

10.7 料金收受の計算

10.7.1 料金導入による交通量予測

料金を導入した場合の交通量予測方法は、経済評価で採用されたものと基本的には同一である。ただし、料金は下式により所要分に変換してMinimum routeを探索している。また交通量配分道路網は経済評価でケース5（プロジェクトA，B双方が供用）とされた道路網である。

$$T = t + F/V$$

T：トリップコスト

t：本来の所要分

F：料金（全車平均）

V：時間価値（全車平均）

時間価値は乗用車類0.281ルビー/分（経済評価で使用されている）、貨物車類0.409ルビー/分（走行経費の中の時間関連コスト）をトリップ数の構成比で加重平均した値0.34ルビー/分（1983年）に将来の実質 per capita GNPの伸び率を適用して下記のように設定した。

1990年　：　0.42ルビー/分

2000年　：　0.56ルビー/分

10.7.2 料金率と料金収入

料金率を様々に変化させて交通量配分計算を行い、交通量と収入の変化を検討した。

料金率は均一料金制と距離比例料金制の2タイプを考え、それぞれ、下表に示される料金水準についてジュミレーションを行った。なお、車種間料金比率は小型車：中型車：大型車＝1：2：3とした。

表 10-4 料 金 水 準

料 金 制	ケースNo	小 型 車	中 型 車	大 型 車	全 車 平 均
均一料金制 (Rs/vehicle)	1-1	5	10	15	8
	1-2	10	20	30	16
	1-3	15	30	45	24
	1-4	20	40	60	32
	1-5	25	50	75	40
	1-6	30	60	90	48
距離比例 料金制 (Rs/km)	2-1	0.25	0.50	0.75	0.40
	2-2	0.50	1.00	1.50	0.80
	2-3	0.75	1.50	2.25	1.20
	2-4	1.00	2.00	3.00	1.60
	2-5	1.25	2.50	3.75	2.00
	2-6	1.50	3.00	4.50	2.40

注) 1. 全車平均料金率は1983年の交通量車種構成比をウエイトとした加重平均値

2. 小型車は private passenger car, Van・Pick up, 中型車は Medium lorry, Micro bus, 大型車は Heavy lorry, Container trailer, CTB (Central Transport Board) バスを含む。

3. 距離比例制料金率は均一料金率を、無料のときの高速道路平均利用距離(約20 km)で除した値

また、配分計算では全車平均料金率が適用されている。各ケースの結果は表10-5、図10-2に示される。結局、収入が最大となる料金は、1990年で均一料金制の場合は10ルピー/台(小型車)、距離比例制の場合は0.5ルピー/km(小型車)となっている。10年後の2000年では均一料金制の場合は設定された料金水準の範囲内に収入最大点は見い出せなかったが、距離比例制の場合は1.25ルピー/km(小型車)の料金率で収入最大となっている。

財務分析には、上記の最大収入をもたらす料金率を適用することとした。(1)

注) *: 収入MAX

10ルピー/Vehicle,あるいは0.5ルピー/km(小型車)は、人々の支払い能力、他の交通機関(例えばコロンボ市~Airport間のバス)の料金と比較しても reasonable な水準と思われる。(1)

注1): "Transport Requirements of the GCEC Area: Interim Report, October 1980"では小型車10ルピー、大型車50ルピーという料金が示唆されている。

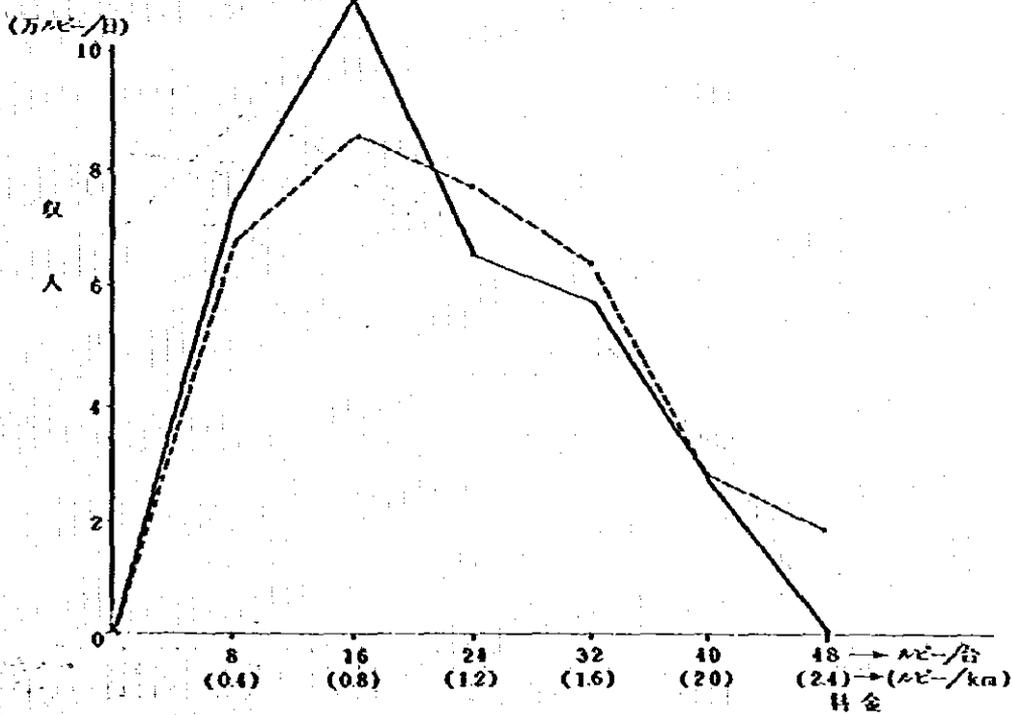
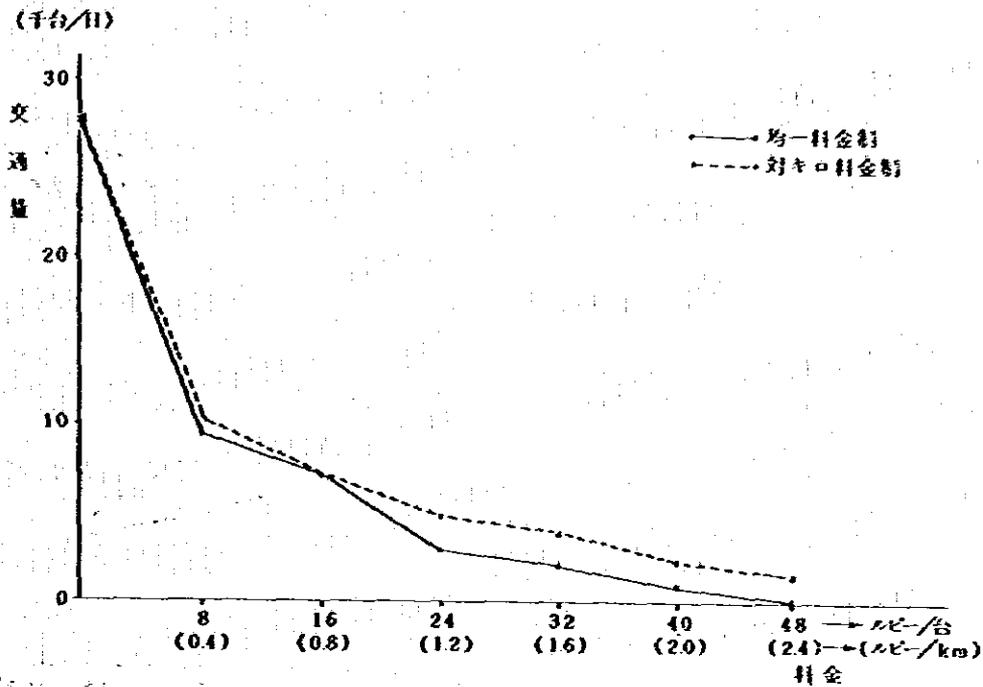


図10-2(I) 料金，交通量，収入の関係(1990年)

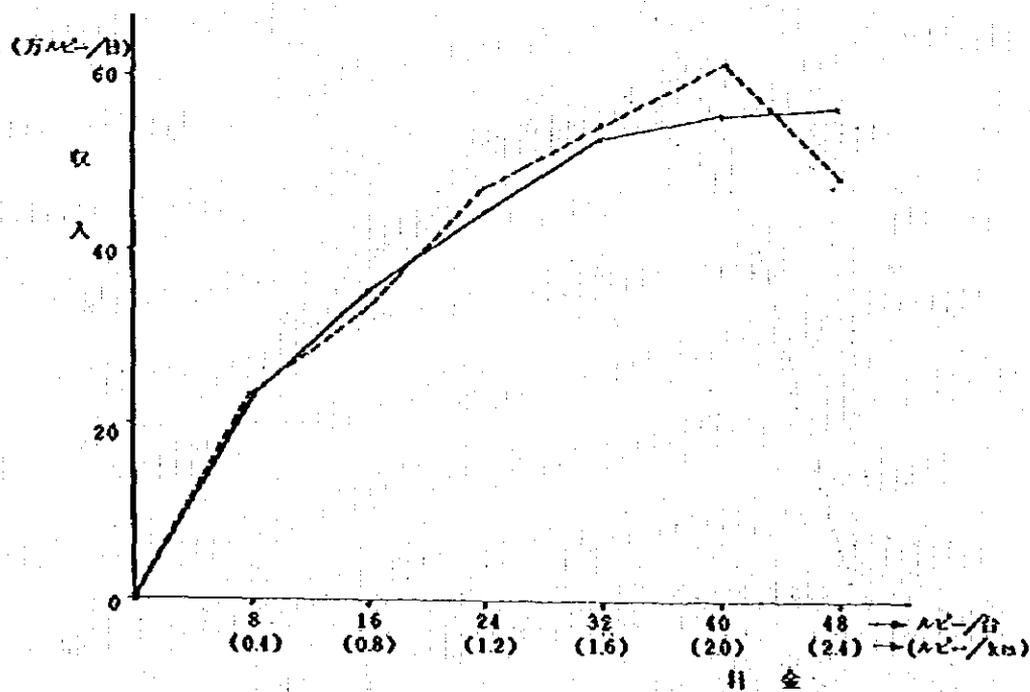
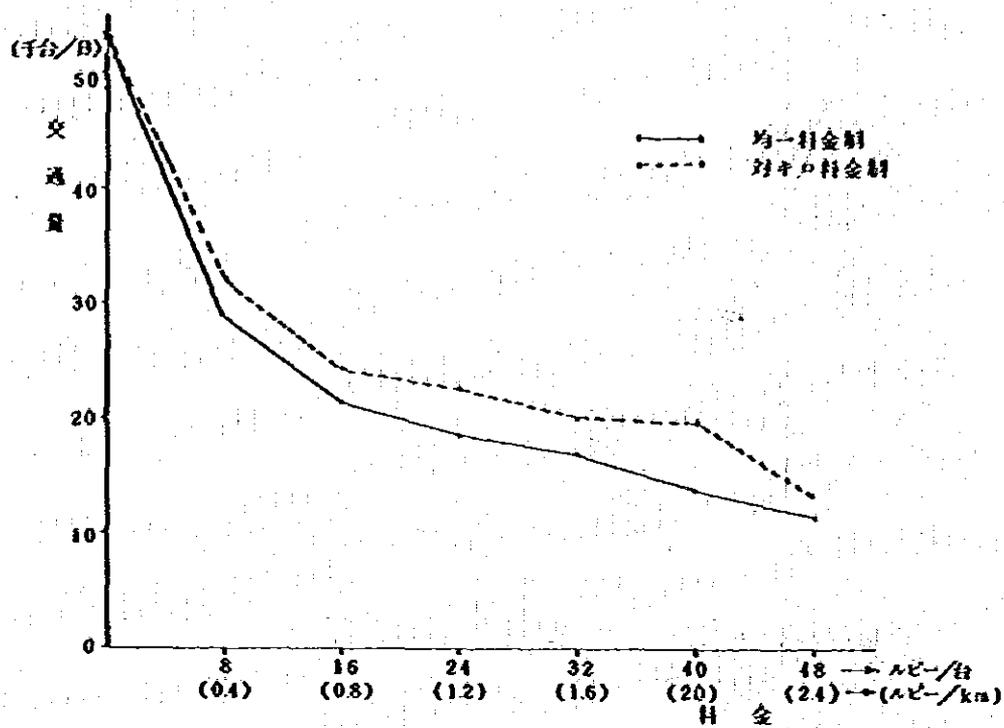


図10-2(2) 料金, 交通量, 収入の関係(2000年)

表 10-5 料金，交通量，収入の関係

均一料金制

ケース	1-0	1-1	1-2	1-3	1-4	1-5	1-6	
全車平均料金率 (ルピー/台)	0	8	16	24	32	40	48	
1990年	交通量 (台/日)	27474	9267	6842	2746	1793	655	0
	収入 (ルピー/日)	0	74136	109472	65904	57376	26200	0
2000年	交通量 (台/日)	53048	28501	21743	18386	16466	13871	11814
	収入 (ルピー/日)	0	228008	347888	441264	526912	554840	567072

距離比例制

ケース	2-0	2-1	2-2	2-3	2-4	2-5	2-6	
全車平均料金率 (ルピー/km)	0	0.4	0.8	1.2	1.6	2.0	2.4	
1990年	交通量 (台/日)	27474	9638	6509	4758	3652	1873	1237
	収入 (ルピー/日)	0	67642	85567	76091	63660	26760	17031
2000年	交通量 (台/日)	53048	32052	24314	22549	20548	19869	13289
	収入 (ルピー/日)	0	228063	334301	470741	545643	615737	484469

なお，表 10-6，図 10-3 は各料金水準における Expressway の平均利用距離を整理したものである。

表 10-6 Expressway の平均利用距離

均一料金制		(km)					
ケース	1-0	1-1	1-2	1-3	1-4	1-5	1-6
料金率 (円/台)	0	8	16	24	32	40	48
1990年	19.2	19.8	18.6	23.2	24.9	25.4	--
2000年	18.9	18.8	18.6	19.8	20.5	21.2	--

距離比例料金制		(km)					
ケース	2-0	2-1	2-2	2-3	2-4	2-5	2-6
料金率 (円/km)	0	0.4	0.8	1.2	1.6	2.0	2.4
1990年	19.2	17.5	16.4	13.3	10.9	7.1	5.7
2000年	18.9	17.8	17.2	17.4	16.6	15.5	15.2

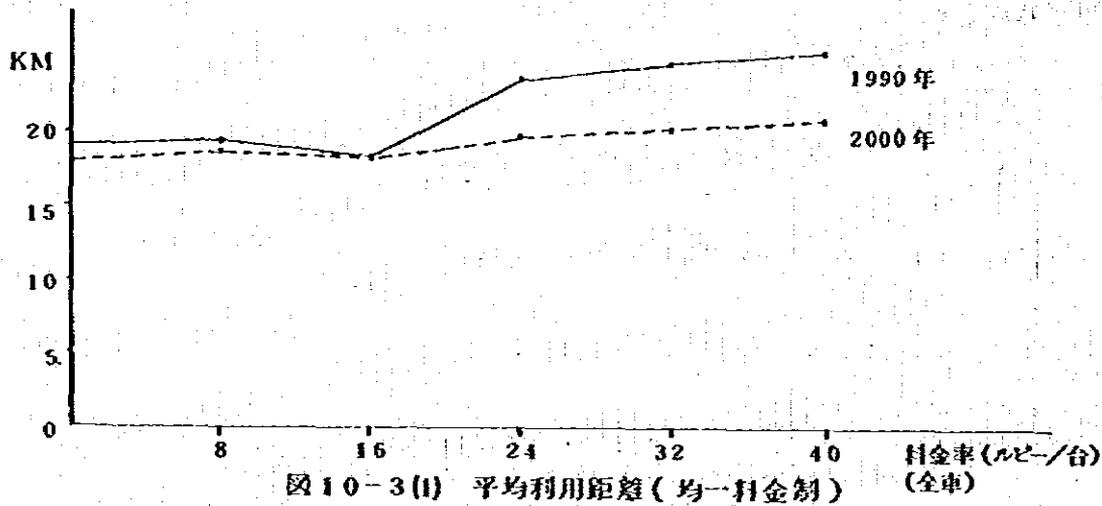


図 10-3(1) 平均利用距離 (均一料金制)

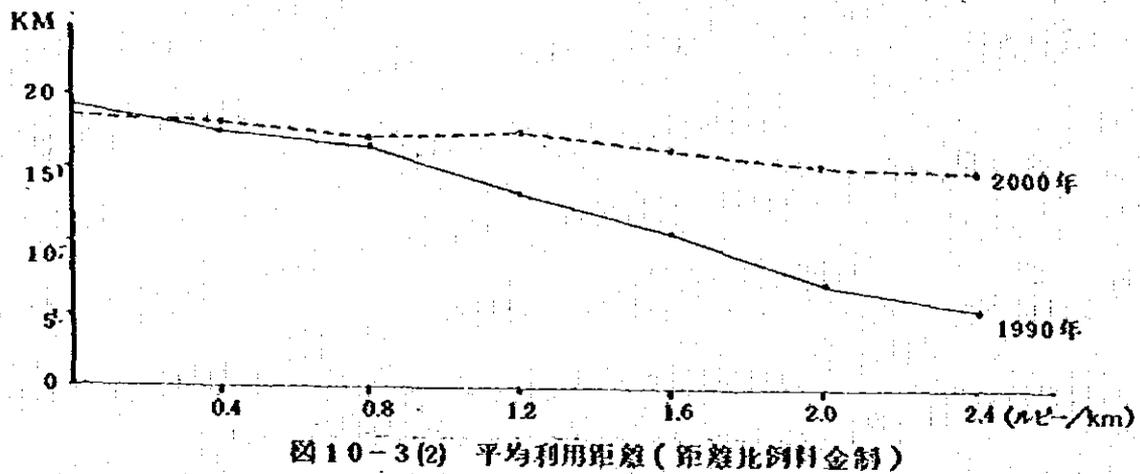


図 10-3(2) 平均利用距離 (距離比例料金制)

10.8 財務評価

10.8.1 前提条件

- 1) 償還計算年数：30年
- 2) 建設費に占める外貨の割合：内貨の割合 = 55%：45%
- 3) 平均金利：年9%
- 4) 運営費：年収の1.0%，2.0%，2.5%の3ケース
- 5) 2000年以降の収入は2000年値で固定
- 6) 料金体系は距離比例制で，1990年0.8ルピー/km，2000年2.0ルピー/kmを適用
- 7) コスト・エスカレーションは考慮しない(ただし，感度分析で考慮される)。

10.8.2 評価結果

以上の前提条件のもとで評価指標を算定した結果が表10-7の分析1～3である(なお分析3には年収の2%の予備費も計上した)。これらの分析の結果，R/Cは1.00～1.03，F.I.R.Rは9.01%～9.26%，投資限度額はいずれも総投資費用 Total investment cost (建設期間中の金利も含む)より大であり，回収年限は供用開始後27年～30年となっている。従って，これらの結果に関する限り，有料道路としての Expressway は財務的にみて viable である。

10.9 感度分析

下記の諸要因を変化させた場合の財務指標の変化をみたものが表10-8のテストI～IIIに示される。

- a. 料金体系：均一料金制にて1990年16ルピー(小型車：約10ルピー，中型車：20ルピー，大型車：30ルピー)，2000年40ルピー(小型車：約25ルピー，中型車：50ルピー，大型車：75ルピー)
- b. 外貨割合：内貨割合 = 45%：55% (平均利子率10.2%)
40%：60% (平均利子率10.8%)
- c. コストエスカレーション：年率 5.0%
年率 15.0%
年率 16.0%

結果を要約すると次のようになる。

- 1) 均一料金制は距離比例料金制と比較して財務的な viability は弱い(ただし，料金收受方式による収受費用の違いはここでは考慮に入れていない)。

- 2) 内貨の割合が増大すると、投資コスト全体に係る金利を押し上げることになるが、外貨と内貨の平均的割合が55%：45%のラインが財務的に viable となる限界であろうと思われる。
- 3) コスト・エスカレーションを加味すると、実行されたテストの中では財務的に viable となるものはない。
- 4) ただし、コスト・エスカレーションの率が、年15%までは投資限度額がプラスであるから、エスカレーションがこの範囲内にとどまるならば、年々の収入の中から維持費、運営費、予備費については賄うことが可能である。

表10-7 財務評価の結果

分析号	資本系		分析の		条件		財務			国取 年度		
	株式投資 比率	総額 割合	1990年	2000年	年間 返済	ローンの内訳		収入/ 費用 比率*	FIRR %		交換 年度	
						外貨	内貨					
1	-	○	0.8 (m^2/km^2)	2.0 (m^2/km^2)	1.0% 毎収入の	-	5.5%	4.5%	1.03	9.26%	1,250 (百万円)	27年
2	-	○	"	"	2.0% 毎収入の	-	"	"	1.02	9.19%	1,236	28年
3	-	○	"	"	2.5% 毎収入の	2.0% 毎収入の	"	"	1.00	9.01%	1,202	30年

(注) * 償還計算年度は30年である。

** 建設期間中の利子も含む。

表10-8 感度分析

サマ 号	感度分析のたのめ			条件			財務			国 年 限					
	コスト 投資	資金体系		年 間 送 貸 率	ローンの内訳		収入/ 費用 比率*	FIRR %	投資 総額 千円						
		距離 比例制	平均 割合		外貨	内貨					総投資費用 千円				
I	-	-	○	16	(ルビー)	40	55%	45%	9%	0.99	4.98	(百万ルビー)	1.198	1.196	31年
II	-	-	○	"	"	"	"	"	"	0.96	8.70	"	"	1.150	35年
III	-	○	-	"	(ルビー/km)	2.0	45%	55%	10.2%	0.84	9.01	1.240	1.032	50年以上	
IV	-	○	-	"	"	"	40%	60%	10.8%	0.77	9.01	1.261	960	"	
V	年平均 5.0%	○	-	"	"	"	55%	45%	9%	0.78	7.24	1.453	1.089	"	
VI	15.0%	○	-	"	"	"	"	"	"	0.39	-	2.100	66	"	
VII	16.0%	○	-	"	"	"	"	"	"	0.35	-	2.176	-202	"	

(注) * 償還計算年数は30年である。

** 建設期間中の利子も含む。

表10-9

有料制の目的及び根拠の例

	主な理由	二次的理由	建設費の償還
韓 国	A	B	必 要
タイ(ETA)	A	B	必 要
(DOH)	B	A	必ずしも必要でない
フィリピン	A	B	必 要
香 港(LRT)	C	A	必ずしも必要でない
(CHT)	A	C	必 要
マレーシア (Selim River)	B	A	必ずしも必要でない
(新規)	A	B	必 要
インドネシア	A	B	必 要

A：資金回収

B：受益者負担

C：効率的利用

表10-10

事業主体と有料制度の例

	事 業 主 体	有 料 制 度
韓 国	1400万株の株式発行による(韓国鉄道公社) (従業員 2222人)	政府が計画した韓国鉄道公社の一部株式を譲渡して公社が設立された。その後の計画、建設、維持費用を自己負担で行っている。
タイ(ETA) (DOH)	6両車両の公社組織(韓国鉄道公社(ETA)) (従業員 250人) 運輸部運輸局直轄	バンコク直轄の国有交通事業(韓国鉄道公社及びメトロラングット)を公社組織の自己負担で行っている。事業計画と支出を公表している。一社員のうち約10%が通勤している。
フィリピン	韓国鉄道の建設維持管理の他、公共交通を確保(実施)する為に設立された民間会社(CDCP) (韓国鉄道公社従業員 2000人)	民間会社が30両のプラットフォームを築き、社会法人による建設管理と維持管理の業務、計画、実施を行う。
香港(LRT) (CHT)	計画は運輸局、建設維持管理は公共交通局直轄(担当職員 140人程度) コンサルタント建設、維持管理の役割として民間 2500名以上の民間会社 (従業員 251人)	政府直轄の多利社で、担当職員の手を借りない。民間会社が建設、維持管理を行い、30両のプラットフォームを築き、この費用は社会法人による負担となる。
マレーシア (Selim River) シブ	公共交通局直轄 (新 規) 公共交通局の直轄下に属する国有法人(マレーシア鉄道公社) (予定従業員 50人)	建設費の回収を前提としたもの(建設はマレーシア鉄道公社に委嘱予定) 企業規模の民間建設会社採用で建設、維持管理する為にスタートした事業計画も企業規模システム。
インドネシア	1000万株の株式発行による(インドネシア鉄道公社) (PT. Jasa Marga) (従業員 350人)	民間として建設費用を回収した事業計画のものであるが、現在のところ政府機関の管理を前提としている。

10.10.3 料金収受システム

前述の財務分析では、有料道路として採算性があるか否かを検討するため、収入が最大となる料金率を適用したが、利用者がExpresswayになじみ、その利便性を確認するまでの移行期間、又は本格的な有料Expresswayへの前段階では、より安い料金を適用するなど弾力的な料金政策を検討する必要があると思われる。

車種区分は、料金設定の基礎を“便益”におくならば細かい程公平の原則からみて望ましい。しかし車種区分が多くなるにつれて料金徴収費用は増加するので採算性の面からは少ない方がよい。本プロジェクトでは2車種(小型車, 大型車)あるいは3車種(小型車, 中型車, 大型車)が提案されよう。特に距離比例料金制の場合は、均一料金制の場合よりも料金徴収費用が高くなる傾向にあるので、それを相殺する意味からも車種区分の統合が望まれる。

距離比例料金制の場合の収受方式は、on rampにて ticket を渡し、off rampにて料金収受、となろう。一方、均一料金制の場合は、on rampにおいてのみ料金を収受し、off rampを無人化することが可能である。

他のアジア諸国における料金収受システムの例および料金設定の方針を整理したものが表10-11である。

表10-11 料金収受システムと料金の設定例

国	料金システム		料 金 の 設 定		
	システム	収受方式	決定機関	設定方針	料金率上げ次第
タイ	open (0-22km) closed (23-100km)	printed ticket	政府の承認	通行距離に依りて(通行料金の減額又はトランプ14元、後者は30%)	料金率上げ次第
タイ (ETA)	closed	printed ticket	政府内閣省の承認	通行距離を25時間未満とする	実現なし
タイ (DOH)	open	printed ticket	政府内閣省決定	通行距離への先着優先	実現なし
フィリピン	closed	現金モード	料金調整委員会	通行距離および通行料の項目と通行距離への先着	料金率上げ次第
香港 (LRT)	closed	printed ticket	各地政府	料金率の低下を主としてない限り	実現なし
(CBRT)	closed	printed ticket	香港政府の認可	料金率と同じく通行距離の項目は可能とする	実現なし
(Salim River) マレーシア	open	printed ticket	政府公共事業局	通行距離を主として	実現なし (ただし料金率) (30%未満)
インドネシア (東部)	closed (一部open)	printed ticket	政府の承認	通行距離を主として料金率も多額分低く設定する目標	実現なし
インドネシア	closed	printed ticket	大 阪 債	通行距離の70%以内、通行料金は30-40%	実現なし(東部)

注) open system: 1車種区分を含む
closed system: 車種区分は多くなく、100%料金率設定

10.10.4 交通管理 (traffic control) と情報システム

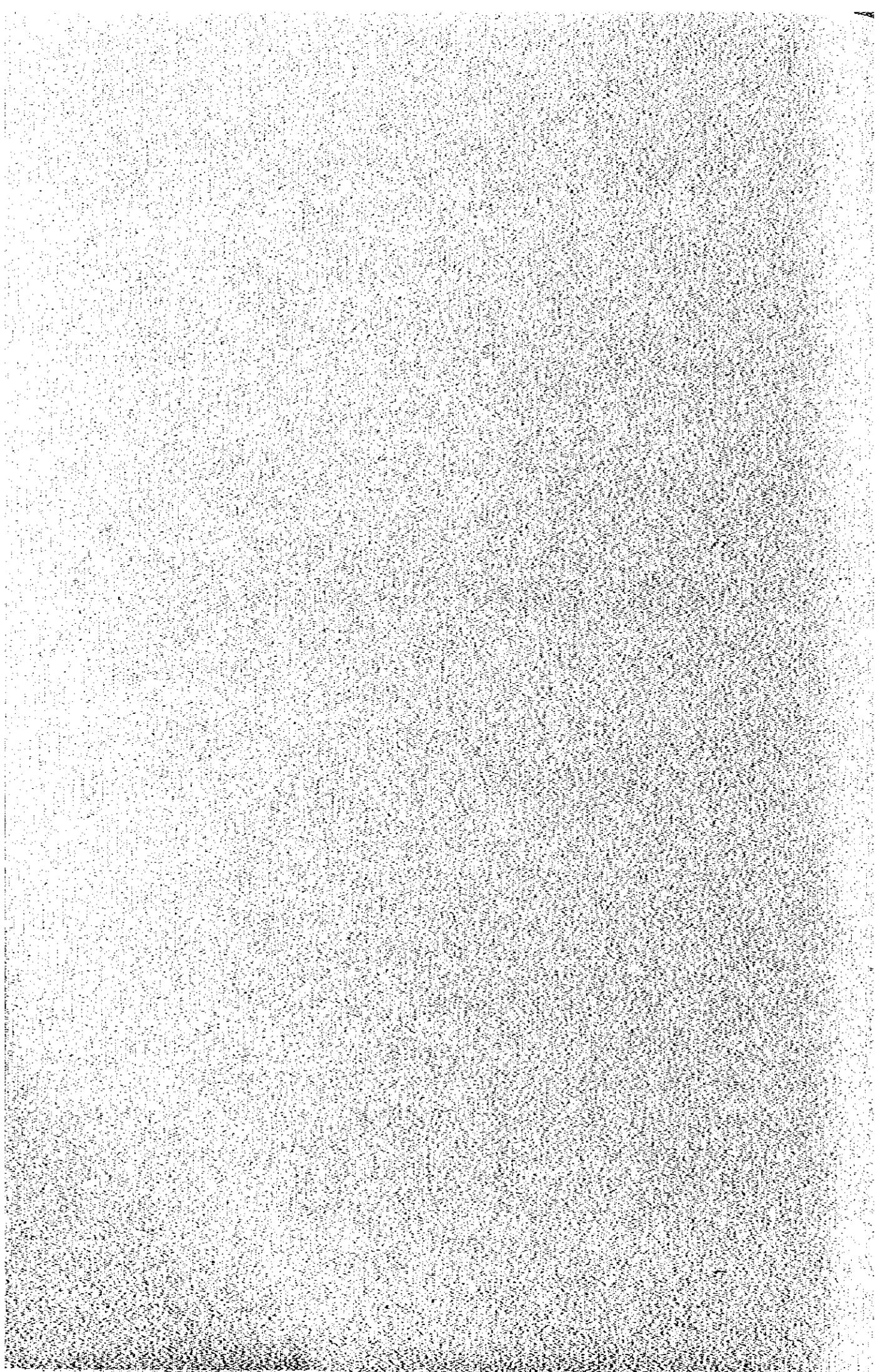
交通管理と情報システムは交通事故や混雑を回避するため、また万一事故が発生した場合に出来るだけ速く通常の状態を回復するため、交通安全とスムーズな交通流の維持の観点から要求される。システムは下記の内容を含む。

- 1) 交通事故、混雑状況の把握
- 2) 情報の収集と提供
- 3) 有料道路上の交通量のコントロール
- 4) security service の維持

10.11 結 論

- 1) 距離比例料金制の方が均一料金制より財務的見地からみて望ましい。
- 2) コスト・エスカレーションの影響を考慮すると財務的に viable とならないので、料金水準も一般的な物価水準を参考にしながら定期的に (例えば 2 年又は 3 年に 1 度) 改訂していくことが必要であり、それによって、財務面での健全性を維持することができよう。
- 3) プロジェクトの収入からみて、たとえ建設費の全額を償還出来ないことがあったとしても、年々の維持管理費等の諸経費は収入の中からカバーすることが可能であると思われる。
- 4) 以上の結論は分析のために設定した一定の条件に基づいて導かれたものであり、今後、実施に移す場合には諸情勢あるいは環境の変化を充分考慮のうえ、それに対応した料金体系、運営方式等を再検討することが望ましい。

付 録 編



付 録

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APPENDIX 1: MOTOR VEHICLE IMPORT RESTRICTION IN SRI LANKA

Before 1977, there were restrictions on the import of vehicles, which allowed only the following companies or persons to import motor vehicles, according to a Cabinet Memorandum by the Ministry of Trade:

- i. Foreign firms and establishments having a branch office in Sri Lanka
- ii. Local firms and establishments in business with foreign participation or working in collaboration with foreign firms.
- iii. Local firms and establishments in –
 - *the plantation sector and industrial sector
 - *the import and export trade united to the economy, functioning as agents of foreign principles.

Other than the abovementioned, invalid persons who cannot use the public transport are also allowed to import a motor vehicle. After 1977, the aforementioned restriction has been relaxed as follows:

- i. Those who earned the foreign currency can buy one new car or up to three second hand cars upto Rs. 150,000/-. These cars can be gifted to blood relatives and/or close relatives.
- ii. As for the commercial vehicles, there is no restriction at all.
- iii. Doctors, Engineers, Civil Officers etc., if they have money, can import cars.

As a result, the number of motor vehicles has gradually increased after 1977, as shown in Table (1).

Table (1): No. of Motor Vehicles Registered by Year and the Type of Vehicle

Item	1973	1974	1975	1976	1977	1978	1979	1980
1.0 Private Transport								
1.1 Cars	85,939	86,871	87,840	89,795	92,910	99,620	109,273	114,443
1.2 Motorcycles	22,134	22,501	22,773	23,384	24,435	29,690	45,087	79,808
2.0 Public Transport								
2.1 Hiring Cars & Taxis	3,832	3,861	3,888	3,974	4,100	4,275	5,180	6,430
2.2 Buses - CTB	11,146	11,562	11,698	11,956	12,859	13,466	14,212	15,000
2.3 Private Coaches	1,046	1,057	1,117	1,186	1,264	1,530	3,105	5,752
3.0 Lorry Transport								
3.1 Lorries & Vans	34,222	34,434	34,438	34,689	35,512	40,386	46,649	55,838
3.2 Tractors Registered as Lorries	1,195	1,195	1,192	1,189	1,185	1,207	1,206	1,245
3.3 Others Registered as Lorries	128	137	135	135	184	235	274	364
3.4 Trailers (Lorries & Cars)	2,830	2,831	2,828	2,832	2,848	2,895	2,932	3,088
4.0 Land Vehicles								
4.1 Tractors	16,736	18,690	19,900	20,930	22,450	24,982	32,043	37,588
4.2 Trailers	8,052	8,407	8,742	9,156	9,834	11,093	13,515	17,208
4.3 Others	411	416	421	434	445	588	604	823
Total	187,671	191,962	194,972	199,660	208,026	229,967	274,080	337,367

Source : Economic & Social Statistics of Sri Lanka
 Statistics Department of the Central Bank of Ceylon

APPENDIX 2: BACKGROUND OF THEORETICAL MODEL

(1) Examination of Data for the Number of Motor Vehicle Registered

The population, GDP, and the number of motor vehicles registered are the necessary input data for the determination of future traffic based on the past trend. The growth rate of overall traffic has a strong relationship with these growth rates. Unfortunately, the relationship between the traffic volume and these socio-economic indicators cannot be derived in Sri Lanka, due to the absence of the time series data on the traffic volume. However, the traffic volume is generally considered to have a stronger relationship with the number of motor vehicles registered than with the other socio-economic indicators available for traffic study.

In this study, the growth rate of overall traffic volume is forecasted based on the growth rate of the number of motor vehicle registered. However in Sri Lanka unlike in many other countries, the import of motor vehicles has been restricted by the national policy. Therefore, prior to forecasting the traffic volume, the examination of the past trend of motor vehicle registration is performed.

As shown in Fig. 3-2, before 1977 the increase of the number of motor vehicles registered as extremely small. However, there is a sudden increase after 1977. GDP also shows a similar trend of expansion before and after 1977 as shown in Fig. 3-3. Therefore, judging from this fact, it may be concluded that irrespective of the existence of vehicle import restrictions, there seems to be a strong correlation between the growth of the number of vehicles registered and the GDP. Based on past trend, it may be, therefore, reasonable to adopt such a correlation as a basic assumption in the future traffic forecasting.

The original source of data in Table (1) in Appx. 1 is the Department of Motor Traffic. However, according to 'Transport Statistics in Sri Lanka 1974 ~ 1981', published by the National Planning Division, Ministry of Finance and Planning, August 1982, there is the following note attached to these figures:

"The number of vehicles on registers is believed to be a significant over-estimate to the number of vehicles which are active as it is thought to include many vehicles which have been scrapped but not removed from registers. For example SLCTB has approximately 7,500 buses in its fleet but 15,024 still on registers."

Judging from this comment, the scrapped or condemned buses in the SLCTB amounts to approximately 50% of the registered number. Therefore, it could be inferred that a situation similar to this may be valid in the case of other vehicles indicating a high rate of scrapped vehicles. Data are not available at this stage to determine the scrapped rate by vehicle type. However, for the purpose of this study it may be reasonable to assume that the percentage of vehicles scrapped each year remain almost a constant.

On the other hand, the estimate of future traffic volume examined here is forecasted not on the basis of total volume itself but on the growth rate of the number of motor vehicles registered. Therefore, the percentage of vehicles scrapped each year will not really pose a problem.

(2) Relationship between the per capita number of motor vehicles registered and per capita GDP in Asian countries.

Table (1) shows the number of motor vehicles registered and per capita GDP of some Asian countries.

Table (1): Comparison of the Per Capita Number of Motor Vehicles Registered and Per Capita GDP by Asian Country

Country	Density of Population (persons/km ²)	Per Capita GDP (US\$)	Motor Vehicles Registered (Vehicle/100 persons)
Sri Lanka	216	158	1.5
Republic of Korea	378	950	6.3
Thailand	88	412	1.6
Philippines	155	459	2.1
Republic of China	446	1,074	4.0
Malaysia	39	1,080	6.6
Indonesia	76	320	0.7
Japan	306	6,903	27.2

Source: Kaigai Keizai Kyoryoku Binran (1980) (in Japanese)

The above data plotted in Fig. (1) shows a strong correlation between the number of motor vehicles registered per capita and the per capita GDP. The higher the per capita GDP, the more the number of motor vehicles registered. In fact, by statistical analysis this relationship can be represented by the following equation for the countries other than Sri Lanka:

$$X = 1.4659 \times 10^4 \cdot X^{0.52134}$$

Although the per capita GDP in Sri Lanka is lowest among these countries as shown in Fig. (1) the per capita number of motor vehicles registered is considerably high. This may be a result of the aforementioned statistical problem, that is, the inclusion of scrapped vehicles in the number of motor vehicle registered, whereas the actual number of vehicles running on the road is considered to be very much lower.

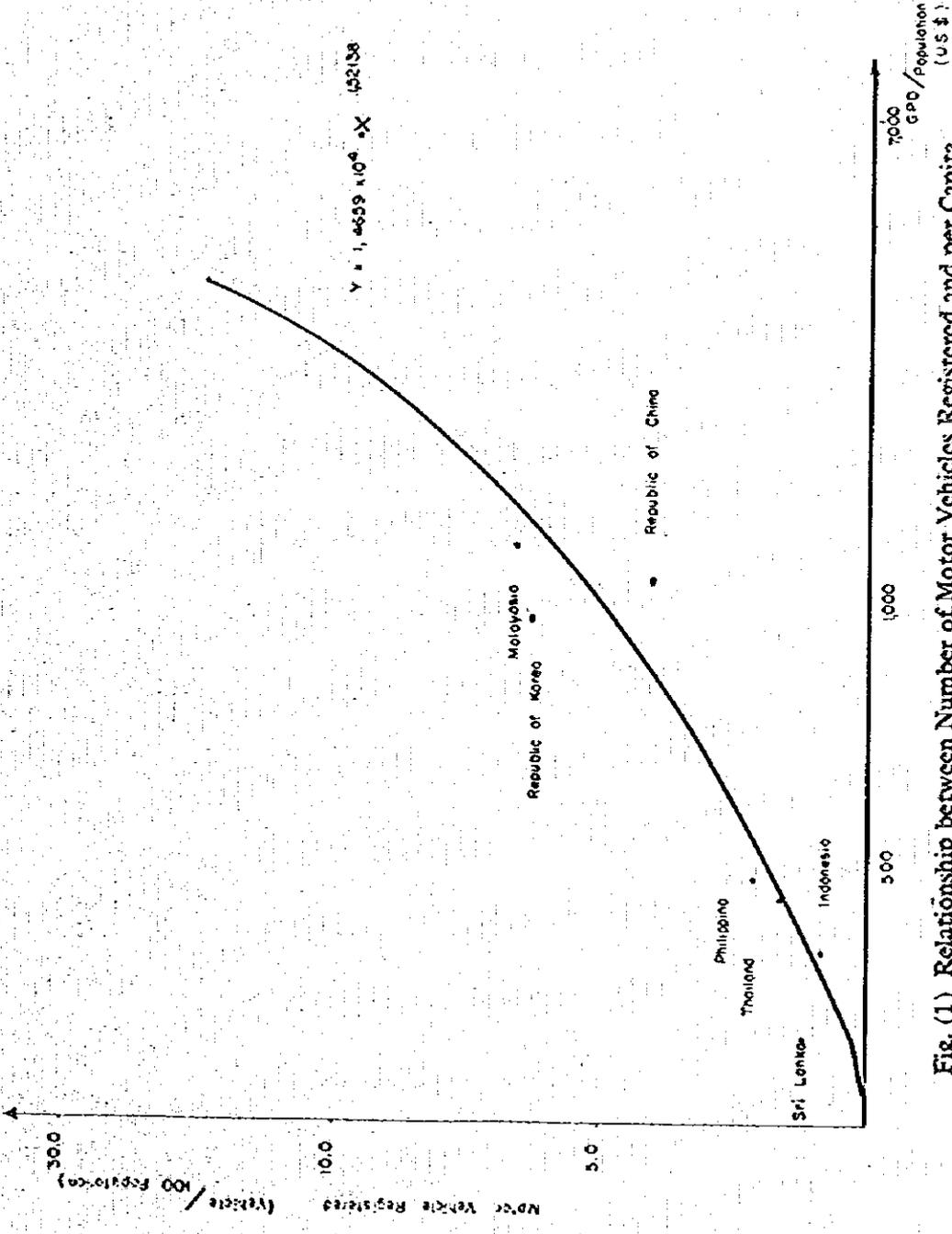


Fig. (1) Relationship between Number of Motor Vehicles Registered and per Capita GDP in Some Asian Countries (1977)

With the gradual growth of economy and increase of per capita GDP, it could be expected that the number of vehicles per capital increase in a trend similar to the curve shown in Fig. (1).

(3) Relationship between the number of motor vehicles registered and running vehicle kilometer.

From what discussed above it became clear that the number of motor vehicles registered has a strong correlation with the socio-economic indicators such as the per capita GDP. However, the relationship between the number of motor vehicles registered and the volume of traffic is not yet clear. To clarify this, the above relationship is examined with the concept of running vehicle kilometers.

The concept of running vehicle kilometers is defined as follows:

$$VK : = \sum_{i=1}^n V_i \cdot D_i$$

VK : Vehicle kilometer

V : Vehicle tripped

D : Distance travelled in each trip

i : 1, 2,, n (No. n trip)

n : The number of vehicle tripped

This is a well known measure to represent the traffic conditions which depend on the number of trips and the distance travelled in each trip. Generally, the average number of trips per vehicle and the average trip distance per vehicle do not change drastically. In other words, vehicle kilometer varies depending mainly on the number of vehicles, which is obtained on the basis of the number of motor vehicles registered.

This relationship based on experience in Japan is shown in Fig. (2).

This figure represents clearly the proportional relationship between the number of motor vehicles registered and the running vehicle kilometers, except in the case of lorries from 1970 to 1975, during which period, the movement of goods and material decreased extremely due to sudden economic recession in Japan followed by the first oil crises. As soon as the business activities adjusted to the new economic structure, the relationship between these two indicators recovered as same as before.

Therefore, in the analysis the growth rate of the number of motor vehicles registered is used in order to forecast the future overall traffic volume.

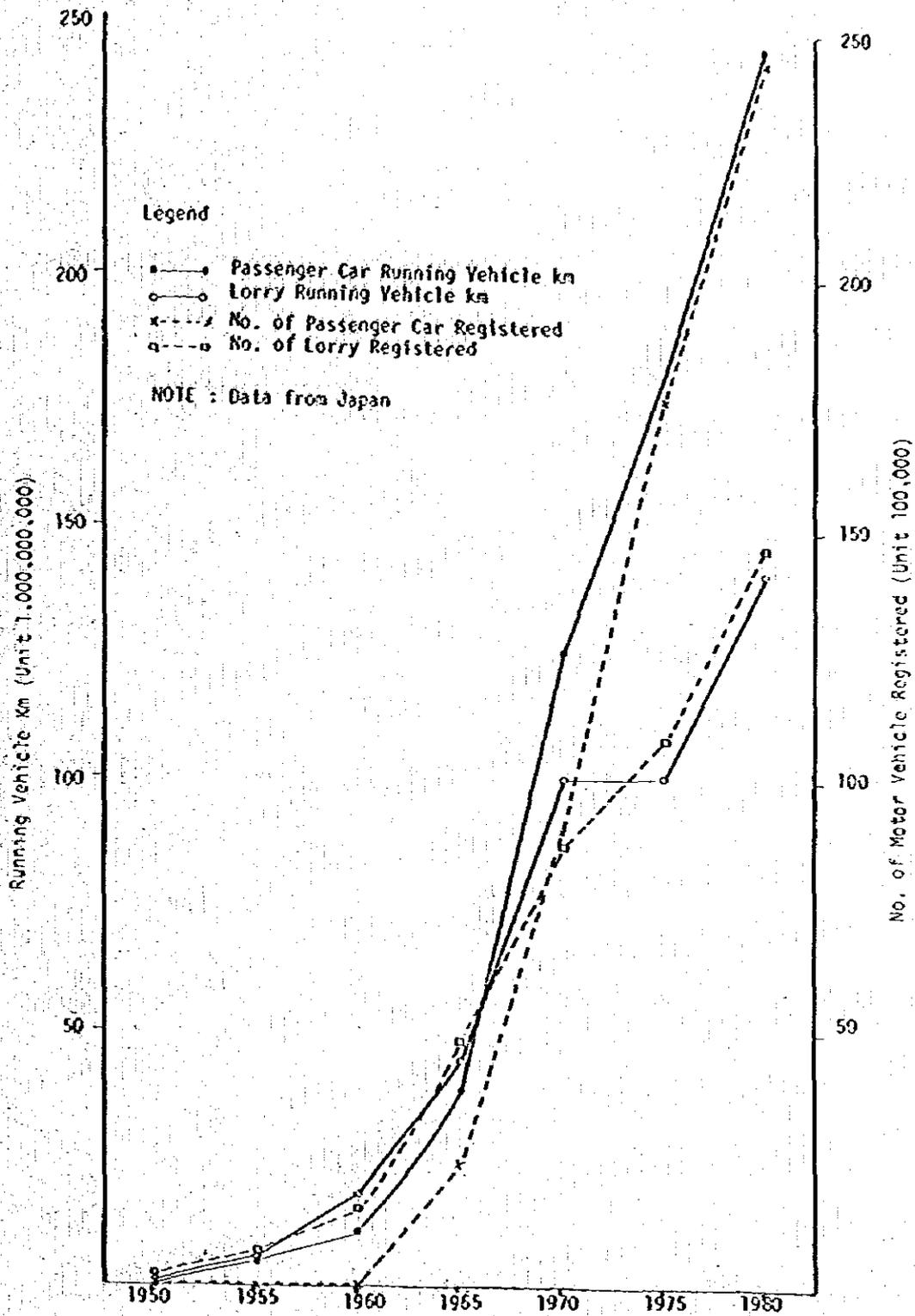


Fig. (2) Relationship between Number of Motor Vehicle Registered and Running Vehicle Kilometer

APPENDIX 3: MODEL BUILDING AND ESTIMATION OF PARAMETERS

(1) Model Building

Technical Note 1

Traffic volume of basic year (indicated by suffix) is assumed to be represented by the following equation

$$T_0 = \alpha \cdot (P_0)^\beta \cdot (G_0)^\gamma \dots\dots\dots (1)$$

T : Traffic volume

P : Population

G : GDP or GNP

α, β, γ : Parameters

Future traffic volume (indicated by suffix 1) is represented by the equation (2) using equation (1):

$$T_1 = \alpha \cdot (P_1)^\beta \cdot (G_1)^\gamma \dots\dots\dots (2)$$

Equation (2) is divided by equation (1)

$$\frac{T_1}{T_0} = \left(\frac{P_1}{P_0}\right)^\beta \cdot \left(\frac{G_1}{G_0}\right)^\gamma \dots\dots\dots (3)$$

By definition,

$$\frac{T_1}{T_0} = t + 1, \quad \frac{P_1}{P_0} = p + 1, \quad \frac{G_1}{G_0} = g + 1$$

By introducing ϵ equation (3) takes into account of the effect of increase of G on the increase of T.

Rewiring the variables in equation (3)

$$t = (p + 1)^\beta (\epsilon g + 1)^\gamma - 1 \dots\dots\dots (4)$$

(2) Estimation of Parameters

In order to determine β and γ , the least squares method is applied to the following equation:

$$T = \alpha \cdot P^\beta \cdot G^\gamma \dots\dots\dots (3)$$

where

T : Traffic volume

P : Population

G : GDP

α : Constant term

Using the data shown in Table (1), the Parameters α , β and γ are estimated.

Table (1): The Number of Motor Vehicles Registered, Population and GDP by Year

Year	Passengers	Lorries	Total	Population (10 ³ persons)	GDP (10 ⁶ Rs.)
1971	120,596	59,686	180,282	12,608	13,209
1972	122,468	61,628	184,096	12,861	13,631
1973	124,097	63,574	187,671	13,091	14,138
1974	125,852	66,110	191,962	13,284	14,585
1975	127,316	67,656	194,972	13,496	14,987
1976	130,295	69,365	199,660	13,717	15,431
1977	135,568	72,458	208,026	13,942	16,078
1978	148,581	83,412	231,993	14,190	17,401
1979	176,857	97,223	274,080	14,471	18,501
1980	221,433	115,949	337,382	14,738	20,653
1981	246,199	127,911	374,110	14,850	21,330

Using these parameters and substituting the projected growth rates of GDP and population in 1990 and 2000 in the above equation, the growth rate of the future motor vehicle registration can be easily obtained.

Annual average growth rates of population and GDP were estimated as follows (Ref. – Technical Report on Regional Economy):

Growth Rate	1980 ~ 1990	1990 ~ 2000
Population	1.78%	1.88%
GDP	4.93%	5.48%

The elasticity (E) in terms of per capita vehicle/per capita GDP differs from year to year as shown in Table (2).

Table (2): Elasticity (E) in Terms of Per Capita Vehicles/per Capita GDP (1977 ~ 1980)

Type of Vehicle	1977	1978	1979	1980
Passenger Car	0.848	1.714	1.288	3.635
Lorry	1.499	3.146	3.365	3.291

The geometric average value from 1977 to 1980 is adopted as the future elasticity of the year of 1990. As for the year of 2000, the value of elasticity is assumed to decrease by 0.3 from the value of 1990, which are shown in Table (3).

Table (3): Future Elasticity (E) in Terms of Per Capita Vehicle/Per Capita GDP

Type of Vehicle	1980 ~ 1990	1990 ~ 2000
Passenger Car	1.6	1.3
Lorry	2.6	2.3

The annual average growth rates determined by substituting the values of P , β , γ , and E into equation (2), are shown in Table 3-8.

APPENDIX 4: SHADOW PRICES

(1) General

Shadow prices may be regarded as the general case, of which the transfers such as taxes and duties are a special case, where market prices do not represent real social resources. As widely known, in economic evaluation, input resources and outputs of the project should be grasped in real value. If the markets were perfect and fully competitive, market prices would reflect the real value. But, there are many market distortions in actual situation. Where there is unemployment of labour, for instance, estimated wage costs should reflect the alternative opportunities for work rather than the actual wage cost. Sometimes the alternative opportunity cost is zero because the labour would otherwise be unemployed.

Another resource for which it may be legitimate to count a shadow price is foreign exchange. In many developing countries, the value of foreign currency is considered to have more higher value than the official rates because of shortage of foreign exchange. In such case, a conversion factor in excess of unity should be attached to any foreign exchange expenditure or earnings involved in projects, and the shadow price of foreign exchange would then be its actual price multiplied by this conversion factor. The correct pricing of factors of production, including labour, capital, land and foreign exchange, is highly complex. Therefore, simplified methods were adapted in this study.

(2) Shadow Wage Rate

According to the survey of labour force 1980/81, unemployment rate of 15.3 per cent and of 18.6 per cent were estimated for All Island and Urban areas respectively. (Refer to Table (1)).

Under such situation, marginal productivity of unskilled labourers are supposed to be at a considerably lower level than the average market wage rate. Therefore, Study Team assumed the economic value of unskilled labourers to be one half of its market price.

On the other hand, market wage rate of skilled labourers is thought to reflect the opportunity cost of labour because the market mechanism well functions. Therefore, no Shadow Wage Rate was applied to skilled labour.

Total labour cost in Project Roads was estimated approximately 37 million Rupees as shown in Table (2). Among this figure, the cost of unskilled labourers is about 11 million Rupees, and share of this cost to total local component (excluding the land acquisition cost) is 5 per cent. Therefore, the conversion factor for translating the market value of local component to the economic cost is calculated as follows:

$$(0.05 \times 0.5) + 0.95 = 0.98$$

Table (1): Unemployment Rate*

Sector	1971 Census of Population	1980/81 Labour Force Survey
All Island		
Male	14.3	12.4
Female	31.1	23.0
Total	18.7	15.3
Urban		
Male	17.0	14.5
Female	47.6	29.3
Total	23.4	18.6
Rural		
Male	13.4	11.9
Female	27.4	21.6
Total	17.3	14.6

$$* \text{Unemployment rate} = \frac{\text{Unemployed population}}{\text{Economically active population}} \times 100$$

Source: Department of Census and Statistics Ministry of Plan Implementation, 'Labour Force and Socio-Economic Survey 1980/81 Preliminary Report'

(3) Shadow Exchange Rate

A formula proposed in UNIDO method was adopted to convert the official exchange rate to real one¹⁾:

$$\text{SER} = \text{OER} \frac{(M + T_i) + (X - S_x)}{M + X}$$

Here,

SER : Shadow Exchange Rate

OER : Official Exchange Rate

M : CIF (Import)

X : FOB (Export)

T_i : Import Duty

S_x : Export Subsidy

Table (2): Summary of Labour Cost Component in Construction Cost

Road Section	Foreman @ Rs.110 per day		Skilled Labour @ Rs.89.7 per day		Operator @ Rs.115.2 per day		Sub-Total		Un-Skilled (Common) @ Rs.58.4 per day		Total	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost		
P-1	2398	253.88	27786	2492.40	6784	781.52	36878	3527.80	15456	902.63	52334	4430.43
P-2	73	8.03	1577	141.46	112	12.90	1762	162.39	357	20.85	2119	183.24
P-3	4136	454.96	35730	3204.98	7723	889.69	47589	4549.63	26954	1574.11	74543	6123.74
Σ P	6517	716.87	65093	5838.84	14619	1684.11	86229	8239.82	42767	2497.59	128996	10737.41
K-1	5213	573.43	41432	3716.45	9309	1072.40	55954	5362.28	34482	2013.75	90436	7376.03
K-2	8178	899.58	39427	3446.90	9833	1132.76	56438	5479.24	46913	2739.72	103351	8218.96
K-3	10067	1107.37	54831	4918.34	9628	1109.15	74526	7134.86	62550	3652.92	137076	10787.78
Σ K	23458	2580.38	134690	12081.69	28770	3314.31	186918	17976.38	143945	8406.39	330863	26382.77
Plants (Installation)	173	19.03	1280	114.82	48	5.53	1501	139.38	302	17.64	1803	157.02
Total	30148	3316.28	201063	18035.35	43437	5003.95	274648	26355.58	187014	10921.62	461662	37277.20

Note : Including Overheads but excluding Engineering fees and Contingencies.

: Cost : in Rs.1000

Note 1): UNIDO (United Nations Industrial Development Organization), 'Guide to Practical Project Appraisal' (Vienna, 1978).

This formula was also calculated in the Feasibility Study on Colombo Port conducted by JICA.

Sri Lanka has not so far employed the direct export subsidy system, but instead, export duty system has been adapted. Therefore, in above formula, export subsidy was displaced by export duty.

According to the statistics of external trade shown in Table (3), export of tea/rubber have been sharing over 50 per cent of total export. It is better to exclude the figures of tea/rubber for the purpose of our study, because the conversion factor would be applied to modify the items related to construction work.

Table (3): External Trade Statistics

Item	(In Million Rs.)	
	1980 Jan. ~ Dec.	1981 Jan. ~ Dec.
Import	33,675	34,598
Import Duty Revenue	3,493	3,960
Export	17,273	19,918
Export Duty Revenue	3,480	3,412
Import except Tea/Rubber	33,237	34,236
Import Duty Revenue except those for Tea/Rubber	3,390	3,872
Export except Tea/Rubber	6,697	9,639
Export Duty Revenue except those for Tea/Rubber	299	320

Source: Sri Lanka Customs, 'External Trade Statistics - Sri Lanka' 1980, 1981.

The results of calculation of the conversion factors were as follows:

1980 - 1.077

1981 - 1.081

Therefore, factor 1.08 was adopted to convert the foreign component to economic cost.

APPENDIX 5: VEHICLE OPERATING COST

(1) General

Studies on vehicle operating cost were conducted for the representative vehicle types, each having different operating characteristics. For each vehicle type, a popular vehicle make was selected.

In general, the vehicle operating cost is composed of running – distance – related cost and time-related cost (fixed cost). In this study, time-related cost was converted to distance-related cost.

(2) Representative Vehicles

Vehicles were classified originally into nine types. Among them, the data about the container trailer were not available. Hence, it was grouped into heavy lorry.

The representative vehicles shown in Table (1) were determined by referring some materials 1) and after interviewing a number of dealers and organizations.

These vehicles had the largest share in recent sales or strong popularity. Their characteristics are also presented in the same table.

Note 1): "Statistics of Motor Vehicles, Statement No. 11" and "Registration of Motor Vehicles, Statement No. IV, (Statistics of Motor Vehicles Registered classified by country of origin make and class)".

(3) Running Distance – Related Cost

Distance related cost is the cost incurred by the movement of vehicles on roads. It is composed of the following items:

1) Fuel Cost

Fuel prices with their breakdown are shown in Table (2). Fuel consumption rate at a normal travelling speed on flat and paved road is shown in Table (3) comparing the experimental data with the results of interviewing the dealers and organizations in Sri Lanka. Decided basic fuel consumption rate is shown as follows:

Type	V = km/H	Litre/km	km/Litre
Motor Cycle	65	0.036	28
Tricycle	55	0.042	24
Passenger Car	65	0.071	14
Pickup	65	0.100	10
Heavy Bus	60	0.217	5
Micro Bus	60	0.109	9
Medium Lorry	55	0.114	9
Heavy Lorry & Container Trailer	55	0.178	6

When the traffic volume on road increases, the travelling speed decreases. Decreases in the travelling speed usually accompany changes in speed cycle such as stopping, slow-down, acceleration, etc. The relationship between the fuel consumption rate and the travel speed is shown in Table (4).

Applying these experimental changing patterns to the above mentioned basic consumption rate (Table (3)), modified and adapted fuel consumption rate was obtained as shown in Table (5).

Engine oil consumption rate was assumed to be 1/100 of fuel consumption rate.

2) Depreciation Cost (Capital Cost)

The depreciation cost is also divided into two components: distance related depreciation cost and time related depreciation cost (capital cost). The depreciation cost per km was estimated by finding the retail price, residual value, years in use, operating distance per year and the discount rate (opportunity cost of capital). Study Team assumed to allocate a half of the depreciation cost on the running distance related cost. Another half of depreciation and interest cost were allocated on time related cost.

The depreciation cost as shown in Table (7) were calculated by the following "Capital Recovery Factor" (CRF).

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Here,

i : Discount rate (= 12%)

n : Life years in use of vehicle

Annualized depreciation cost (F)

= [(Initial price (A) - Present value of residual value (C)) x CRF

where (C) is assumed at 10% of (A)

= Depreciation cost (related to running distance)

+ Depreciation cost (related to operation hours)

+ Interest charge.

Gross Depreciation cost = (Initial price - residual value)/years in use

Gross Depreciation cost x $\frac{1}{2}$ = Distance related cost per annum.

= Time related cost per annum.

Depreciation cost per km = Distance related cost p.a./annual running km.

Average running km and life years, determined after interview, are shown in Table (6).

The price of vehicles and of their components are shown in Table (8).

3) Tyres Cost

Tyre cost per km was calculated from the data on the prices of tyre (refer to Table (8)) and assumed usage in km (refer to Table (6)). The cost per km is shown in Table (12).

It was generally said that when vehicles run at lower speed the tyre wear is less, while at a higher speed the tyre wear becomes larger. However, most of the studies on vehicle running cost do not explicitly explore the tyre wear on congested roads. It can also be said that a low travelling speed of 30 - 20 km/H especially on urban roads, usually means frequent changes in speed with braking which increase tyre friction, and that it is not likely that tyres used by the vehicles running at lower speed have a longer life than those at higher speed if the roads are in the same conditions. Unfortunately there are no experimental data which indicate how the tyre wear differ on the roads under un-interrupted flow and on the roads with frequent speed changes. Accordingly, the tyre wear would be assumed the same regardless of the speed level.

4) Maintenance Cost

The maintenance and repair cost are divided into those of labour and spare parts cost. The spare parts cost is calculated by using the expenditure on spare parts as a percentage of initial vehicle price while the labour cost is calculated based on the labour hours spent for maintenance per annum. These data are shown in Table (9).

Maintenance cost per km is illustrated in Table (12).

(4) Time Related Cost

Time-related cost is part of vehicle operating cost, which is considered suitable to associate with the operating hours regardless of actual running. It is composed of the following items:

1) Capital Cost (Depreciation Cost)

The time-related depreciation cost was calculated simultaneously with distance related cost of depreciation. A half of the depreciation cost was assumed to be the time related cost. Interest charge is also a factor to be included. Calculated costs per hour is shown in Table (7).

2) Crew Cost

The vehicle operation is accompanied by the employment of a driver and assistants (especially in case of commercial vehicles such as taxis, buses and lorries). They receive payment for their work which in turn comprises part of the vehicle operating cost. The current average wage rate was determined as shown in Table (10). Operation hours was also presented in the same table. Crew cost per hour is shown in Table (12).

3) Registration Fees and Insurance Fees

Annual fees of both these are shown in Table (11). Insurance cost was counted as a substitute for part of the accident cost. Per hour cost was calculated in Table (12).

4) Overhead Cost

Overhead cost (or standing cost) includes all costs not covered by the above-mentioned components of the operating costs. These costs include rent, administration, management fees and so on.

According to a previous study¹⁾, the overhead cost are given as a percentage of the total operating costs. And this percentage is shown as 10 percent for private passenger cars and 25 percent for other vehicles. These percentages were adopted in this study.

Note 1): S.W. Abeyanayake, 'Transport and Road Research Laboratory Report 672' 1975.

(5) Total Vehicle Operating Cost by Travelling Speed

Total vehicle operating cost for each vehicle type at various travelling speeds is shown in Table (13) to (18). In these tables, time-related vehicle operating costs (Rs./hour), such as Capital cost, Crew cost, Registration, Insurance and Overhead cost were converted in Repees per 1,000 km by using the corresponding speed. For example, crew cost of

medium lorry was estimated at Rs. 4.0/hour in Table (12). This cost can be converted to Rs. 0.08/km when medium lorry runs at the speed of 50 km/hour.

Table (1): Representative Vehicles Selected for VOC Estimation

Type of Vehicle	Engine HP	Engine CC	Gross Vehicle Weight	Curb Weight	Tyre Size	No. of Tyres	Make
(1) Motorcycle	7.2	86	kg	kg	FR 2.25 - 17 RR 2.50 - 17	2	Honda
(2) Tricycle	5.5	145	610	300	400 x 8	3	Bajaj
(3) Passenger Car	-	1400	-	995	155 - SR - 13	4	Mitsubishi
(4) Wagon, Van Pickup	80	2200	2550	1340	650 - 15 - 8	4	Datsun Pickup
(5) Bus (SICFB)	110	6075	10500	-	900 x 20	6	Ashok Leyland
(6) Medium & Micro	-	3298	4800	2670	6.5 x 16 6PR	6	Mitsubishi Rosa
(7) Medium Lorry (1-4 ton, 2 axles)	-	3298	5500	2305	6.50 x 16 6PR	6	Mitsubishi Canter FE
(8) Heavy Lorry (More than 4 ton 3 axles)	-	6557	9400	2985	8.25 x 20 14PR	6	Mitsubishi Fuso FK
(9) Container trailer	-	-	-	-	-	-	-

Source : Richard Petris & Co., Stafford Motor Co. Ltd., Associated Motorways, United Motors, Sri Lanka Central Transport Board.

Table (2): Fuel Prices

(in rupees per litre)

	(1) Market Price	(2) Duties & Taxes	(3) Economic Cost
Gasoline - Super	12.000	1.080	10.920
Diesel	6.750	0.608	6.142
Engine Oil used in petrol vehicles			
1) Barral grade	17.000	1.530	15.470
2) Multi grade	27.000	2.430	24.570
Engine Oil used in Diesel vehicles	21.000	1.890	19.110

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Source : Ceylon Petroleum Corporation

Note : 5% Import Duty and 4% Business Turnover Tax are
included in the market prices

Table (3): Basic Fuel Consumption Rate

Type of Vehicle	Fuel consumption rate (litre/Km) at free flow of traffic ¹⁾		
	Experimental data in Japan	Sri Lanka	Adapted rate in this study
Motorcycle	-	-	** (0.0355)
Tricycle	-	3) 0.0417	0.0417
Passenger car	1) 0.0714	3) 0.0710	0.0710
Pickup	-	3) 0.1000	0.1000
Heavy bus	2) 0.2174	-	0.2174
Micro bus	-	3) 0.1093	0.1093
Medium lorry	2) 0.1215	3) 0.1136	0.1136
Heavy lorry	2) 0.2326	3) 0.1776	0.1776
Container Trailer	-	-	0.1776

Sources : 1) Kanto Engineering Office, "Fuel Consumption of the Vehicle Running on Roads - The Review on the Reports of Survey on Vehicle Fuel Consumption" 1979 Japan.

2) H.Sano, "Fuel Consumption on Roads" Traffic Engineering Vol.14 No.2, 1979 in Japan.

3) Richard Peiris & Co., Associated Motorways, United Motors, The co-operative Wholesale Establishment.

Note : * Fuel consumption rate is assumed under free flow of traffic on paved, level roads. Running speed is around 55 - 65 Km per hour.

** The figure is estimated from passenger car 3) x 0.5

Table (4): Basic Fuel Consumption Rate (by Each Speed Rank)

Mean Speed (Km/H)	Passenger Car 1)		Heavy Bus 2)		Medium Lorry 2)		Heavy Lorry 2)	
	Fuel consumption (litre/km)	Index						
5	0.2083	292	0.7143	329	0.3650	300	0.7692	331
10	0.1667	233	0.5556	256	0.2841	234	0.5882	253
15	0.1389	195	0.4545	209	0.2326	191	0.4762	205
20	0.1190	167	0.3846	177	0.1980	163	0.4000	172
25	0.1064	149	0.3333	153	0.1761	145	0.3448	148
30	0.0962	135	0.2941	135	0.1590	131	0.3125	134
35	0.0885	124	0.2703	124	0.1460	120	0.2778	119
40	0.0833	117	0.2500	115	0.1361	112	0.2692	113
45	0.0787	110	0.2381	110	0.1280	105	0.2439	105
50	0.0758	106	0.2273	105	0.1230	101	0.2381	102
55	0.0735	103	0.2222	102	0.1215	100	0.2326	100
60	0.0719	101	0.2174	100	0.1220	101	0.2353	101
65	0.0714	100	0.2222	102	0.1245	102	0.2381	102
70	0.0719	101	0.2266	107	0.1280	105	0.2439	105
75	0.0725	102	0.2439	112	0.1335	110	0.2564	110
80	0.0741	104	0.2632	121	0.1391	114	0.2778	119
85	0.0758	106	0.2857	131	0.1451	119	0.2992	129

Sources : 1) Kanto Engineering Office, ibid
2) M. Sano, ibid

Table (5): Fuel Consumption Rate Adapted in this Study (litres/1000km)

Speed (km/h)	Motor Cycle	Tricycle	Passenger Car	Van, Wagon Pickup	Heavy Bus (S/LCTB)	Medium & Micro Bus	Medium Lorry	Heavy Lorry Container Trailer
5	103.7	121.8	207.9	292.0	714.3	359.6	340.8	587.9
10	82.7	97.2	165.4	233.0	555.6	279.8	265.8	449.9
15	69.2	81.3	138.5	195.0	454.5	228.4	217.0	364.1
20	59.3	69.6	118.6	167.0	384.6	193.5	185.2	305.5
25	52.9	62.1	105.8	149.0	333.3	167.2	164.7	262.8
30	47.0	56.3	95.9	135.0	294.1	147.6	148.8	238.0
35	44.0	51.7	88.0	124.0	270.3	135.6	136.3	211.0
40	41.5	48.8	83.1	117.0	250.4	125.7	127.2	200.7
45	39.1	45.9	78.1	110.0	238.1	120.2	119.3	186.5
50	37.6	44.2	75.3	106.0	227.3	114.8	114.7	181.2
55	36.6	43.0	73.1	103.0	222.2	111.5	113.6	177.6
60	35.9	42.1	71.7	101.0	217.4	109.3	114.7	179.4
65	35.5	41.7	71.0	100.0	222.2	111.5	115.9	181.2
70	35.9	42.1	71.7	101.0	232.6	117.0	119.3	186.5
75	36.2	42.5	72.4	102.0	243.9	122.4	124.0	195.4
80	36.9	43.4	73.8	104.0	263.2	132.3	129.5	211.3
85	37.6	44.2	75.3	106.0	297.5	143.2	135.2	229.1

Note: Figures above were made by applying the basic consumption rate of TABLE A8 - 5 to the "Index" of TABLE A8 - 7. In this calculation process, "Index" of TABLE A8 - 7 were applied as follows:

Index of Passenger Car ----- Motorcycle, Tricycle, Van Wagon Pickup
 Index of Heavy Bus ----- Medium & Micro Bus
 Consumption rate of Container Trailer was assumed to be the same as Heavy Lorry.

Table (6): Lives of Vehicle. Operation Hours of Vehicles and Lives of Tyres

Type of Vehicle	Items	Life in use Years	Vehicle Life operation km	Operation per day, hours	Tyre Life km per set
(1) Motorcycle		10	20000	5	20000
(2) Tricycle		3	30000	10	20000
(3) Passenger car		12	20000	5	28000
(4) Wagon, Van, Pickup		10	300000	10	32000
(5) Bus (SLOTB)		13	1105000	16	56000
(6) Medium & Micro bus (private line)		13	520000	10	32000
(7) Medium Lorry (1-4 ton, 2 axles)		15	600000	10	36000
(8) Heavy Lorry & Container Trailer (more than 4ton, 3 axles)		15	750000	10	52000

Source : Those dealers or organizations listed in TABLE A8-4. After interviewing some modifications were made referring to Japanese data.

Table (7): Capital and Interest Cost

Items	Type of Vehicle	Motorcycle	Tricycle	Passenger Car	Van, Wagon Pickup	Bug (SUCT8)	Medium & Micro Bus	Medium Lorry	Heavy Lorry Container
(A) Initial Vehicle Cost (1)		12,909	34,878	113,278	141,005	395,584	275,795	179,676	280,600
(B) Economic Cost without Tyres									
(B) Vehicles use in years	2)	10	3	12	10	13	13	15	15
(C) Residual Value (Present Worth)	3)	416	2,483	2,908	4,540	9,066	6,321	3,283	5,126
(D) Depreciation Value (A - C)		12,493	32,395	110,370	136,465	386,518	269,474	176,393	275,474
(E) Capital Recovery Factor	3)	0.1770	0.6163	0.1614	0.1770	0.1557	0.1557	0.1468	0.1468
(F) Annual Cost (D x E)		2,212	13,486	17,814	24,154	60,181	41,937	25,894	40,440
(G) Life Operation Km	2)	200,000	30,000	200,000	300,000	1105,000	520,000	600,000	750,000
(H) Annual Operation Km (G/B)		20,000	10,000	16,667	30,000	85,000	40,000	40,000	50,000
(I) Distance-Related Cost (D/B) x 1/2 = RS/Km		0.0312	0.5399	0.2759	0.2274	0.1749	0.2597	0.1470	0.1836
(J) Annual Operation Hrs.		1,500	3,000	1,600	3,000	4,800	3,000	3,000	3,000
(K) Time-Related Cost (D/B) x 1/2 = RS/Hr.		0.4164	1.7997	2.8742	2.2744	3.0971	3.4548	1.9599	3.0608
(L) Interest Charge (F-D/B) + J. in RS/Hr.		0.6412	0.8959	5.3853	5.5025	6.3495	7.0761	4.7115	7.3584

Notes : 1) FROM TABLE A8 - 11

2) FROM TABLE A8 - 9

3) i = 12% PER ANNUM

Table (8): Prices of Representative Vehicle and Price of Tyres per Set

(In Rs.)

Vehicle and (No. of Tyres)	Import Price (CIF)	Duties	Local Cost Component	Sales Tax	Total (Retail Price)	W/O Duties and Taxes
Motorcycle	Comp. Tyres	1845	1060	1669	16874	13360
	(2) Net(w/o tyres)	389	62	68	685	451
Tricycle	Comp. Tyres	1791	998	1601	16189	12909
	(3) Net(w/o tyres)	23732	12009	3699	43000	39741
Passenger Car	Comp. Tyres	750	113	132	1320	865
	(4) Net(w/o tyres)	22982	11896	3567	41680	34378
Wagon, Van Pickup	Comp. Tyres	97690	19600	43330	280000	117290
	(5) Net(w/o tyres)	1986	2026	456	5660	4012
Bus (SLCTB)	Comp. Tyres	95704	17574	42874	274340	113278
	(6) Net(w/o tyres)	132731	13796	18563	185000	146627
Medium & micro bus	Comp. Tyres	2134	3388	538	7340	5522
	(7) Net(w/o tyres)	120597	10408	18025	177660	141005
Medium Lorry	Comp. Tyres	250792	158150	25813	516263	408942
	(8) Net(w/o tyres)	4354	9005	332	18828	13353
Heavy Lorry	Comp. Tyres	246438	149145	25481	497435	395534
	(9) Net(w/o tyres)	260000	24281	34719	345000	294281
Container Trailer	Comp. Tyres	2396	6090	696	10620	8486
	(10) Net(w/o tyres)	257604	18191	34023	334380	275795
Heavy Lorry	Comp. Tyres	160000	28162	22838	235000	188162
	(11) Net(w/o tyres)	2396	6090	696	10620	8486
Container Trailer	Comp. Tyres	240000	63877	35123	375000	303877
	(12) Net(w/o tyres)	6371	16906	1880	28980	23277
Container Trailer	Comp. Tyres	233629	46971	33243	346020	280600
	(13) Net(w/o tyres)					

Source : These dealers and organizations listed in TABLE A8-4, as well as State Trading Corporation.

Note : 1) Comp: Completed vehicle including body, tyres.

2) w/o : without

3) Local cost component including dealer's margins and other costs were estimated by the Study Team after interviews.

4) Duties and Sales tax were estimated by referring to 'The Gazette of the Democratic Socialist Republic of Sri Lanka (Extraordinary) - Customs Notification 1983.2.18.' and 'Turnover Tax and Customs Duty changes effective, midnight 18/19th Feb. 1983' Satchithananda, Schokman, Pasupati & Co.

Table (9): Annual Maintenance Cost of Vehicle

Items Vehicle Type	Parts (excluding Tyres)		Labour		
	Expenditures on parts in per cent of Initial Vehicle price	Expenditures on parts in Rupees per annum (Rs/Year)	Labour hours for maintenance per annum	Wage rate per hour (Rs/hour)	Labour cost per annum (Rs/Year)
(1) Motorcycle	4%	516	50	8.0	400
(2) Tricycle	6%	2093	100	8.0	800
(3) Passenger Car	5%	5664	50	10.0	500
(4) Wagon, Van, Pickup	7.5% *	10575	200	10.0	2000
(5) Bus (SLCTB)	7.5%	29669	380 **	10.0	3800
(6) Medium & Micro Bus	7.5%	20685	300	10.0	3000
(7) Medium Lorry	7.5%	13476	200	10.0	2000
(8) Heavy Lorry Container Trailer	7.5%	21045	200	10.0	2000

Source : * Associated Motorways

** Sri Lanka Central Transport Board

Rest of the figures were analogized by Study Team.

Table (10): Crew Cost

Type of Vehicle	Items	Monthly Income per person (Rs.)	Annual Income per person (Rs.)	Annual Crew Cost per vehicle (Rs.)	Operation hours per day	Annual Operation hours 3)
(1) Taxi	Driver	1200	14400	14400	10	3000
(2) Tricycle Taxi	Driver	1000	12000	12000	10	3000
(3) Bus (SLCTB)	Driver	1250	15000	54000	16	4800
	Conductor	*1000	12000			
(4) Medium & Micro Bus (Private line)	Driver	1250	15000	24600	10	3000
	Conductor	800	9600			
(5) Van, Wagon, Pickup	Driver	1000	12000	12000	10	3000
(6) Medium Lorry	Driver	1000	12000	12000	10	3000
	Driver	1500	18000			
(7) Heavy Lorry	Helper	800	9600	27600	10	3000
	Driver	1800	21600			
(8) Container Trailer	Helper	800	9600	27741	10	3000
	Driver	1800	21600			

Source : * Sri Lanka Central Transport Board. Others were assumed by Study Team.

- Note : 1) Average of Heavy Lorry and Container trailer weighted by the number of trips obtained from OD survey conducted in February 1983.
 2) It was assumed to work in shifts of 8 hours.
 3) 300 working days a year, per vehicle.

Table (11): Registration Fees and Insurance Fees
(in rupees per year)

Kind of Fee Vehicle Type	1)		2)	
	Registration Fees	Compulsory Insurance Fees	Comprehensive (all risk)	Total
(1) Motor cycle	100	45	205	250
(2) Tricycle	100	45	205	250
(3) Passenger Car	400	50	1450	1500
(4) Wagon, Van, Pickup	1000	230	1770	2000
(5) Bus (SCTB)	750	10	-	10
(6) Medium & micro bus	800	300	4200	4500
(7) Medium Lorry	800	230	1770	2000
(8) Heavy Lorry	900	300	4200	4500
(9) Container Trailer	400	300	4200	4500

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Source : 1) The Office of the Registrar of Motor Vehicles
2) Insurance Corporation

Table (12): Cost Factor per km and per Hour

	Motorcycle	Tricycle	Passenger Car-Taxi	Van-Wagon Pickup	Bus (SUCTB)	Medium & Micro Bus	Medium Lorry	Heavy Lorry Container
(A) Tire								
1) Price of a set (Rs.)	451	863	4,012	5,522	13,358	8,486	8,486	23,277
2) Tire life in Km	20,000	20,000	28,000	32,000	56,000	32,000	36,000	52,000
3) 1) + 2) in Rs/Km	0.0226	0.0432	0.1433	0.1726	0.2385	0.2652	0.2357	0.4476
(B) Maintenance								
Parts (Rs)	516	2,093	5,664	10,575	29,669	20,685	13,476	21,045
Labour (Rs)	400	800	500	2,000	3,800	3,000	2,000	2,000
1) Total (Rs)	916	2,893	6,164	12,575	33,469	23,685	15,476	23,045
2) Annual operation Km	20,000	10,000	16,667	30,000	85,000	40,000	40,000	50,000
3) 1) + 2) in Rs/Km	0.0458	0.2893	0.3698	0.4192	0.3938	0.5921	0.3869	0.4609
(C) Crew Cost								
1) Wages in a year (Rs)	-	12,000	(1) 1,471	12,000	54,000	24,600	12,000	(2) 27,741
2) Annual operation Hrs.	-	3,000	1,600	3,000	4,800	3,000	3,000	3,000
3) 1) + 2) in Rs/Hr	-	2,000	0.8819	4,000	11,2500	8,2000	4,000	9,2470
(D) Registration								
1) Annual Fee (Rs.)	100	100	400	1,000	750	800	900	(4) 880
2) Annual operation Hrs.	1,500	3,000	(3) 1,600	3,000	4,800	3,000	3,000	3,000
3) 1) + 2) in Rs/Hr	0.0667	0.0333	0.2500	0.3333	0.1563	0.2667	0.2667	0.2933
(E) Insurance								
1) Annual Fee (Rs.)	250	250	1,500	2,000	10	4,500	2,000	4,500
2) Annual operation Hrs.	1,500	3,000	7,600	3,000	4,800	3,000	3,000	3,000
3) 1) + 2) in Rs/Hr	0.1667	0.0833	0.1975	0.6667	0.0021	1.5000	0.6667	1.5000

Note : (1), (3): Average of Private Passenger car and taxi weighted by composition ratio of OD traffic volume in 1983.
 (2), (4): Average of Heavy Lorry and container trailer.

Table (13): Vehicle Operating Cost : Passenger Car, Taxi

(RS/1000KM)

Speed (Km/H)	Fuel	Oil	Tire	Depreci- ation	Maintenance		Capital Cost	Crew Cost	Registr- ation Fees	Insuran- ce fees	Overhead Cost	Total
					Parts	Labour						
5	2263.7	50.9	143.3	275.9	339.8	30.0	1651.9	176.4	50.0	187.5	516.9	5686.3
10	1806.2	40.6	143.3	275.9	339.8	30.0	825.9	88.2	25.0	93.8	366.9	4035.6
15	1512.4	34.0	143.3	275.9	339.8	30.0	550.6	58.8	16.7	62.5	302.4	3326.4
20	1295.1	29.1	143.3	275.9	339.8	30.0	413.0	44.1	12.5	46.9	263.0	2892.7
25	1155.3	26.0	143.3	275.9	339.8	30.0	330.4	35.3	10.0	37.5	238.4	2621.9
30	1047.2	23.6	143.3	275.9	339.8	30.0	275.3	29.4	8.3	31.3	220.4	2424.5
35	961.0	21.6	143.3	275.9	339.8	30.0	236.0	25.2	7.1	26.8	206.7	2273.4
40	907.5	20.4	143.3	275.9	339.8	30.0	206.5	22.0	6.3	23.4	197.5	2172.6
45	882.9	19.2	143.3	275.9	339.8	30.0	183.5	19.6	5.6	20.8	189.1	2079.7
50	822.3	18.5	143.3	275.9	339.8	30.0	165.2	17.6	5.0	18.8	183.6	2020.0
55	798.3	18.0	143.3	275.9	339.8	30.0	150.2	16.0	4.5	17.0	179.3	1972.3
60	783.0	17.6	143.3	275.9	339.8	30.0	137.7	14.7	4.2	15.6	176.2	1938.0
65	775.3	17.4	143.3	275.9	339.8	30.0	127.1	13.6	3.8	14.4	174.1	1914.7
70	783.0	17.6	143.3	275.9	339.8	30.0	118.0	12.6	3.6	13.4	173.7	1910.9
75	790.6	17.8	143.3	275.9	339.8	30.0	110.1	11.8	3.3	12.5	173.5	1908.6
80	805.9	18.1	143.3	275.9	339.8	30.0	103.2	11.0	3.1	11.7	174.2	1916.2
85	822.3	18.5	143.3	275.9	339.8	30.0	97.2	10.4	2.9	11.0	175.1	1925.4

Table (14): Vehicle Operating Cost : Van
(Rs./1000km)

Speed (Km/H)	Fuel	Oil	Tire	Depreci- ation	Maintenance Parts Labour	Capital Cost	Crw. Cost	Registration Fees	Insurance Fees	Overhead Cost	Total
5	3186.6	71.7	172.6	227.4	352.5	66.7	1155.4	800.0	66.7	1558.7	7793.6
10	2544.4	57.2	172.6	227.4	352.5	66.7	577.7	400.0	33.3	1724.6	5623.1
15	2129.4	47.9	172.6	227.4	352.5	66.7	385.1	266.7	44.4	928.7	4643.6
20	1823.6	41.0	172.6	227.4	352.5	66.7	288.8	200.0	33.3	805.7	4028.3
25	1627.1	36.6	172.6	227.4	352.5	66.7	231.1	160.0	26.7	728.5	3642.5
30	1474.2	33.2	172.6	227.4	352.5	66.7	192.6	133.3	22.2	671.5	3357.3
35	1354.8	30.5	172.6	227.4	352.5	66.7	165.1	114.3	19.0	628.1	3140.5
40	1277.6	28.7	172.6	227.4	352.5	66.7	144.4	100.0	16.7	598.7	2993.6
45	1207.2	27.0	172.6	227.4	352.5	66.7	128.4	88.9	14.8	571.7	2858.6
50	1157.5	26.0	172.6	227.4	352.5	66.7	115.5	80.0	13.3	554.6	2772.8
55	1124.8	25.3	172.6	227.4	352.5	66.7	105.0	72.7	12.1	541.3	2706.5
60	1102.9	24.8	172.6	227.4	352.5	66.7	96.3	66.7	11.1	531.7	2658.3
65	1092.0	24.6	172.6	227.4	352.5	66.7	88.9	61.5	10.3	525.4	2627.0
70	1102.9	24.8	172.6	227.4	352.5	66.7	82.5	57.1	9.5	525.2	2626.0
75	1119.8	25.1	172.6	227.4	352.5	66.7	77.0	53.3	8.9	525.4	2627.1
80	1125.7	25.6	172.6	227.4	352.5	66.7	72.2	50.0	8.3	528.8	2646.0
85	1137.5	26.0	172.6	227.4	352.5	66.7	68.0	47.1	7.8	532.4	2667.9

Table (15): Vehicle Operating Cost : Bus (SLCIB)

(RS/1000KM)

Speed (km/H)	Fuel	Oil	Tire	Depreci- ation	Maintenance		Capital Cost	Crew Cost	Registra- tion Fees	Insurance Fees	Overhead Cost	Total
					Parts	Labour						
5	4987.2	136.5	238.5	174.9	349.1	44.7	1888.1	2250.0	31.3	-	2375.1	11875.4
10	3412.5	106.2	238.5	174.9	349.1	44.7	944.1	1125.0	15.6	-	1602.7	8013.3
15	2791.5	86.9	238.5	174.9	349.1	44.7	629.4	750.0	10.4	-	1268.9	6344.3
20	2362.2	73.5	238.5	174.9	349.1	44.7	472.0	562.0	7.8	-	1071.3	5356.5
25	2047.1	63.7	238.5	174.9	349.1	44.7	377.6	450.0	6.3	-	938.0	4689.9
30	1806.4	56.2	238.5	174.9	349.1	44.7	314.7	375.0	5.2	-	841.2	4205.9
35	1660.2	51.7	238.5	174.9	349.1	44.7	269.7	321.4	4.5	-	778.7	3893.4
40	1538.0	47.9	238.5	174.9	349.1	44.7	236.0	281.3	3.9	-	728.6	3642.9
45	1462.4	45.5	238.5	174.9	349.1	44.7	209.8	250.0	3.5	-	694.6	3473.0
50	1396.1	43.6	238.5	174.9	349.1	44.7	188.8	225.0	3.1	-	665.9	3329.5
55	1364.8	42.5	238.5	174.9	349.1	44.7	171.6	204.5	2.8	-	648.4	3241.8
60	1335.3	41.5	238.5	174.9	349.1	44.7	157.3	187.5	2.6	-	632.9	3164.3
65	1364.8	42.5	238.5	174.9	349.1	44.7	145.2	173.1	2.4	-	633.8	3169.0
70	1428.6	44.4	238.5	174.9	349.1	44.7	134.9	160.7	2.2	-	644.5	3222.5
75	1498.0	46.6	238.5	174.9	349.1	44.7	125.9	150.0	2.1	-	657.5	3287.3
80	1616.6	50.3	238.5	174.9	349.1	44.7	118.0	140.6	2.0	-	683.7	3418.4
85	1827.2	56.9	238.5	174.9	349.1	44.7	111.1	132.4	1.8	-	734.2	3670.8

(RS/1000KM)

Table (16): Vehicle Operating Cost : Medium & Micro Bus

Speed (km/H)	Fuel	Oil	Tire	Depreci- ation	Maintenance		Capital Cost	Crew Cost	Registra- tion Fees	Insurance Fees	Overhead Cost	Total
					Parts	Labour						
5	2208.7	68.7	265.2	259.1	517.1	75.0	2106.2	1640.0	59.3	300.0	1873.3	9366.6
10	1718.5	53.5	265.2	259.1	517.1	75.0	1053.1	820.0	26.7	150.0	1234.6	6172.8
15	1402.8	43.6	265.2	259.1	517.1	75.0	702.1	546.7	17.8	100.0	982.4	4911.8
20	1188.5	37.0	265.2	159.1	517.1	75.0	526.5	410.0	13.3	75.0	841.7	4208.4
25	1026.9	32.0	265.2	259.1	517.1	75.0	421.2	328.0	10.7	60.0	748.8	3744.0
30	906.6	28.2	265.2	259.1	517.1	75.0	351.0	273.3	8.9	50.0	683.6	3418.0
35	832.9	25.9	265.2	259.1	517.1	75.0	300.9	234.3	7.6	42.9	640.2	3201.1
40	772.0	24.0	265.2	259.1	517.1	75.0	268.3	205.0	6.7	37.5	606.2	3031.1
45	738.3	23.0	265.2	259.1	517.1	75.0	234.0	182.2	5.9	33.3	589.3	2916.4
50	705.1	21.9	265.2	259.1	517.1	75.0	210.6	164.0	5.3	30.0	563.3	2816.6
55	684.8	21.3	265.2	259.1	517.1	75.0	191.5	149.1	4.8	27.5	548.8	2744.0
60	671.3	20.9	265.2	259.1	517.1	75.0	175.5	136.7	4.4	25.0	537.8	2687.8
65	684.8	21.3	265.2	259.1	517.1	75.0	168.0	126.2	4.1	23.1	534.5	2672.4
70	718.6	22.4	265.2	259.1	517.1	75.0	150.4	117.1	3.8	21.4	537.5	2687.6
75	751.8	23.4	265.2	259.1	517.1	75.0	140.4	109.3	3.6	20.0	541.2	2706.1
80	812.6	25.3	265.2	259.1	517.1	75.0	131.6	102.5	3.3	18.8	552.6	2763.1
85	879.5	27.4	265.2	259.1	517.1	75.0	123.9	96.5	3.1	17.6	566.1	2890.5

(RS/1000KM)

Table (17): Vehicle Operating Cost : Medium Lorry

Speed (KM/H)	Fuel	Oil	Tire	Depreciation	Maintenance		Capital Cost	Crew Cost	Registration Fees	Insurance Fees	Overhead Cost	Total
					Part	Labour						
5	2093.2	65.1	235.7	147.0	336.9	50.0	1334.3	800.0	53.3	193.3	1312.2	6561.0
10	1632.5	50.8	235.7	147.0	336.9	50.0	667.1	400.0	26.7	66.7	903.4	4516.8
15	1332.8	41.5	235.7	147.0	336.9	50.0	444.8	266.7	17.8	44.4	729.4	3647.0
20	1137.5	35.4	235.7	147.0	336.9	50.0	333.6	200.0	13.3	33.3	630.7	3153.4
25	1011.6	31.5	235.7	147.0	336.9	50.0	266.9	160.0	10.7	26.7	569.3	2846.3
30	913.9	28.4	235.7	147.0	336.9	50.0	222.4	133.3	8.9	22.2	524.7	2623.4
35	837.2	26.0	235.7	147.0	336.9	50.0	190.6	114.3	7.6	19.0	491.1	2455.4
40	781.3	24.3	235.7	147.0	336.9	50.0	166.8	100.0	6.7	16.7	466.4	2331.8
45	732.7	22.8	235.7	147.0	336.9	50.0	148.3	88.9	5.9	14.8	445.8	2228.8
50	704.5	21.9	235.7	147.0	336.9	50.0	133.4	80.0	5.3	13.3	432.0	2160.0
55	697.7	21.7	235.7	147.0	336.9	50.0	121.3	72.7	4.8	12.1	425.0	2124.9
60	704.5	21.9	235.7	147.0	336.9	50.0	111.2	66.7	4.4	11.1	422.4	2111.8
65	711.9	22.1	235.7	147.0	336.9	50.0	102.6	61.5	4.1	10.3	420.5	2102.6
70	732.7	22.8	235.7	147.0	336.9	50.0	95.3	57.1	3.8	9.5	422.7	2113.5
75	767.1	23.9	235.7	147.0	336.9	50.0	89.0	53.5	3.6	8.9	428.9	2144.3
80	795.4	24.7	235.7	147.0	336.9	50.0	83.4	50.0	3.3	8.3	433.7	2168.4
85	830.4	25.8	235.7	147.0	336.9	50.0	78.5	47.1	3.1	7.6	440.6	2202.9

Table (18): Vehicle Operating Cost : Heavy Lorry, Container Trailer (Rs/1000Km)

Speed (KM/H)	Fuel	Oil	Tire	Depreciation	Maintenance		Capital Cost	Crew Cost	Registration Fees	Insurance Fees	Overhead Cost	Total
					Parts	Labour						
5	3610.9	112.3	447.6	183.6	420.9	40.0	2088.8	1949.4	58.7	300.0	2276.8	11384.0
10	2759.6	85.9	447.6	183.6	420.9	40.0	1041.9	924.7	29.3	150.0	1520.9	7605.4
15	2236.3	69.6	447.6	183.6	420.9	40.0	694.6	616.5	19.6	100.0	1207.2	6035.9
20	1876.4	58.4	447.6	183.6	420.9	40.0	521.0	462.4	14.7	75.0	1025.0	5125.0
25	1614.1	50.2	447.6	183.6	420.9	40.0	416.8	369.9	11.7	60.0	903.7	4518.5
30	1461.8	45.5	447.6	183.6	420.9	40.0	347.3	308.2	9.8	50.0	828.7	4143.4
35	1296.0	40.3	447.6	183.6	420.9	40.0	297.7	264.2	8.4	42.9	760.4	3802.0
40	1232.7	38.4	447.6	183.6	420.9	40.0	260.5	231.2	7.3	37.5	724.9	3624.6
45	1145.5	35.6	447.6	183.6	420.9	40.0	231.5	205.5	6.5	33.3	687.5	3437.5
50	1112.9	34.6	447.6	183.6	420.9	40.0	208.4	184.9	5.9	30.0	667.2	3336.0
55	1090.8	33.9	447.6	183.6	420.9	40.0	189.4	168.1	5.3	27.3	651.7	3258.6
60	1101.9	34.3	447.6	183.6	420.9	40.0	173.7	154.1	4.9	25.0	646.5	3232.5
65	1112.9	34.6	447.6	183.6	420.9	40.0	160.3	142.3	4.5	23.1	642.5	3212.3
70	1145.5	36.6	447.6	183.6	420.9	40.0	148.8	132.1	4.2	21.4	644.9	3224.6
75	1200.1	37.3	447.6	183.6	420.9	40.0	138.9	123.3	3.9	20.0	653.9	3269.5
80	1297.8	40.4	447.6	183.6	420.9	40.0	130.2	115.6	3.7	18.8	674.7	3373.3
85	1407.1	43.8	447.6	183.6	420.9	40.0	122.6	108.8	3.5	17.6	698.9	3494.4