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Can We Predict Vulnerability to Poverty?

Yuan Zhang[1] and Guanghua Wan[2]

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Abstract

There are alternative definitions of vulnerability to poverty. Most researchers prefer to define vulnerability as the probability of a household or individual falling into poverty in the future. Based on this definition and using household survey panel data from rural China, this paper attempt to assess the extent to which we can measure vulnerability to poverty. The assessment is based on comparisons between predicted vulnerability and actually observed poverty. We find that the precision of prediction, first, varies depending on the vulnerability line; our results suggest setting the line at 50 per cent in order to improve predictive power. Second, precision depends on how permanent income is estimated. Assuming log-normal distribution of income, it is preferable to use past weighted average income as an estimate of permanent income rather than using regressions to gage permanent income. And third, prediction precision depends on the chosen poverty line. More accurate measurement of vulnerability to poverty is obtained with a higher poverty line of US$2 instead of US$1.

Keywords: vulnerability, poverty, permanent income, transitory income

JEL classification: C15, C23, O16, Q12

[1] China Center for Economic Studies, Fudan University, Shanghai; email: zhangyuanfd@fudan.edu.cn;
[2] Asian Development Bank, Manila, email: gwan@abd.org

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UNU World Institute for Development Economics Research (UNU-WIDER)
Katajanokanlaituri 6 B, 00160 Helsinki, Finland

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1 Introduction

A conventional tool for summarizing the welfare status of the less fortunate is to estimate poverty indices based on income or consumption data. However, the welfare of a household depends not only on its present income or consumption, but also on the risks or negative shocks it faces. It is known that today's poor may not be tomorrow's poor and that non-poor households or individuals could fall into poverty due to unexpected shocks such as bad harvests, job losses, and illness. Poverty measured at a particular point of time usually does not take into account the future prospects of household welfare or associated risks. These lead to the recent emergence of the concept 'vulnerability to poverty' in the economics and development literature.

Generally speaking, vulnerability can be defined with respect to different entities such as states, companies or individuals, and with respect to different risks such as natural disaster or financial crises. For example, Glewwe and Hall (1998) perceive vulnerability as a dynamic concept, involving a sequence of events following a macroeconomic shock. They distinguish two kinds of vulnerability: policy-induced and market-induced vulnerability. The latter can be measured by changes in household consumption of goods and services.

As far as household vulnerability to poverty is concerned, alternative definitions exist. Kühl (2003) defines vulnerability to poverty as the propensity of a household to suffer a significant shock that brings its welfare below a socially accepted level. Similarly, Pritchett, Suryahadi and Sumarto (2000) and Mansuri and Healy (2001) conceptualize vulnerability to poverty as the probability that a household would experience at least one episode of poverty in the near future or over a given number of time periods. Yet another definition is given by Chaudhuri, Jalan and Suryahadi (2002) who define vulnerability to poverty at time t as the probability that a household becomes or remains poor at time t+1. It is worth noting the key difference between poverty and vulnerability to poverty. The latter involves future risks, is a forward-looking concept, and cannot be observed. One can, however, estimate the probability that a household may remain or become poor in the future due to various risks.

Corresponding to different definitions of vulnerability, alternative measurement methods exist. These include using the difference between expected consumption and the poverty line (Kochar 1995; Dercon and Krishnan 2000) and using the probability to fall into poverty (see below). Coudouel and Hentschel (2000) use average income and its standard deviation to measure vulnerability. Based on the Foster, Greer and Thorbecke (1984) poverty indices, Kamanou and Morduch (2002) measure vulnerability as the difference between the expected value of poverty in the future and its current value. Since the poverty measure of Foster, Greer and Thorbecke (1984) may lead to underestimation of the effect of risk managing mechanisms, Ligon and Schechter (2003) propose measuring vulnerability as the difference between the value of a utility function evaluated at the poverty line and that evaluated at the expected level of consumption. In addition, Dercon (2005) simply takes the degree of risks faced by individuals or households as a measure of vulnerability.

To date, no preferred definition of, or measurement methodology for, vulnerability to poverty has been agreed on. However, as demonstrated in Zhang and Wan (2006), most researchers prefer to define vulnerability to poverty as the probability of a household or

individual falling into poverty in the future. This is the definition to be adopted in this paper.

Clearly, measuring vulnerability is important because it enables identification of those who are not poor but may fall into poverty and those who will remain to be poor. Once identified, appropriate policies can be designed to prevent the former from falling into poverty and to help the latter to escape poverty. As is usually accepted, prevention is better than cure. Moreover, policies purely based on current poverty profile may not be effective for those vulnerable individuals and households. By obtaining a vulnerability profile, both existing and future poverty can be targeted.

The purpose of this paper is to assess the extent to which one can measure vulnerability. To be more precise, we explore the sensitivities of vulnerability measurement to (i) vulnerability lines; (ii) poverty lines; and (iii) techniques for estimating permanent income. It is known that permanent income can be estimated either using average of past incomes or using income generating functions. Our exercise is conducted under the following conditions: (i) income is assumed to be log-normally distributed; (ii) vulnerability is defined as the probability of falling into poverty.

The exercise proceeds as follows. Based on household survey data collected in 1989, 1991, and 1993 under the China health and nutrition survey, we estimate households' vulnerability using the 1989 and 1991 data and then predict vulnerability to poverty. The predicted vulnerability is compared with the observed poverty in 1993. The closer the predicted vulnerability is to actual poverty, the better the measurement technique is. It is found that the performance of measurement technique:

i) varies depending on the vulnerability line. It seems best to set the line at 50 per cent;

ii) depends on how permanent income is estimated. Assuming log-normal distribution of income, it is appropriate to use past average income as an estimate of permanent income rather than estimating income generating functions;

iii) depends on the chosen poverty line. Setting a higher poverty line such as US$2 instead of US$1 leads to more precise measurement of vulnerability to poverty.

The paper is structured as follows. Section 2 establishes the analytical framework, where two methods for estimating income distribution are discussed. Data description and choices of poverty and vulnerability lines are presented in section 3. In section 4, we compare the measured vulnerability with the observed poverty. Conclusions and some policy implications are summarized in section 5.

2 Conceptual framework

Denote by V, in this paper vulnerability to poverty is defined as:

$$V_{it} = \int_{-\infty}^{z} f_t(Y_{i,t+1}) d(Y_{i,t+1}) \qquad (1)$$

where i and t index household and time period, Y indicates welfare (consumption or income), z denotes a poverty line, $f(Y_{i,t+1})$ denotes a density function.

This definition is most popular in the literature. In addition, it is consistent with Alwang, Siegel and Jorgensen (2001) who point out that the concept of vulnerability should meet the following five general principles: (i) it is forward-looking and could be defined as the probability of experiencing a future loss relative to some benchmark of welfare; (ii) vulnerability is caused by uncertain events; (iii) the degree of vulnerability depended on the characteristics of risks involved and household ability to respond to the risks; (iv) vulnerability depended on the time horizon. That is, a household might be vulnerable to risks next month, the next year, and so on. Meanwhile, the household responds to risks over time, and (v) both the poor and non-poor could be vulnerable because of their limited access to assets and abilities to respond to risks.

In (1), uncertainty of income Y is captured by $f_t(Y_{i,t+1})$ and V_{it} is the probability of obtaining an income in time t+1, which falls below a predetermined poverty line. Before computing V_{it}, the distribution function $f(Y_{i,t+1})$ must be obtained. There are two ways to obtain $f(Y_{i,t+1})$. The first is the so-called bootstrap method. The idea is to make up for the unknown distribution by generating a distribution of possible future incomes based on observed characteristics and past income fluctuations of similar households. This method can be found in Kamanou and Morduch (2002) and Kühl (2003). The second approach is to assume a parametric statistical function for future incomes and then estimate the parameters of this function based on available data. For example, relying on the Sharpiro-Wilk test for normality, Rajadel (2002) postulates a log-normal distribution for per capita food consumption. The ex ante mean and variance of food are then estimated based on information on household characteristics. Chaudhuri, Jalan and Suryahadi (2002), Christiaensen and Subbarao (2005), and Zhang and Wan (2006) also base their works upon the log-normal assumption. In contrast, McCulloch and Calandrino (2003) assume that the intertemporal change in household consumption is normally distributed, and that the mean and variance of the distribution vary by household. They then use the longitudinal component of panel data to estimate the mean and standard deviation of the distribution. Pritchett, Suryahadi and Sumarto (2000) postulate that the difference between the present and future consumption is normally distributed and vulnerability is measured accordingly. Mansuri and Healy (2001) establish their work on the assumption that all historical shocks to expenditures and any measurement errors are normally distributed.

Due to unavailability of consumption data, income is used to represent household welfare in this paper. Now, it is necessary to obtain the statistical distribution of future income. Many statistical functions can be assumed for this purpose (see Champernowne 1953; Rutherford 1955). However, as Singh and Maddala (1976) demonstrate, the Pareto function is superior for modelling the very rich but not the poor while the opposite is true for the log-normal. Given that we are only interested in the poor, log-normal assumption seems to be reasonable. Further, Shorrocks and Wan (2008) support the use of log-normal assumption for modelling the distribution of income.

Having assumed long-normal distribution of income, all we need is to estimate the mean and standard deviation of future income. Based on the permanent income hypothesis, Friedman (1957, 1963), Mansuri and Healy (2001) show that the permanent expenditure

is a good estimator of the mean of future expenditure. Similarly, using panel data, Chaudhuri, Jalan and Suryahadi (2002) and McCulloch and Calandrino (2003) demonstrate that the mean and standard deviation of observed income or consumption are unbiased estimates of their future counterparts.

With the panel data at hand and following the permanent income hypothesis, one can decompose observed income into permanent and transient components by regression (see Mansuri and Healy 2001; Kühl 2003; Zhang and Wan 2006). Alternatively, one can directly calculate the mean and standard deviation of observed income (see Chaudhuri, Jalan and Suryahadi 2002; McCulloch and Calandrino 2003). In this paper, we will follow Bhalla (1980) by constructing two measures of permanent income: one based on regression model and the other using weighted average of past incomes.

3 Data, and vulnerability and the poverty line

The survey data used in this paper come from the China Health and Nutrition Survey (CHNS), a joint project run by the Carolina Population Center at the University of North Carolina, the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. Though not an income survey per se, in-kind incomes and subsidies are imputed. Six rounds of CHNS were conducted in 1989, 1991, 1993, 1997, 2000 and 2004 respectively, each covering around 15,000 individuals from about 4,000 households spread over nine provinces.

The data cover both urban and rural China. As we are only interested in rural China, urban data are dropped altogether. Picking those households that were observed in all three rounds of 1989, 1991, and 1993, a balanced panel data of 2,340 rural households are obtained. Data from 1997, 2000, and 2004 are not considered because they suffer from serious sample attrition problem. It is noted that the data sample is not representative of rural China. However, the main aim of this paper is not to measure vulnerability in rural China but to assess the performance of measurement technique. An advantage of our data is that household income has been deflated to capture regional price variations and overall inflation (anchored by 1988 RMB prices).

To use Equation (1) to measure vulnerability, a poverty line must be chosen. Considerable criticism exists for the poverty line set by the National Bureau of Statistics of China, as it is too low relative to the international standard poverty lines (PPP 1$ or 2$ per day). The latter will be considered in this paper[1] after adjusting for rural inflation. Employing two poverty lines may help us answer an important question: does the accuracy of predicting vulnerability depend on poverty line? It is possible that a higher poverty line will lead to a larger estimate of vulnerability to poverty. However, it is not known which poverty line is better for predicting future poverty.

Also, a vulnerability line must be established. Chaudhuri, Jalan and Suryahadi (2002) argue that the selection of vulnerability line is subjective, and two vulnerability lines deserve special consideration. One is identical to the observed headcount ratio as used

1 Among the 2,340 households covered in our data, 14.8 per cent are poor when PPP US$1 is used as the poverty line. This percentage rises to 40.21 per cent when the poverty line is increased to PPP US$2.

by Rajadel (2002). For example, if the headcount ratio of a region is 40 per cent, and the probability of a household falling into poverty in the future is greater than 40 per cent, then this household is regarded as vulnerable. The other vulnerability line is simply 50 per cent, as adopted by Kühl (2003) and Pritchett, Suryahadi and Sumarto (2000). In this case, those with a 50 per cent or more chance of falling into poverty in the future are identified as vulnerable. The latter vulnerability line is sometimes called percent stringent or high vulnerability threshold (Chaudhuri, Jalan and Suryahadi 2002). Both vulnerability lines are considered in this paper.

4 Results and discussions

Results are presented and discussed separately, depending on how income distribution is obtained.

4.1 Weighted average incomes as permanent income

A common approach to the measurement of permanent income that originates from Friedman's (1957, 1963) analysis of consumption behaviour is to compute weighted average of past incomes, that is,

$$Y_p = \sum W_t Y_t \ , \quad t=-\infty, \ldots, 0, \tag{2}$$

where W_t are the weights and Y_t the estimated income in time period *t*.

Using aggregate time-series data and the theory of income expectation, Friedman (1957) constructed the estimate of permanent income Y_p at time t' as

$$Y_{p,t'} = \delta \int_{-\infty}^{t'} e^{(\delta-\alpha)(t-t')} Y_t dt \ , \tag{3}$$

where α is the trend rate of growth in permanent income and δ is a weighting parameter. When discrete data are used, this method yields the following weighting pattern for $t' = 0$:

$$W_t = \delta \frac{(1+\alpha)^{-t}}{(1+\delta)^{-t}} \quad t= -\infty, \ldots, -3, -2, -1, 0, \tag{4}$$

where δ can now be interpreted as an adjustment parameter from an income-expectation formula.

Friedman (1963) rejects the above income expectation model and offers an alternative rationale for constructing Y_p. This method, applicable to both individual and country level data, assumes trend-adjusted past income as the best estimate of future income. It yields the same formula for permanent income and for the weights as Equations (3) and (4). However, there is an important difference. That is, δ now is a direct estimate of the discount rate rather than an adjustment coefficient in an income-expectation formula.

In this paper, households are assumed to base their expectations for future receipts on the observed income growth rate of all households. The average rate of income growth during the sample period was 6.75 per cent per annum for all rural households. To estimate the discount rate, we follow Friedman (1957), Mohabbat and Simons (1977) and Bhalla (1980), by assuming that households can estimate future income based on the observed income during the past three years. In this case, the discount ratio is equal to 35 per cent.[2] After breaking down the observed incomes in 1989 and 1991 into permanent and transient components according to Equation (4), the permanent income can be taken as the mean of future household income. The variance of the observed income can be taken as the variance estimate of future income.

To assess the extent of predictive power, we can compare predicted vulnerability with observed poverty. Towards this objective, we use 1989 and 1991 panel data from rural China to obtain vulnerability estimates and then compare these estimates with actual poverty occurred in 1993. In an ideal world, one would hope that the predicted vulnerability matches the observed poverty exactly. In reality, this, of course, is not possible. Theoretically speaking, vulnerable households are those with 50 per cent or higher chances of falling into poverty. Non-vulnerable households may also become poor although less likely. Meanwhile, vulnerable households may step out of poverty although with a probability of less than 50 per cent. All factors considered, the evaluation criterion to be used is the percentage of overlap between households predicted to be vulnerable and those actually poor in 1993. The results can be found in Table 1.

It is worth noting that Table 1 is obtained by matching vulnerability predicted in 1991 with actual poverty in 1993, due to unavailability of 1992 data. This is acceptable as poverty is unlikely to change dramatically from 1992 to 1993. Further, uncertainly or potential shocks faced by households in 1991 may materialize in 1992 or 1993.

Two important findings emerge from Table 1. First, when selecting a higher poverty line, the percentage of overlap is larger. Second, with a same poverty line, use of actual headcount ratio produces results inferior to the use of 50 per cent as the vulnerability line.

Table 1
Comparison between predicted vulnerability and observed poverty

Poverty line	Measured vulnerability, 1991	Observed poverty, 1993	Vulnerable households which actually fell into poverty, 1993	Percentage agreement
	Vulnerability line=50%			
1$ a day	97	347	33	34.02
2$ a day	642	941	320	49.84
	Vulnerability line=Headcount ratio=14.83%			
1$ a day	991	347	207	20.89
	Vulnerability line=Headcount ratio=40.21%			
2$ a day	853	941	401	47.01

2 According to Friedman (1963), the appropriate value of δ is dictated by the length of the time horizon, where the time horizon is defined to be $1/\delta$, or 'the number of years purchase implied by the discount rate'.

4.2 Estimating permanent income using income function

Following Bhalla (1980), the income of an individual household *i* in year *t* can be expressed as:

$$Y_{it} = \sum_{j=i}^{k} \beta_j X_{jit} + e^* , \tag{5}$$

where

$$e^* = \gamma_i + \varepsilon_{it} + \varepsilon_t , \tag{6}$$

Y_{it} is observed income, X are determinants of income, β_j are parameters to be estimated, and e^* is a composite error term; γ_i (ε_t) are errors specific to an individual (time period) and ε_{it} is a random error with zero expectation.

According to the permanent income hypothesis, permanent income is determined by household fixed assets, financial assets and human capitals. In what follows, we use household size as a proxy for labour. Financial assets are represented by capital stocks based on irrigation equipment, farming equipment, and other assets. Of course, area of cultivated land is also included as an independent variable. To capture human capital, the age and education level of household head enter the model, together with gender of the household head. A brief description of these independent variables is given in Table 3. It is clear that from 1989 to 1991, average income and average financial assets increased over time while household size and average land holdings declined. These trends correspond to reality in rural China.

The regression results, with both fixed effects (FE) and random effects (RE) estimations, are tabulated in Table 4. The Hausman test suggests rejection of the random effects models. Thus, predicted income from the FE model will be used.

The FE model is used to estimate permanent household income, which can be regarded as the expectation of future income. Subtracting permanent income from the observed income yields the estimate of transient income. On the other hand, with panel data, we can calculate the variance of household income and use it as estimated variance of future income. Now, we are able to predict household vulnerability according to Equation (1). The predicted results are presented in Table 5.

Table 2
Definition of independent variables

Variable	Definition of variables
lnfarmland	logarithmic acreage of farmland cultivated by household
lnfixassets	logarithmic value of fixed assts owned by household
hhmember	number of household members
hhedu	years of formal education completed by household head
hhsex	sex of household head
hhage	age of household head

Table 3
Statistic description of variables

	Mean		Std dev.		Min.		Max.	
Variable	1989	1991	1989	1991	1989	1991	1989	1991
lnincome	7.90	8.52	0.86	0.75	3.61	4.50	10.12	10.86
lnfarmland	1.45	1.16	1.67	0.83	0.00	0.00	9.31	4.43
lnfixasssets	3.54	4.42	3.14	3.13	0.00	0.00	10.55	11.51
hhmember	4.39	4.31	1.48	1.46	1.00	1.00	11.00	12.00
hhedu	5.99	5.99	3.86	3.86	0.00	0.00	19.00	19.00
hhage	43.00	45.00	12.85	12.85	19.00	21.00	83.00	85.00

Table 4
Regression results of FE, and RE models

Independent variable	FE	RE
Lnfarmland	0.0068 (0.0139)	-0.0748*** (0.0095)
Lnfixassets	0.0257*** (0.0059)	0.0256*** (0.0039)
Hhmember	0.1872*** (0.0228)	0.1674*** (0.0090)
Hhedu		0.0463*** (0.0040)
Hhsex		-0.1896*** (0.0445)
Hhage	0.3070*** (0.0103)	0.0017 (0.0012)
Constant	-6.2215*** (0.4706)	7.2951*** (0.0867)
No. of observations	2,340	4,680
R^2	within=0.3138 between=0.0095 overall=0.0018	within=0.0462 between=0.1968 overall=0.1295
F or Wald test	F(5, 2334)=1.84 Prob>F=0.00	Wald chi2(6)=611.72 Prob>chi2=0.00

Note: Figures in parentheses are standard errors; *** indicate significance at the 1% level.

Table 5
Comparison between predicted vulnerability and observed poverty

Poverty line	Measured vulnerability, 1991	Observed poverty, 1993	Vulnerable households which actually fell into poverty, 1993	Percentage agreement
	Vulnerability line=50%			
1$ a day	1,055	347	177	16.78
2$ a day	1,211	941	523	43.19
	Vulnerability line=Headcount ratio=14.83%			
1$ a day	2,210	347	336	15.20
	Vulnerability line=Headcount ratio=40.21%			
2$ a day	1,262	941	537	42.55

Table 5 suggests the use of 50 per cent as the vulnerability line, not the headcount ratio. Also, the higher poverty line of US$2 instead of US$1 leads to more precise measurement of vulnerability. These results are consistent with those in Table 1.

Contrasting Tables 1 and 5, it is clear that regardless of which poverty line or vulnerability line is selected, the use of past average income as an estimate of permanent income works better. Use of regression to gauge permanent income is not recommended.

5 Conclusions and policy implications

The main objective of this paper is to assess the extent to which we can measure vulnerability to poverty. The assessment is based on comparisons between the predicted vulnerability and actually observed poverty. It is found that the precision of prediction:

i) varies depending on the vulnerability line. Our results suggest setting the line at 50 per cent in order to improve predictive power;

ii) depends on how permanent income is estimated. Assuming log-normal distribution of income, it is preferable to use past weighted average income as an estimate of permanent income rather than using regressions to gage permanent income;

iii) depends on the chosen poverty line. More accurate measurement of vulnerability to poverty is obtained with a higher poverty line of US$2 instead of US$1.

These findings may offer useful guidance for future research in measuring vulnerability. For example, when panel data are available, it is sufficient to use average income as an estimate of permanent income. As another example, researchers and policymakers should not use headcount ratio as the vulnerability line as it yields unexpectedly high vulnerability estimate. Under PPP US$1 poverty line, use of headcount ratio as the vulnerability line would lead to 991 (when weighted average income is used as permanent income) and 2210 (when regression mode is used to estimate permanent income) households as vulnerable. They represent almost 43 per cent or 95 per cent of the sample households. Such a high estimate of vulnerability means that the research findings are of little value to policymakers. After all, it is not practical for developing countries to target over 90 per cent of households for vulnerability prevention. More importantly, use of headcount ratio as vulnerability line makes the prediction of vulnerability less accurate, thus making poverty or vulnerability policies less efficient..

This paper only considers two different methods for estimating permanent income. Also, the exercise is limited to two poverty lines and two vulnerability lines. Although the assumption of log-normal distribution is not without justification, experiments with other assumptions are suggested. In fact, use of bootstrapping rather than any parametric assumption is an avenue worth exploring. All these represent good topics for future research.

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