ACTION IN PUBLIC TRANSPORT: COST IMPLICATIONS OF THE ALTERNATIVES

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1. INTRODUCTION

Conventional public transport systems rarely cover their initial capital costs nor annual operating costs for various reasons and is sustained by subsidies from the relevant government agencies. Developing countries are particularly affected as demands for other essential services such as basic health care, education and housing reduces the amount of funds available for transportation needs, which are afforded a lesser priority.

There is an obvious need, therefore to ensure that the existing public transport modes are optimally utilised to reduce the operating costs and hence subsidy dependence. Information on the operating costs is essential to the identification of the most cost effective mode for a given set of circumstances.

In developing a set of cost data on which to base the comparison of various modes, two viewpoints were adopted. The first considered the status where the modes have been in operation for some time and most of the fixed infrastructure already exists as is the case in KwaZulu Natal. The second viewpoint assumed that all capital assets including vehicles, maintenance facilities and travelway infrastructure do not exist and will have to be provided. The cost of the infrastructure was estimated from prevailing unit rates and converted to an equivalent annual amount over the anticipated life of the asset using standard economic evaluation techniques. This approach is useful in providing relevant information when new services are been considered in areas with no existing public transport services.

The overall objective of this study was to provide cost information which could be used to establish the relative cost efficiency of four different public transport operations; conventional and midi buses, minibus taxis and commuter rail. This information could then be used to identify which mode should be promoted or supported under a given set of service-demand conditions.

This study was based on the public transport operations within the Greater Durban Metropolitan Area (GDMA).

This comparative assessment only included the costs incurred by the transport operator as well as the capital cost of providing the infrastructure to support the service. Costs borne by the users and non-users, mainly private motor car users, are excluded along with other social and environmental costs not borne directly by the provider of the infrastructure.

The investigation was based on the present operations of each mode and did not attempt to estimate or quantify the level of efficiency within each particular mode. Only the average annual costs are utilised as the basis of comparison, which counteracts any short term irregularities that may occur in each operations. The following modes, which are currently in service in the GDMA, were included :

- Minibus (minibus taxi) :Carrying capacity of 15 passengers
- Midibus :Carrying capacity of 35 passengers
- Conventional Bus :Carrying capacity of 110 passengers
- Commuter Rail :Carrying capacity per coach of 160 passengers (80 per cent of crush capacity) and 1900 per 12 coach trainset

2. DEVELOPMENT OF A METHODOLOGY

2.1 Initial Formulation of the Cost Model

In order to carry out this assessment cost data were required for the modes and various service demand conditions included in this investigation. The basic requirement of this methodology is to reflect actual operating conditions through the use of appropriate simulation, empirical or mathematical techniques. In other words, the operational requirements for each of the respective modes had to be estimated for a range of service demand conditions.

The cost estimating method adopted for this investigation essentially takes the form of a cost service model developed around the cost allocation technique. Four distinct phases are included :

- Phase One : Cost allocation Module - Derivation of operating, maintenance and administration (OMA) unit costs for chosen output parameters.
- Phase Two : Capital Cost Module - Derivation of capital costs for fixed facilities and infrastructure expressed as unit costs of chosen output parameters.
- Phase Three : Service Build Up Module - Derivation or calibration of service condition factors used to generate output parameters.
- Phase Four : Cost Estimates - Application of unit costs to generated output parameters to obtain the overall estimated costs for each transit mode under different service conditions.

Phases one and two require data from existing operators and local authorities involved in the provision of fixed facilities while Phase three generates system parameters that are representative of the study area. Phase four is simply the product of output parameters generated in Phase three and the unit costs derived in Phases one and two.

2.2 Calibration of Operating Maintenance and Administration Costs

The calibration of typical operating, maintenance and administration (OMA) costs for each transport operation is an integral part of the modelling process. These costs are routinely calibrated during the cost allocation process in Phase 1 of the overall cost model.

Data on typical, formal bus operations were obtained from Durban Transport Services, who operate the largest fleet of buses in the Durban Metropolitan area. Durban Transport Services were chosen as the sole data source while, Metrorail as the only commuter rail operator in the country was the sole data source for commuter rail statistics in the region. Using data from a single region and single operators removes other latent variables due to different regional dynamics and different operating methodologies between operators.

The minibus taxi industry has been the focus of numerous studies since its rise to prominence from the late 1980' s onwards. Various agencies have therefore collected financial information on minibus taxi operations. Of these the Combi Taxi Databank administered by consultants on behalf of the Department of Transport is probably the most comprehensive. The Port Natal - Ebhodwe Passenger Transport Plan (1995) provides relevant information for minibus taxis in the study area. Pather (1996) collected data directly from operators in the Phoenix and Wentworth area. These data were further supplemented by additional interviews with existing operators while additional data for the morning peak period were collected " in vehicle " over a period of two days.

2.3 Capital Costs

Capital costs for public transport include vehicle purchase costs, travelway infrastructure and maintenance and storage facility costs. Several design manuals have been produced which quantify the various infrastructural elements based on empirical functions related to a particular demand pattern.

Guidelines on infrastructure norms were extracted from various design manuals, past studies and actual working designs of public transport projects within the GDMA. Unit costs were extracted from recent infrastructure contracts carried out in the Greater Durban Metropolitan Area and the latest estimating rates compiled by the KwaZulu Natal Department of Transport (1996). Vehicle purchase prices were extracted from previous studies including Del Mistro (1995) and Pather's (1996). Historical cost data for commuter rail is contained in the planning report for the proposed Inanda Rail Line (South African Transport Services, 1986 and 1988).

2.4 Final Formulation Of Cost Service Model

Initial analyses carried out using the cost service model yielded costs per passenger trip that closely match existing costs for each of the operators under the simulated operating conditions that best resemble the actual operating conditions for the respective mode. For example the cost per passenger trip calculated for midi bus under Urban conditions is around R 2.74 versus the existing overall costs of R 2.78, a 1.4 per cent variation. The model correctly predicted an increase in cost per passenger trip as trip distance increased as expected for actual operating conditions. The cost service model has also proven to be relatively insensitive to discount rates except for commuter rail as a result of the relatively higher proportion of capital costs for this mode. Nevertheless, the choice of the optimum mode in terms of cost per passenger trip was only affected by discount rates in one of the thirty six cases tested.

3 COST ANALYSIS USING THE MODEL

3.1 Introduction

Two analyses were carried out using the cost service model. The first analysis examines existing operations whereby existing OMA costs include capital cost items in the form of depreciation and finance charges. All capital cost items were considered at their existing "book" values. Secondly new services were considered where all capital cost items were removed from the OMA costs and included under a separate capital cost module. Here the initial cost of new capital items was estimated using present day unit rates and converted to equivalent uniform annual costs over the life of the facility using standard discounting techniques. Three different operating environment scenarios were considered as follows:

- Urban Conditions – Within 5 km radius of a major urban CBD
- Suburban Conditions – Within 6-15 km radius of a major urban CBD
- Long Distance Conditions – Within 16-50 km radius of a major urban CBD

The analyses were repeated in each instance at the maximum vehicle passenger occupancy for each mode. It was considered necessary to estimate the cost per passenger trip at the practical capacity of each mode's in order to estimate each mode's capabilities in light of the relatively low vehicle occupancies recorded from existing operations.

3.2 Existing operators

This analysis considered a transport company as it currently exists with vehicles of various ages and existing infrastructure, which are presently been depreciated at their current book values. All costs have been included as they exist in practice. In other words, formal operators with the full costs of administration and general overheads are compared to the informal minibus taxis who carry minimal overhead costs. By the same token the existing modus operandi of respective operators have been adopted without modifications. While formal operators maintain fix schedules, minibus taxis operate on demand and do not allow for spare vehicles to cover breakdowns and other service disruptions. It must be noted however that the minibus taxis are bound by commuter demand patterns particularly during peaks and generally follow the same routes as formal buses to cater for this demand. Comparisons were made between modes in terms of the cost per passenger trip to peak demand for each of the three operating condition scenarios. It was not considered necessary to compare the cost per passenger trip to route distance separately as it was considered that the above analysis which covers three different route distances gives an indication of the relationship of trip distance to cost per passenger trip. The results of applying the cost service model to existing operators under varying service demand conditions are summarised in Table 3.1 below.

TABLE 3.1: COST PER PASSENGER TRIP BY COST CENTRE: EXISTING OPERATORS

MODE	COST CENTRE						
	Drivers	Other Labour	Energy	Vehicle Maintenance	Depreciation and Interest	Overheads	Total
Urban Travel (cents)							
Conventional Buses	37	16	21	42	22	31	**169**
Midi Buses	85	25	19	65	28	51	**273**
Minibus Taxis	33	0	22	10	26	16	**107**
Commuter Rail	6	40	10	23	8	27	**114**
Suburban Travel (cents)							
Conventional Buses	95	42	54	108	56	80	**435**
Midi Buses	229	68	51	174	76	136	**734**
Minibus Taxis	87	0	58	26	69	44	**284**
Commuter Rail	15	103	26	59	22	69	**294**
Long Distance Travel (cents)							
Conventional Buses	138	61	79	158	82	117	**635**
Midi Buses	350	104	77	265	116	207	**1119**
Minibus Taxis	126	0	84	38	99	63	**410**
Commuter Rail	20	143	36	81	30	95	**405**

The results clearly indicate the versatility of the minibus taxi where in terms of average cost per passenger trip, this mode is the most cost effective under most demand conditions. The informal nature of the industry allows this mode to be more demand responsive than formal undertakings with fixed schedules and operating procedures. Moreover minibus taxis are not bound by subsidy conditions to operate marginal routes and hence can ensure reasonable loads for each trip. Therefore resulting operating costs per passenger trip are likely to show little variation under these operating conditions.

The midi bus presents the highest cost per passenger trip under all operating conditions and across all demand ranges. This concurs with earlier work carried out by Del Mistro (1995) and Pather (1996), although no reasons were ventured in these earlier investigations for the poor cost performance of this mode.

It is evident from Table 3.1 that the driver costs and vehicle maintenance costs per passenger trip for the midibus are considerably higher than for the other modes. The portion of costs made up by other labour and overheads are also significantly higher than the other road based public transport modes, namely conventional bus and minibus taxi. These results suggest that smaller road based public transport vehicles may not be suited to a formal undertaking where the "add on costs" cannot be distributed amongst a large passenger base as is the case with the larger vehicles. This is supported by the fact that, while the energy costs and vehicle capital costs (depreciation and interest) per passenger trip for the road based public transport modes are similar, the informal minibus taxi operations appear to benefit from the lower overheads, vehicle maintenance costs and absence of other labour. This contributes to the lower cost per passenger trip for minibus taxi whereas the high overheads, vehicle maintenance and other labour costs together with the high driver costs per passenger trip results in higher overall costs per passenger trip for the midi bus.

Commuter rail transport bears additional cost in terms of other labour who are required to manage and maintain infrastructure because of its exclusive use nature. This appears to be balanced by relatively lower direct operating costs (energy and vehicle maintenance costs) which is significantly lower than both the conventional bus and midibus and very similar to minibus taxis.

To summarise the findings, it is evident that operating procedures which affect vehicle loading have a marked effect on operating costs where the minibus taxis currently operate at close to their vehicle capacities at present and hence appear to be the most cost effective mode. As the larger capacity vehicles such as conventional buses and commuter rail are operated at loads closer to or at their respective capacities, these modes offer lower cost than minibus taxis at the higher commuter demands. This trend increases from urban to long distance operating conditions, which may support the use of higher capacity vehicles on longer distance, high demand routes.

3.3 New Services

This second analysis considers the introduction of new public transport services where none exist at present. All vehicles and exclusive use facilities such as vehicle depots and maintenance garages, passenger terminals, and travelways for exclusive use modes have to be established. Travelway costs for road based public transport modes are apportioned in accordance with the proportion of trip length on each particular road class. It has further been assumed that midibuses and minibus taxis inflict negligible pavement damage and hence bear no portion of the travelway costs on collectors or arterials. A summary of costs generated for new services is given in Table 3.2.

As with existing services, the study also found that minibus taxis are the most cost effective public transport mode for new services in terms of average cost per passenger trip under all operating conditions and across all demand ranges. Conventional buses are the next cheapest option for all operating conditions at peak demands below 50 000 commuters except under Suburban conditions where commuter rail appears to be more competitive at lower peak demands from 20 000 onwards. There is considerable overlap, however, between commuter rail, conventional buses and midi buses which indicates some level of interchangeability between these modes at peak demands exceeding 10 000.

Conventional buses and commuter rail appear to compete more closely with minibus taxis as demand increases and each mode is operated at capacity. Trip distance does not appear to have any notable impact on the relative costs of these modes at high demands. The relatively large capital costs borne by new commuter rail and bus services when compared with minibus taxis outweigh any benefit derived by the larger carrying capacity of the former modes over longer distances and higher demands. Minibus taxis incur very few capital cost items apart from vehicles costs and allocated travelway costs, where applicable.

TABLE 3.2 : COST PER PASSENGER TRIP BY COST CENTRE : NEW SERVICES

MODE	COST CENTRE										
	Drivers	Other Labour	Energy	Vehicle Maint	Over heads	Travel – way	On-Line Stops	Vehicle Depot	Terminal	Vehicle Capex	**Total**
Urban Travel (cents)											
Conventional Buses	37	16	21	42	31	0	0	4	3	50	**205**
Midi Buses	85	25	19	65	51	0	0	5	4	54	**308**
Minibus Taxis	33	0	22	10	16	0	0	0	1	35	**117**
Commuter Rail	6	40	10	23	27	12	5	14	incl.	31	**167**
Suburban Travel (cents)											
Conventional Buses	95	42	54	108	80	2	2	9	5	119	**515**
Midi Buses	229	68	51	174	136	0	1	13	6	132	**809**
Minibus Taxis	87	0	58	26	44	0	1	0	1	92	**308**
Commuter Rail	15	103	26	59	69	38	8	35	incl.	79	**432**
Long Distance Travel (cents)											
Conventional Buses	138	61	79	158	117	3	3	12	7	167	**744**
Midi Buses	350	104	77	265	207	1	1	18	8	195	**1227**
Minibus Taxis	126	0	84	38	63	1	1	0	1	125	**438**
Commuter Rail	20	143	36	81	95	71	12	59	incl.	134	**651**

It is evident from Table 3.2 that commuter rail bears significantly greater infrastructure capital costs than road based public transport vehicles. Commuter rail has exclusive use of its travelway and hence bears the full cost of the travelway, which is reflected in the relatively high cost per passenger trip for this item. The cost per passenger trip of vehicle depots is also significantly higher for commuter rail, which is mainly due to the size of the individual trainsets.

Annualised vehicle capital cost per passenger trip for conventional and midi buses are higher than for commuter rail despite the substantially larger initial capital costs of trainsets. However it must be noted that trainsets have an estimated useful life of forty years compared to the ten years for conventional and midi buses. Also the capacity of a single trainset is approximately 1900 passengers compared to the 110 and 35 passengers of conventional buses and midi buses respectively. The initial capital cost of the trainsets is therefore annualised over a longer period while the larger capacity of the vehicle reduces the unit costs per passenger.

3.4 Summary of Findings

The results of the various analyses for existing and new services indicate that the minibus taxi offers the lowest cost per passenger trip for all operating conditions and across all reasonable demand ranges. Commuter rail and conventional buses to a lesser extent offer marginally lower costs than minibus taxis for a limited number of cases and at unrealistically high demand ranges in most of these cases.

The impacts of capital costs on costs per passenger trip for new services are shown in Table 3.3. It must be noted that the costs shown are the lowest costs per passenger trip for each mode under the relevant operating condition. In other words, the costs have been extracted from the "stable" demand ranges for each mode.

TABLE 3.3: SUMMARY OF AVERAGE COSTS PER PASSENGER TRIP FOR ALL MODES

MODE	COST PER PASSENGER TRIP (R)		DIFFERENCE	PERCENT
	EXISTING	NEW	(R)	(%)
Urban Travel				
Conventional Buses	1.68	2.03	0.35	17.2
Midi Buses	2.73	3.07	0.34	11.1
Minibus Taxis	1.06	1.16	0.10	8.6
Commuter Rail	1.14	1.67	0.53	31.7
Suburban Travel				
Conventional Buses	4.35	5.15	0.80	15.5
Midi Buses	7.34	8.09	0.75	9.3
Minibus Taxis	2.84	3.08	0.24	7.8
Commuter Rail	2.93	4.31	1.38	32.0
Long Distance Travel				
Conventional Buses	6.35	7.44	1.09	14.7
Midi Buses	11.19	12.27	1.08	8.8
Minibus Taxis	4.09	4.37	0.28	6.4
Commuter Rail	4.05	6.51	2.46	37.8

The capital cost portion of new services increases as the vehicle size increases. New commuter rail carries the largest proportion of capital costs, which is mainly due to the high capital costs of vehicles and exclusive use travelway. At the other end of the scale, minibus taxis incur the lowest capital costs followed by midi buses. Conventional buses bear the largest capital costs for road based public transport although still substantially lower than commuter rail. The relatively larger capital costs portion borne by the higher capacity formal public transport modes negate any benefits derived from the increased space efficiency of these vehicles, when compared to minibus taxis, for new services under all operating conditions.

The notion that large scale formal public transport is not cost effective when considering direct operating or resource costs expended in providing the service is shared by many practitioners. The results of the analyses in this Paper appear to support this viewpoint. However supporters of public transport correctly point out that formal public transport has associated intangible benefits such as supporting large central business districts and providing permanence to the urban form which in turn helps provide the necessary stability required for long term economic growth. These benefits need to be considered along with other measurable social benefits associated with reducing traffic congestion (and related adverse effects) when considering new public transport services. This investigation only sought to estimate the resource costs expended by the providers of the service and hence did not take into account the numerous "external" costs and/or benefits.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The results of this investigation concur with the earlier investigation by Pather (1996) that the informal minibus taxi appears to be the most cost effective public transport mode under the operation conditions tested. While this may be largely due to its low overhead cost structure, there is a suggestion that its demand responsive nature leads to more effective vehicle utilisation and hence lower costs per passenger trip. This hypothesis is supported by the fact that both commuter rail and conventional buses return lower costs per passenger trip than minibus taxis when these vehicles are operated at capacity under certain peak demand ranges.

The lack of reliable cost data from the minibus taxi industry was considered to be a significant flaw of this and previous investigations. The additional costs of "other labour" and higher overheads costs borne by the formal operators significantly increase overall cost per passenger trip for these modes while the lower vehicle maintenance costs of minibus taxi further reduces the costs per passenger trip for the minibus taxi relative to the other modes. This may change with formalisation of the industry as labour costs and maintenance costs increase with more stringent control of the industry.

It must also be reiterated that this investigation only considered the resource costs expended by the providers and operators of the service. Consideration should be given to the other costs such as traffic congestion, the effects on external traffic, accident costs and commuter journey times amongst others when considering competing transport modes as they may affect the overall cost to society and hence influence the final choice of transport mode. In other words, a more holistic approach to costing of public transport systems may be required before the final comparisons can be made between alternative systems.

4.2 Recommendations

The uncertainty surrounding the operating costs of minibus taxis and the lack of comparable data for the other formal transport operators may cast some doubts on the results. Each of these issues represent major research opportunities in their own right and it is suggested that specific investigations be made to clarify them.

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BRIEF CV

Graduated from the University of Natal in Durban in 1986 with a BScEng (Civil). Began career with Ninham Shand in Cape Town in their highway design and traffic engineering division. Subsequently joined Keeve Steyn as an assistant resident engineer on the construction of Mooi River Toll Plaza and the National Route 3 rehabilitation in the Natal Midlands. Then joined De Leuw Cather for an extended period (5 years) working mainly on highway design, traffic and transportation projects. In the meanwhile, obtained a Post Graduate Diploma in Traffic and Transportation at University of Natal in 1993. Joined Protekon in 1994 working on rail related projects and after 2 years left to start own practice, C Simmer and Associates in 1996. Took an extended break in 1997 to complete a MScEng in Traffic and Transportation and resumed private practice thereafter. Currently Managing Director of the Maxplan group of companies and also directly responsible for the KwaZulu Natal operation.