Measuring poverty over time -
Accounting for welfare variability

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ABSTRACT:

Standard poverty measures focus on static, single-period, snapshot view of poverty. This paper proposes two classes of dynamic poverty measures that extend the static Foster-Greer-Thorbecke poverty indices to account for intertemporal fluctuations in household welfare. The applications to panel data from rural Pakistan show that both methods for accounting for household income variability over time substantially increase estimates of intertemporal poverty incidence.

I. Introduction

Poverty measures tend to be static. Poverty rates calculated from single surveys give snapshot views of poverty. Even the assessment of poverty over time generally does not go beyond looking at poverty trends in the form of comparing snapshot cross-sectional poverty indices across time. While analytically simple, snapshot poverty measures are unlikely to fully characterize poverty over time at the level of the individual household and at the aggregate level of society.

At the individual household level snapshot poverty measures are independent of a household's income and poverty status in previous and subsequent periods. But of course these household income and poverty 'histories' can influence how one perceives poverty. For example, for a given amount of total income[1] over time, income variability reduces welfare under the standard assumption of additively separable, concave household utility. Poverty measures should reflect this.

One main objective of this paper is to develop new classes of poverty measures which are sensitive to households' income variability. A second objective is to compare these new measures with the few other measures proposed in the extant literature. These comparisons highlight that the choice of how to account for income variability will depend on the particular policy or evaluation objective. For example, the appropriate poverty measure would differ if the objective is to minimize the proportion of the

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[1] I use the term 'income' as a short-hand for material well-being. However, the discussion applies equally to any other uni- or multi-dimensional indicator of well-being.

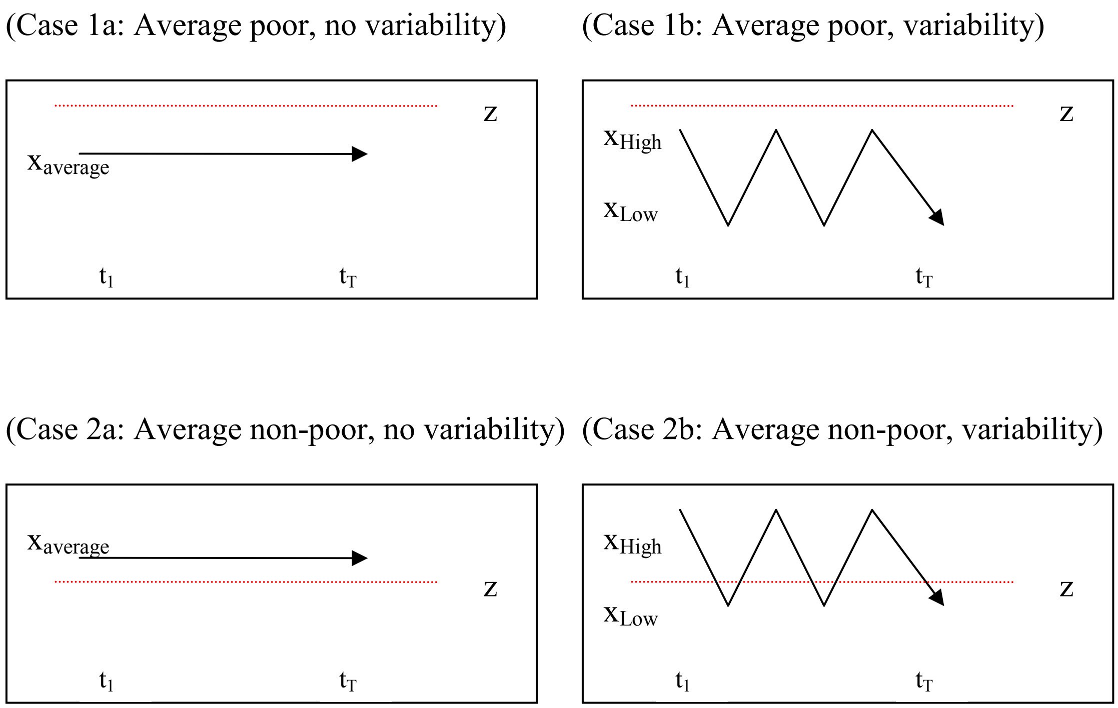
population that ever experiences poverty rather than, say, reduce the aggregate poverty cost from income variability. The third objective is to apply the new and existing poverty measures to survey data from rural Pakistan to demonstrate the extent to which different methods to account for income variability and the intertemporal distribution of poverty affect estimated poverty measures.

The next section proposes two classes of poverty and income measures that account for intertemporal variability in household incomes. Section 3 introduces the panel data from rural Pakistan. Section 4 provides estimates of the new proposed measures. Section 4 concludes.

2. Lifetime household poverty & income variability

The motivation for incorporating income variability into a measure of household poverty is depicted in Figure 1. The household income histories in case 1a and 1b have the same average income below the poverty line z, but does the income variability of 1b make it poorer than 1a? Similarly, 2a and 2b have the same average income, this time above z. Is 2b poorer than 2a? The answer is 'yes' in a wide variety of circumstances, for example, if households are averse to income fluctuations; if household incomes are not truly separable over time, for instance, due to imperfect access to financial markets; if there are irreversibilities so that households cannot physically and materially recover from periods in poverty; if there are stigma costs to having experienced poverty; or if there are disproportional costs associated with falling below a minimum level of welfare such as in the presence of welfare thresholds and poverty traps (Carter and Barrett 2006).

Figure 1 Stylized household income histories – with and without income variability



More generally, define two societies' intertemporal income profiles as matrices A and B in equation (1). x_{it} and y_{jt} denote incomes for households $i \in \{1,...,N\}$ and $j \in \{1,...,M\}$ at time $t \in \{1,...,T\}$.

$$A = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1T} \\ x_{21} & x_{22} & & x_{2T} \\ \vdots & & & \vdots \\ x_{N1} & x_{N2} & \cdots & x_{NT} \end{bmatrix} \quad B = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1T} \\ y_{21} & y_{22} & & y_{2T} \\ \vdots & & & \vdots \\ y_{M1} & y_{M2} & \cdots & y_{MT} \end{bmatrix} \qquad \textbf{(1)}$$

Assume that household[2] poverty over time is a function of the stream of incomes received over time and the variability of income. Lifetime poverty for household *i* is then a row aggregation of its income history, $\left(x_{i1},...,x_{iT}\right)$ and can be defined as:

$LP_i = V\left(x_{i1},...,x_{iT};Z\right)$ where $V:\Re^t \rightarrow \Re$ is the valuation function which maps the sequence of income histories and poverty lines into the real line and *Z* is a sequence of poverty lines $Z = \left\{z_1,..,z_T\right\}$.[3] Total lifetime poverty for a society can be expressed as: $TLP = P_{AGG}(LP_1,...,LP_q)$, where *q* is the number of households who are poor in at least one period and the function P_{AGG} aggregates across household lifetime poverties.

Two approaches for making intertemporal household poverty measures sensitive to income variability

The first method for making an intertemporal household poverty measure sensitive to income variability proposed here can be termed the *constant equivalent income* (*CEI*) approach. It calculates the level of constant income that would produce the same amount of poverty as the average poverty actually experienced by a household over time. The relative and absolute differences between this constant equivalent income and the actual average income are measures of the welfare cost of income variability.

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[2] Throughout the paper I refer to the 'household' as that is the level for which we generally have income survey data. However, we can think of it as the 'individual' for variables for which we have person-specific data, such as education, health or nutrition.

[3] In the applications this paper deflates the poverty line so that z is expressed in real terms and constant across all periods.

Let $\delta \in (0,1]$ be the discount factor and z be the constant real poverty line. For each *i* we can find a constant equivalent income $\bar{x}_i$ which gives the same illfare from poverty as *i*'s actual income stream. For α>1, the constant equivalent income poverty (*CEIP*) for the Foster-Greer-Thorbecke (FGT) class of poverty measures (Foster *et al.* 1984) can be written as:

$$CEIP_i(\alpha) = \frac{1}{T}\sum_{t:x_{it}<z}\delta^t\left(\frac{z-x_{it}}{z}\right)^{\alpha} = \begin{cases}\left(\dfrac{z-\bar{x}_i}{z}\right)^{\alpha} & if\ \bar{x}_i < z \Leftrightarrow \exists x_{it} < z \\ 0 & if\ \bar{x}_i \geq z \Leftrightarrow x_{it} \geq z \forall t \in T\end{cases} \quad \textbf{(2)}$$

α represents the level of aversion to income variability. For a given income history, when α increases $\bar{x}_i$ falls. Note that when δ<1 the impact of incomes further in the past is reduced. Discounting can therefore account for income trends. For example, given the same level of average income and variability, if δ<1 a household is judged to be poorer if its income stream is on a downward, rather than upward trajectory.

The *CEIP* definition in equation 2 distributes any poverty *i* experiences equally across all *t*. Hence, in addition to aversion against variability the *CEI* approach implies strong poverty aversion in the sense that there is no intertemporal compensation of welfare. Hence, household *i* can never fully recover from having ever fallen into poverty.[4] This could reflect potential stigma costs of poverty and any associated losses in social networks (Citation?? As this is a key difference in application of this poverty measure).

[4] Poverty aversion here does not mean giving periods in deeper poverty more weight in the welfare function as is the case for, e.g., the P-2 measure.

In equation 2 this property is ensured by the discontinuous shape of the FGT function. Households can, however, compensate for different depths of poverty across all periods spent in poverty.

Households' *CEI's* can be plugged into a FGT measure to yield a simple measure of the total average lifetime poverty for society: $TLP = \frac{1}{N}\sum_{i:\bar{x}_i<z}\left(\frac{z-\bar{x}_i}{z}\right)^{\alpha}$. Using equation 2 to replace $\bar{x}_i$ with x_{it} and rearranging gives

$$TLP = \frac{1}{N}\sum_{i:\bar{x}_i<z}\left(\frac{1}{T}\sum_{t:x_{it}<z}\delta^t\left(\frac{z-x_{it}}{z}\right)^{\alpha}\right) = \frac{1}{NT}\sum_{i:\bar{x}_i<z}\sum_{t:x_{it}<z}\delta^t\left(\frac{z-x_{it}}{z}\right)^{\alpha} \qquad \textbf{(3)}$$

Note that this is not equivalent to the simple case of aggregating the matrices in equation 1 horizontally (over *t*) and then vertically (over *i*) as that would count the ever-poor households only in periods where they are below *z*. In contrast, the second summation in equation 3 sums across all households whose constant income $\bar{x}_i$ is below *z*.

CEI is defined only for α>1 due to the discontinuous nature of the FGT function. When α=0 the right hand side of equation 2 is a step function and equals either 1 or 0 and the right hand side can only equal the left hand side for never-poor households.

For α=1 and α=2, $\bar{x}_i$ can be calculated as follows.

$$CEIP_i(1) = \left(\frac{z - \overline{x}_i}{z} \right) \quad \Rightarrow \quad \overline{x}_i(1) = z\left[1 - CEIP_i(1)\right] \tag{4}$$

$$CEIP_i(2) = \left(\frac{z - \overline{x}_i}{z} \right)^2 \quad \Rightarrow \quad \overline{x}_i(2) = z\left[1 - \sqrt{CEIP_i(2)}\right] \tag{5}$$

Equations 4 and 5 show that the $CEIP_i(1)$ and $CEIP_i(2)$ for never-poor households are equal to zero. This means that the right hand sides of equations 4 and 5 are also equal to zero, forcing $\overline{x}_i(\alpha)$ to be equal to z. Therefore, calculating the constant equivalent incomes for never-poor households does not provide additional information for analyzing poverty and, in line with Sen's (1976) focus axiom, these households do not affect the CEI estimates. For ever-poor households the CEI is a useful indicator of the cost of income variability if we believe that having ever experienced poverty is not - or at least not completely - reversible.

The second, alternative way of making social welfare sensitive to income variability proposed here can be called the *stability equivalent income (SEI)* approach. This approach exploits the mathematical analogy between ex ante expected utility and income risk on the one hand and ex post utility and income variability on the other. We can replace the stochastic ex ante states of the world from expected utility theory by actual realizations of past household incomes. Similarly, utility over certain past incomes replaces the expected utility over uncertain future states.

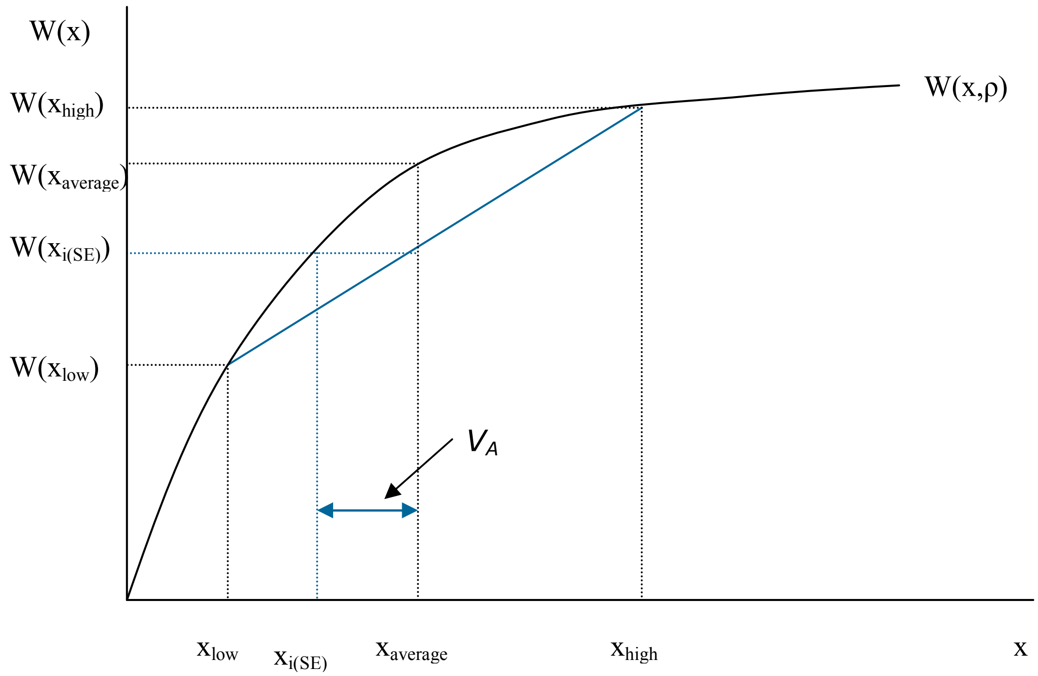
Figure 2 illustrates the concept of stability equivalent income under income variability aversion. For a variability averse household the utility function W(x,ρ) is concave and the Arrow-Pratt-type coefficients of absolute and relative variability aversion are positive. Hence, arithmetic average income, $x_{average}$, lies above the stability equivalent income, $x_{i(SE)}$ and by Jensen's inequality $W(x_{i(SE)})<W(x_{average})$. The absolute and the relative variability premia V_A and V_R can be defined as:

$$V_A = x_{average} - x_{i(SE)} \tag{6}$$

$$V_R = \frac{\left(x_{average} - x_{i(SE)}\right)}{x_{average}} \tag{7}$$

For a given level of variability aversion, the absolute and relative variability premia show the additional amount and percentage of income, respectively, needed to compensate for income variability to maintain the same amount of poverty. Interpreted differently, the stability equivalent premium indicates the upper limit of welfare gains from income stabilization; or, similarly the upper limit of the welfare loss (in currency or in Poverty Measure units) due to fluctuations in past incomes.

Figure 2 Stability Equivalent Income and Variability Premium under Variability Aversion



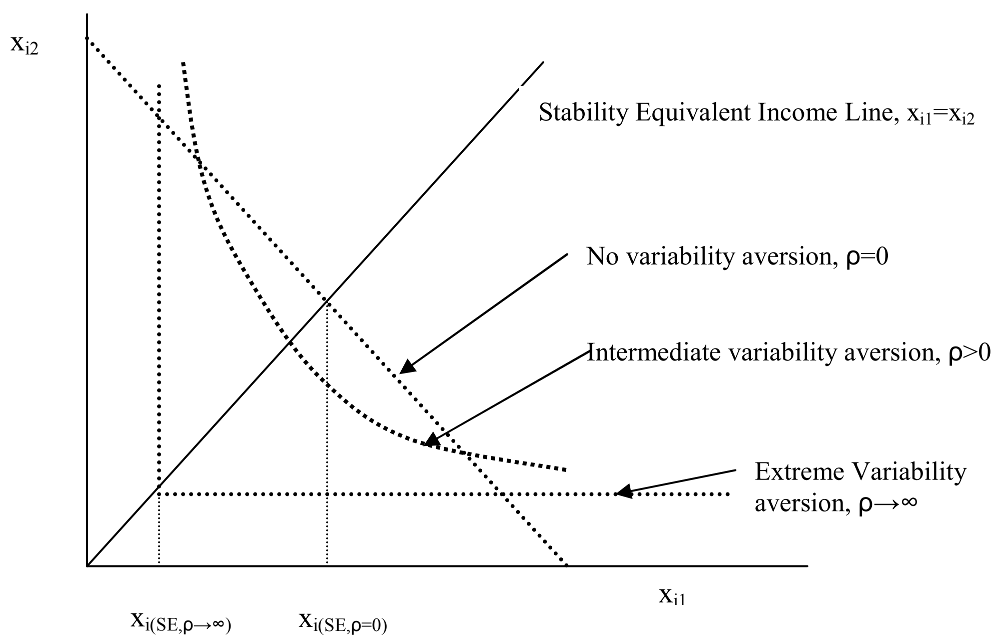
To implement the stability equivalent income approach we need to choose a functional form to penalize past income variability. Analogously to ex ante constant relative risk aversion we can define $x_{i(SE)}$ using a constant relative variability aversion (CRVA) function:

$$x_{i(SE)} = \begin{cases} \left[\frac{1}{T} \sum_{t=1}^{T} \delta^t x_{it}^{1-\rho} \right]^{\frac{1}{1-\rho}} & if\, \rho \neq 1 \\ \prod_{t=1}^{T} \delta^t x_{it}^{1/T} & if\, \rho = 1 \end{cases} \tag{8}$$

where ρ is the constant relative variability aversion coefficient. Again, δ can be used to account for trends in income streams.

By choosing different values of ρ we can allow for different preferences towards income fluctuations or adapt the income measure to the particular policy objective at hand. Lower values of ρ would be appropriate if the objective is to maximize aggregate income; setting a higher ρ would be in line with a 'safety first' goal of minimizing downward fluctuations. Figure 3 shows the indifference curves of the two limiting cases of ρ =0 and $\rho \to \infty$ and the intermediate case where ρ is a finite positive number.

Figure 3 Stability Equivalent Income (2 periods, different values of ρ)



When there is no fluctuation in income so that $x_{i1}=x_{i2}$, or when ρ is equal to zero and households are 'variability neutral' we are at point $x_{i(SE,\rho=0)}$ in figure 3. The stability equivalent income evaluation function reverts back to the straight average of household intertemporal income:

$$x_{i(SE)}^{\rho=0} = \frac{1}{T}\sum_{t=1}^{T}\delta^t x_{it} \quad \textbf{(9)}$$

This gives us the upper limit of the lifetime household income range and represents the utilitarian version[5] of equation 8. Often this is reported in studies which do not explicitly set out to account for income variability. Note that $x_{i(SE)}$ may be lower than the snapshot poverty in each t (Grootaert and Kanbur 1995). As the level of ρ increases the stability equivalent income penalizes income variability more and, hence, increases lifetime poverty compared to simply aggregating snapshot poverty levels. The lower limit is marked by the case when $\rho \to \infty$. This represents the Rawlsian version of equation 8 where households are averse to any degree of income variability, indicated by the point $x_{i(SE,\rho\to\infty)}$ in figure 1. In this case the stability equivalent income reduces to the lowest single period income for a household:

$$x_{i(SE)}^{\rho\to\infty} = \min(x_{it}) \quad \textbf{(10)}$$

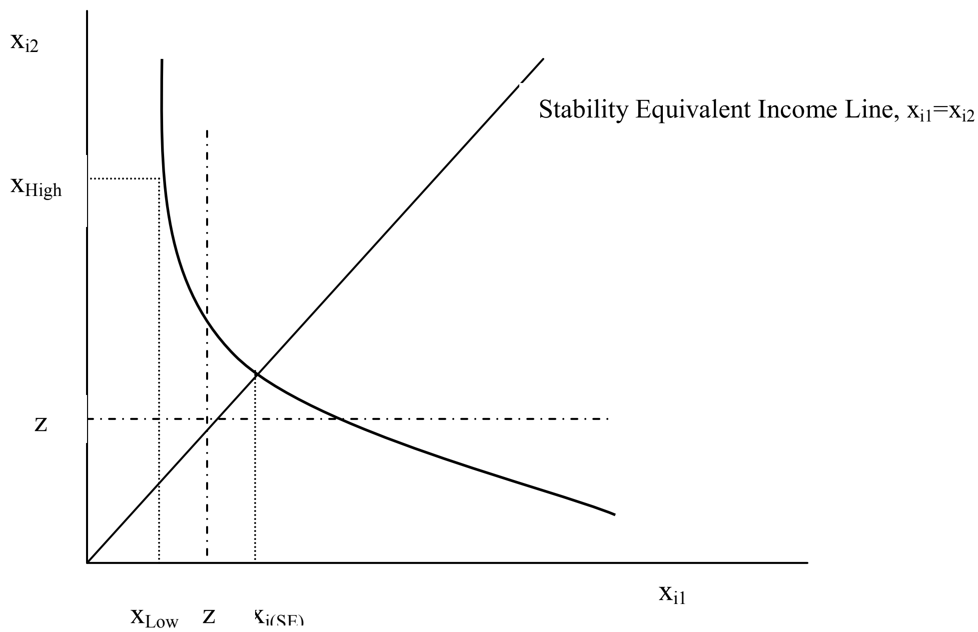
On the basis of these SEI's we can then calculate total variability adjusted lifetime poverty in society. Construct the N-vector $x_{(SE)} = \left(x_{1(SE)}, x_{2(SE)}, \ldots, x_{N(SE)}\right)$ such that the $x_{i(SE)}$'s are ordered from lowest to highest and let q be the number of households with $x_{i(SE)}<z$. Then applying the FGT index yields the *stability equivalent income poverty* (SEIP) aggregate:

[5] Utilitarian in the 'intertemporal within household' sense, where each household is only interested in maximizing the sum of its discounted income stream, not in the distribution of its income over time.

$$SEIP(\mathbf{x}_{(SE)}, \alpha, \rho) = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z - x_{i(SE)}}{z}\right)^{\alpha} \qquad \textbf{(11)}$$

Both the stability equivalent and the constant equivalent income approach imply aversion to income variability, but only the latter implies poverty aversion. To see this consider the lifetime poverty of an ever-poor household based on the stability equivalent approach in Figure 4. The income in period 1 is x_{Low}, which is below the poverty line z, while period 2 income x_{high} is above z. Then the household's lifetime poverty is zero as long as the stability equivalent lifetime income, $x_{i(SE)}$, is above z. Time spent in poverty can be made up by being 'sufficiently' non-poor in other periods. In contrast, under the constant equivalent income approach the household would be poor as $x_{Low} < z$ and a household cannot fully recover from having ever been poor.

Figure 4 Different levels of poverty under CEI and SEI for the same lifetime household income



Why and when one should one choose the constant equivalent income method or the stability equivalent income method of adjusting lifetime household poverty for income variability? Neither method is better than the other per se. Choosing between them depends on the particular evaluation question at hand and/or on one's assumptions about how households' lifetime welfare are affected by spending any time in poverty.

Table 1 summarizes the conceptual differences between the constant equivalent and the stability equivalent approach to measuring income and poverty.

Table 1 Differences between Constant Equivalent Income and Stability Equivalent Income

	Constant Equivalent Income Poverty, *CEIP*	Stability Equivalent Income Poverty, *SEIP*
Policy Objective	Minimize number of HHs ever in poverty (e.g. in presence of thresholds or irreversibilities)	Minimize cost of any income variability ($\uparrow\rho\rightarrow$ "safety first")
Preserves HH poverty histories $(x_{i1},\ldots,x_{iT})$	Yes. Remembers if ever experienced poverty.	No. Possible to make up for periods in poverty
Poverty Aversion	Yes.	No.
Variability aversion	Yes, if ever-poor Trivial variability aversion due to α and δ.	Yes (due to ρ). Trivial variability aversion due to δ.
Choice parameters	δ,α(in income calculation)	δ,α(in poverty calculation),ρ
Measure social welfare loss in income terms	Yes	Yes
Measure social welfare loss in poverty terms	No	Yes

3. The Data

To test empirically to what extent accounting for income variability and the intertemporal distribution of poverty makes a difference, the poverty measures discussed in this paper are applied to data from the Pakistan Rural Household Survey (PRHS). This survey was conducted by the International Food Policy Research Institute (IFPRI) and spans 14 rounds between July 1986 and October 1991. It contains data for around 900 rural households in 46 villages located in four districts in three provinces: Badin in Sindh, Dir in the North Western Frontier Province, and Attock and Faisalabad in Punjab. As often with rural panel surveys, the selection of districts was not random; the first three were selected specifically because they are among the poorest in their province. The richer district of Faisalabad was included as a contrast. The survey is therefore not representative for Pakistan as a whole. It should, however, reflect conditions in poor rural areas. Villages within districts and household within villages were selected by stratified random sampling. Due to the irregular spacing of rounds across the five years the data display varying degrees of seasonality. To overcome this I follow previous studies that have used these data, for example Baulch and McCulloch (1998), and combine rounds by year to construct annual data.

The data include 773 households for which we have income data for any of the five years. To illustrate the full effect of intertemporal income variability I only kept households for which we have income data for all five years (this throws out 97 households) and for which income is positive in all time periods (this eliminates another 9 households), yielding a balanced panel of 667 households.

Following previous studies that have used the IFPRI panel (Alderman and Garcia 1993; Adams and He 1995; McCulloch and Baulch 2000) I use a relative poverty line set to equal the 20th percentile of the distribution of adult equivalent income in 1986/87, the first year of the panel. This works out to be 2000 Rupees per adult equivalent and is also roughly equal to the level of expenditure needed to purchase 2100 calories per adult per day. Using this relative poverty line also circumvents the problem of not having a reference basket of goods for the survey villages that could be used to calculate the cost of basic needs.

4. Estimating the effect of variability on incomes and poverty

Some summary measures of income mobility are useful to get a sense of the magnitude of income variability in the sample from rural Pakistan. Symmetric income movements per household as measured by the Fields-Ok (1996) measure[6] range between 380 and 408 Rupees for the five years covered by the survey. These movements represent between 9.7 and 11.3% of average incomes. Expressed in terms of relative movements in the income distribution, the variations in household incomes mean that on average households moved approximately one income quintile from each year to the next. In short, there is a lot of income movement among households in rural Pakistan which makes this dataset suitable for exploring the effect of income variability on lifetime household poverty and income.

The discussion below reports results for the whole sample of the PRHS and at times refers to disaggregated result by districts to illustrate and how in practice the proposed measures yield different poverty rates and rankings than standard poverty indicators.[7]

To put the effects of income variability on income and poverty measures into perspective, consider two poverty baselines as reference points. Baseline A represents poverty rates in

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[6] $m^{(1)}{}_N\left(x_t, x_{t-1}\right) = \frac{1}{N}\sum_{i=1}^{N}\left|x_{i,t} - x_{i,t-1}\right|$

[7] The complete set of results disaggregated by district are included in the appendix.

the pooled cross section. By treating the panel data as NxT 'cross-sectional' observations it loses the household specific income histories $\left(x_{i1},...,x_{iT}\right)$. This has two consequences: First, it is immaterial whether the cross-sectional aggregate poverty is made up of some households that are chronically poor, or if it results from all households being poor some of the time. Second, any time spent in poverty by any household cannot be compensated.

Baseline B represents the extreme case of no variability aversion. It is similar to Ravallion's (1988) measure of chronic poverty in that it treats households as poor only if their average income is below *z*. Thus, Baseline B does not register any negative welfare cost from income variability. The effects of variability are eliminated by first summing incomes for each household over time so that incomes below the poverty line are compensated Rupee for Rupee by other periods' incomes above *z*. This total intertemporal household income combined with the total period poverty line (i.e., $\sum_{t=1}^{5}\delta^t z$ since we have five years of income data) gives us the Baseline B poverty indices. When households are neutral towards variability in income so that ρ=0, then stability equivalent income poverty is identical to baseline B. This baseline is, therefore, the lower limit for poverty rates under the stability equivalent income approach. As variability aversion ρ rises *SEIP* goes up.

Table 2 Baseline Poverty Measures

	FGT index		
	α=0	**α=1**	**α=2**
Baseline A *Pooled Cross Section*	0.296	0.096	0.046
Baseline B *Household's Average Income < z*	0.214	0.044	0.014

Table 2 shows that, as expected, baseline B is substantially lower than Baseline A. For example, the headcount for all districts is around eight percentage points lower. The choice of baseline and of the method for accounting for income variability, thus, has a large impact on estimated poverty rates, highlighting the need to carefully match poverty measures to the evaluation objective.

Next let us examine how accounting for income variability affects these baselines. Under the constant equivalent income approach in equation 2 the total poverty over time is, by definition, the same as the average poverty actually experienced. The welfare cost of variability can be measured by the differences between the average actual income and the corresponding constant equivalent income $\overline{x}_i$ and is shown in table 3.

For the constant equivalent income approach, the relevant subsample comprises of the 421 households that were poor in at least one period. The average mean income of these ever-poor households is Rs.2606. This is much higher than the mean constant equivalent incomes from equations 4 and 5 reported in the first column in table 3. $\overline{x}_i$ based on α=1 and α=2 are only Rs.1704 and Rs.1553, respectively. This means that the effect of income variability for the average household is equivalent to losing between 902 and 1053 Rupees (or 27 and 34% of household income) based on the poverty gap and the squared poverty gap. Since the estimated percentage shortfalls from average income in table 3 compare actual variable household incomes with stabilized mean incomes, they can be viewed as an upper bound of welfare improvements that would have been possible had past incomes been stable at their mean. The percentage shortfall from average income rises as the *CEI* measures get more distributionally sensitive. This is to be expected as income variability causes more lower income draws, and as higher values of α put more weight onto lower incomes.

Looking at the percentile distribution of the shortfall between $\overline{x}_i$ and average income we see that the incomes of the richest, ever-poor households in the right-most column are most affected when we control for variability, dropping by between 54-59%. The shortfall for the top 25% in the second column from the right is 40-45%. The variability penalty drops monotonically as we move down the income distribution to near zero for the bottom 10 and 25% of the distribution. This is to be expected because in calculating the $\overline{x}_i$'s we excluded all incomes above the poverty line and the bottom percentiles are less likely to have ever had an income above *z*.

Table 3 Constant Equivalent Incomes and Percentage Shortfalls from Average Incomes

	# of obs	Mean	Percentile				
			10%	25%	50%	75%	90%
Average Intertemporal Income	**421**	**2606**	**1462**	**1838**	**2393**	**3069**	**4078**
Constant Equivalent Income, $\overline{x}_i\left(\alpha=1\right)$		1704	1364	1573	1775	1905	1959
% Shortfall from average income, α=1		27%	2%	11%	25%	40%	54%
Constant Equivalent Income, $\overline{x}_i\left(\alpha=2\right)$		1553	1144	1344	1590	1801	1912
% Shortfall from average income, α=2		34%	11%	20%	32%	45%	59%

Disaggregating the sample by district the general pattern of shortfalls is similar to the whole sample (see Appendix table A3). A key result from this disaggregation is that the poverty ranking across districts can change if constant equivalent income is used instead of average intertemporal income. For example, Dir's average intertemporal household income of Rs.2646 is higher than Badin's at Rs.2630. In contrast, for constant equivalent income at α=2 then the ranking is reversed. This example illustrates that using a welfare measure that accounts for income variability can alter interregional poverty profiles.

Under the stability equivalent income approach there are two ways of measuring the social welfare cost of variability. First, we can compare the standard average income with the stability equivalent income. The percentage difference between the two shows the relative variability premium. Second, we can use the stability equivalent income to calculate FGT measures.[8] The difference between these FGTs and those based on the pooled cross sectional data shows the cost of variability in terms of additional poverty.

For the applications below I use the Constant Relative Variability Aversion (CRVA) function from equation 8. This is the ex post analogue to the ex ante Constant Relative Risk Aversion (CRRA) utility functions in the risk literature. Initially, I set the coefficient of relative variability aversion ρ equal to 2. This baseline follows two previous studies which have tried to model vulnerability or variability (Ligon and Schechter (2003) and Cruces and Wodon (2003)) and is a common rule of thumb for CRRA functions. Under CRVA, as under CRRA, higher values of ρ imply greater reduction in welfare due to income variability. As an illustration of the magnitude of this effect on stability

[8] Note that FGT measures can be substituted by alternative poverty measures without loss of generality.

equivalent incomes and poverty measures I also present results for ρ =3 as well as for the two possible extremes when ρ=0 and when $\rho \to \infty$.[9]

Table 4 compares average intertemporal income with stability equivalent income from equation 8 and reports the relative variability premium from equation 7. Note that these income estimates are not directly comparable with those in table 3 as here we can include all 667 households, not just the 421 who were ever poor.

Table 4 Stability Equivalent Incomes and Percentage Shortfalls from Average Incomes

	Mean	Percentile				
		10%	**25%**	**50%**	**75%**	**90%**
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**3834**	**1342**	**1933**	**2950**	**4477**	**7149**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	3111	1251	1721	2555	3664	5516
Relative Variability Premium V_R, ρ=2	18%	4%	7%	13%	24%	39%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	2875	1082	1571	2376	3433	4975
Relative Variability Premium V_R, ρ=3	24%	6%	10%	19%	33%	51%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	2002	655	1041	1648	2418	3590
Relative Variability Premium V_R, ρ→∞	47%	24%	32%	45%	58%	73%

The average relative variability premium is 18 and 24% for ρ equal to two and three, respectively. The welfare loss due to variability in table 4 is more equally distributed across the income quantiles than is the case for constant equivalent income in table 3. But the richer households still tend to 'lose' a larger amount of income due to variability. However, unlike in the constant equivalent income approach, this is not a result of the

[9] For simplicity the results reported below assume δ=1, i.e., no discounting of incomes.

evaluation function, but a reflection of the data; richer households experienced larger variations in incomes.

To illustrate the bounds of the effect of variability on income, consider the two extreme cases. In table 4, ρ=0 represents the baseline B case, hence, the relative variability premium is 0% and there is no loss of welfare compared to using average intertemporal income. Under the Rawlsian case when $\rho \to \infty$, the relevant measure is the minimum income for each household. As expected, the cost of variability is much higher, with a shortfall from average income of 47%.

As under the constant equivalent income approach before, the income rankings across districts can change depending on whether we penalize income variability (see Appendix table A4) . Dir has the higher average intertemporal income than Badin, but a lower stability equivalent income for any positive level of ρ.

In addition to presenting the welfare effect of income variability in terms of stability equivalent income we can also examine the effect of this variability on poverty measures directly. Table 5 shows rates of stability equivalent income poverty from equation 8 for three levels of α and for the same values of ρ as in table 4.

Table 5 Poverty under Stability Equivalent Income for selected levels of ρ

	α=0	α=1	α=2
ρ=0	0.214	0.044	0.014
ρ=2	0.326	0.099	0.043

ρ=3	0.382	0.127	0.061
ρ→∞	0.642	0.265	0.147

Again, accounting for income variability has a large impact. As the coefficient of relative variability aversion ρ goes from zero to three the headcount index (α=0) increases by almost 17 percentage points - nearly doubling the proportion of households classified as poor. Since the poverty gap and squared poverty gap ratio are increasingly sensitive to the distribution of poverty the relative effect of income variability on these two poverty measures is even larger. Poverty for α=1 and α=2 increases three and four-fold as ρ goes from zero to three. Disaggregating by district, Badin and Dir again switch ranks (see Appendix table A4).

5. Conclusions

Economic theory, and common sense, tells us that income variability is reduces household welfare. Thus, measures of poverty that capture the effect of variability are conceptually superior to standard poverty measures for characterizing well-being over time. This paper proposes two new classes of poverty measures that extend standard static FGT indicators that incorporate intertemporal income variability into household welfare measures and, by extension, into poverty indices.

The results from rural Pakistan for both methods showed that accounting for income variability can matter in practice. Poverty rankings across districts changed compared to static poverty measures.

- their sensitivity towards the choice of parameters.
- These measures are also useful as a sensitivity check of traditional static FGT poverty measures and of other intertemporal poverty measures proposed in the literature as they show the effects of making different assumptions (e.g. about irreversibilities, stigma and poverty traps in the case of CEI)
- The measures can be used for any measure of well-being. However, the parameter choice might differ. For instance, consumption data already reflect some smoothing, so fluctuations might be weighed more heavily than for income data.

Looking beyond income averages, the constant equivalent income approach had the greatest impact on poverty estimates of the 'richest poor', whereas under the stability equivalent approach income fluctuations are penalized similarly for all poor. [10]

From a practical policy perspective the choice of dynamic poverty measures and variability aversion parameters will depend on the policy issue at hand. If the emphasis is on minimizing the number of households that have to endure poverty then household lifetime poverty should be measured using constant equivalent income. In contrast, if the main policy focus is on minimizing the social welfare loss due to income variability regardless of whether these income fluctuations cause households to move in and out of

[10] Perhaps some of this is due to greater measurement error for larger incomes.

poverty over time, then using stability equivalent income would be the appropriate income indicator.

The choice of poverty measure and selection of parameters also depends on the explicit value judgment of the evaluator. In practice, value judgments of this type are typically made implicitly. Standard practice of using static FGT measures assumes that intertemporal variation in well-being doesn’t matter. While making value judgments in selecting a particular dynamic poverty measure can be controversial, the proposed measures are preferable as at least they make this judgment explicit.

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Appendix: Results disaggregated by district

The appendix tables are expanded versions of the tables presented in the text. Their numbering follows the numbering of the tables in the text. For example, table A4 is the expanded version of table 4 in the text.

Table A2 Baseline Poverty Measures

		FGT index		
		α=0	**α=1**	**α=2**
Baseline A				
Pooled Cross Section	All districts	0.296	0.096	0.046
	Faisalabad	0.234	0.061	0.025
	Attock	0.413	0.151	0.081
	Badin	0.305	0.091	0.041
	Dir	0.264	0.086	0.040
Baseline B				
Average long single HH poverties	All districts	0.214	0.044	0.014
	Faisalabad	0.152	0.021	0.004
	Attock	0.365	0.098	0.038
	Badin	0.219	0.048	0.016
	Dir	0.167	0.027	0.006

Table A3 Constant Equivalent Incomes and Percentage Shortfalls from Average Incomes

	# of obs	Mean	Percentile				
			10%	25%	50%	75%	90%
All Districts	**421**						
Average Intertemporal Income		**2606**	**1462**	**1838**	**2393**	**3069**	**4078**
Constant Equivalent Income, $\overline{x}_i(\alpha=1)$		1704	1364	1573	1775	1905	1959
% Shortfall from average income, α=1		27%	2%	11%	25%	40%	54%
Constant Equivalent Income, $\overline{x}_i(\alpha=2)$		1553	1144	1344	1590	1801	1912
% Shortfall from average income, α=2		34%	11%	20%	32%	45%	59%
Faisalabad District	**82**						
Average Intertemporal Income		**2772**	**1688**	**2061**	**2656**	**3334**	**4175**
Constant Equivalent Income, $\overline{x}_i(\alpha=1)$		1791	1474	1675	1844	1951	1979
% Shortfall from average income, α=1		28%	8%	18%	30%	42%	53%
Constant Equivalent Income, $\overline{x}_i(\alpha=2)$		1668	1312	1490	1687	1891	1954
% Shortfall from average income, α=2		35%	17%	22%	35%	46%	57%
Attock District	**107**						
Average Intertemporal Income		**2411**	**1262**	**1545**	**2172**	**2878**	**4052**
Constant Equivalent Income, $\overline{x}_i(\alpha=1)$		1607	1177	1454	1653	1851	1928
% Shortfall from average income, α=1		24%	0%	3%	21%	38%	55%
Constant Equivalent Income, $\overline{x}_i(\alpha=2)$		1436	1047	1165	1435	1719	1859
% Shortfall from average income, α=2		32%	8%	16%	31%	44%	61%
Badin District	**130**						
Average Intertemporal Income		**2630**	**1461**	**1925**	**2439**	**3025**	**3833**
Constant Equivalent Income, $\overline{x}_i(\alpha=1)$		1716	1358	1584	1785	1912	1953
% Shortfall from average income, α=1		27%	2%	13%	25%	39%	53%
Constant Equivalent Income, $\overline{x}_i(\alpha=2)$		1576	1184	1398	1609	1823	1903
% Shortfall from average income, α=2		33%	11%	22%	30%	44%	56%
Dir District	**102**						
Average Intertemporal Income		**2646**	**1571**	**1959**	**2247**	**3055**	**4130**
Constant Equivalent Income, $\overline{x}_i(\alpha=1)$		1720	1435	1600	1791	1875	1936
% Shortfall from average income, α=1		28%	6%	13%	25%	42%	56%
Constant Equivalent Income, $\overline{x}_i(\alpha=2)$		1557	1195	1389	1576	1776	1856
% Shortfall from average income, α=2		35%	13%	22%	33%	46%	61%

Table A4 Stability Equivalent Incomes and Percentage Shortfalls from Average Incomes

	Mean	Percentile				
		10%	25%	50%	75%	90%
All Districts						
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**3834**	**1342**	**1933**	**2950**	**4477**	**7149**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	3111	1251	1721	2555	3664	5516
Relative Variability Premium V_R, ρ=2	18%	4%	7%	13%	24%	39%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	2875	1082	1571	2376	3433	4975
Relative Variability Premium V_R, ρ=3	24%	6%	10%	19%	33%	51%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	2002	655	1041	1648	2418	3590
Relative Variability Premium V_R, ρ→∞	47%	24%	32%	45%	58%	73%
Faisalabad District						
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**4562**	**1804**	**2546**	**3437**	**4679**	**7374**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	3877	1536	2184	2981	3916	6072
Relative Variability Premium V_R, ρ=2	16%	4%	8%	13%	21%	30%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	3627	1372	1879	2782	3755	5697
Relative Variability Premium V_R, ρ=3	21%	7%	11%	18%	29%	39%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	2563	881	1264	1896	2625	4102
Relative Variability Premium V_R, ρ→∞	44%	25%	32%	44%	54%	65%
Attock District						
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**3334**	**1319**	**1721**	**2582**	**3896**	**5996**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	2513	762	1312	2125	3211	4497
Relative Variability Premium V_R, ρ=2	22%	5%	7%	15%	28%	51%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	2289	607	1180	1914	2849	4158
Relative Variability Premium V_R, ρ=3	29%	7%	11%	22%	41%	62%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	1551	337	707	1332	2006	3023
Relative Variability Premium V_R, ρ→∞	52%	25%	36%	50%	66%	80%
Badin District						
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**3688**	**1683**	**2270**	**3042**	**4415**	**6242**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	3061	1324	1837	2535	3819	5656
Relative Variability Premium V_R, ρ=2	17%	3%	7%	11%	22%	35%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	2838	1154	1625	2402	3521	5337
Relative Variability Premium V_R, ρ=3	22%	5%	9%	17%	30%	50%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	1999	664	1102	1691	2473	3799
Relative Variability Premium V_R, ρ→∞	45%	23%	31%	43%	56%	75%

Dir District						
Average Intertemporal Income, $x_{i(SE)}^{\rho=0}$	**3823**	**1729**	**2189**	**2944**	**4550**	**7137**
Stability Equivalent Income, $x_{i(SE)}^{\rho=2}$	3027	1411	1733	2542	3424	5516
Relative Variability Premium V_R**, ρ=2**	18%	4%	7%	13%	25%	43%
Stability Equivalent Income, $x_{i(SE)}^{\rho=3}$	2776	1283	1585	2300	3258	4945
Relative Variability Premium V_R**, ρ=3**	25%	6%	11%	19%	33%	53%
Stability Equivalent Income, $x_{i(SE)}^{\rho\to\infty}$	1909	728	1040	1554	2403	3425
Relative Variability Premium V_R**, ρ→∞**	48%	25%	33%	48%	59%	73%