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Estimating poverty and vulnerability to monetary and non-monetary poverty: the case of Vietnam

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Abstract

Drawing on three-wave panel data from the Vietnam Housing Living Standard Surveys (VHLSS) 2010, 2012, and 2014 and employing a fuzzy method, this paper estimates chronic and transient poverty across multiple dimensions (income, education, health, housing, basic services, durable assets, economic status) in Vietnam. Using standard deviation as a measure of risk, this study further defines vulnerability as a probability for becoming poor and estimates vulnerability to poverty from the stochastic variation of expected deprivation within a defined interval. We further apply the method of multilevel analysis to assess the deprivation of households and distinguish vulnerability as influenced by idiosyncratic (household-specific-level) and covariate (province-level) shocks. It is observed that while the number of chronic poor in all dimensions is quite low, the proportion of chronic poor in the housing dimension is the highest (around 5% over the applicable years nationwide). Regional variation in non-monetary dimensions of poverty is substantial and clearly distinct from monetary poverty. We show that there are more multidimensionally poor households that are vulnerable to idiosyncratic shocks than to covariate shocks, and the proportion of vulnerable households (to covariate shocks) in the housing dimension is significantly greater than that in other dimensions. Almost all covariates of household and province are significantly different between vulnerable and non-vulnerable groups across the multiple dimensions of poverty other than health. Our findings suggest an urgent need for policy attention on the explicit nature of vulnerability and on the many dimensions of poverty in specific regions, and to look beyond the current official monetary-based approach.

Keywords Chronic poverty · Transient poverty · Vulnerability · Risk · Vietnam · Multilevel · Regional

JEL Classification I30 · I32 · I38

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1 Introduction

Vietnam has recorded an impressive performance in poverty reduction in the past few decades. During the period 2002–2018, the country experienced an average annual income growth rate of 6.5%, accompanied by a near 90% drop in the number of people earning below USD 3.2 per day (2011 PPP), from 70.8% in 2002 to 8.4% in 2016 (World Bank Group 2017). Vietnam is among the best performers in and one of the earliest achievers of the first target of the Millennium Development Goals (MDGs) due to having halved its rates of extreme poverty and hunger. In the post-2015 period, the country has pledged to maintain continuing efforts to involve Sustainable Development Goals (SDGs) in all its socio-economic strategies and plans. The elimination of extreme poverty and reduction in vulnerability are the first benchmarks for justification of the achievements of the SDGs. There are, however, substantial challenges in measuring and monitoring poverty alleviation that must be faced by the country on the way towards reaching these targets.

Due to the global economic crisis, Vietnam's national growth rate plummeted to 5.5% during the period 2008–2009 with the associated poverty reduction rate also slowing down (World Development Indicators 2018). Moreover, Vietnam is ranked among the five countries in the world that are most vulnerable to natural hazard and climate change (Eckstein et al. 2017), with estimates that national income will decrease up to 3.5 % by 2050 due to the influence of climate change (Arndt et al. 2015). Anti-poverty policies in Vietnam until recently were based on *ex post* poverty profiles not involving any element of risk (see, Minot 2000; Dollar et al. 2004; McCaig 2011; Mont and Cuong 2011; Coxhead et al. 2012). Economists have long argued that in designing effective anti-poverty policies it is vital not only to analyse the current deprivation status of households, but also to take into account forward-looking perspectives on poverty (McGregor and Nachane 1995; Chaudhuri et al. 2002; Ligon and Schechter 2003; Dang and Lanjouw 2017). This perception contributes to the concept of "vulnerability to poverty", which relates to the risk of households falling into poverty in the near future, whether they are currently poor or not. In the context of increasing frequency of economic and non-economic shocks, consideration of vulnerability to poverty allows the formulation of better interventions to avoid serious welfare shortfalls which can push households into poverty (Pritchett et al. 2000; Chaudhuri 2003; and Ward 2016).

Since the World Bank's *World Development Report 2000/01* (World Bank 2001), which emphasized the important role attention to vulnerability must have in fighting world poverty, the literature of vulnerability to poverty has gained increasing attention.

Although there is an abundance of conceptual studies on the measurement of vulnerability to poverty, empirical research on the implementation of these concepts is deficient due to the lack of specialized data (particularly lengthy panel data) for analysing vulnerability (Grimm et al. 2016). Furthermore, most previous empirical studies focus only on the analysis of vulnerability to poverty in the monetary dimension (see, for example, Morduch 1994; Pritchett et al. 2000;

Alwang et al. 2001; Chaudhuri et al. 2002; Kamanou and Morduch 2002; Dercon 2005; Hoddinott and Quisumbing 2003). Even though academics and international agencies recognize the importance of the multidimensional nature of poverty (see Sen 1999; Tsui 2002; Asselin and Anh 2008; Thorbecke 2007; Stoeffler et al. 2016), the number of studies on vulnerability to poverty which encompass non-monetary dimensions is still limited (see, for example, Calvo 2008; Abraham and Kumar 2008; Feeny and McDonald 2016; Azeem et al. 2018; Chakravarty 2017; Gallardo 2020).

Inspired by these concerns, this study utilizes three-wave panel data of Vietnam (2010, 2012, and 2014), covering all 63 provinces and urban and rural areas of the country to construct measures of vulnerability to poverty in monetary and non-monetary dimensions for households. While the previous empirical work on Vietnam analyses poverty dynamics and vulnerability to poverty in the monetary dimension only, concentrating on ethnic minority groups and specific geographical areas (Imai et al. 2011), or on rural households (Justino et al. 2008; Gloede et al. 2015; Klasen et al. 2015; Nguyen et al. 2015; Grimm et al. 2016), this study is the first to attempt to examine the dynamics of poverty and vulnerability across multiple dimensions at the regional and national levels.

Determining which region is more vulnerable in different dimensions of poverty is helpful in targeting poverty alleviation strategies. Our investigation of the dynamics of poverty differentiates between chronic poverty (that is, households are persistently poor over prolonged periods) and transient poverty (that is, households enter into or exit from poverty over time). This analysis is worthwhile because, while structural obstacles such as lack of education, poor health, unemployment, large households, and lower asset accumulation might be the sources of chronic poverty, facing unanticipated risks and short-term shocks that result in high fluctuations in households' well-being are recognized as the main reasons for transient poverty (Jalan and Ravallion 1998; Baulch and Hoddinott 2000; Cruces and Wodon 2003; Barrientos and Hulme 2005; Günther and Harttgen 2009; Feeny and McDonald 2016). Therefore, by examining the dynamics of poverty, this study provides more crucial information for anti-poverty policies beyond the existing static analysis of poverty in Vietnam.

Although there has been increasing frequency and intensity of covariate shocks at the community level (such as natural hazards that effect on households within communities), the empirical literature on vulnerability is still dominated by analyses of the influence of idiosyncratic shocks (household-level shocks such as unemployment, injury, illness or death of a household member) (Günther and Harttgen 2009; Grimm et al. 2016). This study employs multilevel model to estimate deprivation of households and distinguishes vulnerability into idiosyncratic and covariate shocks to establish efficient risk management strategies in Vietnam.

Thus, our study contributes the literature of vulnerability to poverty in both monetary and non-monetary dimensions based on three principal previous approaches. Firstly, instead of using the framework proposed by widely used Alkire–Foster approach (Alkire and Foster 2011) this study utilizes the fuzzy approach which considers everyone's level of destitution with varying degrees (*totally poor* at the maximum and *not at all poor* at the minimum). Some previous authors use fuzzy

measures of poverty to develop a measurement of vulnerability to poverty (for example, Qizilbash (2002), and Abraham and Kumar (2008)); however, their approaches do not capture any risk element of being poor in future. To overcome this weakness, our study utilizes the asset-based approach of unidimensional vulnerability indicator proposed by Chiwaula et al. (2011) and extends the measurement of vulnerability to poverty in multiple dimensions. This is the first attempt incorporating risk elements into fuzzy measurements of poverty to analyse vulnerability to poverty. This is the second contribution of this study. Thirdly, by using a multilevel econometric strategy our study further contributes to the existing literature by extending the approaches of Günther and Harttgen (2009) and Mina and Imai (2017).

The remainder of the paper is structured as follows. The next section explains the methodology employed to determine the extent and nature of household vulnerability, Sect. 3 describes the data and variables used in the study and Sect. 4 discusses the poverty profiles of Vietnam. The estimation results are presented and discussed with their policy implications in Sect. 5. The final section concludes.

2 Methodology and data

2.1 Measuring multidimensional poverty

The official monitoring of poverty in Vietnam mostly utilized an approach based on income or expenditure, neglecting non-monetary dimensions of poverty such as health, education, and living standards (Arouri et al. 2015; Lanjouw et al. 2017; Mahadevan and Hoang 2016; Nguyen et al. 2017). Using a multidimensional approach not only is a more efficient tool for measuring poverty, but also can be used as a tool for eliminating poverty (Alkire and Santos 2010; Alkire et al. 2015; Ravallion 2011; Yang and Mukhopadhaya 2017; Yu 2013). There is a small amount of the literature available on multidimensional poverty in Vietnam (for example, Asselin 2009; Baulch and Masset 2003; Roelen et al. 2010, 2012, 2014), which is mostly based on the Alkire and Foster method that uses a poverty cut-off to divide the population in a dichotomous group of poor and non-poor.[1] The present paper employs instead a fuzzy method to measure poverty in Vietnam following Cerioli and Zani (1990), Cheli and Lemmi (1995), and Betti and Vemma (2008). We present below a brief outline of the fuzzy approach to measuring poverty.[2]

The generalized formulation of a fuzzy measurement of monetary and non-monetary deprivation for any household h can be written as:

[1] See Makdissi and Wodon (2004) for the shortcomings of this method.

[2] The method has been much discussed and widely applied to analyse poverty in various countries. See, for example, Martinetti (1994), Cheli and Betti (1999), Betti et al. (2002), Qizilbash (2003), Qizilbash and Clark (2005), Deutsch and Silber (2005, 2006), Betti et al. (2006a, 2006b), Chakravarty (2006), Abdullah (2011), Kim (2015, and Pham and Mukhopadhaya (2018). This approach is also utilized in Eurostat official publications (Giorgi and Verma 2002).

$$d_h = \left[1 - F_h\right]\left[1 - L_h\right] \tag{1}$$

The fuzzy measurement of deprivation d_h, interpreted as the propensity to poverty for households, varies between 0 (not at all poor) and 1 (totally poor), where F_h is the proportion of households less poor than household h in monetary deprivation (measured by equivalized income) or in non-monetary deprivation (measured by overall score), and L_h is the Lorenz function. It is worth noting that a non-monetary dimension may consist of more than one indicator. In this case, a deprivation measure, $d_{j,h}$ for each indicator j in the dimension is determined, and then, by using a pre-assigned weight, all indicators are integrated into one index in a dimension. The indicators are transformed into the interval 0 to 1 to determine the deprivation score for each by the formula:

$$d_{j,h} = \frac{\varphi - \varphi_h}{\varphi - 1} \; 1 \le \varphi_h \le \varphi \tag{2}$$

where φ_h is the category to which household h belongs and φ is the ordered categories of some deprivation indicators j (a higher φ indicates less deprivation).[3]

Following Betti and Verma (1999, 2008), the weight of each indicator (within each dimension) is calculated distinctly as a product of the inverse of the average correlation coefficients of all indicators and the coefficient of variation. For convenience, the weights of the indicators are standardized to sum to 1 within each dimension. Then a deprivation score is computed for poverty dimension k as follows:

$$S_{k,h} = \sum_{j=1}^{k} w_j d_{j,h} \tag{3}$$

For the empirical study, monetary and six non-monetary dimensions are considered. To measure monetary poverty, the equivalized household income is determined by applying the modified OECD scale.[4] Total household income from all sources is included.[5] For the non-monetary dimensions, based on the available information, we select 19 indicators grouped into six dimensions: education, health, housing, durable assets, basic services, and economic status (see Pham and Mukhopadhaya 2018). A detailed list of the indicators and their descriptions are provided in Table 8 in Appendix.

2.2 Measurement of the extent of vulnerability and a dynamic definition of vulnerable

The growing literature on vulnerability to poverty involves a variety of empirical approaches; however, no agreement has been reached on the best method. According

[3] In the case of binary indicators, $d_{j,h} = 1$ (maximally deprived) or $d_{j,h} = 0$ (not deprived).

[4] To construct the equivalent scale, the first adult in the household is given a point 1, while each extra member who is 15 years or above is assigned 0.5, and each member under the age of 15 is given 0.3.

[5] Comprising wages, salary, and incomes from services, agricultural, fishery, and forestry sectors.

to Hoddinott and Quisumbin (2003), the varied empirical methodologies for assessing vulnerability can be categorized into the three most well-known groups. Vulnerability as low expected utility (VEU) measures vulnerability as the gaps between the utility attained under certainty and the expected utility (Ligon and Schechter 2003; Günther and Maier 2014). While it is argued by Povel (2010) and Dutta et al. (2011) that the risk component should rely on the particular event faced by each household, the risk component in VEU is implied to be the same for all households. The second group, known as vulnerability as uninsured exposure to risk (VER), examines whether shocks reduce households' consumption levels (Cochrane 1991; Townsend 1994; Jalan and Ravallion 1999; Tesliuc and Lindert 2002; Amin et al. 2003; Cafiero and Vakis 2006). Hoddinott and Quisumbing (2010) point out that VER is not an *ex ante* assessment and therefore not actually a vulnerability measurement because it does not estimate probabilities of future deprivation, but a household's deviation from expected welfare caused by negative shocks. The third approach is called vulnerability to expected poverty (VEP), which considers vulnerability as the probability of falling below a predetermined threshold of consumption or income in the future (Mosley et al. 1999; Pritchett et al. 2000; Chaudhuri et al. 2002; Kamanou and Morduch 2002; Suryahadi and Sumarto 2003). Since the work of Chaudhuri et al. (2002), VEP has become prominent among the empirical literature because of its applicability on cross-sectional or short panel data, which is more common in developing countries. VEP not only takes into consideration the risk of being exposed to shocks resulting variability of well-being outcomes, but also accounts for households that have expected poverty outcomes. Since the standard classification of Hodinott and Quisumbin (2003), the literature of vulnerability to poverty has been blossomed into various branches. Gallardo (2018) provides a new version classification of vulnerability measurements in which various novel methodologies developed on the three previous approaches. The Vulnerability as Exposure to Risk (VER) category has been enhanced by the notion of lack of insurance to face the risk of becoming poor or of expected downside risk (see Cafiero and Vakis (2006), Skoufias and Quisumbing (2005), Povel (2010), among others). The VEU category includes two novel approaches proposed by Calvo and Dercon (2005, 2013), considering vulnerability to poverty of individual as the magnitude of the threat of experiencing poverty in the future, and by Günther and Maier (2014)'s reference-dependent utility theory. In particular, Gallardo (2018) grouped two new approaches proposed by Chiwaula et al. (2011) and Gallardo (2013), which utilize standard deviation as a measure of risk, into a new category named Vulnerability by mean risk.

Günther and Harttgen (2009) contribute to the VEP literature by introducing a two-level model into Chaudhuri et al. (2002) approach in order to decompose vulnerability into idiosyncratic and covariance risks by using cross-sectional data on Madagascar as an empirical illustration. More recently, a three-level model is utilized on panel data in the Philippines by Mina and Imai (2017). Our study follows the approaches proposed by Chaudhuri et al. (2002) and extended by Günther and Harttgen (2009) and Mina and Imai (2017) to construct vulnerability to multiple dimensions of poverty using the expected mean and variance of household deprivation estimated from the three-level model with explanatory variables at all levels.

Let d^k_{thp} be deprivation measured at time t (level 1 unit) of household h (level 2 unit) in province p (level 3 unit). At level 1 the deprivation d^k_{thp} in the poverty dimension k is represented as depending linearly on time plus the effect of time-varying covariates as follows:

$$d^k_{thp} = \pi^k_{0hp} + X^k_{thp}\pi^k_{1hp} + e^k_{thp} \tag{4}$$

where $p = 1,\ldots, P$ provinces, $h = 1,\ldots, H_p$ households in pth province, $t = 1, 2, 3$ waves for hth households within the pth province. X represents the vector of time-varying explanatory variables (time variable), π are coefficients in level 1. The residual at level 1, e_{thp}, is assumed to follow a normal distribution with a mean of zero and variance of σ^2 being constant over times, households, and provinces.

While the level 1 model allows each household to have a different initial deprivation status and rate, the level 2 model captures the variation in deprivation parameters among households within a province. The intercept and slopes of the level 1 model are expressed as depending on the characteristics of household:

$$\pi^k_{0hp} = \beta^k_{00p} + Z^k_{hp}\beta^k_{01p} + u^k_{0hp} \tag{5}$$

$$\pi^k_{1hp} = \beta^k_{10p} + Z^k_{hp}\beta^k_{11p} + u^k_{1hp} \tag{6}$$

where Z is a set of time-invariant explanatory variables that may differ over households or provinces, but not over time and β is the estimated coefficients of level 2. The u^k_{0hp} and u^k_{1hp} are the random intercept and random coefficient at household levels and are assumed to be normally distributed with means of zero and variances that do not change over households and provinces.

The level 3 model expresses the variability in the initial deprivation status and rate among provinces and is of the form:

$$\beta^k_{00p} = \alpha^k_{000} + R^k_p\alpha^k_{001} + v^k_{00p} \tag{7}$$

$$\beta^k_{10p} = \alpha^k_{100} + R^k_p\alpha^k_{101} + v^k_{10p} \tag{8}$$

where R is various province characteristics. The v^k_{00p} and v^k_{10p} are the random intercept and random coefficient at province level, assumed as normally distributed with means of zero and constant variances over provinces.

By substituting Eqs. (5) to (8) into Eq. (4), the final form of the model is:

$$\begin{aligned} d^k_{thp} = &\left[\alpha + R^k_p\alpha^k_{001} + Z^k_{hp}\left(\alpha^k_{100} + R^k_p\alpha^k_{101}\right) + X^k_{thp}\left(\beta^k_{10p} + Z^k_{hp}\beta^k_{11p}\right)\right] + \\ &v^k_{00p} + Z^k_{hp}v^k_{10p} + u^k_{0hp} + X^k_{thp}u^k_{1hp} + e^k_{thp} \end{aligned} \tag{9}$$

The first part on the right-hand side of Eq. (9) reflects the fixed part of the model. Following Mina and Imai (2017), we let only the time variable change at household and province levels. Hence, β_{11p} is the interaction between time and

household characteristics and measures the differential change rate in deprivation between households and time; α_{101} is the interaction between province and household characteristics, analysing the cross-level interactions between covariates at the household and province levels.

The last five terms on the right-hand side of Eq. (9) denote the random part of the model. While the random intercept u_{0hp} reflects the variation in initial status among households within a province, v_{00p} captures the variation in initial status across provinces. Meanwhile, the random coefficient at province level $Z_{hp}v_{10p}$ reflects the unexplained heterogeneity across provinces of the slope β_{10p}; the random coefficient at household level $\mathrm{X}_{thp}u_{1hp}$ reflects the unexplained heterogeneity across households of the slope π_{1hp}. The residual term e_{thp} is the random effect at level 1 that captures the remaining unexplained variation of households' deprivation at a specific time point. The residual terms u_{0hp} and $\mathrm{X}_{thp}u_{1hp}$ capture the effects of idiosyncratic shocks, while v_{00p} and $Z_{hp}v_{10p}$ capture the effects of covariate shocks. Furthermore, it is assumed that the influences of measurement errors and non-stochastic heterogeneity have been minimized by using the multilevel model (Mina and Imai 2017).

The expected mean deprivation of household h in province p at time t can be estimated with Eq. (9). As suggested by Hox (2017), only if the estimated β_{11p} or α_{101} is statistically significant the interactions are included in the regression models. Following Chaudhuri et al. (2002), we assume that the variance of deprivation at household and province levels, that is, the effect of idiosyncratic and covariate shocks, depends on a set of household and province characteristics. Thus, in the next step, the squared variance of residuals at each level of Eq. (9) is regressed on a set of time (X_{thp}), household (Z_{hp}) and province (R_p) variables:

$$\sigma^{2,k}_{e_{thp}} = \gamma^k_0 + X^k_{thp}\gamma^k_1 + Z^k_{hp}\gamma^k_2 + R^k_p\gamma^k_3 + X^k_{thp}Z^k_{hp}\gamma^k_4 + Z^k_{hp}R^k_p\gamma^k_5 \tag{10}$$

$$\sigma^{2,k}_{u_{0hp}} = \delta^k_0 + Z^k_{hp}\delta^k_1 + R^k_p\delta^k_1 + Z^k_{hp}R^k_p\delta^k_3 \tag{11}$$

$$\sigma^{2,k}_{v_{00p}} = \theta^k_0 + R^k_p\theta^k_1 \tag{12}$$

$$\left(e^k_{thp} + u^k_{0hp} + v^k_{00p}\right)^2 = \vartheta^k_0 + X^k_{thp}\vartheta^k_1 + Z^k_{hp}\vartheta^k_2 + R^k_p\vartheta^k_3 + X^k_{thp}Z^k_{hp}\vartheta^k_4 + Z^k_{hp}R^k_p\vartheta^k_5 \tag{13}$$

where γ, δ, θ are coefficients of variance residuals at each level and ϑ is the coefficient of the total variance of residual. The final step is to determine the expected idiosyncratic variances $\hat{\sigma}^2_{e_{thp}}$ and $\hat{\sigma}^2_{u_{0hp}}$, the expected covariate variance $\hat{\sigma}^2_{v_{0hp}}$, and total variance of household deprivation, $\hat{\sigma}^2_{(e_{thp}+u_{0hp}+v_{00p})}$, with the estimated parameters of Eqs. (10) to (13). It is argued by Hox et al. (2017) that estimates of variance components using the restricted maximum likelihood (RML) approach are less biased than by using the full maximum likelihood method (FML). Therefore,

this study employs the restricted maximum likelihood method to estimate expected deprivations and variances.

In previous empirical studies (see Tesliuc and Lindert 2002; Christiaensen and Subbarao 2005; Günther and Harttgen 2009; Azeem et al. 2016; and Mina and Imai 2017), following the proposed measure of Prichett et al. (2000), the expected estimated mean and variance are used to construct vulnerability to expected poverty where vulnerability is the conditional probability of deprivation of a household h within a province p to fall below a predetermined poverty line (ζ) in the near future:

$$\hat{V}_{thp} = \hat{P}\left(d_{thp} < \zeta | X, Z, R\right) = \boldsymbol{\Phi}\left(\frac{\zeta - \hat{d}_{thp}}{\sqrt{\hat{\sigma}^2_{thp}}}\right) \tag{14}$$

Thus, here $\hat{V}_{thp}$ represents the probability of being poor or the estimated vulnerability, d_{tph} is the deprivation measurement (this is usually income or consumption level in a monetary approach), $\boldsymbol{\Phi}$ is the Gaussian standard cumulative density distribution, $\hat{d}_{thp}$ is the expected mean of deprivation, and $\hat{\sigma}^2_{thp}$ is the expected variance of deprivation. Based on the type of vulnerability being estimated, different variances are used; for example, idiosyncratic variance $\left(\hat{\sigma}^2_{e_{thp}} \text{ and } \hat{\sigma}^2_{u_{0hp}}\right)$, covariate variance $\left(\hat{\sigma}^2_{v_{0hp}}\right)$, or total variance $\left(\hat{\sigma}^2_{(e_{thp}+u_{0hp}+v_{00p})}\right)$.

However, as pointed out by Hoddinott and Quisumbing (2010), the approach of vulnerability measurement as presented in Eq. (14) may sometimes lead to cases in which increases in variance or risk can reduce the probability of being poor or vulnerable. To overcome this limitation, our study utilizes standard deviation as a measure of risk (Chiwaula et al. 2011). This simple and comprehensible measure based only upon expected variance and expectation parameters does not require the assumption of a specific probability distribution function as used in previous approaches, which could be particular to each household.[6]

Notice that the measure of Chiwaula et al. (2011) is sensitive to variability, but not to asymmetry; thus, it is not able to rationally order the welfare of the two individuals depicted in this example when they are averse to downside risk.

Hence, the worst-off/best-off households in our study are expounded as *definitely poor*/*definitely not poor* in each relevant dimension of poverty. Note that according to our definition (see Eq. (1)), the level of deprivation varies from 0 (no poverty) to 1 (maximum poverty). Since the poverty analysis gives more attention to the lower

[6] Gallardo (2018) argues that even though the approach of Chiwaula et al. (2011) addresses the drawback of sensitivity to variability in Eq. (14), this approach is still not able to reasonably order the deprivation of the two households if they are averse to downside risk. While this is recognized as a limitation of the study, our application of the panel dataset in measuring vulnerability to poverty in both monetary and non-monetary dimensions would provide helpful policy implication since most previous studies on vulnerability based on cross-sectional data and monetary dimension. This is also to acknowledge that, like all other subjective measures, fuzzy approach to measure poverty has its limitations (see Alkire et al. 2015). By using a number of robustness checks, we tried to make our results acceptable within these limitations..

end of the welfare distribution, we define households with values of deprivation equal to or above 0.9 as definitely poor, and with values equal to or below 0.1 as definitely not poor. Then our vulnerability measure is:

$$V_{thp}^{k} = P\left(\hat{d}_{thp}^{k} > Z\right) = \left\{ \begin{array}{lll} 0 & if & \left(\hat{d}_{thp}^{k} - \sigma_{\hat{d}_{thp}^{k}}\right) \leq 0.1 \\ 1 - \frac{\left[\mathbb{Z} - \left(\hat{d}_{thp}^{k} + \sigma_{\hat{d}_{thp}^{k}}\right)\right]}{\left[\mathbb{Z} - \left(\hat{d}_{thp}^{k} - \sigma_{\hat{d}_{thp}^{k}}\right)\right]} & if & 0.1 < \left(\hat{d}_{thp}^{k} + \sigma_{\hat{d}_{thp}^{k}}\right) < 0.9 \\ 1 & if & \left(\hat{d}_{thp}^{k} + \sigma_{\hat{d}_{thp}^{k}}\right) \geq 0.9 \end{array} \right\} \tag{15}$$

where $\mathbb{Z}$ is the threshold of values of deprivation when households are definitely poor.[7]

In the context of existence of risks, a household may experience both positive (for example, good weather and increased rice price) and negative shocks. Therefore, a household's deprivation values may vary stochastically between the lower $\left(\hat{d} - \sigma_{\hat{d}}\right)$ and upper $\left(\hat{d} + \sigma_{\hat{d}}\right)$ bounds of expected deprivation $\hat{d}_{thp}$ when this household faces positive and negative shocks, respectively.

Having defined vulnerability above, we now introduce elements of dynamics for the estimation. Thus, we define a minimum level of vulnerability V above which we classify households as vulnerable to the relevant dimension of poverty and the time horizon, which we regard as the near future. Following previous empirical studies (Chaudhuri et al. 2002; Tesliuc and Lindert 2002), we apply the most common vulnerability benchmark, 50% with a time horizon of two years:

$$V_{t+2,hp}^{'} = 0.5 = 1 - \left[P\left(d_{thp}^{k} > 0.9\right)\right]^{2} \tag{16}$$

where $V_{t+2,hp}^{'}$ is the vulnerability benchmark at time t at which a household will experience deprivation d_{thp}^{k} in excess (at least once) of our cut-off 0.9 for definitely poor households. Given Eq. (16), $0.292\left(= 1 - \sqrt{0.5}\right)$ is the benchmark at which households at time t are classified as vulnerable (at least once) in the next two years. It is worth highlighting that vulnerability in this study is interpreted as the probability of being categorized as *definitely* poor in the near future, whereas in previous approaches that are based on some predetermined poverty lines that divide the population into poor and non-poor, vulnerability is explained as the probability of becoming poor.

We define the major vulnerability groups of households based on the number of times a household is classified as vulnerable. The *highly vulnerable* are referred to as households that are persistently vulnerable from 2010 to 2014. The *relative*

[7] The cut-off 0.9 for $\mathbb{Z}$ is arbitrary here. In the empirical application, we have checked the sensitivity of this choice of $\mathbb{Z}$ by considering various other values (see Table 10). We also provide the robustness checks of other thresholds (0.85 and 0.95) in Table 13.

vulnerable are those households who are vulnerable maximally twice during the period 2010 to 2014. The *not vulnerable* are those households which were consistently non-vulnerable throughout the period.

To evaluate whether our empirical fuzzy measurement is robust when weights are altered, or small changes in thresholds $\mathbb{Z}$, we run two analyses related to the pairwise comparisons, Spearman rank correlation coefficient (R), and the Kendall rank correlation coefficient ((R_τ)). Although the fuzzy poverty estimates are influenced by alternative weights/thresholds, the household rankings are highly robust to such changes. Spearman correlation coefficient $\left(R_\rho\right)$ and Kendall correlation coefficient $\left(R_\tau\right)$ report a minimum value of 0.83 and 0.89, respectively (Table 12), 0.76 and 0.70, respectively (Table 13). Hence, the empirical results appear to be a valid instrument for informing poverty policies.

3 Data and variables

Most international and local studies on the status of Vietnamese poverty have been based on the Vietnam Housing Living Standard Survey (VHLSS) conducted since 1993 by the General Statistics Office with technical support from the World Bank. The VHLSS is a comprehensive survey that is representative of Vietnam at the whole country, regional, urban, rural, and province levels. The household survey includes detailed information on different aspects of living conditions: comprising household-level income, expenditure, housing conditions, durables ownership, and household demographics, as well as the health, education, employment of the household members, and participation in government programs.

The present study uses three waves of the VHLSS conducted nationwide in 2010, 2012, and 2014, important periods in the recent economic and structural transformations that Vietnam has undergone. Each wave covers 9399 households across 63 provinces. Due to the inconsistency in household identification across surveys, three waves of VHLSS from 2010 to 2014 allow for a balanced panel of 1779 households, yielding 5337 observations in total.[8]

Table 1 presents summary statistics for the households used in this analysis. The set of covariates employed in this study are selected following previous poverty studies on Vietnam (Minot 2000; and Van de Walle and Cratty 2004; Baulch and Dat 2010; Imai et al. 2011). The variables chosen for inclusion in the multilevel regression specified in Eq. (9) include a combination of household demographic characteristics and household socio-economic characteristics:

(a) Household size (and its square);

[8] The VHLSS data are large cross-sectional data sets, but it is possible to construct a panel data due to the overlap of samples. Although concerns about the sample attrition might raise while using the household panel data, there are previous studies using the same VHLSS dataset have reported that the evidences of attrition is random (see, Dang et al. (2019), Le et al. (2019), Le and Nguyen (2019), Nguyen (2019), Coxhead et al. (2019), and Liu et al. (2020).

Table 1 Definition and summary statistics for households and provinces

Variables	Description	2010				2012				2014			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Household head profile													
Minority ethnic	Ethnic of (HH): 1 if minority; 0 otherwise	0.191	0.393	0	1	0.191	0.393	0	1	0.191	0.393	0	1
Married	Marital status of HH: 1 if married; 0 otherwise	0.780	0.414	0	1	0.810	0.393	0	1	0.799	0.401	0	1
Household characteristics													
Household size	Number of household members	3.994	1.532	1	12	3.966	1.569	1	11	3.858	1.617	1	11
Square of household size	Square of household size	18.30	14.24	1	144	18.20	14.24	1	121	17.50	14.57	1	121
Urban/Rural	1 if urban; 0 otherwise	0.269	0.443	0	1	0.269	0.443	0	1	0.269	0.443	0	1
Share of works in formal sector	Ratio of household members in wage/salary employment	0.274	0.266	0	1	0.264	0.259	0	1	0.273	0.271	0	1
Share of works in agriculture	Ratio of household members who are self-employed in agriculture, forestry, aquaculture	0.405	0.340	0	1	0.406	0.350	0	1	0.398	0.347	0	1
Share of works in off-farm activities	Ratio of household members who self-engaged in production, business, services outside agriculture, forestry, aquaculture	0.130	0.225	0	1	0.129	0.224	0	1	0.134	0.237	0	1
Share of household members w/completed primary school	Ratio of household members completed primary school	0.230	0.254	0	1	0.235	0.260	0	1	0.231	0.263	0	1
Share of HH members w/completed secondary school	Ratio of household members with or completed secondary school	0.233	0.262	0	1	0.233	0.263	0	1	0.233	0.272	0	1

Table 1 (continued)

Variables	Description	2010				2012				2014			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Share of HH members w/ completed high school or professional education	Ratio of household members with or completed high school or professional education	0.146	0.226	0	1	0.149	0.231	0	1	0.142	0.229	0	1
Province characteristics													
Ratio of migrate in	Ratio of people who migrated in province	0.074	0.103	0.019	0.896	0.060	0.074	0.010	0.591	0.075	0.085	0.014	0.702
Infrastructure index	Principal component analysis (PCA) index of the following: total number of hospitals, schools, and markets	0.278	1.183	−1.385	3.362	0.284	1.284	−1.158	4.267	0.285	1.288	−1.155	4.353
Agriculture index	PCA index of the following: planted area of paddy, production of paddy, production of fishery, poultry	0.095	1.009	−0.781	3.951	0.086	0.998	−0.759	4.140	0.081	0.997	−0.748	4.202
Health index	PCA index of the following: number of doctors, physician, nurse, and midwife	0.203	1.200	−0.781	6.648	0.185	1.181	−0.646	6.798	0.184	1.189	−0.589	6.928

(b) The ratio of dependents (those household members younger than 15 or older than 65);
(c) The share of household members working in the formal sector, in agriculture, and in off-farm activities;
(d) A binary variable to capture the household's status as being female-headed, being married, and being minority ethnic (equals 1);
(e) Proportion of household members who have completed a particular level of education (primary, secondary, and more than secondary);
(f) A binary variable capturing whether household resident in urban or rural; and
(g) The proportion of people who migrate within the province.

To avoid any concern about endogeneity, we use different measurements for variables in our regression models and measurement of deprivation level of education dimension. While level of deprivation in the education dimension ismeasured by using average schooling achievement of adults in household (15 years and above), which is transformed into the interval 0 to 1 to determine the deprivation scores, the variables in the regression models are ratios of household members completed primary, secondary, and high school (See Yang and Mukhopadhaya 2019).

We also include province-level variables, namely the infrastructure index, agriculture index, and health labours index. These indices were generated using principal component analysis (PCA) mainly because some of the component variables of those indices are strongly correlated (Günther and Harttgen 2009; Ward 2016; Mina and Imai 2017).[9] The province-level data are drawn from the *Vietnam Statistical Yearbook* published in 2010, 2012, and 2014.

4 Static versus the dynamics of poverty in Vietnam

Using the method presented in Eq. (1), this section presents and compares the profiles of static and dynamic poverty in Vietnam in multiple dimensions. At the national level, the poverty status measured in alternative dimensions seems to have either improved during the studied period or stayed more or less the same (Table 2). At the regional level, we observe a number of interesting stories about the poverty patterns of the six economic regions during the period 2010–2014. Firstly, the ranking of regions is quite consistent between poverty headcount ratios (with the official poverty line) and a fuzzy monetary measurement. However, while the poverty headcount ratios show improvements in poverty status in all regions and at the national level from 2010 to 2014, the fuzzy monetary approach reports the reverse in some regions (a significant increase in Regions 2 and 5 during 2010–2014 and in Region 5 during 2012–2014). It should be noted that the official statistics are based on the monetary approach to poverty measurement, which divides the population into two groups of poor and non-poor, by a predetermined poverty line, while our approach

[9] See Table 1 for the names of the variables included in these indices. Details are presented in Appendix Tables 8 and 9.

Table 2 Poverty measures in Vietnam, by dimensions, years and regions

Dimensions	Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Poverty	2010	8.400	29.400	20.400	22.200	2.300	12.600	14.200
Headcount	2012	6.000	23.800	16.100	17.800	1.300	10.100	11.100
Ratio(%)	2014	4.000	18.400	11.800	13.800	1.000	7.900	8.400
Monetary	2010	0.396 (0.301)	0.539 (0.294)	0.471 (0.297)	0.452 (0.319)	0.290 (0.256)	0.396 (0.310)	0.434 (0.305)
	2012	0.362 (0.287)	0.573 (0.296)	0.460 (0.296)	0.405 (0.327)	0.295 (0.265)	0.417 (0.310)	0.432 (0.307)
	2014	0.383 (0.288)	0.569 (0.303)	0.464 (0.302)	0.419 (0.336)	0.321 (0.271)	0.404 (0.297)	0.437 (0.307)
Education	2010	0.130 (0.206)	0.245 (0.279)	0.184 (0.244)	0.281 (0.326)	0.186 (0.246)	0.324 (0.284)	0.220 (0.268)
	2012	0.133 (0.221)	0.232 (0.275)	0.204 (0.254)	0.248 (0.275)	0.197 (0.259)	0.320 (0.282)	0.220 (0.266)
	2014	0.128 (0.211)	0.228 (0.247)	0.178 (0.227)	0.277 (0.304)	0.198 (0.241)	0.331 (0.292)	0.217 (0.259)
Health	2010	0.211 (0.307)	0.235 (0.363)	0.180 (0.271)	0.069 (0.062)	0.058 (0.058)	0.098 (0.051)	0.163 (0.257)
	2012	0.218 (0.295)	0.193 (0.337)	0.138 (0.178)	0.104 (0.086)	0.084 (0.084)	0.126 (0.078)	0.158 (0.225)
	2014	0.213 (0.268)	0.185 (0.318)	0.153 (0.190)	0.112 (0.113)	0.112 (0.112)	0.146 (0.107)	0.165 (0.218)
Housing	2010	0.043 (0.091)	0.439 (0.382)	0.184 (0.229)	0.423 (0.278)	0.349 (0.209)	0.567 (0.322)	0.312 (0.328)
	2012	0.042 (0.093)	0.413 (0.374)	0.153 (0.198)	0.403 (0.265)	0.329 (0.173)	0.541 (0.306)	0.291 (0.312)
	2014	0.046 (0.098)	0.390 (0.368)	0.159 (0.184)	0.391 (0.253)	0.315 (0.155)	0.525 (0.309)	0.284 (0.302)
Basic services	2010	0.263 (0.264)	0.284 (0.343)	0.284 (0.284)	0.421 (0.296)	0.154 (0.216)	0.368 (0.299)	0.335 (0.308)
	2012	0.287 (0.288)	0.251 (0.319)	0.251 (0.265)	0.373 (0.280)	0.137 (0.208)	0.363 (0.317)	0.321 (0.304)
	2014	0.216 (0.244)	0.277 (0.330)	0.277 (0.278)	0.412 (0.280)	0.132 (0.198)	0.367 (0.327)	0.323 (0.310)
Durable assets	2010	0.124 0(.168)	0.268 (0.252)	0.180 (0.213)	0.221 (0.262)	0.129 (0.165)	0.191 (0.193)	0.185 (0.214)
	2012	0.119 (0.177)	0.277 (0.238)	0.172 (0.210)	0.253 (0.251)	0.130 (0.192)	0.187 (0.211)	0.185 (0.218)
	2014	0.130 (0.311)	0.254 (0.395)	0.141 (0.318)	0.200 (0.363)	0.126 (0.305)	0.219 (0.381)	0.178 (0.351)
Monetary	Δ 2010–2012	−0.034*	0.030*	- 0.011	−0.047*	0.005	0.021**	−0.003
	Δ 2012–2014	0.02**	−0.003	0.004	0.014	0.026**	−0.013	0.005
	Δ 2010–2014	−0.013	0.030*	0.007	−0.034***	0.030**	0.008	0.003

Table 2 (continued)

Dimensions	Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Education	Δ 2010–2012	0.00	- 0.0134	0.020*	−0.033***	0.011	−0.004	0.000
	Δ 2012–2014	−0.005	−0.0036	−0.026*	0.029	0.001	0.011	−0.003
	Δ 2010–2014	−0.002	−0.0170	−0.006	−0.004	0.012	0.007	−0.003
Health	Δ 2010–2012	0.017	−0.04***	−0.042*	0.035*	0.027*	0.029*	−0.005
	Δ 2012–2014	−0.005	−0.008	0.015***	0.008	0.015**	0.020*	0.007
	Δ 2010–2014	0.002	−0.05**	−0.027**	0.043*	0.042*	0.048*	0.002
Housing	Δ 2010–2012	−0.001	−0.026**	−0.031*	−0.020	−0.020***	−0.025*	−0.021*
	Δ 2012–2014	0.004	−0.023**	0.006*	−0.012	−0.014***	−0.015***	−0.007**
	Δ 2010–2014	−0.003	−0.049*	−0.026*	−0.032***	−0.035*	−0.041*	−0.028*
Basic services	Δ 2010–2012	0.024**	−0.030*	−0.033*	−0.047*	−0.016***	−0.005	−0.014*
	Δ 2012–2014	−0.071*	0.043*	0.026*	0.039**	−0.005	0.003	0.002
	Δ 2010–2014	−0.048*	0.012*	−0.007	−0.009	−0.022**	−0.001	−0.012**
Durable assets	Δ 2010–2012	−0.005	0.010	−0.007	0.031**	0.001	−0.004	0.000
	Δ 2012–2014	0.010	−0.023	−0.031**	−0.053**	−0.004	0.031**	−0.007
	Δ 2010–2014	0.005	−0.014	−0.038*	−0.021	−0.003	0.028***	−0.007

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

For easy presentation, we name the regions in the following way—Region 1: Red River delta; Region 2: Midlands and Northern Mountains; Region 3: Northern and Coastal Central; Region 4: Central Highlands; Region 5: South East; Region 6: Mekong River Delta. The standard errors are presented in parentheses

The poverty headcount ratio is identified according to the Government's poverty line for 2011–2015 (1,000VND/person/month): 530 for rural areas and 660 for urban areas (GSO, 2017)

incorporates the distributional effect as well. The increase in monetary poverty as observed in our estimate is a manifestation of an increase in inequality.

Secondly, the improvement in poverty status in most regions and dimensions demonstrates that the poverty alleviation programs carried out by the government have achieved considerable progress. However, Regions 4, 5, and 6 have experienced a deterioration in health over time, while Regions 2 and 3 show an improvement. Region 1, where the Vietnamese capital is located and the level of income per

Table 3 Dynamics of poverty, by dimensions and regions: headcount ratios of the deprived (%)

Poverty		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Monetary	Chronic	2.94	3.68	2.15	6.87	1.19	1.38	2.75
	Transient	86.36	92.94	91.63	83.21	86.90	87.57	88.87
	Never	10.70	3.37	6.22	9.92	11.90	11.05	8.43
Education	Chronic	0.27	0.31	0.72	0.00	0.00	0.00	0.28
	Transient	55.61	75.15	68.66	74.81	69.05	87.02	71.33
	Never	44.12	24.54	30.62	25.19	30.95	12.98	28.39
Health	Chronic	0.27	0.61	0.24	0.00	0.00	0.00	0.22
	Transient	85.03	71.47	81.34	68.70	82.74	89.23	81.11
	Never	14.71	27.91	18.42	31.30	17.26	10.77	18.66
Housing	Chronic	0.00	10.12	0.24	0.76	0.60	15.19	5.12
	Transient	13.90	62.58	44.74	93.13	95.24	80.39	57.11
	Never	86.10	27.30	55.02	6.11	4.16	4.42	37.77
Basic services	Chronic	0.00	7.06	1.44	2.29	1.79	0.56	2.08
	Transient	66.31	80.98	69.62	90.08	47.61	77.62	72.06
	Never	33.69	11.96	28.95	7.63	50.60	21.82	25.86
Durable assets	Chronic	0.00	1.53	0.24	1.53	0.00	0.28	0.51
	Transient	37.70	67.48	51.20	57.25	41.07	56.63	51.94
	Never	62.30	30.98	48.56	41.22	58.93	43.09	47.55

capita ranks as the second highest of the country, has a significantly low poverty level in housing in comparison with other regions. While ranked as the third-best region in the monetary dimension, Region 6 reports the worst situation in education and housing, and second worst in the basic services dimension. This indicates the presence of high levels of deprivation in non-monetary dimensions in this region.

We construct Table 3 considering households whose values of deprivation persistently equal or are above 0.9 in all three waves as *chronic poor*, while those having deprivation values always equal to or below 0.1 as *never poor*, and those with values of deprivation that fluctuate between 0 and 1 during the studied period as *transient poor*. It may be noted that, at the national level, while the proportion of chronic poor in any poverty dimension is quite small, in the housing dimension it is the highest (particularly high in Regions 2 and 6), at least nearly double that in the other dimensions. More specifically, nationwide, around 5% of households stay in housing deprivation over many years.

Furthermore, when looking more closely at the figures in Table 3, for each non-monetary dimension, it can be observed that differences across regions are substantial. Regions that have a higher proportion of chronic poor in the monetary dimension do not necessarily have a higher percentage of chronic poor in non-monetary dimensions. For example, the region of Central Highlands (Region 4) has the highest rate of chronic poverty in the monetary dimension, but it has the lowest percentage in the education and health dimensions, and the second-lowest percentage in the durable asset dimension. No household in Region 1 experiences chronic poverty in housing, basic services, or durable assets. Likewise, no household in Regions 4, 5

and 6 suffers from chronic poverty in education or health. However, about 10% and 15 per cent of household in Regions 2 and 6, respectively, are in housing deprivation over many years.

Although the rate of chronic poverty in the monetary dimension is quite low in the region of Mekong River Delta (Region 6), this region experiences the highest percentage of this poverty in housing and durable assets. It may be noted that, based on the official poverty lines of the country, Region 4 is ranked as the second-poorest in the country, after the region of Midlands and Northern Mountains (Region 2), and Northern and Coastal Central (Region 3), whereas Region 6 is the fourth-poorest region.[10] Various national target programs and policy groups were implemented during the 2006–2010 period to develop infrastructure, promote production, and improve peoples' lives in areas classified as difficult communes in the country. More than 800,000 poor in ethnic minority groups and poor households were supported with the provision of dwelling houses in the period 2006–2014. It is worth noting that Region 2 has the highest density of ethnic minorities.

Households in Region 3 are more likely to be affected by natural disasters than households in other regions. Therefore, 570 households with a capital of VND 168.4 billion in this region were supported in 2014. However, the main criterion for identification of the beneficiaries for these support programs is based on household income or consumption levels, which does not capture various other non-monetary aspects of poverty. It might be the reason that Region 6 has not received appropriate assistance from social support programs and is observed as the worst region in most non-monetary dimensions.

Furthermore, we find that much of the poverty in Vietnam both in monetary and non-monetary dimensions is transient. To be more specific, most regions that face the worst situation in a particular dimension during the studied period (Table 2) suffer from the highest transient poverty in that dimension (Table 3). The exception is Region 2, which ranks as the poorest in the monetary, health and durable assets dimensions and reports the highest ratio of chronic poor in these dimensions when compared to the other regions ranked worst in some dimensions. The number of studies examining the dynamics of poverty in Vietnam, however, is very limited and all research the monetary dimension alone. Our findings are quite consistent with the previous studies, which indicates that the nature of monetary poverty in Vietnam is mainly transient, and chronic poor households in the monetary dimension are more likely in the minority of households (Baulch and Dat 2010; Imai et al. 2011; Mahadevan and Hoang 2016). Our findings further contribute to the literature by providing an exploration of chronic and transient poverty in non-monetary dimensions. International empirical investigations on the dynamics of multidimensional poverty concentrate mainly at the national level (for example, Mehta and Shah 2003 in India; Wardhana 2010 in Indonesia; and Alkire et al. 2017 in Chile), while we explore the poverty dynamics at regional levels in Vietnam, the results of which will assist to better target regions for alleviating poverty and vulnerability.

[10] Poverty rates based on the government's poverty lines for the period 2011–2015 (GSO, 2017).

Table 4 Regression results of deprivation measures of monetary and non-monetary dimensions

Variables	Monetary	Education	Health	Housing	Basic services	Durable assets
Time	0.000	−0.001	0.002	−0.007***	−0.003**	−0.004**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Household size	−0.042***	−0.052***	0.056***	−0.003	−0.012	−0.102***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
Household size square	0.004***	0.005***	-0.004***	−0.000	0.001*	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Dependant ratio	0.177***	−0.037**	-0.035*	−0.012	0.011	0.029
	(0.020)	(0.017)	(0.021)	(0.018)	(0.020)	(0.021)
Ratio of primary school	−0.058***		0.020**	−0.010	−0.007	−0.043***
	(0.009)		(0.009)	(0.009)	(0.009)	(0.010)
Ratio of secondary school	−0.081***		0.003	−0.037***	−0.036***	−0.120***
	(0.013)		(0.011)	(0.012)	(0.012)	(0.012)
Ratio of high school	−0.140***		0.008	−0.054***	−0.089***	−0.173***
	(0.016)		(0.014)	(0.014)	(0.015)	(0.015)
Share of workers in formal sector	−0.003	−0.108***	-0.021	−0.001	0.023	−0.053***
	(0.015)	(0.015)	(0.016)	(0.014)	(0.016)	(0.016)
Share of workers in agriculture	0.067***	−0.070***	0.036**	−0.017	0.119***	−0.037**
	(0.017)	(0.015)	(0.017)	(0.015)	(0.017)	(0.017)
Share of workers in services sector	−0.220***	−0.111***	0.041**	−0.030*	−0.038**	−0.074***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.018)	(0.019)
Married status of HH	−0.119***	−0.053***	-0.019**	0.006	−0.039***	−0.073***
	(0.014)	(0.013)	(0.009)	(0.013)	(0.012)	(0.010)
Urban	−0.091***	−0.100***	0.002	−0.058***	−0.202***	−0.079***
	(0.013)	(0.012)	(0.009)	(0.012)	(0.012)	(0.010)
Minority	0.198***	0.141***	−0.054***	0.198***	0.214***	0.183***
	(0.016)	(0.015)	(0.011)	(0.016)	(0.015)	(0.012)

Table 4 (continued)

Variables	Monetary	Education	Health	Housing	Basic services	Durable assets
Ratio of migrate in	−0.001**	−0.001*	−0.000	0.001	0.000	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Infrastructure index	−0.001	−0.036***	0.024***	−0.017**	0.008	0.001
	(0.008)	(0.011)	(0.009)	(0.007)	(0.009)	(0.007)
Agriculture index	0.004	0.098***	−0.016**	0.065***	0.044***	−0.001
	(0.010)	(0.015)	(0.007)	(0.020)	(0.016)	(0.009)
Health labour index	−0.027***	−0.011	−0.004	−0.014	-0.013	−0.006
	(0.008)	(0.009)	(0.008)	(0.012)	(0.013)	(0.008)
Interactions						
ratioprishool*infra						
ratioprishool*agri						−0.018**
						(0.009)
ratiosecondshool*infra						
ratiosecondshool*agri	−0.025*					
	(0.013)					
ratiosecondshool*Healthlabor						
ratiohighshool*infra						
ratiohighshool*agri						
ratiohighshool*Healthlabor	0.028***					
	(0.010)					
Hsize*migratein						
Hsize*agri		−0.009***			−0.004**	
		(0.002)			(0.002)	

Table 4 (continued)

Variables	Monetary	Education	Health	Housing	Basic services	Durable assets
Hsize*infra		0.005***				
		(0.002)				
minority*agri	−0.056***			−0.036**	−0.044***	
	(0.015)			(0.015)	(0.014)	
urban*infra	−0.023**		−0.019***			
	(0.009)		(0.007)			
percentjob1*agri	0.061***			0.037***	0.023*	0.034***
	(0.012)			(0.011)	(0.012)	(0.012)
percentjob3*Healthlabor	0.036***					
	(0.011)					
percentjob2*infra	0.037***		−0.053***		−0.030**	
	(0.010)		(0.014)		(0.013)	
percentjob2*agri	−0.063***	−0.024**				
	(0.012)	(0.011)				
percentjob2*Healthlabor			0.102***		0.057**	
			(0.025)		(0.025)	
minority*Healthlabor				−0.022	−0.069***	−0.030**
				(0.014)	(0.016)	(0.012)
urban*agri		−0.030**		−0.040***	-0.024**	
		(0.012)		(0.012)	(0.011)	
percentjob3*infra		0.038***		0.029***		
		(0.012)		(0.011)		
percentjob3*agri		−0.045***				
		(0.016)				

Table 4 (continued)

Variables	Monetary	Education	Health	Housing	Basic services	Durable assets
minority*infra					0.031**	
					(0.013)	
urban*Healthlabor					0.019**	
					(0.009)	
Constant	0.622***	0.479***	0.025	0.346***	0.373***	0.613***
	(0.027)	(0.027)	(0.025)	(0.032)	(0.028)	(0.026)
Observations	5337	5337	5337	5337	5337	5337
Number of groups	63	63	63	63	63	63

Standard errors in parentheses: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

To avoid any possible concern about endogeneity, we drop three explanatory variables: the ratios of primary, secondary, and high school, in the regression of propensity to poverty in education dimension

5 Vulnerability to multidimensional poverty

5.1 Factors determining poverty

The regression results of multilevel models for the estimated mean of deprivation measures are reported in Table 4. The dependent variables are propensity to poverty (see Eq. 1) in six dimensions. We find that households with a higher proportion of educated members and with members working in services and non-farm activities tend to have lower poverty in most dimensions. On the other hand, households with a higher ratio of members working in the agriculture sector and residing in rural areas tend to have a higher propensity to poverty in most dimensions.[11] Similar observations have been made in previous studies on Vietnam and other countries on monetary poverty (see, among others, Ravallion and Van de Walle 2008; Justino et al. 2008; Hoang et al. 2014 in Vietnam; Fan et al. in China; and Ferreira and Lanjouw 2001 in Brazilian Northeast). The results from our study suggest that farmers in rural areas need special poverty alleviation programs from government to help them escape poverty or not to fall (back) into poverty.

With regard to provincial characteristics, households living in provinces that receive higher levels of migration and a higher health index tend to have relatively lower propensity to deprivation in the monetary dimension. It is argued that economic motivation is one of the most important determinants of migration (Lee 1966; Stark and Taylor 1991). Therefore, individuals tend to move to places that provide better opportunities for employment and health care to improve their income level. The agriculture index is positively significant in most non-monetary dimensions, which implies that an increase in the agriculture index will increase propensity to poverty in the education, housing, and basic services dimensions. It should be noted that nearly 65% of the Vietnamese population reside in rural areas. The empirical evidence shows that rural areas where agriculture sector is dominated still lag far behind in the development of the country with poverty rates in rural areas consistently nearly three times that in urban areas (GSO 2018).

Provinces with a higher agriculture index indicate that working people in these areas engage more in the agriculture sector than those in other provinces. The majority of previous studies find that households residing in rural areas with members working in agriculture are more likely to be (income) poor than those living in urban areas and working in other sectors (see, among others, Arif et al. 2000 in Pakistan; Fan et al. 2004 in China; and Quang Dao 2004 in Vietnam).

A number of interaction variables also have significant effects on deprivation. Another interesting finding is that households with members who often engage in the services sector have less propensity to poverty in all dimension, except health. This means that a health shock would easily push these household into poverty. These findings are in agreement with other studies on developing countries, for instance in Ethiopia (Dercon and Krishnan 2000), Kenya (Barrett and McPeak

[11] Nearly 70% of the population of Vietnam lives in rural areas and more than 40% of total employment in the country is in agriculture.

Table 5 Proportion of households at various levels of vulnerability to monetary and non-monetary dimensions, by sources

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Monetary	Total	Not vulnerability	29.95	9.82	19.14	21.37	33.33	17.96	20.97
		Relative vulnerability	18.45	8.90	21.29	12.98	25.60	23.20	18.61
		High vulnerability	51.60	81.29	59.57	65.65	41.07	58.84	60.43
	Idiosyncratic	Not vulnerability	22.99	7.36	13.88	18.32	27.38	13.26	16.08
		Relative vulnerability	19.79	7.06	19.14	10.69	20.83	19.89	16.75
		High vulnerability	57.22	85.58	66.99	70.99	51.79	66.85	67.17
	Covariate	Not vulnerability	95.45	78.22	91.39	84.73	73.21	98.07	88.98
		Relative vulnerability	3.74	16.56	7.18	12.21	5.36	1.10	7.14
		High vulnerability	0.80	5.21	1.44	3.05	21.43	0.83	3.88
Education	Total	Not vulnerability	74.33	49.69	68.66	51.91	60.71	35.64	57.67
		Relative vulnerability	14.97	25.46	18.66	23.66	22.62	27.35	21.64
		High vulnerability	10.70	24.85	12.68	24.43	16.67	37.02	20.69
	Idiosyncratic	Not vulnerability	76.74	46.01	61.72	48.09	56.55	29.56	53.96
		Relative vulnerability	12.03	19.94	21.05	19.08	25.00	23.48	19.67
		High vulnerability	11.23	34.05	17.22	32.82	18.45	46.96	26.36
	Covariate	Not vulnerability	100.00	100.00	100.00	100.00	88.69	96.69	98.26
		Relative vulnerability	0.00	0.00	0.00	0.00	11.31	3.04	1.69
		High vulnerability	0.00	0.00	0.00	0.00	0.00	0.28	0.06

Table 5 (continued)

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Health	Total	Not vulnerability	98.93	99.69	100.00	100.00	100.00	72.93	94.21
		Relative vulnerability	1.07	0.31	0.00	0.00	0.00	20.17	4.38
		High vulnerability	0.00	0.00	0.00	0.00	0.00	6.90	1.41
	Idiosyncratic	Not vulnerability	99.47	99.69	100.00	100.00	100.00	74.86	94.72
		Relative vulnerability	0.53	0.31	0.00	0.00	0.00	19.06	4.05
		High vulnerability	0.00	0.00	0.00	0.00	0.00	6.08	1.24
	Covariate	Not vulnerability	100.00	100.00	99.28	100.00	100.00	77.90	95.33
		Relative vulnerability	0.00	0.00	0.72	0.00	0.00	4.70	1.12
		High vulnerability	0.00	0.00	0.00	0.00	0.00	17.40	3.54
Housing	Total	Not vulnerability	97.86	37.42	92.34	66.41	93.45	57.18	74.48
		Relative vulnerability	0.00	6.44	1.91	3.05	4.76	4.97	3.32
		High vulnerability	2.14	56.14	5.75	30.54	1.79	37.85	22.20
	Idiosyncratic	Not vulnerability	57.75	28.83	61.48	54.96	44.05	15.75	43.28
		Relative vulnerability	31.82	7.36	23.21	9.92	34.52	10.77	19.67
		High vulnerability	10.43	63.80	15.31	35.11	21.43	73.48	37.04
	Covariate	Not vulnerability	39.04	17.18	33.25	35.11	39.88	5.25	26.59
		Relative vulnerability	33.69	15.34	29.43	24.43	34.52	8.56	23.61
		High vulnerability	27.27	67.48	37.32	40.46	25.60	86.19	49.80

Table 5 (continued)

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Basic services	Total	Not vulnerability	59.63	20.86	47.61	47.33	77.98	36.19	45.76
		Relative vulnerability	24.33	10.74	24.64	8.40	19.05	25.97	20.57
		High vulnerability	16.04	68.40	27.75	44.27	2.98	37.85	33.67
	Idiosyncratic	Not vulnerability	37.97	13.80	28.95	64.89	51.19	19.06	28.61
		Relative vulnerability	16.04	3.99	11.96	6.87	19.05	8.84	11.02
		High vulnerability	45.99	82.21	59.09	58.02	29.76	72.10	60.37
	Covariate	Not vulnerability	84.76	42.64	82.54	66.41	86.90	69.89	72.34
		Relative vulnerability	9.36	0.30	7.41	2.29	7.14	18.51	8.38
		High vulnerability	5.88	57.06	10.05	31.30	5.96	11.60	19.28
Durable asset	Total	Not vulnerability	48.93	44.79	54.07	41.22	70.83	77.90	56.77
		Relative vulnerability	49.73	52.15	44.02	56.49	26.79	19.89	41.09
		High vulnerability	1.34	3.07	1.91	2.29	2.38	2.21	2.14
	Idiosyncratic	Not vulnerability	54.54	31.60	54.78	39.69	67.26	69.06	53.46
		Relative vulnerability	41.18	55.52	40.91	54.96	28.57	24.03	40.08
		High vulnerability	4.28	12.88	4.31	5.35	4.17	6.91	6.46
	Covariate	Not vulnerability	95.72	99.38	95.45	100.00	83.93	98.07	96.01
		Relative vulnerability	3.74	0.31	2.87	0.00	11.90	0.55	2.75
		High vulnerability	0.53	0.31	1.67	0.00	4.17	1.38	1.24

Table 6 Proportion of households at various levels of vulnerability to monetary and non-monetary dimensions: by poverty categorization

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Monetary	Chronic	Not vulnerability	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Relative vulnerability	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		High vulnerability	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Transient	Not vulnerability	25.39	8.91	18.54	20.18	30.82	13.25	18.28
		Relative vulnerability	18.89	8.58	20.37	11.93	26.71	23.97	18.53
		High vulnerability	55.73	82.51	61.10	67.89	42.47	62.78	63.19
	Never	Not vulnerability	75.00	45.45	34.62	46.15	55.00	57.50	56.00
		Relative vulnerability	20.00	27.27	34.62	30.77	20.00	20.00	24.00
		High vulnerability	5.00	27.27	30.77	23.08	25.00	22.50	20.00
Education	Chronic	Not vulnerability	0.00	0.00	66.67	0.00	0.00	0.00	40.00
		Relative vulnerability	0.00	0.00	33.33	0.00	0.00	0.00	20.00
		High vulnerability	100.00	100.00	0.00	0.00	0.00	0.00	40.00
	Transient	Not vulnerability	69.23	39.18	64.11	48.98	56.90	29.52	49.72
		Relative vulnerability	14.90	28.98	19.16	22.45	22.41	28.57	23.25
		High vulnerability	15.87	31.84	16.72	28.57	20.69	41.90	27.03
	Never	Not vulnerability	81.21	82.50	78.91	60.61	69.23	76.60	77.82
		Relative vulnerability	15.15	15.00	17.19	27.27	23.08	19.15	17.62
		High vulnerability	3.64	2.50	3.91	12.12	7.69	4.26	4.55

Table 6 (continued)

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Health	Chronic	Not vulnerability	100.00	100.00	100.00	0.00	0.00	0.00	100.00
		Relative vulnerability	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		High vulnerability	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Transient	Not vulnerability	99.37	99.57	100.00	100.00	100.00	72.45	93.62
		Relative vulnerability	0.63	0.43	0.00	0.00	0.00	20.43	4.78
		High vulnerability	0.00	0.00	0.00	0.00	0.00	7.12	1.59
	Never	Not vulnerability	96.36	100.00	100.00	100.00	100.00	76.92	96.69
		Relative vulnerability	3.64	0.00	0.00	0.00	0.00	17.95	2.71
		High vulnerability	0.00	0.00	0.00	0.00	0.00	5.13	0.60
Housing	Chronic	Not vulnerability	0.00	3.03	100.00	0.00	100.00	50.91	34.07
		Relative vulnerability	0.00	3.03	0.00	0.00	0.00	7.27	5.49
		High vulnerability	0.00	93.94	0.00	0.00	0.00	41.82	60.44
	Transient	Not vulnerability	96.15	28.43	85.56	69.67	93.13	59.11	66.34
		Relative vulnerability	0.00	8.33	4.28	2.46	5.00	4.47	4.82
		High vulnerability	3.85	63.24	10.16	0.07	1.88	36.43	28.84
	Never	Not vulnerability	98.14	70.79	97.83	25.00	100.00	43.75	92.26
		Relative vulnerability	0.00	3.37	0.00	12.50	0.00	6.25	0.74
		High vulnerability	1.86	25.84	2.17	62.50	0.00	50.00	6.99

Table 6 (continued)

Dimensions	Vulnerability		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
Basic services	Chronic	Not vulnerability	0.00	0.00	0.00	0.00	33.33	0.00	2.70
		Relative vulnerability	0.00	0.00	16.67	0.00	66.67	0.00	8.11
		High vulnerability	0.00	100.00	83.33	100.00	0.00	100.00	89.19
	Transient	Not vulnerability	45.16	15.53	32.99	44.07	65.00	25.27	33.07
		Relative vulnerability	31.85	12.50	31.27	9.32	30.00	30.60	25.27
		High vulnerability	22.98	71.97	35.74	46.61	5.00	44.13	41.65
	Never	Not vulnerability	88.10	69.23	85.12	100.00	91.76	75.95	84.57
		Relative vulnerability	9.52	5.13	9.09	0.00	7.06	10.13	8.48
		High vulnerability	2.38	25.64	5.79	0.00	1.18	13.92	6.96
Durable asset	Chronic	Not vulnerability	0.00	0.00	0.00	0.00	0.00	100.00	11.11
		Relative vulnerability	0.00	40.00	0.00	100.00	0.00	0.00	44.44
		High vulnerability	0.00	60.00	100.00	0.00	0.00	0.00	44.44
	Transient	Not vulnerability	50.35	36.82	58.88	34.67	73.91	71.71	54.33
		Relative vulnerability	46.10	60.00	37.85	61.33	21.74	24.88	42.21
		High vulnerability	3.55	3.18	3.27	4.00	4.35	3.41	3.46
	Never	Not vulnerability	48.07	64.36	49.26	51.85	68.69	85.90	59.93
		Relative vulnerability	51.93	35.64	50.74	48.15	30.30	13.46	39.83
		High vulnerability	0.00	0.00	0.00	0.00	1.01	0.64	0.24

2006), and Ghana (Novignon et al. 2012). Households located in provinces with a higher infrastructure index tend to have less propensity to poverty when measured in terms of education and housing, but are more vulnerable in terms of health.

5.2 Proportion of vulnerable with various degrees: by source and type of poverty

Tables 5 and 6 summarize the estimated vulnerability of households in multiple dimensions of poverty using a balanced panel data of Vietnam for the period 2010–2014. First, Table 5 indicates that, at the national level, the probability of a household being classified as definitely poor in the monetary dimension at least once in the next two years is very high: about 60%. In other words, 60% of households in the study are highly vulnerable because their income is volatile. The monetary dimension has the highest percentage of panel households that are classified as vulnerable at least once in any of the periods covered, 2010, 2012, and 2014 (a total of "high vulnerability" and "relative vulnerability" of 79%), whereas the highest and lowest% of that in non-monetary dimensions are basic services (52.24%) and health (5.8%), respectively. This result implies that households have a higher probability of being totally poor in the monetary dimension than that in non-monetary dimensions.

Second, in comparison with idiosyncratic shocks, covariate shocks have a much lower impact on households in most dimensions. For example, while around 84 per cent of households are vulnerable to unobservable idiosyncratic shocks in the monetary dimension, only around 7.3% are vulnerable to unobservable covariate shocks. This finding is consistent with the study of Gloede et al. (2015) on monetary poverty in rural Vietnam. Since the impacts of idiosyncratic shocks are more direct, specific (for example, more members in household are unemployed), and can be mutually insured within communities, our findings imply the limitation of successful risk-sharing across households and indicates that it is challenging for households to insure against the idiosyncratic shocks without policy interventions targeting households.

We attempt a regional analysis of the effects of covariate and idiosyncratic shocks on vulnerability to provide valuable information for designing poverty alleviation programs and for the allocation of funds targeted towards the most vulnerable households. Table 5 indicates that, in most regions and dimensions, the impact of unobservable idiosyncratic shocks on households is much greater than that of unobservable covariate shocks. It should be noted that since Regions 2 and 4 have the highest poverty headcount ratios (according to the official measure), the proportion

as beneficiaries from public social support programs are highest in these regions.[12] However, these social support programs are focused on financial support for the poor households only,[13] while our poverty and vulnerability measurements (Tables 2, 3, and 5) reveal different pictures of poverty status and vulnerability prospects in the monetary and non-monetary dimensions. Although Region 6 is not the poorest region in the monetary dimension, this region is the most deprived in the majority of non-monetary dimensions, such as education, housing, and basic services (see Table 2), as well as having the highest rates of vulnerability in the education and health dimensions (see Table 5). However, the participation rate of poor households in Region 6 is always lower than in Regions 2 and 4 in any social support programs. These findings show evidence that the current monetary approach applied in Vietnam needs some modification in targeting the beneficiaries.

Second, our results show that a region with a relatively high rate of propensity to poverty (Table 2) in a particular dimension tends to have a much higher percentage of households identified as vulnerable in that dimension as well, whereas a low propensity to poverty is associated with significantly lower vulnerability. For example, Regions 2, 3, and 4 are the poorest in most dimensions (Table 2) and they also have relatively higher vulnerability to poverty in comparison with the other regions (Table 5). Our findings are consistent with the study of Imai et al. (2011) who use the VHLSS 2002 and 2004 to show that households of ethnic minorities or those living in high mountain areas are both poorer monetarily and more vulnerable than ethnic majority households or those living in other regions.[14] The current study further investigates vulnerability to non-monetary poverty and finds that ethnic minority households are more vulnerable to poverty in most non-monetary dimensions as well. In particular, Region 2, where the proportion of minorities is highest, reports the highest rates of vulnerability in the housing and basic services dimensions, 56.14 and 68.4%, respectively.

[12] The table below presents the participation in social support programs of households, by years and regions in per cent (GSO 2016).

Social Support Programs	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Country
2010	23.3	49.7	32.8	32.0	10.3	20.6	26.7
2012	20.5	55.8	36.2	28.7	10.1	23.3	27.7
2014	16.6	45.3	31.3	26.4	6.6	20.2	23.2

[13] Public social support programs include health insurance support; exemption and reduction in healthcare and tuition fees for the poor; scholarships; vocational training; housing support for the poor; provision of clean and clear water; and food support (GSO 2014).

[14] It should be noted that the highest residential density of ethnic minorities is in Regions 2, 3, and 4.

Third, households in Vietnam have lower vulnerability when confronted with covariate shocks as opposed to idiosyncratic shocks in all dimensions and regions[15] (Table 5). The exception is the housing dimension in all regions. While idiosyncratic shocks, such as unemployment or the sickness of a member of the family, have more influence on members in the same family than on other families, covariate shocks (natural disasters) impact many households within a community. Hence, covariate shocks can be insured against without much complexity by national safety nets of government more easily than idiosyncratic shocks since the former can be straightforwardly observed and targeted. Thus, our findings indicate there is a requirement for some insurance mechanisms among households in Vietnam to reduce vulnerability to idiosyncratic shocks.

Furthermore, the fact that covariate shocks have a greater impact on the housing dimension indicates that there are particular covariate shocks, such as natural hazards, that have stronger influence on households in the housing dimension than in the other dimensions. In our study, Region 6 reports much higher levels of vulnerability to both unobservable covariate shocks and idiosyncratic shocks in the housing dimension than in the other regions. The World Bank (2019) considers that Region 6, the largest agriculture and aquaculture producer in the country, is among the world's most vulnerable to climate change-induced disasters (such as drought, flood) and confronts extreme risks from rising sea levels. During the last decade, the number of people who have left the Mekong Delta is more than twice the average national migration (GSO 2019), and the most important reason for migration out of the region is to escape climate change and poverty (Chapman et al. 2016 and Kim and Mihn 2017). The study of Hallegatte et al. (2015) is based on household surveys in 92 countries and reports empirical evidence that housing and assets of the poor are less protected when they face shocks because of their lower capacity for access to loans or social protections. Hence, our findings call for specific anti-poverty policies and support programs which are alert to regional disparities so as to more effectively target the poor and vulnerable households.

Comparison of different poverty dynamics and vulnerability groups throws up some interesting information. The figures in Table 6 indicate that, at the national level, the percentage of chronically poor households identified as highly vulnerable to poverty is highest in the monetary and basic services dimensions, accounting for 100 and 89.2% of all chronic poor, respectively. The chronic poor in Region 2 are more vulnerable to poverty than the other regions. These findings are consistent with the studies of Imai et al. (2011), Ward (2016), and Mina and Imai (2017) who show that the chronically poor in the monetary dimension are more likely to remain poor in the near future. It is worth noting that, in the monetary dimension, households in

[15] There are contradictory results in previous studies that investigated only the monetary dimension of poverty and vulnerability about the relative importance of idiosyncratic and covariate shocks on households. While Paxson (1992) for Thailand, Udry (1994) for Nigeria, Carter (1997) for West Africa, and Dercon and Krishnan (2000) for Ethiopia report that the impact of covariate shocks is more crucial on households' income than idiosyncratic shocks, Günther and Harttgen (2009) for Madagascar, Azam and Imai (2012) for Bangladesh, Mina and Imai (2017) for Philippines observe a relatively higher influence of idiosyncratic shocks on households. These studies, however, did not employ a multilevel analysis.

all types of poverty dynamics are more vulnerable than those in the other dimensions. Furthermore, it can be observed that the complexion of vulnerability and poverty in the health dimension is different from that of all other dimensions. Although the percentage of never-poor households in the monetary dimension is lower than in non-monetary dimensions, the proportion of those households who identified as highly vulnerable in the monetary dimension are also relatively higher in most regions and at the national level. Among never-poor households, Region 4 reports the highest rates of vulnerability in education and housing, whereas Region 2 shows the highest percentage of vulnerability in basic services (Table 6). Our results indicate that to formulate more effective poverty alleviation programs, the policy makers need to take into account the risk of households being poor in the near future in both monetary non-monetary dimensions.

5.3 Household and province characteristics: vulnerable versus non-vulnerable

In the last section, we distinguished the population into vulnerable and non-vulnerable groups. Now, to specifically target vulnerable households when designing efficient development policies with specific objectives, it is essential to discern the determinants of vulnerability. Following the methodology proposed by Ward (2016), we use a two-sample *t test* to conduct the comparison and examine whether vulnerable and non-vulnerable households have statistically significant differences in regard to the characteristics of household and province. The *t test* of sample means is based on the assumption that populations in the vulnerable and non-vulnerable groups are random, independent and both follow normal distributions. In Table 7, we report the sample means of vulnerable and non-vulnerable groups in six dimensions of deprivation and their differences with the level of significance, assuming that variances for the two groups are different.

Compared to the estimated results in Table 4, almost all covariates of household and province are significantly different between vulnerable and non-vulnerable groups in multiple dimensions of poverty. The exception is that some demographic variables in the health dimension do not show significant disparity between the two groups, including equivalence income, female-headed household, household size, and dependency ratio. In the period 2012–2014, the Vietnam government spent an annual average of VND 12,500 billion specifically for the assistance of health insurance and free medical care for the poor, the near poor, and children under 6 years. This might be a part of the explanation for the insignificant differences between the two groups at these variables. This result also indicates that further micro-level research is necessary for a better understanding of the deprivation in the health dimension particularly for identifying the characteristics that distinguish vulnerable households from the non-vulnerable.

There is a significant disparity between the two groups for most observed characteristics. In terms of demographic characteristics, the vulnerable households have members with less education. Non-vulnerable households have a significantly greater share of members working in off-farm activities (that is, formal and services sectors) and less members working in agriculture than do vulnerable households

Table 7 Characteristics of vulnerable and non-vulnerable households: sample means and their differences

	Monetary			Education			Health		
Characteristic	NV	V	Δ	NV	V	Δ	NV	V	Δ
Equivalence income	184,347	99,640	84,706***	141,866	84,065	57,800***	117,007	123,795	6788
Female-headed	0.18	0.26	0.075***	0.21	0.28	0.07***	0.24	0.24	0
Household size	4.00	3.92	0.074*	4.23	3.54	0.69***	3.94	3.91	0.03
Dependant ratio	0.37	0.37	0	0.31	0.28	0.03***	0.30	0.30	0
Ratio of primary school	0.31	0.33	0.03**	0.33	0.32	0.01	0.32	0.40	0.08***
Ration of secondary school	0.34	0.28	0.06***	0.39	0.16	0.24***	0.30	0.20	0.10***
Ratio of high school	0.30	0.14	0.16***	0.24	0.08	0.16***	0.18	0.07	0.11***
Share of workers in formal sector	0.24	0.28	0.04***	0.29	0.24	0.05***	0.27	0.30	0.03**
Share of workers in agriculture	0.19	0.46	0.27***	0.35	0.48	0.13***	0.41	0.34	0.06***
Share of workers in services sector	0.34	0.08	0.26***	0.15	0.10	0.05***	0.13	0.14	0.01
Married status of HH	0.96	0.78	0.18***	0.88	0.74	0.13***	0.82	0.86	0.05***
Urban	0.69	0.16	0.27***	0.35	0.15	0.20***	0.27	0.21	0.06***
Minority	0.01	0.24	0.23***	0.10	0.31	0.21***	0.20	0.11	0.09***
Ratio of migrate in	8.86	6.46	2.4***	7.33	6.48	0.85***	7.16	3.83	3.32***
Infrastructure index	0.48	0.23	0.26***	0.43	0.08	0.35***	0.27	0.49	0.22***
Agriculture index	0.14	0.07	0.07***	0.03	0.25	0.28***	0.10	3.19	3.29***
Health labour index	0.65	0.07	0.58***	0.27	0.08	0.19***	0.20	0.08	0.12***
	Housing			Basic Services			Durable Assets		
Characteristic	NV	V	Δ	NV	V	Δ	NV	V	Δ
Equivalence Income	130,489	79,203	51,286***	154,089	86,452	67,637***	127,435	104,221	23,214***
Female-headed	0.26	0.18	0.08***	0.27	0.22	0.05***	0.24	0.25	-0.01
Household size	3.82	4.28	0.45***	4.00	3.89	0.11***	3.80	4.12	0.32***
Dependant ratio	0.32	0.23	0.09***	0.37	0.24	0.13***	0.29	0.31	0.02***

Table 7 (continued)

Characteristic	Housing			Basic Services			Durable Assets		
	NV	V	Δ	NV	V	Δ	NV	V	Δ
Ratio of primary school	0.31	0.37	0.06***	0.29	0.35	0.06***	0.36	0.29	0.07***
Ration of secondary school	0.32	0.20	0.12***	0.31	0.28	0.03***	0.31	0.27	0.04***
Ratio of high school	0.20	0.09	0.11***	0.26	0.10	0.15***	0.15	0.21	0.06***
Share of workers in formal sector	0.27	0.27	0.01	0.28	0.27	0.01***	0.28	0.26	0.02***
Share of workers in agriculture	0.36	0.54	0.18***	0.18	0.59	0.41***	0.39	0.42	0.03***
Share of workers in services sector	0.15	0.09	0.06***	0.20	0.07	0.13***	0.13	0.13	0.01
Married status of HH	0.80	0.88	0.08***	0.85	0.80	0.05***	0.83	0.80	0.03***
Urban	0.33	0.09	0.24***	0.56	0.02	0.53***	0.25	0.30	0.05***
Minority	0.01	0.71	0.70***	0.01	0.35	0.34***	0.11	0.30	0.19***
Ratio of migrate in	7.37	5.79	1.58***	8.52	5.65	2.87***	7.61	6.12	1.49***
Infrastructure index	0.39	(0.03)	0.41***	0.20	0.35	0.15***	0.15	0.46	0.32***
Agriculture index	(0.06)	0.53	0.60***	(0.03)	0.19	0.22***	0.19	0.05	0.24***
Health labour index	0.32	(0.18)	0.50***	0.37	0.04	0.34***	0.12	0.28	0.16***

NV: not vulnerable; V: vulnerable; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

in most dimensions. This indicates the importance of off-farm activities as instruments of rural development, not only in terms of raising total household incomes, but also in terms of reducing overall household vulnerability to poverty in non-monetary dimensions. Among province characteristics (rate of people who migrate in that province, infrastructure index, agriculture index, and health labour index), the results in Table 7 imply that vulnerable households are more likely to be from provinces that have lower ratios of migrants. Households in provinces that have more infrastructure facilities (number of schools, hospitals, and markets) and health labour (such as doctors, physicians, nurses, and midwives) are less likely to be vulnerable.

6 Conclusion

Currently the Government of Vietnam targets its poverty alleviation measures at poor and poverty-stricken regions and communities based on monetary measures of poverty. Along with poverty alleviation, vulnerability to poverty is another concern and may be considered an *ex ante* measure. Therefore, understanding vulnerability is important for poverty alleviation policies in identifying the causes of the poor retaining that status, and the non-poor falling into poverty. Using standard deviation as a measurement of risk, in this study vulnerability to poverty is estimated as the probability of becoming definitely poor measured as a proportion of the interval defined by lower and upper bounds of expected deprivation.[16] This simple and comprehensible measure does not require the assumption of a specific probability distribution function as used in some previous approaches. While other studies in Vietnam investigate vulnerability to poverty in aggregate measures, we further apply the method of multilevel analysis to estimate the deprivation of households and distinguish vulnerability to poverty in relation to idiosyncratic (household-specific-level) and covariate (province-level) shocks for establishing efficient risk management strategies. We employ a fuzzy method that allows the inclusion of people who are also in partial poverty and determine separate effects of the monetary dimension and six non-monetary dimensions on household deprivation. For the estimation of poverty and vulnerability, three-wave panel data of Vietnam (2010, 2012, and 2014) are used, covering all 63 provinces and urban and rural areas of the country. We show that households are not only vulnerable to poverty in monetary terms, but also significantly vulnerable in non-monetary dimensions.

Our findings illustrate that most households in Vietnam are in transient poverty in all dimensions. However, the high rates of vulnerability in never-poor households in monetary, housing, and basic services dimensions, especially in the region of Midlands and Northern Mountains and the region of Mekong Delta, call for more priorities to be given for these regions to narrow disparity gaps in these specific dimensions compared with the other regions. Notably, although it is not identified as the

[16] The interval of lower $\left(\hat{d}^k_{thp} - \sigma_{\hat{d}^k_{thp}}\right)$ and upper $\left(\hat{d}^k_{thp} + \sigma_{\hat{d}^k_{thp}}\right)$ bounds of expected deprivation $\hat{d}_{thp}$ equals $(2\sigma_{\hat{d}^k_{thp}})$.

poorest region in the monetary dimension, the region of Mekong Delta (Region 6) emerges as the worst-off area in most non-monetary dimensions in both poverty and vulnerability measures. While more multidimensionally poor households are vulnerable to idiosyncratic shocks than to covariate shocks, the proportion of households who are vulnerable to covariate shocks in the housing dimension is significantly higher than for that in the other dimensions. Furthermore, our findings suggest an urgent need for policy attention in the explicit dimensions of poverty, while the current targeting simply on the basis of the monetary approach might result in a widening of the disparity in deprivation in non-monetary dimensions in Vietnam.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Appendix

See Tables 8, 9, 10, 11, 12, 13 and Fig. 1.

Table 8 Description of dimensions used for the computation of poverty

Dimensions	Indicators	Description	Type of indicator	Computed Weight
Income		Equivalized income	Continuous	
Non-monetary				
Education	Schooling achievement of adult (15 years and above) members	Average level of education of household: No diploma Primary school Lower secondary school Upper secondary school College Bachelor's degree Higher education degree	Order	0.04
	School attendance of children	Households where there is at least one child or adolescent (6 to 15 years) not attending school.	Dichotomous	0.96
Health	Financial difficulties	Household where there is at least one person who was sick in the last 12 months, but the household could not afford to cover all health care expenses for him/her.	Dichotomous	0.82
	Health insurance	Household where there is at least one person who does not have health insurance or free health care certificate.	Dichotomous	0.18

Table 8 (continued)

Dimensions	Indicators	Description	Type of indicator	Computed Weight
Housing	Condition roof	Roof material:	Order	0.48
		Straw, canvas, tar paper		
		Panels/galvanized iron		
		Tile		
		Concrete, cement		
	Condition wall	Wall materials:	Order	0.52
		Branches/bamboo		
		Calcareous earth/straw		
		Wood/galvanized iron		
		Fired brick, stone		
		Concrete		
Basic services	Water	Main water drinking supply:	Order	0.10
		Rainwater		
		Unprotected spring sources		
		Protected spring sources		
		Hand-dug, non-reinforced and uncovered wells		
		Hand-dug and covered wells		
		Deep drill wells		

Table 8 (continued)

Dimensions	Indicators	Description	Type of indicator	Computed Weight
		Public tap water		
		Private tap water inside the house		
	Sanitation	Households with some of the following:	Order	0.13
		No toilet		
		Toilet directly over the water		
		Double vault compose latrine		
		Squat toilet		
		Flush toilet with septic tank/sewage pipes		
	Energy	Main source of lighting/cooking:	Order	0.76
		Candle/other		
		Kerosene/gas		
		Battery/diesel engine		
		Electricity		
Durable assets	Vehicle	Household does not own any bike or motorbike	Dichotomous	0.73
	Telephone	Household does not own any telephone, including mobile phone	Dichotomous	0.17
	TV	Household does not own any black-and-white or colour television	Dichotomous	0.11

Table 8 (continued)

Dimensions	Indicators	Description	Type of indicator	Computed Weight
Economic status	Food (agricultural product)	Household whose own judgment on their consumption of food over the last 30 days was insufficient to meet members' needs	Dichotomous	0.18
	Foodstuff (other than agricultural products)	Household whose own judgment on their consumption of foodstuff over the last 30 days was insufficient to meet members' needs	Dichotomous	0.09
	Electricity	Household whose own judgment on their consumption of electricity over the last 30 days was insufficient to meet members' needs	Dichotomous	0.13
	Water	Household whose own judgment on their consumption of water over the last 30 days was insufficient to meet members' needs	Dichotomous	0.26
	Housing	Household whose own judgment on their consumption of housing over the last 30 days was insufficient to meet members' needs	Dichotomous	0.18
	Clothes, footwear	Household whose own judgment on their consumption of clothes or footwear over the last 30 days was insufficient to meet members' needs	Dichotomous	0.14
	Savings	Household does not have any savings	Dichotomous	0.02

Table 9 Results of principal component analysis

Variables	2010	2012	2014
Infrastructure Index			
Total number of hospitals	0.5815	0.5741	0.582
Total number of schools	0.5904	0.5925	0.586
Total number of markets	0.5597	0.5651	0.5638
Per cent of variance explained	92%	91%	92.7%
Agriculture Index			
Planted area of paddy	0.597	0.5971	0.6037
Production of paddy	0.596	0.5969	0.6035
Production of fishery	0.4793	0.4897	0.4983
Production of poultry	0.242	0.2176	0.1517
Per cent of variance explained	66.5%	66.4%	65%
Health Index			
Total number of doctors	0.5343	0.54	0.5409
Total number of physicians	0.4009	0.3806	0.3849
Total number of nurses	0.5242	0.5318	0.534
Total number of midwives	0.5282	0.5299	0.5235
Per cent of variance explained	83.4%	81.6%	82.4%

Table 10 Sensitive tests of vulnerability with different values of Z

Dimensions	Vulnerability		Z = 0.9	Z = 0.8	Z = 0.7
Monetary	Total	Not vulnerability	20.97	20.85	20.74
		Relative vulnerability	18.61	18.66	18.72
		High vulnerability	60.43	60.48	60.54
	Idiosyncratic	Not vulnerability	16.08	16.02	16.02
		Relative vulnerability	16.75	16.81	16.86
		High vulnerability	67.17	67.17	67.12
	Covariate	Not vulnerability	89.00	77.52	65.04
		Relative vulnerability	7.14	8.99	10.51
		High vulnerability	3.88	13.49	24.45
Education	Total	Not vulnerability	57.67	57.67	57.67
		Relative vulnerability	21.70	21.64	21.53
		High vulnerability	20.63	20.69	20.80
	Idiosyncratic	Not vulnerability	54.02	53.96	53.96
		Relative vulnerability	19.73	19.67	19.62
		High vulnerability	26.25	26.36	26.42
	Covariate	Not vulnerability	98.26	98.26	97.25
		Relative vulnerability	1.69	1.69	2.53
		High vulnerability	0.06	0.06	0.22
Health	Total	Not vulnerability	94.21	93.37	93.37
		Relative vulnerability	4.38	4.50	4.50
		High vulnerability	1.41	2.14	2.14
	Idiosyncratic	Not vulnerability	94.72	93.76	93.70
		Relative vulnerability	4.05	4.27	4.33
		High vulnerability	1.24	1.97	1.97
	Covariate	Not vulnerability	95.33	93.37	93.37
		Relative vulnerability	1.12	3.37	3.37
		High vulnerability	3.54	3.26	3.26
Housing	Total	Not vulnerability	74.48	74.48	74.48
		Relative vulnerability	3.32	3.32	3.32
		High vulnerability	22.20	22.20	22.20
	Idiosyncratic	Not vulnerability	43.28	43.28	43.28
		Relative vulnerability	19.67	19.67	21.25
		High vulnerability	37.04	37.04	35.47
	Covariate	Not vulnerability	26.59	26.31	26.31
		Relative vulnerability	23.61	23.78	23.78
		High vulnerability	49.80	49.92	49.92

Table 10 (continued)

Dimensions	Vulnerability		Z = 0.9	Z = 0.8	Z = 0.7
Basic services	Total	Not vulnerability	45.76	45.76	45.76
		Relative vulnerability	20.57	20.57	20.57
		High vulnerability	33.67	33.67	33.67
	Idiosyncratic	Not vulnerability	28.61	28.56	28.56
		Relative vulnerability	11.02	11.07	12.76
		High vulnerability	60.37	60.37	58.68
	Covariate	Not vulnerability	72.34	48.06	26.31
		Relative vulnerability	8.38	16.13	5.68
		High vulnerability	19.28	35.81	68.02
Durable asset	Total	Not vulnerability	56.77	56.77	56.77
		Relative vulnerability	41.09	41.09	41.09
		High vulnerability	2.14	2.14	2.14
	Idiosyncratic	Not vulnerability	53.46	53.34	53.91
		Relative vulnerability	40.08	42.16	44.97
		High vulnerability	6.46	4.50	1.12
	Covariate	Not vulnerability	96.01	95.45	91.23
		Relative vulnerability	2.75	3.26	5.79
		High vulnerability	1.24	1.29	2.98

Table 11 Likelihood ratio tests for multilevel models versus single-level models

Income		LR $\chi^2_2 = 1959.05$	$Pr > \chi^2 = 0.0000$
Non-income	Education	LR $\chi^2_2 = 780.40$	$Pr > \chi^2 = 0.0000$
	Health	LR $\chi^2_2 = 117.07$	$Pr > \chi^2 = 0.0000$
	Housing	LR $\chi^2_2 = 3297.33$	$Pr > \chi^2 = 0.0000$
	Basic services	LR $\chi^2_2 = 1422.12$	$Pr > \chi^2 = 0.0000$
	Durable assets	LR $\chi^2_2 = 325.47$	$Pr > \chi^2 = 0.0000$

Table 12 Spearman correlation coefficient and Kendall correlation coefficient, by equal weights

Dimension	Spearman correlation coefficient (R_ρ)			Kendall correlation coefficient (R_τ)		
	2010	2012	2014	2010	2012	2014
Education	1.00	1.00	1.00	1.00	0.99	1.00
Health	0.89	1.00	0.95	0.83	0.89	0.91
Housing	0.99	1.00	1.00	1.00	1.00	1.00
Basic services	1.00	1.00	1.00	0.97	0.98	0.99
Durable asset	1.00	1.00	0.99	1.00	1.00	0.95

Table 13 Spearman correlation coefficient and Kendall correlation coefficient

Dimensions	Vulnerability		Z = 0.85		Z = 0.95	
			Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient	Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient
Monetary	Total	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.76	0.70	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
	Idiosyncratic	Not vulnerability	1.00	1.00	1.00	1.00
		Relative vulnerability	0.83	0.73	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
	Covariate	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.86	0.70	0.94	0.87
		High vulnerability	0.94	0.87	1.00	1.00
Education	Total	Not vulnerability	1.00	1.00	1.00	1.00
		Relative vulnerability	0.94	0.87	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
	Idiosyncratic	Not vulnerability	1.00	1.00	1.00	1.00
		Relative vulnerability	0.87	0.70	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
	Covariate	Not vulnerability	1.00	1.00	1.00	1.00
		Relative vulnerability	1.00	1.00	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00

Table 13 (continued)

Dimensions	Vulnerability		Z = 0.85		Z = 0.95	
			Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient	Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient
Health	Total	Not vulnerability	0.99	0.97	1.00	1.00
		Relative vulnerability	0.95	0.93	0.95	0.93
		High vulnerability	1.00	1.00	1.00	1.00
	Idiosyncratic	Not vulnerability	0.94	0.89	1.00	0.89
		Relative vulnerability	0.95	0.93	0.94	0.89
		High vulnerability	1.00	1.00	1.00	1.00
	Covariate	Not vulnerability	1.00	1.00	1.00	1.00
		Relative vulnerability	1.00	1.00	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
Housing	Total	Not vulnerability	0.89	0.73	1.00	1.00
		Relative vulnerability	0.84	0.77	1.00	1.00
		High vulnerability	0.93	0.83	1.00	1.00
	Idiosyncratic	Not vulnerability	0.89	0.73	1.00	1.00
		Relative vulnerability	0.87	0.70	1.00	1.00
		High vulnerability	0.89	0.73	1.00	1.00
	Covariate	Not vulnerability	0.89	0.73	1.00	1.00
		Relative vulnerability	0.83	0.73	1.00	1.00
		High vulnerability	0.94	0.87	1.00	1.00

Table 13 (continued)

Dimensions	Vulnerability		Z = 0.85		Z = 0.95	
			Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient	Spearman correlation coefficient (R_ρ)	Kendall correlation coefficient
Basic services	Total	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.94	0.87	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
	Idiosyncratic	Not vulnerability	0.83	0.73	1.00	1.00
		Relative vulnerability	0.87	0.70	1.00	1.00
		High vulnerability	0.83	0.73	1.00	1.00
	Covariate	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.94	0.87	1.00	1.00
		High vulnerability	1.00	1.00	1.00	1.00
Durable asset	Total	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.81	0.69	0.77	0.60
		High vulnerability	0.82	0.75	0.94	0.87
	Idiosyncratic	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.94	0.87	1.00	1.00
		High vulnerability	0.94	0.87	1.00	1.00
	Covariate	Not vulnerability	0.94	0.87	1.00	1.00
		Relative vulnerability	0.94	0.87	0.94	0.87
		High vulnerability	1.00	1.00	0.94	0.87

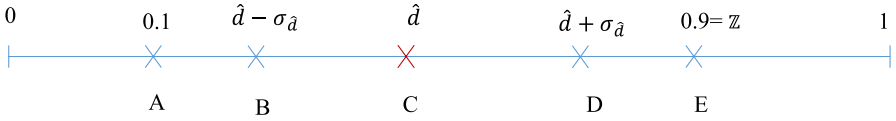

Fig. 1 Explanation of Eq. (15)

The first principal component is therefore given by:

$$Index_i = \sum a_i X_i$$

where a_i is principal component coefficients and X_i is the set of variables in the index i.

The propensity to poverty of a household or the fuzzy measurement of deprivation d varies between 0 and 1. We define a household whose values of deprivation are equal to or above 0.9 as definitely poor and equal to or below 0.1 as definitely not poor. In the context of shocks and risks existence, the deprivation value of a household is expected to fluctuate between B and D in Fig. 1. When a household is facing positive shocks or negative shocks, the standard deviation of expected deprivation $\sigma_{\hat{d}}$ will be subtracted from or added to the expected deprivation of a household $\hat{d}$ which is presented by the distance BC and CD, respectively.

The vulnerable index, V, in Eq. 15, equals one, if the highest potential deprivation, $\hat{d} + \sigma_{\hat{d}}$, is above point E, and households are definitely vulnerable. Households are non-vulnerable ($V=0$) if the lowest potential deprivation, $\hat{d} - \sigma_{\hat{d}}$, is below point A. In Fig. 1, the distance DE represents the prospects of falling into the definitely poor category when the household is facing negative shocks, while BE depicts potential to become definitely poor when the household experiences positive shocks. The closer the household's expected deprivation to E, the higher the probability that the household will be classified as definitely poor in the near future. Vulnerability index V measures vulnerability values of households, hence, is measured by one (1) minus a ratio of DE to BE.

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