Approaches to Appraise the Impact of Rural Road Maintenance in Sub Saharan Africa

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Abstract

A number of agencies have commissioned empirical studies to demonstrate the impacts of investment in rural road infrastructure. This paper by an evidence based systematic review, analyses published methodologies and draws a number of lessons which can be learnt for similar studies in SSA. These findings are utilized to devise an econometric approach which has been developed to assess the impacts of rural road maintenance on the livelihoods of rural communities in thirty communities in three rural districts in Sierra Leone, Uganda and Zambia. The results of the study suggest that road condition has an impact on travel times and transport costs to the local markets. However, the sale prices at the nearest largest market of a variety of goods that have been exported from the communities considered, or imported to the same, were not found to be related to road condition. This suggests that vendors agree, formally or informally, to fix the prices of goods and therefore transport cost savings are retained by the village or market vendor rather than being passed on to the consumer. In some areas it was found that transport availability and costs are governed by the presence of large numbers of motorcycles and their overloading of motorcycles, rather than by road condition.

Keywords— Roads & highways; unpaved roads; developing countries

I. Introduction

It is widely acknowledged that good (i.e. appropriate, sustainable, affordable and safe) rural road networks in developing countries are critical for enabling the connection of people to goods, services, advancing social and economic opportunities and in fostering development. In Sub-Saharan Africa (SSA) the road infrastructure, which moves 80% of the region's goods, was designed for the efficient export of raw materials to export markets[1]. Its rural economies are predominantly agrarian, with supply chains and supporting rural road infrastructure to enable access to markets. However, urgent maintenance and upgrading of SSA's rural road networks are required as 450 million people do not have access to jobs, education and healthcare services[1]. Judicious investment in rural access in the region would help to catalyse hundreds of billions of dollars of trade and improve social and economic development. In realization of these potential benefits major rural road investment programmes are taking place in the region. The benefits of such investment are being scrutinized ever more closely so that government agencies and donors can demonstrate value for money. The evaluation of such benefits however is not straight forward. Road maintenance and the resulting improved road condition do not, in themselves, bring about benefit. Rather the resulting improved access indirectly provides opportunities for improved consumption. It may be expected that a large number of such external contributing factors exist and to enable the benefits of road maintenance investment to be fully understood it is necessary use a methodology which can isolate, or control for, such factors. Further, the selection of roads for maintenance by road authorities is not random, but is based on a number of factors including road condition, economic benefit, political and social reasons.

This paper appraises impact study approaches by means of an evidence based systematic review of the literature. An example of such an approach is provided of a hybrid pragmatic approach developed to evaluate the benefits of rural road maintenance in Sub-Saharan Africa as part of the UK Department for International Development (DFID) funded Research for Community Access Programme (RECAP).

II. Introduction of Impact Study Approaches

A. *Impact Study Approaches*

The impact evaluation techniques described in the literature can be divided into quantitative and qualitative approaches.

B. *Quantitative Approaches*

Experimental design

Experimental designs are usually deemed to be the most robust of all the evaluation methodologies. By randomly assigning the intervention among eligible recipients, the allocation process produces comparable treatment and control groups that are statistically equivalent. [2].

Quasi-Experimental Designs

Quasi-experimental (non-random) techniques can be used to conduct an impact evaluation when it is not feasible to construct treatment and control groups through experimental design. These methods produce control groups that resemble the treatment group, at least in observed

characteristics, through various impact evaluation methodologies such as reflexive comparisons, matching methods, double difference methods and regression methods[2].

Before and after or reflexive approach

The reflexive approach consists of carrying out a survey before and after the road investment project and the impact is determined as the difference between metrics common to both surveys. Since there are no controls and there is no way of knowing what happened to the local economy in general[6]. This type of approach is useful in evaluating network level interventions such as countrywide policies in which it is problematic to have controls[4].

Cross-sectional approach

The cross-sectional (with and without) approach concerns determining the difference between the reported welfare level from a project implementation and the estimated welfare level in a non-intervention scenario.

Matching methods or constructed controls

Matching is a method of sampling from a large stock of potential controls to select the right control group in which the distribution of covariates is comparable to the one of the group subject to the intervention[5]. As it is often problematic to carry out a meaningful impact evaluation without baseline data[6], reliability of the results can be improved by combining matching techniques and other methodologies that make use of baseline data. The most robust, reliable and rigorous design is to combine "with and without" and "before and after" scenarios[7].

Double Difference approaches

This approach combines with and without and before and after approaches and makes use of control data that allows historical trends to be identified and excluded. The essence of this method is to compare a treatment and a control group before and after a project. However, identifying control groups can be challenging because of the likelihood of bias during the selection process. To mitigate this, some researchers choose to combine the double difference approach and propensity score matching. The latter helps in selecting households, roads or communities on a scientific basis that allows control observations to be more judiciously matched with intervention observations[3, 8].

C. *Qualitative approaches*

Qualitative approaches provide critical insights into the beneficiaries' viewpoint, the value of an intervention to beneficiaries, processes that may have influenced outcomes and a deeper interpretation of the results obtained in quantitative analysis. The essence of such approaches is to help in understanding processes, behaviour, and circumstances as perceived by the individuals or groups being studied[2, 8].

III. Systematic Review of Impact Study Approaches

A. *Outline of Review Method*

The review followed an unbiased aggregation approach to identify and appraise empirical studies of the impacts of rural road projects in developing countries. The conceptual framework and

questions posed in the review informed all aspects of the review methodology, including the search strategy, the inclusion and exclusion criteria, data extraction and the approach to synthesis.

The sources considered were bibliographic databases, search engines, professional reports and websites. A summary of the search approach is provided in Figure 1.

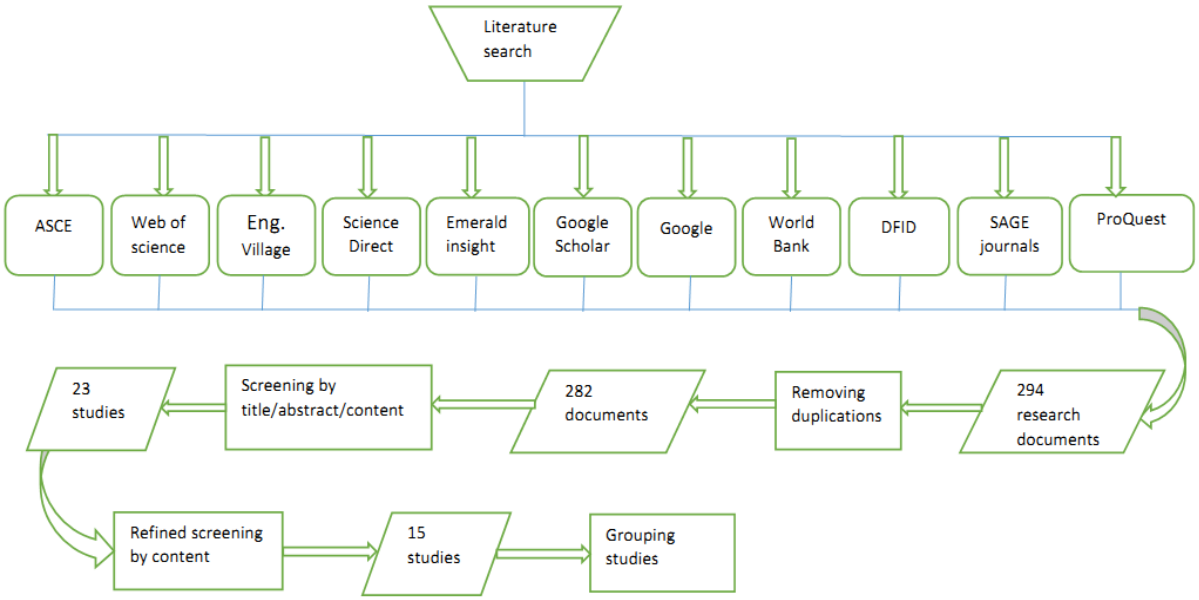

Figure 1: The process of identifying relevant studies relevant to the review

B. *Summary of Main Findings*

Fourteen high quality studies were identified through the evidence based rigorous literature search and screening processes presented in the previous section. The type of studies, in terms of the impact evaluation methods employed are summarized in Figure 2. Two of the studies used a before and after approach, eight were econometric analyses, two adopted a double difference approach (DD) and ten combined the DD approach with Propensity Score Matching (PSM).

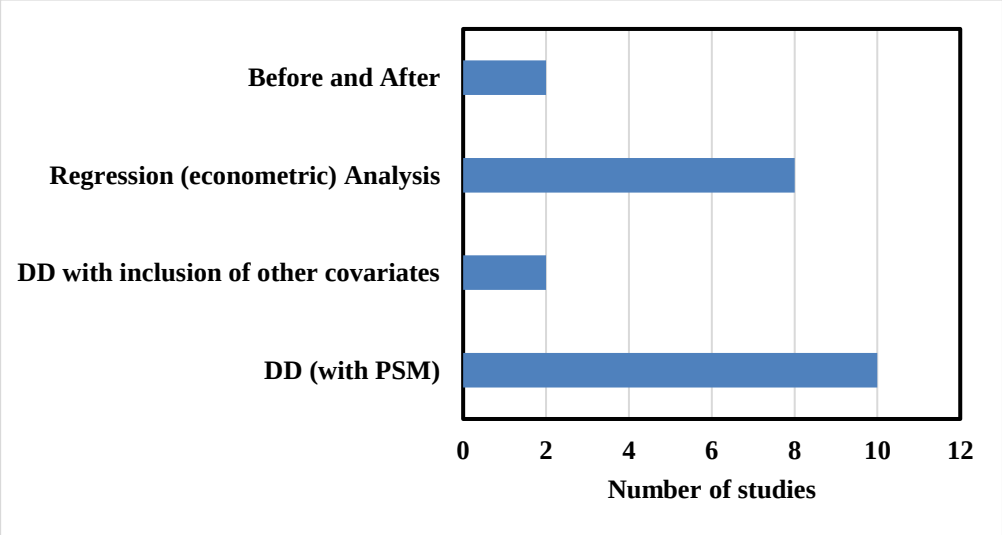

Figure 2: Impact evaluation approaches used

The impacts of rural roads on agriculture (n=9), education (n=11) and transport (n=10) were the most addressed in the studies considered (Figure 3). The spatial distribution of the studies considered was found to be across the globe as shown in Figure 4. Three high quality studies were identified in Sub-Saharan Africa (Ghana, Mozambique and Zambia).

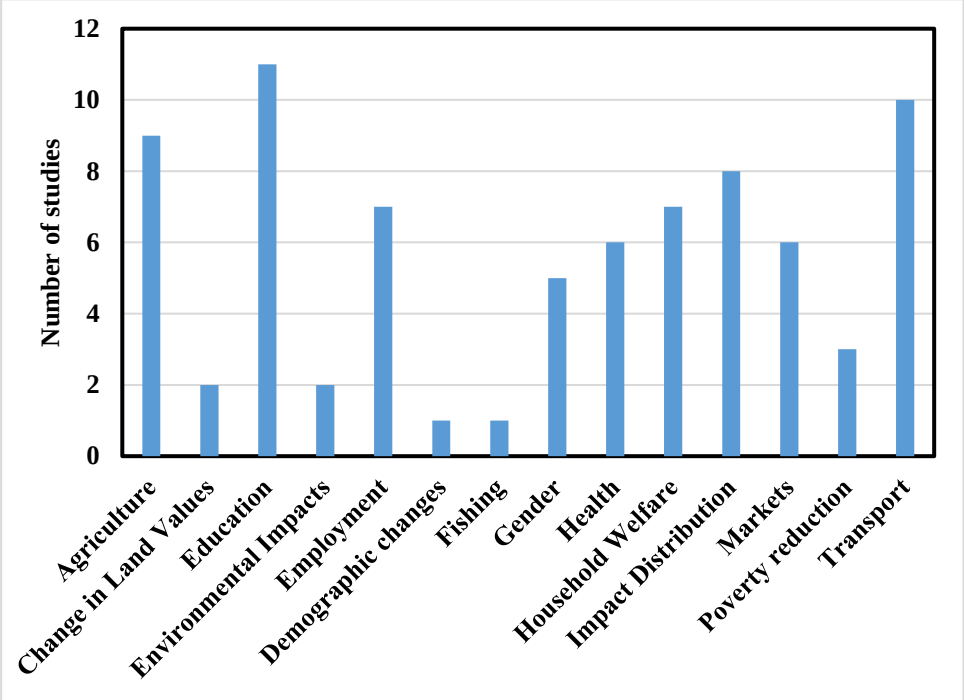

Figure 3: Socio-economic indicators

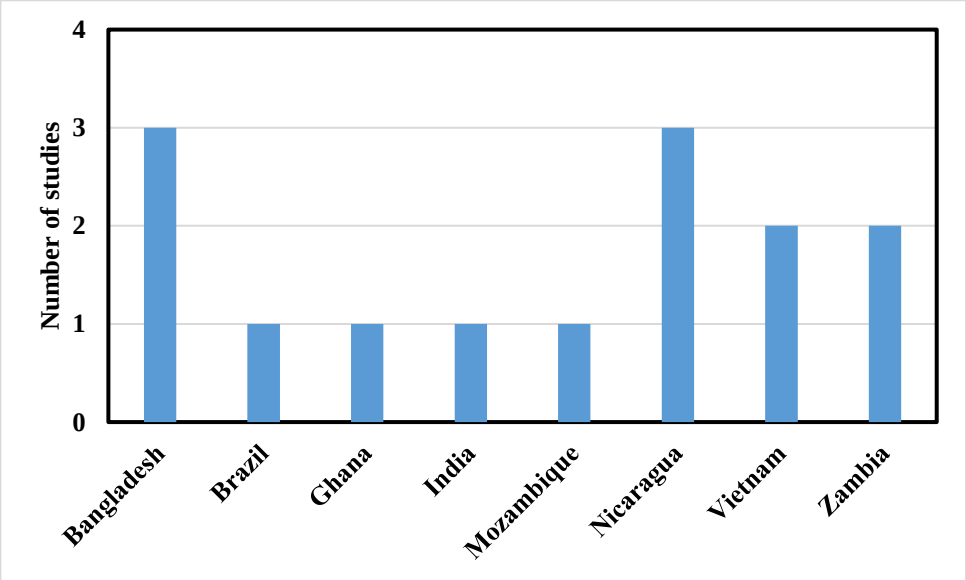

Figure 4: The geographic location of the studies

C. *Methodological Approaches of the Included Studies*

Rationale of impact estimation methodology

For a study to be rigorous time, skills and resources are needed from planning to the final stage of report writing. In general a rigorous study should have (i) baseline and follow-up data taken at pre-defined intervals designed to allow for the impacts to emerge; (ii) the type and size of the selected samples should be representative; (iii) the data collection exercise should be designed in a way that ensures data reliability; (iii) the study should have appropriate controls. The last requirement implies that the most rigorous study should address the counterfactual scenario. In practice the counterfactual scenario cannot be observed (unless there is no intervention and without intervention, there would not be any need of impact evaluation). Econometrics are often used to address these issues. Arguably the most challenging part of an impact evaluation is the attribution of impacts to the intervention (since many other factors can influence the outcomes). In an ideal case where the control fully resembles the treatment group, such other possible factors would also be present in a control and would thus be isolated during impact evaluation provided there is no time related exogenous effect.

It is evident therefore that a method that combines before/after and with/without scenarios is the most reliable. Accordingly the double difference method is often combined with propensity score matching technique to ensure the similarity of control and treatment groups. Regression models are also used which utilize treatment and control data to allow for before and after differences to take into account impacts which emerge over a given period of time.

Sampling

Most of the included studies used a surveying methodology that allows for the collection of data at both household and community level. In the Vietnam study the double matching methodology was used[9]. Even though the project and non-project communities may be well matched using PSM, the households which are included in those communities are not necessarily comparable. Thus, a second matching of households may be required. No randomization approach was used in any of the 14 identified studies and instead a number of approaches were used to select samples from a control group to ensure similar socio-economic characteristics. For example, in Nicaragua[6], the control households were matched with treatment households based on a number of parameters. These included crowding, quality of housing, level of basic services, education, and economic dependency. The households matching criteria may differ to some extent among studies but a considerable number of key parameters may remain the same. For instance, in Zambia[9] the matching criteria included household size, head age, educational attainment, area of the house, water supply, toilet type, main source of lighting and household assets.

It can be challenging to select a sample that is representative of the entire population. In order to mitigate these problems, stratified sampling can be used. The studies in Vietnam[11, 6], Bangladesh[12] and Ghana[13] have employed this approach. Maintaining the same survey samples over time helps in constructing panel (longitudinal) data. Establishing panel data can be extremely important in impact evaluation especially in measuring long-term impacts as in [14-16]. One of the disadvantages of

panel data is that some samples may drop out over time and a careful process is required to replace them[16].

Qualitative approaches

Qualitative methodologies can also help to address sampling and data collection issues. Due to sample size issues, in the Nicaragua study by Danida[10] the resurvey and double difference analysis could not be conducted with reasonable confidence in some areas and so qualitative evaluation methods were employed. A participatory qualitative evaluation of impacts at community level was carried out which relied on community members to discuss the effects and impacts of the programme.

In the Mozambique study, qualitative methods prioritizing participative group discussions were adopted. In all study communities qualitative tools were utilized to characterize the community and as a means of taking into account the opinions of households[18]. Along each of the roads studied, there were group discussions with heads of households, leaders, women and community leaders. Field observations enabled comparative assessment of situations found on each one of the roads.

In the Ghana study both quantitative and qualitative approaches were combined[19]. The use of qualitative approaches was proven to be relevant in many ways. For instance based on the case study of Nicaragua the quantitative approach did not provide any specific effect of the road project to women as far as participation in income generating activities is concerned[10].

Impact estimation techniques

As discussed previously, randomization has a greater statistical significance and thus provides more reliable results compared to other impact evaluation methodologies. However, a randomization approach remains more theoretical than practical. For example among the 14 studies considered, no study was identified where an intervention was randomly assigned without any possible external factors governing the selection of project area.

Among the studies considered, the ones in Ghana[19] and Mozambique[18] are the least rigorous. These have employed before/after impact evaluation approach. Given the weakness of before/after methodology, especially in controlling for the historical trend of observable characteristics, these studies used qualitative analysis to help in reducing methodology limitation caused by absence of controls. Nevertheless, the Mozambique study had control areas but because of the fact that they were actually within areas influenced by other road projects, it was not feasible to identify aspects that could be used for comparison.

The early Vietnam study used double difference analysis with propensity score matching. The study assumed that unobserved characteristics were time invariant[9]. Though this study did not take into account time-varying unobserved heterogeneity, the follow-up study by Mu and Van de Walle[14] did. They adopted a more rigorous methodology that allows for the possibility of time variant selection bias and used the predicted probability of participation in the intervention programme to match control communes in the double difference estimate. The propensity score was estimated using a logit that comprises initial conditions that may affect outcome variables. Such a methodology has also been used in the Nicaragua study[10]. Mu and Van de Walle used different approaches to check the robustness of empirical results.

The early Bangladesh study[20] used a regression model which assumes unobserved heterogeneity to be time invariant. The follow-up study three years later[12] adopted a more rigorous methodology which in addition to controlling for unobserved characteristics of households, the study also controlled for potential observed factors affecting changes in household outcomes over time. Eight years after the baseline, a second follow-up study took place[15].

The Brazil study used two estimation approaches: simple double difference matching and double difference regression[9]. To verify the statistical robustness of the estimated results, instrumental variable estimation was also employed. The Zambia study also employed an estimation based on the double difference analysis with inclusion of other covariates to allow for various time-varying household characteristics.

The Nicaragua study by Kongens[16] used a pooled linear regression model and a fixed effects model. The pooled regression analysis allowed control for both "within each household" and "between households" variation. The fixed effects model allowed for all time-invariant effects to be account for. The disadvantage of these two models is the failure to control for the unobserved heterogeneity which varies over time.

As a key note, controlling for unobserved heterogeneity marks the limitation of double difference analysis and some other regression models. Some studies simply make assumption that the unobserved heterogeneity is time-invariant or just admit the limitation[20, 16, 6]. The need to control for time invariant unobserved heterogeneity highlights the need to use rigorous methodologies. Some studies used regression equations with covariates included[13, 19]. Two studies used a double difference methodology with matching techniques that allow for consideration of initial conditions that may affect the subsequent outcomes[6, 14] and one dynamic panel estimation[15].

IV. Growth Through Effective Asset Management

The Growth through effective asset management (GEM) project aims to demonstrate that improved rural road asset management will improve road condition and thereby contribute towards a general improvement of the socio-economic conditions in rural communities. Three project areas in Chongwe District (Zambia), Kamuli District (Uganda), and Tonkolili District (Sierra Leone) were selected for the trial implementation.

A. *Methodology and Approach*

Phasing

A phased approach was adopted in which the Formulation phase (December 2015- October 2016) developed a detailed implementation methodology, identified socio-economic measures and selected the participating road authorities. Phase two (November 2016 – January 2017) concerns the baseline quantitative socio-economic data gathering phase. Phases three September 2017 to date) and four (September 2018-December 2018) concern the first and second annual data gathering exercises.

Selection of villages

An initial desktop evaluation was conducted to determine candidate villages and round-table discussions were held with district engineers and other technical staff to finalise the choices.

Econometric analysis

Following a review of the variety of approaches available above, it was decided because of issues of resources that a reflexive approach allied to an econometric analysis and supported by a qualitative evaluation of key informant interviews would be used.

B. *Initial Conditions of Villlages*

At the start of the project, the mean travel time to the nearest central market was 48 minutes and 50% of all sample villages were located more than 20 km from the nearest central market. The average speed for journeys to the central market by motorbike was 28 km/h. It might be expected that those villages with better average road condition may be expected to have improved economic circumstances. As household surveys were not undertaken as part of the study, the number of amenities / shops has been used as a measure of the economic circumstances of a village. Figures Figure: 5 andFigure *6* show how the number of amenities in a village were related to both the distance of a village from the nearest central market (Figure: 5) and the speed of travel to the market (Figure 6*Figure 6: Number of amenities in the baseline data as a function of distance to central market (disaggregated by average journey speed*)). In Figure: 5 the relationship has been plotted for villages above and below the median travel time. In Figure 6 journey speed has been used to separate the data.

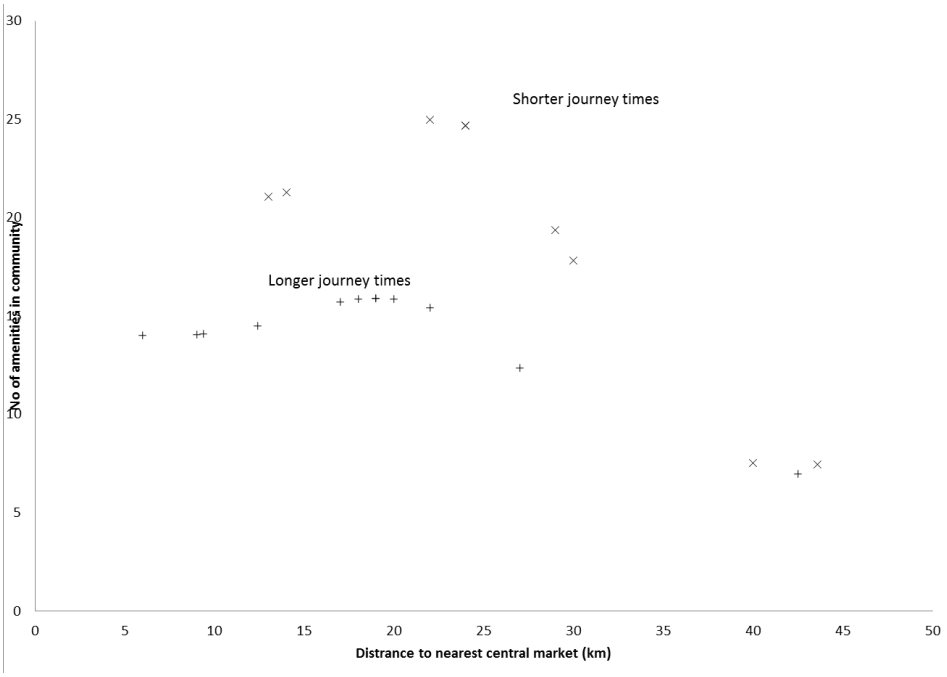

Figure: 5: Number of amenities in the baseline data as a function of distance to central market (disaggregated by journey time).

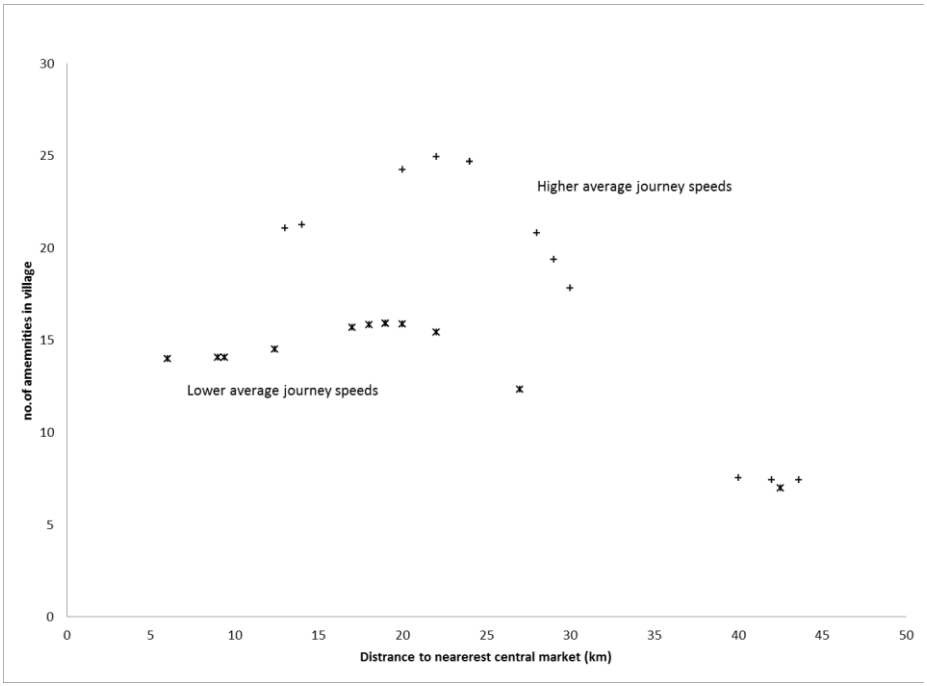

Figure 6: Number of amenities in the baseline data as a function of distance to central market (disaggregated by average journey speed)

Notes: Figures 5 and 6 are non-parametric Gaussian Kernel regressions, using locally weighted smoothed scatter plots. Villages have been disaggregated by journey time (Figure 5) and journey speed (Figure 6).

It is evident from both figures that those communities with most amenities occur at middle distances (circa 20 – 25 km). It may therefore be surmised that the closer a village is to the central market, the less the need for its own amenities. Villages furthest away from the central market are less able to import goods and also supply significant passing trade. For villages with better access the relationship is an inverse parabolic function. The shape of the relationship for villages with poorer access is flatter. Villages with poorer access are shown to have fewer amenities at all distances from the nearest central market.

Tables 1 to 4 examine how villages with below and above median access differ in their initial characteristics. For Kamuli District, access has been defined as the average road condition from the village to the nearest central market. For Chongwe and Tonkolili districts in the absence of suitable average road condition data, access has been defined by the distance to the nearest central market (Chongwe and Magburaka Town respectively). Travel times and speeds have not been used to define access since the available data provides times and speeds for motorbikes only and these may not necessarily be a reliable indicator of road condition as discussed below. Student's two tailed t-test has been used to determine the significance of the differences of the baseline variables.

C. *Kamuli District*

The baseline data for Kamuli District (Table 1) shows that, for two groups of villages categorised in terms of road condition, there is statistically no difference in their population sizes, the distance and travel times to the nearest central market of Kamuli. The roads were generally in a fair state and

with reasonable drainage and were closed for not more than one day during the year. It can also be seen that the transport costs per km across all modes are not statistically different between villages served by roads in better condition compared to those served by roads in poorer condition. Furthermore, the price of a basket of goods (with the exception of sugar) imported from Kamuli market and the price of a basket of goods exported from the villages are similar for villages served by roads in good condition and those in poorer condition. The above may suggest that transport costs savings, if they are significant, are not being passed on to consumers by vendors. It may also be seen that the price of goods in Kamuli both exported to the villages and imported from the villages are the same no matter their village of origin or destination. Market competition may mean that goods are sold at the same price in Kamuli no matter their origin. In terms of agriculture, although the villages served by better roads are visited more regularly by farm extension workers (at the 20% level of significance; i.e. p=20%), the price of the main cash crop in the village is higher (p=20%).

The above findings may be considered surprising given that statistically there is no difference in the population sizes, the distance and the travel times to the nearest central market of Kamuli of the two groups of villages. However, a closer analysis of other aspects of the baseline data and field observations helps to explain these apparent anomalies.

The lack of a correlation between road condition and transport costs per km from the villages may in part be explained by overloading. Informal interviews and observation suggest that the overloading of people and goods tends to occur for all transport modes in the Kamuli District. This has the effect of reducing the cost of transport per person or item. This is not the case on paved roads which are policed. During the collection of the baseline data on many gravel roads Boda-Bodas were seen to carry two to three people and similarly freight transport was found often to be overloaded with goods and in some cases passengers were transported in addition (and literally) on top of goods.

The price of village produced goods in the local trading centre

An analysis of the local trading centre prices of village produced goods and those imported into the village is described below.

Goods exported from the village

For coffee and maize, the greater the availability of Boda-Bodas the lower the selling price (p=10%) and the higher the cost of transport via Boda-Boda the higher the price. As far as the cost of Boda-Boda transport is concerned the villages selling coffee at a lower cost have both lower passenger and freight costs (p=20%). This suggests that a significant amount of coffee and maize are taken to the local trading centre by passengers riding on a Boda-Boda. Given that there does not appear to be a statistically significant correlation between coffee and maize price and transport availability and cost of modes other than the Boda-Boda, it can be surmised that the major mode of transporting coffee to local trading centres is via the Boda-Boda.

Villages with a higher cost of rice have lower truck transport availability (p=20%) and higher truck freight costs (p=10%). Rice cost is also strongly correlated (p=5%) to the distance from the nearest paved road, but not to road quality.

Goods imported into the village

As far as petrol is concerned, there are no petrol stations in the villages and all fuel is bought from petrol stations in Kamuli town centre. There are a number of small makeshift petrol stations that sell petrol illegally, but these did not divulge their cost of petrol.

Villages with a higher than average cost of salt tend to be furthest away from Kamuli (p=10%) and from the nearest paved road (p=5%). Such villages also have higher freight transport costs across all three modes. The cost of soap appears from the baseline data to be statistically significantly related to Boda-Boda activity. Journeys by Boda-Boda to Kamuli from villages with a higher than average cost of soap are longer (p=20%). For such villages the availability of Boda-Bodas is less (p=10%) and the cost of freight transport by Boda-Boda is greater (p=5%).

Boda-Boda motorcycles

Interestingly the baseline data suggests that the availability and speed of Boda-Boda motorcycles are statistically significantly greater in villages served by roads in poorer average road condition. Boda–Boda are relatively inexpensive to purchase, they are easy to learn to ride, easily maneuverable around road defects and can carry several passengers. Hence they appear to be the transport of choice for villages served by roads in poor road condition, explaining the inverse correlation between availability and road condition. As far as the relationship between speed and road condition is concerned, informal interviews with Boda-Boda operators suggest that the speed of these vehicles is often dictated not so much by road condition but by the passenger.

Table 2 explores using the baseline data the influence of Boda-Boda availability with respect to a number of parameters. It may be seen that in general Boda-Boda activity supports socio-economic activity. For example, it is evident that villages with high Boda-Boda availability have statistically higher school attendance rates (p=20%), a greater rate of farm extension worker visits per month (p=10%) and more non-farm local industries and shops (p=5%). The prices of a basket of goods imported into the village (salt, soap and sugar) are lower for such villages, although salt only statistically significantly so (p=5%).

Table 1: Mean baseline characteristics and outcome variables for villages in Kamuli District

Baseline characteristics	Unit	Below median (1)	Above median (2)	Difference (1-2)
Population	No.	6431.67	6217.50	214.17
Distance from nearest paved road	Km	14.50	16.50	-2.00
Distance from district centre (*Kamuli)*	Km	21.00	17.25	3.75
Average travel time to district centre (by different modes of transport) *Boda*	Min	45.83	45.00	0.83
Average speed (Boda)	km/hr	27.45	23.00	4.45**
No. of private transport operators serving the trading centre/village				
Light vehicle	No.	2	1	1
Motorcycle (boda-boda) no of private operators available	No.	73.50	47.50	26**
Freight transport /trucks(10 tonnage)	No.	5.17	6	-0.83
No. of available trips to district centre per day (on a normal day)				
Light vehicle	No.	4.00	2.00	2.00
Motorcycle (boda-boda) available trips	No.	252	125	127*
Bus/Taxi		2.00	0.00	2.00
Freight transport /trucks (10 Tonnage)	No.	5.80	6.00	0.20
No. of available trips to district centre per day (on a market day)				
Light vehicle	No.	4.00	2.00	2.00
bus/Taxi	No.	2.00	0.00	2.00
Freight transport /trucks	No.	5.17	6.00	-0.83
Fares on public transport to the district centre (passenger-km)				
Light vehicle	UGX	145.50	167.50	-22.00
Motorcycle (boda-boda)	UGX	274.33	188.50	85.83
Cost of freight transport to the district centre (ton-km)				
Truck (10 tons)	UGX	1190.83	1221.75	-30.92
Light vehicle (…tons) Taxi fare per passenger	UGX	1666.00	1197.00	469.00
IMTs /motorcycle (…tons) one person per freight	UGX	1943.67	2490.00	-546.33
Prices of three items exported from the village				
Coffee (wet red bean coffee per Kg)	UGX	1067	1050	167
Maize (maize grains per Kg)	UGX	1083	1050	33
Rice (processed rice per Kg)	UGX	2400	2425	-25
Prices of items imported into the village				
Salt (A sachet)	UGX	633	650	-17
Petrol (litre)	UGX	4000	4000	0
Soap (1kg White Star Soap)	UGX	3816.67	3900.00	-83
Sugar (1kg unpacked)	UGX	4200	4525	-325*
Schooling				
Average time to reach the nearest school from the trading centre	(Min)	15.00	11.75	3.25
No of pupils enrolled at the nearest school	No	15	12	3
Average monthly pupil attendance rate for past year	No	668	660	8
No of staff employed at the school	No	578	619	-41*
Average monthly staff attendance rate for the past year	No	12	9	3**
Health				
Average time to reach the nearest health centre from the trading centre	(Min)	27	15	13**
Average no of health workers at clinic each month for the past year	No.	3.60	4.00	-0.40
Average no. of patients treated each month for the past year	No.	484	519	-35
Agriculture				
Average no. of visits per month by an extension worker to the village	No.	6.00	8.00	-2.00**
Price of main cash crop produce in the district centre (per kg)	UGX	1300.00	1300.00	0.00
Price of main cash crop produce in the village/trading centre (per kg)	UGX	1116.67	1175.00	-58.33**
Farm-gate price of main cash crop produce in the village (per kg)	UGX	1000.00	1000.00	0.00
Economic activities - non-farm				
Factories, local industries /cottage industries in the village/trading centre	No.	2.67	2.50	0.17
No. of shops / kiosks in the village/trading centre	No.	33.33	22.50	10.83
Price of goods in the district centre (Kamuli)				
Prices of items exported from the village				
Coffee (wet red bean coffee per Kg)	UGX	1300.00	1300.00	0.00
Maize (maize grains per Kg)	UGX	1300.00	1300.00	0.00
Rice (processed per Kg)	UGX	2800.00	2800.00	0.00
Prices of items imported into the village				
Salt (A sachet)	UGX	600.00	600.00	0.00
Petrol (litre)	UGX	3400.00	3400.00	0.00
Soap (1kg White Star Soap)	UGX	3600.00	3600.00	0.00
Sugar (1kg unpacked)	UGX	4000.00	4000.00	0.00

* Significant at the 10 percent level or higher; ** significant at the 20 percent level or higher

Table 2: Boda-Boda availability and outcome variables for villages in Kamuli District

Baseline characteristics	Unit	Below median (1)	Above median (2)	Difference (1-2)
Population	No.	6106.8	6585.2	-478.4
Distance from nearest paved road	Km	17.4	13.2	4.2
Distance from district centre (*Kamuli)*	Km	19.8	19.2	0.6
Average travel time to district centre (by different modes of transport) *Boda*	Min	48	43	5
Average speed (Boda)	km/hr	25.18	26.16	-0.98
Average quality of the road measured from 1-100 (very poor - Very good)	Points	56	44	12**
No. of private transport operators serving the trading centre/village				
Light vehicle	No.	2	1	1
Freight transport /trucks(10 tonnage)	No.	6.4	4.6	1.8
No. of available trips to district centre per day (on a normal day)				
Light vehicle	No.	2	4	0
Motorcycle (boda-boda) available trips	No.	115	288	-173*
Bus/Taxi		0	2	2
Freight transport /trucks (10 Tonnage)	No.	7.5	4.6	2.9
No. of available trips to district centre per day (on a market day)				
Light vehicle	No.	2.00	4	0
bus/Taxi	No.	0.00	2	0
Freight transport /trucks	No.	6.40	4.6	1.8
Fares on public transport to the district centre (passenger-km)				
Light vehicle	UGX	168	146	22
Motorcycle (boda-boda)	UGX	262	218	46
Cost of freight transport to the district centre (ton-km)				
Truck (10 tons)	UGX	1127	1280	-153
Light vehicle (…tons) Taxi fare per passenger	UGX	1197	1666	-469
IMTs /motorcycle (…tons) one person per freight	UGX	2520	1805	715**
Prices of three items exported from the village				
Coffee (wet red bean coffee per Kg)	UGX	1080	1040	40
Maize (maize grains per Kg)	UGX	1060	1080	-20
Rice (processed rice per Kg)	UGX	2380	2440	-60
Prices of items imported into the village				
Salt (A sachet)	UGX	660	620	40
Petrol (litre)	UGX	4000	4000	0.00
Soap (1kg White Star Soap)	UGX	3920	3780	140*
Sugar (1kg unpacked)	UGX	4380	4280	100
Schooling				
Average time to reach the nearest school from the trading centre	(Min)	12.40	15.00	-2.60
No of pupils enrolled at the nearest school	No	609	719	-110
Average monthly pupil attendance rate for past year	No	427	743	-317**
No of staff employed at the school	No	9.60	11.40	-1.80
Average monthly staff attendance rate for the past year	No	0.65	0.66	0.00
Health				
Average time to reach the nearest health centre from the trading centre	(Min)	20.50	24.00	-3.50
Average no of health workers at clinic each month for the past year	No.	3.48	4.08	-0.60
Average no. of patients treated each month for the past year	No.	344	651	-307
Agriculture				
Average no. of visits per month by an extension worker to the village	No.	8.4	5.2	3.2*
Price of main cash crop produce in the district centre (per kg)	UGX	1300	1300	0
Price of main cash crop produce in the village/trading centre (per kg)	UGX	1160	1120	40
Farm-gate price of main cash crop produce in the village (per kg)	UGX	1000	1000	0
Economic activities - non-farm				
Factories, local industries /cottage industries in the village/trading centre	No.	2	3.2	-1.2*
No. of shops / kiosks in the village/trading centre	No.	17.4	40.6	-23.2*
Price of goods in the district centre (Kamuli)				
Prices of items exported from the village				
Coffee (wet red bean coffee per Kg)	UGX	1300.00	1300.00	0.00
Maize (maize grains per Kg)	UGX	1300.00	1300.00	0.00
Rice (processed per Kg)	UGX	2800.00	2800.00	0.00
Prices of items imported into the village				
Salt (A sachet)	UGX	600.00	600.00	0.00
Petrol (litre)	UGX	3400.00	3400.00	0.00
Soap (1kg White Star Soap)	UGX	3600.00	3600.00	0.00
Sugar (1kg unpacked)	UGX	4000.00	4000.00	0.00

* Significant at the 10 percent level or higher; ** significant at the 20 percent level or higher

D. *Tonkolili District*

The baseline data for Tonkolili District, presented in Table 4, has been categorized in two groups according to the median distance from the nearest central market (Magburaka Town).

The main findings from the baseline data are that the availability and cost of transport to and from the villages appears to be related to the distance from Magburaka Town. These findings would suggest that improved road condition (which would effectively lessen the friction of distance between the villages and Magburaka Town) may be expected to reduce transport costs and increase availability. Concerning the prices of items sold in the villages/ local trading centres, only the cost of fuel can be statistically correlated with the distance of the villages from the main trading market. Fuel is cheaper in villages closer to the market than those further away (p=20%). This finding is substantiated when exploring the relationship between commodity prices and the baseline variables (see below). The prices of goods sold in Magburaka Town were not found to be statistically significantly different in villages nearer the town compared to those further away.

<u>The price of village produced goods in the local trading centre</u>

A statistical analysis of the local trading centre prices of village produced goods and those imported into the village shows that:

<u>Goods exported from the village</u>

The average price of potatoes is less for villages with a greater availability of motorcycle transport and a greater number of available motorcycle trips (p=10% and p=20% respectively). Interestingly the price of potatoes is cheaper in villages further away from a paved road (p=10%). This may be because these villages offer potatoes at a lower price to attract more trade.

Villages which sell peppers more cheaply have less expensive light vehicle transport per ton- km (p=10%).

<u>Goods imported into the village</u>

Villages with lower petrol costs are those with lower populations (p=10%), a greater availability of motorcycles (p=20%) and possibly surprisingly those where the fares of transporting rice by light vehicle or motorcycle to the district centre are higher (p=10% in both cases). The cost of medium and large sized batteries are cheaper for villages where the speed of travel to Magburaka Town is quicker (p=5%) and unexpectedly where motorcycle passenger fares and motorcycle freight transport costs to Magburaka Town are higher (p=5% and p=2.5% respectively).

Table 3: Mean baseline characteristics and outcome variables for villages in Tonkolili District

Baseline characteristics	Unit	Below median (1)	Above median (2)	Difference (1-2)
Population	No.	4002.00	3208.80	793.20
Distance from nearest paved road	km	17.68	21.22	-3.54
Average travel time to district centre (motorbike, car, truck)	Minutes	91.25	103.75	-12.50
Speed	km/h	11.55	14.12	-2.57
No. days of the year road is closed due to rains	Days	5.00	16.67	-11.67
Availability and cost of transport				
No. of private transport operators serving village	No.	58.60	50.40	8.20
Light vehicle	No.	15.67	3.00	12.67**
Motorcycle /boda-boda (Okada)	No.	51.75	48.00	3.75
Freight transport /trucks	No.	12.33	3.00	9.33
No. of available trips to district centre per day (normal day)	No.	25.40	23.00	2.40
Light vehicle	No.	3.67	1.00	2.67*
Motorcycle (bodaboda) /okada	No.	23.60	22.75	0.85
No. of available trips to district centre per day (market day)	No.	30.75	55.25	-24.50
Freight transport /trucks	No.	4.50	3.00	1.50
Motorcycle (bodaboda) /okada	No.	31.33	52.25	-20.92
Fares on public transport to the district centre (passenger-km)				
Light vehicle	Le/person	8833	28750	-19917**
Bus/combi (Poda Poda)	Le/person	0.00	20000.00	0.00
Motorcycle (boda-boda) / Okada	Le/person	12011.00	18773.75	-6762.75
Cost of freight transport to the district centre (ton-km)	Le/50kg	0.00	0.00	0.00
Truck (….tons)	Le/50kg	36667*	75000*	-38333*
Light vehicle (…tons) Rice	Le/50kg	41262.50	55500.00	-14237.50
IMTs /motorcycle (…tons) Rice	Le/50kg	55000.00	83400.00	-28400.00
Price of goods in the trading centre/villages				
Prices of items exported from the village				
Potatoes	Le/50kg	16820.00	1033.33	15786.67
Rice (butter cup)	Le	1200.00	1200.00	0.00
Palm oil (improved variety)	Le/pint	1050.00	800.00	0.00
Palm oil (normal)	Le/pint	1366.67	1400.00	-33.33
Charcoal	Le/50kg	1200.00	3933.33	0.00
Pepper	Le/cup	1500.00	1633.33	-133.33
Prices of items imported into the village				
Petrol (per litre) official price was Le 3,750	Le/Litre	6100	7100	-1000**
Big sized battery	Le/BB	4500.00	4400.00	100.00
Medium sized battery	Le/BM	2300.00	2800.00	-500.00
Big sized battery	Le/BB	3000.00	4000.00	-1000.00
Medium sized battery	Le/BM	2500.00	2333.33	166.67
Education				
Average time to reach the nearest school	Min. (F)	16.67	27.50	-10.83
No. of pupils enrolled at the nearest school	Male	164.67	93.00	71.67**
	Female	151.20	67.20	84.00**
Average monthly pupil attendance rate for past year		104.33	101.00	3.33
No. of staff employed at the school		141.00	111.67	29.33
Average monthly staff attendance rate for the past year	No./%	3.80	4.25	0.00
Health				
Average time to reach the nearest health centre	Min.	8.25	13.67	-5.42
No. of health workers at clinic each month for the past year	Male	7.75	210.96	-203.21
	Female	208.60	318.92	-110.32
Average no. of patients treated each month for the past year	Male	639.00	750.00	-111.00
	Female	906.75	1900.00	-993.25
Agriculture				
Average no. of visits per month by an extension worker	No.	5.20	3.50	1.70**
Price of main cash crop produce in the district centre: Rice	Le/50kg	167500.00	167500.00	0.00
Price of cash crop produce in the village/trading centre: Rice	Le /50kg	160000.00	160000	0.00
Ground nuts	Le/50kg	100000.00	115000.00	-15000.00
Price of goods in the district centre (Chongwe)				
Prices in Magburaka Town of items exported from the village				
Rice	Le	1300.00	1220.00	80.00
Charcoal	Le/ 50kg	5320.00	960.00	4360.00
Potatoes	Le/ 50kg	11200.00	20600.00	-9400.00
Prices Magburaka Town of items imported into the village				
Petrol	Le / Litre	5375.00	6500.00	-1125.00
Big sized battery	Le/BS	1200.00	1300.00	-100.00
Exercise book (80 pages)	Le/ book	1360.00	1625.00	-265.00

*Significant at the 10 percent level or higher; **significant at the 20 percent level or higher; N/A indicates insufficient data

E. Chongwe District

Table 4 presents the baseline data for Chongwe District categorized in two groups according to the median distance from Chongwe, the nearest central market. The baseline data shows that the population of villages closer to Chongwe tend to be greater (p=20%), journeys to Chongwe from these villages are shorter (unsurprisingly; p=5%) but are at lower speeds in general (p=10%) and that their distance from the nearest paved road is less (p=5%). The baseline data shows that none of the roads from the villages are closed due to rain. The condition of the roads to the villages is not currently recorded in the baseline data set. In terms of transport provision villages closer to Chongwe appear to be better served by light vehicles/vans (p=20%) but that there is a greater availability of trucks in villages further away from Chongwe (p=5%). Concerning the prices of items sold in the villages/local trading centres, the baseline data suggests that the prices of three goods (charcoal, maize and rice) exported from the villages are the same across all 10 villages. Similarly the price of goods (fertilizer, petrol and maize) imported into the villages is also the same for all 10 villages. Villages further away from Chongwe tend to have more shops than those nearer (p=20%). The education data appears to be erroneous in that attendance rates for pupils and staff are given as 100%. Therefore it is not possible to infer any meaningful conclusions from this data. In terms of the health metrics, the journey times to health centres of villages nearer Chongwe Average is less (p=20%). These health centres have more staff (p=20%) and treat more patients (p=5%). The prices of a basket of goods produced in the villages and sold in Chongwe were unavailable in the baseline dataset as were the prices of goods bought in Chongwe and taken back to the villages.

Table 4: Mean baseline characteristics and outcome variables for villages in Chongwe District

Baseline characteristics	Unit	Below median (1)	Above median (2)	Difference (1-2)
Population	No.	8,310.20	5,342.80	2,967.40
Distance from nearest paved road	km	6.72	12.88	-6.16
Average travel time to district centre	Min.	30.00	52.00	-22.00
Speed	Km/h	30.78	39.63	-8.85
No of days of the year road closed due to rains	Days	0.00	0.00	0.00
No. of private transport operators serving the village				
Light vehicle - Vans	No.	4.60	5.20	-0.60
Bus/combi	No.	0.80	1.20	-0.40
Motorcycle (boda-boda)	No.	4.00	4.40	-0.40
Freight transport /trucks	No.	3.00	4.40	-1.40
No. of available trips to district centre per day (on a normal day)				
Light vehicle - Vans	No.	3.00	2.20	0.80
Bus/combi	No.	0.20	0.80	-0.60
Freight transport /trucks	No.	3.20	3.20	0.00
No. of available trips to district centre per day (on a market day)				
Light vehicle	No.	3.40	3.60	-0.20
bus/combi	No.	0.80	1.60	-0.80
Freight transport /trucks	No.	3.80	3.00	0.80
Fares on public transport to the district centre (passenger-km)				
Light vehicle - per trip	ZMK	11.00	13.00	-2.00
Bus/combi - per trip	ZMK	1.60	6.40	-4.80
Motorcycle (boda-boda)	ZMK	0.00	0.00	0.00
Cost of freight transport to the district centre (ton-km)				
Truck (….tons)- per load	ZMK	400.00	500.00	-100.00
Light vehicle (…tons)-- per load	ZMK	250.00	270.00	-20.00
IMTs /motorcycle (…tons)	ZMK	0.00	0.00	0.00
Prices of three items exported from the village				
Item 1 (name)- state units: 25kg Charcoal	ZMK	1.60	1.60	0.00
Item 2 (name)- state units: 50kg Maize	ZMK	1.60	1.60	0.00
Item 3 (name)- state units: 10kg Rice	ZMK	13.00	13.00	0.00
Prices of items imported into the village				
Item 1 (name)- state units: 50kg fertilizer	ZMK	245.00	245.00	0.00
Item 2 (name)- state units: 10 litres Petrol	ZMK	125.00	125.00	0.00
Item 3 (name)- state units: 10kg SEEDCO seed (Maize)	ZMK	160.00	160.00	0.00
Education				
Average time to reach the nearest school of transport	Min.	13.00	15.00	-2.00
No. of pupils enrolled at the nearest school	No.	104.40	105.00	-0.60
Average monthly pupil attendance rate for past year	No.	103.00	102.80	0.20
No. of staff employed at the school)	No.	27.20	29.40	-2.20
Average monthly staff attendance rate for the past yea	No.	27.20	29.40	-2.20
Health				
Average time to reach the nearest health centre	Min.	20.00	29.00	-9.00
Average no. of health workers at clinic each month	No.	2.40	1.60	0.80
Average no. of patients treated each month for the past year	No.	463.60	358.20	105.40
Agriculture				
Average no. of visits per month by an extension worker	No.	2.00	2.00	0.00
Price of main cash crop produce in the district centre (per kg) - Maize	ZMK	1.80	1.80	0.00
Price of main cash crop produce in the village/trading centre (per kg)	ZMK	1.70	1.70	0.00
Factories, local industries /cottage industries in the village	No.	0.60	1.80	-1.20
No. of shops / kiosks in the village/trading centre	No.	5.80	7.40	-1.60
Price of goods in the district centre (Chongwe)				
Prices of the three items exported from the village				
Item 1 50 kg - maize (bag)	ZMK	N/A	N/A	N/A
Item 2 25 kg charcoal (bag)	ZMK	N/A	N/A	N/A
Item 3 90kg Groundnuts (bag)	ZMK	N/A	N/A	N/A
Prices of the three items imported into the village				
Item 1 2 kg Packet of sugar	ZMK	N/A	N/A	N/A
Item 2 50 kg pocket of cement	ZMK	N/A	N/A	N/A
Item 3 25 kg breakfast - mealimeal	ZMK	N/A	N/A	N/A

*Significant at the 10 percent level or higher; **significant at the 20 percent level or higher

V. Conclusions and Recommendations

Conclusions

The following conclusions can be drawn from the econometric analysis of data from the three road agencies/district in the GEM Study:

1. Transport availability and cost in villages in Kamuli appears to be governed by the Boda-Boda motor cycle and to some extent via illegal overloading of Boda-Bodas and other vehicles. This may make it problematic to demonstrate road user savings accruing from improvements to road (unless changes in Boda-Boda transport occur), particularly in the short term.

2. The prices of goods in Kamuli centre appear to be the same regardless of their origin or destination, suggesting that these may not be a useful indicator of road improvement benefits.

3. The availability and cost of transport to and from the villages in Tonkolili District is related to the distance from the main market suggesting that that improved road condition may reduce transport costs.

5. The data available for Chongwe District suggest that road improvements may reduce travel times to the district centre.

Recommendations

There is a sufficient evidence base of rural road impact evaluation studies carried out worldwide which can be used to inform studies for rural regions in SSA. A number of recommendations for practice can be drawn from these:

1. Stratified sampling can be helpful when there are concerns that other practical sampling techniques may not be representative of the entire population.

2. Regression models can be used with care to control for unobserved temporal heterogeneity and factors affecting changes in household and community level outcomes over time.

3. In addition to evaluating the impacts resulting from infrastructures directly it is also important to identify and evaluate indirect impacts.

4. The timing of the follow-up survey(s) is critical. Direct outcomes such as travel times, can be observed immediately after project completion, it may take longer to observe derived outcomes such as job creation or improvement in household welfare.

5. Baseline and follow- up surveys should be carried out at the same time of the year. Busy periods of economic activity, such as seeding or harvest time should be avoided so as to encourage the participation of local people.

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