The Impact of Road Condition on Operating Costs of Bicycles

A Technical Brief from I.T. Transport Ltd. May, 2003

INTRODUCTION

Bicycles are the most commonly used form of Intermediate Means of Transport (IMT) in Sub-Saharan Africa, greatly increasing personal mobility and load-carrying capacity for rural people. They are increasingly used for providing local transport services, for example bicycle taxis are widely used in Uganda and some parts of Western Kenya. Previous studies have shown that repair and maintenance costs for bicycles are high due to carrying heavy loads on poor roads and tracks. It is likely that improved infrastructure reduces both operating costs and also trip times, benefiting both personal users and also operators and users of bicycle transport services. However, the economic benefits to bicycle users are rarely included in the appraisal of rural transport projects.

With this in mind the aim of this study was to evaluate the impact of infrastructure quality on bicycle operating costs in order to develop improved tools for including these costs in appraisal of transport projects. Influencing transport planners to include bicycles in appraisal of rural transport projects should improve the viability of projects focussed on district and village level access. Bicycles are the most effective means for improving mobility of the rural poor. Reducing operating costs and service charges will therefore particularly benefit the poor.

METHODOLOGY

The methodology chosen for the study was to monitor the operations of bicycle taxi operators (persons using bicycles to provide transport services for passengers and goods) in two areas, Uganda and Western Kenya. It was observed that these operators worked predominantly along certain routes so it would be possible to identify speeds and operating costs for specific road surfaces. Three roads were chosen in each area with different surfaces – bitumen, gravel and earth. Ten operators were monitored on each road over a period of 12 months to obtain reliable average results and to identify any seasonal effects. Data was entered into spreadsheets to evaluate average values of speeds, fares and repair costs on each type of road. An econometric analysis was also carried out to identify statistically reliable links between various parameters.

The most useful data was obtained from Uganda where about 90% of data could be linked to specific roads. In Kenya much of the data that was obtained was for operation on a mixture of roads. This data was therefore analysed to identify trends to compare with the findings from Uganda.

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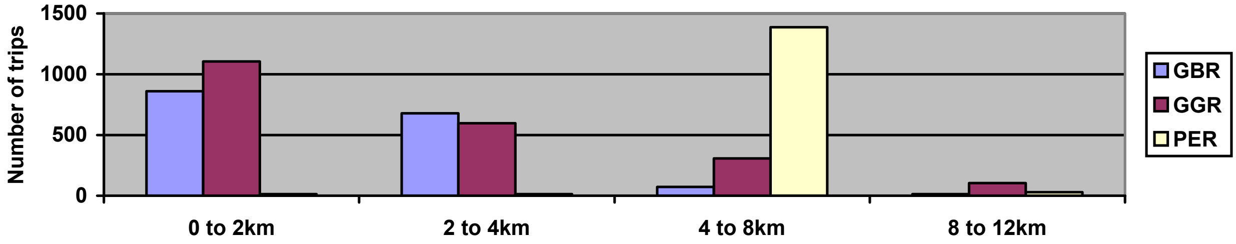
This study was funded by the United Kingdoms, Department for International Development.

DFID can accept no responsibility for any information provided or views expressed.

RESULTS AND FINDINGS

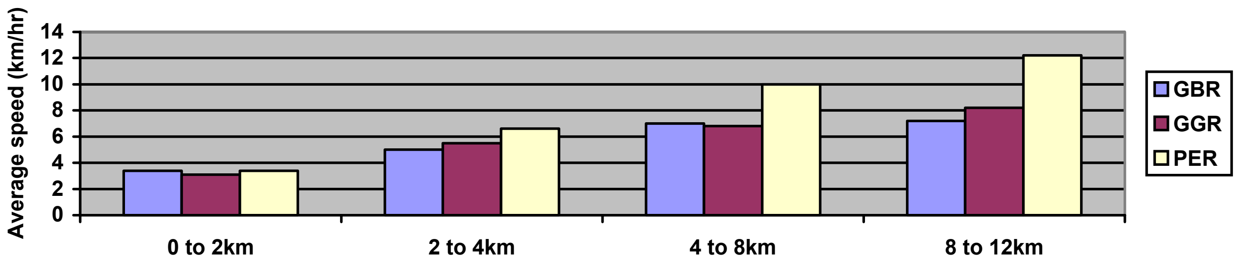
The results from the study are summarised in the following charts where **GBR** = Good Bitumen Road; **GGR** = Good Gravel Road; **PER** = Poor Earth Road. These were the classifications given to the study roads by local roads engineers.

Figure 1:   Frequency of trip lengths on each road



Most trips on the *bitumen* and *gravel* roads were less than 4km because the ready availability of bicycle taxis saved time over waiting for a motorised taxi. For longer trips, motorised taxis were usually used because higher speeds reduced overall trip times and fares were similar or lower. On the *earth* road there were few motorised vehicles and most trips were between destinations about 8km apart.

Figure 2:   Average speeds on each type of road



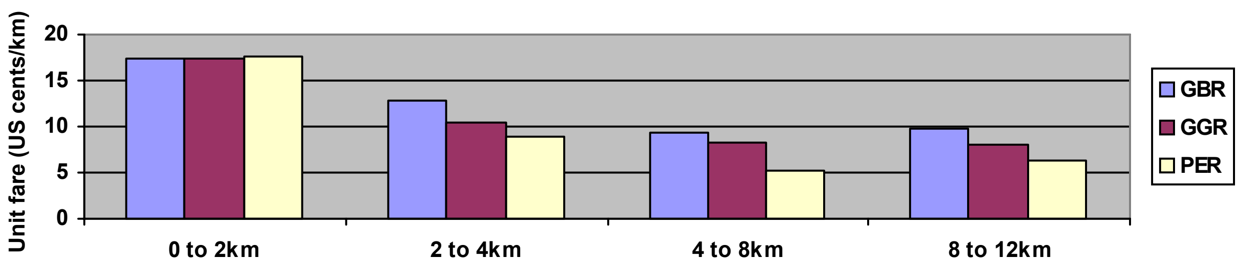
Speeds are influenced by trip length because of inclusion of loading and unloading times. This influence decreases with trip length. Actual travel speeds are seen to be higher on the *earth* road than on the *bitumen* and *gravel* roads. Two reasons were identified for this through discussions with operators –

i. The significantly higher levels of motorised traffic on the *bitumen* and *gravel* roads increased safety fears and cyclists often stopped when passed or approached by motorised vehicles, particularly larger vehicles such as trucks and buses. On the *earth* road there was little interference from motorised traffic;

ii. The operators considered it was easier to cycle on the smooth *earth* surface than on the rougher *bitumen* and *gravel* surfaces

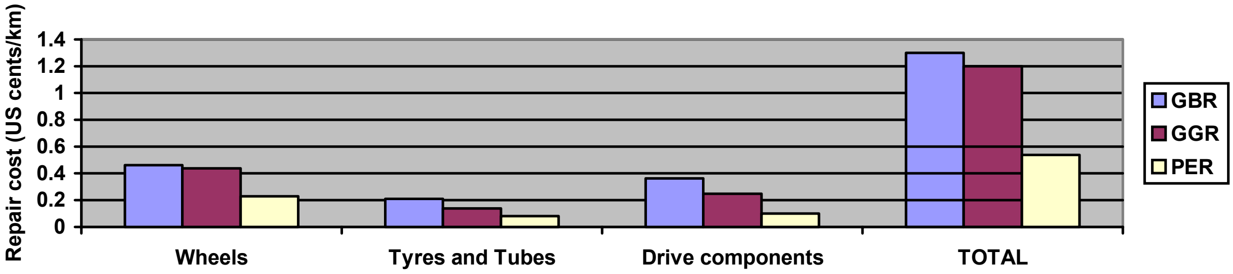
In relation to interference from traffic the bitumen and gravel roads were 6m standard wide. Operators cycled on the road not on the shoulders.

Figure 3:   Average unit fares on each type of road



The trend for fares to decrease with increasing trip length is typical of transport services in developing countries as fares become less affordable to users for longer trips. Fares were highest on the *bitumen* road and lowest on the *earth* road. Operators indicated that fares were set not only by distance but also by demand and what users were prepared to pay. On the *bitumen* road customers were often in a hurry and used bicycle taxis for short trips to save time. They were therefore prepared to pay high fares. Demand was less on the *gravel* and *earth* roads and customers were more inclined to walk if they considered fares too high. The above chart compares total unit repair and maintenance costs (RMC) on the three road types and also the

Figure 4: Average unit repair costs on each road type



main cost components. It is seen that RMC for the *bitumen* and *gravel* surfaces are over double those for the *earth* road. The reasons are indicated by the component costs –

- *Wheel costs* are from repair of rims and replacement of spokes. It is apparent that these are higher on the harder and rougher (texture) *bitumen* and *gravel* surfaces. Other evidence suggests this is due to a higher level of impact loading on these surfaces
- *Tyre and tube* costs result mainly from wear of tyres – punctures were not identified as a significant cost. Wear is greater on the harder, rougher *bitumen* and *gravel* surfaces and is probably also increased by more frequent stopping and starting on these surfaces
- *Drive components* comprise pedals, chain and sprockets. The higher costs on the *bitumen* and *gravel* roads are assumed to result from more frequent stopping and starting on these roads because of the higher level of motorised traffic.

The above findings from the results from Uganda were supported by the trends found from the results from Kenya.

OBSERVATIONS

The results obtained are surprising and generally opposite to conventional thinking on the impact of improving roads. The surface that was considered the easiest for cycling, *Bitumen*, in fact had the lowest speed, the highest fares and the highest repair costs; whereas the surface considered the most difficult, *Earth*, had the highest speed and the lowest fares and repair costs. The results for the *Gravel* surface were generally closer to the bitumen surface.

Conventional thinking is that operating speeds and costs are related to the longitudinal bumpiness of the road as measured by the average road roughness index. This has been the basis for appraising the benefits to motorised traffic of improving roads and also is the basis of the recently introduced appraisal method for Non-Motorised Transport (NMT) in HDM-4[1]. This approach predicts that upgrading roads from earth to gravel and gravel to bitumen should increase operating speeds and reduce repair and maintenance costs. **The results from this study were opposite to this, measuring Repair and Maintenance Costs (RMC) on *bitumen* and *gravel* roads of 4 to 5 times those predicted by HDM-4 and over 2 times those on *earth* roads.**

[1] J. B. ODOKI and H. R. KERALI: *Modelling Non-motorised Transport Costs and Benefits in the Highway Development and Management System;* Transportation Research Record 1695, Paper No. 99-1129

The findings from the study indicate that for bicycles the local surface texture of the surface *also* has a significant impact on ease of cycling and on RMC. In fact in this study this factor was dominant so that speeds were lower and repair costs higher on the less bumpy but rougher textured bitumen and gravel roads than on the more bumpy but smoother textured earth road. It is concluded that cyclists can more easily avoid potholes, ruts, stones etc. than motorised vehicles. However, this may not always be the case, for instance on stony or rocky roads or where there are large ruts on the edge of the road from run-off water. Therefore both surface texture and overall longitudinal roughness need to be taken into account.

The findings on the influence of surface texture are supported by results from measurement of rolling resistance and level of impact loading on various surfaces (IT Transport study, 1981)). These showed that a smooth earth path was better for cycling than a rough bitumen road but in wet weather the earth path could be more difficult if there were significant muddy areas. However, this would not affect repair costs which would still be higher on rough bitumen roads.

An econometric model with a high degree of confidence and fit to the data confirmed the impact of the road surface and showed that the following factors have significant impact on RMC:

Loading: carrying additional loads on the bicycle increases repair costs disproportionately i.e. repair costs increase at a higher rate than the increase in loading

Speed: speed has a significant impact on repair and maintenance costs with an elasticity of about 0.8, i.e. an increase in speed of 50% increases RMC by 40%.

IMPLICATIONS OF THE FINDINGS

Although the results of the study are for bicycle taxi operators, the findings on the impact of road surface are relevant for all bicycle users. The average load carried by the operators was 50kg. Domestic users often carry loads up to this level so that unit RMC are likely to be not far below the levels found in the study. The main difference for domestic users will be in the distance travelled per year which will be much lower so that annual RMC will be substantially lower than for the taxi operators.

The condition of the road surface affects the speed, effort needed and repair costs of bicycle users. Speed governs journey times and can be related to costs or savings by the value of time. The need for increased effort in travelling by bicycle is considered a considerable disadvantage by users, whilst an increase in repair costs may result in bicycles being out of service for longer periods because owners cannot afford to repair them. In the case of bicycle taxi operators, both reduced speeds and increased RMC will reduce incomes.

The main implication of the findings for transport planners and designers is that in regard to the impact on bicycle operations three factors need to be considered in the improvement/upgrading of roads – *surface texture, surface roughness, potential increase in motorised traffic and estimation of benefits.*

***Surface texture* –** an earth road that is rough and bumpy for motorised vehicles may provide reasonably smooth tracks for bicycles that use the edges and can steer round potholes, ruts etc. Regravelling the road will benefit motor vehicles but will dis-benefit cyclists because the gravel surface will be less easy to cycle on and will increase repair costs. The best treatment for cyclists would be to repair the road with earth fill or to leave smooth, firm earth shoulders

***Surface roughness* –** if the road surface is very stony or rocky and/or has substantial ruts along the edges, then regrading and resurfacing are likely to benefit cyclists, but again an earth surface or earth shoulders will be better than a gravel surface

***Traffic level* –** if improving or upgrading a road is likely to increase levels of motorised traffic then it will disadvantage bicycle users in regard to safety, operating speeds and repair costs. If the impact is likely to be significant then serious consideration should be given to providing bicycle paths along the shoulders of the road.

Estimation of benefits - the benefits from road "improvements" result from increased speeds and reduced RMC. Depending on the 'value of time' assumed, the impact of speed may unrealistically dominate benefits. For example using the recommended value from HDM-4, $0.36/hr, would give a benefit of $0.015/km for the difference in speed found on earth (8km/hr) and gravel(6km/hr)roads in the study, compared to a benefit of $0.007/km in RMC. However, owners are likely to find the saving in RMC of greater consequence as it is a tangible cost that they have to pay to keep their bicycles operational.

Because new issues are identified by this study, further studies are needed to support the findings before definite guidelines can be prepared for transport planners.