The Impact of Piped Water on Household Welfare: Evidence from Vietnam

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ABSTRACT

Clean water is essential for human survival, yet many people do not have access to clean water in Vietnam. Only around 23 percent of the population had access to piped water in 2006. Other households have to use water from wells, rivers, and ponds without any purification. This study measured the effect of piped water on household welfare using difference-in-differences estimators on panel data from the Vietnam Household Living Standard Surveys. Results showed a positive effect of piped water on household income and labor supply, but these were not statistically significant. Piped water showed a negative effect on sickness of household members, but this was also not statistically significant.

1.0 INTRODUCTION

Clean water is essential for human living. Yet, many poor people do not have access to sufficient and clean water. And the use of unimproved water was prevalent in low-income countries as found by Komives et al. (2003) using living standard measurement surveys in the 1990s. According to UNICEF (2010), "over 884 million people still use unsafe drinking water sources".

Unclean water can cause diseases, health problems, and low working productivity, low income and consumption, thereby poverty. On the other hand, poverty means low income and poor living conditions as well as limited access to clean water.

Lack of clean water causes diseases and sickness. The World Health Organization (2004) attests that contaminated water causes thousands of deaths every day, mostly of children under five years in developing countries. UNDP (2006) likewise claims that unsafe water and shortage of basic sanitation cause 80 percent of diseases in developing countries.

Many empirical studies show the linkage between water and welfare.[1] Collin et al. (1981) found that epidemics tended to be associated with poor quality water in France. But the provision of clean water enhanced welfare. Dasgupta (2004) found that increased availability of water reduced the incidence of water-washed diseases in India. Galiani et al. (2005) found that the privatization of water services reduced child mortality in Argentina. In Brazil, Macinko et al. (2005) found that access to clean water was negatively associated with infant mortality. Piped water also reduced the diarrhea of children in rural India as shown in the study of Jalan and Ravallion (2003). Recently, Gamper-Rabindran et al. (2010) showed that the provision of piped water reduced the infant mortality rate in Brazil.

Although there are numerous studies on the effect of piped water on health, only a few studies have investigated its effect on other household welfare indicators such as labor supply and income (Waddington et al., 2009). Only the study of Devoto et al. (2011) examined the effect of water on labor and income. They found that water connection could improve households' leisure and social activities but not income and labor supply in urban Morocco.

There are indications, however, that piped water can increase income in the long-run. Clean water can reduce health problems, hence enhancing working efforts and income. Piped water in households save members from using other water sources, some of which can be very far from their homes and require

[1] For review of studies on the effect of water on health, see Fewtrell and Kaufmann (2005), Günther and Fink (2010), Waddington et al. (2009), and Fewtrell et al. (2009).

purification before use. Thus, having piped water can save time for people and allow them more productive activities and increasing income.

This study aims to measure the impact of piped water on several household welfare indicators in Vietnam such as income, labor supply, and health. The study used recent household surveys and difference-in-differences estimators.

Vietnam is an interesting case study for the effect of piped water. First, the country has a low proportion of people with access to improved water. According to the Vietnam Household Living Standard Survey in 2006, around 26 percent of the population and only 4.3 percent of the poor had access to piped water. Around 80 percent of cases of infectious diseases are related with unclean water (Xuan-Long, 2010). Nearly one million diarrheal cases are reported ever year (MOH, 2008).

Considering the situation, the provision of improved water supply is an important policy of the government of Vietnam. Since 1998, the government has launched a national program on clean water and sanitation for the rural areas with the aim of improving the people's health and of reducing poverty. Thus, policy makers as well as researchers are interested in the effect of improved water supply on welfare outcomes of households in Vietnam.

Second, there are still no quantitative and evidence-based studies that measure the effect of clean water on the household welfare in Vietnam. The many studies on the quality of drinking water in Vietnam (Hoang,1990; Le et al.,1993; Nguyen et al.,1994; Le and Munekage, 2004; and Agusa et al.,2006) focused on the chemical aspects of water. Other studies mentioned the adverse effects of unclean water on health but without giving any quantitative evidences (World Bank, 2000 and 2004; Xuan-Long, 2010; Suc Khoe Newspaper, 2010).

Third, the Vietnam Household Living Standard Surveys (VHLSS) for 2002, 2004, and 2006 are available. These surveys allow the estimation of the effect of piped water on outcomes beyond water-related diseases using the difference-in-differences with matching estimator. The VHLSSs contain data on water use of households and household welfare indicators including sickness, labor supply, and income. The VHLSSs also contain panel data that can allow for the difference-in-differences estimator. A difficulty in measuring the effect of piped water on household welfare is endogeneity of the piped water. However, the difference-in-differences with matching estimator can solve the endogeneity bias provided that this bias is caused by time-invariant unobserved variables.[2]

The paper is structured into six sections. The second section introduces data sources used in this study. The third section presents the access of piped water in Vietnam. The fourth section discusses the methodology. And the fifth section highlights the empirical findings of the impact of piped water on health, labor supply, and income of households. The sixth section gives the conclusion.

2.0 DATA SOURCES

The study relied on data from the Vietnam Household Living Standard Surveys (VHLSS), which were conducted in 2002, 2004, and 2006 by the General Statistics Office of Vietnam (GSO) with technical support from the World Bank (WB). The surveys contain detailed information on households including basic demography, employment and labor force participation, education, health, income, expenditure, housing, fixed assets and durable goods, participation of households in poverty alleviation programs, and access to different water sources. Further, the 2004 and 2006 VHLSS contain information on the sickness of individuals. However, these surveys have no data on diseases and weight and heights of individuals.

The sample size of households in the VHLSS is 74,341 (2002), 45,943 (2004), and 45,945 (2006). Having a panel data of 21,695 households in the 2004 and 2006 VHLSS is very useful. In addition, 10,365

[2] Randomization design and instrumental variables are two ideal methods in dealing with endogeneity. However, randomization design of piped water is difficult to implement in reality. Finding a good instrument for piped water is also challenging. Using a weak or invalid instrument can lead to a large estimation bias.

households are covered in the three VHLSS - 2002, 2004, and 2006. The panel data represent households in the urban and rural areas and at the regional level.

3.0 ACCESS TO PIPED WATER IN VIETNAM

Although Vietnam has achieved remarkable success in poverty reduction, the current poverty rate remains rather high, especially in rural areas where the poverty rate was at 19.7 percent in 2006.[3] The poor are often characterized by poor living conditions including the lack of reliable water shortage. Limited access to improved water and sanitation is often mentioned in most Poverty Participatory Assessment Reports (MONRE, 2007). Compared with other countries in Southeast Asia, Vietnam has a lower proportion of people with access to improved water. In 2000, only around 56 percent of the people had access to improved water supply in Vietnam (WHO, 2000).[4] This is rather low compared to the rate of other Southeast Asian countries such Indonesia (76%), Thailand (80%), Philippines (87%), and Lao (90%) (WHO, 2000).

It is almost impossible to measure the quality of water supply throughout a country. In studies in other countries, water supply is often considered to be improved as piped water is introduced (Fewtrell et al., 2009).

This study examined the impact of piped water on household welfare in Vietnam using the VHLSS. Households with access to piped water are defined as those using piped water for drinking and cooking. Other water sources for drinking include deep drill wells, reinforce-concrete wells, bottled water, ponds, and rivers. Some households use a purification system before using water. Boiling water before drinking is also a popular and effective way to reduce water-related diseases in Vietnam. According to the 2006 VHLSS, around 86 percent of households always boiled their drinking water. However, information on whether piped water was really clean and potable for each household was not available in the data sets.

Figure 1 shows that access to piped water had been increasing in Vietnam. The proportion of households using piped water increased from 17.5 percent in 2002 to 23.2 percent in 2006. The proportion of urban households with piped water increased from 54 percent to 62 percent during the same period. In rural areas, the proportion of households with piped water also increased from 5.9 to 8.4 percent.

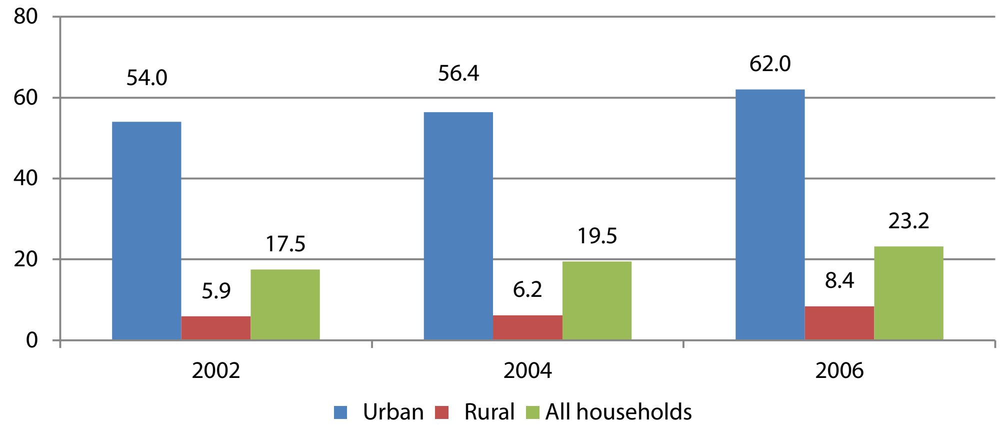

Figure 1. Access to piped water, 2002-2006
Source: Estimation from VHLSSs 2002, 2004, and 2006

[3] This estimation is based on the Vietnam Household Living Standard Survey (VHLSS) in 2006. The poor are classified based on the expenditure poverty line constructed by the World Bank and the General Statistics Office of Vietnam. The poverty line in 2006 is 25,600 VND.

[4] In WHO (2000), improved water includes water from household connection, public standpipe, borehole, protected dug well, protected spring, and rainwater collection.

Access to piped water was widely disparate across geographic areas and among different population groups. The proportion of households with piped water in urban areas was 62 percent compared to a very low 8.4 percent in rural areas in 2006. Households in delta regions were more likely to have access to piped water than households in mountainous areas (Table 1). Disadvantaged households including poor and ethnic minority households had much lower access to tap and clean water than better-off households and Kinh/Chinese households.

Table 1. Households with access to piped water by household characteristics, 2002-2006

Households	2002 (%)	2004 (%)	2006 (%)
Region			
Red River Delta	17.5	17.9	23.7
North East	10.2	12.2	15.9
North West	11.1	8.1	12.2
North Central Coast	10.7	11.6	13.2
South Central Coast	14.1	17.5	21.0
Central Highlands	10.7	12.3	12.0
South East	31.6	37.5	40.8
Mekong River Delta	20.0	20.6	24.8
Ethnicity			
Kinh, Chinese	19.1	21.3	25.4
Ethnic minorities	3.9	3.7	5.4
Poverty			
Non-Poor	22.5	22.9	26.2
Poor	3.1	3.1	4.2
Expenditure quintiles			
Poorest	3.2	3.0	4.3
Near poorest	3.9	6.5	8.7
Middle	7.6	10.0	15.6
Near richest	17.6	20.2	27.7
Richest	48.5	51.5	52.7
All households	**17.5**	**19.5**	**23.2**

Source: Estimation from VHLSSs 2002, 2004, and 2006

Figures 2 to 5 present the geographical pattern of drinking water in Vietnam. Figures 2 and 3 are based on the VHLSS data, which do not allow for estimates at the district level. Figures 4 and 5 use data from the 2006 Agricultural Census, which allow for estimates at the provincial and district levels.

The figures show strong spatial differences in water quality in Vietnam. The use of tap water and clean water was much more prevalent in the delta regions such as the Red River Delta, South East, and Mekong River Delta than in mountainous regions such as North West and North East.

The proportion of households having tap water for drinking was 62 percent for urban areas and only 8.4 percent for rural areas in 2006. Disadvantaged households including poor and ethnic minority households had much lower access to tap and clean water than better-off households and Kinh/Chinese households.

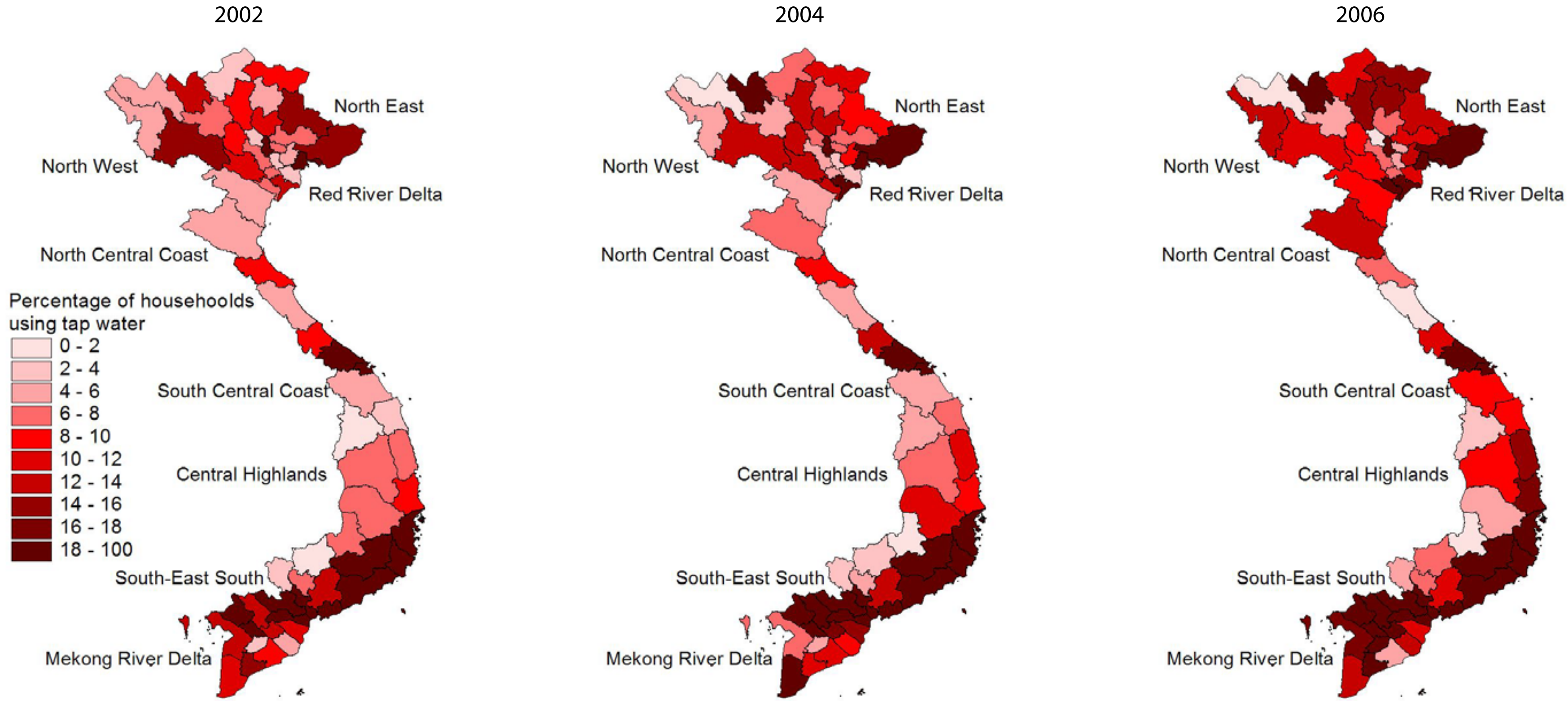

Figure 2. Percentage of households using drinking tap water (in Vietnam)
Source: Estimation from VHLSSs 2002, 2004, and 2006

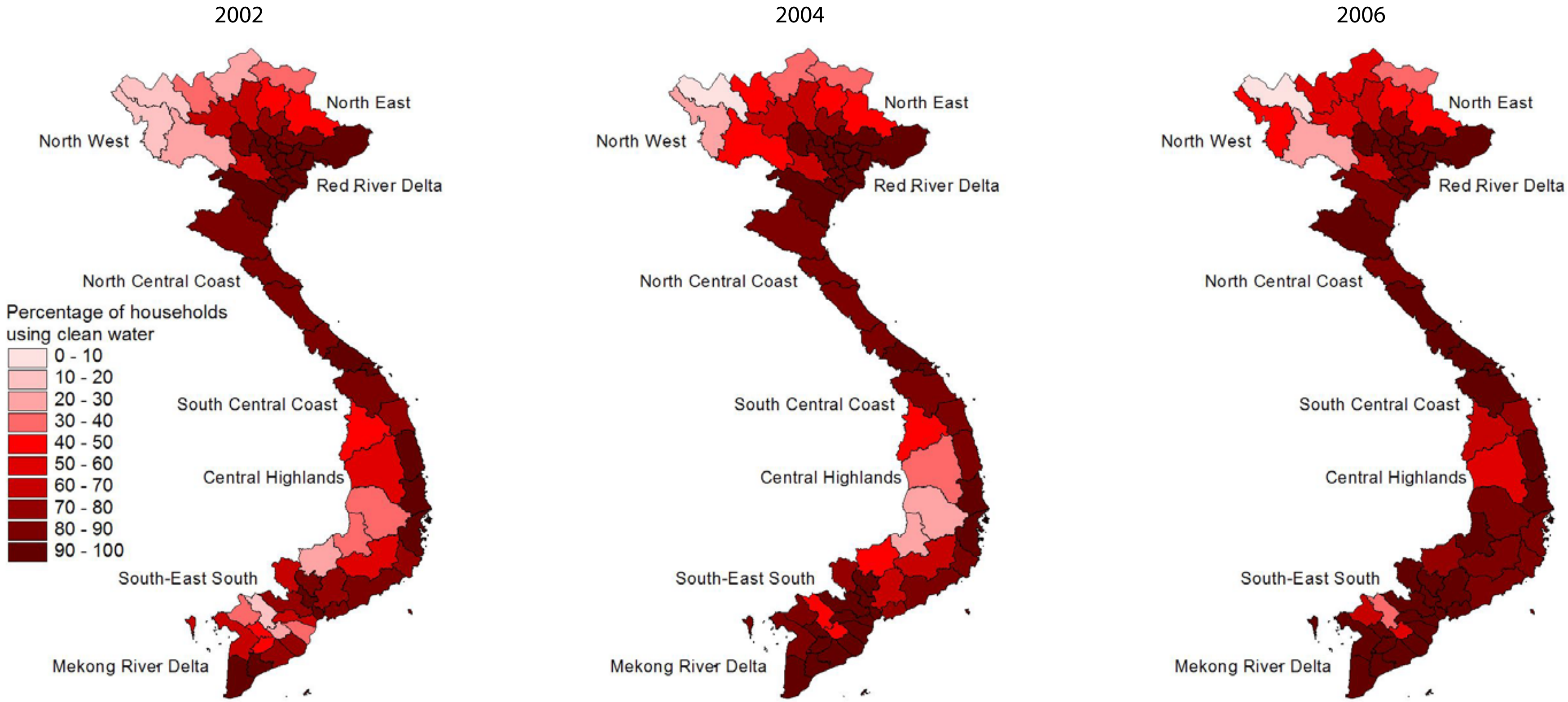

Figure 3. Percentage of households using clean water (including tap water) in Vietnam
Source: Estimation from VHLSSs 2002, 2004, and 2006

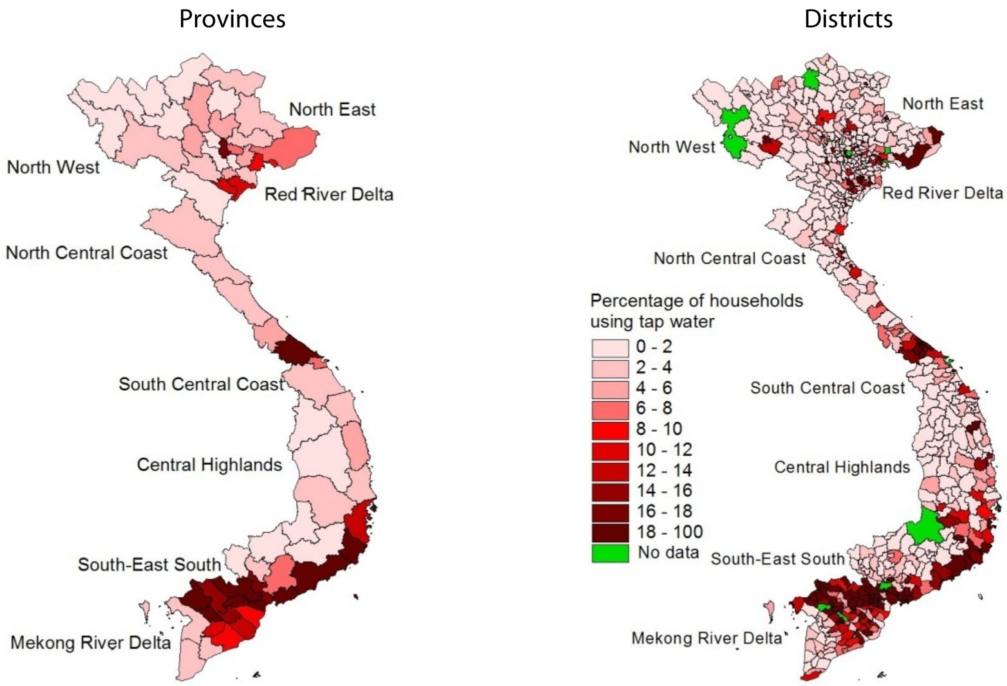

Figure 4. Percentage of households using tap water in rural Vietnam in 2006
Source: Estimation from the Rural Agriculture and Fishery Census 2006

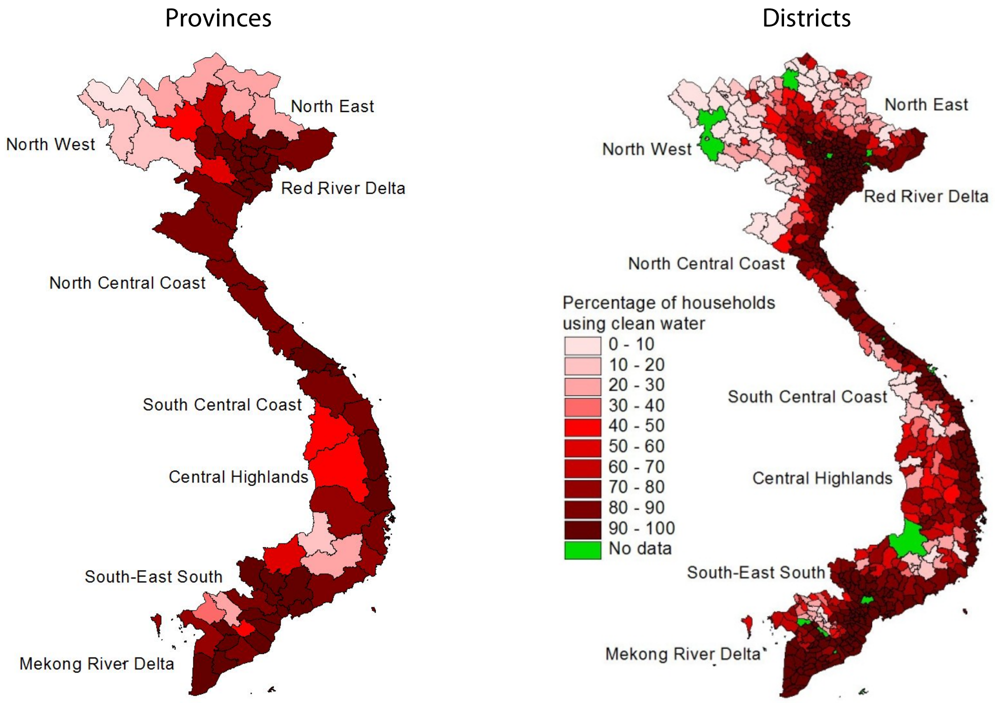

Figure 5. Percentage of households using clean water (including tap water) in rural Vietnam in 2006
Source: Estimation from the Rural Agriculture and Fishery Census 2006

4.0 IMPACT ESTIMATION METHOD

4.1 Parameters of Impact

Denote *D* as a binary variable indicating access to piped water, i.e. *D* equals 1 if a household is using piped water, and *D* equals 0 if otherwise. Further let *Y* denote the observed value of household welfare (so-called outcomes). This variable can have two potential values depending on the value of *D*, i.e. $Y = Y_1$ for $D = 1$, and $Y = Y_0$ for $D = 0$.

The most popular parameter of the program impact is Average Treatment Effect on the Treated (ATT) (Heckman et al., 1999), which is the expected impact of access to piped water on outcomes of households using piped water:[5]

$$ATT = E(Y_1 - Y_0 | D = 1) = E(Y_1 | D = 1) - E(Y_0 | D = 1) \quad (1)$$

More generally, ATT can vary across a vector of the observed variables X:

$$ATT_{(X)} = E(Y_1 - Y_0 | X, D = 1) = E(Y_1 \mid X, D = 1) - E(Y_0 \mid X, D = 1) \quad (2)$$

Estimation of ATT is not straightforward since $E(Y_0 \mid D = 1)$ is not observed and cannot be estimated directly. $E(Y_0 \mid D = 1)$ is called counterfactual, which would have been the expected outcome of households if they had not used piped water.

4.2 Difference-in-differences with Propensity Score Matching

Since panel data on households with piped water and without piped water were available, the impact of piped water on household welfare using a method of difference-in-differences with matching was estimated. The basic idea of the matching method is to find a control group composed of households without piped water with a similar distribution of the variables *X* as the treatment group, which are households with piped water.[6] The matching method can be combined with difference-in-differences method to allow 'access to piped water' to be based on unobserved variables. However, these unobserved variables must be time-invariant.

More specifically, let Y_0^B denote the outcome before access to piped water. After access to piped water, the potential outcomes with and without piped water were denoted by Y_1^A and Y_0^A, respectively.

In this study, 2002 (or 2004) and 2006 were the years before and after access to piped water, respectively. The $ATT_{(X)}$ after access to piped water was defined as:

$$ATT_{(X)} = E(Y_1^A | X, D = 1) - E(Y_0^A | X, D = 1) \quad (3)$$

The difference-in-differences with matching relies on an assumption that conditional on *X*, the difference in the expectation of outcomes between households with piped water and households without piped water would be unchanged before and after access to piped water, i.e.:

[5] There are other parameters such as average treatment effect (ATE), local average treatment effect, marginal treatment effect, or even effect of "non-treatment on non-treated," which measures what impact the program would have on the non-participants if they had participated in the program, etc.

[6] Important literature on matching methods of impact evaluation include the researches of Rubin (1977, 1979, 1980), Rosenbaum and Rubin (1983), Heckman et al. (1997), Dehejia (1998), and Smith and Todd (2005).

$$E(Y_0^B \mid X, D=1) - E(Y_0^B \mid X, D=0) = E(Y_0^A \mid X, D=1) - E(Y_0^A \mid X, D=0). \tag{4}$$

Under this assumption, the conditional parameter $ATT_{(X)}$ could be identified by the matching method, since:

$$\begin{aligned} ATT_{(X)} = \ & E(Y_1^A|X, D=1) - E(Y_0^A|X, D=1) - \left[E(Y_0^A|X,D=0) - E(Y_0^B|X,D=0)\right] \\ & + \left[E(Y_0^A|X,D=1) - E(Y_0^B|X,D=1)\right] \\ = \ & \left[E(Y_1^A|X, D=1) - E(Y_0^A|X,D=0)\right] - \left[E(Y_0^B|X,D=1) - E(Y_0^B|X,D=0)\right] \end{aligned} \tag{5}$$

The unconditional parameter was also identified, since:

$$ATT = \int_{X|D=1} ATT_{(X)} dF(X|D=1). \tag{6}$$

To estimate the impact of clean water, households without piped water were matched with households with piped water based on their variables *X*. The matched households without piped water formed a control (comparison) group. However, to find a control group that had similar variables *X*, we required a so-called common support assumption:

$$0 < P(D=1 \mid X) < 1 \tag{7}$$

This assumption means that there were households without piped water that had the *X* variables similar to households with piped water.

The remaining problem was how to match households without piped water with households that had piped water. There would have been no problem if there was a single conditioning variable *X*. However, *Xs* are often a vector of variables, and finding "close" non-users to match with a user is not straightforward. A widely-used way to find the matched sample is the propensity score matching.[7] Matching is often conducted based on the probability of being assigned into a program, which is called the propensity score (Rosenbaum and Rubin, 1983).

In this paper, the matching based on the propensity score was employed. We could have different matching estimators depending on the number of households without piped water that had to be matched with households with piped water. We used nearest-neighbors, kernel, and local linear regression matching schemes to examine the sensitivity of the impact estimates. The matching estimator was based on equation (5). It was equal to the difference in differences in outcomes between households with piped water and matched households without piped water before and after access to piped water. The formulas of the estimators are presented in Appendix 1. The standard errors were calculated using bootstrap techniques.

This study used two ways to define the treatment group (households with piped water) and the control group (households without piped water). First, we used the feature of the panel data from VHLSS 2002, 2004, and 2006 to define the control and treatment groups before and after the use of piped water.

There were 10,365 households covered by the three VHLS. Among these households, 373 households did not have piped water in 2002 but had piped water in 2004 and 2006. This was called the treatment group. The 7,960 households that did not have piped water during 2002, 2004, and 2006 were called the control group. Other households were dropped.

The years 2002 and 2006 refer to the years before and after access to piped water, respectively. This construction of treatment and control groups allowed for longer 'time of use of piped water'. It was expected that piped water would require 'long time enough' so that the effect of piped water on labor

[7] Other matching methods can be subclassification (e.g., Cochran and Chambers, 1965; Cochran, 1968) and covariate matching (Rubin, 1979, 1980).

supply and income could be detected. However, the 2002 to 2006 panel data did not have information on sickness of individuals because the 2002 VHLS did not have this information.

Thus, the second way to construct the treatment and control group was to use the panel data of VHLSS 2004 and 2006, which contained information on individual sickness in both years. There were 21,695 households covered by this panel data set. The treatment group consisted of 1,242 households that had piped water in 2006 but not in 2004. The control group consisted of 16,763 households that did not have piped water in 2004 and 2006. Other households that did not belong to the treatment and control groups were dropped. This construction of treatment and control groups allowed for more observations, but the time lag of using piped water was rather short.

The first step in the difference-in-differences with propensity score matching was to estimate propensity scores, which was the probability of having piped water. The control variables were household characteristics in baseline years (i.e., 2002 for the first way and 2004 for the second way of constructing treatment and control groups). These variables included household demographic variables, household heads' characteristics, education, land and housing, and regional and urban variables.

The probit models to estimate the propensity score are reported in Appendix 2. The predicted propensity scores are graphed in Appendix 7 and 8.[8] Many households in the treatment and control groups had a similar propensity score (large common support).

4.3 Difference-in-differences Regression

In addition to the matching, we also ran a standard difference-in-differences regression to examine the impact estimate of piped water on different estimation strategies. The difference-in-differences model is as follows:

$$\ln(Y_{it}) = \beta_0 + T_{it}\beta_1 + D_{it}\beta_2 + D_{it}T_{it}\beta_3 + X_{it}\beta_4 + \varepsilon_{it}\,, \qquad (8)$$

where Y_{it} is the outcome of household *i* in year *t*; T_i is the time dummy, which is equal to 1 for 2006 and 0 for 2002 (or 2004 if the panel data 2004-2006 are used); D_{it} is the dummy variable of piped water and X_{it} are observed characteristics for household *i* in year *t*. The effect of piped water (ATT) was measured by β_3 (the coefficient of interaction between *D* and *X*).

5.0 ESTIMATION RESULTS

As mentioned earlier, we used different matching estimators including nearest-neighbors, kernel, and local linear regression matching. All the estimators produced very similar results. For interpretation, we used estimates from kernel matching with bandwidth of 0.01.[9] Estimates of the impact of piped water using the 2002-2006 panel data are presented in Table 2. [10] For comparison and correction of inflation, income was adjusted to the price of January 2006.

[8] We also conducted balancing tests of equality of covariate variables between the treatment group (households with piped water) and the matched control group (households with piped water). For most variables, we could not reject the hypothesis on the equality of variable means between the treatment and matched control groups. The balancing tests can be provided on request.

[9] Estimates from other matching estimators are not presented, but they can be provided on request.

[10] Standard errors were computed using bootstrap techniques. Abadie and Imbens (2008) show that bootstrap produces invalid standard errors for the nearest neighbor matching estimator. However, there is no evidence on the validity of bootstrap in estimating standard errors for other matching estimators.

Table 2. Impact estimation using panel data 2002-2006: kernel matching

Outcomes	2006			2002			ATT
	Treatment group	Control group	Difference 2006	Treatment group	Control group	Difference 2002	
Per capita annual income (VND thousand)	10391.3****	8878.6****	1512.7***	6782.4****	5952.6****	829.8*	682.9
	[650.8]	[568.2]	[685.1]	[524.1]	[306.7]	[489.2]	[659.3]
Annual working hours per working-age person	1465.7****	1402.6****	63.1	1539.3****	1510.2****	29.1	34.0
	[37.0]	[35.9]	[44.2]	[43.6]	[38.5]	[47.6]	[53.3]

Note: Definition of outcomes:

- 'Per capita annual income of a household' is equal to the total annual income of the household divided by the household size.
- 'Annual working hours per working-age person' is equal to the total annual working hours of household members divided by the number of household members from 15 to 60 years old.

Standard errors are in brackets. Standard errors are calculated using bootstrap with 500 replications.

* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Estimation from panel data of VHLSS 2002-2006

The difference in per capita income between the treatment and control group in was 1512.7 thousand VND in 2006 and 829.8 thousand VND in 2002. ATT is measured by the 2006 difference minus the 2002 difference. The estimates of ATT for household income and working hours were positive but not statistically significant.

Table 3 presents the impact estimates from the matching method using the 2004-2006 panel data. Similarly, the impact of piped water on income and labor supply was not statistically significant. While the effect of piped water on sickness outcome was negative, the figure was very small and not statistically significant.

There might be two possible explanations for the small effects. First, there might be a small difference in quality between piped water and other water sources. There was no information from the VHLSS on whether the piped water was really clean or not. Piped water is sometimes said to be unclean by mass media (e.g., Xuan-Danh, 2011). Further, when using non-piped water, some households might have used purification or boiling, which reduced the incidence of waterborne diseases. According to the 2006 VHLSS, around 86 percent of households always boil their drinking water. Thus, piped water did not increase income and labor supply through it improved health and saved time.

Second, the time duration in this study (four years between 2002 and 2006 and two years between 2004 and 2006) might be not long enough to manifest a significant effect of piped water on health and labor supply. In addition, data on labor supply measured by the annual working hours and income might have large measurement errors, which may have caused the large standard errors.

The difference-in-differences regressions were also used to estimate the impact of piped water. The regressions are presented in Appendix 3 to 5. Similar to the matching method, the impact of piped water on income, working hours, and sickness had the expected sign, but it was not statistically significant.

Finally, it should be noted that the difference-in-differences estimators can still be biased if endogeneity is caused not only by time-invariant but also by time-variant unobserved variables. The endogeneity bias caused by time-variant variables was expected to be relatively small. In addition, when we examined the sensitivity of the impact estimate of piped water, we found that adding more control variables tended to reduce the impact estimate. Controlling for time-invariant unobserved variables also reduced the impact estimate significantly. This implies that omitted variables might overestimate the impact of piped water. Thus, the unbiased estimate might be even smaller than the difference-in-differences estimates in this study.

Table 3. Impact estimation using panel data 2004-2006: kernel matching

Outcomes	2004			2002			ATT
	Treatment group	Control group	Difference 2004	Treatment group	Control group	Difference 2002	
Per capita annual income (VND thousand)	10631.0***	9125.1***	1505.8***	8920.0***	7595.3***	1324.6***	181.2
	[549.1]	[350.5]	[463.2]	[447.8]	[309.9]	[365.0]	[373.9]
Annual working hours per working-age person	1449.1***	1384.8***	64.2**	1489.1***	1451.9***	37.2	27.0
	[28.7]	[19.3]	[28.1]	[29.3]	[20.0]	[29.6]	[29.7]
Proportion of members sick during the past four weeks	0.2056***	0.2031***	0.0026	0.1407***	0.1262***	0.0145	-0.0120
	[0.0099]	[0.0067]	[0.0113]	[0.0102]	[0.0062]	[0.0112]	[0.0151]
Proportion of members sick during the past 12 months	0.3448***	0.3441***	0.0007	0.3288***	0.3141***	0.0147	-0.0140
	[0.0179]	[0.0099]	[0.0194]	[0.0166]	[0.0110]	[0.0178]	[0.0220]
Annual number of sickness days in bed per person	1.7833***	2.2655***	-0.4823*	1.6585***	1.9290***	-0.2705	-0.2118
	[0.2250]	[0.1744]	[0.2701]	[0.2072]	[0.1565]	[0.2538]	[0.3401]

Note: Definition of outcomes:

- 'Per capita annual income of a household' is equal to the total annual income of the household divided by the household size.
- 'Annual working hours per working-age person' is equal to the total annual working hours of household members divided by the number of household members from 15 to 60 years old.
- 'Proportion of members sick during the past four weeks' is the number of household members reporting 'sickness' during the past four weeks divided by the household size.
- 'Proportion of members sick during the past 12 months' is the number of household members reporting 'sickness' during the past 12 months divided by the household size.
- 'The annual number of sickness days in bed per person' is the number of sickness days in bed of all the household members divided by the household size.

Standard errors in brackets. Standard errors are calculated using bootstrap with 500 replications.

* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Estimation from panel data of VHLSS 2002-2006

6.0 CONCLUSION

This study aimed to measure the effect of piped water on household welfare indicators including income, working effort, and sickness. Our findings are similar to Devoto et al.'s (2011) results. The effect of piped water on household income and labor supply was positive but not statistically significant. Also, the effect of piped water on sickness of household members was negligible and not statistically significant. However, the results do not mean that piped water is unimportant. Households still care greatly about the aesthetic and life-style benefits of piped water, and they tend to prefer piped water than water from other sources.

A better impact evaluation design is recommended to give more informative results. When measuring the effect of water quality on household welfare, one should use a continuous indicator of water quality such as pollution or arsenic measures, which allows for more variation in water quality. Direct outcomes of piped water such as waterborne diseases should also be used to detect the effect of piped water on health. The impact estimation will be more accurate if a randomization design or instrumental-variables regressions with valid instruments are used. These issues are beyond the scope of this study but certainly important for the future studies.

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APPENDICES

Appendix 1. Propensity score matching estimators

The control group is constructed by matching each participant (i.e., households with piped water) *i* in the treatment group with one or more non-participants (i.e., households without piped water) *j* whose propensity scores are closest to the propensity score of the participant *i*. For a participant *i*, denote n_{ic} as the number of non-participants *j* who are matched with this participant, and *w(i,j)* the weight attached to the outcome of each non-participant. These weights are defined non-negative and sum up to 1, i.e.:

$$\sum_{j=1}^{n_{ic}} w(i,j) = 1 . \qquad \text{(A.1)}$$

The estimator of ATT is expressed as follows:

$$A\hat{T}T = \frac{1}{n_1}\left\{ \sum_{i=1}^{n_1}\left[Y_{1i}^{A} - \sum_{j=1}^{n_{ic}} w(i,j)Y_{0j}^{A}\right] - \sum_{i=1}^{n_1}\left[Y_{0i}^{B} - \sum_{j=1}^{n_{ic}} w(i,j)Y_{0j}^{B}\right]\right\} \qquad \text{(A.2)}$$

where n_1 is the number of the participants in the data sample. Y_{1i}^{A} and Y_{0j}^{A} are the observed outcomes of participant *i* and matched non-participant *j* after the access to piped water (in 2006), respectively. Y_{0i}^{B} and Y_{0j}^{B} are the observed outcomes of participant *i* and non-participant *j* before the access of piped water (in 2002 or 2004), respectively.

If each participant is matched with one non-participant with the minimum value of *d(i,j)* (where *d(i,j)* is the distance between the propensity scores of participant *i* and that of non-participant *j*), the weight *w(i,j)* equals 1 for all pairs of matches. This is called one nearest neighbor matching. When more than one non-participants are matched with each participant (or vice-versa), we need some ways to define the weights attached to each non-participant.

A number of methods use equal weights for all matches. N-nearest neighbors matching involves matching each participant with n non-participants who have the closest propensity scores. Each matched non-participant will receive weight $w(i,j) = 1/n$.[11] However, it could be reasonable to assign different weights to different non-participants depending on metric distances between their covariates and the covariates of the matched participant (e.g., Heckman et al., 1997; Smith and Todd, 2005). The kernel matching method matches a participant with one or many non-participants depending on kernel function G and a selected bandwidth h. The weight is defined as:

$$w(i,j) = \frac{G\left[\frac{d(i,j)}{h}\right]}{\sum_{k=1}^{n_2} G\left[\frac{d(i,k)}{h}\right]}, \qquad \text{(A.3)}$$

where n_2 is the number of the non-participants in the data sample. In this paper, we used kernel with bandwidth of 0.01, and the kernel function is the Epanechnikov one:

$$\begin{aligned} G(z) &= 0.75(1-z^2) \ \text{ if } \ -1 \le z \le 1 \\ &= 0 \ \text{ if } |z| > 1, \end{aligned} \qquad \text{(A.4)}$$

[11] Caliper matching (e.g., Dehejia and Wahba, 1998; Smith and Todd, 2005) uses equal weights for matched subjects whose distance *d(i,j)* is smaller than a specific value, say 0.05 or 0.1. This criterion aims to ensure the quality of matching. Stratification (interval) matching divides the range of estimated distances into several strata (blocks) of equal ranges. Within each stratum, a participant is matched with all non-participants with equal weights (e.g., Dehejia and Wahba, 1998; Smith and Todd, 2005).

Appendix 2. Probit regressions of access to piped water in 2002
(dependent variable is 1 if households have piped water and 0 otherwise)

Explanatory variables	Panel data 2002-2006		Panel data 2004-2006	
	Coefficient	Std. Err.	Coefficient	Std. Err.
Head's age	0.0021	0.0031	0.0001	0.0017
Head's gender (male = 1; female =0)	-0.0858	0.0698	-0.1353***	0.0401
Head without education degree	Omitted			
Head with primary education degree	0.0156	0.0756	0.0425	0.0439
Head with lower secondary degree	-0.0783	0.0872	0.0070	0.0508
Head with upper secondary degree	0.0960	0.1131	0.1808***	0.0696
Head with technical degree	-0.2190	0.1918	0.1744**	0.0833
Head with post secondary degree	-0.5971***	0.2522	-0.0061	0.1308
Ethnic minorities (yes = 1)	0.0972	0.1109	0.0214	0.0571
Household size	-0.0241	0.0195	-0.0057	0.0106
Proportion of members over 60	-0.4516	0.1793	0.0429	0.0888
Proportion of members under 16	0.0988	0.1607	-0.0579	0.0904
Proportion of female members	-0.0327	0.1412	-0.1252	0.0831
Proportion of members having technical degree	0.5819	0.3580	0.0930	0.1540
Proportion of members having post-secondary degree	0.9349**	0.4354	0.1055	0.2221
Solid house	Omitted			
Semi-solid house	-0.2175***	0.0801	-0.1607***	0.0440
Temporary house	-0.2979***	0.1011	-0.2631***	0.0582
Having flush toilet	Omitted			
Having toilet	-0.4405***	0.0765	-0.3270***	0.0417
Not having toilet	-0.2694***	0.0974	-0.1483***	0.0569
Annual crop land (1000m2)	-0.0078	0.0052	-0.0056	0.0055
Perennial crop land (1000m2)	0.0028	0.0048	-0.0247*	0.0139
Urban (yes=1)	0.9011***	0.0654	0.7197***	0.0375
Red River Delta	Omitted			
North East	-0.4534***	0.1190	-0.0813	0.0616
North West	-0.7635***	0.2280	-0.1584	0.1009
North Central Coast	-0.2773**	0.1086	-0.1728***	0.0646
South Central Coast	-0.1023	0.1077	-0.0713	0.0655
Central Highlands	-0.7658***	0.1691	-0.1861**	0.0807
South East	-0.0766	0.1006	0.1477**	0.0582
Mekong River Delta	0.3109***	0.0895	0.4572***	0.0520
Constant	-1.1829***	0.2225	-1.2011***	0.1295
Observations	**8333**		**18005**	
Pseudo R2	**0.16**		**0.114**	

Note: For definition of dependent variables, see the note in Table 3.
Robust standard errors (corrected for sampling weight and cluster correlation)
* significant at 10%; ** significant at 5%; *** significant at 1%
Source: Estimation VHLSS 2002, 2004 and 2006

Appendix 3. Difference-in-differences regressions: panel data 2002-2006

Explanatory variables	Dependent variables			
	Log of per capita income	Per capita income	Log of working hours per person above 14	Working hours per person above 14
Drinking piped water (yes = 1) * time dummy (2006 = 1)	-0.0843 [0.0807]	683.66 [1,027.18]	0.0425 [0.0424]	58.14 [54.30]
Drinking piped water (yes = 1)	0.1020** [0.0417]	507.29 [378.66]	0.012 [0.0326]	8.21 [44.33]
Time dummy (2006 = 1)	0.2313*** [0.0128]	1,247.01*** [98.60]	-0.0750*** [0.0130]	-115.70*** [15.44]
Head's age	0.0055** [0.0027]	43.52*** [16.72]	0.0123*** [0.0031]	11.86*** [2.80]
Head's age squared	-0.0001** [0.0000]	-0.43*** [0.16]	-0.0001*** [0.0000]	-0.13*** [0.03]
Gender of head (male=1)	-0.0135 [0.0156]	-91.66 [146.85]	0.0443*** [0.0154]	62.90*** [17.42]
Head without education degree	Omitted			
Head with primary education degree	0.1101*** [0.0141]	715.69*** [112.81]	-0.0168 [0.0140]	-16.4 [15.52]
Head with lower secondary degree	0.1768*** [0.0172]	897.25*** [117.68]	-0.0321* [0.0170]	-26.41 [19.91]
Head with upper secondary degree	0.2687*** [0.0226]	1,503.02*** [280.31]	-0.0465** [0.0204]	-37.17 [26.55]
Head with technical degree	0.1311*** [0.0321]	440.73 [270.70]	-0.1639*** [0.0320]	-165.02*** [38.38]
Head with post secondary degree	0.1460*** [0.0480]	149.17 [685.99]	-0.1860*** [0.0517]	-197.42*** [51.81]
Ethnic minorities (yes=1)	-0.2329*** [0.0238]	-1,048.19*** [122.10]	-0.0025 [0.0244]	-17.49 [31.22]
Household size	-0.0699*** [0.0118]	-661.75*** [133.38]	-0.0423*** [0.0111]	-93.87*** [11.53]
Household size squared	0.0013 [0.0010]	25.18** [11.88]	0.0015* [0.0008]	4.05*** [0.88]
Proportion of members under 16	-0.2647*** [0.0344]	-1,274.74*** [293.71]	-0.7268*** [0.0423]	-736.60*** [37.11]
Proportion of members over 60	-0.5140*** [0.0308]	-2,111.15*** [318.65]	0.5769*** [0.0279]	849.07*** [36.60]
Proportion of female members	-0.1720*** [0.0283]	-1,262.15*** [249.93]	-0.0391 [0.0287]	-61.53* [33.38]
Proportion of members with technical degree	0.7636*** [0.0595]	4,971.49*** [600.62]	0.3261*** [0.0568]	351.63*** [70.20]
Proportion of members having post-secondary degree	0.9678*** [0.1030]	8,930.23*** [1,487.84]	0.0674 [0.1103]	153.62 [105.68]
Solid house	Omitted			
Semi-solid house	-0.1304*** [0.0200]	-603.27*** [194.51]	0.022 [0.0166]	18.67 [20.57]
Temporary house	-0.3162*** [0.0240]	-1,417.12*** [215.07]	0.0038 [0.0223]	-6.2 [26.59]
Having flush toilet	Omitted			
Have toilet	-0.2781*** [0.0208]	-2,623.67*** [272.41]	-0.019 [0.0181]	-29.3 [23.08]

Appendix 3 continued

Explanatory variables	Dependent variables			
	Log of per capita income	Per capita income	Log of working hours per person above 14	Working hours per person above 14
Does not have toilet	-0.3661***	-2,862.15***	-0.0414*	-44.64
	[0.0275]	[272.71]	[0.0246]	[29.99]
Annual crop land (1000m2)	0.0127***	92.83***	-0.0024**	-2.72**
	[0.0013]	[12.67]	[0.0010]	[1.18]
Perennial crop land (1000m2)	0.0122***	156.04***	-0.0009	-0.63
	[0.0014]	[42.44]	[0.0009]	[1.11]
Urban (yes=1)	0.1450***	756.15***	0.0574**	61.13**
	[0.0275]	[220.93]	[0.0235]	[28.61]
Red River Delta	Omitted			
North East	0.0811***	254.38	0.0864***	98.23**
	[0.0293]	[195.09]	[0.0298]	[40.39]
North West	-0.0728	-343.73	0.0384	32.00
	[0.0450]	[270.00]	[0.0407]	[57.52]
North Central Coast	-0.1042***	-438.14**	-0.0406	-65.91*
	[0.0301]	[202.36]	[0.0291]	[35.19]
South Central Coast	0.0919***	6.62	0.0111	-7.89
	[0.0322]	[205.87]	[0.0309]	[39.01]
Central Highlands	0.027	23.36	-0.0124	-37.37
	[0.0374]	[372.73]	[0.0366]	[48.97]
South East	0.3878***	2,012.31***	0.0254	22.57
	[0.0363]	[292.29]	[0.0340]	[45.17]
Mekong River Delta	0.3640***	1,917.09***	-0.1953***	-230.97***
	[0.0286]	[231.88]	[0.0315]	[36.82]
Constant	8.7512***	8,642.54***	7.0585***	1,491.27***
	[0.0871]	[653.98]	[0.0850]	[86.15]
Observations	**16666**	**16666**	**16666**	**16666**
R-squared	**0.41**	**0.23**	**0.24**	**0.25**

Note: For definition of dependent variables, see the note in Table 3.

Robust standard errors in brackets (corrected for sampling weight and cluster correlation)

* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Estimation from panel data of VHLSS 2002-2006

Appendix 4. Difference-in-differences regressions: panel data 2004-2006

Explanatory variables	Dependent variables			
	Log of per capita income	Per capita income	Log of working hours per person above 14	Working hours per person above 14
Drinking piped water (yes = 1) * time dummy (2006 = 1)	0.0073 [0.0202]	650.81* [349.12]	0.0507 [0.0419]	39.65 [27.50]
Drinking piped water (yes = 1)	0.0794*** [0.0212]	754.56** [303.55]	-0.0139 [0.0371]	17.26 [25.25]
Time dummy (2006 = 1)	0.0461*** [0.0067]	51.83 [101.28]	-0.0872*** [0.0116]	-43.30*** [8.80]
Head's age	0.0011 [0.0021]	15.92 [23.31]	0.0492*** [0.0063]	9.57*** [2.22]
Head's age squared	0.0000 [0.0000]	-0.10 [0.22]	-0.0005*** [0.0001]	-0.11*** [0.02]
Gender of head (male=1)	-0.0079 [0.0102]	32.55 [110.05]	0.0704*** [0.0186]	70.57*** [11.51]
Head without education degree	Omitted			
Head with primary education degree	0.1224*** [0.0099]	730.61*** [93.38]	-0.0173 [0.0196]	-5.02 [11.60]
Head with lower secondary degree	0.1908*** [0.0123]	1,104.94*** [122.36]	-0.0616*** [0.0233]	-12.17 [14.55]
Head with upper secondary degree	0.2730*** [0.0172]	1,939.18*** [253.30]	-0.0831*** [0.0274]	-45.27** [19.38]
Head with technical degree	0.1745*** [0.0206]	877.95*** [279.32]	-0.1957*** [0.0347]	-154.63*** [23.30]
Head with post secondary degree	0.2046*** [0.0306]	583.53 [656.82]	-0.3372*** [0.0583]	-216.78*** [34.12]
Ethnic minorities (yes=1)	-0.2464*** [0.0212]	-882.00*** [141.26]	-0.0081 [0.0234]	-22.97 [24.52]
Household size	-0.0779*** [0.0074]	-889.50*** [87.04]	0.2790*** [0.0306]	-89.08*** [9.16]
Household size squared	0.0021*** [0.0006]	41.95*** [7.46]	-0.0228*** [0.0028]	3.42*** [0.74]
Proportion of members under 16	-0.2884*** [0.0228]	-1,795.04*** [241.64]	-1.8472*** [0.0845]	-798.25*** [27.18]
Proportion of members over 60	-0.4868*** [0.0221]	-2,306.11*** [229.99]	0.3946*** [0.0429]	863.14*** [27.18]
Proportion of female members	-0.1651*** [0.0191]	-1,061.52*** [202.70]	-0.2722*** [0.0522]	-74.92*** [22.62]
Proportion of members with technical degree	0.6855*** [0.0382]	4,919.42*** [492.17]	0.3133*** [0.0900]	285.99*** [47.27]
Proportion of members having post-secondary degree	1.0167*** [0.0573]	11,255.05*** [1,169.36]	0.4813*** [0.1224]	291.96*** [69.69]
Solid house	Omitted			
Semi-solid house	-0.1796*** [0.0123]	-1,574.00*** [173.67]	0.0191 [0.0215]	12.10 [12.85]
Temporary house	-0.3948*** [0.0160]	-2,673.96*** [191.24]	-0.0335 [0.0287]	-19.57 [17.57]
Have flush toilet	Omitted			
Have toilet	-0.2677*** [0.0129]	-2,620.95*** [161.40]	0.0129 [0.0231]	-85.45*** [14.01]

Appendix 4 continued

Explanatory variables	Dependent variables			
	Log of per capita income	Per capita income	Log of working hours per person above 14	Working hours per person above 14
Do not have toilet	-0.3956***	-3,197.44***	-0.0075	-89.16***
	[0.0179]	[168.81]	[0.0314]	[18.93]
Annual crop land (1000m2)	0.0120***	130.65***	-0.0012	-3.49***
	[0.0008]	[23.69]	[0.0009]	[0.80]
Perennial crop land (1000m2)	0.0078***	101.27***	0.0009	-0.31
	[0.0017]	[35.24]	[0.0006]	[0.92]
Urban (yes=1)	0.1058***	954.64***	0.0333	79.37***
	[0.0182]	[220.39]	[0.0289]	[21.08]
Red River Delta	Omitted			
North East	0.1200***	722.98***	0.1351***	111.28***
	[0.0227]	[173.30]	[0.0316]	[27.32]
North West	0.0431	294.19	0.0476	38.13
	[0.0354]	[218.00]	[0.0483]	[49.36]
North Central Coast	-0.1113***	-399.93***	-0.0375	-50.89**
	[0.0216]	[149.40]	[0.0360]	[23.85]
South Central Coast	0.0991***	460.87**	0.0345	-61.98**
	[0.0232]	[185.25]	[0.0381]	[26.75]
Central Highlands	0.2182***	1,345.06***	0.0434	34.85
	[0.0266]	[266.91]	[0.0371]	[30.57]
South East	0.5096***	4,001.19***	0.0440	127.84***
	[0.0258]	[336.79]	[0.0373]	[28.07]
Mekong River Delta	0.3904***	2,593.26***	-0.1014***	-127.82***
	[0.0201]	[201.26]	[0.0342]	[24.87]
Constant	9.0582***	11,102.29***	5.4607***	1,516.24***
	[0.0628]	[676.99]	[0.1739]	[70.57]
Observations	**36010**	**36010**	**36010**	**36010**
R-squared	**0.43**	**0.27**	**0.33**	**0.26**

Note: For definition of dependent variables, see the note in Table 3.

Robust standard errors in brackets (corrected for sampling weight and cluster correlation)

* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Estimation from panel data of VHLSS 2002-2006

Appendix 5. Difference-in-differences regressions: panel data 2004-2006

Explanatory variables	Dependent variables			
	Proportion of members sick during the past four weeks	Proportion of members sick during the past 12 months	The annual number of sick days per person	The annual number of sick days in bed per person
Drinking piped water (yes = 1) * time dummy (2006 = 1)	-0.0068 [0.0139]	-0.0202 [0.0208]	0.2240 [0.4771]	0.0128 [0.2898]
Drinking piped water (yes = 1)	0.0142 [0.0105]	0.0169 [0.0175]	0.0097 [0.3661]	-0.2886 [0.2312]
Time dummy (2006 = 1)	0.0756*** [0.0039]	0.0356*** [0.0057]	-0.1310 [0.1601]	0.1021 [0.1265]
Head's age	-0.0001 [0.0009]	0.0002 [0.0012]	-0.0776 [0.0556]	-0.3731*** [0.0727]
Head's age squared	0.0000 [0.0000]	0.0000 [0.0000]	0.0012** [0.0006]	0.0039*** [0.0007]
Gender of head (male=1)	-0.0140*** [0.0043]	0.0122** [0.0060]	-0.2881 [0.2145]	-0.4142** [0.1802]
Head without education degree	Omitted			
Head with primary education degree	-0.0030 [0.0049]	-0.0109* [0.0061]	0.4143* [0.2423]	0.1015 [0.1849]
Head with lower secondary degree	-0.0131** [0.0057]	-0.0134* [0.0072]	0.0081 [0.2423]	0.2311 [0.1941]
Head with upper secondary degree	-0.0277*** [0.0070]	-0.0131 [0.0101]	-0.6813*** [0.2557]	0.2047 [0.2372]
Head with technical degree	-0.0039 [0.0085]	-0.0049 [0.0113]	-0.1022 [0.3714]	0.1758 [0.3219]
Head with post secondary degree	-0.0190 [0.0121]	0.0091 [0.0195]	-0.0069 [0.5248]	0.7128* [0.3958]
Ethnic minorities (yes=1)	-0.0065 [0.0081]	-0.0103 [0.0119]	-0.6557* [0.3465]	-0.3148** [0.1538]
Household size	-0.0413*** [0.0042]	-0.0425*** [0.0049]	-1.3249*** [0.1899]	-0.3463** [0.1459]
Household size squared	0.0025*** [0.0004]	0.0020*** [0.0004]	0.0786*** [0.0154]	0.0287** [0.0121]
Proportion of members under 16	0.1516*** [0.0120]	0.0349** [0.0138]	6.3067*** [0.8581]	3.7236*** [0.5520]
Proportion of members over 60	0.0437*** [0.0091]	0.0511*** [0.0122]	-1.7523*** [0.4267]	-1.3225*** [0.2935]
Proportion of female members	0.0343*** [0.0093]	0.0315*** [0.0115]	0.0165 [0.4921]	-0.3621 [0.4749]
Proportion of members with technical degree	0.0098 [0.0176]	0.0461** [0.0225]	0.8532 [1.0090]	-0.6030 [0.6169]
Proportion of members having post-secondary degree	-0.0492** [0.0223]	-0.0092 [0.0328]	-1.9984* [1.0658]	-0.7421 [1.3534]
Solid house	Omitted			
Semi-solid house	0.0070 [0.0045]	-0.0062 [0.0071]	0.4366** [0.1871]	0.5552*** [0.1280]
Temporary house	0.0214*** [0.0066]	-0.0318*** [0.0092]	1.5341*** [0.3359]	0.9846*** [0.2075]
Have flush toilet	Omitted			
Have toilet	0.0177*** [0.0048]	0.0159* [0.0082]	0.7904*** [0.2098]	0.1077 [0.1577]

Appendix 5 continued

Explanatory variables	Dependent variables			
	Proportion of members sick during the past four weeks	Proportion of members sick during the past 12 months	The annual number of sick days per person	The annual number of sick days in bed per person
Do not have toilet	0.0181**	0.0422***	1.7934***	0.1526
	[0.0076]	[0.0116]	[0.3598]	[0.2662]
Annual crop land (1000m2)	-0.0003	0.0007	-0.0156**	-0.0148***
	[0.0003]	[0.0005]	[0.0079]	[0.0050]
Perennial crop land (1000m2)	-0.0001	0.0001	0.0030	-0.0031
	[0.0002]	[0.0004]	[0.0103]	[0.0042]
Urban (yes=1)	0.0026	0.0028	-0.4730	-0.1795
	[0.0087]	[0.0138]	[0.2886]	[0.1834]
Red River Delta	Omitted			
North East	0.0150	-0.0416***	-0.6566*	-0.5161**
	[0.0096]	[0.0131]	[0.3608]	[0.2212]
North West	0.0217	-0.0521***	0.5104	0.0969
	[0.0145]	[0.0185]	[0.5630]	[0.3321]
North Central Coast	-0.0052	-0.0391***	0.1969	-0.1509
	[0.0090]	[0.0138]	[0.4673]	[0.2546]
South Central Coast	-0.0031	0.0099	-0.6802	0.0701
	[0.0102]	[0.0178]	[0.4711]	[0.3830]
Central Highlands	0.0682***	0.0960***	1.0577**	0.3411
	[0.0127]	[0.0185]	[0.4499]	[0.3101]
South East	0.0699***	0.1389***	-0.7969*	-0.5756**
	[0.0114]	[0.0196]	[0.4704]	[0.2786]
Mekong River Delta	0.0333***	0.1049***	-0.9255**	-0.5824**
	[0.0089]	[0.0154]	[0.3951]	[0.2663]
Constant	0.1658***	0.3429***	8.8418***	10.9909***
	[0.0270]	[0.0359]	[1.5008]	[1.9117]
Observations	**36010**	**36010**	**36010**	**36010**
R-squared	**0.10**	**0.06**	**0.06**	**0.04**

Note: For definition of dependent variables, see the note in Table 3.

Robust standard errors in brackets (corrected for sampling weight and cluster correlation)

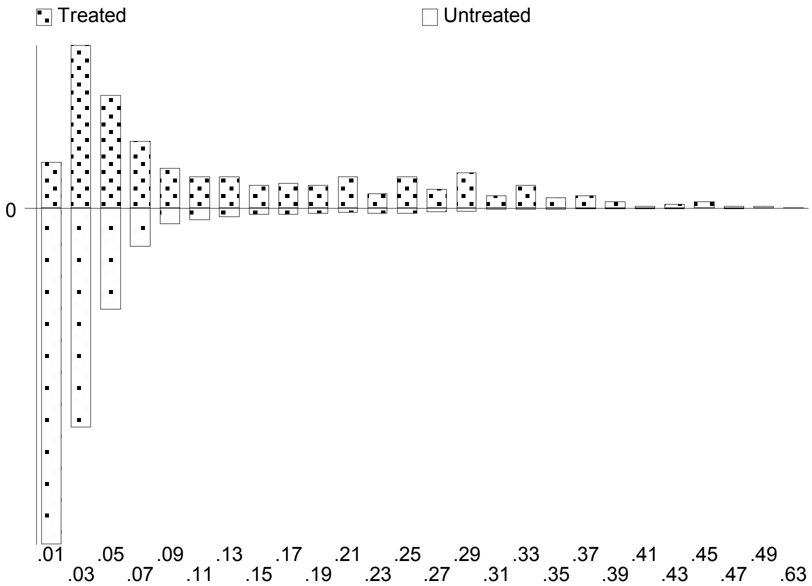
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Estimation from panel data of VHLSS 2002-2006

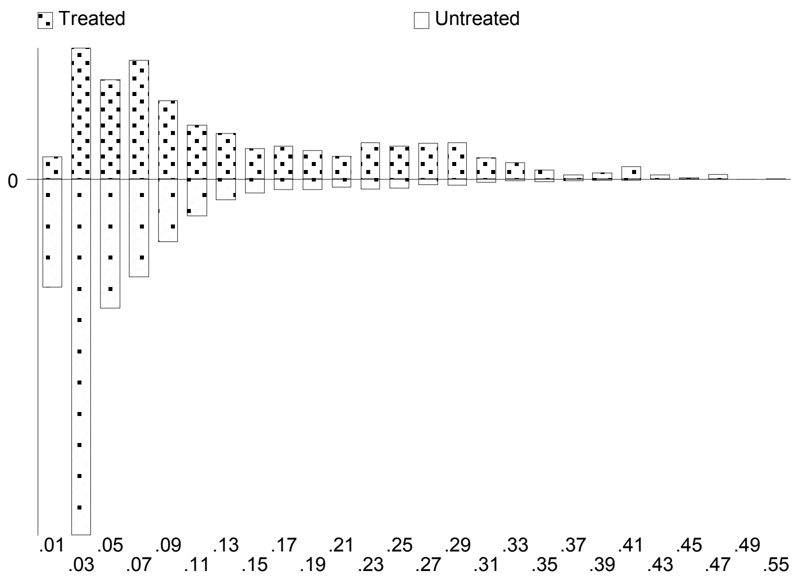
Appendix 6. Description of covariate variables in 2002 for matching

Variables	Meaning	Type	Mean	Std. Dev.
ethnic02	Ethnic minorities (yes = 1)	Binary	0.132	0.338
hhsize02	Household size	Discrete	4.547	1.793
pelderly02	Proportion of members over 60	Continuous	0.114	0.238
pchild02	Proportion of members under 16	Continuous	0.305	0.219
rtechnical02	Proportion of members having technical diploma	Continuous	0.026	0.099
rposecond02	Proportion of members having post-secondary diploma	Continuous	0.013	0.069
age02	Age of household head	Discrete	47.248	14.171
headedu1	Head without education degree	Binary	0.334	0.472
headedu2	Head with primary education degree	Binary	0.256	0.437
headedu3	Head with lower secondary degree	Binary	0.268	0.443
headedu4	Head with upper secondary degree	Binary	0.076	0.265
headedu5	Head with technical degree	Binary	0.047	0.212
headedu6	Head with post secondary degree	Binary	0.019	0.135
anualand02	Annual crop land (10000m2)	Continuous	0.346	0.608
pereland02	Perennial crop land (10000m2)	Continuous	0.128	0.487
aqualand02	Water surface (10000m2)	Continuous	0.025	0.207
region1	Red River Delta	Binary	0.235	0.424
region2	North East	Binary	0.123	0.329
region3	North West	Binary	0.031	0.173
region4	North Central Coast	Binary	0.154	0.361
region5	South Central Coast	Binary	0.090	0.286
region6	Central Highlands	Binary	0.059	0.235
region7	South East	Binary	0.121	0.326
region8	Mekong River Delta	Binary	0.188	0.391
urban02	Urban (yes =1)	Binary	0.130	0.336

Source: Estimation from the 2002 VHLSS



Appendix 7. Propensity scores: panel data 2002-2006
Source: Estimation from panel data of VHLSS 2002-2006



Appendix 8. Propensity scores: panel data 2004-2006
Source: Estimation from panel data of VHLSS 2004-2006

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