

# Poverty and Inequality Dynamics.

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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

$$\Pr(\pi_t | \pi_{t-1}, \pi_{t-2}, \dots) = \Pr(\pi_t | \pi_{t-1})$$

- That is, this periods income distribution is a function of last periods 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  $\mathbf{P}$  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,  $\bar{\pi} = \lim_{t \rightarrow \infty} \pi_t$
  - 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  $\mathbf{P}$ .

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

- 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

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

## An illustrative example

- Then the *k*-period vulnerability measure is

$$V(\mathbf{P}) = \frac{\pi_{2t} P_{21}^k + \pi_{3t} P_{31}^k}{\pi_{2t} + \pi_{3t}}$$

- 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.  $\mathbf{P}$ )
  - Estimate functions of interest (  $\bar{\pi}$  ,  $V^k(P)$  )
  - 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  $\mathbf{P}$  (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

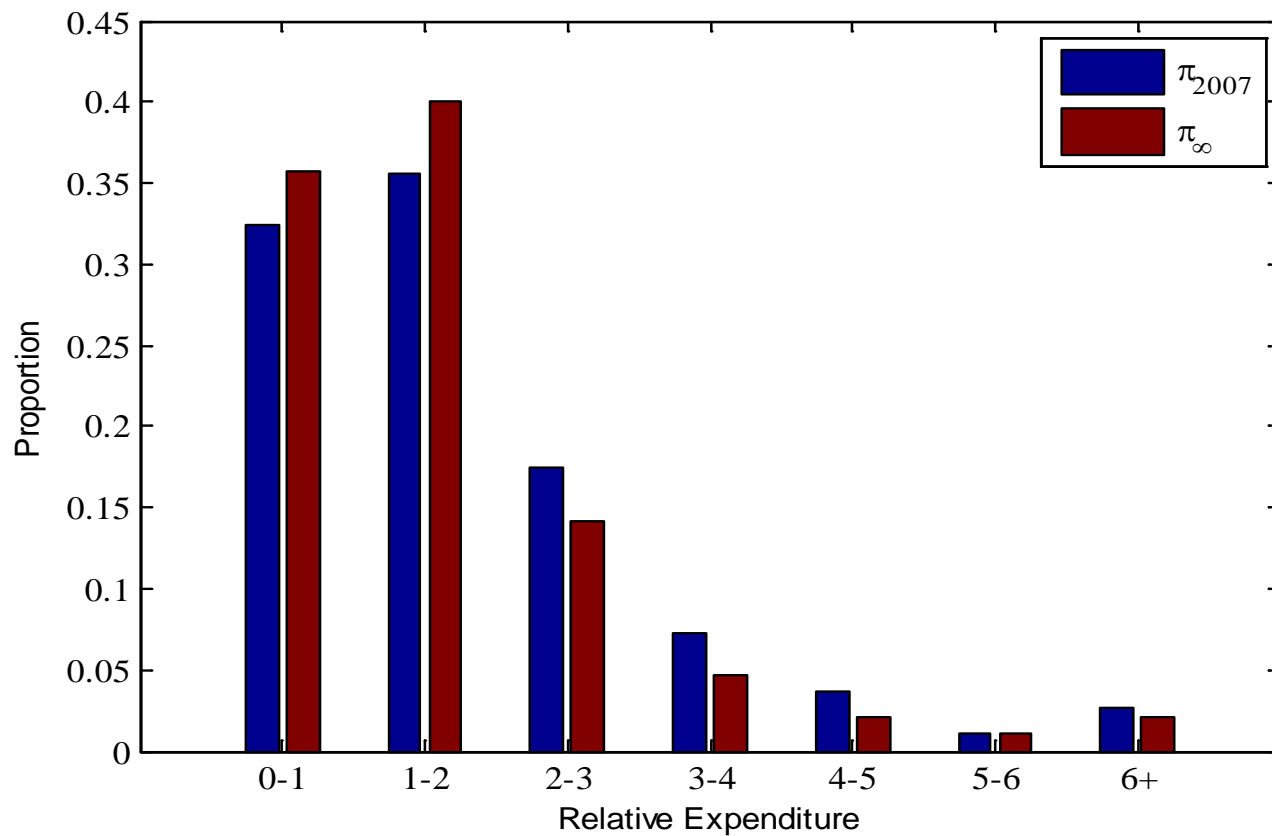
- We use household level income and expenditure data
- Total income includes
  - Total receipts from employment
  - Net transfers from govt
  - Remittances
  - The market value of assets consumed
  - The market value for good and services when payment for labor services was in kind
- We use per person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

# Our Study

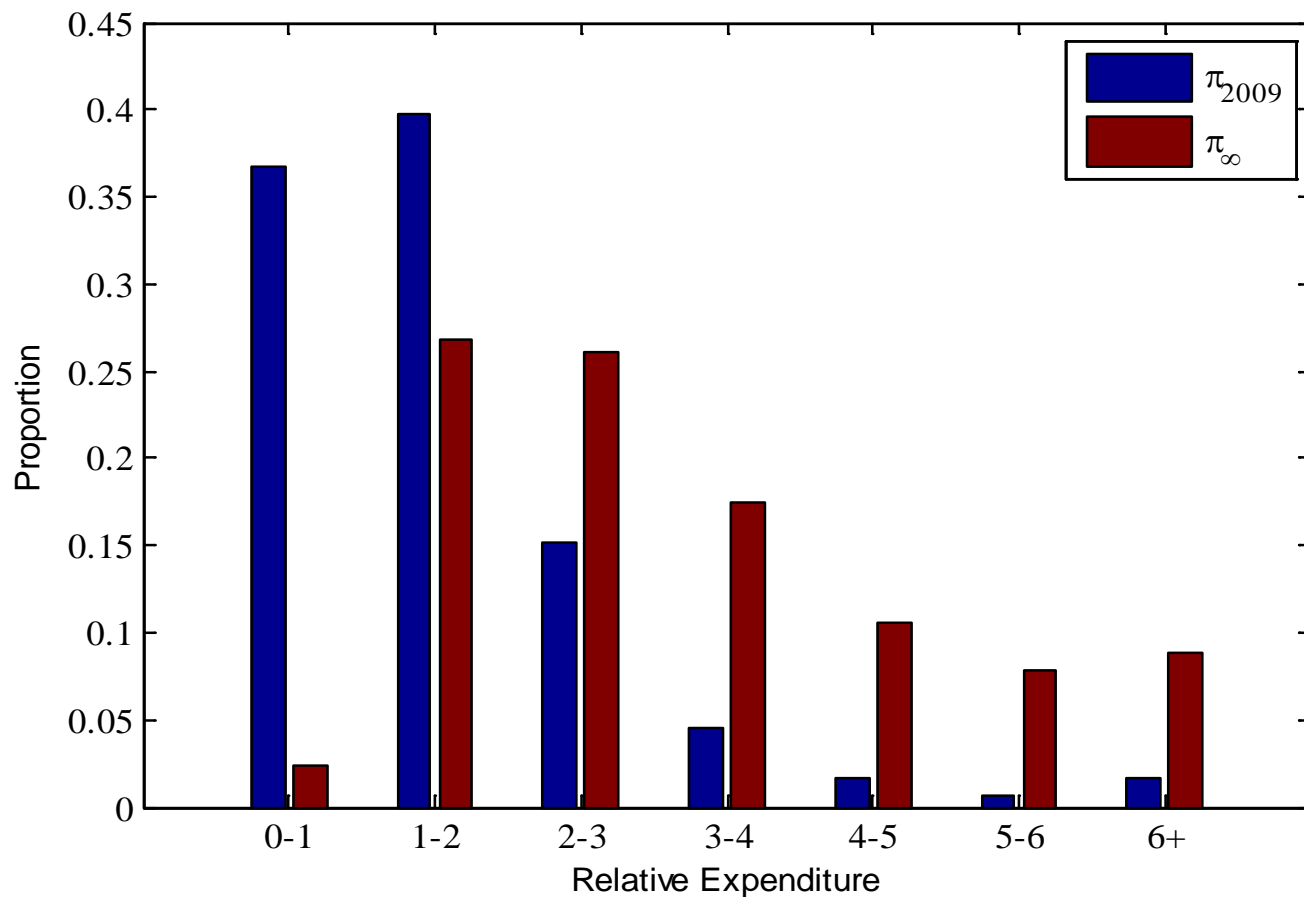
- We use World Bank 2007 study on poverty line and convert to current units for 2009 and 2011.
- Poverty line was
  - 139 Sonomi (pp) in 2007
  - 169 Sonomi (pp) in 2009
  - 214 Sonomi (pp) in 2011
- We divide the relative income variable into 10 classes

1	2	3	4	5	6	7	8	9	10	11
<1	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+

# First Transition 2007-2009



# 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))

Sample	$M_s(\mathbf{P})$	$M_u(\mathbf{P})$	$M_d(\mathbf{P})$
<b>07-09</b>	0.966 (0.010)	0.289 (0.013)	0.677 (0.015)
<b>09-11</b>	1.002 (0.012)	0.636 (0.014)	0.366 (0.016)

# Vulnerability Measures

Sample	$V^1(\mathbf{P})$	$V^2(\mathbf{P})$	$V^5(\mathbf{P})$
<b>07-09</b>	0.314 (0.015)	0.348 (0.014)	0.357 (0.015)
<b>09-11</b>	0.019 (0.004)	0.023 (0.007)	0.024 (0.008)

# Vulnerability Measures

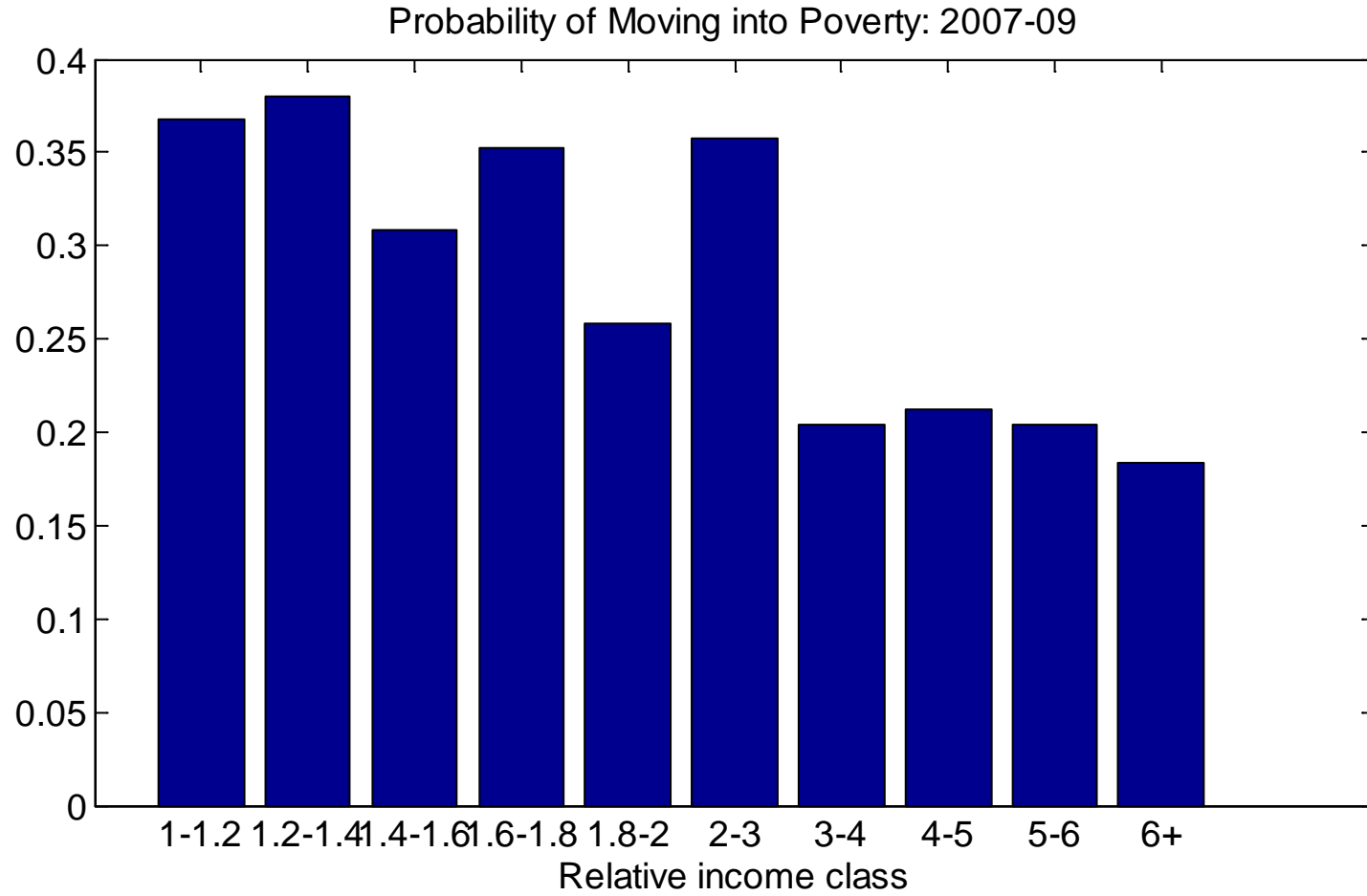
- The transition during the recession shows significantly more vulnerability than the recovery transition
- Most of the vulnerability is in the first period.
- We will focus on the 1-period vulnerability going forward



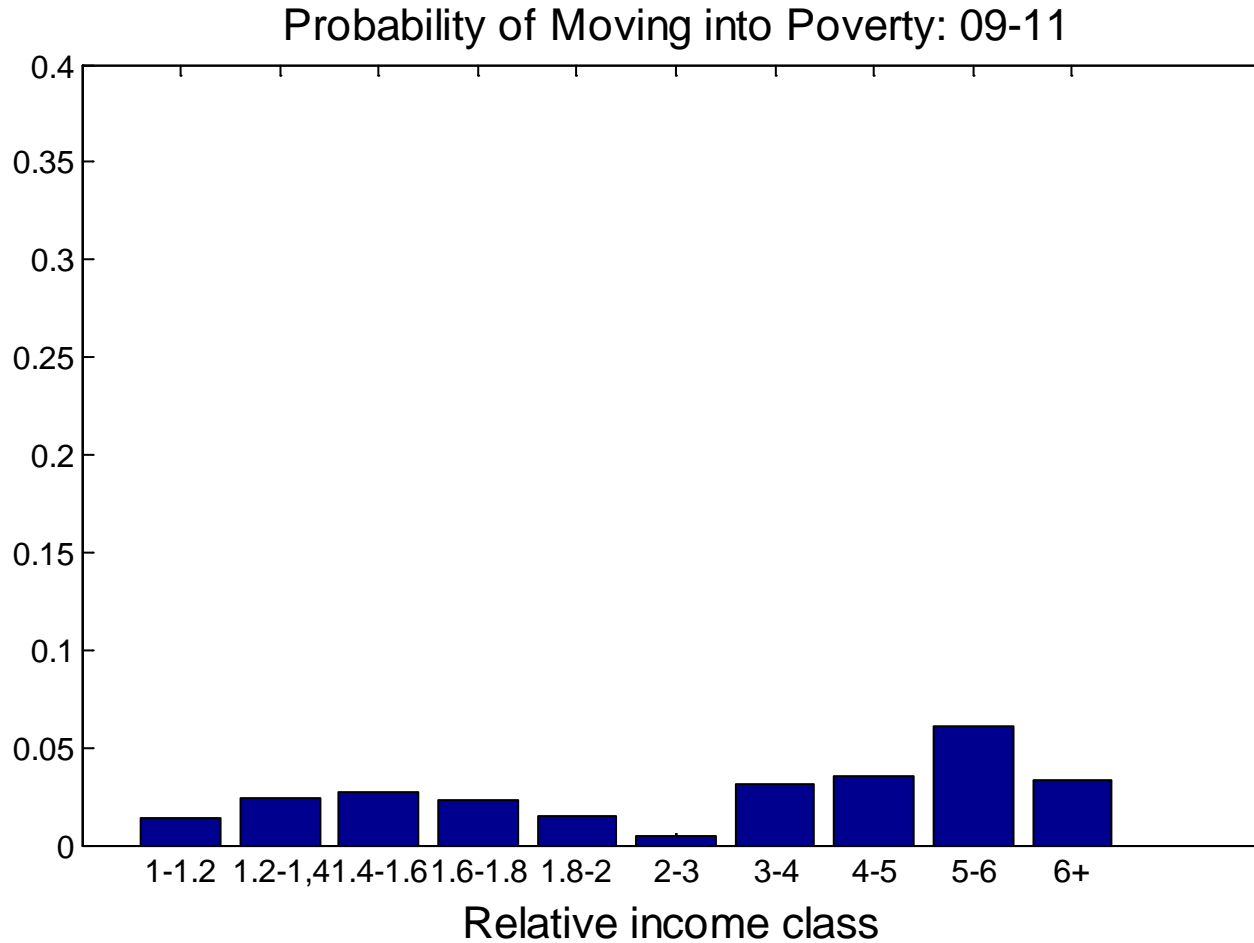
# 1-period vulnerability by covariate 2007-2009

Covariate	$V^1(\mathbf{P})$	Covariate	$V^1(\mathbf{P})$
Urban	0.190 (0.020)	Remittances	0.204 (0.029)
Rural	0.351 (0.019)	No-Remittances	0.314 (0.016)
Informal	0.241 (0.018)	> Secondary	0.245 (0.019)
No-informal	0.360 (0.023)	Secondary or lower	0.336 (0.020)

# Determining the vulnerable population



# Determining the Vulnerable Population 09-11



# 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