Risk exposure and wealth inequality in a pre-modern society (Work in Progress)

Dorice Agol
(Friends of Lake Turkana)

Konstantinos Angelopoulos
(University of Glasgow and CESifo)

Spyridon Lazarakis
(Lancaster University)

Rebecca Mancy
(University of Glasgow)

Elissaios Papyrakis
(Erasmus University)

15/07/2022, CRETE 2022
Acknowledgements

- This work was supported by Global Challenges Research Fund Small Grants (2018-2020).
- We are grateful for support from Friends of Lake Turkana, and thank the field research team based in Turkana for their contribution to data collection and processing.
- Rebecca Mancy is grateful for support from the Leckie Fellowship.
- The views expressed here are solely our own.
Theoretical Motivation

- Models with incomplete financial markets and heterogeneous agents facing idiosyncratic risk form the workhorse used to analyse wealth inequality and the economic implications of idiosyncratic risk.

- For example, see the extensive literature following the seminal contributions of Bewley (1986), Imrohoroglu (1989), Aiyagari (1994), and Huggett (1994).

- In these models, lack of insurance implies that shocks pass through to wealth accumulation via incentives to smooth consumption over time and across states of nature.
Theoretical Motivation

- Although extended models based on this idea have been successful in capturing many aspects of inequality in developed economies, empirical validation of this premise requires a context where the basic conditions are met.
- These conditions are difficult to satisfy in complex developed economies. Why?
- Because, there are several financial instruments, various frictions, different opportunities, occupations and skills etc...
- The complexity of advanced economic systems and of relevant shock processes imply likely measurement error (wealth/shocks) and misspecification of the channels for the effects of shocks.
Theoretical Motivation

- Put it differently, how can we be sure that a model with usually one asset and one source of risk is the appropriate tool to examine wealth inequality?
- If the shocks-responses explanation is correct, it should be (at least as) successful in an environment where wealth, shocks, and the channels by which they act, are as well defined as possible. Is it?
Research Question

• Can imperfectly insured idiosyncratic shocks to resources explain wealth inequality if households have the same preferences, constraints and opportunities?

• To answer this Q, we need to "test" the theory in a context where the basic conditions are met.

• Answering this question constitutes a test of the premise underlying a major strand of quantitative macroeconomic analysis of wealth inequality.
Turkana Pastoralists

- The pre-modern society of Turkana pastoralists in Kenya meets these conditions because households are very similar in terms of lifestyle, preferences, constraints and opportunities, permitting falsifiable testing of this theory.

- *Our results provide full support for the generality of the theory.*
Second Research Question (work in progress though)

- We aim to quantify the contribution to inequality and deprivation of different sources of shocks to households (reflecting drought risk, livestock risk, human productivity risk, and employment/additional income risk).

- *Our results highlight the devastating impact of droughts on poverty, but also inequality.*

- *Our analysis contributes to assessing the impact of governmental and non-governmental interventions to alleviate the effect of negative shocks.*
Turkana Pastoralists

- Turkana pastoralists in Kenya live in arid and semi-arid rural areas (85% of population of Turkana).
  - Rely strongly on herding (primarily goats and sheep)
  - Have limited access to essential services and infrastructure (mainly in towns)
  - Are exposed to shocks (rainfall, human and animal health and productivity)
  - Basic intervention from NGOs and local/national government
  - Basic commercial activity/industry (mainly in towns), but limited opportunity for income other than livestock
Turkana Pastoralists
Situation in Turkana relative to Western economies

- Wealth is predominantly (or in effect) livestock
  - More easily *defined* and *measured* compared to developed economies.

- Livestock accumulation is, in practice, the only insurance option.
  - As close as we can get to a *single-asset economy*

- Uncertainty (risk) affecting livelihoods is very high but sources are known
  - Stochastic processes can be measured and risk should be a critical factor driving both poverty and inequality

- Households have similar lifestyles and technology for resource generation
  - As close as we can get to *ex ante identical* households?
# Wealth inequality in pastoralist societies

<table>
<thead>
<tr>
<th>Tribe</th>
<th>N</th>
<th>Gini</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datoga</td>
<td>189</td>
<td>0.386</td>
<td>livestock</td>
</tr>
<tr>
<td>Juhaina Arabs</td>
<td>33</td>
<td>0.346</td>
<td>camels</td>
</tr>
<tr>
<td>Sangu (Ukwaheri)</td>
<td>130</td>
<td>0.694</td>
<td>cattle</td>
</tr>
<tr>
<td>Yomut (Charwa)</td>
<td>22</td>
<td>0.599</td>
<td>patrimony (livestock)</td>
</tr>
<tr>
<td>Turkana</td>
<td>1275</td>
<td>0.52</td>
<td>livestock units</td>
</tr>
<tr>
<td>Turkana</td>
<td>1275</td>
<td>0.48</td>
<td>livestock numbers</td>
</tr>
</tbody>
</table>

\(^a\)Borgerhoff Mulder et al. (2009, 2010)
Dataset

- We collected quantitative data via a survey of 1,347* pastoralist households (data on 9,179 individuals in total) in Turkana County, Kenya, during November-December 2018.
- Dataset includes information on individual-level and household-level characteristics:
  - Household composition and demographic variables (including age, gender and education of household members)
  - Productive and non-productive periods including paid work outside of the household (for 2017 and 2018)
  - Detailed livestock numbers (goats, sheep, etc.) and livestock population dynamics (births, deaths, theft, sales and purchases; for 2017 and 2018)
  - Information on important durables (e.g. vehicles)
  - Other economic activities (e.g. running a business, selling at the market or at roadside, etc.)
  - Access to financial markets.
Modelling approach

- We develop a model of the link between idiosyncratic risk exposure and wealth inequality: a stochastic model in which economic agents engage in the economic activities that are relevant for Turkana pastoralists, in the appropriate stochastic environment.

- The model belongs to the family of incomplete markets heterogeneous agent models with idiosyncratic and aggregate risk, going back to e.g. Aiyagari (1994) and Imrohoroglu (1989) (hence, wealth inequality is driven by stochasticity and human responses), but the model specification reflects the environment in Turkana.

- We exploit the information we have collected via the household survey to measure wealth inequality, calibrate the model and estimate the relevant stochastic processes.
The model: Stochastic environment

Four random variables (NB: common persistent aggregate shock is drought):

- Growth rate of livestock units capturing the net annual increase in livestock that is due to factors such as births, deaths and theft.
- Human effective labour time (i.e. devoted to production) capturing shocks due to exogenous circumstances like ill health, need to care for others or devote time to matters that do not generate resources (persistent idiosyncratic shocks).
- Additional income capturing e.g. minimum income support from local/national authorities, NGOs and from the community, and income from trade or employment (idiosyncratic).
- Natural resources for non-meat production capturing e.g. water, pasture, wood for charcoal/construction, materials for basket weaving, trees providing food for animals, and fruits and seeds for humans (persistent aggregate shocks).
The model: the problem of the household

The problem of a typical household is given by

$$\max_{\{c_t, a_{t+1}\}_{t=0}^\infty} E_0 \left\{ \sum_{t=0}^\infty \beta^t u(c_t) \right\} , \tag{1}$$

where $\beta \in (0, 1)$, subject to the resource constraint, which is expressed in protein content units

$$c_t + a_{t+1} = (1 + l_t) a_t + \eta y_t + e_t , \tag{2}$$

with $c_t \geq \eta y_t \geq 0$,

where $\eta \equiv \frac{p^o}{p^m}$, $p^m$ is the protein content (valuation) of one unit of livestock (as meat, i.e. 455kg of cattle) and $p^o$ the protein valuation of one unit of milk-equivalent non-meat home production, $y_t$ (one tonne of milk).
The model: the problem of the household

- Non-meat output captures home production output in the form of dairy, gathering of fruits and seeds from trees, charcoal, materials for the construction of the boma (providing basic accommodation), or transportation services (e.g. of water).

- We assume that it is given by a constant returns to scale production function that uses as inputs human effective labour services ($h_t$), and a the non-human stock comprised of livestock ($a_t$) and an open access natural resource ($w_t$):

$$y_t = M h_t^\gamma (\omega a_t + (1-\omega) w_t)^{(1-\gamma)} , \quad (3)$$

- We impose the constraint $c_t \geq \eta y_t$ because the home production $y_t$ cannot be directly transformed into livestock, and there are no markets for these goods in rural Turkana (market income is captured by $e_t$)
Solution: the household

- We solve the household’s problem using stochastic dynamic programming.
- The policy function $a_{t+1} = g^d(a_t, l_t, h_t, e_t|d_t)$ exists and is unique and continuous.
- An invariant distribution for each household exists, and we confirm that for the model calibration below, this invariant distribution is unique.
Solution: the cross-section

- We compute the time series of cross-sectional distributions in a situation where each household evolves over time according to the invariant distribution.
- At the household level, the time series is consistent with the invariant distribution.
- However, the cross-sectional distribution changes over time, driven by aggregate shocks:
  - Aggregate fluctuations imply non-existence of a time-invariant cross-sectional distribution.
  - Instead, the equilibrium reflects a situation in which the cross-sectional distribution fluctuates in response to aggregate shocks (droughts).
Calibration: livestock growth risk

- Data-based discretisation proposed in Toda (2018)
Calibration: Human effective labour time risk
Calibration: Droughts

- First, we use geospatial precipitation data for the location of interest from the International Research Institute - World Bank (2019) 1920 to 1960.
- Second, we use same type of data from www.worldclim.org, from 1961 to 2018
- Inspired by McPeak et al. (2011) we calculate a measure of droughts by examining whether the rainfall fails during the rainy seasons by examining the deviation from the monthly long-run mean. Note that there are two rainy seasons in Turkana, the so called the Long (March-May) and the Short Rains (Oct-Dec).
- Then, we average over months to name a year as drought year.
Calibration

\[ \gamma = 0.5 \]
\[ \sigma = 1.5 \]
\[ \eta = 0.3769 \]
Calibration

Three targets

1. Average livestock units $= 0.5665$ (averaged over 2017 and 2018)
2. The proportion of households with less than 5% of the average livestock units $= 5.3$
3. Consumption of 0.146 tonnes of milk per capita annually (long term average 2006-2019, NDMA March 2020, Turkana County)

Three parameters to calibrate internally: $\{\beta, M, \omega\}$
The distribution changes over time
Empirical wealth distributions: Shocks explain inequality
Shocks explain inequality: Model versus data

Graphs by state
Droughts are important: Especially for mean livestock and absolute poverty

<table>
<thead>
<tr>
<th>Abs Poverty</th>
<th>Av. Livestock</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>0.11</td>
<td>0.65</td>
</tr>
<tr>
<td>model</td>
<td>0.21</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.51</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rel poverty</th>
<th>top10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>0.21</td>
</tr>
<tr>
<td>model</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future steps

- Policy experiments
- Further robustness checks (interrelation between human health risk and livestock risk)
<table>
<thead>
<tr>
<th></th>
<th>Cl95%</th>
<th></th>
<th>Cl95%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>LB</td>
<td>UB</td>
</tr>
<tr>
<td>mean 2018</td>
<td>0.650</td>
<td>0.608</td>
<td>0.693</td>
</tr>
<tr>
<td>mean 2017</td>
<td>0.483</td>
<td>0.447</td>
<td>0.519</td>
</tr>
<tr>
<td>p9050 2018</td>
<td>3.573</td>
<td>3.218</td>
<td>3.928</td>
</tr>
<tr>
<td>p9050 2017</td>
<td>4.179</td>
<td>3.670</td>
<td>4.687</td>
</tr>
<tr>
<td>p5010 2018</td>
<td>4.861</td>
<td>4.086</td>
<td>5.637</td>
</tr>
<tr>
<td>p5010 2017</td>
<td>8.889</td>
<td>5.014</td>
<td>12.764</td>
</tr>
</tbody>
</table>