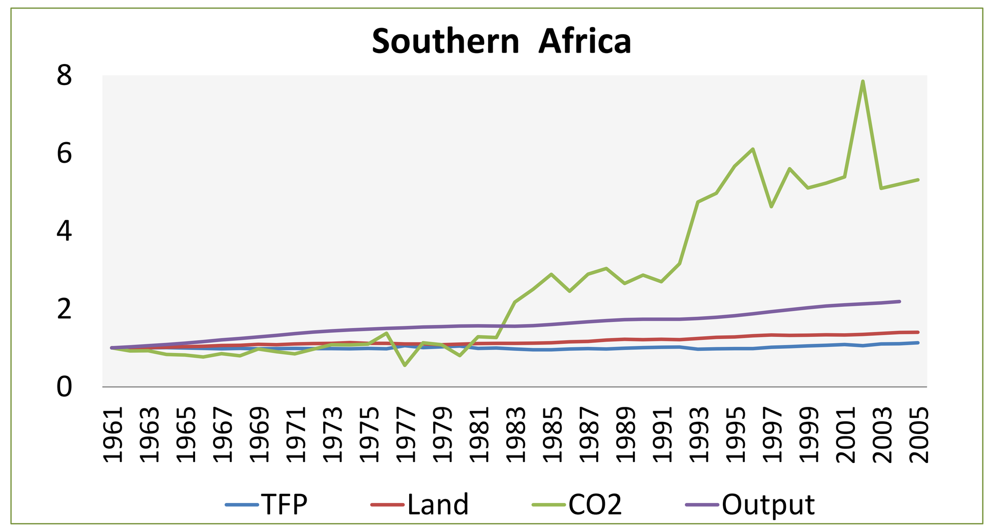






TC = technical change
EC = efficiency change





❖ CONCLUSION

- when CO_2 is a joint output, TFP growth rates are higher as the amount of inputs are used to produce two outputs instead of one.
  - What is being compared is the growth in two output versus the growth of one output (the output distance function does not differentiate between a desirable and undesirable output).
- When CO_2 emissions due to clearing are treated as an input to production, it is effectively treated as a "bad" output.
  - CO_2 emissions is effectively treated as a "bad", and punishes the system with lower TFP growth rates.
- Extension of the study would be to examine the extent to which countries are becoming more efficient over time by increasing desirable output while reducing CO_2 emissions.

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