Updating Poverty Maps of Vietnam using Vietnam Household Living Standard Survey 2002 and Population Census 1999

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15. December 2007

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Abstract

Poverty maps is an important for poverty targeting in developing countries. In this study, we combine the Vietnam Household Living Standard Survey (VHLSS) in 2002 and the Population Census in 1999 to estimate poverty and inequality indexes of all provinces and districts of Vietnam in the year 2002.

JEL classification: I31, I32, O15

Keywords: Poverty measurement, poverty mapping, agricultural census, household survey, Vietnam.

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1. INTRODUCTION

Elbers *et al.* (2003) proposes a method to combine a household survey and a census to estimate poverty and inequality at the small areas. Ideally, the survey and the census should be conducted in the same year. Using Vietnam Living Standard Survey (VLSS) 1998 and Population Census 1999, Minot *et al.* (2003) estimate poverty and inequality at the provincial and district levels. In this study, we combine the Vietnam Household Living Standard Survey (VHLSS) in 2002 and the Population Census in 1999 to estimate poverty and inequality indexes of all provinces and districts of Vietnam for the year 2002.

The research is structured into 6 sections as follows. The second section describes data sources. The third section presents the method of small area estimation of Elbers *et al.* (2003). The fourth section discusses the selection of common explanatory variables used to construct the expenditure models. The fifth section reports the estimation results of the expenditure models and the estimates of poverty and inequality in 2002. Finally some conclusions are drawn in the sixth section.

2. DATA SOURCES

The poverty mapping in this study relies on two data sources to estimate poverty rates at province, district and commune levels. The first is Vietnam Living Standard Survey (VHLSS) conducted by the General Statistical Office of Vietnam (GSO) in the year 2002. The survey collects information on household characteristics including basic demography, employment and labor force participation, education, health, income, expenditure, housing, fixed assets and durable goods, the participation of households in the most important poverty alleviation programs.

The 2002 VHLSS covered 30000 households. The basic sample frame of this sample is obtained from the Population Census conducted in the year 1999. The selection of the sample of 30000 households follows a method of stratified random cluster sampling so that it is representative for national, rural and urban, and regional levels. The sample is divided further into 4 sub-samples. Each one covers 7500 households and is conducted in a quarter in 2002 in order to eliminate information bias due to seasonal effects. However after processed and cleaned the number of households in the sample is reduced to 29412, of which 6876 households are located in urban area, and 22536 ones in rural areas.

The second data set is the Population and Housing Census that was carried out by the GSO in 1999. It was conducted with the financial and technical support of the United Nations Family Planning Agency and the UNDP. The full results of the census are not made available by the GSO, but this study uses a 33 percent sample of the census. The 33 percent sample was selected by GSO using systematic sampling of every third household on the list of households organized by administrative unit. The sample includes 5,553,811 households.

3. METHODOLOGY

The method of "Small area estimation", which are developed by Elbers et. al. (2003), Hentschel et. al. (2000), combines a household survey and a population census to estimate poverty rate at small area. The main idea is to estimate a expenditure equation from a household survey, and use this equation to predict expenditure for households in a census given these the households' characteristics. Once predicted expenditures are available, poverty rate can be estimated at small areas.

Basically, the method of small area estimation can be described by three steps:

Step 1: Select common variables in a household survey and a population census. These variables will be used in regression of household income, therefore these should be correlated with income.

Step 2: Run regression of per capita income on selected variables using data of the household survey:

$$\ln(y_{ch}) = X'_{ch}\beta + \eta_c + \varepsilon_{ch} \qquad (1)$$

where:

- Y_{ch} and X_{ch} are per capita income and observed characteristics of household h in cluster c, respectively.
- η_c and ε_{ch} are unobserved cluster variables and idiosyncratic variables, respectively. This decomposition allows for correlation of error terms of households within a cluster.

Step 3: Apply this equation into the population census to predict the expected probability of being poor of households, and the poverty rate for an area can be estimated according to Elbers *et al* (2003):

$$\hat{\mu} = \frac{1}{N}\sum_{ch=1}^{N}\Phi\left[\frac{\ln z - X_{ch}^{C}\hat{\beta}}{\sqrt{\hat{\sigma}_{\eta}^{2} + \hat{\sigma}_{\varepsilon,ch}^{2}}}\right] \quad (2)$$

Where N is the number of households in the area.

Estimators of other poverty and inequality indexes are presented in Elbers et. al. (2003).

If the years of the survey and the census are the same or very close, there is no problem in interpreting poverty estimates. However, if the year of the survey is far from the year of the census, it is not clear which year the poverty is estimated for. For example, in this study we have the census in the year 1999, while the survey in the time 2002. To construct the poverty estimates for the year 2002, we have to run regression of per capita expenditure in 2002 on explanatory variables in 1999. More specifically, equation (1) is written as follows:

$$\ln(y_{ch}^{02}) = X_{ch}^{99}\beta^{99-02} + \eta_c + \varepsilon_{ch} \quad (3)$$

Since we do not have panel data during the period 1999-2002, we have to use household variables that are time-variant. In addition, cluster variables from the census are also used to estimate model (3).

Once model (3) is estimated, the parameter estimates will be used to estimate the poverty rates for the year 2002 using equation (2).

4. SELECTION OF EXPLANATORY VARIABLES IN EXPENDITURE MODELS

The variables that are used in the expenditure models must be collected in both the census and survey. In addition, these variables should be time-invariant between 1999 and 2002. However, we do not have panel data between this period. Instead, we use the panel data of VHLSS 2002 and 2004 to assess changes in the common variables.

The VHLSS 2004 covers 9000 households. This sample is representative at the regional level. The VHLSS 2004 and 2002 set up panel data of around 4008 household which is representative at the national level.

To assess the change in household variables, we create 4 binary variables as follows:

(i) A binary variable that equals one if there has been no change from 2002 to 2004;

(ii) A binary variable that equals one if the change is positive;

(iii) A binary variable that equals one if the change is a negative one

(iv) A variable that equals the absolute difference between the 2002 value and the 2004 value.

There are 4008 households to be matched from VLHSS 2002 and VLHSS 2004 datasets. We have used 18 original variables to compare and find out change of household' characteristics and assets.

Household' characteristics include household size, percentage of children and elder, age and education level of household head, education level of household head spouse, household ethnic situation…; Household' assets include household type, using water resource, toilet type, telephone, television type (color or black), motorbike, house area,… These variables are also collected in the population census 1999.

Table 1 reports the time-invariant assessment of total of 41 new variables. For each variable, sum of no change, positive change and negative change equals 100%.

Table 1: Change of household between 2002-2004

Variable	No change between 2002-2004		Positive change between 2002-2004		Negative change between 2002-2004		Absolute change between 2002-2004	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
Household size	4008	0.5981	4008	0.1761	4008	0.2258	4008	0.6569
Household size (square)	4008	0.5981	4008	0.1761	4008	0.2258	4008	6.5267
Percentage of male	4008	0.5856	4008	0.2131	4008	0.2013	4008	0.0677
Percentage of children	4008	0.5492	4008	0.1794	4008	0.2715	4008	0.0854
Head ethnic minorities	4008	0.9820	4008	0.0102	4008	0.0077	4008	0.0180
Percentage of elderly	4008	0.8009	4008	0.1140	4008	0.0851	4008	0.0526
Age of household head	4008	0.0082	4008	0.9286	4008	0.0631	4008	3.4768
Education of head spouse								
Primary	4008	0.9376	4008	0.0359	4008	0.0264	4008	0.0624
Lower-secondary school	4008	0.8815	4008	0.0519	4008	0.0666	4008	0.1185
Upper-secondary school	4008	0.8293	4008	0.0868	4008	0.0838	4008	0.1707
Post-secondary school	4008	0.8815	4008	0.0529	4008	0.0656	4008	0.1185
Occupation of head								
Leaders/Managers	4008	0.9788	4008	0.0135	4008	0.0077	4008	0.0212
Professionals/Technicians	4008	0.9775	4008	0.0110	4008	0.0115	4008	0.0225
Clerks/Service Workers	4008	0.9593	4008	0.0235	4008	0.0172	4008	0.0407
Agriculture/Forestry/Fishery	4008	0.8066	4008	0.0853	4008	0.1080	4008	0.1934
Skilled Workers	4008	0.9114	4008	0.0437	4008	0.0449	4008	0.0886
Unskilled Workers	4008	0.8476	4008	0.0796	4008	0.0729	4008	0.1524
Not working	4008	0.8960	4008	0.0549	4008	0.0492	4008	0.1040
House type								
Permanent house	4008	0.8802	4008	0.0711	4008	0.0487	4000	0.1183
Semi-Permanent	4008	0.7500	4008	0.1307	4008	0.1193	4000	0.2488

Variable	No change between 2002-2004		Positive change between 2002-2004		Negative change between 2002-2004		Absolute change between 2002-2004	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
Temporary	4008	0.8436	4008	0.0624	4008	0.0941	4000	0.1550
Water type								
Tap-water	4008	0.9296	4008	0.0452	4008	0.0252	4008	0.0704
Filtered water	4008	0.7817	4008	0.1335	4008	0.0848	4008	0.2183
others	4008	0.8231	4008	0.0541	4008	0.1228	4008	0.1769
Toilet type								
Flush	4008	0.8787	4008	0.0898	4008	0.0314	4008	0.1213
Others	4008	0.7635	4008	0.0978	4008	0.1387	4008	0.2365
toilet	4008	0.8518	4008	0.0654	4008	0.0828	4008	0.1482
Television								
black television	4008	0.8782	4008	0.0374	4008	0.0843	3965	0.1122
color television	4008	0.7892	4008	0.1669	4008	0.0439	3965	0.2023
telephone	4008	0.8787	4008	0.0946	4008	0.0267	3965	0.1117
Computer	4008	0.9563	4008	0.0292	4008	0.0145	3965	0.0333
motorbike	4008	0.8051	4008	0.1457	4008	0.0492	3965	0.1861
Logarithm of living area	4008	0.1250	4008	0.5195	4008	0.3555	3999	0.3894
% agricultural working	4008	0.6544	4008	0.1385	4008	0.2071	4008	0.1602

Based on the comparison, the time-invariant variables selected include:

- Age and sex of head
- Ethnicity
- Education:
    - less than primary
    - Technical degree
    - Post upper-secondary
- Head occupation:
    - Leaders/Managers
    - Professionals/Technicians
    - Clerks/Service Workers
- Permanent house
- No toilet
- Tap water
- Working in agriculture or not.

In addition, the cluster variables from the census are merged to the survey to construct the consumption model. The list of all variables used in the expenditure model is presented in Table 2.

Table 2: Cluster variable in expenditure models (in VHLSS 2002)

Variable	Meaning	Obs	Mean	Std. Dev.
housetp1_c	Ratio of households with permanent house	28215	0.128	0.164
housetp2_c	Ratio of households with semi-permanent house	28215	0.504	0.264
housetp3_c	Ratio of households with temporary house	28215	0.367	0.318
toilettp1_c	Ratio of households with flush toilet	28215	0.161	0.272
toilettp2_c	Ratio of households with other toilet	28215	0.677	0.319
toilettp3_c	Ratio of households with no toilet	28215	0.162	0.232
watertp1_c	Ratio of households with tap water	28215	0.133	0.274
watertp2_c	Ratio of households with clean water	28215	0.648	0.350
watertp3_c	Ratio of households with other water	28215	0.218	0.295
headedu1_c	Ratio of heads with primary school	28215	0.392	0.214
headedu2_c	Ratio of heads with lower-secondary school	28215	0.399	0.157
headedu3_c	Ratio of heads with upper-secondary school	28215	0.170	0.098
headedu4_c	Ratio of heads with post-secondary school	28215	0.040	0.064
spouseedu1_c	Ratio of no spouse	28215	0.238	0.084
spouseedu2_c	Ratio of spouse with primary school	28215	0.318	0.201
spouseedu3_c	Ratio of spouse with lower-secondary school	28215	0.319	0.160
spouseedu4_c	Ratio of spouse with upper-secondary school	28215	0.103	0.078
spouseedu5_c	Ratio of spouse with post-secondary school	28215	0.021	0.033
headoc1_c	Ratio of head Leaders/Managers	28215	0.008	0.009
headoc2_c	Ratio of head Professionals/Technicians	28215	0.041	0.051
headoc3_c	Ratio of head Clerks/Service Workers	28215	0.061	0.061
headoc4_c	Ratio of head Agriculture/Forestry/Fishery	28215	0.555	0.279
headoc5_c	Ratio of head Skilled Workers	28215	0.084	0.082
headoc6_c	Ratio of head Unskilled Workers	28215	0.027	0.033
headoc7_c	Ratio of head Not working	28215	0.223	0.110
spouseoc1_c	Ratio of no spouse	28215	0.238	0.084
spouseoc2_c	Ratio of spouse Leaders/Managers	28215	0.002	0.004
spouseoc3_c	Ratio of spouse Professionals/Technicians	28215	0.030	0.032
spouseoc4_c	Ratio of spouse Clerks/Service Workers	28215	0.052	0.055
spouseoc5_c	Ratio of spouse Agriculture/Forestry/Fishery	28215	0.432	0.265
spouseoc6_c	Ratio of spouse Skilled Workers	28215	0.033	0.046
spouseoc7_c	Ratio of spouse Unskilled Workers	28215	0.017	0.027
spouseoc8_c	Ratio of spouse Not working	28215	0.195	0.130
tv_c	Ratio of households with tv	28215	0.541	0.204
radio_c	Ratio of households with radio	28215	0.452	0.134
reduc1_c	Ratio of people with primary school	28215	0.526	0.162
reduc2_c	Ratio of people with lower-secondary school	28215	0.320	0.100
reduc3_c	Ratio of people with upper-secondary school	28215	0.125	0.082
reduc4_c	Ratio of people with post-secondary school	28215	0.030	0.051
rwork_c	Ratio of working people	28215	0.457	0.051
ragri_c	Ratio of people working in agriculture	28215	0.613	0.302
rindustry_c	Ratio of people working in industrial sector	28215	0.110	0.124
rservice_c	Ratio of people working in service sector	28215	0.197	0.185
lc_natfor	% natural land	28215	8.997	17.179

Variable	Meaning	Obs	Mean	Std. Dev.
lc_plantfor	%planted land	28215	1.004	4.016
lc_barerocky	% bare land	28215	1.623	6.412
markets	Number of markets in district	28215	17.645	9.320
mktpercom	Number of markets in district	28215	0.968	0.554
mktpaym	Market payment to State	27724	283211	615094
e_0_250m	Percentage of total area by elevation range area 0-250m	28215	85.430	29.586
elev_mean	District elevation mean	28215	117.611	221.563
pctslope1	Pct 0-4% slope	28215	82.967	25.933
road_km	Length of roads by type	28210	340779	228702
lc_arable	% arable land	28215	0.476	0.267
mainroad_den	Main road density	28185	2.070	3.273
minrroad_den	Minor road density	28210	4.261	5.908
tracks_dens	Track density	28210	5.548	2.351
road_dens	Road density	28210	11.932	7.431
prec_annual	Annual rainfall	28215	1815.68	308.90
temp_avg	Average temperature	28215	24.535	1.814
sun_annual	Annual sunshine duration	28215	2076.56	462.52
hum_avg	Average humidity	28215	82.970	1.371

5. EXPENDITURE MODELS AND WELFARE ESTIMATES

The first step in estimating the poverty and inequality is to construct the expenditure models. There are 8 geographical regions in Vietnam. To allow for geographical heterogeneity, we estimates separate expenditure models for each region. Interaction terms between explanatory variables with urban dummy variables are also included.

To examine the sensitivity of the poverty estimates to model specifications, for each region, we compare 3 different models, which mostly vary in the number of explanatory variables they included. Models 1, 2 and 3 refer to a large, medium, and a relatively small specification. In total, there are 24 expenditure regressions. The full regression results are reported in separate files. In this paper, regression results of the medium model (Model 2) are presented in Tables 5 to 13 of Appendix.

It should be noted that we used the latest version of the PovMap program to estimate poverty and inequality (updated on December 13, 2007).[2] Districts are specified as cluster in modeling location effect. The estimates of poverty are similar when communes are selected as clusters.

[2] The program is developed by researchers of WB.
http://iresearch.worldbank.org/PovMap/PovMap2/PovMap2Main.asp

Figure 1 graph the estimates of the headcount index of 61 provinces in Vietnam. The blue line is the poverty ratio that is estimated directly from VHLSS 2002. It shows that estimates from three models are quite close, especially Model 1 and 2. However, these estimates are rather different from those based on the 2002 VHLSS for some provinces.

Figure 1: Poverty estimates at the provincial level

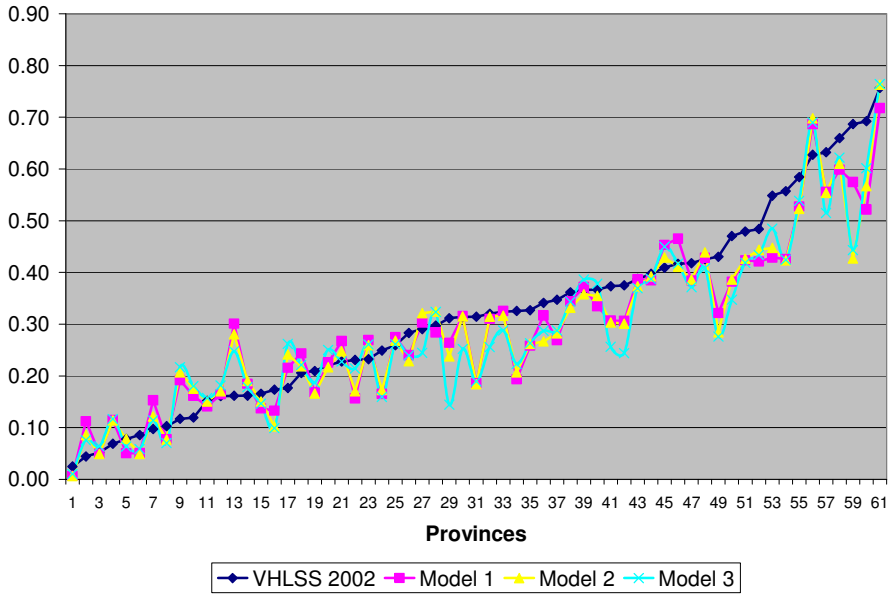


Figure 2: Standard errors of headcount index estimates

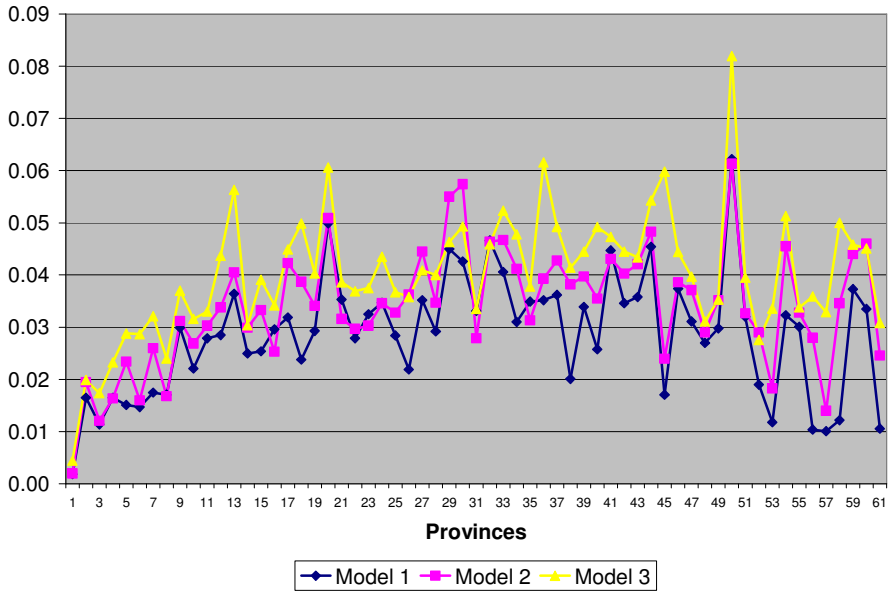
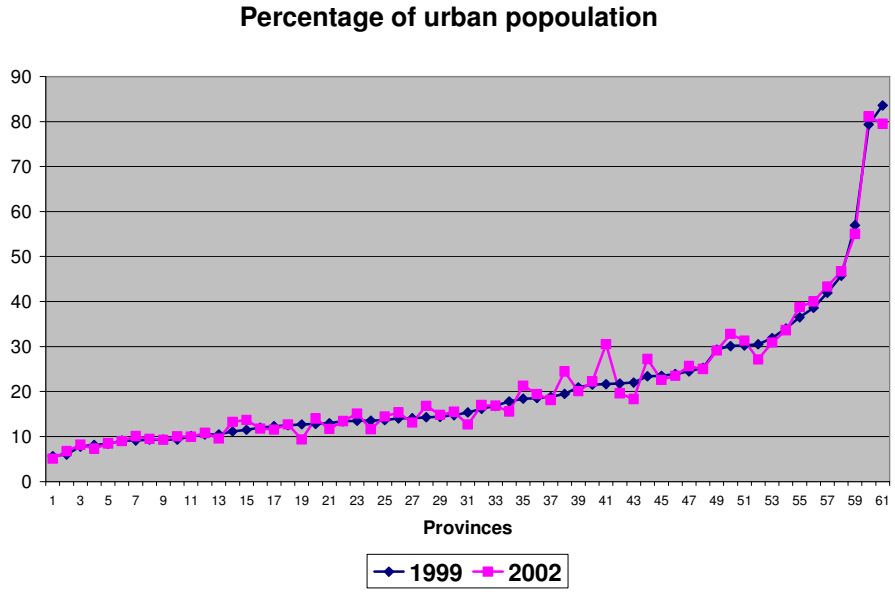


Figure 2 graphs the standard errors of headcount index estimates in the three models. Model 3 results in highest standard errors, while Model 1 has lowest standard

errors. However, we prefer Model 2 to avoid the over-fitting problem when we use a large number of cluster variables.

Although, the 2002 VHLSS is not representative at the provincial level, its sample size is very large and can be used for comparison. The representativeness of VHLSS 2002 is assessed by comparing the percentage of urban population between this survey and the census 1999. Figure 3 shows that two data sets give very close estimates of urban share at the provincial level.

Figure 3: The percentage of urban population of provinces in Census 1999 and VHLSS 2002



Since the 2002 VHLSS is representative at the regional level, we compare the estimates of regional poverty rate between the mapping method and the 2002 VHLSS. Figure 4 shows that poverty estimates of poverty mapping method are lower than those based on the survey.

Figure 5 presents the estimates of poverty headcount index for the years 1999 and 2002 at the provincial level. It shows that most of provinces experienced a reduction in poverty rate. However, it is not a clear trend that the poverty reduction is higher for the provinces with high poverty in 1999. In addition, poverty estimates increased for several provinces. Figure 6 presents the poverty maps of these years.

Figure 4: Poverty estimates of regions

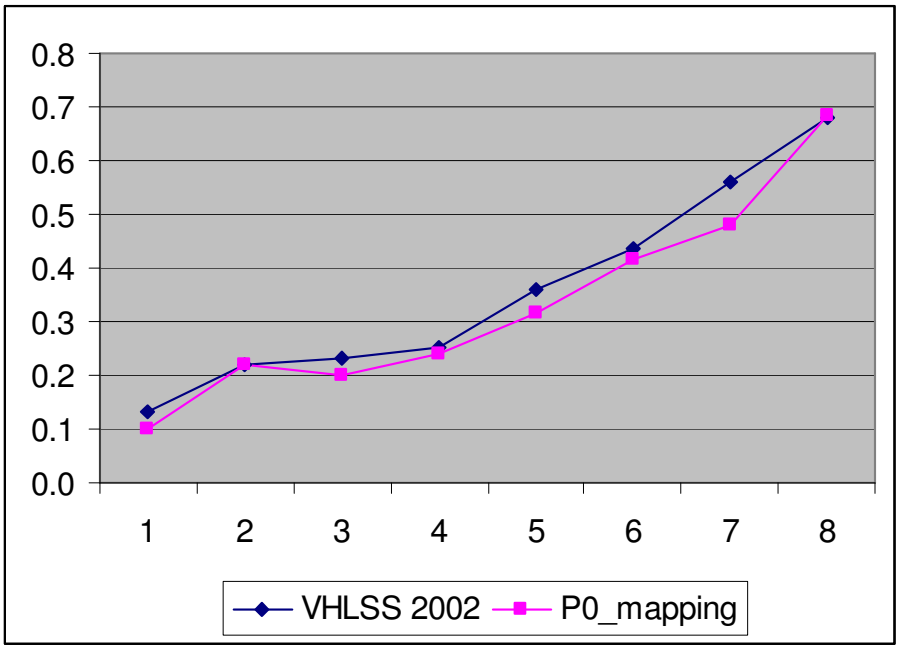


Figure 5: Estimates of poverty headcount index in 1999 and 2002

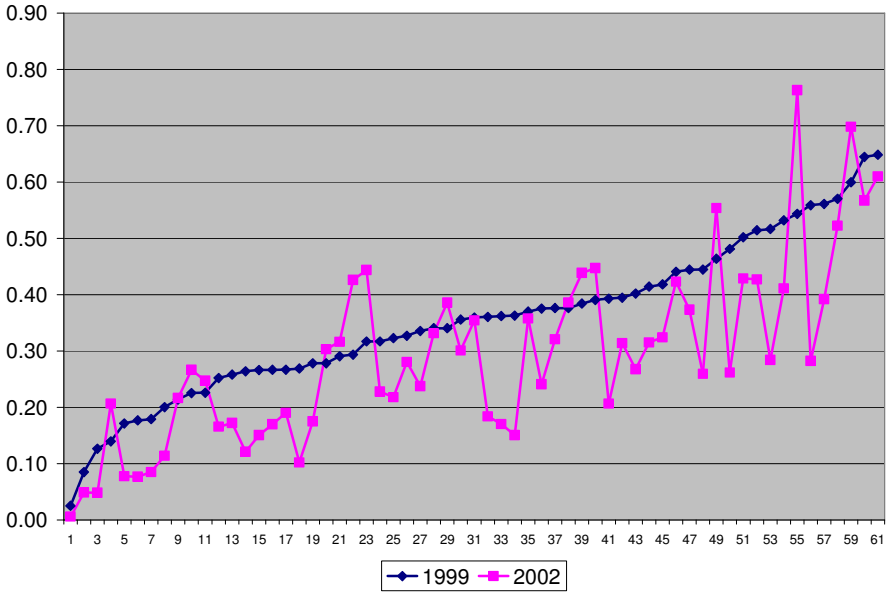


Figure 6: Poverty Map in 1999 and 2002

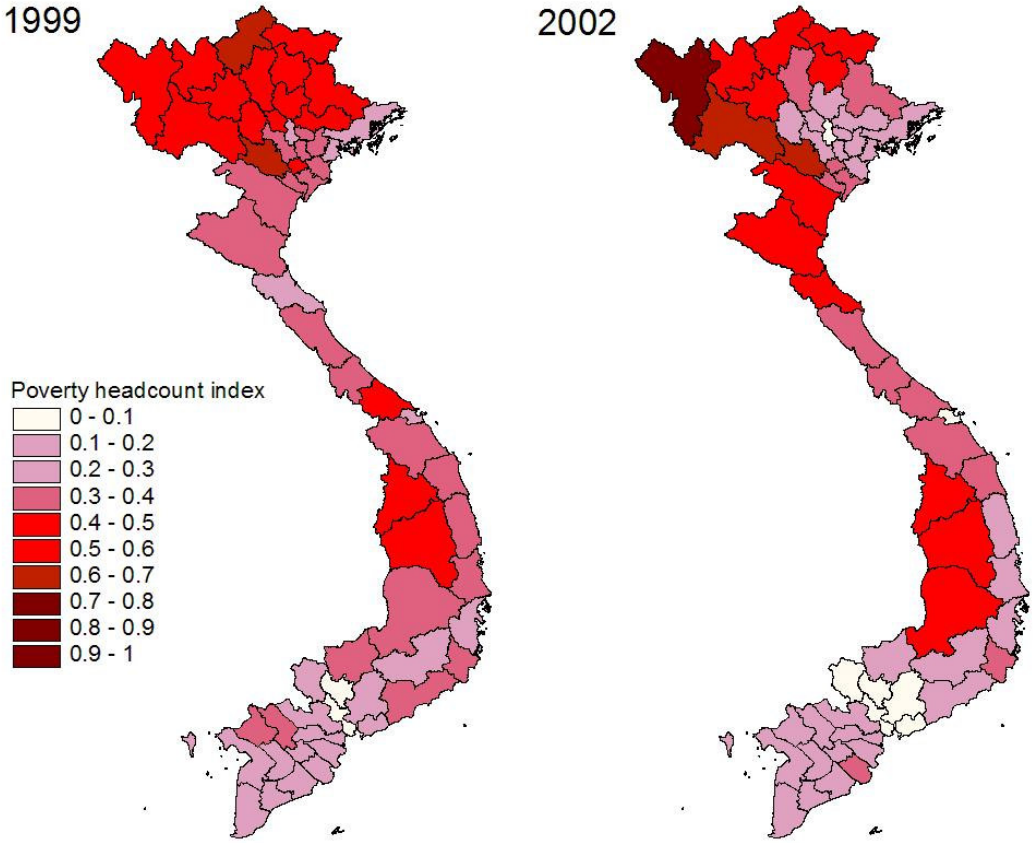
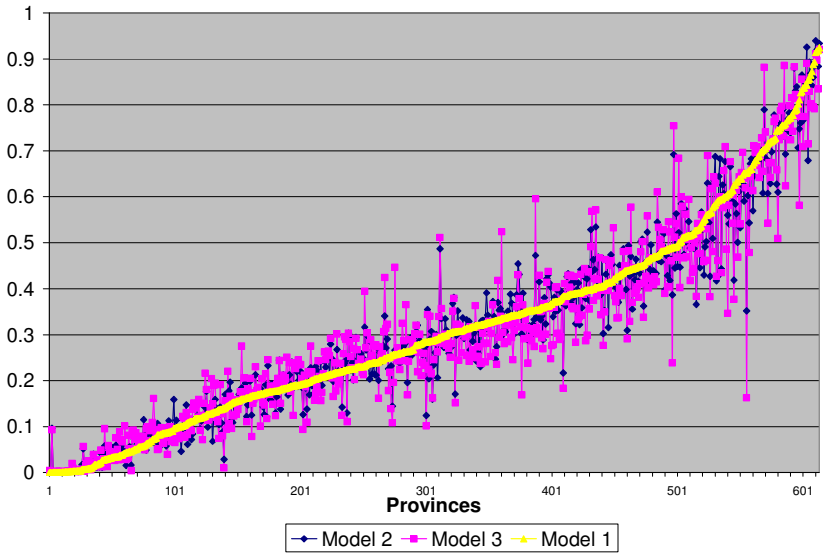


Figure 7: Poverty estimates of districts



Poverty estimates at the district level are graphed in Figure 7. It shows that differences in poverty estimates among three models at the district level are much larger than at the provincial level (Figure 1).

Finally, Table 3 presents the estimates of poverty depth and severity indexes (P1 and P2), and Gini index from Model 2.

Table 3: Estimates of poverty depth and severity indexes and Gini index

	P0		**P1**		**P2**		**Gini**	
Provinces	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
101	0.0488	0.0121	0.0084	0.0025	0.0023	0.0008	0.3691	0.0137
103	0.1755	0.0269	0.0342	0.0071	0.0101	0.0025	0.3422	0.0179
105	0.2680	0.0328	0.0538	0.0089	0.0163	0.0032	0.2687	0.0094
107	0.1706	0.0297	0.0306	0.0066	0.0086	0.0021	0.2523	0.0093
109	0.2413	0.0423	0.0459	0.0103	0.0134	0.0034	0.2323	0.0058
111	0.3151	0.0574	0.0656	0.0175	0.0205	0.0069	0.2320	0.0087
113	0.3211	0.0445	0.0682	0.0131	0.0214	0.0049	0.2644	0.0146
115	0.3010	0.0403	0.0616	0.0116	0.0189	0.0044	0.2426	0.0087
117	0.3145	0.0464	0.0666	0.0136	0.0209	0.0052	0.2558	0.0107
201	0.5671	0.0460	0.1496	0.0206	0.0538	0.0098	0.2800	0.0104
203	0.4232	0.0455	0.0998	0.0165	0.0332	0.0071	0.3060	0.0149
205	0.5228	0.0328	0.1443	0.0160	0.0537	0.0080	0.3209	0.0118
207	0.4272	0.0440	0.1060	0.0170	0.0371	0.0077	0.2818	0.0113
209	0.3735	0.0421	0.0852	0.0137	0.0279	0.0055	0.3087	0.0130
211	0.3923	0.0483	0.0930	0.0169	0.0315	0.0071	0.2968	0.0118
213	0.4113	0.0386	0.1035	0.0147	0.0365	0.0065	0.3188	0.0155
215	0.2597	0.0303	0.0541	0.0086	0.0168	0.0033	0.2972	0.0131
217	0.2842	0.0352	0.0577	0.0102	0.0174	0.0039	0.2766	0.0101
219	0.2826	0.0428	0.0552	0.0117	0.0162	0.0042	0.2451	0.0101
221	0.2618	0.0313	0.0513	0.0082	0.0151	0.0029	0.2576	0.0086
223	0.2069	0.0312	0.0397	0.0077	0.0116	0.0026	0.2653	0.0102
225	0.1141	0.0164	0.0211	0.0036	0.0060	0.0012	0.3024	0.0118
301	0.7630	0.0246	0.3201	0.0203	0.1622	0.0149	0.3570	0.0150
303	0.6982	0.0280	0.2333	0.0200	0.0989	0.0120	0.3617	0.0141
305	0.6100	0.0346	0.1869	0.0206	0.0756	0.0115	0.3239	0.0157
401	0.4439	0.0290	0.1119	0.0107	0.0398	0.0048	0.2681	0.0082
403	0.4389	0.0290	0.1144	0.0108	0.0418	0.0048	0.2867	0.0109
405	0.4263	0.0327	0.1080	0.0125	0.0389	0.0057	0.2767	0.0080
407	0.3580	0.0397	0.0855	0.0133	0.0294	0.0056	0.2831	0.0104
409	0.3862	0.0371	0.1030	0.0133	0.0385	0.0059	0.3136	0.0127
411	0.3246	0.0347	0.0831	0.0129	0.0304	0.0058	0.3416	0.0198
501	0.0853	0.0195	0.0180	0.0051	0.0059	0.0019	0.3461	0.0217
503	0.3319	0.0382	0.0821	0.0115	0.0298	0.0049	0.2521	0.0079
505	0.3547	0.0355	0.0916	0.0106	0.0341	0.0046	0.2684	0.0109
507	0.2282	0.0363	0.0467	0.0095	0.0146	0.0035	0.2629	0.0117
509	0.2184	0.0387	0.0461	0.0100	0.0147	0.0037	0.2643	0.0114
511	0.1214	0.0260	0.0245	0.0061	0.0077	0.0022	0.3019	0.0185
601	0.4289	0.0240	0.1236	0.0105	0.0484	0.0053	0.3681	0.0116

	P0		P1		P2		Gini	
Provinces	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.	Est.	Std. Err.
603	0.5540	0.0140	0.2101	0.0084	0.1020	0.0056	0.3893	0.0110
605	0.4474	0.0183	0.1280	0.0078	0.0512	0.0040	0.3073	0.0089
701	0.0063	0.0020	0.0009	0.0004	0.0002	0.0001	0.3021	0.0138
703	0.2668	0.0393	0.0705	0.0142	0.0267	0.0065	0.3297	0.0162
705	0.3864	0.0613	0.1072	0.0251	0.0416	0.0121	0.3607	0.0341
707	0.2377	0.0550	0.0557	0.0172	0.0192	0.0071	0.2770	0.0110
709	0.1023	0.0253	0.0185	0.0058	0.0053	0.0020	0.2675	0.0099
711	0.0493	0.0160	0.0084	0.0035	0.0023	0.0011	0.2804	0.0157
713	0.0771	0.0168	0.0137	0.0037	0.0038	0.0012	0.2825	0.0160
715	0.2806	0.0405	0.0662	0.0132	0.0229	0.0056	0.3369	0.0275
717	0.0780	0.0234	0.0135	0.0050	0.0037	0.0016	0.2851	0.0179
801	0.1904	0.0299	0.0393	0.0081	0.0122	0.0030	0.2884	0.0099
803	0.1842	0.0279	0.0354	0.0070	0.0104	0.0025	0.2667	0.0097
805	0.1507	0.0303	0.0294	0.0075	0.0087	0.0027	0.2862	0.0117
807	0.1507	0.0333	0.0296	0.0081	0.0089	0.0028	0.2833	0.0118
809	0.1726	0.0346	0.0332	0.0084	0.0097	0.0029	0.2717	0.0136
811	0.1703	0.0338	0.0325	0.0081	0.0095	0.0027	0.2605	0.0087
813	0.2476	0.0316	0.0551	0.0097	0.0180	0.0039	0.3224	0.0185
815	0.1657	0.0341	0.0329	0.0088	0.0099	0.0032	0.2932	0.0167
817	0.3165	0.0467	0.0728	0.0151	0.0243	0.0062	0.2794	0.0104
819	0.3033	0.0431	0.0698	0.0137	0.0233	0.0055	0.2868	0.0095
821	0.2168	0.0509	0.0465	0.0143	0.0149	0.0054	0.2806	0.0109
823	0.2069	0.0412	0.0438	0.0114	0.0139	0.0044	0.2882	0.0133

6. CONCLUSION

The present study is to combine Population Census 1999 and VHLSS 2002 to estimate poverty and inequality for the year 2002 using the poverty mapping method of Elbers *et al.* (2003). Although the estimates from this method are rather close to those based on the 2002 VHLSS at the regional level, they are not very close at the provincial level. One possible reason is that there could be population changes between the districts and provinces during the period 1999-2002. In addition, the population growth can be very different between districts and provinces. The modeling of these population changes should be taken into account in the future studies to produce more accurate estimates of welfares.

REFERENCE

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APPENDIX: REGRESSION RESULTS OF MODEL 2

Table 4: Name and meaning of explanatory variables in expenditure model

Variable name	Meaning
AGE	Head age
AGESQUARED	Head age squared
DAGRI_1	Member working in agriculture
ETHNIC_1	Head ethnic minorities
HEADEDU1_1	Head primary school
HEADEDU4_1	Head post secondary school
HEADOC1_1	Head Leaders/Managers
HEADOC2_1	Head Professionals/Technicians
HEADOC3_1	Head Clerks/Service Workers
HOUSETP1_1	Permanent house
LC_ARABLE	% arable land
LNAGE	Log of head age
RWORK_C	Commune ratio of working people
HEADEDU2_C	Commune ratio of head post secondary
MKTPERCOM	Number of markets per commune
MAINROAD_DEN	Main road density
MINRROAD_DEN	Minor road density
MKTPAYM	Market payment to State
LC_NATFOR	% natural land
LC_PLANTFOR	% planted land
PREC_ANNUAL	Annual rainfall
HEADEDU1_C	Commune ratio of head primary school
HEADEDU3_C	Commune ratio of head upper-sec school
HEADEDU4_C	Commune ratio of head post secondary
REDUC1_C	Commune ratio of people with primary school
REDUC2_C	Commune ratio of people withlower-secondary
HEADOC3_C	Commune ratio of head clerks/services
HEADOC4_C	Commune ratio of head agriculture
HEADOC6_C	Commune ratio of head Unskilled Workers
HEADOC7_C	Commune ratio of head not working
SPOUSEEDU2_1	Spouse primary school
SPOUSEEDU3_C	Commune ratio of spouse lower-sec school
SPOUSEEDU4_C	Commune ratio of spouse upper-seco secondary
SPOUSEOC2_1	Ratio of spouse leaders/managers
SPOUSEOC3_1	Spouse professionals/technicians
SPOUSEOC4_1	Spouse clerks/service workers
SPOUSEOC2_C	Commune ratio of spouse leaders
SPOUSEOC3_C	Commune ratio of spouse professionals/technicians
SPOUSEOC4_C	Commune ratio of spouse clerk/services
SPOUSEOC5_C	Commune ratio of spouse agri.
SPOUSEOC8_C	Commune ratio of spouse not working
RAGRI_C	Commune ratio of agr. workers
TOILETTP1_C	Commune ratio of flush toilet
TOILETTP2_C	Commune ratio of other toilet
TOILETTP3_C	Commune ratio of no toilet

Variable name	Meaning
TOILETTP3_1	Have no toilet
TV_C	Commune ratio of having TV
RADIO_C	Commune ratio of having radio
WATERTP1_C	Commune ratio of tap water
WATERTP2_C	Commune ratio of clean water
WATERTP3_C	Commune ratio of unclean water
WATERTP1_1	Tap water
HOUSETP1_C	Commune ratio of permanent house
HOUSETP3_C	Commune ratio of temporary house
PCTSLOPE1	Pct 0-4% slope
ROAD_KM	Length of roads
TRACKS_DENS	Track density
TEMP_AVG	Average temperature
HUM_AVG	Average humidity
SUN_ANNUAL	Annual sunshine duration
_URBAN$AGESQUARED	Urban * Head age squared
_URBAN$TOILETTP1_C	Urban * Commune ratio of flush toilet
_URBAN$HOUSETP1_C	Urban * Commune ratio of permanent house
_URBAN$HOUSETP2_C	Urban * Commune ratio of semi-permanent house
_URBAN$HOUSETP3_C	Urban * Commune ratio of temporary house
_URBAN$MAINROAD_DEN	Urban * Main road density
_URBAN$MINRROAD_DEN	Urban * Minor road density
_URBAN$HEADEDU1#1	Urban * Head primary school
_URBAN$HEADEDU3_C	Urban * Head upper-secondary
_URBAN$REDUC4_C	Urban * Commune ratio of post secondary
_URBAN$SPOUSEEDU5_C	Urban * Commune ratio of spouse post secondary
_URBAN$SPOUSEOC2#1	Urban * Spouse leaders/managers
_URBAN$SPOUSEOC4#1	Urban * Spouse clerks/service workers
_URBAN$SPOUSEOC8_C	Urban * Spouse not working
_URBAN$WATERTP1#1	Urban * Tap water
_URBAN$WATERTP2_C	Urban * Commune ratio of clean water
_URBAN$TOILETTP3#1	Urban * No toilet
_URBAN$TOILETTP3_C	Urban * Commune ratio of no toilet
_URBAN$HOUSETP1#1	Urban * Permanent house
_URBAN$DAGRI#1	Urban * Agr. Worker
_URBAN$ETHNIC#1	Urban * Head ethnic minorities
_URBAN$LC_BAREROCKY	Urban * % bare land
_URBAN$LC_PLANTFOR	Urban * % planted forest
_URBAN$LC_NATFOR	Urban * % natural forest
_URBAN$SPOUSEEDU2#1	Urban * Spouse primary school
_URBAN$SPOUSEOC3#1	Urban * Spouse clerks/service workers
_URBAN$MKTPAYM	Urban * Market payment to State
_URBAN$MKTPERCOM	Urban * Number of market per commune
_URBAN$RWORK_C	Urban * Commune ratio of working peole
_URBAN$TRACKS_DENS	Urban * Track density

Table 5: Expenditure model of Region 1 “Red River Delta”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	11.8408	0.9792	12.0922	0.0000
AGE	0.1098	0.0185	5.9377	0.0000
AGESQUARED	-0.0007	0.0001	-6.8662	0.0000
DAGRI_1	-0.1940	0.0136	-14.2510	0.0000
HEADEDU1_1	-0.2134	0.0181	-11.8091	0.0000
HEADEDU4_1	0.1795	0.0282	6.3603	0.0000
HEADOC1_1	0.2759	0.0398	6.9302	0.0000
HEADOC2_1	0.1909	0.0294	6.4950	0.0000
HEADOC3_1	0.1650	0.0285	5.7813	0.0000
HOUSETP1_1	0.1557	0.0125	12.4516	0.0000
LC_ARABLE	-0.3426	0.0486	-7.0480	0.0000
LNAGE	-1.8261	0.4217	-4.3303	0.0000
PREC_ANNUAL	-0.0006	0.0001	-8.4803	0.0000
REDUC1_C	1.0914	0.1574	6.9345	0.0000
SPOUSEEDU2_1	-0.1021	0.0191	-5.3403	0.0000
SPOUSEOC3_1	0.1925	0.0283	6.7905	0.0000
TOILETTP1_C	0.4848	0.0498	9.7317	0.0000
TV_C	0.7607	0.0637	11.9323	0.0000
_URBAN$REDUC4_C	3.5940	0.2485	14.4601	0.0000
_URBAN$SPOUSEEDU5_C	-4.9644	0.4331	-11.4625	0.0000
Number of obs.	5240			
Number of regressors	159			
Number of regressors in model	20			
Adjusted R squared	0.6102			
Number of clusters in survey	91			
Number of clusters in census	93			
$\hat{\sigma}_\eta^2 / \hat{\sigma}_u^2$	0.085			

Table 6: Expenditure model of Region 2 “North East”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	18.7310	1.0360	18.0797	0.0000
AGE	0.1265	0.0180	7.0464	0.0000
AGESQUARED	-0.0008	0.0001	-7.7514	0.0000
DAGRI_1	-0.2321	0.0159	-14.5652	0.0000
ETHNIC_1	-0.1561	0.0163	-9.5626	0.0000
HEADEDU1_1	-0.1561	0.0159	-9.8101	0.0000
HEADEDU2_C	-0.5301	0.0514	-10.3137	0.0000
HEADEDU4_1	0.1858	0.0347	5.3511	0.0000
HEADOC2_1	0.2045	0.0335	6.0981	0.0000
HEADOC3_1	0.1304	0.0282	4.6218	0.0000
HOUSETP1_1	0.2093	0.0153	13.6654	0.0000
HUM_AVG	-0.0749	0.0076	-9.8492	0.0000
LNAGE	-2.2030	0.3813	-5.7779	0.0000
SPOUSEEDU2_1	-0.1026	0.0164	-6.2456	0.0000
SPOUSEOC3_1	0.2119	0.0273	7.7710	0.0000
SPOUSEOC5_C	-0.0484	0.0492	-0.9852	0.3246
TOILETTP3_1	-0.1717	0.0190	-9.0287	0.0000
TV_C	0.4720	0.0535	8.8202	0.0000
_URBAN$SPOUSEOC2#1	0.5271	0.1298	4.0612	0.0000
_URBAN$WATERTP3_C	0.3606	0.0787	4.5791	0.0000
Number of obs.	4816			
Number of regressors	159			
Number of regressors in model	20			
Adjusted R squared	0.5141			
Number of clusters in survey	116			
Number of clusters in census	129			
$\hat{\sigma}_{\eta}^{2} / \hat{\sigma}_{u}^{2}$	0.088			

Table 7: Expenditure model of Region 3 “North West”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	4.1493	0.5792	7.1640	0.0000
AGESQUARED	0.0000	0.0000	3.8057	0.0002
DAGRI_1	-0.1887	0.0478	-3.9508	0.0001
ETHNIC_1	-0.1825	0.0368	-4.9664	0.0000
HEADEDU1_1	-0.1678	0.0332	-5.0510	0.0000
HEADOC1_1	0.3431	0.0652	5.2593	0.0000
HEADOC7_C	-1.4456	0.3211	-4.5014	0.0000
MINRROAD_DEN	-0.1232	0.0406	-3.0361	0.0025
PCTSLOPE1	0.0098	0.0015	6.4098	0.0000
REDUC2_C	1.3127	0.3690	3.5570	0.0004
RINDUSTRY_C	1.0516	0.3201	3.2854	0.0011
ROAD_DENS	-0.0568	0.0096	-5.9068	0.0000
SPOUSEEDU2_1	-0.1134	0.0335	-3.3848	0.0007
SPOUSEEDU3_C	-1.7110	0.2322	-7.3692	0.0000
SPOUSEOC3_1	0.2942	0.0606	4.8523	0.0000
TEMP_AVG	0.1862	0.0275	6.7581	0.0000
TOILETTP3_1	-0.1152	0.0361	-3.1875	0.0015
TV_C	0.8651	0.1154	7.4965	0.0000
WATERTP2_C	-0.2134	0.0613	-3.4782	0.0005
_URBAN$LC_BAREROCKY	0.0186	0.0038	4.8692	0.0000
Number of obs.	938			
Number of regressors	154			
Number of regressors in model	20			
Adjusted R squared	0.6356			
Number of clusters in survey	28			
Number of clusters in census	30			
$\hat{\sigma}_{\eta}^{2} / \hat{\sigma}_{u}^{2}$	0.067			

Table 8: Expenditure model of Region 4 “North Central Coast”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	8.0166	1.1809	6.7887	0.0000
AGE	0.0946	0.0217	4.3703	0.0000
AGESQUARED	-0.0006	0.0001	-4.8994	0.0000
DAGRI_1	-0.2505	0.0210	-11.9039	0.0000
HEADEDU1_1	-0.1239	0.0205	-6.0432	0.0000
HEADOC1_1	0.3153	0.0474	6.6562	0.0000
HEADOC2_1	0.3436	0.0399	8.6096	0.0000
HEADOC3_1	0.2042	0.0553	3.6952	0.0002
HEADOC4_C	-0.2056	0.0689	-2.9857	0.0029
HOUSETP1_1	0.1792	0.0236	7.6011	0.0000
LNAGE	-1.6264	0.4819	-3.3750	0.0007
SPOUSEEDU2_1	-0.1300	0.0202	-6.4498	0.0000
SPOUSEOC3_1	0.2403	0.0370	6.4884	0.0000
TEMP_AVG	0.1268	0.0181	7.0218	0.0000
TOILETTP3_1	-0.1340	0.0241	-5.5642	0.0000
TRACKS_DENS	-0.0193	0.0040	-4.8204	0.0000
TV_C	0.5985	0.0592	10.1150	0.0000
_URBAN$DAGRI#1	0.1629	0.0443	3.6779	0.0002
_URBAN$RINDUSTRY_C	-0.9377	0.1911	-4.9055	0.0000
_URBAN$WATERTP1#1	0.2806	0.0432	6.4939	0.0000
Number of obs.	3272			
Number of regressors	159			
Number of regressors in model	20			
Adjusted R squared	0.4533			
Number of clusters in survey	77			
Number of clusters in census	81			
$\hat{\sigma}_{\eta}^{2} / \hat{\sigma}_{u}^{2}$	0.076			

Table 9: Expenditure model of Region 5 “South Central Coast”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	6.8041	0.2597	26.1972	0.0000
AGESQUARED	-0.0001	0.0000	-4.2540	0.0000
DAGRI_1	-0.1346	0.0178	-7.5609	0.0000
ETHNIC_1	-0.4141	0.0756	-5.4760	0.0000
HEADEDU1_1	-0.1606	0.0200	-8.0233	0.0000
HEADEDU4_1	0.1484	0.0421	3.5232	0.0004
HEADOC2_1	0.1382	0.0404	3.4198	0.0006
HOUSETP1_1	0.3044	0.0306	9.9558	0.0000
HOUSETP3_C	-0.3045	0.0620	-4.9123	0.0000
LNAGE	0.4344	0.0746	5.8210	0.0000
MINRROAD_DEN	0.0186	0.0033	5.5888	0.0000
PREC_ANNUAL	-0.0001	0.0000	-7.3523	0.0000
REDUC1_C	0.4810	0.1469	3.2737	0.0011
ROAD_KM	0.0000	0.0000	-5.1179	0.0000
SPOUSEOC3_1	0.1845	0.0432	4.2692	0.0000
TOILETTP1_C	0.2620	0.0632	4.1448	0.0000
TOILETTP3_1	-0.1931	0.0177	-10.8999	0.0000
WATERTP1_1	0.1792	0.0294	6.0863	0.0000
WATERTP1_C	-0.3346	0.0940	-3.5591	0.0004
_URBAN$MKTPAYM	0.0000	0.0000	5.7095	0.0000
Number of obs.	2600			
Number of regressors	160			
Number of regressors in model	20			
Adjusted R squared	0.5349			
Number of clusters in survey	49			
Number of clusters in census	58			
$\hat{\sigma}_{\eta}^{2} / \hat{\sigma}_{u}^{2}$	0.0744			

Table 10: Expenditure model of Region 6 “Central Highland”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	9.2504	0.4490	20.6026	0.0000
DAGRI_1	-0.1621	0.0403	-4.0249	0.0001
ETHNIC_1	-0.3055	0.0312	-9.7793	0.0000
HEADEDU1_1	-0.1830	0.0304	-6.0248	0.0000
HEADOC1_1	0.5780	0.1067	5.4150	0.0000
HEADOC2_1	0.3709	0.0761	4.8765	0.0000
HOUSETP1_1	0.1949	0.0582	3.3514	0.0008
LC_ARABLE	0.5695	0.1119	5.0875	0.0000
LC_NATFOR	0.0053	0.0009	5.7917	0.0000
LNAGE	0.1612	0.0431	3.7368	0.0002
REDUC3_C	2.6159	0.6300	4.1520	0.0000
SPOUSEEDU5_C	8.2310	2.0783	3.9605	0.0001
SPOUSEOC5_C	0.5383	0.1367	3.9368	0.0001
SUN_ANNUAL	-0.0013	0.0002	-6.8744	0.0000
TOILETTP3_1	-0.1010	0.0305	-3.3109	0.0010
WATERTP1_1	0.1461	0.0563	2.5935	0.0096
_URBAN$HEADEDU4#1	0.2838	0.0983	2.8864	0.0040
_URBAN$HOUSETP1#1	0.2734	0.0843	3.2441	0.0012
_URBAN$HOUSETP2_C	0.5362	0.1010	5.3086	0.0000
_URBAN$REDUC4_C	-7.0019	1.1740	-5.9641	0.0000
Number of obs.	1114			
Number of regressors	157			
Number of regressors in model	20			
Adjusted R squared	0.5769			
Number of clusters in survey	32			
Number of clusters in census	37			
$\hat{\sigma}_\eta^2 / \hat{\sigma}_u^2$	0.027			

Table 11: Expenditure model of Region 7 “North East South”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	7.5747	0.0623	121.5565	0.0000
DAGRI_1	-0.1503	0.0194	-7.7584	0.0000
ETHNIC_1	-0.2755	0.0383	-7.1876	0.0000
HEADEDU1_1	-0.0801	0.0164	-4.8953	0.0000
HEADEDU4_1	0.3071	0.0355	8.6418	0.0000
HOUSETP1_1	0.2676	0.0222	12.0608	0.0000
LC_NATFOR	0.0024	0.0003	6.9676	0.0000
PCTSLOPE1	0.0036	0.0005	7.7613	0.0000
RINDUSTRY_C	0.6390	0.0703	9.0874	0.0000
ROAD_DENS	-0.0279	0.0026	-10.5697	0.0000
ROAD_KM	0.0000	0.0000	-6.2367	0.0000
TOILETTP3_1	-0.1842	0.0227	-8.1005	0.0000
TRACKS_DENS	0.0454	0.0041	11.0395	0.0000
TV_C	0.4446	0.0753	5.9083	0.0000
_URBAN$AGESQUARED	0.0000	0.0000	-5.1074	0.0000
_URBAN$MKTPERCOM	-0.1806	0.0207	-8.7337	0.0000
_URBAN$ROAD_DENS	0.0369	0.0026	14.0487	0.0000
_URBAN$SPOUSEEDU5_C	2.6291	0.3642	7.2189	0.0000
_URBAN$WATERTP1#1	0.2816	0.0250	11.2494	0.0000
Number of obs.	3806			
Number of regressors	159			
Number of regressors in model	19			
Adjusted R squared	0.6307			
Number of clusters in survey	81			
Number of clusters in census	84			
$\hat{\sigma}_\eta^2 / \hat{\sigma}_u^2$	0.096			

Table 12: Expenditure model of Region 8 “Mekong River Delta”

	Coefficient	Std. Err.	t	|Prob|>t
intercept	7.4917	0.1081	69.3175	0.0000
DAGRI_1	-0.1051	0.0144	-7.2861	0.0000
ELEV_MEAN	0.0058	0.0008	7.4368	0.0000
ETHNIC_1	-0.1543	0.0246	-6.2819	0.0000
HEADEDU1_1	-0.1515	0.0130	-11.6329	0.0000
HEADOC2_1	0.2560	0.0397	6.4519	0.0000
HOUSETP1_1	0.3343	0.0250	13.3575	0.0000
HOUSETP1_C	-2.5688	0.3244	-7.9173	0.0000
HOUSETP3_C	-0.5148	0.0548	-9.3874	0.0000
LNAGE	0.1845	0.0206	8.9445	0.0000
MKTPERCOM	0.0753	0.0102	7.3531	0.0000
RADIO_C	0.4232	0.0826	5.1241	0.0000
SPOUSEEDU2_1	-0.1234	0.0125	-9.8540	0.0000
SPOUSEOC2_C	18.5993	3.9339	4.7279	0.0000
SPOUSEOC8_C	0.2681	0.0428	6.2613	0.0000
TOILETTP3_1	-0.1104	0.0151	-7.3284	0.0000
WATERTP1_1	0.1398	0.0174	8.0260	0.0000
_URBAN$AGESQUARED	-0.0001	0.0000	-7.2447	0.0000
_URBAN$HEADOC3#1	0.1782	0.0441	4.0422	0.0001
_URBAN$HOUSETP1_C	2.1786	0.3441	6.3315	0.0000
_URBAN$SPOUSEEDU5#1	0.2965	0.0712	4.1625	0.0000
_URBAN$TOILETTP3_C	0.3495	0.0632	5.5284	0.0000
Number of obs.	5908			
Number of regressors	159			
Number of regressors in model	22			
Adjusted R squared	0.3364			
Number of clusters in survey	102			
Number of clusters in census	107			
$\hat{\sigma}_{\eta}^{2} / \hat{\sigma}_{u}^{2}$	0.101			