Poverty and Inequality Dynamics.

Ira N. Gang, Rutgers University
Ksenia Gatskova, IOS-Regensburg
John Landon-Lane, Rutgers University
Myeong-Su Yun, Tulane University

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Introduction and Overview

• This paper is our effort to employ rigorous empirical methods to the study of poverty dynamics.
  – Related to our earlier work on mobility and informal sector behavior
• We use a simple model of income to measure the movements into and out of poverty.
• Using this model we can
  – Predict changes to income distribution over the long run
  – Measure the size of the economy below the poverty line currently and predict its size over time
  – Measure the probability that any entity (individual, household) will fall into poverty in both short and long run.
  – Endogenously determine the size of the “at risk” or vulnerable population.
Introduction and Overview

• We apply our methodology to household level data from Tajikistan over the years 2007 to 2011.
  – We are able to observe two distinct periods
    1. A period of great stress (the global financial crisis)
    2. A period of recovery from a recession

• We construct a formal measure of vulnerability that is consistent with standard mobility axioms

• We show that the definition of those vulnerable to poverty is not fixed over time and varies substantially between “good” and “bad” times
A model of income dynamics

• We use a discrete state first order Markov model of income
• That is
  – We divide the income distribution into a finite number of non-overlapping intervals that cover the whole income distribution
  – Let \( \pi_t \) be the probability vector such that \( \pi_{jt} \) is the probability that a household has income that is contained in income classification \( j \).
  – We assume that
    \[
    \Pr(\pi_t | \pi_{t-1}, \pi_{t-2}, \ldots) = \Pr(\pi_t | \pi_{t-1})
    \]
    – That is, this period's income distribution is a function of last period's income distribution only.
  – Note: More complicated structure can be accommodated in our framework as higher ordered Markov models can be reformulated as a first order model given the appropriate transformation of the state space.
A model of income dynamics

• The Markov transition probability matrix $P$ is a matrix

\[ P = [p_{ij}] \]

• $p_{ij}$ is the probability that a household moves from income class $i$ in period $t-1$ to income class $j$ in period $t$.

• We define the income classes in such a way as to model poverty and to endogenously identify the vulnerable part of the population.
Background

- The use of Markovian models to model income mobility has a long history
  - Champernowne (53), Prais (53)

- The use of the Markov transition matrix to measure mobility also has a long history
  - Shorrocks (78)
  - Geweke, Marshall and Zarkin (86)
  - Gang, Landon-Lane and Yun (04)

- We follow this literature in that our vulnerability measure is based on individual elements of $P$
Background

• All of our functions of interest are linear and non-linear functions of the elements of $\pi_t$ and $P$.

• These include
  – Limiting income distribution, $\bar{\pi} = \lim_{t \to \infty} \pi_t$
  – Measures of mobility $M(P)$
  – Measures of vulnerability $V(P)$
An illustrative example

• Suppose we break the income distribution up into 3 classifications
  – Class 1: below the poverty line
  – Class 2: an between the poverty line and twice the poverty line
  – Class 3: an income above twice the poverty line

Then

\[
\pi_t = \begin{bmatrix}
\pi_{1t} \\
\pi_{2t} \\
\pi_{3t}
\end{bmatrix}
\]

represents the state of the world in period \( t \).

• \( \pi_{1t} \) is the proportion of the population below the poverty line
An illustrative example

• The Markov transition matrix is

\[
P = \begin{bmatrix}
p_{11} & p_{12} & p_{13} \\
p_{21} & p_{22} & p_{23} \\
p_{31} & p_{32} & p_{33}
\end{bmatrix}
\]

• Here, e.g., \( p_{21} \) is the probability that a household that was in Class 2 in period \( t \) falls back to Class 1 in period \( t+1 \)
An illustrative example

• Our measure of vulnerability is a function of the probabilities in the first column of $\mathbf{P}$.

$$
\mathbf{P} = \begin{bmatrix}
  p_{11} & p_{12} & p_{13} \\
  p_{21} & p_{22} & p_{23} \\
  p_{31} & p_{32} & p_{33}
\end{bmatrix}
$$

• We define $V(\mathbf{P}) = \frac{\pi_{2t}p_{21} + \pi_{3t}p_{31}}{\pi_{2t} + \pi_{3t}}$ as our measure of overall vulnerability.
An illustrative example

• The measure given above is a 1-period measure.
• We can also define multiple period measures
• Under the assumption of stability we know from the Markov model that

\[ \pi'_{t+k} = \pi'_t P^k \]

• Let

\[ P^k = \begin{bmatrix} p^{k}_{11} & p^{k}_{12} & p^{k}_{13} \\ p^{k}_{21} & p^{k}_{22} & p^{k}_{23} \\ p^{k}_{31} & p^{k}_{32} & p^{k}_{33} \end{bmatrix} \]
An illustrative example

• Then the *k-period* vulnerability measure is

\[
V(P) = \frac{\pi_{2t} p_{21}^k + \pi_{3t} p_{31}^k}{\pi_{2t} + \pi_{3t}}
\]

• This is the unconditional probability that a household will fall below the poverty line after *k* periods.
Estimation and Inference

• In this paper we use Bayesian methods to
  • Estimate underlying parameters of the model (e.g. $P$)
  • Estimate functions of interest ($\pi$, $V^k(P)$)
  • Produce confidence intervals and do statistical tests

• Estimation of the discrete state first order Markov model is simple by Bayesian standards.
• No MCMC needed. The posterior distribution is known i.i.d. draws can be efficiently made from it.
• The priors are designed to reflect our prior uncertainty about the underlying parameters.
• Full details of the design and prior specification can be found in the paper.
Covariates

- While we do not use covariates in this paper a recent paper by Gang, Landon-Lane, and Yun (2014) shows how the marginal effects of covariates on functions of $P$ (e.g. mobility and vulnerability measures) can be estimated.
- Thus it is straightforward to add covariates to our analysis.
An application to Tajikistan

- In this paper we use a panel of households from the Tajikistan LSMS survey.
- We have a balanced panel for the year 2007, 2009, and 2011.
- One nice feature (for us at least) is that the global financial crisis hit in the midst of the first transition (2007-2009).
- Thus the first transition is one of crisis. A priori one would expect households to be more vulnerable to poverty during this period.
- The second transition from 2009-2011 was one of recovery.
- So we have two very distinct periods to study.
Background on Tajikistan

- Poor former Soviet republic who gained independence in 1991
- Between 2001-2010 GDP grew on average 8.8%.
- Poverty by headcount ratio was 46.7% in 2009.
- Remittance dependent economy – remittances account for 52% of GDP in 2009
- Large differences between urban and rural households, educated and non-educated households and households with and without migrants
Our Study

• We use household level income and expenditure data
• Total income includes
  – Total receipts from employment
  – Net transfers from govt
  – Remittances
  – The market value of assets consumed
  – The market value for good and services when payment for labor services was in kind
• We use per person household income relative to per person poverty line
Our Study

• We use World Bank 2007 study on poverty line and convert to current units for 2009 and 2011.

• Poverty line was
  – 139 Sonomi (pp) in 2007
  – 169 Sonomi (pp) in 2009
  – 214 Sonomi (pp) in 2011

• We divide the relative income variable into 10 classes

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1</td>
<td>1-</td>
<td>1.2-</td>
<td>1.4-</td>
<td>1.6-</td>
<td>1.8-</td>
<td>2-</td>
<td>3-</td>
<td>4-</td>
<td>5-</td>
<td>6+</td>
</tr>
</tbody>
</table>
First Transition 2007-2009

![Bar chart showing relative expenditure proportions for different expenditure ranges in 2007 and π∞. The chart compares the proportion of individuals in each expenditure range. The x-axis represents the relative expenditure categories (0-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6+), and the y-axis represents the proportion of individuals. The bars for π2007 and π∞ are shown side by side for each category.]
Second Transition: 2009-2011
Tajikistan

• 2007-2009 was a period of retrenchment
• 2009-2011 was a period of recovery.
• If 2009-2011 process was to continue then we would see a massive shrinking of proportion of population in poverty
Mobility Measures

- We report Shorrocks’ (1978) overall mobility measure and its decomposition into upward and downward components (Gang, Landon-Lane and Yun (2004))

<table>
<thead>
<tr>
<th>Sample</th>
<th>$M_s(P)$ (0.010)</th>
<th>$M_u(P)$ (0.013)</th>
<th>$M_d(P)$ (0.015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-09</td>
<td>0.966</td>
<td>0.289</td>
<td>0.677</td>
</tr>
<tr>
<td>09-11</td>
<td>1.002 (0.012)</td>
<td>0.636 (0.014)</td>
<td>0.366 (0.016)</td>
</tr>
</tbody>
</table>
## Vulnerability Measures

<table>
<thead>
<tr>
<th>Sample</th>
<th>$V^1(P)$</th>
<th>$V^2(P)$</th>
<th>$V^3(P)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>07-09</td>
<td>0.314 (0.015)</td>
<td>0.348 (0.014)</td>
<td>0.357 (0.015)</td>
</tr>
<tr>
<td>09-11</td>
<td>0.019 (0.004)</td>
<td>0.023 (0.007)</td>
<td>0.024 (0.008)</td>
</tr>
</tbody>
</table>
Vulnerability Measures

- The transition during the recession shows significantly more vulnerability than the recovery transition.
- Most of the vulnerability is in the first period.
- We will focus on the 1-period vulnerability going forward.
### 1-period vulnerability by covariate 2007-2009

<table>
<thead>
<tr>
<th>Covariate</th>
<th>$V^1(P)$</th>
<th>Covariate</th>
<th>$V^1(P)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>0.190 (0.020)</td>
<td>Remittances</td>
<td>0.204 (0.029)</td>
</tr>
<tr>
<td>Rural</td>
<td>0.351 (0.019)</td>
<td>No-Remittances</td>
<td>0.314 (0.016)</td>
</tr>
<tr>
<td>Informal</td>
<td>0.241 (0.018)</td>
<td>&gt; Secondary</td>
<td>0.245 (0.019)</td>
</tr>
<tr>
<td>No-informal</td>
<td>0.360 (0.023)</td>
<td>Secondary or lower</td>
<td>0.336 (0.020)</td>
</tr>
</tbody>
</table>
Determining the vulnerable population

Probability of Moving into Poverty: 2007-09

Relative income class

1-1.2 1.2-1.4 1.4-1.6 1.6-1.8 1.8-2 2-3 3-4 4-5 5-6 6+

Probability

0.0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4
Determining the Vulnerable Population 09-11

Probability of Moving into Poverty: 09-11

Relative income class

- 1-1.2
- 1.2-1.4
- 1.4-1.6
- 1.6-1.8
- 1.8-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6+

Probability distribution for different income classes.
Determining the Vulnerable Population

• For 07-09 transition then relative incomes up to 3 times the poverty line have more than 0.3 probability of falling into poverty.
• For 09-11 transition no income class has a probability of falling into poverty greater than 0.3.
Summary

• We have used existing methodology to show how poverty dynamics can be formally measured.
• It is simple to use
• Covariates can be included in the analysis
• The threshold for the vulnerable population can be endogenously determined.
• We applied the method to Tajikistan