

## WELFARE DYNAMICS MEASUREMENT: TWO DEFINITIONS OF A VULNERABILITY LINE AND THEIR EMPIRICAL APPLICATION

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We propose a new approach to develop vulnerability lines that are explicitly anchored to the idea of a subset of the population at risk of falling into poverty. We suggest that lines developed in this way can also be applied for the purpose of identifying the middle class (or “secure”). We illustrate that such vulnerability lines can be straightforwardly estimated with panel data, drawing on data from the USA and Vietnam. Importantly, given the relative scarcity of panel datasets, we show further that our method can be applied to synthetic panel datasets. We demonstrate this by means of an illustration using repeated cross-section data from India. Our results indicate that in Vietnam and India during the 2000s, the population shares that can be designated as poor and as secure have, respectively, been falling and expanding, with the vulnerable share of the population remaining fairly stable. Sharply contrasting trends are seen in the USA.

**JEL Codes:** C14, D31, I32

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### 1. INTRODUCTION

It is not unusual for empirical assessments of poverty to employ multiple poverty lines when describing the extent and dimensions of poverty in a given setting. Poverty assessments, such as those routinely undertaken by international organizations such as the World Bank in collaboration with the governments of developing countries, often publish poverty rates estimated against a set of poverty lines. These studies commonly refer to the highest amongst the specified poverty lines as a “vulnerability” line. This choice of terminology is evocative, and appears to suggest that the segment of the population sandwiched between the main, benchmark, poverty line and this higher, “vulnerability” line, while perhaps not currently poor, is facing a heightened risk of falling into poverty.<sup>1</sup>

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<sup>1</sup>Pritchett *et al.* (2000) define a vulnerability line as the level of income below which a household experiences a greater than even chance of experiencing an episode of poverty in the near future, but include in their assessment also those who are currently poor. Such an approach differs from that taken here, where our concern is to separate out the non-poor population segment facing a heightened risk of experiencing poverty in the near future.

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Furthermore, when a vulnerability line is defined in this way, one might naturally consider the population lying above this line, and therefore neither poor nor facing a significant risk of falling into poverty, as secure (or “prosperous”, or “middle class”).

Although the notion is suggestive, there are few studies that attempt to explicitly connect the specification of a *vulnerability line* to the risk of falling into poverty. In practice, common approaches—at least those that are currently employed in various countries—tend to be rather *ad-hoc*.<sup>2</sup> For example, in India it has been proposed to define vulnerability as simply occurring within a fixed income range between 1.25 times and twice the national poverty line (NCEUS, 2007); Vietnam recently proposed a vulnerability line that simply, and arbitrarily, scales up the national poverty line by 30 percent (World Bank, 2012).<sup>3</sup> Such *ad-hoc* approaches stand in marked contrast to the often painstaking lengths taken to establish the conceptual grounding of absolute poverty lines (see Ravallion, 2012, for a review).

In this paper we propose two approaches to setting a vulnerability line that are explicitly linked to the risk of the non-poor falling into poverty. Both approaches are predicated on an up-front statement of what the analyst deems as a meaningful risk of falling into poverty by the non-poor, and the vulnerability lines are derived from that articulation. In our first approach, we seek to identify a population that is not vulnerable and to define the vulnerability line as the lower bound income level for this population group. In our second approach, we consider the population that is not poor, but whose situation is such that they face a heightened risk of falling into poverty; we set the vulnerability line as the upper bound income level for this population.<sup>4</sup> The two approaches outlined here offer a simple but conceptually grounded way to capture an aspect of vulnerability that, to the best of our knowledge, has not been attempted elsewhere.

Our approach is related to the literature on estimating vulnerability as expected poverty (e.g., Pritchett et al., 2000; Chaudhuri, 2003) and identifying the middle class (e.g., Lopez-Calva and Ortiz-Juarez, 2014), but differs from this literature in several respects, both conceptually and empirically. Our first conceptual contribution is we start with a given level of vulnerability (say, 10 percent) and then work backward to identify the appropriate vulnerability line associated with that specific vulnerability level. The desirable vulnerability level can be anchored to various ideas or objectives, including budgetary planning, (ideal or desirable)

<sup>2</sup>Hoddinott and Quisumbing (2010) provide a recent review of approaches to measuring vulnerability of households, and document the important conceptual and empirical challenges confronting such efforts. Alwang, Siegel, and Jorgensen (2001) and Adger (2006) discuss the vulnerability concept in other related literatures including sociology and ecology. See also Foster (2009) and Hojman and Kast (2009) for recent related studies on poverty dynamics.

<sup>3</sup>In other settings, the vulnerability line is proposed to be equal to twice and four times the poverty line respectively for Pakistan (Lopez-Calix et al., 2014) and Brazil (Ferreira de Souza and Osorio, 2014).

<sup>4</sup>The first approach is perhaps more relevant for the purpose of measuring prosperity, and the second approach is more closely linked to poverty measurement. Which approach should be applied depends on the specific context and objective under consideration; and the order we present them in later sections is merely for convenience of presentation purposes.

social welfare objectives, or relative concepts of well-being. As such, our approach avoids some of the arbitrariness that arises from either fixing the vulnerability level at 50 percent, as done in many existing studies on vulnerability, or from scaling up the poverty line by a certain factor, as has been implemented by some governments.<sup>5</sup> Furthermore, our approach is intuitive and can be explained fairly straightforwardly to policy makers or other stakeholders.

Second, by directly considering the risks of falling into poverty for the whole non-poor population, our approach operates at a more aggregate, “macro,” level than existing studies on vulnerability that tend to look at specific households or household groups. It also employs simple non-parametric modelling techniques. This provides two attractive features. First, we can work with the same level of vulnerability for a country over different time periods as well as across different countries. This option is not available with an arbitrary scaling of the poverty line, at least with multi-country comparisons where countries may use a different scaling factor. Nor does it exist with studies that estimate vulnerability as a function of various household and community variables: such studies would need to ensure these variables are comparable across different settings for their results to be comparable. The second feature is that the vulnerability line is explicitly linked to the poverty line, which can help smoothly integrate analysis of vulnerability with standard analysis of poverty. (We come back with more detailed discussion on these issues in section 4).

Third, as indicated above, by identifying the population segment that is vulnerable to poverty, our conceptual framework can also help classify the population into three distinct income (or consumption) groups: the “poor,” the “vulnerable,” and the “middle-class” (alternatively designated as the “secure” or “prosperous”). By separating out both the poor, and the non-poor but vulnerable, this approach offers a plausible basis for defining and identifying the middle class in society.<sup>6</sup> The policy relevance of identifying the middle class is clear for both developing countries and high income countries. However, an appropriate definition for the middle class remains elusive.<sup>7</sup> For example, using a money-metric measure, Banerjee and Duflo (2008) define households in developing countries as belonging to the middle class if their daily expenditures are between \$2 and \$10 PPP (Purchasing Power Parity) dollars. These consumption levels would, however, hardly permit

<sup>5</sup>It is interesting to note the literature on vulnerability as expected poverty follow a different approach from the poverty measurement context. The former first fix the vulnerability level (or aggregation) and then solve for the vulnerability line (or identification), while the latter follow a reverse procedure. We come back with more detailed discussion on these issues in section 4.

<sup>6</sup>In this paper, we broadly refer to the “middle class” as the top-income group (or the residual group other than the poor and the vulnerable), which by definition can also include the rich.

<sup>7</sup>Studies employing cross country analysis suggest that a larger middle class results in higher economic growth, better human development outcomes and stronger quality of governance (Easterly, 2001; Loayza *et al.*, 2012). More recently, unequal economic growth in high income countries such as the USA has sparked debates on what comprises the middle class and accompanying questions related to economic mobility (see, e.g., Piketty and Saez, 2003; Burkhauser *et al.*, 2012). In a recent speech on economic mobility, US President Obama considered the middle class as the “engine of... [the USA’s] prosperity” for the three decades after World War II and stated that rising inequality and declining mobility in recent years have had harmful effects on the economy, social cohesion, and democracy. (<http://www.whitehouse.gov/the-press-office/2013/12/04/remarks-president-economic-mobility>)

a middle class classification in richer countries.<sup>8</sup> Our paper circumvents this particular concern by defining both the vulnerable and the middle class within a common framework of future exposure to poverty. It appears to be the first to do so.

On the empirical front, one great hurdle that prevents researchers from empirically estimating vulnerability is the ubiquitous absence of true panel data. A most useful feature of our vulnerability lines is that they can be straightforwardly estimated from either panel or cross sectional household survey data, since our estimation approach is non-parametric, and involves relatively simple estimation procedures that make only “light” demands of underlying data. In particular, where true panel data are not available, our vulnerability lines can be estimated using only two rounds of cross sections with relatively parsimonious modelling assumptions. Since nationally representative panel data sets are quite scarce, particularly in the developing world, while “snap-shot” cross-sectional surveys are far more common, our approach thus offers a means to estimate vulnerability lines where panel-based methods would not be applicable. Consequently, vulnerability lines can be presented alongside standard poverty lines, yielding an expanded analysis of economic welfare for poverty and vulnerability, in a significantly larger number of country settings.

We provide empirical illustrations of vulnerability lines derived on the basis of both true panel data and synthetic panel data from three countries at differing income levels and from different geographic regions—India, the USA, and Vietnam. Our estimation results reveal that in both Vietnam and India the percentage of the population in poverty has fallen significantly between 2004 and 2008/9, matched almost fully by an expansion of the middle class—while leaving the share of the vulnerable population roughly constant at 35–50 percent of the total population. In contrast, in the USA, the same time period saw a marked increase in poverty, a decline in the middle class, and a discernable increase in the share of the population that can be considered vulnerable. We also find that there is more economic mobility in India and Vietnam than in the USA.

We provide in the next section the definition and main properties for these vulnerability lines and offer a brief note on computation. We then present empirical findings in Section 3, offer some further reflection on broader issues in Section 4, and conclude in Section 5.

## 2. CONCEPTUAL FRAMEWORK

### 2.1. Definition

Let  $y_t$  and  $Z_t$  represent the household’s consumption and the poverty line, respectively, in time  $t$ ,  $t = 0$  and  $1$ .<sup>9</sup> We define  $V_0$  as the vulnerability line such that

<sup>8</sup>On a related note, Birdsall *et al.* (2014) recently propose to call those with a daily income per capita between \$4 and \$10 the “strugglers” to clearly distinguish them from the middle class. Interestingly, the struggle to define the middle class is not just a matter of academic interest, but has attracted broader public attention in high-income countries including the UK and the USA. A recent article in the Financial Times (Donnan *et al.*, 2014) even names those earning between \$2 and \$10 a day the “fragile middle” to emphasize their precarious living on the brink of poverty. See also the recent articles on this topic in the Financial Times (Coupland, 2014; Tett, 2014), the New York Times (O’Leary, 2013; Porter, 2013), the opinion piece by Krugman (2014), and the online Great British class calculator maintained by the BBC (2013).

<sup>9</sup>We suppress the subscript for households to make notation less cluttered.

a specified proportion of the population with a consumption level above this line in time 0 will fall below the poverty line  $Z_1$  in time 1. As the population with consumption levels above the vulnerability line would generally be regarded as “secure” we will refer to this proportion as the “insecurity” index  $\mathcal{P}^1$ . Equivalently, given a specified insecurity index  $\mathcal{P}^1$ ,  $V_0$  satisfies the following equality

$$(1a) \quad \mathcal{P}^1 = P(y_1 \leq Z_1 | y_0 > V_0)$$

or assuming  $P(y_0 > V_0)$  is positive,<sup>10</sup> an equivalent expression rewritten based on Bayes’ theorem

$$(1b) \quad \mathcal{P}^1 = \frac{P(y_1 \leq Z_1 \cap y_0 > V_0)}{P(y_0 > V_0)}$$

Equality (1b) lends itself to straightforward estimation using household panel survey data, where the denominator can be estimated from the cross section in time 0, and the numerator from the panel data spanning both time 0 and time 1. Given appropriate adjustments for inflation rates, the vulnerability line in time 0 can then be updated for later periods just as with poverty lines.

Some parallels can be drawn between the familiar poverty line and this vulnerability line. First, just as a poverty line can be anchored to a benchmark (e.g., level of energy or median household consumption), a vulnerability line can be constructed given a specific value for the insecurity index  $\mathcal{P}^1$  (say, 5 or 10 per cent). Second, a lower value for the insecurity index is desirable and implies that a lower proportion of the population designated as “secure” is at risk of falling into poverty.

However, a major difference between this vulnerability line and the conventional poverty line is that the former is constructed using a dynamic poverty framework while the latter is essentially static. Another is that this vulnerability line is defined to be used at the population level for population-averaged estimates, rather than at the household level. Put differently, the construction of vulnerability lines is a two-step process. In the first step, (absolute) poverty lines are constructed (in practice, they are often linked to notions of minimum nutritional requirements). Then in the second step, these poverty lines act as building blocks and are combined with supplementary information on the shares of the population defined in relationship to these poverty lines in both periods, to construct vulnerability lines.

<sup>10</sup>This assumption is generally satisfied in practice as long as  $V_0$  is less than the maximum value of household consumptions in time 0. Despite its deceptively straightforward formula, this framework can provide a wieldy tool for analysis. An example of its application (usually with an additional assumption of bivariate normality) is a topic known as the “screening problem” in the statistics literature on quality control. This problem exists in situations where the performance of an individual (or quality of a product) on an immediate test is correlated with a future performance and the former is easy to measure while the latter is not. See, for example, Owen (1988) or Tang and Tang (1994) for brief overviews.

## 2.2. Properties

To further operationalize our framework, we make the following assumption

**Assumption 1.**  $y_1$  is stochastically increasing in  $y_0$ , that is  $P(y_1 > h | y_0 = Y)$  is increasing in  $Y$  for all thresholds  $h$ .

The intuition behind this assumption is that if an average household has a high consumption level in time 0, this household is likely to have high consumption in time 1 regardless of the threshold its consumption is measured against. This assumption is weaker than the commonly used normality assumption (i.e.,  $y_0$  and  $y_1$  follow a bivariate normal distribution) and allows a non-parametric and more flexible estimation for the vulnerability line (i.e., we make no assumption about the underlying distribution of the consumption data).<sup>11</sup> While this assumption may not hold for each individual household, we expect it to hold for (most of) the population for several reasons. First, the existence of any time-invariant household characteristics (i.e., household fixed effects) would help result in households having a higher consumption in the second period given their higher consumption in the first period.

Second, for particular households we may see some negative correlation in consumption over time, but these households usually form a small share of the population. For example, a household without the ability to smooth consumption over time (e.g., lacks access to credit) may cut expenditure in period 1 in order to pay for a wedding in period 2. For such a household we would see lower than average consumption in period 1, and higher than average consumption for period 2. But this is unlikely to occur for the majority of households at the same time. In our empirical analysis below, we will show that Assumption 1 holds using panel data from both the USA and from Vietnam.<sup>12</sup>

We examine below some key properties of the relationship between the vulnerability line and the insecurity index.

### Proposition 1. First definition of the vulnerability line

- 1.1. The vulnerability line  $V_0$  is a decreasing function of the insecurity index  $\mathcal{P}^1$ .
- 1.2. Any value of  $V_0$  that is higher than the poverty line  $Z_0$  results in a value for the insecurity index  $\mathcal{P}^1$  in the range  $[0, \mathcal{P}]$ , where  $\mathcal{P}$  is defined as  $\mathcal{P} \equiv P(y_1 \leq Z_1 | y_0 > Z_0)$  (i.e., the proportion of the population that were non-poor in time 0 but poor in time 1).

<sup>11</sup>We usually work with the logarithm of household consumption in practice. Thus more strictly speaking, we use  $y_j$  to refer to this (log of consumption) variable.

<sup>12</sup>Assumption 1 is also known in the statistical literature as positive regression dependency (PRD) (see, e.g., Lehman and Romano, 2005) and is weaker than the standard assumption of a bivariate normal distribution with a positive correlation. Dang and Lanjouw (2013) find that the (Pearson's) correlation for household consumption over time is positive and ranges between 0.43 and 0.70 for countries at different income levels and in different geographical settings such as Bosnia-Herzegovina, Lao PDR, Peru, the USA, and Vietnam. This is (qualitatively) consistent with the findings by Fields *et al.* (2003) for Indonesia, Spain, South Africa, and Venezuela, and Jenkins (2011) for Britain. See also Dang *et al.* (2014) for discussion on a similar assumption.

**Proof.** Online Appendix 1. ■

Note that if  $V_0$  is a strictly decreasing function of the insecurity index  $\mathcal{P}^1$ , or equivalently, if  $\mathcal{P}^1$  is strictly decreasing in  $V_0$ , Proposition 1.1 guarantees a unique solution to the vulnerability line  $V_0$  given the insecurity index  $\mathcal{P}^1$  since the latter provides a one-to-one mapping to the former<sup>13</sup> (see, e.g., Drouet-Mari and Kotz, 2001, pp. 38). Otherwise, if  $\mathcal{P}^1$  is non-increasing in  $V_0$ , the lowest value of  $V_0$  that satisfies expression (1a) should provide a natural solution.

### 2.3. An Alternative Definition

As noted above, our definition of the insecurity index can be linked to a notion of a “secure” population since it refers to a population with current consumption levels above the vulnerability line and indicates the risk amongst this population of falling into poverty by the next period. We consider below an alternative definition that focuses on those with a consumption level *higher* than the poverty line but still *below* the vulnerability line in period 0. We designate the likelihood amongst this population of falling into poverty in period 1 as the “vulnerability” index. The “insecurity index” and “vulnerability index” provide operational measures for households’ vulnerability to poverty, but the insecurity index focuses on households in the top part of the consumption distribution while the vulnerability index focuses instead on those located in the middle.

Figure 1 provides a simple graphical illustration of the intuition behind the insecurity and vulnerability indexes, where the dynamic transitions of household welfare statuses in the two periods are represented by the arrows. For example, the percentage of households that move from the vulnerable group in period 0 (i.e., the middle group in the top panel) to the poor group in period 1 (i.e., the left-most group in the bottom panel) forms the vulnerability index.<sup>14</sup>

We thus define the new vulnerability line as one that satisfies the following equality, given a specified vulnerability index  $\mathcal{P}^2$

$$(2a) \quad \mathcal{P}^2 = P(y_1 \leq Z_1 | Z_0 < y_0 < V_0)$$

or its equivalent expression,<sup>15</sup>

$$(2b) \quad \mathcal{P}^2 = \frac{P(y_1 \leq Z_1 \cap Z_0 < y_0 < V_0)}{P(Z_0 < y_0 < V_0)}$$

Similar to the first definition of the vulnerability line, the second definition of the vulnerability line is closely related to the vulnerability index  $\mathcal{P}^2$ . We examine some key properties of this relationship in Proposition 2 below.

<sup>13</sup>Strictly speaking, we also require that  $\mathcal{P}^1$  be a continuous function, which should generally be satisfied in practice.

<sup>14</sup>Note that while Figure 1 depicts household consumption as increasing from period 0 to period 1 for illustration purposes, no such condition on (the directions of) the dynamics of household consumption is necessary for the definitions of these indexes.

<sup>15</sup>This assumes that  $P(Z_0 < y_0 < V_0)$  is positive, which should be satisfied as long as  $V_0$  is reasonably larger than the poverty line  $Z_0$  for observed household consumptions. To make notation less cluttered, we use the same notation  $V_0$  to refer to the vulnerability line, even though its values can be different depending on whether it is obtained from equation (1) or equation (2).

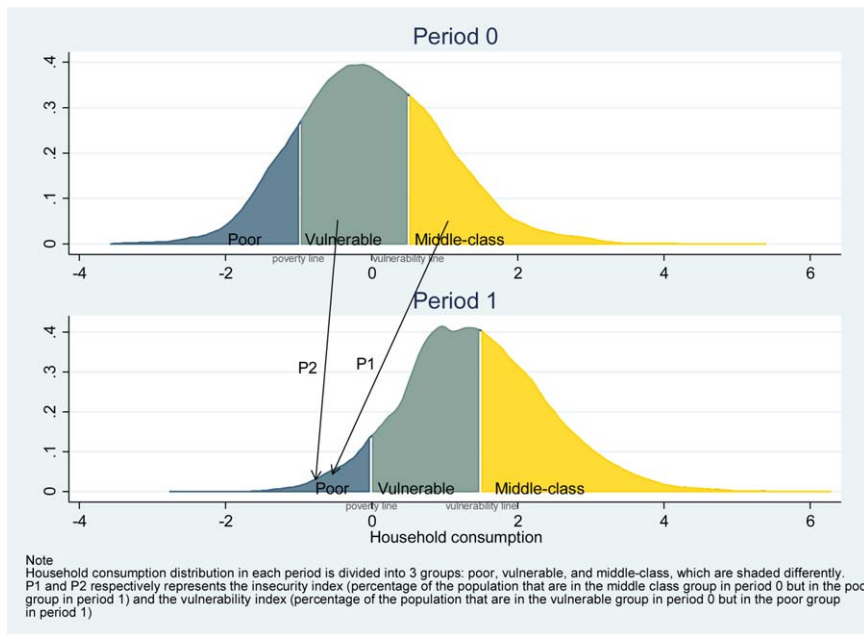


Figure 1. Illustration of the Definitions of the Insecurity Index and Vulnerability Index [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**Proposition 2. Alternative definition of the vulnerability line**

- 2.1. The vulnerability line  $V_0$  is a decreasing function of the vulnerability index  $\mathcal{P}^2$ .
- 2.2. Any value of  $V_0$  that is higher than the poverty line  $Z_0$  results in a value for the vulnerability index  $\mathcal{P}^2$  in the range  $[\mathcal{P}, \mathcal{P}^*]$ , where  $\mathcal{P} \equiv P(y_1 \leq Z_1 | y_0 > Z_0)$  and  $\mathcal{P}^* \equiv P(y_1 \leq Z_1 | y_0 = Z_0)$ .

**Proof.** Online Appendix 1. ■

A couple of remarks are in order about these two definitions of the vulnerability line. First, broadly speaking, both the insecurity index and the vulnerability index are by construction a summary measure of the population groups that are vulnerable to falling into poverty in the next period. Thus these two indexes can also be referred to under the same term “vulnerability index;” we prefer, however, to use different terms just to highlight the different population groups targeted by each index. Second, borrowing terminology from an emerging development literature (see, e.g., Conostas and Barrett, 2013; Barrett and Conostas, 2014;),<sup>16</sup> these indexes measure the degree of resilience for these population groups to the undesirable state of poverty. Interestingly enough, there appears no consensus in this literature on a common measurement framework for resilience

<sup>16</sup>This literature builds on the original concept of resilience developed earlier in the ecology literature. For example, Holling (1973) defines resilience of ecological systems as “... the ability of these systems to absorb change... and still persist”.



(or lack thereof); our definitions of the vulnerability lines can thus provide a modeling option to this literature.<sup>17</sup>

Finally, both definitions of the vulnerability line can be regarded as providing a lower bound for the middle class. The vulnerability line can work in both cases as a lower bound value where households with a higher consumption than this line would be considered as belonging to the middle class, and with households located in the interval between this line and the poverty line belonging to the group that is most vulnerable to poverty. For consistency, we will refer to this latter group as the vulnerable group in the remainder of this paper. The only difference between the two definitions (besides the terminology) is that the first definition focuses on the vulnerability of the former group of households, while the second refers to the latter group. We will come back in the next section with an empirical illustration for this second use of these vulnerability lines.

#### 2.4. Other Properties

We then turn to examining some other properties of the vulnerability and insecurity index and their associated vulnerability lines. These are provided in the following Propositions. We consider in turn the relationship between the insecurity index and the vulnerability index (Proposition 3), the overall relationship between these indexes and their associated parameters (Proposition 4), and the relationship between these indexes over different time periods (Proposition 5).

#### **Proposition 3. Relationship between the insecurity index and the vulnerability index**

*The proportion of the population that were non-poor in time 0 but poor in time 1  $P$  (i.e.,  $\mathcal{P} \equiv P(y_1 \leq Z_1 | y_0 > Z_0)$ ) are bounded below and above respectively by the insecurity index  $\mathcal{P}^1$  and the vulnerability index  $\mathcal{P}^2$ , that is  $\mathcal{P}^1 \leq \mathcal{P} \leq \mathcal{P}^2$ .*

**Proof.** Online Appendix 1. ■

Proposition 3 is an interesting result from Propositions 1 and 2. Note that when the vulnerability line  $V_0$  coincides with the poverty line  $Z_0$ , the insecurity index  $\mathcal{P}^1$  is identical to the traditional quantity of poverty dynamics  $\mathcal{P}$ . On the other hand, when the vulnerability line  $V_0$  is set too high such that no one will attain that level of consumption, the vulnerability index  $\mathcal{P}^2$  is identical to  $\mathcal{P}$ .<sup>18</sup> One practical implication from Proposition 3 is that, we can use the traditional quantity of poverty dynamics  $\mathcal{P}$  as a useful benchmark when setting the relevant

<sup>17</sup>Thus another term to use for these indexes can be “non-resilient index”.

<sup>18</sup>Mathematically speaking, after some straightforward manipulations, we can express the relationship between the two indexes and the traditional quantity of poverty dynamics as  $\mathcal{P} = w_1 \mathcal{P}^1 + w_2 \mathcal{P}^2$ , where  $w_1 = \frac{P(V_0 < y_0)}{P(Z_0 < y_0)}$  and  $w_2 = \frac{P(Z_0 < y_0 < V_0)}{P(Z_0 < y_0)}$ . When the vulnerability line  $V_0$  equals the poverty line  $Z_0$ ,  $w_1$  and  $w_2$  would respectively equal 1 and 0; similarly, when  $V_0$  is larger than the maximal observed household consumption, the opposite holds. The stated results thus follow. An implication of Proposition 3 is the rule of thumb that at a given vulnerability index of, say, 10 percent, households in the vulnerable group have *at least* a 10 percent chance of falling into poverty in the next period, while the corresponding figure for those in the middle class group is *at most* 10 percent.

index. In particular, different values for  $\mathcal{P}$  can affect the range of values for the two indexes; for example, a smaller value would provide a tighter range of values for the insecurity index compared to the vulnerability index. We come back with more discussion on this in the empirical illustration.

**Proposition 4. Homogeneity of degree zero (Scale invariance)**

*Both the insecurity index  $\mathcal{P}^1$  and the vulnerability index  $\mathcal{P}^2$  are homogenous of degree 0 in  $y_0, y_1, Z_1, V_0$  and  $Z_0$ ; that is, increasing (or decreasing)  $y_0, y_1, Z_1, V_0$  and  $Z_0$  by the same positive factor will have no effect on these indexes.*

**Corollary 4.1.** *The insecurity index  $\mathcal{P}^1$  is homogenous of degree 0 in  $(y_1, Z_1)$  or  $(y_0, V_0)$ .*

**Corollary 4.2.** *The vulnerability index  $\mathcal{P}^2$  is homogenous of degree 0 in  $(y_1, Z_1)$  or  $(y_0, Z_0, V_0)$ .*

**Proof.** Online Appendix 1. ■

Proposition 4 has much practical relevance, since we would usually work with household consumption converted to a different scale (say, logarithmic scale for better model fits) rather than in its original format. Thus the homogeneity of degree zero property of these indexes provides us with some flexibility in selecting the appropriate denomination unit for household consumption. Since the correlation of household consumption over two periods does not depend on its unit of measurement, we can work with different scales of household consumption in different periods if necessary. In addition, certain countries use more zeroes in their currencies than others, thus it may be computationally more convenient to work with these countries' household consumption, say, in the thousandth unit. In other words, Proposition 4 helps highlight the fact that these indexes are unit-free and can be used for comparison with different countries.

Comparability over longer time periods, however, is more involved and described in the following Proposition.

**Proposition 5. Comparison of the indexes over different time periods**

*Assuming a non-negative and non-increasing correlation for household consumption over time and household consumptions in each pair of periods follow a bivariate normal distribution (that is,  $y_t$  and  $y_0$  follow a bivariate normal distribution with non-negative correlation coefficient  $\rho_t$  with  $\rho_t \geq \rho_{t'}$ , where period  $t'$  is more recent than period  $t$ ), and given a fixed vulnerability line for the original period,*

- i) if household consumption growth remains stagnant over time (i.e.,  $y_t$  and  $y_{t'}$  are identically distributed), then both the insecurity index  $\mathcal{P}^1$  and the vulnerability index  $\mathcal{P}^2$  are non-decreasing in time.*
- ii) if household consumption growth is stronger than the decaying effect of household consumption correlation over time, then both the insecurity index  $\mathcal{P}^1$  and the vulnerability index  $\mathcal{P}^2$  can decrease in time.*

**Proof.** Online Appendix 1. ■

The first assumption about a specific form of economic mobility over time (i.e., non-negative and non-increasing correlation for household consumption) put forward in Proposition 5 is commonly shown to be true with panel data, and is confirmed again with the panel data we use for the USA and Vietnam, as will be shown later. The second assumption about normality with the distribution of household consumption is stronger than the stochastic relationship assumed in Assumption 1 but is rather standard, and renders the mathematical derivations more tractable.

The intuition behind Proposition 5 is that, given these assumptions, if household consumption growth remains stagnant over time, both the insecurity index and vulnerability index are likely to be larger the longer the time interval that is considered. However, if household consumption growth is strong enough and can offset the decaying effect of the correlation of household consumption over time, we will see the opposite situation where households are better off and thus the indexes are likely to be smaller (i.e., households are less susceptible to falling back into poverty) the longer the time interval. How much economic growth would be sufficient is an empirical issue, which we will come back to in the next section.

Regardless of the different economic scenarios, Proposition 5 provides a couple of useful inferences. First, the vulnerability (and insecurity) index may either increase or decrease over time, and the direction of change depends to a large extent on the growth of consumption levels. Second, as a result of these likely changes over time, these (vulnerability lines and) indexes would be best compared over similar time periods, since Proposition 5 implies that, a, say, 20 percent vulnerability index over a 5-year period does not necessarily indicate the same degree of vulnerability over each year as a 20 percent vulnerability index does over a 10-year period.<sup>19</sup> An alternative would of course be to ignore the different time lengths and estimate the same vulnerability index (and line) for these different time intervals. However, this would be useful only if these two different time intervals are assumed to be equivalent in terms of change with vulnerability to poverty.<sup>20</sup>

Finally, it may be more convenient to keep the vulnerability (insecurity) index fixed over time and update the associated line. Indeed, just as with poverty lines that should be updated over time to allow for changes in prices or consumption patterns (against a relatively more fixed level of living standards), vulnerability lines should also be periodically updated. It may sometimes be better to calculate the vulnerability line directly from the given data rather than, say, simply updating it with consumption deflators, since the vulnerability index is more sensitive to the shape of the consumption distribution.

<sup>19</sup>This comparability issue over different time intervals broadly holds for other welfare transition comparisons as well (e.g., 10 percent of the poor escape poverty over a 5-year period can indicate different dynamics from the same figure over a 10-year period).

<sup>20</sup>Another option is to assume that the rate of change of vulnerability is proportionate to the length of the time interval (say, based on macroeconomic conditions including GDP growth). For example, if vulnerability is assumed to be inversely proportionate to the length of time interval thanks to strong economic growth, then a vulnerability index of 20 percent over a 5-year period can be reduced in half (i.e., 10 percent) over a twice-longer period of 10 years.

### 2.5. Note on Computation

There is no closed-form solution for  $V_0$  in equalities (1) and (2). However, given household consumption in both periods, the poverty line  $Z_1$ , and a pre-specified value for either the insecurity or vulnerability index, we can empirically solve for the vulnerability line  $V_0$ . In particular, since  $\mathcal{P}^1$  ( $\mathcal{P}^2$ ) is a decreasing function of  $V_0$ , we can iterate from the poverty line upward until we reach a value for  $V_0$  that provides the specified insecurity (vulnerability) index. But a practical note is that if  $V_0$  is close to  $Z_0$ , the sample size for households in between the poverty line and the vulnerability line (i.e., with  $Z_0 < y_0 < V_0$ ) that can be used to estimate the vulnerability index  $\mathcal{P}^2$  can be small; this similarly holds with the estimation sample for  $\mathcal{P}^1$  when  $V_0$  is set close to the maximal observed household consumption level. One solution is identifying an adequately large sample size to start with (i.e., similar to ensuring that a population group has a sufficient sample size for statistical inference); another is to keep iterating from the poverty line upward but using estimation results only when estimated values show steady iteration.

Another issue that should be considered is the incremental (step) value used in the iteration. There always exists a tradeoff between using either a large incremental value or a smaller incremental value. The former would perhaps require less computer time but would provide a less full (and less continuous) range of solutions than the latter.<sup>21</sup>

## 3. EMPIRICAL ILLUSTRATIONS

The above framework can be amenable to estimation using either true panel data or synthetic panel data that are constructed from cross sections. We provide examples in the next sections using both types of data in various settings ranging from lower-income countries (India and Vietnam) to a high-income country (the USA).

### 3.1. True Panel Data

We use true panel data from a low-income country—Vietnam—and a high-income country—the USA—for illustration. Data for the former comes from three rounds of the VHLSS (Vietnam Household Living Standards Survey) in 2004, 2006, and 2008, and the latter the sample persons (i.e., those with a positive longitudinal weight) from three rounds of the PSID (Panel Study of Income Dynamics) in 2005, 2007, and 2009. The VHLSS follows a rotating panel design where half of the sample in the previous round is repeated in the succeeding round, thus resulting in a panel sample for all three survey rounds of roughly one-fourth of the original sample in 2004.<sup>22</sup> Sample sizes for Vietnam are around 3,700 households between 2006 and 2008, and 1,800 households between 2004

<sup>21</sup>A Stata program to estimate the vulnerability lines is available from us upon request.

<sup>22</sup>We construct panel data for the VHLSS using household identification codes. Where we suspect mismatching between panel households due to incorrect identification codes, we correct these cases using a matching procedure that uses household heads' names. Since there are no longitudinal weights with the VHLSS, we use the cross sectional weights in 2008 instead. The distributions for the panels and cross sections are similar; see also Dang and Lanjouw (2013) for more details with preparing these panel data.

TABLE 1  
VULNERABILITY LINES AT GIVEN INSECURITY INDEXES, 2006–2008

No	United States				Vietnam		
	Vulnerability index (%)	Vulnerability line (US\$)	Increase (%)	Pop. Share with consumption above V-line (%)	Vulnerability line (D'000)	Increase (%)	Pop. Share with consumption above V-line (%)
1	6	N/A	N/A	N/A	2560	0	84.2
2	5	N/A	N/A	N/A	2800	9	80.4
3	4	13305	0	89.0	3080	20	75.7
4	3	17905	35	83.5	3320	30	71.6
5	2	26505	99	73.6	3920	53	61.0
6	1	61305	361	40.8	5320	108	40.7

*Note:* Vulnerability lines are in US\$ per household and D'000 per capita respectively for the US and Vietnam. The relative increases of the vulnerability line from the poverty line each country is shown under the columns “Increase” (columns 4 and 7). All numbers are estimated with true panel data and weighted with population weights. Estimation sample size are 5,335 panel households for the US, and 3,735 panel households for Vietnam. The incremental values for iteration are US\$100 and D20,000 respectively for the US and Vietnam. The exchange rate is US\$1 for D16,302 in 2008 (World Bank, 2013).

and 2008; the corresponding figures are 5,335 households for the USA for both periods. We restrict the panel households to those that have the same household head over time, and provide all estimates using population weights.

These surveys provide respectively consumption and income data for the same years in 2004, 2006, and 2008 (since income data are from the last tax year in the USA). In a slight abuse of notation, we hereafter refer to the specific PSID survey round by the tax year, and use income and consumption interchangeably. There is no one single national poverty line for the USA, so for illustration purposes we choose for the national poverty line the total household income level that provides the same poverty rates as those based on the Census Bureau’s household-varying thresholds. For example, this poverty line in 2006 is \$US 13,305 per household yielding a poverty rate of 11 percent. The poverty line for Vietnam is constructed instead based on a basket of consumption items and is benchmarked to a minimum requirement of calorie intake (without adjustments for different household sizes or composition as with those for the USA); for example, this poverty line is D 2,560,000 per capita in 2006 (Glewwe, 2009), yielding a poverty rate of 16 percent.<sup>23</sup>

### 3.1.1. Vulnerability Lines

Estimation results for the first definition of the vulnerability line ( $\mathcal{P}^1$ ) are provided in Table 1, where the incremental values for iteration are respectively set

<sup>23</sup>Note that Assumption 1 is satisfied for both datasets. For example, letting  $h$  equal the poverty line in 2008 and  $Y$  the poverty line in 2006 for Vietnam, we have  $P(y_1 > h | y_0 = Y) = 0.55$ ; then increasing the poverty line  $Y$  by 1.05, 1.15, and 1.5 times respectively results in higher (non-poverty) rates of 0.77, 0.80, and 0.93.

at \$100 and D20,000 for the USA and Vietnam, which are less than 1 percent of the poverty line in each country. Table 1 shows that the proportion of the population that were non-poor in the first period but fell into poverty in the second period are rather low at 6 percent for Vietnam (column 2). This is also the maximum value for the insecurity index (Proposition 1.2) given the existing poverty line—or minimum vulnerability line—for this country. If we want to reduce the insecurity index to, say, 3 percent for Vietnam, we would have to set the vulnerability line above the poverty line by 30 percent (equal to D 3,320,000 or \$US 204), which coincidentally is equal to the arbitrary scaling-up of the poverty line by 30 percent that has been proposed by the Government of Vietnam.

Since the vulnerability line is a non-linear function of the insecurity index, reducing the latter further to less than 1 percent would require a much higher increase to the former of 108 percent. Only 41 percent of the population (column 8) has an income level above this line. Table 1 also shows that these results for Vietnam are qualitatively similar to those for the USA despite the differences in magnitude; that is, reducing the vulnerability index to 3 percent or 1 percent for the USA requires raising the poverty line by respectively as much as 35 percent and 361 percent.

Estimation results for the second definition of the vulnerability line ( $\mathcal{P}^2$ ) are provided in Table 2. As discussed earlier, we start iterating from a minimum sample size of 500 households whose consumption is between the poverty line and vulnerability line, which yields a maximum vulnerability index of 19 percent and 22 percent respectively for the USA and Vietnam. If we are to apply the same automatic scaling of 30 percent to the poverty line for Vietnam as before, this would result in a vulnerability index of 22 percent. Reducing these vulnerability indexes to, say, 10 percent would entail increasing the poverty line by 177 percent and 114 percent respectively for each country. As discussed earlier, since the proportion of the population that were non-poor in time 0 but poor in time 1 is small for both the US and Vietnam, the vulnerability index provides a larger range of values compared to the insecurity index.

### 3.1.2. Welfare Dynamics over Comparable Time Periods

Both Tables 1 and 2 also offer potential ranges of values for the vulnerability line that can work as a middle class income line. For example, if we use the second definition and a vulnerability index of 10 percent, it would translate into a middle class income line (or vulnerability line) of \$US 36,905 and D 5,480,000 for the USA and Vietnam. These lines are respectively 71 percent and 92 percent of the median incomes for each country in the same year (i.e., \$US 52,163 for the USA (DeNavas-Walt et al., 2009) and D 5,986,000 for Vietnam (our calculations)). We can then update these middle class lines with the appropriate consumer price indexes in the second period and use these to estimate different measures of welfare transitions.<sup>24</sup>

<sup>24</sup>These consumer price indexes are 7 percent for the USA (Census Bureau, 2013) and 33 percent for Vietnam (our calculations based on data provided by Vietnam's General Statistical Office). We focus on using the second definition of the vulnerability line in this paper for illustration given its larger range of values.

TABLE 2  
VULNERABILITY LINES AT GIVEN VULNERABILITY INDEXES, 2006–2008

No	United States				Vietnam		
	Vulnerability index (%)	Vulnerability line (US\$)	Increase (%)	Pop. Share with consumption above poverty line but less than V-line (%)	Vulnerability line (D'000)	Increase (%)	Pop. Share with consumption above poverty line but less than V-line (%)
1	22	N/A	N/A	N/A	3340	30	12.9
2	21	N/A	N/A	N/A	3380	32	13.5
3	20	N/A	N/A	N/A	3500	37	15.3
4	19	21105	59	9.0	3660	43	18.2
5	18	22205	67	10.3	3700	45	19.0
6	17	22805	71	11.0	3780	48	20.6
7	16	24305	83	12.6	3920	53	23.3
8	15	25105	89	13.9	4140	62	26.7
9	14	27905	110	16.8	4260	66	28.6
10	13	29005	118	18.5	4500	76	32.2
11	12	30405	129	20.1	4860	90	37.1
12	11	32405	144	22.2	5140	101	40.9
13	10	36905	177	26.4	5480	114	45.5
14	9	45905	245	34.1	6080	138	51.6
15	8	50605	280	39.2	7080	177	59.3
16	7	59105	344	46.1	8980	251	69.5
17	6	74405	459	56.8	17500	584	81.8
18	5	104405	685	69.9	N/A	N/A	N/A
19	4	290905	2086	86.9	N/A	N/A	N/A

*Note:* Vulnerability lines are in US\$ per household and D'000 per capita respectively for the US and Vietnam. The relative increases of the vulnerability line from the poverty line each country is shown under the columns "Increase" (columns 4 and 7). All numbers are estimated with true panel data and weighted with population weights. Estimation sample size are 5,335 panel households for the US, and 3,735 panel households for Vietnam. The incremental values for iteration are US\$100 and D20,000 respectively for the US and Vietnam. The exchange rate is US\$1 for D16,302 in 2008 (World Bank, 2013).

Table 3 shows the welfare transition matrices respectively for the USA based on the poverty line and middle class line defined above. Estimation results suggest that the lower income groups enjoy stronger growth during 2006–2008, with the poor shrinking by 9 percent (= (11-10)/11) and the middle class remaining almost unchanged, while the vulnerable category expand by 6 percent over this period. However, while these changes are favorable for the lower income groups, the population still remain largely immobile with roughly 80 percent of the population (i.e., the sum of the cells on the diagonal) staying in the same income categories, and around 20 percent experiencing (upward or downward) mobility. This result based on our classification of the different income groups for the USA may thus add another angle to the various discussions on economic inequality for this country.<sup>25</sup>

<sup>25</sup>A quick way to check on the vulnerability index is to divide the cell percentage for the vulnerable in 2006 but poor in 2008 (2.6 percent) by that for the vulnerable in 2006 (26.4 percent), which yields the given index of 0.1.

TABLE 3  
WELFARE TRANSITION DYNAMICS BASED ON TRUE PANEL DATA, UNITED STATES 2006–2008  
(CELL PERCENTAGE)

		2008			
		Poor	Vulnerable	Middle class	Total
2006	Poor	6.3 (0.3)	3.7 (0.3)	1.0 (0.1)	11.0 (0.4)
	Vulnerable	2.6 (0.2)	18.1 (0.5)	5.6 (0.3)	26.4 (0.6)
	Middle class	1.0 (0.1)	6.1 (0.3)	55.4 (0.7)	62.6 (0.7)
	Total	10.0 (0.4)	27.9 (0.6)	62.1 (0.7)	

*Note:* The vulnerability index is defined as  $P(Y1 < Z1 | Z0 < Y0 < V0) = 0.1$  for period 2006–2008 yielding a yearly vulnerability line of \$US36,905 per household in 2006 prices, which is then adjusted for inflation in 2008 to obtain the vulnerability line in this year as \$US39,488. The national poverty lines are constructed such that these yield the same poverty rate as those based on the Census Bureau's household-varying thresholds for each year. These poverty lines are respectively \$US13,305 and \$US13,668 per household for 2006 and 2008. Standard errors are in parentheses. All numbers are estimated with true panel data and weighted with population weights. Estimation sample sizes are 5,335 panel households.

A qualitatively similar situation happens in Vietnam during the same period (Table 4). Specifically, the poor and middle class categories shrink respectively by 8 and 5 percent during 2006–2008; but the vulnerable category expands slightly over the two years by around 7 percent. The overall population in Vietnam is, however, more mobile with approximately 30 percent of the population experiencing mobility (upward or downward).

TABLE 4  
WELFARE TRANSITION DYNAMICS BASED ON TRUE PANEL DATA, VIETNAM 2006–2008  
(CELL PERCENTAGE)

		2008			
		Poor	Vulnerable	Middle class	Total
2006	Poor	9.6 (0.6)	5.7 (0.5)	0.4 (0.1)	15.8 (0.8)
	Vulnerable	4.6 (0.4)	32.1 (0.9)	8.8 (0.5)	45.5 (0.9)
	Middle class	0.3 (0.1)	11.0 (0.6)	27.4 (0.9)	38.7 (0.9)
	Total	14.5 (0.8)	48.8 (1.0)	36.7 (0.9)	100

*Note:* The vulnerability index is defined as  $P(Y1 < Z1 | Z0 < Y0 < V0) = 0.1$  for period 2006–2008 yielding a yearly vulnerability line of D5,480,000 per capita in 2006 prices, which is then adjusted for inflation in 2008 to obtain the vulnerability line in this year as D7,288,400. The poverty lines are D2,559,850 and D3,358,180 per capita respectively for 2006 and 2008. All numbers are estimated with true panel data and weighted with population weights. Standard errors in parentheses are estimated adjusted for the complex survey design. Estimation sample sizes are 3,735 panel households.



### 3.1.3. Welfare Dynamics over Different and Longer Time Periods

Where there is interest in comparing the same vulnerability index (or vulnerability line) over different time periods, we fix the vulnerability index at 10 percent in the period 2006–2008 in 2006 prices for both the USA and Vietnam, and adjust the associated vulnerability lines backward and forward to two adjacent pairs of periods, 2004–2006 and 2004–2008 using consumption deflators.<sup>26</sup> By definition, the vulnerability index for 2004–2006 measures the movement of those who were in the vulnerable group in 2004 but fall into poverty in 2006, and similarly with the period 2004–2008. The estimated consumption transition dynamics are then provided in Table 5 for the US and Table 6 for Vietnam.

The vulnerability index for the USA in the period 2004–2006 is around 13 percent ( $=3.4/26.4$ ), which remains more or less the same two years later for the period 2004–2008 (Table 5). However, the vulnerability index for Vietnam is lower over these same periods, hovering around 7 or 8 percent (Table 6). This points to the role of economic growth in reducing vulnerability: during the period 2004–2008, the growth in the mean household income is 4 percent for the USA, but the corresponding growth in per capita consumption is 84 percent for Vietnam.

If the rate of change of vulnerability is assumed to be equal for each of the two periods 2004–2006 and 2004–2008 (regardless of the different time intervals), another alternative is to estimate the vulnerability line directly for each period rather than making the adjustments for this line from another period. For example, using household survey data for Vietnam in the period 2004–2006, we estimate the vulnerability line associated with a vulnerability index of 10 percent to be D 3,758,400 in 2006 prices; repeating this exercise for data in the period 2004–2008, we estimate the vulnerability line to be roughly 15 percent higher at D 4,315,000 in the same prices. Clearly, rising consumption levels in Vietnam reduce vulnerability, thus drive up the vulnerability line in the period with higher consumption levels if the same vulnerability index is to be fixed for all periods.<sup>27</sup>

Tables 5 and 6 also indicate that for the periods 2004–2006 and 2004–2008, Vietnam sees slightly more economic mobility than the USA, with the proportion of the immobile population decreasing from around 68 percent ( $=11.3 + 33.4 + 23$ ) to 63 percent, while the corresponding figures for the USA are 77 percent and 74 percent. But the distribution of economic growth is quite

<sup>26</sup>Note that the assumption of a weaker correlation of household consumption over time in Proposition 5 is satisfied with data for both the USA and Vietnam. For example, this correlation coefficient is 0.55 and 0.47 respectively for the USA in the period 2004–2006 and 2004–2008. Using longitudinal earning data from the Social Security Administration between 1937 and 2004, Kopczuk, Saez, and Song (2010) also finds that the (rank) correlation of earnings decreases over longer time intervals. This assumption also holds for data from other countries such as China (Khor and Pencavel, 2006), India (Chaudhuri and Ravallion, 1994), Peru (Dang and Lanjouw, 2013), and the UK (Jenkins, 2011).

<sup>27</sup>We also re-estimate the consumption dynamics using the new vulnerability lines estimated above. Estimation results (shown in Table 3.3, online Appendix 3) are qualitatively similar and indicate that the poor and vulnerable categories shrink in both periods while the middle class expands. However, the changes in the vulnerability lines unsurprisingly result in different income categories accounting for different proportions of the population. This indicates that the larger changes with the vulnerability index in Vietnam is not (strongly) driven by the fact that the vulnerability line is fixed in one period and simply adjusted for other periods.

TABLE 5

WELFARE TRANSITION DYNAMICS BASED ON TRUE PANEL DATA, USA 2004–2008 (CELL PERCENTAGE)

			2006			
			Poor	Vulnerable	Middle class	Total
Panel A	2004	Poor	5.5 (0.3)	2.7 (0.2)	0.8 (0.1)	8.9 (0.4)
		Vulnerable	3.4 (0.2)	16.5 (0.5)	6.5 (0.3)	26.4 (0.6)
		Middle class	2.1 (0.2)	7.2 (0.4)	55.4 (0.7)	64.7 (0.7)
		Total	11.0 (0.4)	26.4 (0.6)	62.6 (0.7)	
			2008			
			Poor	Vulnerable	Middle class	Total
Panel B	2004	Poor	4.6 (0.3)	3.2 (0.2)	1.1 (0.1)	8.9 (0.4)
		Vulnerable	3.3 (0.2)	15.9 (0.5)	7.2 (0.4)	26.4 (0.6)
		Middle class	2.1 (0.2)	8.8 (0.4)	53.8 (0.7)	64.7 (0.7)
		Total	10.0 (0.4)	27.9 (0.6)	62.1 (0.7)	

*Note:* The vulnerability index is defined as  $P(Y1 < Z1 | Z0 < Y0 < V0) = 0.1$  for period 2006–2008 yielding a yearly vulnerability line of \$US36,905 per household in 2006 prices. This vulnerability line is then adjusted for inflation in 2004 and 2008 to obtain the vulnerability lines in these two years respectively as \$US34,491 and \$US39,488. The national poverty lines are constructed such that these yield the same poverty rates as those based on the Census Bureau's household-varying thresholds for each year. These poverty lines are respectively \$US12,400, \$US13,305, and \$US13,668 per household for 2004, 2006, and 2008. Standard errors are in parentheses. All numbers are estimated with true panel data and weighted with population weights. Panel A and Panel B provide estimates using the panel data respectively in 2004–2006 and 2006–2008. Estimation sample sizes are 5,335 panel households for both periods.

different for these two countries. In the USA the poor and vulnerable categories expand in each period (except for the period 2004–2006 where the vulnerable category remains unchanged) while the middle class shrinks. In contrast, the opposite happens in Vietnam.

### 3.2. Synthetic Panel Data

As noted above, we do not have panel data to develop estimates of the vulnerability line in India. In order to implement the procedure described in the preceding sections, it is necessary to first convert the series of cross-section datasets available for India into synthetic panel data. We do so by applying a method proposed by Dang and Lanjouw (2013) (see, also Dang et al. (2014) for a related study). A brief discussion of this method and its validation against actual panel data from Vietnam is provided in Appendix 2 of the online supporting material.

TABLE 6  
WELFARE TRANSITION DYNAMICS BASED ON TRUE PANEL DATA, VIETNAM 2004–2008  
(CELL PERCENTAGE)

			2006			
			Poor	Vulnerable	Middle class	Total
<b>Panel A</b>	<b>2004</b>	<b>Poor</b>	11.3 (1.1)	8.3 (0.8)	0.4 (0.2)	20.0 (1.3)
		<b>Vulnerable</b>	3.4 (0.5)	33.4 (1.2)	14.2 (0.9)	51.0 (1.4)
		<b>Middle class</b>	0.1 (0.0)	5.9 (0.6)	23.0 (1.1)	29.0 (1.1)
		<b>Total</b>	14.8 (1.2)	47.6 (1.3)	37.6 (1.3)	100
			2008			
			Poor	Vulnerable	Middle class	Total
<b>Panel B</b>	<b>2004</b>	<b>Poor</b>	10.0 (1.0)	9.7 (0.9)	0.4 (0.1)	20.0 (1.3)
		<b>Vulnerable</b>	4.0 (0.5)	32.3 (1.3)	14.7 (1.0)	51.0 (1.4)
		<b>Middle class</b>	0.3 (0.2)	7.7 (0.7)	21.0 (1.1)	29.0 (1.1)
		<b>Total</b>	14.3 (1.1)	49.7 (1.4)	36.0 (1.3)	

*Note:* The vulnerability index is defined as  $P(Y1 < Z1 | Z0 < Y0 < V0) = 0.1$  for period 2006–2008 yielding a yearly vulnerability line of D5,480,000 per capita in 2006 prices. This vulnerability line is then adjusted for inflation in 2004 and 2008 to obtain the vulnerability lines in these two years respectively as D4,724,138 and D7,288,400. The poverty lines are D2,077,210, D2,559,850 and D3,358,180 per capita respectively for 2004, 2006, and 2008. Standard errors in parentheses are estimated adjusting for the complex survey design. All numbers are estimated with true panel data and weighted with population weights. Panel A and Panel B provide estimates using the panel data respectively in 2004–2006 and 2006–2008. Estimation sample sizes are 1,818 panel households for both periods.

Note that the standard errors of estimates based on the synthetic panels can in fact be even smaller than that of the true (or design-based) rate if there is a good model fit (or the sample size in the target survey is significantly larger than that in the base survey; see, e.g., Matloff, 1981).

We thus construct the synthetic panel data using two cross sections of the National Sample Survey (NSS) in 2004 and 2009 to investigate consumption dynamics for India. Similar to the USA, there is no single national poverty line for India. Thus we construct a population-weighted monthly national poverty line from those for urban and rural areas in the Tendulkar report (GOI, 2009), which is 483 rupees per capita in 2004 prices. This poverty line yields a national poverty rate of 38 percent in 2004/05, which is close to the rate of 37.2 percent in the cited report. All expenditures data in 2004 are then converted to a common scale using as deflators the ratios of this national poverty line and the state poverty lines (which also vary between urban and rural areas). We also convert all

TABLE 7  
WELFARE TRANSITION DYNAMICS BASED ON SYNTHETIC PANEL DATA, INDIA 2009  
(CELL PERCENTAGE)

		2009			
		Poor	Vulnerable	Middle class	Total
2004	Poor	24.1 (0.1)	9.8 (0.0)	0.5 (0.0)	34.4 (0.1)
	Vulnerable	4.9 (0.0)	21.2 (0.0)	9.2 (0.0)	35.3 (0.0)
	Middle class	0.1 (0.0)	4.9 (0.0)	25.3 (0.1)	30.3 (0.1)
	Total	29.1 (0.1)	35.8 (0.0)	35.0 (0.1)	

*Note:* The vulnerability index is defined as  $P(Y1 < Z1 | Z0 < Y0 < V0) = 0.15$  for period 2004–2009 yielding a yearly vulnerability line of 803 rupees per capita in 2004 prices. The single national poverty line for 2004 is constructed from those for urban and rural areas in the Tendulkar report (GOI, 2009) with population weights. This poverty line is 483 rupees per capita per month in 2004 prices. All numbers are estimated with synthetic panel data and weighted with population weights, where the 2009 data are used as the base year. Bootstrap standard errors in parentheses are estimated with 1,000 bootstraps adjusting for the complex survey design. Estimation sample size is 76,497 households. Household head's age range is restricted to between 25 and 55 for the first survey and adjusted accordingly for the second survey.

expenditure data in 2009 to 2004 prices, using as deflators the state poverty lines in the two years.

Given the national poverty line of 483 rupees per capita in 2004 prices, and using the second definition of the vulnerability line ( $\mathcal{P}^2$ ), we estimate its range of vulnerability index as 10 percent to 43 percent.<sup>28</sup> For illustration purpose, we then fix  $\mathcal{P}^2$  at 15 percent and use its corresponding monthly vulnerability line of 803 rupees per capita, which is somewhat close to the higher end of the income range (i.e., as twice the poverty line or  $966 = 483 \times 2$ ) that defines vulnerability as proposed by a government agency in India (NCEUS, 2007).<sup>29</sup>

Estimation results provided in Table 7 show strong welfare improvement for both the poor category and the middle class, while the vulnerable category remains almost the same and accounts for around 35 percent of the population. In particular, the poverty category decreases by 15 percent and the middle class increases by 16 percent in this period. The population as a whole are rather mobile, with 20 percent of the population experiencing upward mobility while 10 percent experience downward mobility. Compared to the USA and Vietnam at a similar vulnerability index of 20 percent over a roughly similar period (2004–2008), it can be calculated that India has the second most mobility with 30 percent of the population churning their consumption levels, which is lower than the

<sup>28</sup>These correspond to vulnerability lines of 1148 and 538 rupees per capita respectively.

<sup>29</sup>Using different values for the vulnerability index provides qualitatively similar results. For example, Table 2.2. in Appendix 2 in the online supporting information shows that while a vulnerability index of 20 percent would render the population share of the vulnerable category smaller, it hardly changes the estimation results discussed above for India.

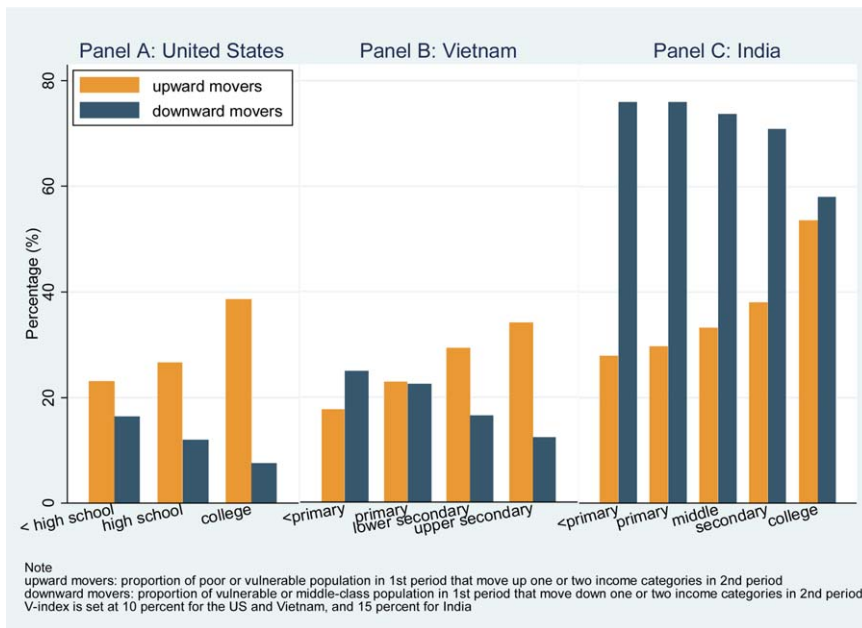


Figure 2. Welfare Mobility by Education Levels [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

corresponding figure for Vietnam (34 percent) but higher than that of the USA (18 percent).<sup>30</sup>

### 3.3. Profiling of Mobility for All Three Countries

This vulnerability framework is also amenable to analysis of welfare transitions at a more disaggregated population level such as the relationship between these transitions and household characteristics. This analysis can be implemented using either true or synthetic panel data. As an example, a graphical presentation is provided in Figure 2 of the relationship between education and welfare mobility for the USA (Panel A), Vietnam (Panel B), and India (Panel C), where the data for the first two countries are true panel data while those for India are synthetic panel data. For illustration purpose, we set the vulnerability index at 10 percent for the USA and Vietnam, but at 15 percent for India; while these indexes are not perfectly comparable, they can provide qualitatively similar results.

Higher education levels are clearly associated with a higher chance of upward mobility and a lower chance of downward mobility for all three countries. For

<sup>30</sup>Given the small sample size with the panel data for Vietnam for 2004–2008, we estimate the vulnerability index for both countries in the period 2006–2008 and adjust the resulting vulnerability lines with CPI deflators for 2004. The vulnerability index for the USA is 19 percent instead since this is the largest index available for this country. See Appendix 2, Table 2.2 and Appendix 3, Table 3.4 in the online supporting material for more details. For a more detailed discussion of income mobility for India during this period and over longer periods, see Dang and Lanjouw (2015) and Rama *et al.* (2015).

example, the percentage of the upward movers in the USA (i.e., the percentage of the population in the poor or vulnerable categories in the first period that move up one or two income categories in the second period) is roughly 25 percent for those with a high school education or lower, but jumps to almost 40 percent for those with a college education or higher. The corresponding figure for India is highest at 38 percent and 54 percent respectively for those with a secondary education (i.e., completed grades 9–12) and college education.

Figure 2 thus confirms the (perhaps standard) finding that education is an important driver behind welfare mobility in developing and richer countries alike.<sup>31</sup> It is rather straightforward to apply a similar analysis to study the relationship between mobility and other key variables of interest.

#### 4. FURTHER REFLECTIONS ON OTHER ISSUES

Our proposed framework to construct the vulnerability lines is motivated by the need to better identify the population group that is not currently poor, but that faces a significant risk of falling into poverty. Table 8 provides a comparison between our approach and some existing studies on estimating vulnerability as expected poverty. While sharing a similar conceptual approach and motivation with these studies (rows 1 and 2, Table 8), our approach can be distinguished in several respects. Notably, our target population consists of the currently non-poor households rather than all households (row 3). We employ simpler non-parametric estimation methods to estimate vulnerability as a function of consumption alone (row 5),<sup>32</sup> and can work with either actual panel data or synthetic panel data that can be constructed from cross sections (row 4). Perhaps most importantly, we explicitly provide a framework to estimate the vulnerability line—rarely, if at all, discussed in previous studies—that is associated with a vulnerability index that can be derived in various and more flexible ways including budgetary planning, (ideal or desirable) social welfare objectives, or relative concepts of well-being (row 6).

Given the centrality of this vulnerability level, or index, a couple of remarks are in order about how to obtain it in the first place. First, specifying the appropriate vulnerability level is likely to be heavily context-specific and to include a degree of subjective judgment.<sup>33</sup> Most, if not all, existing studies arbitrarily fix the index at 50 percent (e.g., Chaudhuri, 2003). We offer below a few suggestions to improve on this arbitrary threshold. First, from a social protection viewpoint, there may be practical budgetary concerns governing the choice of vulnerability index available to policy makers. A specific, albeit simplistic, example can help illustrate this point. Let us assume that the total population consists of 1,000 households, where the poverty rate is 20 percent (i.e., 200 households are poor). Assume that a budget of \$1000 is available to allocate to a social cash transfer

<sup>31</sup>Further examples of profiling of welfare transitions using synthetic panel data are provided in Dang *et al.* (2014) or Dang and Lanjouw (2013).

<sup>32</sup>Strictly speaking, both existing studies and ours also employ threshold parameters (i.e., poverty lines or vulnerability lines) in modelling vulnerability.

<sup>33</sup>Of course, the construction of the poverty line is also full of arbitrary choices, for example over the composition of food basket or how to add the non-food expenditure component.

TABLE 8  
COMPARISON BETWEEN SOME EXISTING VULNERABILITY STUDIES AND OUR PROPOSED APPROACH

NO	Highlights	Existing Studies	Our Approach
<b>Common features</b>			
1	Conceptual approach	Vulnerability defined as probability of falling into poverty in the next period	
2	Implementation	Obtain the vulnerability threshold (index) first, then employ this threshold to identify vulnerable households (i.e., aggregation before identification)	
<b>Different features</b>			
3	Target population	All currently poor and non-poor households	Currently non-poor households
4	Data	Actual panel data, and cross sectional data if assuming inter-temporal variation is the same as intra-temporal variation	Actual panel data, and cross sectional data that can be employed to construct synthetic panels
5	Modelling	i) Vulnerability as a function of household, community and other characteristics, thus more relevant for each household ii) Parametric estimation methods (e.g. assume that consumption is log-normally distributed)	i) Vulnerability as a function of household consumption alone, thus more relevant for population groups ii) Non-parametric estimation method, with no assumption on the distribution of household consumption
6	Vulnerability index and vulnerability line	i) Employ an index of 50 percent ii) Not focus on vulnerability line; identify households as being vulnerable if their vulnerability index greater than 50 percent	i) To be determined based on various considerations including budgetary planning, societal aspiration, or relative poverty concepts ii) Focus on identifying the vulnerability line, which is closely associated with a given vulnerability index; households are considered vulnerable if their consumption level falls between the poverty line and the vulnerability line.

**Notes:** Reviewed studies include Pritchett et al. (2000), Chaudhuri (2003), Christiansen and Subbarao (2005), and Hoddinott and Quisumbing (2010).

program to help the vulnerable population (i.e., those who are identified as currently non-poor but are subject to a high risk of falling into poverty by our definition). Assume further that careful scrutiny of the distribution of households above the poverty line revealed that some 50 non-poor households currently at risk of falling into poverty in the next period could be made secure with a transfer

of \$15 and a further 50 non-poor households could be similarly made secure with a smaller transfer of \$5.

Thus with perfect targeting a total of 100 households could be made secure with the available budget, consistent with a vulnerability index set at 12.5 percent (i.e., obtained by dividing 100 households that can be aided and that would have fallen into poverty without this support over the total of 800 non-poor households). Without (perfect) targeting, this budget would be equally distributed to a larger number of households, say 200 households, thus making secure only 50 non-poor households (those that can be helped with the smaller transfer of \$5). The vulnerability index in this case would be set twice lower at 6.3 percent, with the lower vulnerability level (and its associated higher vulnerability line) resulting from imprecise targeting.

This example is clearly very simple, and assumes away other practical complexities with program implementation such as eligibility identification or other targeting issues. But it helps elucidate the point that as long as there are relevant parameters on the budget, an allocation rule, and some reasonable targeting, we can work out a vulnerability index from the existing household consumption data.

Second, despite the lack of a universally accepted level of vulnerability, there can be a commonly appealing notion in setting a lower, rather than a higher, vulnerability index. Just as with poverty reduction, reducing vulnerability can be an aspirational social welfare objective. Indeed, we have provided both theoretical and empirical evidence suggesting that the vulnerable can be considered a transitional group in between the poor and the middle class. Shrinking the poor as a group would most likely be associated with an expansion of the vulnerable (and perhaps to a lesser extent, an expansion of the middle class). Consequently, in striving for a target of reducing poverty to under 5 percent it may be appealing to attach to this goal an accompanying one of keeping vulnerability, say below 10 or 15 percent. The success of setting goals in this way is perhaps well illustrated by the recent achievement of the MDG goal of halving global poverty by half before 2015.

Finally, the poverty line itself can be constructed using either an absolute concept (e.g., based on some nutritional anchor) or a relative concept (e.g., equal to a proportion of mean or median household consumption as with most European countries). Some evidence suggests that as countries get richer, they tend to move toward employing the latter concept more often (Ravallion, 2012; Chen and Ravallion, 2013). One main argument for the relative concept is that people obtain utility from benchmarking their income against some reference level in their country. Seen from this perspective, setting a vulnerability index is conceptually similar: if, say, 50 percent of the median household consumption is considered the minimum acceptable consumption level below which households are poor, then a certain figure referring to a minimum acceptable risk of falling into poverty (e.g., 10 percent) can be used as a cut-off point to identify vulnerable households.

Another more general issue concerns how vulnerability should be defined. More specifically, should we define vulnerability taking into account different population characteristics (e.g., agricultural workers versus formal wage



workers)? Numerous approaches exist in the literature, defining vulnerability as expected poverty (see, e.g., Prichett et al., 2000; Chaudhuri, 2003), low expected utility (see, e.g., Ligon and Schechter, 2003), uninsured exposure to risk (see, e.g., Dercon and Krishnan, 2003), variability around a given permanent income level or mean consumption over time (see, e.g., Morduch, 1994; Jalan and Ravallion, 2000), some combination of expected poverty and low expected utility (see, e.g., Calvo and Dercon, 2013), shortfalls with current living standards (see, e.g., Dutta *et al.*, 2011), or reference-dependent utility (see, e.g., Gunther and Maier, 2014). Most of these studies work with household survey data and provide estimates at the household level. Our approach employs simpler and non-parametric techniques, requires much less data, and focuses on defining vulnerability at a more aggregate, macro, level. As earlier discussed, this provides an appealing connection between the vulnerability line and the poverty line and facilitates consistent comparisons across countries. A further advantage that is not to be under-emphasized is that the analysis is reasonably intuitive and can be straightforwardly explained to policy makers.

While our approach is more related to studies that define vulnerability as expected poverty, it also straddles the literature on defining the middle class (see, e.g., Banerjee and Duflo, 2008; Birdsall, 2010; Ravallion, 2010), which generally aims at producing income thresholds that apply to the whole population. There are certain advantages with our approach both on the technical and policy fronts. On the technical side, this approach allows us to offer simpler modelling assumptions and consequently straightforward estimation, as well as applicability to more contexts through constructing synthetic panels from cross sectional data. And the strongly compatible nature between our proposed vulnerability line and the poverty line can facilitate its interpretation and relevance for social protection and poverty reduction policies.<sup>34</sup>

## 5. CONCLUSION

We propose in this paper two approaches towards setting a vulnerability line that are constructed based on the existing poverty lines and the risk of falling into poverty, and which can be flexibly adapted to welfare objectives in both low-income and high-income country settings. These vulnerability lines could replace the common current *ad hoc* practices in different countries, and could be presented together with poverty lines as an enhanced welfare measurement package. These vulnerability lines can also serve as lower bounds for the middle class lines, and can be used to compare the welfare dynamics for different countries during similar periods, as well as over different time intervals. Our framework is broad enough to allow for more disaggregated investigation of welfare dynamics for subpopulation groups.<sup>35</sup>

<sup>34</sup>We leave other issues such as measurement error for future research. The recent review by Janti and Jenkins (2015) points to little evidence on this topic, and the currently few existing studies suggests measurement error has somewhat negligible effects on mobility measures using actual panel data in practice. Note that our synthetic panels are constructed using the cross sections, so are much less affected by this issue.

<sup>35</sup>Tracking the welfare of these various groups can provide related and practically useful welfare estimates for the whole population such as shared prosperity (e.g., Dang and Lanjouw, 2016).

We provide in this paper empirical illustrations using both true panel data from the USA and Vietnam and synthetic panel data constructed using cross sections from India. These vulnerability lines are thus rather flexible and are amenable to application in most settings with few data requirements. We focus on a money-metric measure of welfare outcome in this paper but our framework may also be extended to incorporate non-monetary welfare measures. Other promising directions for future research include analyzing mobility concepts other than the ones used in this paper, and expanding this framework to more than two periods.

## REFERENCES

- Adger, W. Neil, "Vulnerability," *Global Environmental Change*, 16, 268–81, 2006.
- Alwang, J., P. B. Siegel, and S. L. Jorgensen, "Vulnerability: A View from Different Disciplines," Social Protection Discussion Paper No. 0115, World Bank, Washington, DC, 2001.
- Banerjee, A. and E. Duflo, "What Is Middle Class about the Middle Classes around the World?" *Journal of Economic Perspectives*, 22, 3–28, 2008.
- Barrett, C. B. and M. A. Conostas, "Toward a Theory of Resilience for International Development Applications," *Proceedings of the National Academy of Sciences*, 111, 14625–30, 2014.
- Birdsall, N., "The (Indispensable) Middle Class in Developing Countries", In R. Kanbur and M. Spence, ed., *Equity and Growth in a Globalizing World*, 157–88, World Bank, Washington, DC, 2010.
- Birdsall, N., N. Lustig, and C. J. Meyer, "The Strugglers: The New Poor in Latin America?" *World Development*, 60, 132–46, 2014.
- British Broadcasting Corporation (BBC), "The Great British Class Calculator: What Class Are You?", 2013. Accessed on March 24, 2014 at <http://www.bbc.com/news/magazine-22000973>.
- Burkhauser, R. V. and J. L. Kosali Simon, "A Second Opinion on the Economic Health of the American Middle Class and Why it Matters in Gauging the Impact of Government Policy," *National Tax Journal*, 65, 7–32, 2012.
- Calvo, C. and S. Dercon, "Vulnerability to Individual and Aggregate Poverty", *Social Choice and Welfare*, 41, 721–40, 2013.
- Census Bureau, *Consumer Price Indexes (CPI-U) by Major Groups*, 2013. Accessed on September 11, 2013 at [http://www.census.gov/compendia/statab/cats/prices/consumer\\_price\\_indexes\\_cost\\_of\\_living\\_index.html](http://www.census.gov/compendia/statab/cats/prices/consumer_price_indexes_cost_of_living_index.html).
- Chaudhuri, S., "Assessing Vulnerability to Poverty: Concepts, Empirical Methods and Illustrative Examples", Working paper, Department of Economics, Columbia University, 2003.
- Chaudhuri, S. and M. Ravallion, "How Well Do Static Indicators Identify the Chronically Poor?" *Journal of Public Economics*, 53, 367–94, 1994.
- Chen, S. and M. Ravallion, "More Relatively-Poor People in a Less Absolutely-Poor World", *Review of Income and Wealth*, 59, 1–28, 2013.
- Christiaensen, L. J. and K. Subbarao, "Towards an Understanding of Household Vulnerability in Rural Kenya", *Journal of African Economies*, 14, 520–58, 2005.
- Conostas, M. A. and C. B. Barrett, "Principles of Resilience Measurement for Food Insecurity: Metrics, Mechanisms, and Implementation Plans", Paper presented at the *Expert Consultation on Resilience Measurement Related to Food Security*, Food and Agricultural Organization and World Food Program, Rome, Italy, 2013.
- Coupland, D., "Unclassy", *Financial Times*, 2014. Accessed on March 19, 2014 at <http://www.ft.com/intl/cms/s/2/81e53694-78c5-11e3-a148-00144feabdc0.html#axzz2wRXCvb4W>
- Dang, H.-A. and P. Lanjouw, "Measuring Poverty Dynamics with Synthetic Panels Based on Cross Sections", *World Bank Policy Research Working Paper No. 6504*, World Bank, Washington, DC, 2013.
- . "Poverty Dynamics in India between 2004–2012: Insights from Longitudinal Analysis Using Synthetic Panel Data", *World Bank Policy Research Paper # 7270*, World Bank, Washington, DC, 2015.
- . "Toward a New Definition of Shared Prosperity: A Dynamic Perspective from Three Countries", in K. Basu and J. Stiglitz, ed., *Inequality and Growth: Patterns and Policy*, Palgrave MacMillan Press, 2016.
- Dang, H.-A., P. Lanjouw, J. Luoto, and D. McKenzie, "Using Repeated Cross-Sections to Explore Movements in and out of Poverty", *Journal of Development Economics*, 107, 112–28, 2014.

- DeNavas-Walt, C., B. D. Proctor, and J. C. Smith, *Income, Poverty, and Health Insurance Coverage in the United States: 2008*, U.S. Census Bureau, Washington, DC, 2009.
- Deron, S. and P. Krishnan, "Risk Sharing and Public Transfers", *Economic Journal*, 113, C86–C94, 2003.
- Donnan, S., B. Bland, and J. Burn-Murdoch, "Fragile Middle: 2.8bn People on the Brink", 2014. *Financial Times*. Accessed on April 15, 2014 at <http://www.ft.com/intl/cms/s/2/e8f40868-c093-11e3-a74d-00144feabd0.html#axzz2yy4grbmy>
- Drouet-Mari, D. and S. Kotz, *Correlation and Dependence*, Imperial College Press, London, 2001.
- Dutta, I., J. Foster, and A. Mishra, "On Measuring Vulnerability to Poverty", *Social Choice and Welfare*, 37, 743–61, 2011.
- Easterly, W., "The Middle Class Consensus and Economic Development", *Journal of Economic Growth*, 6, 317–35, 2001.
- Fields, G. S., P. L. Cichello, S. Freije, M. Menéndez, and D. Newhouse, "For Richer or for Poorer? Evidence from Indonesia, South Africa, Spain, and Venezuela", *Journal of Economic Inequality*, 1, 67–99, 2003.
- Foster, J. E., "A Class of Chronic Poverty Measures", in T. Addison, D. Hulme, and R. Kanbur, ed., *Poverty Dynamics: Interdisciplinary Perspectives*, 59–76, Oxford University Press, New York, 2009.
- Glewwe, P., "Mission Report for Trip to Vietnam June 5–16, 2009", Report submitted to the World Bank, 2009.
- Government of India, Planning Commission. (GOI), *Report of the Expert Group to Review the Methodology for Estimation of Poverty*, 2009. Accessed on March 15, 2013 at [http://planningcommission.nic.in/reports/genrep/rep\\_pov.pdf](http://planningcommission.nic.in/reports/genrep/rep_pov.pdf)
- Gunther, I. and J. K. Maier, "Poverty, Vulnerability, and Reference-Dependent Utility", *Review of Income and Wealth*, 60, 155–81, 2014.
- Hoddinott, J. and A. R. Quisumbing, "Methods for Microeconomic Risk and Vulnerability Assessment", in R. F.-N. and P. A. Seck, ed., *Risk, Vulnerability and Human Development: On the Brink*, Palgrave Macmillan- United Nations Development Programme, London, 2010.
- Hojman, D. and F. Kast, "On the Measurement of Poverty Dynamics", Working Paper Series RWP09-035, John F. Kennedy School of Government, Harvard University, 2009.
- Holling, C. S., "Resilience and Stability of Ecological Systems", *Annual Review of Ecology and Systematics*, 4, 1–23, 1973.
- Jalan, J. and M. Ravallion, "Is Transient Poverty Different? Evidence for Rural China", *Journal of Development Studies*, 36, 82–99, 2000.
- Jantti, M. and S. P. Jenkins, "Income Mobility", In A. B. Atkinson and F. Bourguignon, ed., *Handbook of Income Distribution*, 807–935, North Holland, Oxford, 2015.
- Jenkins, S. P., *Changing Fortunes: Income Mobility and Poverty Dynamics in Britain*, Oxford University Press, Oxford, 2011.
- Khor, N. and J. Pencavel, "Income Mobility of Individuals in China and the United States", *Economics of Transition*, 14, 417–48, 2006.
- Kopczuk, W., E. Saez, and J. Song, "Earnings Inequality and Mobility in the United States: Evidence from Social Security Data since 1937", *Quarterly Journal of Economics*, 125, 91–128, 2010.
- Krugman, P., "Money and Class", *New York Times*, 2014. Accessed on March 19, 2014 at <http://krugman.blogs.nytimes.com/?s=%22money±and±class%22>
- Lehmann, E. L. and J. P. Romano, *Testing Statistical Hypotheses*, Springer Press, New York, 2005.
- Ligon, E. and L. Schechter, "Measuring Vulnerability", *Economic Journal*, 113, C95–C102, 2003.
- Loayza, N., J. Rigolini, and G. Llorente, "Do Middle Classes Bring about Institutional Reforms?" *Economics Letters*, 116, 440–44, 2012.
- Lopez-Calix, J., C. Mejia, D. Newhouse and C. Sobrado, "Pakistan Poverty Trends, Scenarios and Drivers", *Policy Paper Series on Pakistan, PK 23/12*, Washington DC: World Bank, 2014.
- Lopez-Calva, L. F. and E. Ortiz-Juarez, "A Vulnerability Approach to the Definition of the Middle Class", *Journal of Economic Inequality*, 12, 23–47, 2014.
- Matloff, N. S., "Use of Regression Functions for Improved Estimation of Means", *Biometrika*, 68, 685–89, 1981.
- Morduch, J., "Poverty and Vulnerability", *American Economic Review Papers and Proceedings*, 84, 221–25, 1994.
- National Commission for Enterprises in the Unorganised Sector (NCEUS), *Report on Conditions of Work and Promotion of Livelihoods in the Unorganised Sector*, New Delhi, India, 2007.
- O'Leary, A., "What Is Middle Class in Manhattan?" *New York Times*, 2013. Accessed on March 19, 2014 at [http://www.nytimes.com/2013/01/20/realestate/what-is-middle-class-in-manhattan.html?\\_r=0](http://www.nytimes.com/2013/01/20/realestate/what-is-middle-class-in-manhattan.html?_r=0)
- Owen, D. B., "Screening by Correlated Variables" in S. Kotz and N. L. Johnson, ed., *Encyclopedia of Statistical Sciences* 8, John Wiley & Sons, New York, 309–12, 1988.

- Piketty, T. and E. Saez, "Income Inequality in the United States, 1913–1998". *Quarterly Journal of Economics*, 118, 1–39, 2003.
- Porter, E., "America's Sinking Middle Class", *New York Times*, 2013. Accessed on March 19, 2014 at <http://www.nytimes.com/2013/09/19/business/americas-sinking-middle-class.html>
- Pritchett, L., A. Suryahadi, and S. Sumarto. "Quantifying Vulnerability to Poverty: A Proposed Measure, Applied to Indonesia", *Policy Research Working Paper No. 2437*, World Bank, Washington, DC, 2000.
- PSID Main Interview User Manual: Release 2012.1. Institute for Social Research, University of Michigan, January 23, 2012. Accessed on October 15 2012 at <http://psidonline.isr.umich.edu/data/Documentation/UserGuide2009.pdf>.
- Rama, M., T. Béteille, Y. Li, P. Mitra K., and J. L. Newman, *Addressing Inequality in South Asia*, World Bank, Washington DC, 2015.
- Ravallion, M., "The Developing World's Bulging (but Vulnerable) Middle Class", *World Development*, 38, 445–54, 2010.
- . "Poverty Lines across the World", in P. N. Jefferson, ed., *Oxford Handbook of the Economics of Poverty*, Oxford University Press, New York, 2012.
- de Souza, P. H. G. F. and R. G. Osorio, "A Profile of Poverty in Brazil and Its Changes between 2003 and 2011", in T. Campello and M. C. Neri, ed., *Bolsa Família Program: A Decade of Social Inclusion in Brazil: Executive Summary*, Ipea-Institute for Applied Economic Research, Brasília, 2014.
- Tang, K. and J. Tang, "Design of Screening Procedures: A Review", *Journal of Quality Technology*, 26, 209–26, 1994.
- Tett, G., "Which Middle Class, Which Squeeze?" *Financial Times*, 2014. Accessed at <http://www.ft.com/intl/cms/s/2/c34696d6-8ec4-11e3-b6f1-00144feab7de.html#axzz2wRXCvb4W> on March 19 2014.
- World Bank, "Well Begun, Not Yet Done: Vietnam's Remarkable Progress on Poverty Reduction and the Emerging Challenges", *Vietnam Poverty Assessment Report 2012*, World Bank, Hanoi, 2012.

## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web-site.

**Appendix 1:** Proofs.

**Appendix 2:** Overview and Validation of Synthetic Panel Data Method.

**Appendix 3:** Additional Tables.