THE IMPACT OF ROAD DEVELOPMENT ON POVERTY IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

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This paper summarizes evidence suggesting that road improvement in rural areas can contribute significantly to lowering the incidence of poverty, improving educational participation of primary school aged children, and reducing rates of illness. This is done in the context of rural areas of the Lao People's Democratic Republic. It is widely recognized that rural roads in the countries are a major developmental problem. It seems obvious, just by inspecting these roads, that improving them would produce benefits. But demonstrating and quantifying the effects on indicators relevant to the Millennium Development Goals, such as the incidence of poverty, educational participation and health standards, is another matter.

The case study uses household level data from the Lao Expenditure and Consumption Survey (LECS) relating to the years 1997-98 and 2002-03. These data indicate that rural areas of the Lao People's Democratic Republic account for 87 per cent of all poor people in that country. Reducing poverty in that country thus means, primarily, reducing rural poverty. But what works and what does not work in achieving the goal of poverty reduction? This paper is directed at that question and looks at three broadly conceived dimensions of poverty: consumption poverty (meaning expenditure on privately purchased goods and services), educational opportunity and health standards. Consumption poverty measures only the availability of goods and services which people can purchase with their own funds and makes no allowance for the availability of goods and services provided at a collective level, principally by the Government. For this reason, by allowing for such collectively provided items as educational and health services, it is possible to achieve a usefully broad definition of the concept of poverty reduction.

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The results of this analysis suggest that to effect poverty reduction the most important form of road improvement is the conversion of dry season access roads to all season access. This is in fact the principal form of road improvement that occurred between 1997-98 and 2002-03. Over this same period, the incidence of poverty declined from 42.5 to 37.6 per cent of the rural population. The results of this analysis suggest that about one fourth of the poverty reduction that actually occurred can be directly attributed to this form of road improvement: the conversion of roads which are accessible only in the dry season to roads which are accessible in all seasons. These results therefore suggest that the principal form of road improvement which has occurred in the Lao People's Democratic Republic in the past has been consistent with the goal of maximizing the rate of poverty reduction.

The data also indicate that the improvement of roads affects educational participation and health standards. The results are not as robust, statistically, as those for poverty, but an interesting difference emerges. Whereas the effect on the incidence of poverty are strongest for the upgrading of dry season access roads to all weather roads, educational and health benefits are derived mainly from the provision of dry season access roads to households which previously were accessible only by walking. Over the five year period examined in this paper, very little road improvement of this kind actually occurred in the Lao People's Democratic Republic. The results suggest that significant educational and health benefits would be derived by providing dry season road access to the 20 per cent of rural households which presently lack it.

I. INTRODUCTION

How do development projects affect the welfare of the population? This question is fundamental to the operation of many public agencies, including multilateral and bilateral development institutions. The tools of analysis employed to study such questions are various and all have limitations. The basic problem is that the social sciences generally lack the possibility of controlled experimentation, which has been so successful within the natural sciences for identifying causal relationships. This fact necessitates the use of imperfect

substitutes for properly controlled experiments as a method of determining the way interventions like public sector projects impact on social and economic variables of interest.

This paper seeks to determine the way that project interventions affect the achievement of basic social objectives such as the internationally adopted Millennium Development Goals (MDGs). These goals include poverty reduction and improvements in basic education, health, gender equity, environmental quality, and other objectives central to the agenda of development. If the activities of development institutions are to promote the achievement of these goals, it is necessary to know how project interventions affect them. That is not easy.

One approach is to use socio-economic surveys to study the statistical relationship between the incidence of poverty and the implementation of public projects of various types. The existence or non-existence of a project is treated as an exogenous (independent) variable whilst the impact variables (poverty, education, health, and so forth) are treated as the endogenous (dependent) variables. The relationships between the former and the latter may be studied with or without a project, in the case of cross-sectional data, or before and after a project, in the case of time series data. The fact that the 'experiments' concerned are not properly controlled is relevant, however. Suppose, for example, that areas with high levels of income per person had previously been chosen by the Government or another implementing institution for the location of a particular kind of project. If a study found that low incidence levels of poverty were statistically associated with the existence of the project this would not necessarily indicate that the project reduced poverty. It might simply reveal the way the government had decided about the location of the project. In this case, a better approach would be to study the changes in the variables concerned over time, using the change from one survey period to another. As with the cross-sectional approach, however, the problem is that many variables change over time, and not just the existence or non-existence of the project. The changes that occur over time might not be due to the project at all, but to some other variable which also changed over time.

Another approach is to use computerized models of the economy to study the way that economic changes, such as the existence or non-existence of a particular kind of project, affect variables of interest. The advantage of this approach is that it makes true experiments possible. The models facilitate the changing of one variable at a time and analysis of the effects that this change produces, holding everything else constant. The obvious disadvantage of this approach is that the results are only as good as the models that are used and it is often difficult for non-specialists to assess the quality of the models underlying the

results and hence the value of the results themselves. All such models rest heavily on assumptions about the qualitative functioning of the economy and the quantitative relationships between variables of interest. These assumptions are always open to doubt and dispute, producing uncertainty about the reliability of the results that emerge from them.

This paper reports on a case study that examined the effects of improved roads using the socio-economic surveys approach. An earlier study (Warr 2005) examined the effect of improved roads on consumption expenditures and measures of the incidence of poverty based on consumption. The present paper draws upon these results and also reports new results on the effect of improved roads on two other Millennium Development Goals: improved health and education.

II. SUMMARY DATA ON ROADS, POVERTY, EDUCATION AND HEALTH

Background

Since the late 1980s, a programme of market oriented economic reforms, translated from Lao as the New Economic Mechanism (NEM), has shifted the economy away from the rigidly socialist pattern instituted immediately after the declaration of the Lao People's Democratic Republic in 1975. Since the reforms began, overall economic growth has been impressive. From 1991 to 2002 annual growth of GDP averaged 6.2 per cent per annum, or around 3.8 per cent per person. The agricultural sector dominates employment, with 80 per cent of the workforce, and contributes about 50 per cent of GDP, down from just over 60 per cent in 1990. The country receives substantial external support. In 2002/3 external donors contributed 61 per cent of the Government's capital budget, representing 39 per cent of total public expenditure, and 7.6 per cent of GDP. Over the decade 1992-93 to 2002-03 estimates for the incidence of poverty in the country declined from 46 to 33.5 per cent of the population.

The reform process has been successful, but it is hardly surprising that many problems remain. One of the most serious, evident to any visitor to rural areas of the country, is the poor state of rural roads. Many villages have no road access at all, meaning that vehicles cannot reach them. They are accessible only by walking. Others have access only during the dry season, meaning that during the extended rainy season, vehicle access to their village is impossible. Poor roads impede the capacity to participate in the market economy. Reforms may remove prohibitions on participating in the market economy, but this might be of little help if roads are so bad that market participation is prevented by high transport

costs. It seems likely that improved rural roads will improve living conditions in rural areas, but can this effect be demonstrated and quantified? That is the focus of this paper. It asks whether improving rural roads is an effective instrument for reducing poverty and for improving health and educational outcomes for the rural population.

Indicators of socio-economic progress in the Lao People's Democratic Republic

The most useful source of socio-economic data on the population is the Lao Expenditure and Consumption Survey (LECS). This survey has been conducted every five years since 1992-93. The number of households surveyed is around 8,900, about 1.2 per cent of the total number of households in the country, containing around 57,600 individuals.[1] The individual households sampled in each survey are seldom the same and, in any case, households are not identified individually and it is therefore not possible to compare the same households across time, using the LECS survey data.

Data from the LECS surveys indicate that in 2002-03, 77 per cent of the population resided in rural areas, but the incidence of poverty in rural areas (the proportion of the population with real expenditures below the poverty line) was almost double that of urban areas (figure 1). Most tellingly, rural areas accounted for 86.5 per cent of all poor people.[2] Poverty in the country is overwhelmingly a rural phenomenon and it follows that poverty reduction is primarily a matter of reducing rural poverty. We now turn to data which may help identify the determinants of poverty in rural areas and the ways it can be addressed, focusing on the contribution of roads.

"Distance to main road" is one of the variables listed in LECS, but this variable is known to be of unreliable quality, a point that is emphasized by LECS data enumerators. The variables "Rural with access to road" and "Rural without access to road" are considered more reliable and these are the data used in the present study. These variables reflect yes/no answers from households and are treated as dummy (0, 1) variables in the regression analysis.

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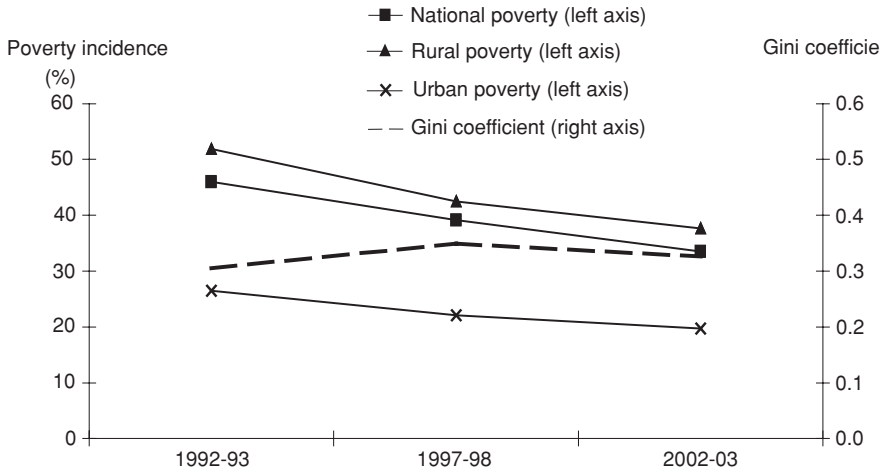
1 A fuller description of the survey and its variables is provided in Warr (2005).

2 It can be shown that the share of rural areas in the total number of poor people is given by $S_R^P = \alpha_R P_R / P$, where α_R is the share of the total population residing in rural areas, P_R is the share of the rural population that is poor (that is, the headcount measure of poverty incidence in rural areas) and P is the share of the total population that is poor.

Figure 1. Lao People's Democratic Republic: The incidence of poverty and inequality, 1992-93 to 2002-03



Source: Richter, van der Weide and Souksavath (2005), using data from LECS, National Statistical Center, Vientiane.

Table 1 summarizies data assembled by Richter and others (2005) and presents results drawn from the three LECS surveys conducted to date. Between the LECS I and LECS II surveys (1992-93 and 1997-98, respectively), both the format of the LECS survey and the sampling method used were changed. For this reason, accurate comparison of the results from these two surveys is difficult. The format and sampling method remained the same from LECS II to LECS III, so comparison between these two surveys (1997-98 and 2002-03) is more reliable and our discussion will emphasize these two surveys.

The LECS surveys make it possible to classify households into three categories of road access: All season access, meaning wet and dry seasons; dry season access only; and no road access. No road access means that the village can be reached only on foot. Of all the nation's households, 77 per cent were rural in 2002-03, 43.9 per cent (57 per cent of all rural households) had all season road access, 13.1 per cent (17 per cent of all rural households) had dry season access, leaving 20 per cent (26 per cent of all rural households) without any road access at all. This problem of lack of road access is a particular problem in rural areas of the northern region, which is also the poorest. There, 38 per cent of households lack road access. In some specific areas of the country this problem is even worse. Along the northern border with Viet Nam the proportion is 53 per cent and

Table 1. Lao People's Democratic Republic: Socio-economic change and road access, 1997-98 to 2002-03

		1997-98	*2002-03*
Population (million)		5.087	5.519
Population shares (%)	– Urban	16.7	23.0
	– Rural	83.3	77.0
	With all season road	36.0	43.9
	Without all season road	47.3	33.1
	– Dry season access only	26.7	13.1
	– No road access	20.6	20.0
The incidence of poverty (%)		39.1	33.5
	– Urban	22.1	19.7
	– Rural	42.5	37.6
	With all season road	31.7	31.3
	Without all season road	50.8	46.2
Poverty gap (%)		10.3	8.0
	– Urban	4.9	4.1
	– Rural	11.4	9.2
	With all season road	7.3	7.1
	Without all season road	14.5	12.0
Gini index of per capita consumption (%)		34.9	32.6
	– Urban	39.7	34.8
	– Rural	32.1	30.3
	With all season road	32.1	30.3
	Without all season road	30.9	29.4
Access to electricity (%)		31.1	47.6
	– Urban	91.1	97.1
	– Rural	19.0	32.0
	With all season road	35.4	44.0
	Without all season road	6.6	18.1

Source: Richter, van der Weide and Souksavath (2005), using data from LECS, National Statistical Center, Vientiane.

along the southern border with Cambodia 54 per cent of households lack any road access.

Table 1 shows that the proportion of the population residing in rural areas who had all season road access increased from 1997-98 to 2002-03 from 36 per cent to 44 per cent. This improvement in road access coincided with other dimensions of socio-economic improvement in rural areas. The headcount measure of the incidence of poverty in rural areas declined from 42.5 per cent to 37.6 per cent. Some part of this decline might be attributable to improved access to all season roads, but not all of it. Within the population having all season road access the incidence of poverty remained almost constant (declining from 31.7 per cent to 31.3 per cent), but it declined significantly within the population lacking any road access (from 50.8 per cent to 46.2 per cent). Events other than the improvement in roads must have caused the latter's change. The question that remains is to what extent, if any, can reduced poverty be attributed to improved roads? We return to this question in the following section.

Of course, the headcount measure is only one indicator of absolute poverty, but other indicators show a similar picture. The poverty gap measure (unlike the headcount measure) is sensitive to how far a household's consumption per capita falls below the poverty line, it is also shown in table 1 and behaved very similarly to the headcount measure. Measures of inequality, like the Gini coefficient shown in table 1, are quite different. Measured inequality increased slightly in virtually all areas of the Lao People's Democratic Republic over this decade. Access to electricity improved in all rural areas over this decade, including both those with all season road access and those without it.

The LECS surveys also include data on other socio-economic outcomes of interest. Table 2 focuses on educational participation. It looks at the proportion of children in the primary school age group 5 to 12 who attend school. These data relate to LECS III, covering the year 2002-03. Not surprisingly, school attendance is highest among rural households who have all season road access, and lowest among those without road access, among both males and females. The data indicate that the average time taken to reach school *per head of the school age population* is actually higher among those with all season access than those without road access. But this is a consequence of lower school participation rates in the latter group. The average time taken to reach school *among those actually attending school* is highest for those without road access. Expenditure on education per student is highest among those households for which road access is best. This reflects higher incomes and the higher priority placed on education by the latter group.

Table 2. Lao People's Democratic Republic: Educational participation and road access, 2002-03

	All Season Access	*Dry Season Access Only*	*No Road Access*	*All*
School Attendance	80.67	70.48	51.90	69.41
Females (%)	80.00	67.82	47.54	67.06
Males (%)	81.37	72.98	56.27	71.72
Average time traveling to school	8.14	9.02	6.24	7.79
Average expenditure on education (kip per student per month)	111 963	86 973	65 152	96 209

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: Expenditure on education is measured in kip per student per month.

Table 3 summarizes data from LECS relating to health. The survey includes questions on the proportion of people who became ill in the past 4 weeks. This proportion is somewhat higher in households with low levels of road access. Moreover, in areas with poor roads, those who did become ill were less likely to seek treatment. In these households, more days were missed from work than in households with better roads and, not surprisingly, less was spent on transport to hospital.

Table 3. Lao People's Democratic Republic: Health status and road access, 2002-03

	All Season Access	*Dry Season Access Only*	*No Road Access*	*All*
Proportion of persons who became ill in the last 4 weeks (%)	13.31	13.37	15.63	14.07
Of those ill, those who did not seek treatment (%)	80.69	83.16	89.80	84.35
No treatment because too difficult to get there (%)	11.83	24.83	24.10	18.55
Average days missed due to poor health (days per household, last 4 weeks)	0.58	0.58	0.76	0.64
Average expenditure on transport to hospital (kip per household per year)	102 958	72 460	50 564	85 494

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Two features of tables 1 to 3 are especially notable. Firstly, the final row of "Population shares" in table 1 makes it clear that the change in road access over the five year period 1997-98 to 2002-03 was heavily concentrated in the provision of all season road access to households which already had dry season access. The proportion of rural households with "All season access" increased and the proportion with "dry season access only" declined correspondingly. But the proportion with "no road access" barely changed.

Secondly, turning to tables 2 and 3, by comparing households that have all season access against those with dry season access only and then comparing households with dry season access against those without road access, one clear point emerges. The greatest differences in education and health outcomes are in the second comparison – those with dry season access only against those without road access. Those who attained dry season road access, having previously had none, showed a greater improvement in education and health than those who attained all season road access, having previously had only dry season access.

The above suggests that improved roads coincide with lower levels of the incidence of poverty, higher levels of school participation, more spending on education at the household level, better standards of health and better care for those who become ill. However, areas with roads and those without roads differed in many respects. Therefore it is not possible to infer directly from these data whether improved road access is alleviating poverty and raising educational and health levels, or whether some other factors are at work. The following section will examine this matter.

III. ISOLATING THE EFFECTS OF ROADS ON POVERTY[3]

Multiple regression is a way of coping with the fact that more than one factor which potentially influences the dependent variable is changing across the sample. This occurs when the data are not generated by controlled experiments, changing only one independent variable at a time. The problem that this raises is how to sort out the respective causal influences of each of these independent variables. The LECS surveys make it possible to deal, imperfectly, with this point, by taking note of the variation in many independent variables using multiple regression methods. Results are reported in this section.

[3] This section draws upon, but also updates, results presented in Warr (2005) reporting research supported by the Asian Development Bank Institute. The updating is based on the official 2002-03 poverty incidence estimates provided in Richter and others (2005).

Does road improvement reduce poverty, and if so, by how much? The LECS survey has data on consumption expenditures at the household level. Data were converted into a per capita form and deflated by regional consumer price indices from concurrent months. This method takes account of both the regional variation in consumer prices and the variation in prices over time. The analysis regresses real household expenditure per capita on the independent variables shown in table 4, including road access, using dummy variables *D* for dry season access roads and *W* for an season access. Then these regression results are used to simulate the change in the distribution of real consumption expenditures that results from hypothetical improvements in road access, as explained below. The incidence of poverty is then estimated from these projected levels of real expenditures at the household level.

The regression results for LECS 3 are reported in table 4. To allow for province-specific effects provincial dummy variables were used, but for brevity, these results are not presented in this or subsequent tables of results.[4] The estimated coefficients had the expected values, including the education variables and asset ownership variables. The variables "access dry season" and "access wet season" each had the expected positive signs, and each was significant at the 1 per cent level of significance. According to these results, having road access in both dry and wet seasons was associated with higher levels of real expenditure per person, after allowing for the impact of other relevant variables.

The implications of these results for the incidence of poverty are explored in table 5. The method of analysis is illustrated in figure 2. The figure shows the projected cumulative distribution of the logarithm of real consumption expenditures per person obtained from the LECS III data set combined with the regression results reported in table 4. These data were assembled by calculating real consumption expenditures per person for all rural households, taking the natural logarithm and then sorting them from the lowest to the highest. The diagram shows three estimated distributions:

P1. The predicted level of real expenditures using the actual values of the dummy variables *D* and *W* as observed in the data as well as actual values of all other independent variables. The difference between this prediction and the actual data is the error of the regression.

[4] As is standard practice, dummy variables were used for all but one of the 18 provinces. The effect of the 18th, for which no dummy variable was used, is incorporated into the constant term. Of the 17 provinces shown in table 4, provinces 1 to 7 belong to the Northern region, province 8 and 10 to 13 belong to the Central region and 15 to 17 belong to the Southern region, along with the 18th province (not listed in the table), Attapeu. The capital region, Vientiane Municipality (Province 9), is in a separate regional category.

Table 4. Lao People's Democratic Republic: Real per capita expenditure and road access, 2002-03, Regression results at household level

Dependent variable: Log of real per capita expenditure			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	10.911	87.710	0.000
Age at last birthday	0.032	7.073	0.000
Age at last birthday squared (household head)	0.000	-6.138	0.000
Primary (1-5 years)	0.140	6.159	0.000
Lower secondary (6-8 years)	0.330	10.439	0.000
Upper secondary (9-11 years)	0.380	6.900	0.000
Higher (vocational training or university/institute)	0.541	9.679	0.000
Paid employment	0.257	4.623	0.000
Farm employment	0.055	1.021	0.307
Not in labour force	0.135	2.098	0.036
Number of adults in household (18 <= AgeAdult < 65)	0.060	6.070	0.000
Total number of members in household	-0.115	-23.015	0.000
Total number of cows and buffaloes	0.021	11.543	0.000
Electricity_n	0.194	8.408	0.000
Daily market_n	0.084	1.381	0.167
Bus stop_n	0.029	0.988	0.323
Clean water_n	0.061	2.883	0.004
Hospital in village	0.350	5.619	0.000
Access dry season_n	0.102	3.403	0.001
Access wet season_n	0.086	2.638	0.008

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.318; adj. R^2 = 0.314; s.e. of estimate = 0.729; F = 85.55; significance level: p = 0.000.

P2. The predicted level of real expenditure when all households have the value of D = 1 and W takes its values from the actual data, along with the actual values of all other independent variables.

P3. The predicted level of real expenditure when D = 1 and W = 1 for all households, along with the actual values of all other independent variables.

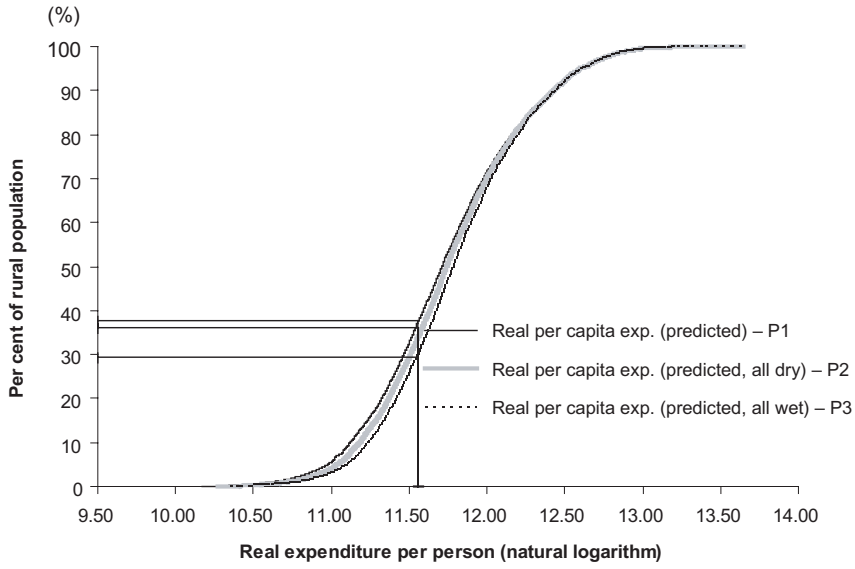
The difference between P1 and P2 is an estimate of the degree to which real consumption expenditures could be increased if all households had access to roads in the dry season, but wet season access remained as observed in the data.

Table 5. Lao People's Democratic Republic: The incidence of poverty and road access, 2002-03, simulation results – estimated the incidence of poverty under alternative road conditions

Dry season road access	*Wet season road access*	*Code*	*Estimated the incidence of poverty (%)*
Observed levels in data	Observed levels in data	P1	37.60
All households with access	Observed levels in data	P2	36.17
All households with access	All households with access	P3	29.36

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Figure 2. Lao People's Democratic Republic: Predicted distribution of real expenditures per person in rural areas under alternative road conditions, 2002-03



Source: Author's calculations based on LECS 3 household survey data from National Statistical Center, Vientiane, and regression results shown in table 4, above.

Note: Units on the horizontal axis are the natural logarithm of real household consumption expenditures per person expressed in December 1999 prices. "real per capita exp. (predicted)" refers to P1 in the text. "real per capita exp. (predicted, all dry)" refers to P2 in the text. "real per capita exp. (predicted, all wet)" refers to P3 in the text.

The difference between P2 and P3 is the degree to which real expenditures could be increased if all households had access to roads in the dry season and the wet season as well. Clearly, the difference between P1 and P3 indicates the overall potential for increasing real expenditures through road improvement.

Figure 2 then uses these calculations to project estimates of the incidence of poverty. The results of this exercise are summarized in table 5. In this exercise the poverty line is selected so that the predicted incidence of rural poverty (P1 above) replicates the incidence of rural poverty officially estimated from the LECS III data – 37.6 per cent – as shown in table 1. In figure 2, this is the uppermost of the three horizontal lines. The difference between the estimated incidence of poverty under condition P1 and P2 is 0.43 per cent of the rural population (the incidence of poverty under condition P2 is 36.17 per cent – the middle horizontal line in figure 2). The difference between P3 and P2 is a further 6.81 per cent of the rural population (the incidence of poverty under condition P3 is 29.36 per cent – the lowest of the three horizontal lines in figure 2). Combining the two, the incidence of rural poverty in the Lao People's Democratic Republic could be reduced by 7.24 per cent by providing all season weather roads to all rural people. This number of rural people is equivalent to about 5.6 per cent of the total population of the Lao People's Democratic Republic. This reduction in poverty would be permanent, assuming that the roads were properly maintained.

A surprising feature of these results is that the difference between the incidence of poverty under condition P1 and P2 is small. Holding other variables constant, providing dry season access, by itself, does little for poverty reduction. Other conditions also have to be met, particularly educational conditions, the availability of electricity supplies and the presence of productive assets such as buffaloes. Much larger gains, in terms of poverty reduction, are available from upgrading dry season access to all-weather access. As noted in relation to table 1 above, the investment in road improvement that has taken place has primarily been the provision of all weather roads to households which already had dry season road access. The results above suggest that this was a good strategy for poverty reduction.

Between the execution of LECS II and LECS III, access to wet weather roads was provided to an additional 7.9 per cent of the rural population. This may be compared with the 47.3 per cent of the same population that lacked it in 1997-98. This improvement was therefore about one sixth of the potential increase in wet season access. Our simulation exercise above indicates that providing all weather access to all rural households would reduce the incidence of poverty by 7.24 per cent. Interpolating linearly, the reduction in the incidence of

poverty may therefore be estimated at about 1.2 per cent of the rural population. The incidence of poverty in rural areas actually declined by 4.9 per cent over this same period (table 1). Therefore, these results imply that about 24 per cent, or one quarter, of the reduction in rural the incidence of poverty that occurred between LECS II and LECS III can be attributed to improved wet season road access.

A possible objection to the analysis performed above is that it ignores the possible implications of a phenomenon now known as the "endogenous placement" problem. Suppose that, in the past, improved roads had been provided *selectively* to better off areas. This would mean that, in part at least, the cross-sectional statistical relationship between better roads and higher real expenditures which is observed in the data would not indicate that better roads caused real expenditures to be higher, but rather the reverse. In this case, it would be invalid to interpret the statistical findings reviewed above as indicating that improving roads reduces poverty.

This possibility was tested by assembling data on road improvement that occurred between the undertaking of LECS II and LECS III.[5] These data were assembled at the district level of which there are 140 in the country. The data are not derived from LECS but from an independent compilation of data from regional government offices and from the Ministry of Roads in Vientiane. Some judgment is involved in assessing whether roads were or were not 'all weather' and whether they were maintained. These judgments reflect the assessments of regional level officers of the Ministry of Roads.

The change in average real expenditures per capita between LECS II and LECS III was then related to the improvement or non-improvement of roads as captured in this data set. The results are summarized in table 6. The base level of real per capita expenditures in LECS II (1997-98) was significant and had a negative coefficient, meaning that better off households did less well in proportional terms (the dependent variable is the change in the log of real expenditures) than poorer households. The base level of road access in 1997-98 was less important in explaining the improvement in average real consumption expenditures at the district level than the change in road access, where the coefficient was significant (at 7 per cent) and numerically of similar magnitude to the value obtained from the cross sectional results.

A further test of the endogenous placement problem was conducted by regressing the change in road access that occurred between LECS II and III on the level of initial real per capita expenditure in LECS II. If a positive relationship was

[5] See Warr (2005) for a full description of these data.

Table 6. Lao People's Democratic Republic: Change in real expenditure from 1997-98 to 2002-03, regression results at district level

Dependent variable: Change in real per capita expenditure			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	3.934	4.131	0.000
Real per capita expenditure LECS2	-0.334	-4.210	0.000
Age at last birthday (household head)	0.078	0.390	0.697
Age at last birthday squared (household head)	-0.001	-0.342	0.733
Primary (1-5 years)	0.441	1.535	0.128
Lower secondary (6-8 years)	0.537	1.006	0.317
Upper secondary (9-11 years)	-0.442	-0.478	0.634
Higher (12+ years)	2.536	2.847	0.005
Working_Head1	0.330	0.855	0.395
Farming_Head1	0.389	1.136	0.259
NotLF_Head	0.162	0.471	0.638
Adult (18 <= AgeAdult < 65)	0.080	0.425	0.672
Total number of members in the household	-1.241	-2.225	0.028
Total number of members in the household squared	0.075	1.780	0.078
Cows or buffalo, owned and free access, no. of animals	-0.001	-0.030	0.976
Market_n	0.128	0.421	0.675
Transport_n	0.068	0.525	0.600
Piped water_n	0.095	0.635	0.527
Community health_n	0.075	0.537	0.593
District has all weather road in 1997	0.021	0.199	0.842
District built road during 1997 and 2002	0.188	1.821	0.071

Source: Author's calculations from LECS II and LECS III survey data, National Statistical Center, Vientiane.
Summary diagnostics:
R^2 = 0.393; adj. R^2 = 0.155; s.e. of estimate = 0.1322; F = 6.944; significance level: p = 0.000.

found, this would support the existence of an endogenous placement problem. The regression was done using provincial level observations. The means of the district level dummy variables for improved road access for each district within the province, as recorded between LECS II and LECS III, were regressed on the provincial means of the district level real per capita expenditure, as recorded in LECS II. If better off areas received preferential treatment in road improvement a significant and positive coefficient would be expected. The estimated coefficient was negative but insignificant. The existence of an endogenous placement problem was therefore rejected.

These results are supportive of the findings of the cross-sectional analysis reported above, confirming that improving road access is a powerful instrument for raising the real consumption expenditures of households, thereby reducing poverty.

IV. ISOLATING THE EFFECTS OF ROADS ON EDUCATION AND HEALTH

Educational participation

Does improving road access improve educational participation? Table 7 reports the results of regressing educational participation rates of children in the primary school age group on the same set of independent variables discussed above. Because participation at the household level is a binary variable (0, 1) for each child, participation was aggregated to the district level to obtain the average participation rate for the district, of children in the relevant age group. The independent variables were similarly aggregated to the district level. So far as road improvement is concerned, the results are not highly significant, but indicate tentatively that providing dry season access raises participation rates (which are significant at 13 per cent), but that providing wet season access has no additional impact.

These results are interesting in that they suggest that road access, by itself, is not the greatest determinant of school attendance. More important variables are the level of education of the head of the household (the variable "lower secondary") and the availability of clean water. Similar results apply to school participation of both female (table 8) and male children (table 9). Over longer periods, improved roads may raise school participation, but these results suggest that in the short term addressing the availability of clean water is more important than providing improved roads.

Health standards

Does improving roads contribute to raising health levels? The LECS surveys include questions which are relevant to this issue. Table 10 reports a regression similar to that described above for education, but for which the dependent variable is the share of people in the district who reported having been ill in the previous 4 weeks. The results are surprising. They suggest that providing dry season road access has a powerful effect in reducing the rate of illness (significant at 2 per cent). How could this be? The mechanism may be that road access, along with the availability of clean water, makes it possible for the household to attain higher levels of hygiene. The ability to obtain treatment for those who become ill may

Table 7. Lao People's Democratic Republic: Primary school participation and road access, 2002-03, regression results at district level

Dependent variable: Share of prime age children in school per district			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	1.625	1.021075	0.310259
Age at last birthday	-0.063	-0.83256	0.407543
Age at last birthday squared (household head)	0.001	0.908241	0.366445
Primary (1-5 years)	0.093	0.770173	0.443438
Lower secondary (6-8 years)	0.762	3.204874	0.001934
Upper secondary (9-11 years)	-0.183	-0.36678	0.714739
Higher (vocational training or university/institute)	0.436	0.801859	0.42498
Paid employment	0.115	0.396726	0.692613
Farm employment	0.394	1.381979	0.170777
Not in labour force	0.164	0.44677	0.656234
Number of adults in household (18 <= AgeAdult < 65)	0.000	-0.23967	0.811192
Total number of members in household	0.000	-0.22999	0.818677
Total number of cows and buffaloes	-0.004	-0.42221	0.673989
Electricity_n	0.060	0.920383	0.360106
Daily market_n	-0.173	-1.1994	0.23387
Bus stop_n	0.060	0.808697	0.421058
Clean water_n	0.126	2.165333	0.033304
Hospital in village	-0.071	-0.47954	0.632845
Access dry season_n	0.003	1.531388	0.12957
Access wet season_n	0.000	-0.18556	0.853257

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.727; adj. 0.605; s.e. of estimate = 0.1493; F = 5.987; significance level: p = 0.000.

also reduce illness among other members of the household. The level of education of the head of the household is again important (the variable "lower secondary"). The results presented in table 11 are loosely supportive of the effect of dry season road access in raising the likelihood of seeking treatment. However, the level of significance is not strong.

Table 8. Lao People's Democratic Republic: Primary school participation of females and road access, 2002-03, regression results at district level

Dependent variable: Share of prime age female children in school per district			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	2.214	1.044881	0.299186
Age at last birthday	-0.096	-0.94732	0.346294
Age at last birthday squared (household head)	0.001	1.026731	0.307604
Primary (1-5 years)	0.245	1.530683	0.129744
Lower secondary (6-8 years)	0.726	2.294988	0.024321
Upper secondary (9-11 years)	-0.149	-0.22439	0.823015
Higher (vocational training or university/institute)	0.816	1.127259	0.262961
Paid employment	0.083	0.21374	0.831287
Farm employment	0.358	0.943538	0.348212
Not in labour force	0.059	0.120504	0.904382
Number of adults in household (18 <= AgeAdult < 65)	0.000	-0.17342	0.862757
Total number of members in household	0.000	-0.28628	0.775395
Total number of cows and buffaloes	0.000	0.000829	0.999341
Electricity_n	0.100	1.147392	0.254597
Daily market_n	-0.196	-1.0177	0.311851
Bus stop_n	0.000	0.00159	0.998735
Clean water_n	0.120	1.554888	0.123872
Hospital in village	0.057	0.29301	0.770264
Access dry season_n	0.004	1.610362	0.111209
Access wet season_n	0.000	-0.18224	0.855853

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.664; adj. 0.515; s.e. of estimate = 0.1988; F = 4.452; significance level: p = 0.000.

V. CONCLUSIONS

This paper summarizes evidence suggesting that road improvement in rural areas of the Lao People's Democratic Republic can contribute to lowering the incidence of poverty, improving educational participation of primary school aged children, and reducing the rates of illness. It is widely recognized that rural roads are a major developmental problem. It is obvious by just inspecting these roads, that improving them will generate benefits. But demonstrating and quantifying the effects on indicators relevant to the Millennium Development Goals, such as the incidence of poverty, educational participation and health standards, is another matter.

Table 9. Lao People's Democratic Republic: Primary school participation of males and road access, 2002-03, regression results at district level

Dependent variable: Share of prime age male children in school per district			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	1.053	0.598558	0.551159
Age at last birthday	-0.037	-0.43474	0.664922
Age at last birthday squared (household head)	0.000	0.469283	0.640144
Primary (1-5 years)	0.020	0.146775	0.883679
Lower secondary (6-8 years)	0.798	3.021298	0.003379
Upper secondary (9-11 years)	0.074	0.119113	0.905485
Higher (vocational training or university/institute)	-0.067	-0.10881	0.913623
Paid employment	0.189	0.589999	0.556854
Farm employment	0.489	1.551408	0.124751
Not in labour force	0.466	1.150286	0.253453
Number of adults in household (18 <= AgeAdult < 65)	-0.001	-0.40397	0.687315
Total number of members in household	0.000	0.081828	0.934988
Total number of cows and buffaloes	-0.008	-0.78427	0.435197
Electricity_n	-0.002	-0.02933	0.976671
Daily market_n	-0.139	-0.85458	0.395337
Bus stop_n	0.121	1.464071	0.147093
Clean water_n	0.181	2.816381	0.006115
Hospital in village	-0.147	-0.88072	0.381108
Access dry season_n	0.002	0.972241	0.333861
Access wet season_n	-0.001	-0.46407	0.643861

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.645; adj. 0.486; s.e. of estimate = 0.1650; F = 4.042; significance level: p = 0.000.

The results of this analysis suggest that for poverty reduction the important form of road improvement is the conversion of dry season access roads to all season access roads. This is in fact the principal form of road improvement that occurred in between 1997-98 and 2002-03. Over this same period, the incidence of poverty declined from 42.5 to 37.6 per cent of the rural population. The results of this analysis suggest that about one fourth of this amount of poverty reduction can be directly attributed to the conversion of roads which are accessible only in the dry season to roads which are accessible in all seasons.

Table 10. Lao People's Democratic Republic: Determinants of incidence of illness, 2002-03, regression results at district level

Dependent variable: Share of Ill people per district			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	-1.640	-2.463	0.015917
Age at last birthday	0.083	2.591	0.011351
Age at last birthday squared (household head)	-0.001	-2.545	0.012822
Primary (1-5 years)	-0.010	-0.186	0.85253
Lower secondary (6-8 years)	0.212	2.076	0.041093
Upper secondary (9-11 years)	-0.150	-0.695	0.488971
Higher (vocational training or university/institute)	-0.523	-2.297	0.024184
Paid employment	0.065	0.517	0.606656
Farm employment	0.088	0.713	0.477671
Not in labour force	0.230	1.450	0.151007
Number of adults in household (18 <= AgeAdult < 65)	-0.014	-0.420	0.675582
Total number of members in household	-0.004	-0.258	0.797167
Total number of cows and buffaloes	-0.005	-1.321	0.190145
Electricity_n	-0.023	-0.846	0.399944
Daily market_n	0.048	0.775	0.44077
Bus stop_n	0.061	1.687	0.095458
Clean water_n	-0.036	-1.460	0.148194
Hospital in village	-0.062	-0.968	0.335788
Access dry season_n	-0.083	-2.398	0.018775
Access wet season_n	0.020	0.601	0.549419

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.602; adj. 0.425; s.e. of estimate = 0.0634; F = 3.399; significance level: p = 0.000.

The data also indicates that the improvement of roads has effects on educational participation and health standards. The results are not as robust, statistically, as those on poverty, but an interesting difference emerges. Whereas the positive effects are strongest for the upgrading of dry season access roads to all weather roads, educational and health benefits derive mainly from the provision of dry season access to households which previously had no road access, meaning that they were accessible only by walking. Over the five year period examined in a case study, very little road improvement of this kind actually occurred. The results suggest that substantial educational and health benefits could be derived by providing dry season road access to the 20 per cent of rural households which presently lack it.

Table 11. Lao People's Democratic Republic: Determinants of decision to seek treatment when ill, 2002-03, regression results at district level

Dependent variable: Share of Ill people not seeking treatment per district			
Independent variables:	*Coefficient*	*t-statistic*	*p-value*
Constant	-2.049	-1.09355	0.277392
Age at last birthday	0.147	1.629321	0.107128
Age at last birthday squared (household head)	-0.002	-1.52987	0.129944
Primary (1-5 years)	-0.003	-0.01648	0.986894
Lower secondary (6-8 years)	0.368	1.283208	0.203078
Upper secondary (9-11 years)	0.036	0.05964	0.95259
Higher (vocational training or university/institute)	-1.050	-1.63933	0.105022
Paid employment	-0.712	-2.02015	0.046674
Farm employment	-0.420	-1.21859	0.226536
Not in labour force	0.087	0.19432	0.846412
Number of adults in household (18 <= AgeAdult < 65)	0.084	0.864484	0.389875
Total number of members in household	-0.017	-0.42956	0.66866
Total number of cows and buffaloes	0.002	0.165343	0.869086
Electricity_n	-0.014	-0.18438	0.854173
Daily market_n	-0.142	-0.81892	0.415234
Bus stop_n	0.026	0.253088	0.800841
Clean water_n	-0.024	-0.34742	0.729176
Hospital in village	-0.098	-0.54537	0.586997
Access dry season_n	-0.117	-1.19857	0.234189
Access wet season_n	0.019	0.202277	0.840207

Source: Author's calculations from LECS III survey data, National Statistical Center, Vientiane.

Note: For brevity, coefficients on provincial dummy variables have been deleted from the reported results.

Summary diagnostics:

R^2 = 0.656; adj. 0.431; s.e. of estimate = 0.1774; F = 1.701; significance level: p = 0.025.

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