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ORIGINAL RESEARCH

Targeting Administrative Regions for Multidimensional Poverty Alleviation: A Study on Vietnam

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Abstract
This study investigates seven dimensions of poverty in Vietnam (income, health, education, housing, assets, basic services and economic status) using the Household Living Standard Survey data of 2014. The Government of Vietnam disburses funds for poverty alleviation to regions on the basis of incidence of household income poverty. Our study shows that this method neither fully captures the complex regional diversity of poverty nor does it accurately identify regions with a higher severity of poverty. For the first time in poverty studies of Vietnam, we explore the role of multiple spatial levels on poverty in multiple dimensions. Unlike the practice in the existing literature which classifies the poor with an arbitrary poverty cut-off, we use a fuzzy method that allows the inclusion of people who are in partial poverty. Furthermore, by utilizing random intercept multilevel models to decompose the variation of poverty at the household, commune, district and province levels, poverty maps for Vietnam are developed to visualize the spatial evidence of the severity and incidence of poverty. We identify that the provinces that are relatively less (more) poor in the income dimension are more (less) destitute in several other dimensions, which clearly shows a need for special policy attention. Our method reveals that the poverty ranking of provinces in regional Vietnam departs widely from those obtained through traditional single-level analysis. This suggests that poverty in Vietnam can be explained not only by characteristics at the household level, but also by contextual factors at higher levels (commune/village, district, province). These empirical findings can help Vietnamese policy makers determine suitable strategies to effectively target the most deprived regions and to develop more appropriate poverty-alleviation programs.

Keywords Multilevel · Multidimensional · Fuzzy · Poverty · Province

JEL Classification I30 · I32 · I38

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1 Introduction

Over recent decades, the outstanding achievements of Vietnam in economic growth and reduction in poverty have transformed the nation from one of the poorest to a lower middle-income country. With an average annual real GDP growth rate of 6.5% during the period 2000–2017 (ADB 2018), Vietnam is now considered one of the most dynamic emerging nations in the East Asian region. The poverty rate in Vietnam dropped from 28.9% in 2002 to 5.8% in 2016 (GSO 2017),[1] and the provision of basic services has also substantially improved (GSO 2015). For the next stage in the fight against poverty, the Vietnamese government announced the estimated budget for the national target programme on poverty alleviation for 2016–2020 to be VND46.1 trillion (USD2.1 billion).

To date, the monitoring of poverty in Vietnam has utilised an approach based on income or expenditure; a method that neglects non-income dimensions of poverty such as health, education, living standards and so forth (Arouri et al. 2015; Lanjouw et al. 2017; Mahadevan and Hoang 2016; Nguyen et al. 2017). However, there is no disagreement about the necessity for identifying deprivation as a factor in a multidimensional approach, and this has increasingly expanded the measurement of poverty in many countries. It is also argued that using a multidimensional approach is not only a more efficient tool for measuring poverty; it can also be employed 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 literature available on multidimensional poverty in Vietnam (for example, Asselin 2009; Baulch and Masset 2003; Roelen et al. 2010, 2012; Tran et al. 2015); however, these studies use an arbitrary poverty cut-off to divide the population in a dichotomous group of poor and non-poor. Such a classification results in a huge loss of information on those who are partially poor, especially when they are living in similar conditions to those who are considered poor, but happen to just fall on the opposite side of the poverty line (Makdissi and Wodon 2004). To overcome this shortcoming, this paper employs a fuzzy method to measure poverty in Vietnam following Cerioli and Zani (1990), Cheli and Lemmi (1995), and Betti and Verma (2008).[2]

Furthermore, given the constraints in the government's budget, it is often desirable to target the invariable scarce resources for those beneficiaries whose disparities in living standards are the worst. Since inequality in economic growth and poverty in many developing countries, including Vietnam, is spatially concentrated (Huang and Magnoli Bocchi 2008; Klasen et al. 2007), public spending on poverty-alleviation programs is directed to areas where the poverty rate is higher.[3] To determine these target regions it is necessary to evaluate poverty from the perspective of households' socioeconomic and demographic factors and also include some of the regional macro traits. In this regard, the traditional

[1] Based on the national poverty line: for 2006–2010 the poverty lines are 360,000 and 450,000VND/person/month for the rural and urban areas respectively; for the period 2011–2015, the poverty lines are respectively 630,000 and 780,000 VND/person/month.

[2] Because of the use of dichotomous variables to specify the poverty status of a household (for instance "1" indicates poor and "0" not poor) in previous studies on Vietnam, the relative influence of household level could not be calculated directly from the empirical model but was derived from the latent variable methods proposed by Browne et al. (2005) and Goldstein et al. (2002). This drawback is corrected through our approach as we will show later. See also Pham and Mukhopadhaya (2018).

[3] Empirical evidence also reveals that the impact on poverty is most powerful when poverty alleviation efforts use spatial targeting for small administrative or geographic units; for instance, districts, villages or communes (Baker and Grosh 1994; Amarasinghe et al. 2005; Elbers et al. 2004).

approach uses a single-level linear regression framework, which either aggregates up to contextual level information or disaggregates down to household level information. Moreover, the existing approach is prone to generating spurious outcomes, because poor households in the same village/commune/district/province tend to be more similar to each other than to those in different villages/communes/districts/provinces. Due to this within-administrative area correlation, households within the same administrative region are not independent. In technical terms, this group dependence can lead to a violation of the independence assumption of linear regression. To avoid this problem, a multilevel model is an alternative that partitions the error structure into components at the household and higher levels.[4] Estimation of separate error terms at each level of analysis avoids violation of the assumption that originates in single-level regression models. The multilevel framework has further advantages because it appropriately handles variables that are measured at different levels, which allows the possibility of examining micro-level (household) and macro-level (commune, district, province) determinants of poverty simultaneously. Using a multilevel model, the current study identifies impoverished target regions in Vietnam from the combined perspectives of regional macro traits and household micro characteristics.

Beyond the household level, we also explore the relative effects of higher regional administrative levels on different dimensions of poverty in Vietnam, after controlling for household characteristics. This multilevel approach produces more efficient estimates than those obtained from a standard single-level regression, and is therefore an effective methodology to validly integrate the influences of household characteristics with contextual factors at the higher administrative levels to determine the poverty distribution of the country. The approach allows us to decompose the error terms to evaluate the relative impact of different geographical levels that can be attributable to levels of deprivation (Goldstein 2011; Raudenbush and Bryk 2002).

Our study contributes to the empirical literature in several ways. Firstly, this is the only study to investigate the relative importance of each administrative level and hierarchical clustering in explaining poverty in Vietnam beyond simply the income dimension. Secondly, although the Vietnam government has previously applied geographic targeting, it has been criticized due to the limited effectiveness of targeting in benefiting those in need since the government relied on a relatively arbitrary list of poor villages (Minot and Baulch 2004; Nguyen et al. 2017; van de Walle 2002). By using a multilevel and multidimensional approach, the present study derives an objective standard in locating the impoverished administrative areas in the country, which will help in targeting resources more efficiently. Thirdly, this paper brings out the complex characteristics of poverty in Vietnam where the current income-based targeting of poverty alleviation has been ineffective from the wider perspective of meeting the sustainable development goals. Our examination identifies the regions that need specific support in the explicit dimensions of poverty.

The paper is organized as follows. In the next section we describe the method used to measure poverty and the empirical strategy of the multilevel model. Section 3 describes the data, the choice of dimensions and the household-level variables. Section 4 presents the empirical results and discussion, followed by conclusions and policy implications.

[4] A limited number of studies is available in this respect. See, for example, Gräb and Grimm (2008) on Burkina Faso, Kim et al. (2016) on India, and Arpino and Aassve (2014) on rural Vietnam among others. However, all these studies utilise the uni-dimensional approach to measuring poverty, which cannot capture the multidimensional nature of deprivation.

2 Methodology

2.1 Measurement of Poverty—Income and Non-income Dimensions

The traditional approach to measuring poverty has been criticised for having two major shortcomings. Firstly, it is unidimensional; that is, either income or expenditure level is used as a proxy for poverty. Thus, the approach is limited in its capacity to capture the complex nature of poverty and in informing policy makers on poverty-alleviation strategies (Alkire and Santos 2013; Sen 1992). Secondly, the most widely used multidimensional measures of poverty (for example, the Alkire-Foster measure) divide the population into two groups: poor and non-poor, by using arbitrary poverty thresholds, resulting in a substantial loss of information from excluding those who are partially poor (Makdissi and Wodon 2004). Our study applies a relative measure of poverty that does not use the arbitrary cut-off and includes people who are *somewhat* poor, following fuzzy approach of Cerioli and Zani (1990). We consider that all households are subject to poverty but of different degrees, so that each has a certain propensity for poverty in the continuum range of [0, 1] (Verma and Betti 2002). Unlike the Alkire-Foster and other measures of poverty, this method allows for the possibility of determining the separate magnitudes of income and non-income dimensions of household deprivation that we are interested in. The following part of this section explains the fuzzy computations of poverty for income dimension (P_h) and non-income dimensions $\left(P_h^{(k)}\right)$. These measures are utilized to discuss the average degrees of poverty in income and non-income dimensions ($AP_{k,r}$) for six economic regions of the country in the Sect. 4.1, and in multilevel analyses discussed in the Sects. 4.2 and 4.3.

The income poverty measure for the household h is presented as:

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

This measure varies between 0 (not poor) to 1 (maximum poor), where L_h is the value of the Lorenz curve (which is the proportion of the total income earned by all households who are less poor than household h), and F_h is the share of households less poor than household h (which can be acquired from the cumulative distribution function, denoted as F). This measure of poverty is highly sensitive because it combines the actual disparities in income with the cumulative distribution function.

Similar to the income measure of poverty, we measure poverty for non-income dimensions (see Betti et al. 2015). A non-income dimension may consist of more than one indicator. First, 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:

$$d_{j,h} = \frac{Z - z_h}{Z - 1} \quad 1 \le z_h \le Z \tag{2}$$

z_h being the category to which household h belongs; Z is ordered categories of some deprivation indicator j (a higher Z indicates less deprivation).[5]

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

Following Betti and Verma (1999, 2008) the weight of each indicator is calculated within each dimension distinctly; as a product of the inverse of the average correlation coefficients of all indicators in the dimension 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:

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

where w_j is the weight of indicator j.

Like income poverty (as defined in Eq. (1)), we define a household's degree of non-income deprivations $P_h^{(k)}$ as:

$$P_h^{(k)} = \left[1 - F_h^{(k)}\right]\left[1 - L_h^{(k)}\right] \tag{4}$$

where $F_h^{(k)}$ is a distribution function of $S_{k,h}$ and $L_h^{(k)}$ represents the value of the Lorenz curve of $S_{k,h}$, calculated according to the form below:

$$\left[1 - L_h^{(k)}\right] = \frac{\sum_k S_k | S_k > S_h}{\sum_k S_k | S_k > S_1} \tag{5}$$

Having defined the deprivation of households as above, the poverty in dimension k (income or non-income) of a region is computed as an average of all households' poverty in that region

$$\text{Average poverty in region } r = AP_{k,r} = \frac{\sum_{h=1}^{n_r} P_{h,r}^{(k)}}{n_r} \tag{6}$$

where $P(k_{h,r})$ is the poverty measure of dimension k for the household h in region r, n_r is the number of households in region r. The average poverty in the region is computed for the analysis of poverty profile in six administrative regions in Vietnam (see Sect. 4.1)

2.2 Identification of Poverty-Prone Regions—Multilevel Models

To fight poverty with scarce resources, public spending on poverty-alleviation programs is directed to areas where the poverty rate is higher than others. However, the unavailability of dependable information on economic wellbeing at the local level is the main hindrance to spatial targeting. Data on welfare levels are traditionally derived from household surveys representative at the national level. These surveys are usually too small in size to disaggregate reliable measures of poverty at local levels. On the other hand, the population census data have a sufficient sample size but have limited welfare information that is required to estimate poverty directly. To overcome this problem, Ghosh and Rao (1994), Hentschel et al. (2000) and Elbers et al. (2002, 2003) proposed the approach of small area estimation (SAE); combining census data with household survey data, and employing estimations of households' expenditure or income from the latter to the former. The SAE method has been

utilized to develop poverty maps in some studies (Van der Weide et al. 2010; and Lanjouw et al. 2017 for Vietnam[6]); however, they are prone to a number of limitations. Firstly, such maps depend on individual-level analyses which do not take into account the hierarchical or clustered structure of household or census data, where the lowest level (households) are grouped within higher levels (communities, districts, provinces, regions).[7] As a result, the single-level studies violate the independence assumption of observations which generate underestimation of standard errors of regression coefficients, leading to an overstatement of statistical significance (Walsh 1947). Secondly, none of these studies is able show the relative importance of each level in an explanation of poverty. It may be difficult for policy makers to decide what sub-nation levels (for example, whether at province or community level) should be given priority over the other if the results from poverty maps show evidence supporting for spatial targeting of social programs.

The available data on Vietnam comprise a four-level hierarchical structure with households at level 1, nested within communes/villages at level 2, districts at level 3, and provinces at level 4 (Fig. 1 summarizes the hierarchical structure of the data). In this paper we utilize a multilevel exploration of the spatial nature of poverty that overcomes the shortcomings of prevalent single-level analyses, and is more efficient in poverty-alleviation strategies.[8]

Let P^k_{hcdp} be the measurement of the poverty dimension k for household h nested within communities c, which is further nested within districts d, and that is nested within province p using poverty measures defined by the Eq. (1) and (4) presented in Sect. 2.1.[9] Unlike the traditional linear regression model, here we suppose that the means of P are different in each hierarchical level. Moreover, we split the residual into 4 components that are equivalent to the 4 levels in the data, to examine the nature of between-level differences, which cannot be performed in the common linear regression models. We specify a series of following four-level random intercept models for poverty dimension k of household h in commune c, district d, province p:

$$\begin{aligned} P^k_{hcdp} &= \beta^k_0 + \beta^k X^k_{hcdp} + \left(u^k_p + v^k_{dp} + w^k_{cdp} + e^k_{hcdp}\right) \\ u^k_p &\sim N\left(0, \sigma^2_u\right),\ w^k_{cdp} \sim N\left(0, \sigma^2_w\right),\ e^k_{hcdp} \sim N\left(0, \sigma^2_e\right) \end{aligned} \tag{7}$$

Equation (7) estimates the outcome of dimension k, adjusted for a vector X'^k_{hcdp} of explanatory variables measured at the household level (see Sect. 3.3 for more details).

The parameter β^k_0 represents an overall mean of Y^k_{hcdp} (controlling for household characteristics) across all households in the sample. The mean of Y^k_{hcdp} for province p is $\beta^k_0 + u^k_p$ and so the random province effect u^k_p is the difference between province p's mean and the overall mean. Provinces with high values of u^k_p tend to have households with high values of

[6] For studies on other developing countries, see Amarasinghe et al. (2005), Carletto et al. (2007), Christiaensen et al. (2012), Demombynes et al. (2002) among others.

[7] Therefore, households from the same community (say, the minorities) can have a poverty status more similar to those in another area than to households from different communities, and the poverty status of households in the same community in the same district are more like another than they are like those households of the same community in a different district.

[8] We use STATA 15 software with the fully maximum likelihood (FML) method to obtain all parameter estimations. To show the gross heterogeneity across provinces, districts, and communes, and to examine which level(s) has the greatest impacts on poverty after controlling for household compositional effects, this study employs multilevel random intercept models.

[9] It ranges from 0 (*not at all poor*) to 1 (*totally poor*).

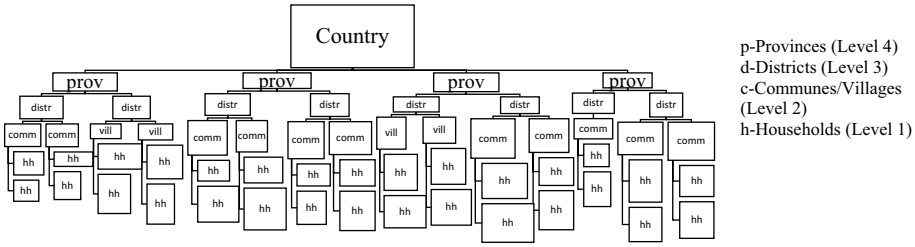


Fig. 1 Nesting structure of households within communes/villages within districts within provinces

poverty in dimension k. The mean of Y^k_{hcdp} for district d is $\beta^k_0 + u^k_p + v^k_{dp}$ and so the random district effect v^k_{dp} is the difference between district d's mean and province p's mean. Districts with high (low) values of v^k_{dp} tend to have households with high (low) values of poverty in dimension k, relative to households from other districts belonging to the same province. The mean of Y^k_{hcdp} for commune c is $\beta^k_0 + u^k_p + v^k_{dp} + w^k_{cdp}$ and so the random commune effect w^k_{cdp} is the difference between commune c's mean and district d's mean. Communes with high values of w^k_{cdp} have a high value of dimension k or vice versa. The observed Y^k_{hcdp} for household h is $\beta^k_0 + \left(u^k_p + v^k_{dp} + w^k_{cdp} + e^k_{hcdp}\right)$ and so e^k_{hcdp} is the difference between household h's observed measurements and commune c's mean. The random effects and residual errors in the random part of the model are assumed to be independent of the vector of predictor variables and normally distributed with a mean of zero; the variances between-province $\left(\sigma^2_u\right)$, between-district (σ^2_v), between-commune/village $\left(\sigma^2_w\right)$, and between-household (σ^2_e), having adjusted for the predictor variables, describe the part of the outcome variation which is unexplained by the explanatory variables.

2.2.1 Variance Partitioning at Household, Commune, District, and Province Levels

Based on the variance estimates of random effects, we calculate variance partition coefficients (VPCs), which describe the percentage of variance in Y^k_{hcdp} that is attributed to each level (Goldstein et al. 2002). It may be noted that the total variance in a poverty dimension for household h is the sum of the four separate variance components:

$$var\left(Y^k_{hcdp}\right) = \sigma^2_u + \sigma^2_v + \sigma^2_w + \sigma^2_e \tag{8}$$

and the VPC for each level is calculated as the ratio of that level's variance to the total variance. Thus, the province-level VPC is:

$$VPC_u = \frac{\sigma^2_u}{\sigma^2_u + \sigma^2_v + \sigma^2_w + \sigma^2_e} \tag{9}$$

while the district-level VPC is:

$$VPC_v = \frac{\sigma_v^2}{\sigma_u^2 + \sigma_v^2 + \sigma_w^2 + \sigma_e^2} \tag{10}$$

the commune-level VPC is:

$$VPC_w = \frac{\sigma_w^2}{\sigma_u^2 + \sigma_v^2 + \sigma_w^2 + \sigma_e^2} \tag{11}$$

and the household-level VPC is:

$$VPC_e = \frac{\sigma_e^2}{\sigma_u^2 + \sigma_v^2 + \sigma_w^2 + \sigma_e^2} \tag{12}$$

VPCs allow us to establish the relative importance of provinces, districts, communes and households as sources of variation in households' poverty. VPCs evaluate the percentage of outcome variation unexplained by the observed household variables that is attributable to each level. The higher the VPC, the larger is the impact of that level (for example the province) on the deprivation of households.

In the next section, based on the models of Eq. (7), the extent of poverty at various administrative levels in multiple dimensions is estimated by a maximum likelihood method using following two steps:

Step 1: Models containing household-level variables, allowing for the varying intercepts, are specified so as to inspect whether measurements of different dimensions of poverty vary by higher administrative level. Then variance estimates and VPCs are obtained from the models by applying Eqs. (9)–(12).

Step 2: Maps are created that allow us to recognize areas of high poverty concentration in the country. We apply the Empirical Bayes (EB) estimates (posterior estimates) to obtain predictions of random errors at each level after fitting the multilevel models. We then rank the residuals of each level together at 95% confidence intervals. These residuals symbolise the administrative levels' (for example, province) departures from the overall mean predicted by β_0^k.

Hence a province whose confidence interval of residual does not overlap the mean poverty value across all provinces is deemed significantly different from the average at the 5 percent level. The procedure proposed by Goldstein and Healy (1995) to assess the province effect is:

$$\text{(province-specific residual} \pm 1.96 \times \text{standard deviation of the residual)} \tag{13}$$

Provinces with the upper bound calculated by Eq. (13) greater than zero were classified as "good" provinces in the *k*th dimension. In other words, poverty levels in good provinces, after controlling for household traits, are significantly below the overall level of poverty for the whole country (which is the average for the provincial poverty). On the other hand, provinces with the lower bound greater than zero were classified as "bad" provinces. This means that in these provinces the levels of poverty are very high. Even the variation of provincial macro traits in these provinces cannot significantly reduce poverty. Provinces with residuals within the 95% coverage bounds of the overall province average were classified as "medium" provinces. In other words, poverty in the medium provinces is not significantly different from the average poverty for the whole country after considering both household traits and provincial variations.

3 Data and Choice of Dimensions

3.1 Data and Sample Size

The Vietnam Housing Living Standard Survey (VHLSS) is conducted by the General Statistics Office (GSO) with technical support from the World Bank since 1993. This is a comprehensive survey that is representative of the whole country, the region, urban, rural and province levels. The household survey covers detailed information on various aspects of living standards; household demographics and household-level income, expenditure, housing conditions, ownership of durables, as well as the health, education and employment of the household members, and participation in government programs. Although the VHLSS is not the only large scale survey in the country, other surveys rarely report the expenditure or income required to measure poverty directly. This paper uses the current wave of VHLSS conducted nationwide in 2014. It covers 9399 households nested within 3132 communes and wards, 698 districts, and 63 provinces. The largest city, Hanoi, comprises 420 households, 140 communes, and 30 districts.

3.2 Dimensions of Poverty Considered

Income and six non-income dimensions are considered in this study. To measure income poverty, the equivalised household income is used by applying the modified OECD scale.[10] Total household income from all sources is included.[11] For non-income dimensions, based on the available information in the 2014 VHLSS, we select 19 indicators grouped into six dimensions: education, health, housing, durable assets, basic services, and economic status. A detailed list of the indicators is provided in Table 1.

3.2.1 Education

It has been determined in various welfare research studies that education level has significant effects on poverty reduction (see, for example, Alkire 2007; Alkire and Santos 2014; Santos et al. 2015). A number of previous studies in Vietnam report that there is high overlap between chronic income poverty and out-of-school primary school-age children (Roelen et al. 2010; Baulch and Masset 2003). Therefore, based on the Sustainable Development Goals (SDGs; also called Global Goals for Sustainable Development) on education, we include two indicators to identify the education dimension: average schooling achievement of adult members, and school attendance of the children.

3.2.2 Health

The SDGs argue that ensuring healthy lives is vital for sustainable development. Van Doorslaer et al. (2006) and Van Minh et al. (2013) find that more than 60% of health care payments in Vietnam are paid as out-of-pocket expenses by households, and this possibly leads to impoverishment. Therefore, health is an important measure of poverty. To

[10] 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.

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

Table 1 Description of dimensions used for the computation of poverty

Dimensions	Indicators	Description	Type of indicator	Computed weight
Income		Equivalised income	Continuous	
Non-monetary				
Education	Schooling achievement of adult (15 years and above) members	Average level of education of household: No diploma (1) Primary school (2) Lower secondary school (3) Upper secondary school (4) College (5) Bachelor degree (6) Higher education degree (7)	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
Housing	Condition roof	Roof material: Straw, canvas, tar paper (1) Panels/Galvanized iron (2) Tile (3) Concrete, cement (4)	Order	0.48
	Condition wall	Wall materials: Branches/bamboo (1) Calcareous earth/straw (2) Wood/galvanized iron (3) Fired brick, stone (4) Concrete (5)	Order	0.52

Table 1 (continued)

Dimensions	Indicators	Description	Type of indicator	Computed weight
Basic services	Water	Main water drinking supply: Rainwater (1) Unprotected spring sources (2) Protected spring sources (3) Hand-dug, non-reinforced and uncovered wells (4) Hand-dug and covered wells (5) Deep drill wells (6) Public tap water (7) Private tap water inside the house (8)	Order	0.10
	Sanitation	Households with some of the following: No toilet (1) Toilet directly over the water (2) Double vault compose latrine (3) Squat toilet (4) Flush toilet with septic tank/sewage pipes (5)	Order	0.13
	Energy	Main source of lighting/cooking: Candle/other (1) Kerosene/gas (2) Battery/diesel engine (3) Electricity (4)	Order	0.76
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 1 (continued)

Dimensions	Indicators	Description	Type of indicator	Computed weight
Economic status	Food	Household whose own judgment on their consumption of food over the last 30 days was insufficient to meet members' needs	Dichotomous	0.18
	Foodstuff[a]	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

[a]While "food" includes agricultural products, "foodstuff" includes other food items

maximize the available information in the VHLSS 2014, and to follow the targets of the SDG on health,[12] this study encompasses two indicators in the health dimension. The first indicator determines a household as deprived in health if the family could not afford to cover all necessary health care expenses for any household member who was sick in the last 12 months. The second indicator determines a household as poor in the health dimension if there is at least one household member who does not participate in public health insurance or have a free health care certificate.

3.2.3 Housing and Basic Services

Housing and accessibility to basic services are used in numerous poverty analyses and comprise an important part of minimum cost-of-living (for example, Fiadzo et al. 2001; Battiston et al. 2013; Santos et al. 2015). In Vietnam, a number of studies have concluded that quality of housing and basic services has statistically significant effects on the probability that a household is poor (Minot 2000; Dasgupta et al. 2005; Baulch and Dat 2010). We include conditions of roof and wall as two ordered indicators to define the housing dimension. In basic services there are three indicators that are also recognized as important in the SDGs: clean water, improved sanitation, and cooking fuel.

3.2.4 Durable Assets

Diverse studies consider ownership of a radio, television, telephone, and motorbike or bicycle as indicators of poverty (see, among others, for Vietnam: Baulch and Masset 2003; Baulch and Dat 2010; Minot 2000; for Africa: Sahn and Stifel 2000; Heltberg and Tarp 2002; for Mozambique: Stifel and Christiaensen 2007). In our study, a household is deprived in durable assets when it does not have any one of the goods from the list.

3.2.5 Economic Status

Martinetti (2000) claims that the inclusion of the subjective indicator of well-being does not substitute but complements our judgment and allows us to compare the findings developed from a combination of subjective and objective assessment criteria. The economic status dimension, hence, is defined by seven indicators that take into account a subjective perception on a household's own condition or assessment by the household head, about the level of contentment concerning sufficient consumption of essential goods such as food, water, electricity, housing, clothes and footwear. In addition, we include the households' savings ability.

3.3 Household Level Variables

The socio-economic characteristics of households are selected to connect the seven dimensions of poverty. These are also the most used determinants in previous studies on poverty in Vietnam (Arouri et al. 2015; Dasgupta et al. 2005; Imai et al. 2015; Lanjouw et al. 2017;

[12] One of the targets of the SDG on health is "Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all".

Paul et al. 2002, among others) as well as in studies on other developed countries (see Azeem et al. 2016; Brady and Kall 2008; Brady et al. 2009; Chen and Wang 2015; Kim et al. 2010). Table 2 provides a list and description of these variables.

4 Results of Empirical Analysis and Discussions

4.1 Pattern of Average Regional Poverty in Vietnam in Different Dimensions

Table 3 shows the average degrees of poverty in seven dimensions for the whole country, urban and rural, and for the six administrative regions, using the Eq. (1) for income dimension and the Eq. (4) for non-income dimensions. At the country level, no significant disparity is observed in the income and non-income dimensions except in housing and education. It is perceived that while the lower degrees of deprivation in most non-income dimensions move in line with the higher average levels of income, deprivation rates in health move in the opposite direction. This suggests that the most deprived households in the income dimension may not be the poorest in health. The government projects that relate to financing and health insurance, the Social Health Insurance and the Population Coverage Rate (introduced in 1992) have made outstanding achievements in health financing. By June 2010, 62% of the population had health insurance, with the objective of 80% of Vietnamese being insured by 2020 (Van Tien et al. 2011).[13] The estimation presented in Table 3 shows the relative consistency of ranking between our income poverty measure and the headcount poverty ratio based on official statistics in six regions of the country. While the South East and the Red River Delta regions are least poor, the Midlands and Northern Mountains, where the majority of Vietnam's ethnic minorities reside, have the highest income poverty.[14]

However, when looking more closely at the figures for each non-income dimension in the last 6 columns of Table 3, it can be observed that differences across regions are substantial. The South East region experiences the lowest income poverty (0.24) but health poverty (0.13) in this region is greater than that of the Central Highlands (0.12) where income poverty (0.46) is nearly twice that of the South East. The region of the Red River Delta has the lowest degrees of deprivation in the education, housing, and economic status dimensions (0.17, 0.05, and 0.05, respectively). However, this region has the highest population in the country (more than 20 million) and has the worst situation in health poverty. It is worth noting that the capital of the country, Ha Noi City, is located in this region, which has 50 thousand immigrants arriving every year (GSO, 2014). Since the informal sector of the labour market is excluded from the benefit of health care insurance, more than 37% of the Red River Delta's citizens are not eligible for any health care insurance or free health care programs (as calculated from VHLSS, 2014 data).

In contrast, the Midlands and Northern Mountains region experiences the highest poverty values in health, basic services and economic status. However, compared to other regions, health poverty here is moderate. The Midlands and Northern Mountains is the

[13] In 2009 the Government of Vietnam passed the Health Insurance Law, which offers up to 100% subsidies on health insurance premiums for the very poor, ethnic minorities, the elderly, and all children under 6 years of age.

[14] The results in the previous studies show that poverty rates are lowest in the regions of Red River and Mekong deltas; the Midlands and Northern Mountains region has the highest poverty rates in the income dimension (see among others, Lanjouw et al. 2017; Cuong 2009; Baulch and Dat 2010).

Table 2 Various socio-economic variables used for the estimations of different dimensions of poverty in multilevel models

Variable names	Description	Type of variable
Age	Age of household head	Continuous
Minority	Ethnicity of household head	1: Minorities; 0: Kinh
Female	Gender of household head	0: male; 1: female
Urban	Residency of household	0: Rural 1: Urban
noMale	No. of male in household	Discrete
noFemale	No. of female in household	Discrete
noKid04	Number of kids below 5 in household	Discrete
avgeduMale	Average education of males in household	Continuous
avgeduFemale	Average education of females in household	Continuous
Migrant household	Households from which former members have migrated (moved to a different place from their place of residence)	1: Migrated household; 0: non-migrated
Percentage job 1	Percentage of wage/salary employment	Proportion
Percentage job 2	Percentage of self-employment in agriculture, forestry, aquaculture	Proportion
Percentage job 3	Percentage of non-farm activities (self-engagement in production, business, services outside agriculture, forestry, aquaculture)	Proportion

region that lags behind and cannot participate in the growth process of the country because of its undeveloped infrastructure and disadvantaged physical environments (such as poor soils, deforestation and environmental degradation).[15] It can be noted that the Health Insurance Law of the Government contributes significantly towards a reduction in the deprivation level of health in the Midlands and Northern Mountains region due to that area having the highest number of ethnic minorities.

4.2 Multilevel Analyses: Magnitude of Various Dimensions of Poverty at Different Administrative Levels

4.2.1 Influence of Household Characteristics

To determine the influence of household level variables prompting various dimensions of poverty we use a multilevel regression model. We include household characteristics variables to the random intercept models, which allow intercepts to vary across higher levels (as discussed in Sect. 2.2). Table 4 shows the results of separate random intercept models for seven dimensions of poverty.[16]

[15] See Glewwe et al. (2004), and Rambo and Lê (1996).

[16] The results reported here are from the *best* models based on the Akaike Information criterion (AIC) (see Goldstein, 2011). The likelihood ratio test was used to test whether a multilevel model is preferred to a single-level model. We provide the results in Table 9 in the Appendix. Our tests show that the random effects and residual errors in the random part of the model are independent of the vector of predictor variables and approximately normally distributed. A sample of test results are provided in Appendix Table 8.

Table 3 Extent of income and non-income poverty in Vietnam—urban rural and 6 regions

	Number house-holds	Average income (1,000VND)	Poverty head-count ratio[a] (%)	Income poverty (P_h)	Non-income poverty ($P_h^{(k)}$)					
					Education	Health	Housing	Basic service	Asset	Economic status
Vietnam	9399	109,049.5	8.4	0.42	0.31	0.16	0.28	0.32	0.15	0.10
Urban	2781	153,865	3.0	0.24	0.21	0.15	0.21	0.10	0.20	0.06
Rural	6618	75,224.04	10.8	0.50	0.35	0.17	0.31	0.41	0.14	0.12
Red River delta	1992	123,947.8	4.0	0.34	0.17	0.21	0.05	0.22	0.15	0.05
Midlands and Northern Mountains	1662	82,312.01	18.4	0.56	0.34	0.18	0.41	0.51	0.12	0.20
Northern and Coastal Central	2067	96,892.3	11.8	0.46	0.28	0.15	0.17	0.29	0.14	0.10
Central Highlands	651	102,699.5	13.8	0.46	0.38	0.12	0.36	0.43	0.13	0.14
South East	1122	152,629.9	1.0	0.24	0.28	0.13	0.29	0.13	0.18	0.07
Mekong River delta	1905	106,491.1	7.9	0.43	0.45	0.15	0.50	0.35	0.20	0.08

[a]The poverty head count ratio is identified according to the Government of Vietnam's poverty line for 2011–2015 (1000VND/person/month): 630 for rural areas and 780 for urban areas. Source for this column is GSO (2014)

Table 4 Estimates of the influences of household traits in different dimensions of poverty: multilevel models (VHLSS 2014)

Variables	Dimensions						
	Income	Education	Health	Housing	Basic services	Durable asset	Economic status
Age	0.000**	0.001***	−0.001***	−0.001***	−0.001***	0.004***	−0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	0.018***	0.002	−0.001	0.011*	0.014**	−0.008	0.007
	(0.006)	(0.004)	(0.006)	(0.006)	(0.006)	(0.008)	(0.007)
Minority	0.158***	0.066***	−0.102***	0.151***	0.147***	0.067***	0.105***
	(0.009)	(0.006)	(0.008)	(0.009)	(0.009)	(0.010)	(0.011)
Urban	−0.066***	0.008*	0.001	−0.042***	−0.135***	0.034***	−0.022**
	(0.007)	(0.005)	(0.007)	(0.008)	(0.008)	(0.009)	(0.009)
noMale	−0.010***	−0.005**	0.021***	−0.003	0.003	−0.025***	0.002
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
noFemale	−0.009***	0.000	0.016***	−0.009***	−0.002	−0.013***	−0.005*
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
nokid04	0.017***	−0.017***	0.018***	0.005	0.010**	0.000	0.017***
	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
avgeduMale	−0.064***	−0.137***	−0.012***	−0.021***	−0.030***	0.004	−0.023***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
avgeduFemale	−0.040***	−0.074***	−0.005*	−0.022***	−0.028***	−0.001	−0.016***
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Percentage job 1	−0.103***	0.052***	−0.000	0.038***	0.034***	−0.062***	0.020*
	(0.009)	(0.006)	(0.009)	(0.009)	(0.009)	(0.011)	(0.011)
Percentage job 2	0.059***	−0.010*	0.028***	0.010	0.113***	−0.076***	−0.002
	(0.009)	(0.006)	(0.008)	(0.008)	(0.008)	(0.010)	(0.010)
Percentage job 3	−0.208***	−0.036***	0.054***	−0.032***	−0.070***	−0.008	−0.028**
	(0.011)	(0.007)	(0.010)	(0.010)	(0.010)	(0.013)	(0.012)
Migration	−0.032***	−0.004	−0.001	−0.018***	−0.003	−0.016**	−0.008
	(0.006)	(0.004)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Constant	0.731***	0.850***	0.200***	0.452***	0.487***	0.027	0.233***
	(0.018)	(0.012)	(0.017)	(0.025)	(0.019)	(0.020)	(0.020)

Table 4 (continued)

Variables	Dimensions						
	Income	Education	Health	Housing	Basic services	Durable asset	Economic status
AIC	646.2753	−9081.125	−2502.607	−2450.439	−2389.851	1238.07	646.2753

In Eq. (7), $\beta_0^k + \beta^k X_{hcdp}^k$ is the fixed part of the model and $\left(u_p^k + v_{dp}^k + w_{cdp}^k + e_{hcdp}^k\right)$ is the random part with random parameters $\sigma_u^2, \sigma_v^2, \sigma_w^2$, and σ_e^2. The fixed part of the model denotes the overall mean relationship between the outcome and the explanatory variables; that is, the relationship that uses in the average province. The random part of the model specifies how the province, district, and commune-specific relationships differ from this overall mean relationship. Table 4 presents the estimates of the fixed effects

Standard errors in parentheses

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

In general, most explanatory variables are statistically significant and have expected signs. For example, ethnic minority households have significantly higher rates of deprivation in all dimensions compared to their non-minority counterparts, except in the health dimension. The estimated coefficient for ethnic minority households has a 10.2% lower health deprivation level than the ethnic majority citizens. This is possibly the effect of government policies and programs that have been in place to assist the ethnic minorities in health insurance since 2005. According to a report from the Ministry of Finance, during the period 2012–2014 an annual average of VND12500 billion (USD 545.8 million) was spent to support ethnic minorities, students and children under 6 years of age by providing free health insurance cards.

The results also reveal that, as expected, higher average education levels (for both males and females) have significant effect in lowering deprivation rates in most dimensions. These results are consistent with numerous previous studies on the positive effects of education on reducing poverty.[17] Furthermore, the rates of deprivation in almost all dimensions are significantly lower for households with higher proportion of members working in non-farm activities. Households with older heads have a lower deprivation level in the health, housing, basic services, and economic status dimensions, but suffer from higher deprivation rates in income, education, and durable assets. The findings shown in Table 4 affirm the complex nature of poverty in Vietnam and highlight the necessity of targeting poverty beyond the current approach based on income deprivation alone.

4.2.2 Partitioning Variation at Higher Administrative Levels

Figure 2 presents VPCs in seven dimensions of poverty attributable to each administrative level after controlling for specific household characteristics. The VPCs in these models enable us to establish the relative importance of provinces, districts, communes/villages and households in explaining the variation in households' deprivation in different dimensions of poverty. In general, as observed in Fig. 2, household level accounts for the highest per cent of the total variation in deprivation rates. This suggests that household characteristics in Vietnam play a crucial role in explaining the income and non-income poverty status of households. However, nearly 15% VPCs in the higher levels indicate that households from the same higher administrative area are significantly more alike than housholds from different areas. Therefore, the impact of province, district, commune/village levels is also an important clustering factor on the level of deprivation in all dimensions.

Specifically, while the VPCs of the housing and basic services dimensions report the highest values at higher administrative levels, the VPCs of the health, education and asset dimensions have the lowest values at these levels. For example, after controlling for household characteristics we observe that more than 50% of the total unexplained variation in housing deprivation is above the household level. Especially in this dimension the province level has a VPC value of 0.346,[18] showing that the province level plays an important role in explaining the variance of housing poverty. As far as the asset dimension is concerned, 13.4% of the variation in deprivation is explained by factors at commune, district,

[17] See, for example, in Romania (Mihai et al. 2015), in South Sudan (Shimeles and Verdier-Chouchane 2016), and in Vietnam (Klasen et al. 2015; Gloede et al. 2015).

[18] $\left(\frac{\sigma_u^2}{\sigma_u^2+\sigma_v^2+\sigma_w^2+\sigma_\varepsilon^2} = \frac{0.025}{(0.025+0.007+0.006+0.034)} = 0.364\right)$. Table 10 in the Appendix provides the crude values of all variations. These are the ingredients of the computation of VPCs presented in Fig. 2.

and province levels. These high values of VPCs confirm the necessity of using a multilevel approach in analysing poverty in Vietnam. Our results indicate that the contextual factors of province, district, and commune/village should be taken into account in future poverty studies in Vietnam. Detailed analysis of contextual factors is beyond the scope of this study; however, our findings show the presence of gross significant heterogeneity across administration levels. This highlights the drawbacks of the current poverty-alleviation programs by the government which rely solely on targeting administrative areas on the basis of a single-level observation (i.e. head count of household income poverty).

4.2.3 Maps of Poverty in Vietnam Based on Multilevel Analysis

Having observed the significant variation of poverty at higher levels (particularly at the province level), this section aims to classify the provinces of Vietnam on the basis of varying intensity of poverty. Using the predictions of the random effects (errors of province, district, commune, and household levels) of our model, we examine the contribution of unobserved contextual effects of the poverty status of the household. Unlike previous well-being studies in Vietnam, our empirical findings are derived from a multilevel model which simultaneously takes into account the effects of both the household level factors and the between administrative area (mainly province) variability of poverty. We present in Fig. 3 the maps for each poverty dimension, clearly distinguishing the bad, medium, and good provinces (following the method we discussed in Sect. 2.2) as obtained from the multilevel models (see right panel of Fig. 3). The numbers within the maps represent ranking of the provinces in seven dimensions of poverty. The province ranking is further discussed in the Sect. 4.3.1.

These maps reveal some interesting facts. Firstly, there is no province which is classified as *good* across all dimensions. Secondly, provinces identified as *bad* in the income dimension are not necessarily determined as *bad* in non-income dimensions. This demonstrates that current poverty-alleviation programs in Vietnam, which are based on a unidimensional approach, may lead to inappropriate decision-making and mal-utilization of scarce resources. Our results from a multilevel analysis reveal significant implications that should encourage province authorities to focus on certain other aspects of poverty. For example, quite a few provinces in the south are *good* in terms of the income dimension, but *bad* in terms of education or housing. Thus, the local government in these provinces, while designing policies and programs to reduce poverty, need to improve the deprivation levels in education and housing.

The Ministry of Labour, Invalids and Social Affairs (MOLISA) has prime accountability for the redistribution of funds for social support programs to the poor in Vietnam. MOLISA has applied a "bottom-up" approach that produces a list of poor households, which is aggregated up to village/commune level and then to district and province levels. It is challenging to ensure consistent exercise of those criteria in the field when applying different guidelines and standards in collecting data by different provinces (Conway 2001). Moreover, it has also been claimed that the list of poor households based on MOLISA's approach is relatively arbitrary and fails to properly determine the majority of the poor (Baulch and Minot 2002; Nguyen and Tran 2014). This results in limited efficiency in poverty-alleviation programs based on the list from MOLISA (Walle 2002; Minot and Baulch 2004). Our identification of provinces according to incidence and severity of household poverty provides useful indications to enhance the effectiveness of dissemination of poverty-alleviation funds.

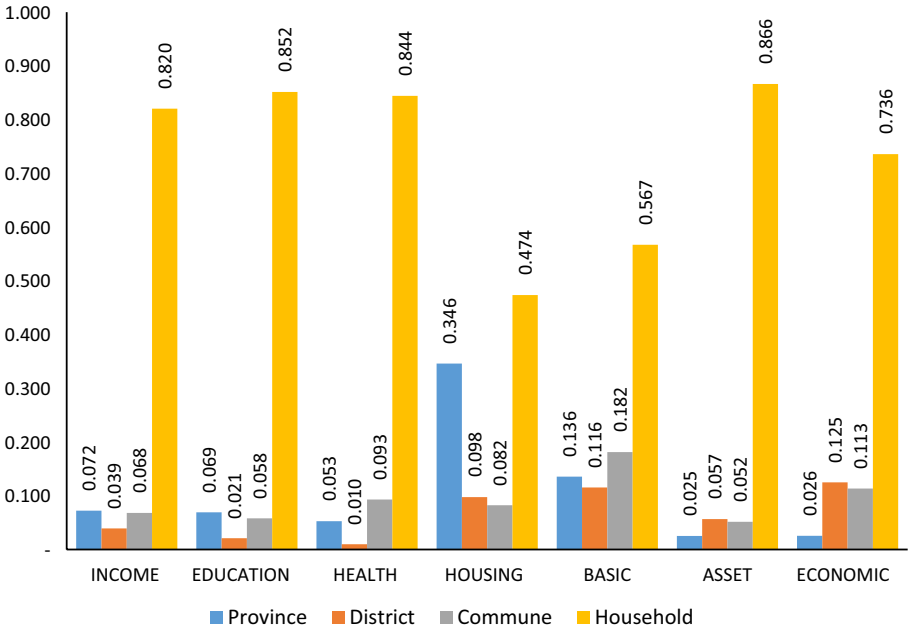


Fig. 2 Variance partitioning in various levels in dimensions of poverty

Figure 3 shows a clear difference in distribution of bad and good provinces in income and non-income dimensions between Northern and Southern Vietnam. In the income and health dimensions, while bad provinces are only located in Northern Vietnam (Red River Delta, Midlands and Northern Mountains, and Northern and Coastal Central regions), the majority of good provinces are located in South Vietnam (Central Highlands, South East, and Mekong River Delta regions). However, the scenario is reversed in the education and housing dimensions where most good provinces belong to North Vietnam and a greater number of bad provinces are situated in South Vietnam.

According to GSO (2014), the highest poverty rates[19] in the country prevail particularly in three regions: Midlands and Northern Mountains (18.4), Central Highlands (13.8), and the Northern and Coastal Central region (11.8) (see Table 3). It is also interesting to observe that while the official poverty rates in the Midlands and Northern Mountains region are nearly twice the rates experienced in Northern and Coastal Central, the latter region having the greater number of bad provinces in the income dimension. Also, in the Central Highlands region, which is the second poorest in the country (according to GSO 2014), not one province shows as bad in our income measure of poverty. This discrepancy in the results is a manifestation of the between-province variation that has been mostly neglected in previous studies.

The Vietnam Government's perspective towards poverty reduction policies has experienced transmutations during the process of socio-economic development. In the beginning of "Doi Moi" (1986–2000) the government prioritized hunger eradication and poverty

[19] The Vietnam Government's poverty lines for 2014 were updated by CPI as 605 and 750 thousand VNDs per capita per month for the rural and urban areas respectively (GSO 2016).

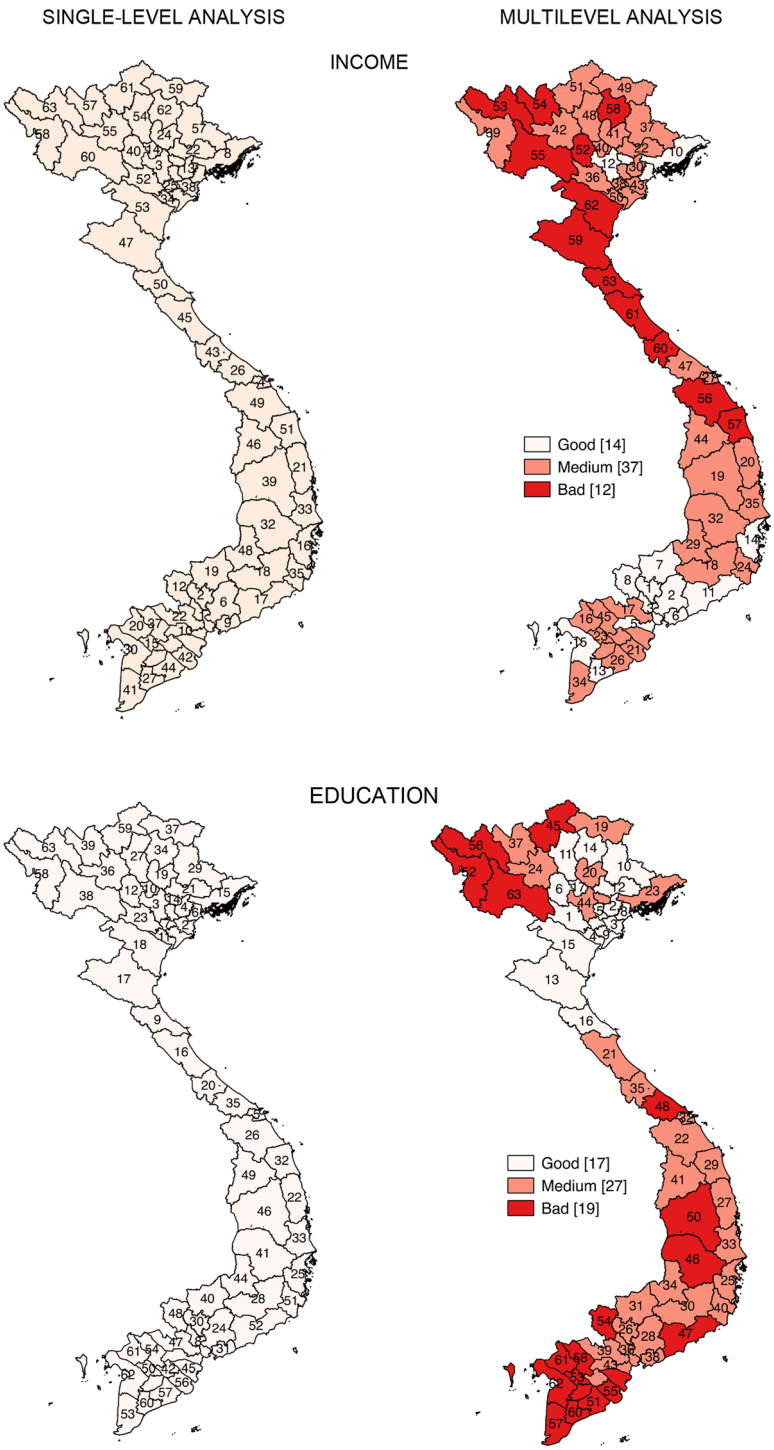


Fig. 3 Maps of provincial poverty (various dimensions)—single-level versus multilevel analyses

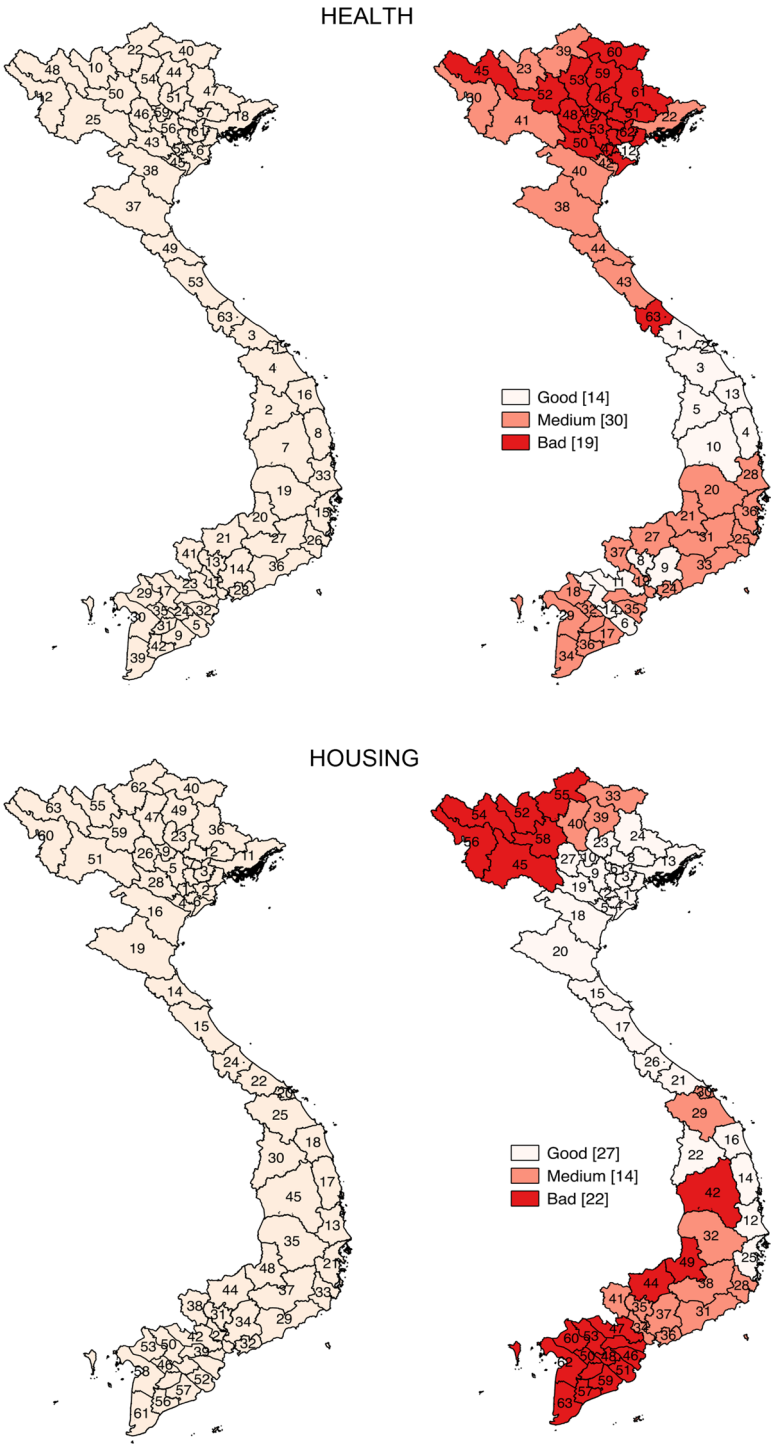
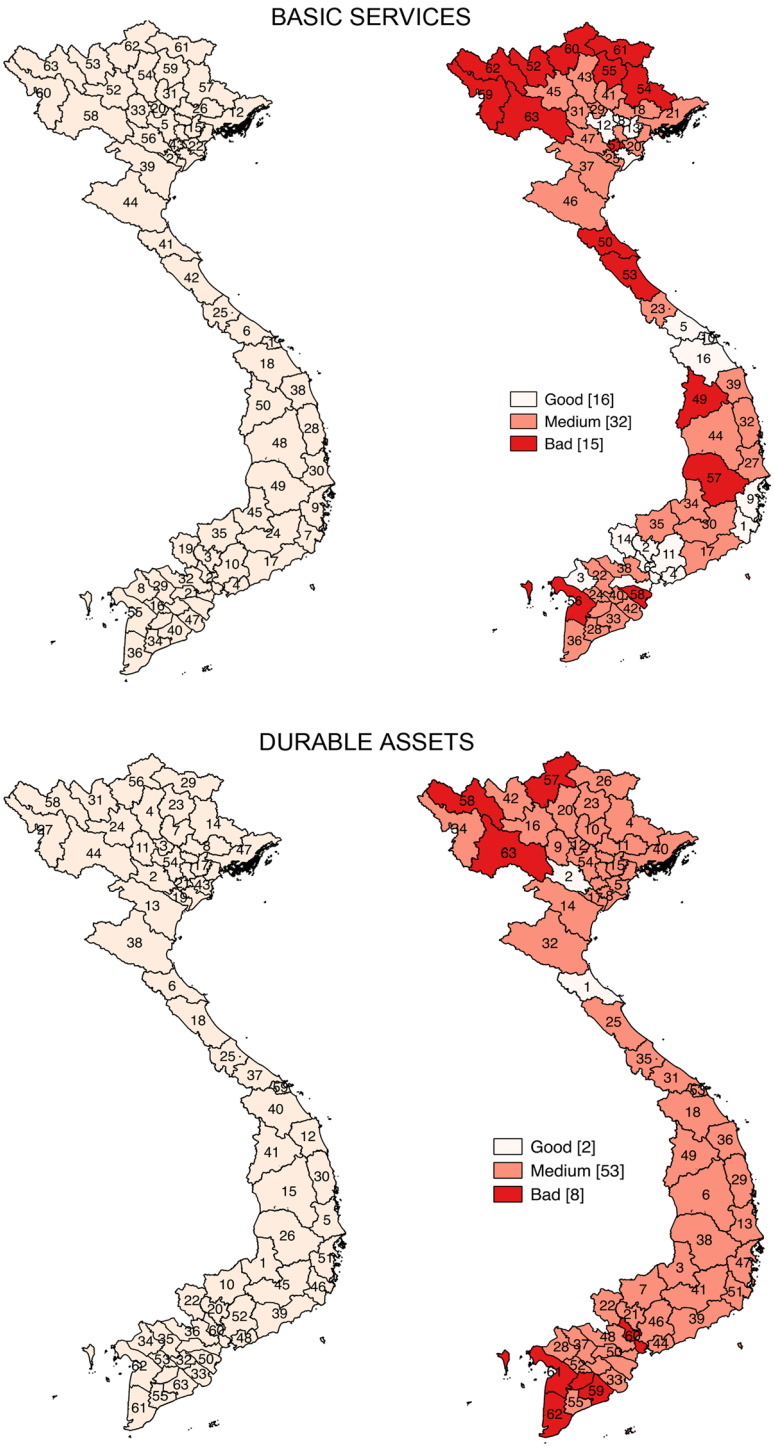


Fig. 3 (continued)



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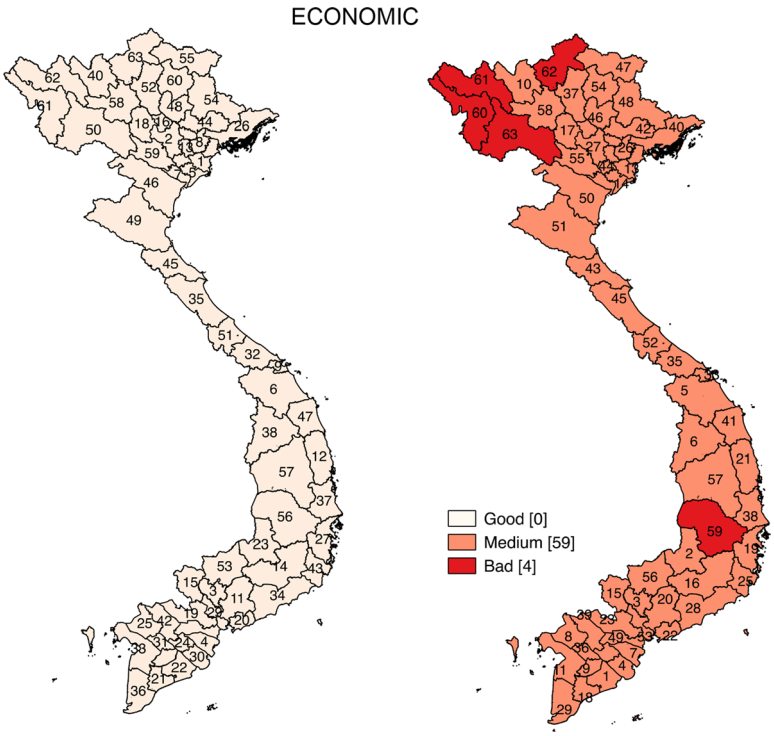

Fig. 3 (continued)

reduction, in 2000–2015 poverty policies were extended to support access to health services, education, housing, and clean water for the poor. Since MOLISA's list of poor households that are eligible for specific social support programs (such as education or health insurance) is based on the income approach, the majority of the beneficiaries reside in those regions where income poverty rates are highest. Thus, many households that are detected as non-income poor in our analysis are not considered by the Department as eligible for social support programs.[20],[21]

While at the household level, there is a low likelihood of a "minority" household having high levels of health poverty (as seen in Table 4), the multilevel analyses maps in Fig. 3

[20] Public social support programs include: health insurance support; exemption and reduction of 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).

[21] In this context, it is worth noting that the largest ethnic minority populations who are considered the poorest in the country reside in the poorest regions of the country (GSO 2014). Since 2005, the government has implemented policies to support poor households and ethnic minorities in sustainable poverty reduction. According to the VHLSS 2014, nearly 70 % of the beneficiaries of social support programs are in the three poorest regions. According to MOLISA (2016), on an annual average, the total state budget in the period 2012–2014 allocated for social support programs reached nearly VND 25,500 billion, including health care for the poor (VND12,500 billion); education, training and vocational training for the poor (nearly VND12,000 billion); accommodation support, clean water and electricity provision (VND,000 billion). Although these programs contribute to notable achievements in poverty reduction of the country, our findings indicate obvious drawbacks in monitoring and evaluating poverty.

show that the regions of Red River Delta and Midlands and Northern Mountains are the worst performers in terms of the health dimension. The latter region has the highest population of ethnic minorities. This implies that ethnic minorities living in the Red River Delta or Midlands and Northern Mountains regions experience higher levels of deprivation in health than households with same background living in the other regions. Even if the households in this region are eligible for free health care certificates according to MOLISA's approach, the provision is insufficient. Nearly 70% of ethnic minority households who, based on the VHLSS 2014, are eligible for health insurance or free health care certificates were unable to cover their health care expenses. In these regions the average distance from communes where minorities live to the nearest health care facilities is greatest compared to the other regions in the country. This necessitates an additional amount in total health care expenses for the poor in the Midlands and Northern Mountains region, which points to an important implication that not only household characteristics but also contextual factors are vital in evaluating health poverty.[22]

We note in Fig. 2 that variability in some dimensions at the commune level is substantial. Since maps of district and commune levels could not be created due to a lack of information, Table 5 presents a cross-tabulation of commune/village- versus province-level poverty in seven dimensions to analyse the clustering of good, medium, and bad communes. We observe that it is rare for a bad commune to be nested within a good province as well as a good commune to be nested within a bad province. It is often the case that a bad commune is nested within a bad province, and a good commune in good province. Of seven poverty dimensions, only the housing and basic services dimensions have bad communes nested in good provinces: in the case of housing, there are 73 good communes clustered in bad provinces and 66 bad communes clustered in good provinces; while in the case of basic services, there are 48 communes clustered in bad provinces and 10 bad communes clustered in good provinces. This finding clearly indicates the complexities in housing and basic services poverty in Vietnam (a similar observation is made in Fig. 2). We note also that income, education, durable assets and economic factors of poverty are less complexly clustered at the hierarchical levels.

[22] We also note that the government does provide ad hoc support on the basis of regional characteristics. For example, households in the Northern and Coastal Central regions are more likely to be affected by natural disasters than the households in other regions. The proportion of households affected by storms, typhoons, floods and flash floods is highest in these regions (Bui et al. 2014, and Chaudhry and Ruysschaert 2007). During the period 2012–2014, more than 500,000 poor households of this region were supported in housing and building houses to respond to floods and flash floods. The highest percentage of households benefiting from the housing support programs to this region might be one reason that the provinces of this region present significantly lower levels of deprivation in the housing dimension than the overall average. Although ethnic minorities have higher levels of housing deprivation than the ethnic "majorities", the former living in the Northern and Coastal Central region may be better off in the housing dimension than households living in other regions.

4.3 Targeting Provinces for Ameliorating Poverty—Single Versus Multilevel Analysis

4.3.1 Traditional Single-Level Analysis Versus the Multilevel Analysis—Variations in Poverty Ranking of Provinces

As we observe above, the target provinces for controlling poverty as determined by our multilevel analysis are different from those obtained from the traditional single-level analysis. In this section we further refine our identification of provinces that need prime attention for poverty alleviation.

In Appendix Table 11, computed values of poverty are presented without considering the effects of variation at the higher (commune/district/province) levels. These poverty values depend solely on household traits, which is the traditional method utilized in Vietnam (on income poverty only) for targeting areas for financial support in eradicating poverty. We rank the provinces from best (rank 1 for least poverty) to worst (province with the greatest poverty ranks 63) and present them in the left panel of Fig. 3 and in Table 12 in the Appendix. In the right panel of Fig. 3, the provinces are marked by rank according to the predictions of the random effects (province errors) of multilevel models, which constitute the contribution of unobserved contextual factors to the level of deprivation, controlled for differences in the characteristics of households. Thus, Fig. 3 (and Table 12) presents the poverty ranking from both methods in seven poverty dimensions. For each dimension, the province level residual, u_p^k of dimension k for province p is predicted after the models are fitted. The predictions and their standard errors are yielded by using the Empirical Bayes (EB) method. We then rank the predicted errors (or residuals) of each level together with 95% confidence intervals. These residuals symbolise the province level departure from the overall mean predicted by the β_0^k. A province with negative (positive) predictions of residuals is likely to have households whose measurements of deprivation are below (above) the population mean. A detailed diagram of the estimation for ranking is presented in the Appendix (Fig. 5).

A clear difference can be seen in the ranking of provinces between the two approaches, especially in the income, health, and basic services dimensions. In the right panel of Fig. 3 (using a multilevel analysis), all the "bad" provinces with the highest values in income poverty are located in the Midlands and Northern Mountains region. However, the distribution of the worst provinces in terms of a single-level study are less concentrated in the Midlands and Northern Mountains and the Northern and Coastal Central regions. In the health dimension, provinces in the Midlands and Northern Mountains region depart substantially in ranking between the two models. All provinces except two in this region are in the middle (those ranked 40 and above) of the distribution from the single-level analysis, while accounting for the between-province variation, we find 71 provinces are in a worse situation. In the basic services dimension, while the majority of lower-ranked provinces are located in the Midlands and Northern Mountain region in the single-level analysis, the distribution of "bad" provinces in the multilevel model is concentrated in both the Northern and Coastal Central region and the Midlands and Northern Mountains region.

Table 6 presents the list of provinces and the values of the differences in ranking between the single-level and multilevel analyses. A positive (negative) value indicates that the province is in a better (worse) position in the poverty rankings in terms of a multilevel analysis. Tables 6, 11 and Fig. 3 reveal that the changes in the average absolute ranking in the income dimension for bad and good provinces are greatest among the seven poverty

Table 5 Cross-tabulation of commune versus province level poverty—various dimensions

		N, % of total commune					
		Good		Medium		Bad	
Commune-level Income Poverty							
Province-level Income Poverty	Good	6	0.19%	856	27.33%	0	0.00%
N (% of total commune)	Medium	0	0.00%	1681	53.67%	0	0.00%
	Bad	6	0.19%	561	17.91%	22	0.70%
Commune-level Education Poverty							
Province-level Education Poverty	Good	0	0%	884	28.22%	0	0.00%
N (% of total commune)	Medium	0	0%	1312	41.89%	0	0.00%
	Bad	0	0%	914	29.18%	22	0.70%
Commune-level Health Poverty							
Province-level Health Poverty	Good	0	0%	777	24.81%	0	0.00%
N (% of total commune)	Medium	0	0%	1428	45.59%	0	0.00%
	Bad	0	0%	914	29.18%	13	0.42%
Commune-level Housing Poverty							
Province-level Housing Poverty	Good	3	0.10%	1370	43.74%	66	2.11%
N (% of total commune)	Medium	18	0.57%	673	21.49%	21	0.67%
	Bad	73	2.33%	845	26.98%	63	2.01%
Commune-level Basic Services Poverty							
Province-level Basic Services Poverty	Good	39	1.25%	930	29.69%	10	0.32%
N (% of total commune)	Medium	22	0.70%	1401	44.73%	74	2.36%
	Bad	48	1.53%	570	18.20%	38	1.21%
Commune-level Durable Assets Poverty							
Province-level Durable Assets Poverty	Good	0	0.00%	88	2.81%	0	0.00%
N (% of total commune)	Medium	18	0.57%	2502	79.89%	37	1.18%
	Bad	0	0.00%	437	13.95%	50	1.60%
Commune-level Economic status Poverty							
Province-level Economic status Poverty	Good	0	0.00%	0	0.00%	0	0.00%
N (% of total commune)	Medium	0	0.00%	2826	90.23%	136	4.34%
	Bad	11	0.35%	106	3.38%	53	1.69%

dimensions. This means that variation in the higher-level contextual factors in regard to the income dimension in determining poverty in Vietnam is substantially high. Thus, disbursement of poverty-alleviation funds in provinces on the basis of household traits alone is not the most efficient way of reducing income poverty in Vietnam. Consideration of regional variations must be included in any strategy for attacking the problems of poverty.

4.3.2 Large Changes in Ranking of Provinces: Single Versus Multilevel Analysis

The poverty scenario in Vietnam can be studied in more detail by looking at large changes in ranking between single and multilevel analyses. For this purpose, let's consider a change in ranking of 5 points as a *large* change. We note from results presented in Table 7 that in the income dimension, 21 provinces show an increase in ranking, while for 23 provinces the ranking decreases. A 5-point change in the ranking of 70% of provinces is definitely a significant variation; as the utilization of funds from poverty-alleviation programs

Table 6 Difference in poverty rankings of provinces—multilevel versus single-level analysis

	Province	Income	Education	Health	Housing	Basic	Asset	Economic
Red River Delta	Ha Noi City	−9	−42	2	−4	−7	42	−26
	Quang Ninh	−2	−8	−4	−2	−9	26	−15
	Vinh Phuc	−26	−7	10	−1	−9	−26	−16
	Bac Ninh	1	−4	5	1	3	8	−7
	Hai Duong	−17	2	−1	0	2	4	−18
	Hai Phong City	−2	−2	−3	−1	−6	30	−21
	Hung Yen	−18	−4	2	1	−3	2	−20
	Thai Binh	−5	−1	−6	1	2	23	−12
	Ha Nam	−13	0	8	−1	−8	−30	−6
	Nam Dinh	−14	4	2	2	7	2	−9
	Ninh Binh	−16	7	3	−1	2	−6	−17
Midlands and Northern Mountainous Areas	Ha Giang	10	13	−17	7	1	−5	0
	Cao Bang	10	18	−20	7	−1	−33	7
	Bac Can	4	20	−15	10	4	−32	5
	Tuyen Quang	6	16	1	7	11	−39	14
	Lao Cai	3	1	−13	3	1	−21	30
	Dien Bien	19	5	−18	4	0	−33	0
	Lai Chau	10	6	3	9	0	−5	0
	Son La	5	4	−16	6	−1	−15	23
	Yen Bai	13	12	−2	1	7	−21	−1
	Hoa Binh	16	22	−7	9	9	−45	3
	Thai Nguyen	−17	−1	5	0	−10	−34	1
	Lang Son	20	19	−14	12	3	−40	5
	Bac Giang	1	9	6	4	8	−10	1
	Phu Tho	−12	6	−2	−1	2	−20	1

Table 6 (continued)

	Province	Income	Education	Health	Housing	Basic	Asset	Economic
Northern and Coastal Central Region	Thanh Hoa	−9	3	−2	−2	2	−24	−5
	Nghe An	−12	4	−1	−1	−2	−8	−3
	Ha Tinh	−13	−7	5	−1	−9	−44	1
	Quang Binh	−16	−5	10	−2	−11	−35	−11
	Quang Tri	−17	−16	0	−2	2	2	−2
	Thua Thien - Hue	−21	−14	2	1	1	32	−4
	Da Nang City	−22	−27	−1	−10	−9	49	−25
	Quang Nam	−7	4	1	−4	2	24	1
	Quang Ngai	−6	3	3	2	−1	−27	5
	Binh Dinh	2	−5	4	3	−4	−2	−9
	Phu Yen	−2	0	5	1	3	−22	−2
	Khanh Hoa	3	−36	−21	−36	−19	23	−10
	Ninh Thuan	12	10	1	5	6	45	18
	Binh Thuan	6	4	3	−2	0	22	5
Central Highlands	Kon Tum	2	7	−3	8	1	−8	32
	Gia Lai	21	−5	−3	3	4	−29	−1
	Dac Lac	0	−6	−1	3	−8	−31	−4
	Dac Nong	20	9	−1	−1	11	−33	21
	Lam Dong	1	−2	−4	−1	−6	15	−2

Table 6 (continued)

	Province	Income	Education	Health	Housing	Basic	Asset	Economic
Southeastern Area	Binh Phuoc	12	9	−6	0	0	−25	−4
	Tay Ninh	4	−7	4	−3	5	8	0
	Binh Duong	1	4	5	−4	1	18	0
	Dong Nai	4	−4	5	−3	−1	41	−9
	Ba Ria - Vung Tau	3	−8	4	−4	0	44	−2
	Ho Chi Minh City	−2	−29	−8	−7	−4	54	−25
Mekong Delta	Long An	6	7	12	−5	−6	−2	−4
	Tien Giang	5	−1	8	−4	6	27	−9
	Ben Tre	9	−5	−3	−5	−7	−8	−3
	Tra Vinh	22	0	−1	1	5	−9	26
	Vinh Long	−2	−1	10	−5	−3	−8	12
	Dong Thap	−8	−5	10	−3	7	13	2
	An Giang	5	−1	11	−7	5	31	17
	Kien Giang	16	−1	1	−4	−1	6	22
	Can Tho	−7	−4	3	−4	−8	29	−6
	Hau Giang	−2	−5	16	−7	−2	9	8
	Soc Trang	19	5	−8	−2	7	30	21
	Bac Lieu	14	−1	6	−1	6	27	−16
	Ca Mau	7	−5	5	−2	0	25	6

Table 7 Number of provinces where ranking changed by more than 5 units

Number of Provinces	Monetary	Education	Health	Housing	Basic	Asset	Economic
Total number of provinces = 63							
Decrease in ranking	21	14	12	7	15	15	19
Increase in ranking	23	19	18	10	14	13	18
Red River delta (total number of provinces = 11)							
Decrease in ranking	8	3	1	0	5	2	11
Increase in ranking	0	1	3	0	1	2	0
Midlands and Northern Mountainous Areas (total number of provinces = 14)							
Decrease in ranking	2	1	8	0	2	4	1
Increase in ranking	9	11	2	8	4	2	5
Northern and Coastal Central Region (total number of provinces = 14)							
Decrease in ranking	9	6	0	1	3	5	3
Increase in ranking	2	2	3	1	1	5	4
Central highlands (total number of provinces = 5)							
Decrease in ranking	0	1	0	0	2	2	0
Increase in ranking	2	2	0	1	1	1	2
Southeast area (total number of provinces = 6)							
Decrease in ranking	0	3	2	1	0	0	2
Increase in ranking	1	1	2	0	1	1	0
Mekong River delta (total number of provinces = 13)							
Decrease in ranking	2	0	1	5	3	2	2
Increase in ranking	9	2	8	0	6	2	7

in Vietnam is based only on MOLISA's list of income-poor households, these significant departures in the ranking of provinces in the two approaches could have a serious implication for the correct targeting of the current poverty reduction efforts in the country.

In the non-income dimensions, variation in the poverty rankings of provinces is also evidenced in the education, health, and economics dimensions, with 32 (51%), 30 (48%), and 37 (59%) provinces respectively, showing a substantial change in ranking (Table 7). In particular, the region of Midlands and Northern Mountains reports the largest number of provinces changing their rank in the health and education dimensions. This region is ranked as the best in the health and second worst in the education dimension in the traditional single-level poverty analysis (Tables 3 and 10). However, the results of a multilevel analysis indicate that mostly all provinces in this region have a higher rank (indicating higher levels of poverty) in the education dimension, with a lower rank (less poverty) in the health dimension. Given the fact that the Midlands and Northern Mountains is the poorest region in terms of income poverty, the remarkable departures in ranking of provinces in the region strongly indicate that both income and non-income dimensions should be considered in a multilevel analysis for designing more effective poverty-reduction strategies for Vietnam in the future.

5 Conclusions

This study investigates income and non-income dimensions of poverty in Vietnam in light of regional variations (due to contextual effects) and household traits. Seven dimensions of household poverty are measured using a fuzzy method. Four administrative levels (comprising provinces, districts, communes/villages and households) are partitioned in seven dimensions of deprivation utilizing VHLSS 2014 data. Our results show that the amount of variation in non-income and income poverty that is attributable to provinces and to communes/villages is considerable even after controlling for the recognized factors at the household level. For example, of the total variation in poverty in the basic services and housing dimensions, 13.6% and 34.6%, respectively, are attributable to provinces and 18.2% and 8.2%, respectively, are attributable to communes/villages (Fig. 2). These significant variations at province and commune/village levels imply that a definition of poverty-prone areas based on household deprivation alone cannot fully expound the method of regional poverty targeting in Vietnam. This reveals a need for multilevel analysis of poverty for the efficient utilization of poverty-alleviation funds. However, studies in this respect are limited and those that are available are based on an income approach to poverty alone.[23]

Poverty alleviation has always played a critical role in the sustainable development strategies of the Vietnamese government. The government has approved a series of poverty reduction and social support programs with a total budget of over USD 2 billion and has taken a multidimensional approach for the period 2016–2020; however, the methodology used for measuring poverty and in identification of the poor are based on an income approach only. Our empirical results prove that in Vietnam there are many regions in which people are better off in the income dimension of poverty but are worse off in some non-income dimensions. For example, the region of Mekong River Delta is a relatively good region in the income dimension with three good and no bad provinces. However, of the 13 provinces in this region, all 13 are classified as bad provinces in education, and 10 are bad in the housing dimension. Especially, Kien Giang province was identified as good in the income dimension but is found to be bad in most of the non-income dimensions (see Tables 5 and 6). The proportion of poor people who have benefited from social support programs in the region of Mekong River Delta is always lower than in the region of Midlands and Northern Mountains, and lower than in the region of Northern and Coastal

[23] To date, there are only two studies in which multilevel models are applied to explore the role of location-specific contributions to households' welfare in Vietnam. Using panel data from two waves of the Vietnam Living Standards Measurement Surveys (VLSMS) 1993 and 1997, Arpino and Aassve (2014) investigate the contribution of villages in households' exit from poverty. Haughton and Nguyen (2010) focus on investigating geographical variations in the inequality gap in expenditure levels between urban and rural areas. While both studies apply the income approach to measure the welfare levels of households, we examine multiple dimensions of poverty for the whole of the country. Arpino and Aassve (2014) employed EB predictions of village-level random effects to find the good and bad villages and regions in rural Vietnam. Since the authors do not include the higher levels in their multilevel model, the random errors accumulate all the unobserved contextual factors at village and higher geographic levels. Therefore, the variance component at the village level is inflated because the specified model disregards higher hierarchical levels (Tranmer and Steel 2001). There are four administrative levels involved in our empirical models that allow us not only to distinguish the random effects of each higher level, but also to gain more efficient estimations. Haughton and Nguyen (2010) show that spatial effects play an important role in inequality gaps between urban and rural areas. Although the authors take into account all four administrative levels in their empirical model, they do not examine the relative importance of these levels on household welfare nor which members in each level report higher effects on household welfare.

Central in every program. This disbursement of poverty-alleviation funds is justifiable from the perspective of income poverty, but our findings indicate that the region is worse off in terms of education, housing and durable asset poverty. Thus, targeting the poor by the current income poverty approach as used by MOLISA results in widening the disparity in deprivation of non-income dimensions in the Mekong River Delta. We observe that the poverty-alleviation approach in Vietnam leads to financial overlapping activities and inefficiencies in the use of resources and in implementation of policies, and poor monitoring.

Our results show that the variance partitioning at the household level is at the maximum for all dimensions. However, the consistent and significant variations at higher levels of administration indicate that even after controlling for predictors of poverty at the household level, considerable variability in poverty is left unexplained for the province, district, and commune/village levels. In particular, the amount of variation in most dimensions of poverty attributed to provinces was greater than at district or commune/village levels. Therefore, this study suggests that in future analyses of poverty in Vietnam in particular, and developing countries in general, attention should also be paid to examining provincial characteristics.

Appendix

Since the major analyses of the study are based on province level, we provide here tests of normal distribution at province level. We utilize the Skewness-Kurtosis (Jarque–Bera) test in Stata to test against the null hypothesis that random effects and residual errors are normally distributed. Therefore, in Table 8, a value of adj chi2 greater than 0.05 (Prob > chi2) implies its significance at 5% level. Consequently, the null hypothesis cannot be rejected and random effects and residual errors show normal distribution. In Table 8, the normality assumption of deprivation is satisfied in all dimensions (Figs. 4, 5).

Based on the result of the likelihood ratio test in Table 9, the estimated multilevel models (Models in Table 4) is preferred to OLS models (Tables 10, 11, 12).

Table 8 Tests for normal distribution of random effects (province level)

	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2	Prob > chi2
Income	63	0.15	0.37	3.03	0.22
Education	63	0.63	0.02	5.28	0.07
Health	63	0.29	0.03	5.61	0.06
Housing	63	0.15	0.37	3.03	0.22
Basic Services	63	0.90	0.20	1.72	0.42
Durable Asset	63	0.20	0.64	1.94	0.38
Economic Status	63	0.13	0.12	4.70	0.10

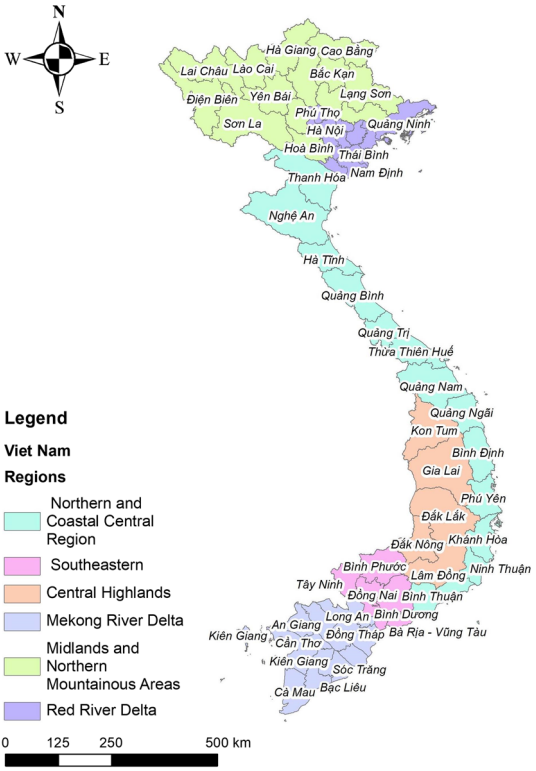

Fig. 4 Map of Vietnam by regions and provinces

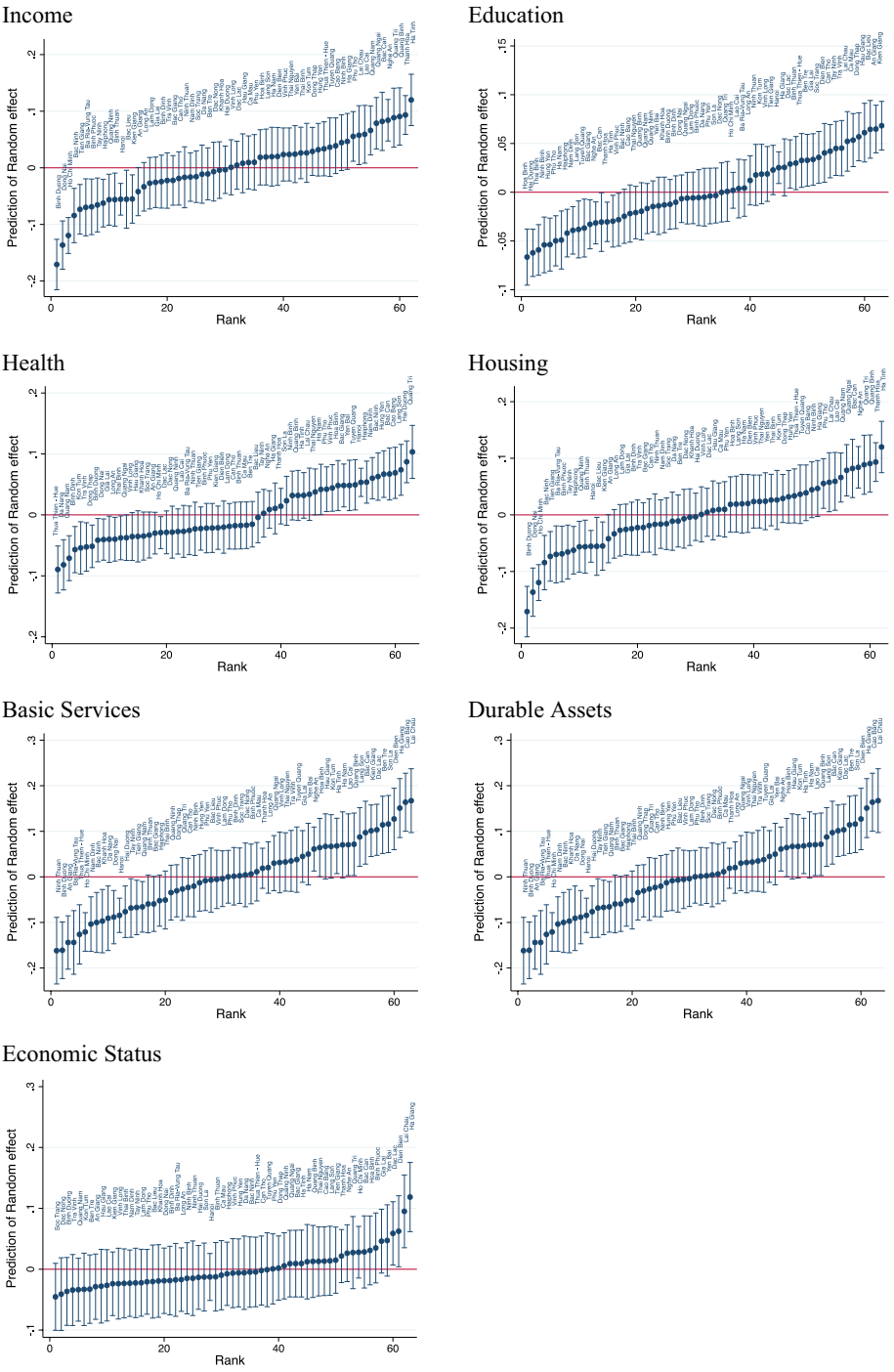

Fig. 5 EB predictions of province-level random effects for multiple dimensions of poverty with 95% confidence intervals (Since residuals are assumed to follow a normal distribution with zero mean, the zero line in Fig. 1 represents the estimated overall mean, β_0^k. Black dots represent the estimated province-level residuals, u_p^k, which are the differences between province j's mean of the kth dimension of poverty, and the estimated overall mean, β_0^k.)

Table 9 Likelihood ratio tests for multilevel models versus single-level models

Income		LR $\chi^2_3 = 579.03$	$\Pr > \chi^2 = 0.0000$
Non-income	Education	LR $\chi^2_3 = 460.78$	$\Pr > \chi^2 = 0.0000$
	Health	LR $\chi^2_3 = 368.38$	$\Pr > \chi^2 = 0.0000$
	Housing	LR $\chi^2_3 = 3566.86$	$\Pr > \chi^2 = 0.0000$
	Basic services	LR $\chi^2_3 = 1587.89$	$\Pr > \chi^2 = 0.0000$
	Durable assets	LR $\chi^2_3 = 306.54$	$\Pr > \chi^2 = 0.0000$
	Economic status	LR $\chi^2_3 = 649.79$	$\Pr > \chi^2 = 0.0000$

Table 10 Variances from multilevel models

Dimensions		Levels			
		Household	Commune	District	Province
Income		0.044	0.004	0.002	0.004
Non-income	Education	0.018	0.001	0.000	0.001
	Health	0.038	0.004	0.000	0.002
	Housing	0.034	0.006	0.007	0.025
	Basic	0.032	0.010	0.007	0.008
	Asset	0.061	0.004	0.004	0.002
	Economic	0.051	0.008	0.009	0.002

Table 11 Measures of poverty in Vietnam by provinces

	Provinces	No. of observations	Income	Education	Health	Housing	Basic	Asset	Economic
Red River delta	Ha Noi City	420	0.227	0.149	0.219	0.038	0.123	0.213	0.031
	Quang Ninh	147	0.277	0.225	0.129	0.085	0.190	0.183	0.074
	Vinh Phuc	135	0.369	0.190	0.239	0.066	0.263	0.065	0.060
	Bac Ninh	138	0.242	0.207	0.271	0.045	0.184	0.110	0.078
	Hai Duong	183	0.369	0.154	0.267	0.027	0.205	0.112	0.050
	Hai Phong City	186	0.272	0.161	0.212	0.076	0.196	0.188	0.054
	Hung Yen	147	0.425	0.137	0.240	0.056	0.285	0.138	0.056
	Thai Binh	189	0.478	0.137	0.098	0.026	0.284	0.172	0.017
	Ha Nam	123	0.413	0.163	0.218	0.022	0.417	0.118	0.104
	Nam Dinh	195	0.361	0.199	0.233	0.039	0.198	0.087	0.039
	Ninh Binh	129	0.454	0.194	0.188	0.033	0.304	0.117	0.047
Midlands and northern mountainous areas	Ha Giang	105	0.665	0.501	0.138	0.657	0.681	0.218	0.433
	Cao Bang	102	0.631	0.351	0.178	0.394	0.668	0.140	0.211
	Bac Can	102	0.684	0.340	0.186	0.462	0.601	0.123	0.249
	Tuyen Quang	114	0.539	0.302	0.214	0.441	0.490	0.066	0.156
	Lao Cai	102	0.578	0.368	0.118	0.555	0.489	0.150	0.104
	Dien Bien	102	0.621	0.490	0.120	0.634	0.635	0.134	0.323
	Lai Chau	102	0.707	0.575	0.196	0.691	0.728	0.235	0.370
	Son La	126	0.635	0.366	0.143	0.503	0.597	0.175	0.151
	Yen Bai	114	0.555	0.348	0.196	0.622	0.488	0.125	0.243
	Hoa Binh	114	0.535	0.268	0.184	0.246	0.512	0.060	0.247
	Thai Nguyen	147	0.407	0.241	0.199	0.196	0.346	0.076	0.130
	Lang Son	108	0.600	0.311	0.195	0.319	0.582	0.105	0.200
	Bac Giang	168	0.406	0.263	0.222	0.102	0.302	0.079	0.114
	Phu Tho	156	0.482	0.194	0.195	0.222	0.356	0.090	0.065

Table 11 (continued)

	Provinces	No. of observations	Income	Education	Health	Housing	Basic	Asset	Economic
Northern and coastal central region	Thanh Hoa	246	0.538	0.240	0.171	0.148	0.381	0.104	0.123
	Nghe An	225	0.520	0.232	0.169	0.162	0.425	0.159	0.136
	Ha Tinh	150	0.531	0.180	0.196	0.130	0.396	0.074	0.115
	Quang Binh	120	0.500	0.227	0.214	0.135	0.396	0.117	0.096
	Quang Tri	102	0.494	0.262	0.295	0.206	0.294	0.128	0.155
	Thua Thien - Hue	135	0.415	0.347	0.072	0.179	0.138	0.159	0.089
	Da Nang City	123	0.240	0.157	0.067	0.167	0.032	0.247	0.051
	Quang Nam	159	0.529	0.285	0.082	0.208	0.241	0.169	0.044
	Quang Ngai	147	0.534	0.324	0.127	0.151	0.375	0.102	0.123
	Binh Dinh	162	0.395	0.265	0.108	0.150	0.305	0.142	0.056
	Phu Yen	123	0.453	0.333	0.159	0.118	0.317	0.071	0.103
	Khanh Hoa	138	0.375	0.281	0.125	0.175	0.157	0.200	0.075
	Ninh Thuan	102	0.461	0.447	0.145	0.285	0.139	0.177	0.114
	Binh Thuan	135	0.385	0.450	0.163	0.260	0.236	0.167	0.093
Central highlands	Kon Tum	102	0.508	0.420	0.071	0.266	0.482	0.170	0.103
	Gia Lai	141	0.480	0.406	0.106	0.419	0.457	0.107	0.227
	Dac Lac	165	0.450	0.371	0.131	0.312	0.479	0.132	0.214
	Dac Nong	102	0.523	0.391	0.132	0.453	0.427	0.032	0.071
	Lam Dong	141	0.389	0.305	0.145	0.353	0.294	0.177	0.056

Table 11 (continued)

	Provinces	No. of observations	Income	Education	Health	Housing	Basic	Asset	Economic
Southeastern area	Binh Phuoc	120	0.390	0.369	0.138	0.408	0.362	0.090	0.166
	Tay Ninh	135	0.367	0.415	0.179	0.364	0.245	0.123	0.060
	Binh Duong	177	0.168	0.312	0.121	0.275	0.076	0.117	0.033
	Dong Nai	207	0.246	0.274	0.121	0.309	0.179	0.210	0.055
	Ba Ria - Vung Tau	132	0.297	0.323	0.152	0.283	0.095	0.184	0.068
	Ho Chi Minh City	351	0.143	0.177	0.120	0.229	0.032	0.256	0.079
Mekong delta	Long An	156	0.395	0.408	0.139	0.403	0.354	0.158	0.066
	Tien Giang	171	0.348	0.391	0.161	0.379	0.267	0.170	0.109
	Ben Tre	153	0.463	0.398	0.156	0.398	0.483	0.194	0.038
	Tra Vinh	129	0.489	0.477	0.086	0.536	0.448	0.151	0.086
	Vinh Long	135	0.428	0.387	0.142	0.403	0.368	0.150	0.072
	Dong Thap	168	0.473	0.461	0.129	0.501	0.308	0.156	0.113
	An Giang	186	0.394	0.521	0.152	0.540	0.155	0.155	0.073
	Kien Giang	162	0.429	0.522	0.152	0.604	0.497	0.265	0.090
	Can Tho	138	0.370	0.425	0.163	0.437	0.224	0.212	0.086
	Hau Giang	111	0.449	0.465	0.156	0.546	0.440	0.223	0.061
	Soc Trang	144	0.496	0.488	0.117	0.602	0.395	0.274	0.071
	Bac Lieu	114	0.417	0.501	0.182	0.567	0.360	0.214	0.070
	Ca Mau	138	0.485	0.459	0.175	0.635	0.364	0.263	0.099
Overall mean			0.420	0.309	0.163	0.281	0.318	0.155	0.103

Table 12 Ranking of provinces based on poverty measures (ascending from least to most deprived) – single and multilevel analyses

	Name of provinces	Income		Education		Health		Housing		Basic		Asset		Economic	
		SLA[a]	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA
Red River delta	Ha Noi City	3	12	3	44	56	53	5	9	5	12	54	54	2	27
	Quang Ninh	8	10	15	23	18	22	11	13	12	21	47	40	26	40
	Vinh Phuc	14	40	10	17	59	48	9	10	20	29	3	12	16	31
	Bac Ninh	5	4	14	18	62	56	7	6	11	8	16	19	28	34
	Hai Duong	13	30	4	2	61	61	3	3	15	13	17	15	8	26
	Hai Phong City	7	9	6	8	52	54	10	11	13	19	49	45	10	30
	Hung Yen	28	46	1	5	60	57	8	7	23	26	28	24	13	32
	Thai Binh	38	43	2	3	6	12	2	1	22	20	43	5	1	13
	Ha Nam	25	38	7	7	55	46	1	2	43	51	21	27	39	44
	Nam Dinh	10	24	13	9	58	55	6	4	14	7	9	8	5	14
	Ninh Binh	34	50	11	4	45	41	4	5	27	25	19	17	7	24
Midlands and northern mountainous areas	Ha Giang	61	51	59	45	22	39	62	55	62	60	56	57	63	62
	Cao Bang	59	49	37	19	40	59	40	33	61	61	29	26	55	47
	Bac Can	62	58	34	14	44	58	49	39	59	55	23	23	60	54
	Tuyen Quang	54	48	27	11	54	52	47	40	54	43	4	20	52	37
	Lao Cai	57	54	39	37	10	23	55	52	53	52	31	42	40	10
	Dien Bien	58	39	58	52	12	30	60	56	60	59	27	34	61	60
	Lai Chau	63	53	63	56	48	44	63	54	63	62	58	58	62	61
	Son La	60	55	38	63	25	63	51	45	58	63	44	63	50	63
	Yen Bai	55	42	36	24	50	51	59	58	52	45	24	16	58	58
	Hoa Binh	52	36	23	1	43	49	28	19	56	47	2	2	59	55
	Thai Nguyen	24	41	19	20	51	45	23	23	31	41	7	10	48	46
	Lang Son	57	37	29	10	47	60	36	24	57	54	14	4	54	48
	Bac Giang	22	21	21	12	57	50	12	8	26	18	8	11	44	42
	Phu Tho	40	52	12	6	46	47	26	27	33	31	11	9	18	17

Table 12 (continued)

	Name of provinces	Income		Education		Health		Housing		Basic		Asset		Economic	
		SLA[a]	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA
Northern and coastal central region	Thanh Hoa	53	62	18	15	38	40	16	18	39	37	13	14	46	50
	Nghe An	47	59	17	13	37	38	19	20	44	46	38	32	49	51
	Ha Tinh	50	63	9	16	49	43	14	15	41	50	6	1	45	43
	Quang Binh	45	61	16	21	53	42	15	17	42	53	18	25	35	45
	Quang Tri	43	60	20	35	63	62	24	26	25	23	25	35	51	52
	Thua Thien - Hue	26	47	35	48	3	1	22	21	6	5	37	31	32	35
	Da Nang City	4	26	5	32	1	2	20	30	1	10	59	53	9	33
	Quang Nam	49	56	26	22	4	3	25	29	18	16	40	18	6	5
	Quang Ngai	51	57	32	29	16	13	18	16	38	39	12	36	47	41
	Binh Dinh	21	19	22	27	8	4	17	14	28	32	30	29	12	21
	Phu Yen	33	35	33	33	33	28	13	12	30	27	5	13	37	38
	Khanh Hoa	16	13	25	25	15	16	21	25	9	9	51	47	27	19
	Ninh Thuan	35	23	51	40	26	25	33	28	7	1	46	51	43	25
	Binh Thuan	17	11	52	47	36	33	29	31	17	17	39	39	34	28
Central highlands	Kon Tum	46	44	49	41	2	5	30	22	50	49	41	49	38	6
	Gia Lai	39	18	46	50	7	10	45	42	48	44	15	6	57	57
	Dac Lac	32	32	41	46	19	20	35	32	49	57	26	38	56	59
	Dac Nong	48	28	44	34	20	21	48	49	45	34	1	3	23	2
	Lam Dong	18	17	28	30	27	31	37	38	24	30	45	41	14	16

Table 12 (continued)

	Name of provinces	Income		Education		Health		Housing		Basic		Asset		Economic	
		SLA[a]	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA	SLA	MLA
Southeastern area	Binh Phuoc	19	7	40	31	21	27	44	44	35	35	10	7	53	56
	Tay Ninh	12	8	48	54	41	37	38	41	19	14	22	22	15	15
	Binh Duong	2	1	30	26	13	8	31	35	3	2	20	21	3	3
	Dong Nai	6	2	24	28	14	9	34	37	10	11	52	46	11	20
	Ba Ria-Vung Tau	9	6	31	38	28	24	32	36	4	4	48	44	20	22
	Ho Chi Minh City	1	3	8	36	11	19	27	34	2	6	60	60	29	53
Mekong delta	Long An	22	16	47	39	23	11	42	47	32	38	36	48	19	23
	Tien Giang	10	5	43	43	34	26	39	43	21	15	42	50	41	49
	Ben Tre	36	27	45	49	32	35	41	46	51	58	50	43	4	7
	Tra Vinh	42	20	56	55	5	6	52	51	47	42	33	33	30	4
	Vinh Long	29	31	42	42	24	14	43	48	37	40	32	30	24	12
	Dong Thap	37	45	54	58	17	7	50	53	29	22	35	37	42	39
	An Giang	20	15	61	61	29	18	53	60	8	3	34	28	25	8
	Kien Giang	30	14	62	62	30	29	58	62	55	56	62	61	33	11
	Can Tho	15	22	50	53	35	32	46	50	16	24	53	52	31	36
	Hau Giang	31	33	55	59	31	15	54	61	46	48	57	56	17	9
	Soc Trang	44	25	57	51	9	17	57	59	40	33	63	59	22	1
	Bac Lieu	27	13	60	60	42	36	56	57	34	28	55	55	21	18
	Ca Mau	41	34	53	57	39	34	61	63	36	36	61	62	36	29

[a]SLA: Ranking based on single-level analysis of poverty. MLA: Ranking based on multilevel analysis of poverty

References

ADB (Asian Development Bank). (2018). Key Indicators for Asia and the Pacific 2018 available at www.adb.org/statistics.

Alkire, S. (2007). Choosing dimensions: The capability approach and multidimensional poverty. *Chronic Poverty Research Centre Working Paper*, (88).

Alkire, S., Roche, J. M., Ballon, P., Foster, J., Santos, M. E., & Seth, S. (2015). *Multidimensional poverty measurement and analysis*. Oxford : Oxford University Press.

Alkire, S., & Santos, M. E. (2010). *Acute multidimensional poverty: A new index for developing countries* (No. HDRP-2010-11). Human Development Report Office (HDRO), United Nations Development Programme (UNDP).

Alkire, S., & Santos, M. E. (2013). A multidimensional approach: Poverty measurement & beyond. *Social Indicators Research, 112*(2), 239–257.

Alkire, S., & Santos, M. E. (2014). Measuring acute poverty in the developing world: Robustness and scope of the multidimensional poverty index. *World Development, 59,* 251–274.

Amarasinghe, U., Samad, M., & Anputhas, M. (2005). *Locating the poor: Spatially disaggregated poverty maps for Sri Lanka* (Vol. 96). Colombo: IWMI.

Arouri, M., Nguyen, C., & Youssef, A. B. (2015). Natural disasters, household welfare, and resilience: Evidence from rural Vietnam. *World Development, 70,* 59–77.

Arpino, B., & Aassve, A. (2014). The role of villages in households' poverty exit: Evidence from a multilevel model for rural Vietnam. *Quality & Quantity, 48*(4), 2175–2189.

Asselin, L. M. (2009). *Analysis of multidimensional poverty: Theory and case studies* (Vol. 7). Berlin: Springer.

Azeem, M. M., Mugera, A. W., & Schilizzi, S. (2016). Poverty and vulnerability in the Punjab, Pakistan: A multilevel analysis. *Journal of Asian Economics, 44,* 57–72.

Baker, J. L., & Grosh, M. E. (1994). Poverty reduction through geographic targeting: How well does it work? *World Development, 22*(7), 983–995.

Battiston, D., Cruces, G., Lopez-Calva, L. F., Lugo, M. A., & Santos, M. E. (2013). Income and beyond: Multidimensional poverty in six Latin American countries. *Social Indicators Research, 112*(2), 291–314.

Baulch, B., & Dat, V. H. (2010). Poverty dynamics in Vietnam, 2002–2006. World Bank. http://documents.worldbank.org/curated/en/309531468267611416/pdf/642780WP0P107600Box0361535B0PUBLIC0.pdf.

Baulch, B., & Masset, E. (2003). Do monetary and nonmonetary indicators tell the same story about chronic poverty? A study of Vietnam in the 1990s. *World Development, 31*(3), 441–453.

Baulch, B., & Minot, N. (2002). *The spatial distribution of poverty in Vietnam and the potential for targeting*. Washington DC: The World Bank.

Betti, G., Gagliardi, F., Lemmi, A., & Verma, V. (2015). Comparative measures of multidimensional deprivation in the European Union. *Empirical Economics, 49*(3), 1071–1100.

Betti, G., & Verma, V. (1999). Measuring the degree of poverty in a dynamic and comparative context: A multi-dimensional approach using fuzzy set theory. In *Proceedings, ICCS-VI* (Vol. 11, p. 289).

Betti, G., & Verma, V. (2008). Fuzzy measures of the incidence of relative poverty and deprivation: A multi-dimensional perspective. *Statistical Methods and Applications, 17*(2), 225–250.

Brady, D., Fullerton, A. S., & Cross, J. M. (2009). Putting poverty in political context: A multi-level analysis of adult poverty across 18 affluent democracies. *Social Forces, 88*(1), 271–299.

Brady, D., & Kall, D. (2008). Nearly universal, but somewhat distinct: The feminization of poverty in affluent Western democracies, 1969–2000. *Social Science Research, 37*(3), 976–1007.

Browne, W. J., Subramanian, S. V., Jones, K., & Goldstein, H. (2005). Variance partitioning in multilevel logistic models that exhibit overdispersion. *Journal of the Royal Statistical Society: Series A (Statistics in Society), 168*(3), 599–613.

Bui, A. T., Dungey, M., Nguyen, C. V., & Pham, T. P. (2014). The impact of natural disasters on household income, expenditure, poverty and inequality: Evidence from Vietnam. *Applied Economics, 46*(15), 1751–1766.

Carletto, C., Dabalen, A., & Moubayed, A. (2007). Constructing and using poverty maps for policy making: The experience in Albania. In *More than a pretty picture: Using poverty maps to design better policies and interventions.* Washington DC: The World Bank.

Cerioli, A., & Zani, S. (1990). A fuzzy approach to the measurement of poverty. In C. Dagum and M. Zenga (Eds.) *Income and wealth distribution, inequality and poverty: Proceedings of the second international conference on income distribution by size: Generation, distribution, measurement and applications.*

Held at the University of Pavia, Italy, September 28–30, 1989 (pp. 272–284). Berlin, Heidelberg: Springer.
Chaudhry, P., & Ruysschaert, G. (2007). *Climate change and human development in Viet Nam: A case study for the human development report 2007/2008*. Hanoi: UNDP.
Cheli, B., & Lemmi, A. (1995). A "Totally" fuzzy and relative approach to the multidimensional analysis of poverty. *Economic Notes-SIENA, 24,* 115–134.
Chen, K. M., & Wang, T. M. (2015). Determinants of poverty status in Taiwan: A multilevel approach. *Social Indicators Research, 123*(2), 371–389.
Christiaensen, L., Lanjouw, P., Luoto, J., & Stifel, D. (2012). Small area estimation-based prediction methods to track poverty: Validation and applications. *The Journal of Economic Inequality, 10*(2), 267–297.
Conway, T. (2001). *Using government data to target activities to poor communes and monitor poverty reduction: A review of options for the Cao Bang-Bac Kan Rural Development Project*. Hanoi: Commission of the European Communities.
Cuong, N. V. (2009). Updating poverty maps without panel data: Evidence from Vietnam. *Asian Economic Journal, 23*(4), 397–418.
Dasgupta, S., Deichmann, U., Meisner, C., & Wheeler, D. (2005). Where is the poverty–environment nexus? Evidence from Cambodia, Lao PDR, and Vietnam. *World Development, 33*(4), 617–638.
Demombynes, G., Elbers, C., Lanjouw, J., Lanjouw, P., Mistiaen, J., & Özler, B. (2002). *Producing an improved geographic profile of poverty: Methodology and evidence from three developing countries* (No. 2002/39). WIDER Discussion Papers//World Institute for Development Economics (UNU-WIDER).
Elbers, C., Fujii, T., Lanjouw, P., Yin, W., & Özler, B. (2004). *Poverty alleviation through geographic targeting: How much does disaggregation help?*. Washington DC: The World Bank.
Elbers, C., Lanjouw, J. O., & Lanjouw, P. (2002). *Micro-level estimation of welfare* (Vol. 2911). Washington DC: World Bank Publications.
Elbers, C., Lanjouw, J. O., & Lanjouw, P. (2003). Micro-level estimation of poverty and inequality. *Econometrica, 71*(1), 355–364.
Fiadzo, E. D., Houston, J. E., & Godwin, D. D. (2001). Estimating housing quality for poverty and development policy analysis: CWIQ in Ghana. *Social Indicators Research, 53*(2), 137–162.
Ghosh, M., & Rao, J. N. K. (1994). Small area estimation: An appraisal. *Statistical Science, 9*(1), 55–76.
Glewwe, P., Agrawal, N., & Dollar, D. (Eds.). (2004). *Economic growth, poverty, and household welfare in Vietnam*. Washington DC: World Bank Publications.
Gloede, O., Menkhoff, L., & Waibel, H. (2015). Shocks, individual risk attitude, and vulnerability to poverty among rural households in Thailand and Vietnam. *World Development, 71,* 54–78.
Goldstein, H. (2011). *Multilevel statistical models* (Vol. 922). Hoboken: Wiley.
Goldstein, H., Browne, W., & Rasbash, J. (2002). Partitioning variation in multilevel models. *Understanding Statistics: Statistical Issues in Psychology, Education, and the Social Sciences, 1*(4), 223–231.
Goldstein, H., & Healy, M. J. (1995). The graphical presentation of a collection of means. *Journal of the Royal Statistical Society. Series A (Statistics in Society), 158,* 175–177.
Gräb, J., & Grimm, M. (2008). Spatial inequalities explained: Evidence from Burkina Faso.
GSO (General Statistics Office of Vietnam). (2014). *Statistical Yearbook of Vietnam 2014.* Statistical Publishing House.
GSO (General Statistics Office of Vietnam). (2015). *Statistical Yearbook of Vietnam 2015.* Statistical Publishing House.
GSO (General Statistics Office of Vietnam). (2017). *Statistical Yearbook of Vietnam 2017.* Statistical Publishing House.
Haughton, D., & Nguyen, P. (2010). Multilevel models and inequality in Vietnam. *Journal of Data Science, 8*(2), 289–306.
Heltberg, R., & Tarp, F. (2002). Agricultural supply response and poverty in Mozambique. *Food policy*, *27*(2), 103–124.
Hentschel, J., Lanjouw, J. O., Lanjouw, P., & Poggi, J. (2000). Combining census and survey data to trace the spatial dimensions of poverty: A case study of Ecuador. *The World Bank Economic Review, 14*(1), 147–165.
Huang, Y., & Magnoli Bocchi, A. (Eds.). (2008). *Reshaping economic geography in East Asia*. Washington DC: The World Bank.
Imai, K. S., Gaiha, R., & Thapa, G. (2015). Does non-farm sector employment reduce rural poverty and vulnerability? Evidence from Vietnam and India. *Journal of Asian Economics, 36,* 47–61.
Kim, K. S., Lee, Y., & Lee, Y. J. (2010). A multilevel analysis of factors related to poverty in welfare states. *Social Indicators Research, 99*(3), 391–404.

Kim, R., Mohanty, S. K., & Subramanian, S. V. (2016). Multilevel geographies of poverty in India. *World Development, 87,* 349–359.
Klasen, S., Grimm, M., & McKay, A. (2007). *Determinants of pro-poor growth: Analytical issues and findings from country cases*. Houndmills: Palgrave Macmillan.
Klasen, S., Lechtenfeld, T., & Povel, F. (2015). A feminization of vulnerability? Female headship, poverty, and vulnerability in Thailand and Vietnam. *World Development, 71,* 36–53.
Lanjouw, P., Marra, M., & Nguyen, C. (2017). Vietnam's evolving poverty index map: patterns and implications for policy. *Social Indicators Research, 133*(1), 93–118.
Mahadevan, R., & Hoang, V. N. (2016). The nexus between poverty and deprivation in Vietnam. *Journal of Policy Modeling, 38*(2), 290–303.
Makdissi, P., & Wodon, Q. (2004). Fuzzy targeting indices and orderings. *Bulletin of Economic Research, 56*(1), 41–51.
Martinetti, E. C. (2000). A multidimensional assessment of well-being based on Sen's functioning approach. *Rivista internazionale di scienze sociali, 108,* 207–239.
Mihai, M., Ţiţan, E., & Manea, D. (2015). Education and poverty. *Procedia Economics and Finance*, *32*, 855–860.
Minot, N. (2000). Generating disaggregated poverty maps: An application to Vietnam. *World Development, 28*(2), 319–331.
Minot, N., & Baulch, B. (2004). *The spatial distribution of poverty in Vietnam and the potential for targeting* (Vol. 842, p. 229). Washington DC: World Bank Publications.
Nguyen, C. V., & Tran, A. (2014). Poverty identification: Practice and policy implications in Vietnam. *Asian-Pacific Economic Literature, 28*(1), 116–136.
Nguyen, C. V., Tran, T. Q., & Van VU, H. (2017). Ethnic Minorities in Northern Mountains of Vietnam: Employment. *Poverty and Income. Social Indicators Research, 134*(1), 93–115.
Paul, G., Gragnolati, M., & Zaman, H. (2002). Who gained from Vietnam's boom in the 1990s. *Economic Development and Cultural Change, 50*(4), 773–792.
Pham, A. T. Q., & Mukhopadhaya, P. (2018). Measurement of poverty in multiple dimensions: The case of Vietnam. *Social Indicators Research, 138*(3), 953–990.
Rambo, A. T., & Lê, T. C. (1996). *Development trends in Vietnam's northern mountain region*. Honolulu: East-West Center, Program on Environment.
Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Thousand Oaks: Sage.
Ravallion, M. (2011). *On multidimensional indices of poverty*. Washington DC: The World Bank.
Roelen, K., Gassmann, F., & de Neubourg, C. (2010). Child poverty in Vietnam: Providing insights using a country-specific and multidimensional model. *Social Indicators Research, 98*(1), 129–145.
Roelen, K., Gassmann, F., & de Neubourg, C. (2012). False positives or hidden dimensions: What can monetary and multidimensional measurement tell us about child poverty in Vietnam? *International Journal of Social Welfare, 21*(4), 393–407.
Sahn, D. E., & Stifel, D. C. (2000). Poverty comparisons over time and across countries in Africa. *World Development, 28*(12), 2123–2155.
Santos, M. E., Villatoro, P., Mancero, X., & Gerstenfeld, P. (2015). *A multidimensional poverty index for Latin America* (No. ophiwp079). Queen Elizabeth House, University of Oxford.
Sen, A. K. (1992). *Inequality reexamined*. New York, Cambridge: Harvard University Press.
Shimeles, A., & Verdier-Chouchane, A. (2016). The key role of education in reducing poverty in South Sudan. *African Development Review, 28*(S2), 162–176.
Stifel, D., & Christiaensen, L. (2007). Tracking poverty over time in the absence of comparable consumption data. *The World Bank Economic Review*, *21*(2), 317–341.
Tran, V. Q., Alkire, S., & Klasen, S. (2015). Static and dynamic disparities between monetary and multidimensional poverty measurement: Evidence from Vietnam. In *Measurement of poverty, deprivation, and economic mobility*, pp. 249–281. Emerald Group Publishing Limited.
Tranmer, M., & Steel, D. G. (2001). Ignoring a level in a multilevel model: Evidence from UK census data. *Environment and Planning A, 33*(5), 941–948.
Van der Weide, R., Cuong, N. V., & Truong, T. N. (2010). *Poverty and inequality maps for rural Vietnam: An application of small area estimation*. Washington DC: The World Bank.
Van Doorslaer, E., O'Donnell, O., Rannan-Eliya, R. P., Somanathan, A., Adhikari, S. R., Garg, C. C., et al. (2006). Effect of payments for health care on poverty estimates in 11 countries in Asia: An analysis of household survey data. *The Lancet, 368*(9544), 1357–1364.
Van Minh, H., Phuong, N. T. K., Saksena, P., James, C. D., & Xu, K. (2013). Financial burden of household out-of-pocket health expenditure in Viet Nam: Findings from the National Living Standard Survey 2002–2010. *Social Science and Medicine, 96,* 258–263.

Van Tien, T., Phuong, H. T., Mathauer, I., & Phuong, N. T. K. (2011). A health financing review of Vietnam. World Health Organization. https://www.who.int/health_financing/documents/oasis_f_11-vietnam.pdf.

Verma, V., & Betti, G. (2002). *Longitudinal measures of income poverty and life-style deprivation*. Dipartimento di scienze statistiche: Università di Padova.

Walle, D. V. D. (2002). The Static and Dynamic Incidence of Vietnam's Public Safety Net, *World Bank Policy Research, Working Paper*, no. WPS 2791. The World Bank.

Walsh, J. E. (1947). Concerning the effect of intra class correlation on certain significance tests. *The Annals of Mathematical Statistics, 18*(1), 88–96.

Yang, J., & Mukhopadhaya, P. (2017). Disparities in the level of poverty in China: evidence from China family panel studies 2010. *Social Indicators Research, 132*(1), 411–450.

Yu, J. (2013). Multidimensional poverty in China: Findings based on the CHNS. *Social Indicators Research, 112*(2), 315–336.