Agricultural Household Models and Heterogeneity: Exploring Input Subsidy Impacts in Malawi

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The Setting/context and data

- Central (38% of population and 34% of the poor) and Southern (40 % of population and 50% of the poor) Regions of Malawi (WB, 2007)
- About 52.4% with income < poverty line in 2004 and 50.7% in 2010/11 (WB Malawi website 2014)
- After the introduction of the large scale targeted input subsidy program in 2005
- Agricultural smallholders with maize as the main staple food (93% of cereal consumption), majority deficit producers of maize
- Unimodal rainfall, rain-fed production mostly, hoe-based smallholder agriculture dominates, tobacco main cash crop for export
- Factor market imperfections (land, labor, inputs, credit) and household heterogeneity (land endowment, gender, subsidy access, other market access)
- Three years (2005/06, 2006/07, 2008/09) of household panel data during years with good rainfall from 450 households in 6 districts
- Detailed farm plot level data where all plots of households were measured with GPS

Theory/model characteristics

- Single year non-separable farm household models
  - Time recursive for cash-constrained input demand
  - Seasonality with year split in 11 periods according to the agricultural seasons
  - Calibrated sets of production activities to data
- Chayanovian drudgery averse peasant/subjective equilibrium theory (Nakajima, 1986)
- Hierarchical and weighted utility function (Holden, 1993)
  - 1.level: Satisfaction of basic food needs and taste preferences
  - 2.level: Residual net income – aggregate drudgery of work (weighted net income-lesure goal)
- Multiple market imperfections:
  - Labor markets – access limitations and seasonality
  - Land rental markets – access constraints and transaction costs
  - Input markets (fertilizers and seeds): Constrained access to subsidized inputs
  - Price bands for outputs
- Household heterogeneity in resource endowments, especially labor, land, and cash
  - Regional differences, Land-poor and land-rich male-headed hhs, Female-headed hhs.
- Policy issues: Subsidy levels/access; targeting, targeting errors and leakages; household heterogeneity and impacts; factor market imperfections/heterogeneity and impacts

Methodology/Key findings

- Calibrated simple linear programming models solved with Solver in Excel
  - Piecewise linearized utility function
  - Multi-dimensional constraints give non-linear responses
  - Sensitivity analysis: Assess the importance of specific forms of heterogeneity in market and household characteristics for policy impacts
- Explore policy impacts and specific impact mechanisms under alternative assumptions (market characteristics) for different household types under diverse *ceteris paribus* assumptions
- **Key findings**:
  - High risk that access to subsidized inputs crowds out commercial demand for fertilizer and improved seeds
  - Increasing land scarcity leads to increased demand for improved maize seeds
  - The ability to efficiently utilize subsidized inputs depends on the availability of complementary inputs and the severity of land, labor and cash constraints
  - Access to subsidized inputs relaxes the household cash constraint and this can have quite unpredictable side effects such as crowding in demand for fertilizer for tobacco production or change in land renting behavior
  - Land-poor households with limited access to *ganyu* employment are the most vulnerable group that depends most on/benefit most from input subsidies
  - Introducing better functioning land rental markets may facilitate land access for land-poor households
  - Investigate and suggest avenues for scaling down the subsidy program

Challenges faced in implementation/Limitations

- Data limitations
  - Detailed labor data from Malawi not available: Utilized my own detailed labor allocation studies in Zambia in similar hoe-based systems in calibration of seasonal labor requirements in production activities
  - Surveys did not include detailed consumption expenditure data
  - Survey data on off-farm income were weak, the modeling revealed that more such income was necessary for land-poor households to survive and purchase sufficient staple food (maize): Sensitivity analysis
- Staying within the limits of Solver/Excel (low cost/user friendly: KISS)
  - Limited sofistication of models
  - Still sofisticated enough to provide interesting insights! (?)
- Many types of heterogeneity not yet explored with the models such as;
  - Land quality variation, variation in ability/technological skills, risk, heterogeneity in preferences (such as risk preferences), variation in degree of rationality/irrationality of responses, variation in local general equilibrium effects due to limited market integration,
  - Many of these will require a switch to more sofisticated (expensive/less accessible) software and models

Model limitations/Impact assessment

- Static LP models developed so far:
  - Multiple constraints more important than fine-tuned functional forms in this context! (?)
  - No detailed consumption side (except minimum food requirements and taste preference restrictions on staple foods) in the models
  - Only crude poverty measure ("supernumerary income" – aggregate drudgery)
  - Assume strictly rational responses
  - Models without risk (based on years with good rainfall like the period 2006-2010) and have therefore ignored risk aversion/loss aversion
  - Further sensitivity analyses implemented: Variation in storage losses, transaction cost variation in factor markets, tobacco price shocks, reduced fertilizer use efficiency for subsidized fertilizer,

- Follow-up work (in progress)
  - Seasonality in input demand (Holden and Lunduka 2014 AJAE)
  - Risk and time preference experiments (2012)
  - Another survey round (drought year in 2011/12)
  - Price response experiments (paper with Sofie Skjeflo)
  - General equilibrium effects: Maize price and wage rate changes as indirect impacts from the input subsidy program

Some references

- Holden, S. T. (2014). Agricultural Household Models for Malawi: Household Heterogeneity, Market Characteristics, Agricultural Productivity, Input Subsidies, and Price Shocks. A Baseline Report. CLTS Working Paper No. 5/2014. Centre for Land Tenure Studies, Norwegian University of Life Sciences, Ås, Norway.

- Holden, S. T. and Lunduka, R. (2014). Input Subsidies, Cash Constraints and Timing of Input Supply. *American Journal of Agricultural Economics 96(1): 290–307.* **Link**

- Holden, S. T. and Lunduka, R. (2013). Who Benefit from Malawi's Input Subsidy Program? *Forum For Development Studies* 40(1), 1-25. **Link**

- Holden, S. T. and Lunduka, R. (2012). Do Fertilizer Subsidies Crowd Out Organic Manures? The Case of Malawi. *Agricultural Economics* 43, 301-312. **Link**

- **Other working papers: http://www.steinholden.com/fertilizes.html** or **www.umb.no/clts/article/clts-working-papers**