Infrastructure Development and Poverty Reduction:

Evidence from Cambodia's Border Provinces

Phim Runsinarith

Graduate School of International Studies

Nagoya University

1. Introduction

At the end of the 20th century, governments around the world agreed on a set of common goals for developing countries, known as the Millennium Development Goals. These goals pave the way forward to cut world poverty by half by 2015. Cambodia has also made efforts to achieve the goal. Among other things, infrastructure has been seen as one important factor for poverty reduction and its potential effects on improving livelihood are raised in Cambodia Millennium Development Goals (CMDGs). Investing in pro-poor rural infrastructure such as small-scale irrigation facilities, all weather roads, rural electrification and physical market infrastructure will stimulate production, enhance productivity and facilitate trade and labour mobility (RGC 2003).

In Cambodia, the poor barely have any access to basic social services and facilities. A WB report on poverty profile in Cambodia in 2004 states that the poorest quintile have to travel 7 kilometers to reach a communal health center, while the richest quintile do not have to travel that far. People in the poorest quintile, on average, live twice as far from the nearest road as those in the richest quintile. About 60 percent of the richest quintile have access to publicly provided electric lighting, while less than 15 percent in the poorest quintile receive the same service. The same report also indicates that only 2 percent of people in the poorest consumption quintile have access to piped water compared to 36 percent in the richest consumption quintile. Similarly, access to sanitation facilities by the poor is very limited or non-existent. More than 90 percent of the people in the poorest quintile have no access to or do not use toilet facilities.

The significance of expected contribution of infrastructure to economic development and poverty reduction has been widely recognized and infrastructure investment has been put on top priority list on the government's development agenda. The RGC's Rectangular Strategy fully acknowledges that among other things, continued rehabilitation and construction of physical infrastructure – which include continued restoration and construction of transport infrastructure, management of water resources and irrigation, development of energy and power grids, and development of Information and Communication Technology – are crucial for promoting sustainable development and poverty reduction (RGC 2004).

Although there are plentiful assumptions regarding the potential effects of infrastructure development on poverty reduction, quantitative studies to measure those effects remain scarce. This paper attempts to fill the gap by addressing two questions: (1) Who are the poor? and (2) How could infrastructure help reduce poverty?

To answer the first question, poverty incidence, poverty gap, poverty severity by location, household characteristics, sources of income and access to infrastructure, will be computed based on an updated poverty line and poverty formula proposed by Foster, Greener and Thorbecke. Gini coefficients will also be computed to examine inequality between the worse-off and the better-off groups. Two different regression techniques: Ordinary Least Square with robust option and quantile regression will be employed to investigate the impact of infrastructure on per capita consumption. Household survey data collected in 2006 in two border provinces of Cambodia will be utilized for analysis. It is worth noting that those provinces which are on the so-called economic corridors of the Greater Mekong Sub-region (GMS) are where infrastructure is most directly affected by increased regional integration.

The next section develops a basic framework for analysis. It will discuss how infrastructure which includes cell phone, irrigation, electricity and road would impact on household welfare. Section 3 elaborates the methodology of how data are collected and how poverty line, poverty indices and Gini coefficient are constructed. Section 4 examines poverty profile of households in the border province by decomposing poverty incidence, poverty gap, poverty severity and inequality coefficient by location, household characteristics, sources of income, and access to infrastructure. Section 5 provides some notes on regression techniques used in the paper and discusses the effects of infrastructure on per capita consumption and poverty reduction. Section 6 is the conclusion and policy recommendation section.

2. A Framework

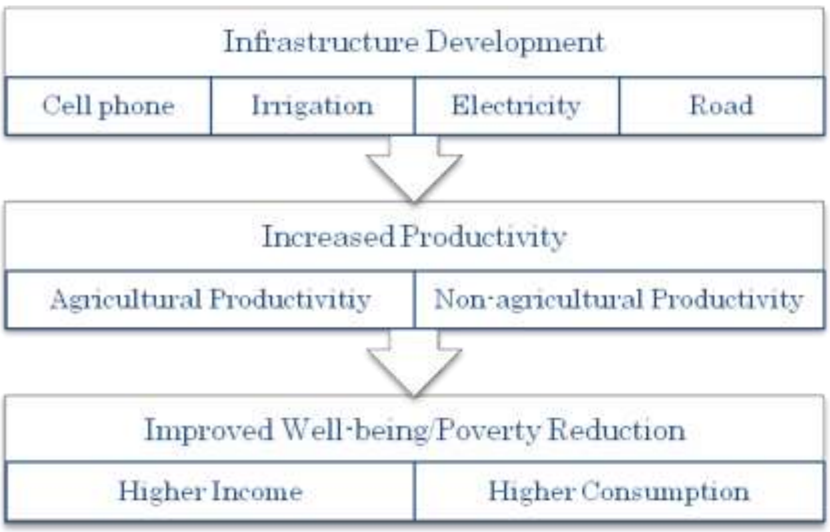
This paper follows neo-classical growth model approach to scrutinize the effect of infrastructure on poverty reduction. The neoclassical growth model effectively highlights an important correlation between economic growth and poverty reduction. This model theorizes that economic growth is contingent upon the accumulation of capital, both human and physical, and technological progress. Human capital refers to the increase in labor productivity due to levels of education, skills and experience, and the health of the people. Physical capital represents the tools used in production. Lastly, technological progress has a two-fold meaning: it is the ability of larger quantities of output to be produced with the same quantities of capital and labor. Equivalently, technological progress represents the key ingredient in developing new, better and a larger variety of products for the public to consume. Based on this neo-classical theory, physical capital infrastructure is assumed to exert positive impact on economic growth as through increased labor productivity.

Existing literatures have demonstrated the existence of a positive relationship between infrastructure investment and economic growth as well as the existence of a strong connection between economic growth and poverty reduction. Some earlier works on infrastructure investment found that public expenditure on infrastructure yields a very positive impact on economic growth (Easterly and Rebelo, 1993; Canning, 1998; Calderon and Servon 2004; Phim 2004). This suggests that it is worth investing more on infrastructure if achieving economic growth is the goal. Other literatures on economic growth and poverty have also found a positive relationship between economic growth and poverty reduction and concluded that growth is good for the poor (Dollar and Kraay 2000) or that economic growth and poverty reduction clearly go largely hand in hand (Rodrik 2000).

The analytical framework in this paper is simply adopted from the neo-classical model theory above with an attempt to show how infrastructure would impact on economic well-being through improved productivity.

The term infrastructure is imprecisely defined by development economists and originally encompassed elements of social overhead capital. For this paper, however, infrastructure is defined and confined to only include cell-phone, irrigation, electricity and road so as to reflect the four key infrastructures mentioned in Rectangular Strategy of the Royal Government of Cambodia. Figure1 summarizes the process of how infrastructure development affects poverty reduction.

Figure1: Infrastructure and poverty reduction



Cell phones can raise welfare of the poor. Grameen Village Phone of Bangladesh provides a good case of how phones may increase the productivity and welfare of villagers in developing countries. The Village Phone program yields significant positive social and economic impacts, including relatively large consumer surplus and immeasurable quality of life benefits (Don Richardson, Ricardo Ramirez, Moinul Haq, 2000). Besides reducing risks of remittance transfer, phones could help villagers get accurate information about market prices, market trends and exchange rates, which will consequently lead to reduction in unnecessary costs and increase in profitability.

Irrigation is expected to be growth-enhancing and poverty reducing. There is evidence showing that irrigation significantly contributes to farm productivity and wages, reducing poverty. Research in India, Philippines, Thailand, and Vietnam suggests that poverty is substantially lower in irrigated areas compared with unirrigated areas (Bhattarai et al, 2002). In an agrarian economy where a vast majority of population still depends on agriculture for livelihood, water is dispensable for crop cultivation and irrigation will play an important role to improve farm productivity.

Electricity is proved to have big favorable impacts on the livelihood of rural people. Not only it can be used for lighting and household purposes but it can also be used for mechanization of agriculture which allows for greater productivity at reduced cost. An evaluation of Word Bank-assisted rural electrification projects in Asia indicates that rural electrification in Bangladesh and India raises the use of irrigation, thereby significantly reducing poverty incidence (Songco 2002). It is expected that through improved productivity in farm and non-farm activities, electricity will also bring a positive impact to poverty reduction in both of the sample border provinces.

Like previous infrastructure mentioned above, road development is a means for poverty reduction. A good road network system supported by an appropriate level of transport services can lower costs and prices. This enhances economic opportunities for the poor and helps reduce poverty. A road investment could result in an increase in agricultural productivity, non-farm employment and productivity, directly raising the wages and employment of the poor and, hence, their economic welfare. In addition, higher productivity and expanded employment would lead to higher economic growth, affecting the supply and prices of goods and, thus, the well-being of the poor (Ifzal Ali and Ernesto Pernia 2003).

Overall, development in such infrastructure as phones, irrigation, electricity and roads is expected to create employment and help increase productivity in farm and non-farm sectors which eventually brings benefits to remote households who tend to be poor (this will be discussed in greater detail in the next section).

3. Data and Poverty Measurement

3.1 Data

In this paper, a set of survey data of National Institute of Statistics (NIS) from two provinces, Banteay Meanchey and Svay Rieng in 2006 is used to measure and explain the poverty impact of infrastructure. The data set consists of 600 households in Banteay Meanchey and 599 households in Svay Rieng. The dependent variable is the natural logarithm of per capita household expenditure, *lny*. The total household expenditure is grouped into three categories (i) Food items, (ii) Non-food items that are consumed more frequently/regularly and (iii) Other non-food items which are not so frequently consumed. Per capita consumption expenditure is calculated by dividing the total household expenditure by the household size.

3.2 Poverty Measurement

Poverty Line

Three poverty lines for three different areas: Phnom Penh, other urban areas and rural areas, were constructed in Cambodia. In this paper, poverty lines of other urban and rural areas in 2004 are updated with the rates of inflation occurred from 2005 to 2006. Specifically, because the poverty line was 1,952 riel in other urban and 1,753 riel in rural areas are 1,952 riel and according to the figures produced by CDRI, inflation rate were 16 percent in 2005, the poverty updated line is 2,264 riel for other urban and 2,033 riel for rural areas. If one's consumption expenditure is below 2,264 riel per day, he is classified as a poor in other urban areas and if below 2,033 riel, a poor in the rural areas.

Poverty Indices

Poverty headcount, poverty gap, and poverty severity in Table1, are constructed following the formula proposed by Foster, Greener and Thorbecke (1984).

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha \qquad (1)$$

where

N = total population

y_i = welfare indicator, e.g., consumption per cap

z = poverty line

q= number of poor in the population

$\boldsymbol{y_i, \ldots, y_q < z < y_{q+1} \ldots y_n}$

The Foster, Greener and Thorbecke (FGT) measures are defined for $\alpha \geq 0$, with α as a measure of the sensitivity of the index to poverty. If $\alpha = 0$, equation (1) becomes the headcount index P_0. If $\alpha = 1$, it becomes the poverty gap index P_1 and if $\alpha = 2$, the poverty severity index P_2.

The Headcount Index denoted as P_0 is the proportion of the population for whom, per consumption is below the poverty line. But this headcount index has a disadvantage because it assumes all the poor are in the same situation. The poverty gap index P_1 gives a better idea of how deep poverty is as it reflects the average shortfall of the poor. Despite this virtue the poverty gap index does not capture differences in the severity of poverty amongst the poor and ignore "inequality among the poor". The poverty severity index or the squared poverty gap index P_2 takes inequality among the poor into account by having weights given to each observation and by putting more weight on those that fall well below the poverty line.

Inequality

Poverty measures focus on the situation of persons or households at the bottom of the consumption distribution. Inequality is a broader concept than poverty in that it is defined over the entire population. A measure of inequality attempts to capture the deviation of a given distribution of consumption from the ideal distribution, called perfect equality.

In this paper, Gini coefficient which is the most commonly used measure for inequality is also computed along with the poverty indices above. The Gini coefficient is calculated with the following formula:

$$Gini = 2\,\frac{Cov(y_i, f_i)}{\frac{1}{N}\sum_{i=1}^{N} y_i} \qquad (3)$$

where

y_i is the expenditure of household i

f_i is the rank of household i in the distribution

(f varies between 0 for poorest and 1 for richest)

4. Poverty Profile of the Border Provinces:

Location: Among the two provinces, Banteay Meanchey is found to have higher poverty incidence (P0) than Svay Rieng. Across all provinces, both border rural and rural non-border households which make up 70 percent of the total surveyed population, respectively have 44 percent and 47 percent of population living below poverty line while only 25 to 29 percent of urban households are found to be poor. This finding indicates that poverty is largely a rural phenomenon. The poverty gap P(1) poverty severity P(2) are lower in Svay Rieng than in Banteay Meanchey meaning that the poor are less poor and the gap among the poor is smaller in the former province. However it seems that overall inequality is higher in areas where poverty rate is lower. Table1 shows that Gini coefficient is relatively smaller in Svay Rieng and rural stratum implying that the gap between the rich and the poor is relatively narrower.

Household Characteristics: Poverty rate and inequality are a bit higher with households headed by female. This finding conforms well to previous studies which showed that female-headed households are usually poorer than male-headed households. As far as age is concerned, poverty incidence increases when the age of household head increase and is the highest among 50-60 year-old group. The inequality, however, is high among 30-40 and 40-50 year-old groups. When it comes to education, poverty rate decreases as the education level of household heads increase. About 68 percent of heads, however, never finished primary education and the poverty rate, poverty gap and poverty severity is highest among this group.

Sources of Income: Of households in both provinces, 14 percent of them are cross border traders and 33 percent are cross-border workers. Poverty incidence, poverty gap, and poverty severity are found to be highest among the later group, indicating that the number of the poor is higher, the poor are relatively poorer, and the inequality among the poor is larger within cross-border workers as compared to other groups. Nevertheless, the overall disparity between the rich and poor is highest among the trader group. Breaking down by sources of income, it is found that 51 percent of households earn money from cultivation of cereal crops, 16 percent from manual labor, and 17 percent from own enterprises. Poverty rate is higher than the average for many groups. Among those who rely on cultivation of cereal crops and manual labor, the respective poverty rate is 43 percent and 56 percent. The poverty gap and poverty severity index suggest that the poor in manual labor group is relatively poorer and the inequality is relatively higher than any other groups. Consistently the Gini coefficient is highest in the groups with lower poverty rate.

Access to Infrastructure

Cell phone: During the surveyed period only 17 percent of households in the sample are found to have cell phone. Among the households that have this communication equipment only 11 percent of them lives below the poverty line. The poverty gap and poverty severity are also found lower among this group. However the overall gap between the rich and the poor is relatively larger compared to the group having no phone.

Electricity: Access to electricity is very limited in the border provinces. Only 15 percent of households are found to have access to city power during the surveyed period. As shown in Table1 many households use kerosene (42 percent) or battery (40 percent) for lighting. The poverty incidence, poverty gap, and poverty severity are relatively higher among households that use kerosene. The gap between the better-off and the worse-off, however, is relatively larger among households that use city power.

Irrigation: The majority of population has no access to irrigation system. Only some 28 percent of household were able to access to irrigation system. Poverty rate and Gini coefficient are found to be highest within the households who did not have access to irrigation system. However no noticeable differences in poverty gap and poverty severity are detected between these two groups. Investment in irrigation system would greatly benefit the poor as most of them rely on cultivation of cereals for livelihood.

School: Of the total households in the sample, 75 percent of them live far from a primary school. As can be seen, the poverty rate is higher when households locate farther from the school – ranging from 35 percent for the group that lives within 200 meters to 42 percent with group that lives between 1km and 5 km far from school. The poverty gap and poverty severity are higher within groups living far away from school. Being near school seems not only to provide opportunity for the children from all socio-economic status groups to attend class but also give them more time to directly or indirectly help household business. As a result, households near school tend to have relatively better economic status.

Health Center: Almost all of households live farther than 200 meters from a health center. Health center is relatively scarce compared to primary school. Like in the case of primary school, households who live farther away from a health center tend to be poorer. The poverty rate varies from 24 percent with group of households within 200 meter distance to 45 percent with group of households beyond 5 km away from the center. Again the Gini coefficient is larger within the lower poverty rate groups.

Road: Some 69 percent of the surveyed households live farther than 1km from a main road and 37 percent of them live below the poverty line. Inequality is found to be high with groups of lower rate of poverty. Being near the main road enhances chance for households to engage with business activities. Being near the main road also facilitates households to access to social services including electricity, irrigation, school, and health center mentioned above. Therefore, a relatively small percentage of households who live near the main road are found to be poor.

Table1: Poverty Characteristics

			Share	P(0)	P(1)	P(2)	Gini
Total			1.00	0.40	0.10	0.04	0.35
Location	Province	Banteay Meanchey	0.50	0.44	0.13	0.05	0.30
		Svay Rieng	0.50	0.36	0.08	0.03	0.39
	Strata	urban border	0.20	0.25	0.05	0.02	0.39
		rural border	0.20	0.44	0.10	0.03	0.30
		urban non-border	0.10	0.29	0.08	0.03	0.38
		rural non-border	0.50	0.47	0.13	0.05	0.31
Household Characteristics	Gender	Male	0.79	0.40	0.10	0.04	0.35
		Female	0.21	0.41	0.10	0.04	0.37
	Age	20-30	0.13	0.32	0.07	0.03	0.34
		30-40	0.28	0.38	0.09	0.03	0.37
		40-50	0.28	0.42	0.12	0.05	0.36
		50-60	0.17	0.46	0.12	0.04	0.34
		60 and above	0.13	0.40	0.11	0.05	0.29
	Education	None	0.68	0.46	0.12	0.05	0.30
		Primary	0.22	0.35	0.08	0.03	0.38
		Lower Secondary	0.09	0.18	0.03	0.01	0.38
		Higher Secondary	0.01	0.14	0.03	0.01	0.28
		College Graduate	0.00	0.00	0.00	0.00	0.17
	Occupation	Trader	0.14	0.18	0.04	0.01	0.38
		worker	0.33	0.56	0.16	0.07	0.32
		Others	0.53	0.36	0.09	0.03	0.33
	Income Sources	Cultivation of Cereal Crops	0.51	0.43	0.11	0.04	0.29
		Cultivation of Other crops	0.01	0.33	0.06	0.01	0.31
		Forest Produce	0.00	0.40	0.18	0.08	0.28
		Livestock	0.02	0.48	0.13	0.05	0.25
		Fisheries	0.01	0.33	0.07	0.02	0.51
		Wage / Salary from manual labor	0.16	0.56	0.16	0.07	0.35
		Wage / Salary from non-manual labor	0.08	0.26	0.07	0.03	0.33
		Own Enterprises (non-agricultural)	0.17	0.23	0.06	0.02	0.41
		Remittances	0.03	0.53	0.15	0.06	0.29
		Subsidy, social security (pensions)	0.00	0.00	0.00	0.00	0.00
		Others	0.01	0.20	0.06	0.02	0.24
	Land title	No	0.20	0.55	0.18	0.07	0.32
		Yes	0.80	0.38	0.09	0.03	0.34
Access to Infrastructure	Cellphone	No	0.83	0.46	0.12	0.05	0.30
		Yes	0.17	0.11	0.02	0.01	0.36
	Electricity	City Power	0.15	0.14	0.03	0.01	0.40
		Generator	0.01	0.12	0.04	0.03	0.31
		power and generator	0.00	0.25	0.06	0.02	0.23
		Kerosene/Gasoline	0.42	0.59	0.17	0.07	0.27
		Candle	0.01	0.57	0.16	0.08	0.35
		Battery/Flashlight	0.40	0.32	0.07	0.03	0.29
		None	0.00	0.00	0.00	0.00	0.00
	Irrigation	Not Irrigated	0.72	0.43	0.11	0.04	0.32
		Irrigated through canals	0.28	0.38	0.08	0.03	0.31
		Irrigated Otherwise	0.01	0.20	0.10	0.05	0.30
	Primary school	Less than 200 meters	0.15	0.35	0.07	0.02	0.40
		Between 200 m and 1 Km	0.48	0.40	0.11	0.04	0.35
		Between 1 Km and 5 Km	0.36	0.42	0.11	0.04	0.30
		Beyond 5 Km	0.01	0.38	0.15	0.09	0.41
	Health center	Less than 200 meters	0.04	0.24	0.05	0.02	0.37
		Between 200 m and 1 Km	0.19	0.38	0.09	0.04	0.37
		Between 1 Km and 5 Km	0.44	0.39	0.11	0.04	0.36
		Beyond 5 Km	0.33	0.45	0.11	0.04	0.31
	Main road	Less than 100 meters	0.12	0.24	0.06	0.03	0.39
		Between 101 m and 500 m	0.12	0.30	0.07	0.02	0.40
		Between 501m and 1 Km	0.08	0.40	0.12	0.06	0.37
		More than 1 Km	0.69	0.45	0.12	0.04	0.31

Source: Author's calculation

Regression Analysis

Model Specification

A model used for regression analysis is developed from per capita consumption model which has been used in many poverty studies. The basic consumption model theorizes per capita consumption as a function of a set of household characteristic variables including household size, assets, education, and sanitation. However, it is arguable that development level of an area could play significant role in poverty determinants. Further, variables, which represent for development level, should also be included into the basic model to reflect the effect of development on consumption. However, as discussed in Section 2, the neo-classical framework posits that economic growth can be achieved by increase in capital, either human or physical, and technological progress. Since infrastructure would increase capital productivity, it is also safe to assume that infrastructure would increase economic growth or per capita income. Here, per capita consumption is used as a proxy of per capita income. Incorporating a set of development variables and a set of infrastructure variables into the basic per capita consumption equation, a model to detect the impact of infrastructure can be specified as follow:

$$ln\mathbf{y_i} = \boldsymbol{\alpha} + \boldsymbol{\beta}'\mathbb{x}_i + \boldsymbol{\gamma}'\mathbb{y}_i + \boldsymbol{\delta}'\mathbb{z}_i + \boldsymbol{\mu}_1 \qquad (3)$$

where

$\mathbf{y_i}$ is a per capita consumption of household i

$\mathbb{x}_i$ is a vector of household characteristic variables.

$\mathbb{y}_i$ is a vector of development level variables

$\mathbb{z}_i$ is a vector of infrastructure variables and

It is worth noting that as development level and infrastructure variables can be correlated; there is a need to enter these two groups of variables into the estimation equation separately. Estimation (2), (3) and (4) in both OLS and quantile regression are created in order to address such multi-collinearity issue. It should also be noted that the coefficients in these semi-log equations have the interpretation of percentage changes, not changes in levels. This is because the dependent variable is the log per capita expenditure not the per capita expenditure itself, and the changes in logs equal the percentage change in levels.

Description of Explanatory Variables

The explanatory variables include household characteristics, the development level of the area, and the infrastructure variables. As mentioned earlier, the household characteristics include household size, education of household head, sanitation, land size, land title and hand-tractor. The basic concepts of these variables and their relationships to the welfare are briefly explained below.

HHS is the household size or the number of household members. In general, the larger the household size the smaller the per capita consumption expenditure. Thus the sign of the household size coefficient is expected to be negative.

Education is the educational level of the household head. In the current survey, people were asked the highest educational level that he/she has successfully completed and codes were used to represent their grade level. Here, the variable is classified into 6 categories: 1 no education, 2 primary, 3 lower secondary, 4 upper secondary, 5 college graduate, 6 post graduate. The sign of the coefficient of Education would be positive, as on average, higher levels of education are associated with higher income and hence higher per capita expenditure.

Sanitation is a dummy variable indicating whether or not a household have a toilet. It takes value one if household possesses a toilet and zero otherwise. As a large proportion of diseases are caused by limited access to sanitation, the poor are particularly susceptible to health-related outcomes arising from poor sanitation (Murshid and Phim 2005). The sign of the coefficient of Sanitation would be positive because household with knowledge of sanitation would less frequently suffer from ill-health and therefore could more productively engage with income generating activities which would in turn result in relatively higher per capita expenditure.

Land is the area of land owned by households. Land is considered to be the most valuable asset for farmers and the size of land owned by households is often used as household welfare indicator. The better off households generally possess larger agricultural land and hence they are able to produce and consume more than the worse off ones. Per capita consumption expenditure would then be expected to be positively associated with this independent variable.

Title is a dummy variable showing if the land owned by household has any certified document. Households which lack secure land rights are vulnerable to land grabbing, encroachment, and other types of conflicts (CDRI 2008). This in turn reduces investment incentives, even when capital resources are available. Those households are also unable or otherwise reluctant to assume the risks associated with variable soil and climate conditions, especially drought and floods. Hence, household that owns land with secure title is expected to use that land more productively and would be able to generate higher income and afford higher per capita expenditure.

Tractor is a variable of household that has productive asset. Evidence from CDRI's Moving Out of Poverty study conducted in nine villages showed that not only that tractor or hand-tractor can be used as farming tools but they can also be used as taxi to transport people to make extra earning.

Urban is a dummy variable denoting a development level of an area. It takes value one if a household live in urban area and zero if in rural. Urban dummy variable is expected to have a positive sign because urban is expected to have more economic activities which can provide employment to urban residents.

Border is an integration intensity variable with regional economy. This border dummy is set to one if household resides near border and zero otherwise. The economic activities are observed to be more intensified in the border areas compared to others. Many migrants come to get benefits that border can offer which include cross border trade and cross border work (Phim et al 2007). Household that resides in border areas are expected to economically benefit from cross border interaction and afford higher expenditure.

Phone is dummy variable indicating whether or not a household has a technology to communicate with others. It is widely accepted that information has economic value because it allows households to make choices that yield higher expected payoffs or expected utility than they would obtain from choices made in the absence of information. Hence households with information equipment are expected to have higher welfare than those without it.

Irrigation is a dummy variable which represents whether or not households have access to irrigation system. Irrigation has been seen as a way to reduce poverty of rural households. Anders Engvall and Ari Kokko (2007) suggest that irrigation along with land improvement provides additional improvements in human development outcomes. As irrigation is expected to improve the livelihood of households who has access to it, the sign of Irrigation would be positive.

Electricity is a dummy variable indicating whether or not households have access to electricity. The importance of energy to development is well documented and there is empirical basis to the relationship between access to modern technology and human development (UN Millennium Project 2005). Electricity is expected to have positive sign as households who can access to electricity may be able to expand opportunities for other businesses and improve household welfare.

Mroad is a dummy variable that represents the proximity to the main road. To construct the road dummy, the distance of 200 meters away from the main road is used as the cutting point. Mroad is set to 0 if households locate farther than 200 meters from the main road and set to zero otherwise. Households located near the main road are expected to receive greater economic benefits and so its coefficient sign would be positive.

Table 2: Variables Included in Econometric Estimation

Variable name	Variable nature	Mean	Std Dev	Expected sign
lny	natural logarithm of per capita consumption	13.77	0.59	
Controlled variables				
Household size	numeric variable	5.21	2.05	-
Education	ordinal variable	1.44	0.73	+
Sanitation	dummy variable	0.25	0.43	+
Land	numeric variable	1.43	1.78	+
Title	dummy variable	0.80	0.40	+
Tractor	dummy variable	0.06	0.25	+
Border	dummy variable	0.24	0.43	+
Urban	dummy variable	0.17	0.38	+
Infrastructure variables				
Phone	dummy variable	0.17	0.38	+
Irrigation	dummy variable	0.28	0.45	+
Electricity	dummy variable	0.17	0.38	+
Mroad	dummy variable	0.12	0.32	+

Regression Note

Regression analysis is performed using STATA software package. Heteroskedasticity is the common econometric problem when dealt with cross-sectional data analysis. To tackle this issue two different methods are used to estimate the coefficients of variables. The first one is OLS regression with robust option. The STATA regress command includes a robust option for estimating the standard errors using the Huber-White sandwich estimators. With the robust option, the point estimates of the coefficients are exactly the same as in ordinary OLS, but the standard errors take into account issues concerning heterogeneity and lack of normality.

The second method is quantile regression or median regression. Quintile regression estimates often have better properties than OLS as a way of assessing the heteroskedasticity in the conditional distribution of the variables for interest (Angus Deaton 2000). STATA can do a median regression in which the coefficients will be estimated by minimizing the absolute deviations from the median. As an estimate of central tendency, the median is a resistant measure that is not as greatly affected by outliers as is the mean.

To investigate the stability of coefficients and to evaluate the relative importance of the impact of explanatory variables on poverty reduction as well as to address the issue of multi-collinearity, regression analysis based on all models specified above will be performed. This technique will be employed with both regression methods above.

Results

Table 3 presents the results of regression analysis based on OLS with robust option and those based on quantile regression. As can be seen, the results obtained from both OLS with robust option and quantile regression analysis are very much similar. All coefficients of explanatory variables estimated from both methods have the same signs and almost equal effect on per capita consumption. Within each regression method, estimation1 examines the effect of household characteristics on per capita consumption, estimation2 examines the effect of development level, estimation3 looks at the impact of infrastructure, and estimation4 is the full model which attempts to capture the effect of household characteristic, development level and infrastructure variables. Using different sets of variables gives a good sense of how robust the results are.

Focusing primarily on estimation4 of quantile regression, it is seen that all household characteristic variables have significant effects on consumption. Household size is statistically significant at a 1 percent level across all estimations in both OLS and quantile estimations, and the coefficient suggests that one member additional to a household decreases per capita consumption about 9 to 10 percent. Households whose heads have higher education can enjoy higher consumption per capita. Education level variable is statistically significant at a 1 percent level across all estimations, and its coefficient suggests that it increases consumption by 12 to 19 percent. Sanitation is also found to have positive and statistically significant impact on per capita consumption at a 1 percent level in all estimations and the effect on consumption varies from 12 percent to 42 percent. Land size is statistically significant at a 1 percent level. One hectare of additional land would increase per capita consumption by 4 percent to 6 percent. Land title is not significant in model1 and model2 in quantile regression and model1 in OLS but significant in other models which include infrastructure variables. When controlled for infrastructure effect, land title could raise per capita consumption by 6 to 8 percent. Finally, tractor is statistically significant in all estimations and the use of tractors would increase per capita consumption up to 23 percent. The result for household characteristics is underpinned by earlier studies on other countries. There are negative welfare effects for large households and positive effect for education（Deaton and Paxson 1998; Ellis and Bahiigwa 2003; Woolard and Klasen 2005).

For the development level variables, it is seen that both border and urban variables have positive effect on consumption when estimated with OLS when infrastructure variables are not included. Focusing on estimation2, it is found that border is statistically significant and the coefficient suggests that being in the border areas increases per capita consumption by 14 percent to 16 percent. Unlike border, urban has consistent statistically significant effect on per capita consumption in all estimations. Being in urban areas increases per capita consumption by 16 to 34 percent. Evidence from similar studies on other countries also reveals the positive effect of development variable, urban dummy, on welfare (Shinkai 2006).

The effect of infrastructure variables on per capita consumption is found to be positive and statistically significant in all models and estimation methods. Phone is consistently and statistically significant at a 1 percent level and the coefficient implies that households with a cell phone have 41 to 43 percent higher per capita consumption. Irrigation is statistically significant in all estimations and its coefficient suggests that access to irrigation system increase per capita consumption by 7 to 8 percent. Electricity is consistently significant at a 1 percent level. Households that can access to electricity have 22 to 29 percent per capita consumption higher compared to those who cannot. Main road is also statistically significant across all estimations. The results indicated that being near the main road increases per capita consumption by 7 percent to 14 percent. The result for infrastructure variables is broadly in line with what is typically found in similar studies on other countries. Grameen phone exemplifies a good case of phone use for poverty reduction. There is evidence showing that poverty is substantially low in irrigated areas compared with unirrigated areas in India, Philippines, Thailand and Vietnam (Bhattarai et al 2002). Electricity is also found to have strong impact on poverty reduction in other countries (Fan et al 2002; Balisacan and Permia 2002). There are positive impact of road on poverty reduction (Kwon2000; Balisancan, Pernia, and Asra 2002; Fan et al 2002; Jalan and Ravallion 2002).

Table 3: Effect of Infrastructure on Per Capita Consumption

	OLS with Robust Option								Quantile Regression							
	Estimation(1)		Estimation(2)		Estimation(3)		Estimation(4)		Estimation(1)		Estimation(2)		Estimation(3)		Estimation(4)	
Constant	13.753	***	13.686	***	13.730	***	13.715	***	13.747	***	13.650	***	13.718	***	13.677	***
Controlled Variables																
HHS	-0.091	***	-0.093	***	-0.099	***	-0.099	***	-0.090	***	-0.089	***	-0.103	***	-0.102	***
Education	0.194	***	0.176	***	0.120	***	0.119	***	0.166	***	0.179	***	0.138	***	0.145	***
Sanitation	0.425	***	0.319	***	0.140	***	0.124	***	0.424	***	0.294	***	0.141	***	0.142	***
Land	0.043	***	0.056	***	0.058	***	0.062	***	0.039	***	0.050	***	0.050	***	0.055	***
Title	0.046		0.063	**	0.081	***	0.078	***	0.038		0.039		0.065	*	0.081	**
Tractor	0.138	**	0.162	***	0.153	***	0.162	***	0.120	*	0.152	**	0.218	***	0.204	***
Border			0.156	***			0.070	**			0.136	***			0.032	
Urban			0.337	***			0.159	***			0.313	***			0.190	***
Infrastructure Variables																
Phone					0.424	***	0.412	***					0.429	***	0.406	***
Irrigation					0.077	***	0.063	**					0.075	**	0.066	**
Electricity					0.288	***	0.241	***					0.266	***	0.224	***
Mroad					0.139	***	0.100	***					0.109	**	0.074	*
(Pseudo) R2	0.286		0.340		0.431		0.441		0.156		0.189		0.244		0.251	
Observation	1199		1199		1199		1199		1199		1199		1199		1199	

Note: *** statistically significant at 1% level
** statistically significant at 5% level
* statistically significant at 10% level

Effect of Infrastructure on Poverty Reduction

The results of the OLS regression investigation with estimation4 show that cell phone, irrigation, electricity and main road, all have positive and statistically significant impacts on per capita consumption. These results show very positive impacts on per capita consumption but still nothing is known in terms of how these infrastructure variables would help reduce poverty.

Here attempts are made to estimate the infrastructure effects on poverty reduction. These can be done by using the estimated parameters of estimation4 of OLS regression with robust option and the predicted consumption per capita can be used as a base for comparison. To detect the impact of each infrastructure variable, all households are assumed to have access to respective infrastructure. With this assumption and coefficients obtained from estimation4 of OLS regression, the consumption per capita when all households have access to each of these infrastructure variables can be predicted. Based on these predicted consumption per capita and the same poverty lines constructed earlier, poverty incidence, poverty gap and poverty severity can also be estimated.

Table 4 presents the simulations of the poverty impact of infrastructure variables based on the findings from OLS regression analysis with estimation4. For cell phone the simulation result shows that having cell phone could increase consumption per capita by 36 percent. Poverty incidence would drop dramatically from 31 percent in base point to only about 4 percent with the presence of cell phone. The effect of cell phone is not limited to those who live near poverty lines but it runs deeper. The simulation shows that cell phone also reduce both the depth of poverty and the severity of poverty by about 92 percent.

The second simulation explores the effect of irrigation on poverty reduction. The result of estimated coefficients indicates that irrigation could raise the mean of consumption per capita by 3 percent. This can result in alleviating 15 percent of poverty incidence, 17 percent of poverty gap and 19 percent of poverty severity. The fact that the effect of irrigation is not as strong as that of cell phone can be explained by the efficiency of these two variables and the law of diminishing return. Even though irrigation seems crucial for agricultural production, its quality is not so good. Secondly, since cell phone is relatively new to people, the marginal return from using it is extremely high.

The third simulation scrutinizes the effect of electricity on poverty reduction. Results from regression analysis suggest that access to electricity increases the mean of per capita consumption by 19 percent. The depth of poverty and the severity of poverty are reduced by 75 and 77 percent respectively. Among all infrastructure variables, the impact of electricity is the second strongest to reduce poverty following that of cell phones.

Last but not least, the impact of road on poverty reduction is estimated in the fourth simulation. It is understood from the regression analysis that living near a main road would increase per capita consumption by 11 percent raising the mean of per capita consumption from 2839 riels per day to 3054 per day. Poverty rate, poverty gap and poverty severity decline by 30 percent, 36 percent and 40 percent respectively. The impact of road on poverty ranks third among the four variables. The same reasons for the case of irrigation can also be applied to road in explaining its relatively low impact.

Table4: Impact of Infrastructure on poverty reduction

	mean per capita consumption	poverty incidence	poverty gap	poverty severity
Base	2849	0.310	0.052	0.013
All households has phone	3865	0.037	0.004	0.001
All households has access to irrigation	2937	0.263	0.043	0.011
All households has access to electricity	3401	0.108	0.013	0.003
All households locate near road	3054	0.218	0.033	0.008
Change				
All households has phone	35.7%	-88.2%	-91.5%	-92.3%
All households has access to irrigation	3.1%	-15.3%	-16.6%	-19.0%
All households has access to electricity	19.4%	-65.3%	-74.6%	-77.2%
All households locate near road	7.2%	-29.8%	-36.2%	-40.5%

5. Summary and Policy Recommendation

Findings from poverty profile confirm that poverty is largely a rural phenomenon. Poverty rate is surprisingly lower with households headed by female. Age decomposition shows that poverty incidence increases when the age of household head increase and is the highest among 50-60 year-old group and that the majority of heads never finished primary education. Decomposing by occupation, poverty rate is found to be higher than the average for those who rely on cultivation of cereal crops and manual labor. Consistently the Gini coefficient is highest in the groups with lower poverty rate. Access to public infrastructure is still very limited in the border provinces during the survey period. Only a small proportion of households have access to city power and irrigation system. A vast majority of households locate far from primary school, health center and main roads. Poverty rate is high among the group of majority who cannot access to city power and irrigation and is found to get higher the farther from those public facilities households are situated.

Results from both OLS and quantile regression mostly conform well to expectation. For household size, it is found that one member additional to a household could decrease per capita consumption by 10 percent. One the other hand, one level higher of education and one hectare of additional land to household would increase per capita consumption up to 19 percent and 6 percent respectively. Sanitation, land title, and tractor could increase per capita consumption by up to 43 percent, 7 percent and 23 percent, respectively. For the development level variables, being in the border and urban areas could increase per capita consumption by 15 percent and 30 percent respectively. Finally, the infrastructure variables, the variables of interest, are found to exert positive impact on consumption. Phone, irrigation system, electricity and road could increase per capita consumption by 42 percent, 8 percent, 29 percent, and 11 percent respectively.

The simulations to detect the impact of infrastructure variables on poverty produce encouraging results. Cell phone, irrigation, electricity and road could reduce poverty incidence by 94 percent, 56 percent, 88 percent and 64 respectively. The effect of infrastructure is not limited to those who live near poverty lines but run deeper. The simulation shows that these variables also reduce the depth of poverty by 97 percent, 78 percent, 94 percent, and 82 percent, and decrease the poverty severity by 97 percent, 86 percent, 96 percent and 88 percent, respectively. Among the four infrastructure variables, cell phone has the hugest impact on poverty reduction followed by electricity, road and irrigation.

However, the cost of using infrastructure in Cambodia is extremely high (Lundsrom and Ronnas 2006). Telephone and internet communications is a type of infrastructure for which the cost is extremely expensive and the quality is low due to oligopoly markets. Electricity was ranked high as a business constraint. The electricity cost can be decreased, either by new sources of energy or by importing cheaper energy. Transportation cost is very high, mainly due to the poor quality of roads. This has been a major problem for commercialisation of the agricultural sector as well as industrialisation outside Phnom Penh.

Royal Government of Cambodia has recognized the important role of infrastructure for economic development. To further advance rural development there is a need to invest in rural infrastructure. In the National Strategic Development Plan 2006-2010, the rehabilitation of physical infrastructure include: primary and secondary roads, railways, airports, ports, irrigation facilities, telecommunications, electricity generation and distribution networks, etc., receive top priority with maximum attention being paid to attracting private sector to undertake work on a BOT basis wherever possible.

Based on empirical investigation above, all the four infrastructure variables which are included in the Rectangular Strategy appear to have strong effects on poverty reduction. Project design including location of infrastructure investments is critical.

Poverty reduction can be hastened if rural roads, irrigation, and rural electrification interventions are made in locations that are pivotal in terms of distributive and multiplier effects.

References

Agénor, P-R, A. Izquierdo, and H. Fofack, (2001), "IMMPA: A Quantitative Macroeconomic Framework for the Analysis of Poverty Reduction Strategies," Washington, DC: World Bank.

Ali and E. Pernia, (2003), "Infrastructure and Poverty Reduction—What is the Connection?" Economics and Research Department, Policy Brief No.13, ADB, Manila

Anders, Orjan, and Fredrik, (2008), "Poverty in Rural Cambodia: The Differentiated Impact of Linkages, Inputs and Access to Land," Asian Economic Papers

Anders and Kokko, (2007), "Poverty and Land Policy in Cambodia," Stockholm School of Economics, Working Paper 233.

Asian Development Bank, (1999), "Fighting Poverty in Asia and Pacific: The Poverty Reduction Strategy, ADB: Manila

Asian Development Bank, (2001),"Participatory Poverty Assessment: Cambodia," Manila.

Asian Development Bank, (2003) "Assessment of Implementation of Selected Sectoral Policy Initiatives and Reforms in Cambodia," ADB: Manila

Balisacan, A.M., E.M. Pernia, and A. Asra, (2002), "Revisiting Growth and Poverty Reduction in Indonesia: What Do Subnational Data Show? ERD Working Paper Series No.25, Economics and Research Department, ADB:Manila

Bhattarai, M.,R. Sakhitavadivel, and Intizar Hussain, (2002), "Irrigation Impacts on Income Inequality and Poverty Alleviation," International Water Management Institute Working Paper 39, Colombo

Calderon, C. and L. Serven (2004), "The Effects of Infrastructure Development on Growth And Income Distribution", Policy Research Working Paper No. 3400, World Bank, Washingtong, DC.

Chan Sophal and Kim Sedara, (2003), "Enhancing Rural Livelihoods," Cambodia Development Review, CDRI: Phnom Penh.

CDRI, (2008), "Rural Land Titling," Cambodia Development Resource Institute, Phnom Penh

Deaton, Angus, (1997), "The Analysis of Household Surveys: A Microeconometric

Approach to Development Policy," Baltimore, The Johns Hopkins University Press.

DFID, (2002), "Making the Connections: Infrastructure for Poverty Reduction," London

Dollar, David and Kraay, Aart (2000), "Growth is Good for the Poor," Washington DC, World Bank

Don Richardson, Ricardo Ramirez, Moinul Haq, (2000), "Grameen Telecom's Village Phone Progamme in Rual Bangladesh: A Multi-Media Case Study," Canadian Development Agency.

Ellis, F. & Bahiigwa, G. (2003), "Livelihoods and Rural Poverty Reduction in Uganda" World Development, (31) 997-1013

Fan, S., L.X. Zhang, and X. B. Zhang, (2002), "Growth, Inequality, and Poverty Reduction in Rural China: The Role of Public Investments," Research Report 125, International Food Policy Research Institute, Washington, DC.

CDRI, (2007), "Moving Out of Poverty? Trends in Community Well-Being and Household Mobility in Nine Cambodian Villages," Cambodia Development Resource Institute.

Jalan, J., and M. Ravallion, (2002), "Geographic Poverty Traps? A Micro Model of Consumption Growth in Rural China", Journal of Applied Econometrics 17(4): 329-46.

John Weiss, (2003), "Infrastructure Investment for Poverty Reduction: A Survey of Key Issues," www.adbi.org/cfinfra03/contents.htm

Knowles, James C, (2003) "Cambodia Poverty Review," Asian Development Bank: Manila

Kwon, E.K.,(2000) "Infrastructure, Growth, and Poverty Reduction in Indonesia: A Cross-Sectional Analysis," Asian Development Bank, Manila

Lord, Montague, (2001), "Macroeconomic Policies for Poverty Reduction in Cambodia," Final Report to the Asian Development Bank, Manila.

Lubker et al, (2002) "Growth and the Poor: A Comment on Dollar and Kraay," Journal of International Development, (14) 555-571.

Mankiw, N.G., D. Romer and D. Weil (1992), "A Contribution to the Empirics of Economic Growth," Quarterly Journal of Economics, (107): 407-437.

Martin Ravallion, (1996), "Issues in Measuring and Modelling Poverty" The Economic Journal, (106) 1328-1343

Milbourne, R., Otto, G., and Voss, G.(2003), "Public Investment and Economic Growth," Applied Economics, (35) 527-540

Phim Runsinarith, (2004), "Empirical Study on Economic Growth Effect of Government Activities in Developing Countries," Master Thesis.

Roger Koenker and Kevin F. Hallock, (2001) "Quantile Regression," Journal of Economic Perspectives, (15) 143-156

Royal Government of Cambodia, (1994) "First Five-Year Socioeconomic Development," Ministry of Planning: Phnom Penh

Royal Government of Cambodia, (1999) "Cambodia Poverty Index," Ministry of Planning, UNDP; SIDA, World Bank: Phnom Penh

Royal Government of Cambodia, (2000) "Governance Action Plan," Ministry of Planning, Phnom Penh:

Royal Government of Cambodia, (2000) "Interim Poverty Reduction Strategy Paper," Ministry of Planning, Phnom Penh

Royal Government of Cambodia, (2001) "A Pro-Poor Trade Sector Strategy for Cambodia: A Preliminary Concept Paper," Presented at the Pre-Consultative Group Donor Meeting, January

Royal Government of Cambodia, (2001) "First Draft of the Second Five Year," Ministry of Planning, Phnom Penh

Royal Government of Cambodia, (2003) "Cambodia Millennium Development Goals Report," CSD/GSCD/PMATU, Phnom Penh, Royal Government of Cambodia

Royal Government of Cambodia, (2004) "Rectangular Strategy," Phnom Penh

Shinkai Naoko, (2006), "Infrastructure Development and Poverty Reduction: The Case of Vietnam," Forum of International Development Studies, Graduation School of International Studies, Nagoya University

Songco, J., (2002) "Do Rural Infrastructure Investments Benefit the Poor? World Bank Working Paper 2796, Washington, DC

UNCTAD, (2004) "The Least Developed Countries Report, 2004, Linking International Trade with Poverty Reduction," United Nations: New York and Geneva

Woolard, I. and Klasen S. (2005), "Determinants of Income Mobility and Household Poverty Dynamics in South Africa," Journal of Development Studies (41) 865-897.

World Bank, (1997), "Infrastructure Strategies in East Asia: The Untold Story," World Bank Working Papers No.17148.

World Bank, (2004), "Cambodia at the Crossroads – Strengthening Accontability to Reduce Poverty," Report No. 30636-KH, East Asia and the Pacific Region

World Bank, (2002), “A Source Book for Poverty Reduction Strategies,” Washington DC

World Bank, (2004), “Making Services Work for the Poor People,” Washington DC

World Bank, (2006), “Cambodia – Poverty Assessment 2006,” Phnom Penh

World Bank, (2009), “Poverty Profile and Trends in Cambodia,2007,” Phnom Penh

Xianbin Yao, (2003) “Infrastructure and Poverty Reduction-Making Markets Work for the Poor,”Asian Development Bank, Manila.