The Drivers and the Speed of Agricultural Intensification in Uganda

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Objectives

- **Applying the Boserup-Ruthenberg Framework of the Evolution of farming systems** towards higher intensification and crop-livestock interaction, agricultural technology and farm output that is driven by population density and market access with new LSMS-ISA Household Panel Level Data produced by the World Bank on SSA countries.

- **Characterize the farming systems and technology in use for each of the hundreds of EAs of the surveys up to 6 countries of Africa** (Malawi, Tanzania, Uganda, Ethiopia, Nigeria and Niger).

- **Part of a larger project promoted by AfDB and WB on “Agriculture in Africa: Myths and Facts”**
  - Making use of HH level data to revisit the agriculture stylized facts.
  - Provide governments and policy makers with a solid picture of Africa’s agriculture to increase the effectiveness of food security programs.
  - Establish a publicly available harmonized cross-country database of core agricultural and food security variables Stimulate analysis of African agricultural and food security policy.
Background and Motivations

• The Boserup-Ruthenberg framework was tested by Pingali, Bigot and Binswanger (1987) using a sample of around 50 locations in sub-Saharan Africa (SSA) for which they collected the farming systems and technology characteristics using focus group discussions.

• Binswanger, Khandker and Rosenzweig (1993) showed for India, depending on the variable, in a cross section between 40 and 70 percent of the variation in each of the dependent variables could be explained by agroclimatic potential variables alone. None of the dependent variables can therefore be assumed to be exogenous to the agroclimate => PANEL DATA in which the agroclimatic fixed-effects can be removed via the use of the within estimators.

• 30 years later we now want to update this study using the new LSMS-ISA data sets in order to complement with additional determinants of farming systems, technology in use and output, namely a broad set of infrastructure variables, access to agricultural services, changes in available technology, and the impact of prices and wages.
More recent literature

- Turner et al, (1993): historical evolution of farming systems in 10 high population density areas of Kenya, Rwanda, Uganda and Nigeria: and found that higher population density led to intensification + increased higher labor use and agricultural output, land investments, little increase of mechanization and capital investment, and little or no land degradation

- Baltenwick et al (2003) analysis of 48 sites in 15 countries of Africa, Latin America, and Asia: review focused on crop-livestock integration implemented by McIntire et al. (1992), find that the forces of population density and market access transcend national and continental specificities and applied well across the study sites in all three continents. Their reviews, following McIntire et al (1992), focuses especially on crop-livestock integration and confirm the general trends and more detailed findings of these authors
Research questions:

- Is higher population densities leading to increasing agricultural production and productivity, agricultural development, higher rate of technical change, intensive use of land autonomously through the development of market forces?

- Historically in Europe and Asia: higher population pressure => higher demand => autonomous growth in agriculture driven by market forces.

- Lack of spontaneous agricultural intensification requires higher public policy support, and incentives for shifting to higher value or productive crops, or more productive land, the so-called policy-led intensification of agriculture.

- Understand why evolution of farming system in SSA has not followed pattern of Europe of Asia. Reduced mechanization because farming system has not progressed from shifting cultivation while rising population density.
Estimation Strategy (1)

- Short term: Explaining the farming systems characteristics, technologies, aggregate output and inputs using ultimate reduced form regressions with the cross section data as they become available.

- Long term: use more informative panel data analysis first for the Uganda Panel data from 2005/06 and 2009/10, and then for the other countries as and when the panel data become available.

- Estimate Reduced form equations using EA level variables from HH level national representative surveys combined with globally available crop modeling work of the GAEZ system of IASA and FAO to calculate for each enumeration area the innate agroclimatic potential.
Analytical Framework

- Let index $i$ stand for household, $j$ for the Enumeration Area and $k$ for the $k$th dependent variable that characterizes the farming system. The ultimate reduced form regression then will take the form

$$ D_{ijk} = f(\Omega_j) $$

(1)

- Where $D$ stands for any of the dependent variables and $\Omega$ stands for the agroclimatic potential

- The Dependent variables $D_k$ are
  - $\Psi$ = Agroclimatic Population density
  - $I$ = Road density or a vector of infrastructure variables
  - $Q$ = Aggregate crop output per ha
  - $\pi$ = Farm profits
  - $C$ = Aggregate capital stock or a vector of capital stock
  - $R$ = Irrigation
  - $T$ = High yielding varieties, or a vector of technologies in use
  - $\tau$ = A variable that characterizes available technology, such as research expenditures
Data and Descriptive Statistics

- We use household and community level data from the LSMS-ISA Uganda 2009-2010 located into 4 rural areas (Center, East, North, and West) and characterized by 4 AEZ.

- We restrict our analysis on 280 EAs and transform HH/Community level data into EAs data.

- We complement our dataset with GIS data (5x5 pixel) on Agro Ecological Zone/HarvestChoice GAEZ/IASA (International Institute for Applied Systems Analysis (2009 and 2011), and FAO, 2010.

- And population density from the Uganda National Livestock Census 2008 (representative only at District level).
UGANDA:
The Tropic Agro-ecological Zone

<table>
<thead>
<tr>
<th>AEZ</th>
<th>Temperature</th>
<th>LGP (days/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropic Cool Humid</td>
<td>&lt;20 C</td>
<td>270-364</td>
</tr>
<tr>
<td>Tropic Cool sub-humid</td>
<td>&lt;20 C</td>
<td>180 to 269</td>
</tr>
<tr>
<td>Tropic Warm Humid</td>
<td>&gt;20 C</td>
<td>270-364</td>
</tr>
<tr>
<td>Tropic Cool sub-humid</td>
<td>&gt;20 C</td>
<td>180 to 269</td>
</tr>
</tbody>
</table>

Source: HarvestChoice
Agricultural Intensification:

*in Humid Areas*: bimodal distribution

*in Sub-Humid Areas*:
- Cool areas: inverted U-Shape
- Warm areas: increasing trend
Agro-ecological potential

\[ \Omega_j = \sum_i S_{ij} P_i Q_{ij} \]

- i stands for crops, and j for the EA
- Where \( S_{ij} \) weights: is the cropping pattern computed at the HH level, share on land under the top 25% crops in terms of value of production in 2009/2010 (extracted by FAOSTAT)
- \( Q_{ij} \) is the agroclimatic yields for each crop at intermediate input level) from IIASA/GAEZ
- International prices: Pink Sheet and the AMAD (Agriculture Market Access) - World Unit Value Database WUV: we compute a price centered at 2008 with 5 years average for each crop.
Agro-Ecological Potential

**in Humid Areas:**
Lower probabilities of having higher Ag. potential

**in Sub-Humid Areas:**

- **Cool areas:** Inverted U-Shape => decreasing probabilities of higher potential
- **Warm areas:** increasing probabilities of higher potential

Higher probabilities of having LOW AEP in densely populated areas.
In High Pop. Dens. Areas higher probabilities of having shorter fallow, and low probabilities of Having longer fallow.
Reduced Form Regression: clustering for AEZ and robust standard errors

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Log Pop. Density</th>
<th>Log Own Area</th>
<th>Rvalue</th>
<th>Crop Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Agroecological Potential</td>
<td>0.59*</td>
<td>-0.37***</td>
<td>-0.21**</td>
<td>-0.22**</td>
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<tr>
<td>Log Agroecological Potential Square</td>
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<td>0.05***</td>
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<td>0.03**</td>
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<tr>
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<td>2.44***</td>
<td>2.35*</td>
<td>2.51*</td>
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<td>Observations</td>
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<td>280</td>
<td>280</td>
<td>280</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.46</td>
<td>0.17</td>
<td>0.06</td>
<td>0.08</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Log Length of Fallow</th>
<th>Proportion of land ever fallowed</th>
<th>Proportion of land irrigated</th>
<th>Probit HH used Improved variety</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Constant</td>
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<tr>
<td>Observations</td>
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<td>280</td>
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<td>280</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.11</td>
<td>0.07</td>
<td>0.01</td>
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</table>
Preliminary conclusions and next steps

- Some evidence of the Boserup-Ruthemberg Model. Autonomous intensification system.
- However this requires further and ad hoc policy intervention in order to speed up an exogenous and natural agriculture process
- Extend the model to UGA panel, although limitations of the time interval
- Extend the analysis to the remaining countries
- Investigate an “AEZ” type of regressions among countries in order to identify constraints to technology development of areas with similar characteristics.