This paper presents an analysis of a highway project to illustrate the application of the Little-Mirrlees approach to project appraisal. The paper contains a discussion of the method as well as an application of it and includes sections on some of the conceptual and practical problems encountered in applying it.

It is intended that the evaluation of projects using efficiency prices and social weights for the benefit and cost streams will eventually become routine in Bank lending operations. To date, however, there are few practical examples of ordinary operations in which the method is used with the result that it is still poorly understood or understood only as a vague theoretical construct. This paper provides a familiar practical background for use of this still unfamiliar technique.

Prepared by: St. Catherine’s College
Sudhir Anand
Consultant
Transportation and Urban
Projects Department
Central Projects Staff

St. Catherine’s College
Oxford, OX1 3UJ
England
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This paper reports on the appraisal of a highway project carried out in November/December 1972, while I was on a short-term assignment in the then Transportation Department. It is a revised version of the preliminary draft report prepared in March 1973.

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Section 6 - Results of the Little Mirrlees Appraisal

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1. **INTRODUCTION**

1.1 There are as yet no case studies applying the Little-Mirrlees (henceforth LM) method to projects in the transportation sector. This paper reports on an experimental attempt to apply the LM method to such a project. The project appraised is a highway in West Malaysia.

1.2 The LM method used here corresponds to the method of appraisal of a project at efficiency prices developed in *Economic Analysis of Projects*, by H. G. van der Tak and L. Squire, World Bank Staff Working Paper No. 194. An attempt is also made here to bring out the special features and difficulties in implementing them for highway projects. Needless to say, some ad hoc short cuts to estimation have been necessary, but these do not travesty the results. Since each project is unique, however, discretion must obviously be exercised before the same corners are cut again.

1.3 The plan of this paper is as follows:

Section 2 of the paper describes the highway project in Malaysia.

Section 3 discusses the benefits and costs of the project.

Section 4 briefly discusses the LM method of project appraisal, and examines some conceptual problems in applying the method to highway projects. These are (i) the valuation of time savings, and (ii) the conversion to the LM numeraire of the consumer surplus arising from generated traffic. The problems associated with incorporating income distributional weights ("social prices" in the Bank's new *Economic Analysis of Projects*) are also considered.

Section 5 derives all the shadow prices needed to appraise the project by the LM method. These are: the standard conversion factor; the shadow price of land; the shadow wage rate; the shadow prices for construction and maintenance; and vehicle operating costs at shadow prices.

The concluding section 6 presents the results of the LM appraisal of the project. It contains in addition a risk analysis for the appraisal. This was deemed necessary in view of the uncertainties surrounding the traffic forecasts and the construction costs - for which only preliminary engineering estimates were available.
2. THE PROJECT

2.1 The project appraised in this paper is the construction of a new road between Ipoh and Kuala Kangsar in the State of Perak in West Malaysia. The road is part of a section of the Federal Route 1 Project, which comprises new construction or improvement of four separate road sections along Federal Route 1. The 1967-68 General Transport Survey found approximately 210 miles of the total length of Route 1, the principal road in West Malaysia, close to (or at) capacity under traffic; it recommended that further studies be undertaken to determine the feasibility of upgrading the existing highway. Four separate sections totalling 143 miles of road were selected in 1970 for a first feasibility study, financed by the UNDP with the IBRD as Executing Agency. The feasibility study was carried out by the Australian consulting firm of Valentine, Laurie and Davies (VLDR).

Proposed Road

2.2 The new road proposed between Ipoh (the state capital of Perak) and Kuala Kangsar follows a more direct alignment than the existing road (see map in Annex A). The new road links mile 3 to mile 33.8 on the present Route 1 from Ipoh to Kuala Kangsar, and has a total length of 18.2 miles. It thus represents a total saving in distance of 12.6 miles. The direct route will be a single carriageway, access controlled road which could be incorporated in a future north-south expressway along the west coast of Malaysia. The new alignment is physically difficult because the main mountain ridge runs at right angles to it. In order to eliminate excessive grades, a tunnel (8,100 feet) through the ridge with 5.5 miles of climbing lane on the approaches will be required. The construction also includes a major bridge (1,080 feet) over the Sugei Perak.

Existing Road

2.3 The present route from Ipoh (population about 200,000) to Kuala Kangsar (population 15,000) passes through only one other important town, Sungei Siput (population 7,000), which is approximately midway. Otherwise, it passes through rubber estates, occasional quarrying and tin mining areas, and tapioca gardens. The terrain is flat to rolling. The alignment of the road is generally good, although there are several winding sections. The carriageway is bitumen surfaced and varies from a width of eighteen to twenty-two feet. The riding quality is good, although close inspection has revealed some fretting and fine cracking of the surface. Shoulders vary from hard gravel to poor grass or eroded earth, and are sometimes several inches below pavement level with widths as small as two feet. Most culverts along the stretch are adequate and in reasonably good condition.

1/ The new road is Major Deviation D7 of Section III of the VLD Feasibility Study: Malaysia Highway Feasibility Study, Route 1, West Malaysia, Final Report, April 1972, Valentine, Laurie and Davies, Consulting Engineers, Kuala Lumpur.

2/ The need for such an expressway was identified in the 1967-68 General Transport Survey.
Traffic

2.4 The average annual daily traffic (AADT) on the existing road in 1972 amounted to 12,600 vehicles per day (vpd) in the outskirts of Ipoh, falling to 8,200 about 12 miles north of Ipoh and to 5,400 at Kuala Kangsar. The through traffic on this section of the road amounted to approximately 4,300 vpd. Local traffic accounted for the remainder, and was thus 8,300 vehicles per day near Ipoh, 3,900 12 miles further north, and 1,100 near Kuala Kangsar.

2.5 The AADT is expected to reach 16,000 vpd near Ipoh by 1977 rising to 25,500 by 1986 and to 40,000 by 1996. At mile 12, the predicted totals are 11,400 vpd in 1977 rising to 29,000 in 1996. Near Kuala Kangsar, the daily traffic is expected to be 7,800 vehicles in 1977 approaching 23,000 vehicles by 1996. These traffic volumes are based on predicted growth of existing traffic as well as of development traffic (arising e.g. from the East-West Highway after its completion). The forecasts have been obtained through a combination of different factors: crude modelling of future zonal growth (together with a road-rail split of zonal commodity and passenger flows); previous traffic trends; and considered judgement.

Volume and Composition of Diverted Traffic

2.6 The major generators of through traffic over the Ipoh-Kuala Kangsar section of Route 1 are the towns of Ipoh and Butterworth-Penang. With the construction of the new road it is estimated that 97% of the through traffic will divert onto it. The daily volume of such traffic, plus that diverted from the railway, is estimated at 5,500 vpd in 1977. It is expected to grow at an average rate of 5.5 percent per annum for ten years thereafter, and at about 4.5 percent per annum for the next ten years until 1996. The percentage composition of traffic, for the seven types considered in this paper, has been estimated (average for 1977-1996) as follows:

1/ These data refer to an interview survey conducted between Chemor and Sungei Siput (at approximately mile 12 north of Ipoh) in March 1972: Report on Supplementary Interview Survey for Traffic Diversion Ipoh-March 16 & 17, 1972, Federal Route 1 Project, VLD, April 1972. This survey was specifically requested by the Public Works Department since the origin-destination surveys carried out for the VLD Feasibility Study did not require through traffic stopping between Ipoh and Kuala Kangsar to be enumerated by purpose. Instead, the AASHO Diversion Curve formula was used in the Feasibility Study to estimate the volume of through traffic which would be diverted to the new road. The Feasibility Study had estimated that as much as 97% of through traffic would be diverted, whereas the results of the additional survey indicate a reassuringly close figure of 96%.

2/ The section of the existing road near Ipoh which carries these high traffic volumes has been appraised separately in the VLD Feasibility Study (as segments E300 and E301 representing mile 0 to mile 4.5 on the existing road from Ipoh to Kuala Kangsar). The VLD recommendation for this stretch is to upgrade it into a dual carriageway road.
### Timing of Project

2.7 Detailed engineering design for the new road began in November, 1972 and was expected to be completed in about one year. Land acquisition should have been completed towards the end of 1973, and construction began shortly thereafter. A construction period of almost 40 months was envisaged, so that the new road would be opened in early 1977.

### Project Benefits and Costs

#### Savings in Vehicle Operating Costs (VOC)

3.1 Data on vehicle operating costs have recently been prepared by the Highway Planning Unit (HPU) of the Public Works Department (PWD). These data have been compiled for nine different vehicle types. The operating costs for each vehicle type have been derived either for the most common model of that type or for a weighted average of models representing that type. The weights were previously determined from a traffic survey (sample of 412 vehicles) conducted by HPU.

3.2 In this study we adapt average vehicle operating cost to compute the benefits of VOC savings. This amounts to spreading all of the fixed cost of the vehicle over its expected mileage. Such a procedure reflects the usual assumption that depreciation is proportional to mileage and the additional approximation that interest costs are proportional to mileage. The latter amounts to an assumption that a project to shorten distance will not reduce overall vehicle use per time period (which would raise interest charges per mile) but rather releases the vehicle for other (equal) mileage elsewhere in that time period. With these assumptions it is legitimate to average out fixed cost (such as the new price of the vehicle) over the expected lifetime mileage, and add these to the per mile variable cost, in order to calculate per-mile savings from distance reduction.

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1/ The various reasons there has been some slippage in the timing of the project, the Consultants having originally estimated an opening date of early 1976.

2/ Messrs. J. de Weille and W. Weiss have compiled a table on average vehicle operating costs: Average Vehicle Operating Costs on Paved Roads in West Malaysia, August 1972, Unit Perancang Jalan, Kementerian Kerja Raya dan Tenaga, Malaysia. These operating costs have been derived mainly from the VLD Feasibility Study, although other sources have also been used to cross-check for consistency.
3.3 Average vehicle operating costs are presented in Annex Table 1. Row 26 of that table shows average operating costs per mile at domestic prices excluding taxes. The costs are presented for the seven vehicle types into which traffic on the Ipoh-Kuala Kangsar road has been divided.

**Accident Benefits**

3.4 The average operating cost approach can also cover benefits of distance reduction other than savings in actual running cost. The inclusion of insurance premiums in VOC can take account of accident benefits if one assumes that annual insurance premiums approximate the total cost of accidents. For then VOC savings through distance reduction automatically imply a saving in the insurance component of operating cost, and therefore in total accident costs. These savings will capture the true savings as long as accident rates remain the same on the old and the new roads. 1/ Accident savings will then be correctly measured by mileage savings multiplied by the accident cost per mile. Even if accident rates do not remain the same, only a negligible error is involved in this appraisal since accident benefits represent just 3 percent of total benefits for this project 2/.

**Time Benefits**

3.5 The inclusion of wages in average operating cost savings allows one to take account of time savings for one category of road users, viz. paid crews. Provided that travel speeds are the same on the old and new roads, savings in time are proportional to savings in mileage. If the wage rate is an accurate indicator of the social value of time, the wage cost savings from a distance reduction will measure the value of time savings for paid crew. 3/

1/ Although the effect on the accident rate of the improved design standards of the new road is difficult to predict, the rate may not be much different on the old and new roads. While on the one hand the rate is reduced because of better curvature and geometry generally, it is increased on the other hand precisely because the better geometry permits higher speeds. If these opposing factors balance each other, then accidents may be assumed proportional to distance.

2/ VLD attempted an elaborate quantification of accident savings based on formulae developed by Winfrey for America conditions and driving habits. Their Feasibility Study came up with the savings figure of 3 percent on this basis.

3/ Travel speeds are likely to be a little higher on the new road, so this method will underestimate the true value of time savings. However, paid crews' time might be deemed less valuable socially than their wage rate, since some of them are unskilled. The latter's time should be valued at the shadow wage rate (see para 4,8). As an approximation therefore it may not be unreasonable to quantify time savings of paid crew in this manner.
3.6 Time benefits for other categories of road users have been evaluated separately. For the purposes of this appraisal we do not place any social value on savings in leisure or commuting time. Value is only placed upon "productive" or "business" time (see paras 4.12 and 4.13).

3.7 As we have already counted business time savings for commercial vehicle crews through the VOC factors, it only remains to compute business time savings for passengers of commercial vehicles, and for passengers and crew of non-commercial vehicles. The VLD Feasibility Study has calculated time values for road travellers by class of vehicle 1/. It estimates that 6% of all vehicles -- 1.1 percent taxis and 4.9 percent passenger cars -- will come under the category of business trips ("on the job while on the road"). The unit time value computed for a taxi on a business trip was M$8.23 per hour, and for a passenger car M$5.47 per hour. 2/

3.8 Time savings benefits for these business trips were computed by determining travel times on the existing road (without the project) and on the new road (with the project). The major time savings accrue from the distance reduction of 40 percent, rather than from higher travel speeds on the new road. On average over the life of the project, travel speeds on the new road will be higher by only about 10 m.p.h. This is due to the fact that the geometric of the existing road are already fairly good (para 2.3), and that traffic congestion is not expected to be a serious problem without the project in the short to medium run (paras 2.4 and 2.5). Non-paid-crew business time savings in any year represent slightly less than 5 percent of total VOC savings in that year. 3/

1/ See VLD Feasibility Study, Volume 3, Tables 156 and 157.

2/ The average occupancy of the taxi was 3.5 persons, with the average person's time being worth M$2.35 per hour. Since the driver's wages were already included in VOC, this gave a time value of M$8.23 per hour for the business trip taxi. For the passenger car on a business trip the corresponding time value of M$5.47 per hour consists of the car driver's time at M$2.65 per hour, and an average of 1.2 car passengers' time at M$2.35 per hour.

3/ For instance in 1977 non paid-crew business time savings were estimated at M$342,000, while average VOC savings at domestic prices (net-of-taxes) for the same year were M$7,373,000.
Benefits from Generated Traffic

3.9 Traffic between Ipoh and Kuala Kangsar has been projected independently of the construction of the new road (paras 2.4 and 2.5). But the new road will lower private (or financial) costs of travel between the two points. It may therefore be expected to generate some traffic. The volume of traffic generated as a proportion of normal traffic can be obtained by multiplying the price elasticity of demand for travel by the percentage savings in financial cost per trip.

3.10 We believe the price elasticity of demand for travel on this road is rather low. The present land use patterns along the existing alignment and the new alignment are such that there appears little scope for commercial traffic to be generated during the life of the project. Land use plans show that future agricultural, industrial and residential developments do not depend on the new road. Some "leisure" or "social" trips are however likely to be generated from the shorter route. But the elasticity of demand for such travel (for downward price movements) is probably rather low. At the relatively low levels of income, savings in transport are more likely to be spent on other goods rather than on additional travel. 2/

3.11 With the aid of the report "Data on Motorists in West Malaysia" (prepared in 1970 by Survey Research Malaysia), the Consultants guesstimated the price elasticities of demand for "non-essential" motorcycle, car and taxi trips, and applied them to the "perceived" cost savings and normal traffic in each trip category. The generated traffic thus estimated for 1977 was 258 vehicles, compared with a normal traffic of 5,500 vehicles. The benefits to generated traffic are traditionally evaluated at half the benefits to normal traffic. 3/ In this case therefore, the benefits to generated traffic turn out at about 2 percent of total benefits. Ignoring them makes a negligible difference to the project's rate of return. For convenience, we choose to ignore them throughout our analysis of this project.

Construction Costs

3.12 The consultants estimated construction quantities and costs on the basis of preliminary engineering for the new road. 4/ Since then, however, some of the estimates for construction costs have been revised

1/ In general, one would expect the price elasticity of demand for travel to be different for different vehicle types. So the above aggregate measure refers to a weighted average of the elasticities of demand for each vehicle type.

2/ A price elasticity of 0.5 implies that half of the savings in transport cost will be spent on additional travel.


4/ These estimates are contained in Table 145, Volume 3 of the VLD Feasibility Study.
The best estimate for the project's capital cost at 1972 prices excluding taxes is M$45,424,000 (M$46,313,000 including all taxes. It comprises M$1,556,000 for design and engineering; M$1,345,000 for land acquisition; and M$42,577,000 for construction proper (and M$889,000 taxes).

Maintenance Costs

3.13 Maintenance consists of routine maintenance of the road each year, and pavement resurfacing every 12 years. Routine maintenance costs were assumed to be a function of this type of the road, the age of its surface, and the volume of traffic carried. The formula used was one developed for another country, but "calibrated" to Malaysian conditions. Pavement resurfacing involves a lump sum cost at intervals of 12 years from the date of the last resurfacing. Resurfacing costs have been calculated on the basis of area at the rate of M$4.50 per square yard.

Maintenance cost streams /2/ for the old road carrying the entire projected traffic, and for the old and new roads together carrying this traffic, are shown in Annex Table 2.

4. THE METHOD OF SHADOW PRICING

4.1 The shadow pricing system used for this project is fully set out in Little and Mirrlees, op. cit. So we shall only very briefly outline the main principles involved. We shall focus here on some specific issues that are of importance in applying the method to highway projects. We shall also indicate some of the problems involved in the evaluation of highway projects when income distribution objectives are important.

4.2 One can distinguish five main elements in the IM method of shadow pricing:

1/ The original (Phase I of Feasibility Study) cost estimate for the tunnel was based on a length of 7,800 feet, whereas the final design length is now estimated at 8,100 feet. It is now also thought that there may be more rock in the deep cuts than was anticipated. For these reasons, the Consultants have revised upward their estimate of the tunnel by M$ 5 millions.

2/ The direct foreign exchange component of capital cost has been estimated at 46.9 percent. The costs of construction supervision, and detailed engineering are based on recent contracts for similar work in Malaysia. The work on the project has been divided into three contracts: One contract for the new road construction; one for the tunnel; and one for the Sungai Perak bridge.

3/ Volume was measured in passenger car units (pcu's) equivalent from the viewpoint of determining the rate of deterioration.

4/ We have taken the Consultants' streams for maintenance cost directly from the VLD Feasibility Study, Volume 5C, Computer Printout Section III.
(i) The valuation of traded goods;

(ii) the valuation of non-traded goods;

(iii) the choice of numeraire, and the possibility that additional consumption (committed through modern sector employment) is less valuable than uncommitted government income;

(iv) the possibility that wage rates in the organized sector overstate the alternative product of labor, and the implication of this for the shadow price of labor; and

(v) the rate of discount.

(i) The Valuation of Traded Goods

4.3 It is natural to look to world prices to value traded goods since these prices reflect their opportunity cost to the country. Thus if the good in question is, or could be, imported and it is in perfectly elastic supply, then it should be valued at its cif price. If world supply is inelastic it should be valued at marginal cost. Similarly, if the good is or could be exported, and the demand is perfectly elastic, then it should be valued at its fob price. If world demand is inelastic it should be valued at marginal revenue.

(ii) The Valuation of Non-traded Goods

4.4 Non-traded goods are valued by decomposing their marginal costs of production into the traded goods and labor embodied in them. In practice this is usually done by the input-output technique, which will be strictly correct only if there are constant costs of production. 1/ The valuation of non-traded items in this manner gives the net foreign exchange value of the resources used in producing them.

4.5 The valuation of all goods in terms of their direct and indirect foreign exchange impact should not be taken to mean that the LM investment criterion is to maximize the country's net earnings of foreign exchange 2/. Rather, this procedure happens to be correct for a variety of objective functions and assumptions about commercial policy.

(iii) The Numeraire

4.6 The unit of account in the Little-Mirrlees system is uncommitted public income. This is natural enough for their method since it is the optimal allocation of public revenue which forms the purpose of public sector project selection. Thus, everything is measured in terms of this quantity. But to render the numeraire comparable to other values in the system, it needs to be denominated in world prices. Hence the unit of account used by LM is uncommitted public income, measured in terms of convertible foreign exchange. 3/

1/ The assumption of constant costs ensures equality of average costs implicit in input-output to the required marginal costs of production.

2/ Indeed, employing a shadow wage rate for project evaluation lower than the market wage rate immediately implies that net foreign exchange earnings are not maximized.

3/ In this exercise the unit is Malay dollars equivalent to convertible foreign exchange, the conversion into M$ being at the official rate.
4.7 The shadow prices of the IM method are based on an intertemporal optimization model in which the government is fiscally constrained in its ability to alter the balance between aggregate consumption (committed through employment) and ‘uncommitted government income’. This leads to the latter being more valuable at the margin than consumption. Since different projects have different surplus generating implications, the government can use project selection itself to raise uncommitted government income relative to consumption. To do so, it should give extra weight to those projects which generate more surplus.

(iv) The Shadow Wage Rate (SWR)

4.8 Suppose there is a divergence between the wage rate (c) in the organized sector and the marginal product of labor (m) drawn from the traditional sector. This could be for institutional reasons such as trade union pressure, or because of government minimum wage laws. In such a situation, the employment of an extra man in a project in the organized sector raises aggregate consumption by (c-m), assuming that he consumes his entire wage. The social cost of employing labor on the project is thus measured by the loss of project surplus (c) less the social gain which results from the increase in consumption. The latter is \( \frac{1}{s} (c-m) \), where \( s \) is the relative value of project surplus to consumption. The formula for SWR is, therefore, \( \text{SWR} = c - \frac{1}{s} (c-m) \) where c and m are measured in world prices to make them comparable to other values in the system.

(v) The Rate of Discount

4.9 Using uncommitted government income as numeraire implies that the discount rate should be the rate at which its value falls over time. IM call this the accounting rate of interest (ARI). It is different from the consumption rate of interest (CRI), which is the rate at which the social value of employment-generated consumption falls over time. The difference is obviously the rate at which the relative value of uncommitted public income to consumption, i.e. \( s \), changes over time. It follows that the two rates ARI and CRI will be equal only if \( s \) is actually constant over time. This is an important point because it implies that for a constant \( s \) the same discount rate should be used whichever is chosen as numeraire, uncommitted public income or consumption.

Valuation of Time Savings in a Highway Project

4.10 Time savings sometimes constitute the major benefit of a highway project, and it is not immediately obvious how they should be valued in the Little-Mirrlees scheme. Unlike other non-tradeables, we cannot calculate the world price value of time by decomposing it into its costs of production. Time is not a produced good. However, as in the case of

1/ If the Government had unlimited fiscal powers, it should produce (and employ) in the current period the maximum that was technically possible; and it should tax away from this as much as was necessary to achieve its desired investment or other expenditure goals.

2/ Since (c), the wage rate, is a direct deduction from money in the hands of the government, its units are already those of the numeraire. Increased consumption (c-m) is converted to the numeraire by the weight \( \frac{1}{s} \) value of consumption \( \frac{1}{s} \) value of money held by the government, or 1/5.
land, we might attempt to value time in terms of the goods that it produces. If these goods happen to be tradeable there is no problem; we simply compute their world price value.

4.11 It is doubtful however that time savings generally lead to the production of more marketed goods. In most instances in fact, one might expect time savings to add to leisure rather than to labor time. In such cases we need to put a value on additional leisure. Note that this is just as difficult to do in domestic prices as it is in world prices. If people were free to choose the number of hours they worked, the wage rate would measure the private marginal value of time. At the margin the wage rate would indicate the money value of the consumption goods that people were willing to sacrifice for additional leisure. But, since hours of work are institutionally fixed, it is no longer true that time is privately valued at the wage rate; the value could be lower or higher than the wage rate.

4.12 There is an even more fundamental problem in assigning a value to time from the social point of view. Although individuals might place a positive value on (leisure) time in the sense of being willing to pay for it, society may decide not to respect these individual preferences in investment planning. In developing countries with very low levels of income, more 'production' might be the only social goal. If so, only those time savings which make possible more output would have social value. Time savings which add to leisure on the other hand would be valued at zero. If, however, society were to respect individual preferences, the social value of time would be equated to the world price value of the consumption goods that individuals were willing to sacrifice for the additional time.

4.13 Note that the same value judgement would also imply the addition of a positive term to SWR if the modern sector job used more time than the traditional sector job. This constitutes the positive social value placed on the individual disutility of effort involved in a modern sector job compared to a traditional sector job. Including leisure in the analysis would thus raise project costs as well as project benefits.

Consumers' Surplus

4.14 Benefits to generated traffic are usually valued at half the unit savings in VOC to normal traffic. The rationale for this procedure is that the gain in consumers' surplus from generated traffic can be so approximated. Since the criterion underlying this valuation is 'willingness-to-pay', the gain may be treated as equivalent to a gain in


2/ See van der Tak and Ray, op. cit.

3/ It would exactly equal the gain in consumers' surplus if the transport demand curve were a straight line.
actual consumption (or income). To convert it into world prices, we therefore need a consumption conversion factor (CCF). This should be defined as a weighted average of world prices to domestic prices of goods in the 'typical' consumption basket.

4.15 Perhaps it should be pointed out that benefits to generated traffic should not be evaluated at half the savings in VOC measured at shadow prices. Shadow prices are not the prices that confront road users; therefore, consumers' surplus at shadow prices does not represent willingness to pay. Half the savings in VOC at market prices (including taxes) represents the gain in consumers' surplus. It is this quantity converted at the CCF which measures the gain at world prices.

4.16 Consumers' surplus for normal traffic, however, may indeed be measured at net-of-tax prices. Although there is a higher actual gain in consumers' surplus to road users, there is an offsetting tax loss to the government which needs to be subtracted. Taxes merely represent a transfer within the economy in the case of normal traffic. The net gain to the economy can here be measured at net-of-tax prices, provided that income distribution may be ignored (as it usually is in any aggregate consumer surplus analysis).

**Income Distribution**

4.17 The immediate benefits of this highway project accrue as savings in vehicle operating costs to road users. The actual money savings to road users may be divided into two elements: the savings measured at producer prices (i.e. net of indirect taxes), and the savings in indirect tax payments to the government. The former measure the real resource savings to the economy. The latter have usually been ignored in economic appraisals on the grounds that they merely represent a transfer within the economy, and thus have no effect on national economic welfare.

4.18 The assumption which permits us to ignore transfers within the economy is that income be optimally distributed among all the 'agents' of the economy. This means that the social valuation of an extra dollar of income in the hands of any agent, road user or government, is the same. But if income is not optimally distributed in the economy, we need to know the social weights attaching to the incomes of the different agents (income classes), relative to our numeraire - uncommitted government income. The project leads to an increase in the incomes of the different road users and a change in government income. The social valuation of net benefits is made by applying the given weights to the income change of each agent, with government income having a weight of unity.

4.19 The private savings in indirect tax payments by road users leads, in the first instance, to a redistribution of income from government to road users. The reduced tax take is likely to impose a distributional cost on society, since the income weights of most road users are probably less
than unity. However, the net change in government revenue will be somewhat smaller than the first round tax loss, and could even be positive. The reason is that the (additional) expenditure out of the total money income savings of road users could carry tax rates higher than those applicable to average VOC. To trace the full distributional effects therefore, we need detailed information on the expenditure patterns (demand functions) of road users.

Yet another problem in trying to incorporate distributional concerns into highway project appraisal stems from the often serious difficulties in identifying the ultimate beneficiaries of the project. These are not only the actual road users, but others who may benefit indirectly from a reduction in VOC. For instance, a reduction in the operating costs of road haulage companies could lead to a reduction in the freight rates of the various commodities transported. The eventual price reductions of final goods depend on market conditions in the user and supplier (e.g. trucking) industries. We need also to establish the income class of persons benefitting from these price reductions. Given the variety of suppliers, users, and market conditions, it becomes very difficult as a practical matter to trace the ultimate beneficiaries of a highway project. It is the intermediate good aspect of a road project which causes these problems.

It is only when income is optimally distributed, or can be optimally distributed (by other policy instruments), that we may ignore the above complications. We do not then need to trace the indirect effects of changes in freight rates and other tariffs. Moreover, when we are indifferent about the distribution of marginal income between road users and governments we may also ignore the above-mentioned effect of indirect taxes on government revenue (see para 4.19). But whatever the distribution of income, indirect taxes should always be ignored from the cost side of a public project. These taxes represent a transfer solely within the government, and thus do not affect the overall distribution of income. For example, the tax component of construction costs is merely a payment from one hand of the government, the Ministry of Public Works, to another, the Ministry of Finance.

1/ Given the government's concern about inequality, it could use government revenues to subsidize the consumption of persons much poorer than most road users (see also paras 5.8 and 5.9). This would imply income weights less than unity for most road users.

2/ Competitive market conditions in the trucking industry should generally imply larger reductions in freight rates than monopolistic conditions. However, if the commodities transported are intermediate goods supplied to a monopolist, the final consumer may not benefit from a reduction in VOC. On the other hand, the pricing policy of a bus company which is a state monopoly may result in fare reductions benefitting bus users.
5. DERIVATION OF SHADOW PRICES

5.1 In this section, we estimate all the shadow prices needed for the appraisal of the highway project by the Little-Mirrles method. In order of presentation, these are: the standard conversion factor; the shadow price of land; the shadow wage rate; the shadow prices for construction and maintenance; and vehicle operating costs at shadow prices.

The Standard Conversion Factor (SCF) 1/

5.2 There are non-traded items in the project for which it was not easily possible to obtain the direct and indirect breakdown into traded goods and labor. For such items we apply the standard conversion factor to convert their domestic values into their foreign exchange (i.e. numeraire) values. 2/ Ideally, one would like a different SCF to convert different categories of goods, varying from the consumption of unskilled labor in agriculture to the local output of miscellaneous construction materials. However, it was not feasible to work at that level of detail, and we settled for a single SCF to convert non-traded output or consumption from domestic into world prices.

5.3 The SCF depends on the average amount of protection of afforded to goods traded by Malaysia. In the last few years, import duties have been at an average level of about 15 percent, and export taxes at an average level of about 5 percent. The recent average tariff and tax levels applicable to imports and exports are shown below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Import Tariff</th>
<th>Average Export Duty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>15.68%</td>
<td>5.20%</td>
</tr>
<tr>
<td>1969</td>
<td>16.25%</td>
<td>5.92%</td>
</tr>
<tr>
<td>1970</td>
<td>14.18%</td>
<td>5.37%</td>
</tr>
<tr>
<td>1971</td>
<td>14.69%</td>
<td>5.05%</td>
</tr>
</tbody>
</table>


1/ The derivation of the SCF in this paper closely follows the one by I.M.D. Little and D.G. Tipping in: A Social Cost Benefit Analysis of the Kulai Oil Palm Estate (West Malaysia), Development Centre, OECD, Paris, 1972.

2/ The SCF is thus the reciprocal of a shadow exchange rate, which converts foreign exchange values into domestic values.

3/ The average import tariff in any year was calculated as the ratio of import tariff revenue to retained import values (i.e. net of re-exports) in that year.

4/ The average export duty in any year was calculated as the ratio of total export duties to the value of net exports (i.e. gross exports minus re-exports) in that year.
5.4 The divergence of SCF from unity can be calculated as the average import tariff less export duty, each weighted by its relevant elasticity (demand for imports, and supply for exports). 1/ Thus the divergence will be somewhere between -15 and +5 percent, or the SCF will be between 0.85 and 1.05. Now the elasticity of demand for imports is probably somewhat higher than the elasticity of supply for exports. 2/ Therefore, the SCF may be expected to be somewhat closer to 0.85 than to 1.05. We choose the same value as Little and Tipping (op. cit., page 32), viz. 0.90.3/

The Shadow Price of Land

5.5 Land purchase for this project has been estimated by the Consultants at M$ 1,345 million. Of this sum, 70.3 percent represents rural land, and 29.7 percent represents urban land. The rural land consists, in roughly equal value, of forest reserves and small-holder rubber plots. The urban land consists mainly of private urban properties, but there is also some tin mining land.

5.6 We have assumed a shadow price of zero for rural land. There are large tracts of virgin land in West Malaysia, and an absolute land shortage is not envisaged in the forseeable future. 4/ For urban land we assume that its opportunity cost is reflected by its market value. In other words, we assume that the market price of urban land adequately captures its locational and resource value to the economy. 5/ These assumptions are in any case not crucial since land is a very small item (under 3%) of capital costs.

The Shadow Wage Rate (SWR)

5.7 The formula for the SWR (see para 4.8) is:

\[ \text{SWR} = c - \frac{1}{s} (c - m) \]

where c is the project worker's wage, m is the marginal product in the rural sector, and s is the social value of uncommitted public income relative to the workers' consumption. Both c and m are measured at world prices.

1/ These elasticities do not need to be multiplied by the import and export values since the latter are assumed equal (due to near equilibrium in the balance of trade).

2/ See Little and Tipping, op. cit., page 32.

3/ Note that an SCF of 0.90 implies a shadow exchange rate of 1.11.

4/ Presently some 7.0 million acres in the country are cultivated while some 20.5 million acres are unused. Of the latter, it is estimated that as many as 9.0 million acres are cultivated.

5/ To convert the domestic market value of urban land into world prices, we apply the SCF.
5.8 To estimate \( s \), one needs to consider the best use to which the government can put public income, and compare it with project workers' consumption. Aggregate investment in Malaysia is already high, and if more investment were desirable, more public savings could very likely have been generated through taxation to finance it. 1/ The government might consider its funds more valuably spent on subsidizing the poor than on raising public investment. \( s \) would then reflect the weight the government attaches to money in the hands of the poorest persons relative to money in the hands of construction workers. The fact that there are people much poorer than construction workers should then imply an \( s \) greater than unity. 2/

5.9 Although the potential to redistribute income to the poorest has not been much deployed in the past, the government does now appear to be seriously concerned about income inequality. 3/ To take into account in the project appraisal involves (i) the estimation of \( s (> 1) \) and of income 'weights' from a social utility function, and (ii) the re-evaluation of project benefits as a weighted sum of actual benefits accruing to the different income classes. Owing to inadequate data on the ultimate beneficiaries of the project, we were unable to tackle the issue of distributional weights, and it has had to be ignored here. On the labor side at any rate, the omission is unlikely to be very significant. The reason is that labor costs for the project are a relatively small proportion (about 10 percent) of total costs.

5.10 We have taken \( s = 1 \), from which it follows that \( SWR = m \). The shadow wage is now simply the marginal product of labor in traditional agriculture. However, the actual cost of transferring labor out of the rural sector seems to be a little higher than this in Malaysia. Whereas the marginal product in agriculture has been estimated at roughly M$ 50 per month 4/, the supply price of labor in the more urban construction

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1/ The fiscal constraint appears to be non-binding, as evidenced by the recent (February 29, 1972) introduction of the 5 percent sales tax.

2/ This will be so provided that redistribution to the poorest is not administratively too expensive. Strictly speaking, \( s \) is supposed to measure the relative worth of money in government hands to money in the hands of construction workers. In order to equate the former to money in the hands of the poorest, costless redistribution must be assumed.


4/ There are various socio-economic surveys of farms which indicate approximately this figure. Alternatively, see: Economic Planning Unit, Project Analysis - A Methodological Note (Working Paper No. 37 of the Pahang Tenggara Regional Masterplanning Study, Kuala Lumpur, July 1971). This source suggests a figure of M$10 per month. In the Ipoh-Kuala Kangsar area, where our highway project is located, a spot survey in a Kampung confirmed the figure of approximately M$50 per month as the earnings of landless or near-landless (1 to 2 acres of land) labor. Note that there are no seasonal variations in earnings because the crops in this area (rubber and tapioca) are all-year round.
areas is probably closer to M$ 70 per month. Partly, this has been
explained in terms of the 'gifts of nature', such as fish, wild vegetables
etc., that are freely available in rural agriculture but have to be paid
for elsewhere. 1/ Partly, it also represents the costs of transportation
and relocation. We have therefore put the shadow wage at M$ 70 per month.
In other words, we are saying that it costs the economy M$ 70 per month to
keep a man as well off in a construction job as he was when earning M$ 50
per month in traditional agriculture. 2/

5.11 Whereas the shadow wage has been estimated as M$ 70 per month, the
market wage for unskilled labor in construction is approximately M$ 150 per
month. 3/ The difference is largely due to the fact that construction is a
closed activity, subject to government's minimum wage scales. As a fraction
of the market wage, the SWR is 47%. It has still to be converted into world
prices, and this is done by applying the SCF of 0.9.

The Shadow Price for Skilled Labor

5.12 Unlike unskilled labor, the market for skilled labor in Malaysia
(construction and other) is fairly tight. One may therefore assume that
its opportunity cost is adequately reflected by its market wage (which, in
turn, reflects the market value of its marginal product). To obtain the
opportunity cost at world prices, we apply the SCF to the market wage.

Shadow Prices for Construction and Maintenance

5.13 The Consultants divided the unit cost of each item in the
construction bill of quantities into local and foreign exchange components
and taxes. These were then aggregated into the following input categories
shown in Table 1: unskilled labor; skilled labor; foreign and local plant;
foreign and local materials; expatriate labor, overheads and profit. Taxes

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1/ This hypothesis is due to S.H. Wafa: Land Development Strategies in

2/ Our definition of the opportunity cost of transferring labor out of the
rural sector is therefore the money value of 'utility' foregone rather
than the money value of 'output' foregone.

3/ This is based on the figure of about M$ 6 per day being paid to unskilled
labor in neighboring Grik (in the same State of Perak) for the construction
of the East-West Highway.
were omitted from each category. The first row of Table 1 shows the percentage composition of these inputs in total construction costs (excluding taxes). Thus, for instance, the proportion of local materials in construction is 21.23 percent. A similar cost breakdown for design and supervision is shown in the second row of the table.

5.14 Cost breakdowns for routine maintenance and periodic resurfacing were obtained from the Perak State Public Works Department. Routine or normal maintenance involves jobs such as grass cutting and the clearing of roadside drains. As such it is more unskilled labor-intensive than periodic maintenance. The latter, since it involves complete resurfacing, is more materials-intensive. The cost breakdowns for these two types of road maintenance are shown in rows 3 and 4 of Table 1.

5.15 The LM method shadow prices traded inputs at border prices. Since our cost data separate local from foreign currency expenditures, the directly traded inputs of the project can be valued immediately. But the local or non-traded inputs need to be valued by decomposing (e.g., via the input-output technique) their costs of production into traded goods and primary factors. The input-output table for Malaysia is not sufficiently disaggregated to allow the decomposition of the various different elements of local cost in our project. However, by interviewing local manufacturers, we managed to determine the production structure of the largest (single) category of local currency expenditure, viz., local construction materials. We interviewed the manufacturers of six major local materials which account for over 70 percent of the project's total local materials cost. The individual cost structures of these materials, and their composition in the project's total local materials cost, are shown in Table 1.

5.16 To calculate shadow prices, we regrouped all project expenditures (except on land acquisition) into the following four categories: unskilled labor, skilled labor, foreign exchange, and local non-labor. Expenditure breakdowns by these four categories are shown in Table 2. For design and supervision, routine maintenance, and periodic resurfacing, the breakdowns were obtained by simply collapsing the more detailed breakdowns in Table 1. For construction, however, the breakdown was calculated by going one step further back into the input structure. Of the 37.67 percent direct local non-labor cost in construction 21.23 percent (local materials) was itself broken down into unskilled labor, skilled labor, foreign exchange and local non-labor. The breakdown used for construction reflects this further (indirect) split. It is shown in the first row of Table 2, while the

1/ Maintenance in Malaysia is organized so that the State, and not the Central, Public Works Department is responsible for the maintenance of federal highways (such as the existing road between Ipoh and Kuala Kangsar) running through a state.

2/ The latest input-output Table on Malaysia is for the year 1965.
### TABLE I

PERCENTAGE BREAKDOWN OF DIRECT COST (net of taxes)

<table>
<thead>
<tr>
<th>Unskilled Labor</th>
<th>Skilled Labor</th>
<th>Plant F.</th>
<th>O/H &amp; Profit F.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Construction by foreign contractor (VLD engg. estimates)</td>
<td>7.45</td>
<td>6.29</td>
<td>31.02</td>
<td>7.47</td>
</tr>
<tr>
<td>2. Design &amp; Supervision</td>
<td>-</td>
<td>32.0</td>
<td>-</td>
<td>5.0</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Routine Maintenance</td>
<td>25.0</td>
<td>10.0</td>
<td>45.0</td>
<td>10.0</td>
</tr>
<tr>
<td>4. Periodic Resurfacing</td>
<td>-</td>
<td>10.0</td>
<td>30.0</td>
<td>-</td>
</tr>
</tbody>
</table>

**Local Materials in Construction**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Concrete Pipes</td>
<td>17.5</td>
<td>12.0</td>
<td>4.5</td>
<td>12.5</td>
</tr>
<tr>
<td>6. Cement</td>
<td>5.0</td>
<td>3.5</td>
<td>14.9</td>
<td>5.3</td>
</tr>
<tr>
<td>7. Quarry Products</td>
<td>15.0</td>
<td>45.0</td>
<td>5.0</td>
<td>17.5</td>
</tr>
<tr>
<td>8. Bitumenous Products</td>
<td>6.0</td>
<td>11.3</td>
<td>-</td>
<td>69.5</td>
</tr>
</tbody>
</table>

* The 21.23 percent local materials cost in Construction was itself broken down for this study into its unskilled labor, foreign plant, etc., components. We chose six major materials which accounted for over 70% of the local materials used, and attributed all of the 21.23 to these six. The proportions in which this was done are the same as the proportions of each in the total of the six. They are as follows:

Concrete Pipes 1.16  
Cement 1.22  
Quarry Products 8.27  
Bitumenous Products 7.60  
Reinforced Steel 0.66  
Wood 2.32 (Wood unit cost: unsk. lab. 89%, direct foreign exchange 11%)

**Sources:**

1) Consultants: Valentine, Laurie and Davies, Kuala Lumpur.
2) Interviews with Central and State PWD officials for maintenance cost breakdowns.
3) Interviews with local manufacturers of cement, pipes etc., for local material cost breakdowns.
<table>
<thead>
<tr>
<th></th>
<th>Unskilled Labor</th>
<th>Skilled Labor</th>
<th>Foreign Exchange</th>
<th>Local Non-Labor</th>
<th>Total</th>
<th>Conversion Factor or Shadow Price (^b/)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Construction</td>
<td>10.71</td>
<td>7.09(^a/)</td>
<td>60.87</td>
<td>21.33</td>
<td>100.00</td>
<td>0.9095</td>
</tr>
<tr>
<td>(Direct breakdown)</td>
<td>(7.45)</td>
<td>(6.29)</td>
<td>(48.59)</td>
<td>(37.67)</td>
<td>(100.00)</td>
<td>(0.9130)</td>
</tr>
<tr>
<td>2. Design and Supervision</td>
<td>-</td>
<td>32.0</td>
<td>41.0</td>
<td>27.0</td>
<td>100.0</td>
<td>0.9411</td>
</tr>
<tr>
<td>3. Routine Maintenance</td>
<td>25.0</td>
<td>10.0</td>
<td>48.0</td>
<td>17.0</td>
<td>100.0</td>
<td>0.828</td>
</tr>
<tr>
<td>4. Periodic Resurfacing</td>
<td>-</td>
<td>10.0</td>
<td>65.0</td>
<td>25.0</td>
<td>100.0</td>
<td>0.965</td>
</tr>
</tbody>
</table>

\(^a/\) In order to compute this number we arbitrarily divided the combined (skilled plus unskilled) labor costs for concrete pipes, quarry and bituminous products (Table 1) in the same proportion as the ratio of skilled to unskilled labor in the direct cost breakdown for construction.

\(^b/\) The shadow price for any expenditure item was obtained by multiplying the Unskilled Labor portion by SWR x SCF (= 0.47 x 0.9), the Skilled by SCF, Foreign Exchange by unity, and Local Non-Labor by SCF, and adding and expressing the sum as a fraction of 1.000.

Source: Table 1
numbers in the brackets below show the direct breakdown. 1/ Finally, the shadow price for each expenditure item was calculated by multiplying its unskilled labor component by SWR (times SCF), skilled labor by SCF, foreign exchange by unity, and local non-labor by SCF.

5.17 Shadow prices calculated in this manner are shown in the last column of Table 2. These shadow prices are factors by which the actual expenditures net-of-tax need to be multiplied to convert costs at domestic prices into costs at world prices. It is interesting to note that construction, the largest element of project capital costs by far, has a shadow price (0.9095) so close to the SCF. 2/ Shadow prices for other project cost items are nevertheless somewhat different from the SCF.

5.18 Project capital costs at market and shadow prices are shown below in $ thousand:

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Land</th>
<th>Total</th>
<th>Taxes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sup.</td>
<td>Acquis-</td>
<td>Construc-</td>
<td>(net-of-</td>
<td>(including</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tion</td>
<td>tion</td>
<td>taxes)</td>
<td>taxes)</td>
</tr>
<tr>
<td>1. At Market</td>
<td>1,502</td>
<td>1,345</td>
<td>42,577</td>
<td>45,424</td>
<td>889</td>
</tr>
<tr>
<td>Prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. At Shadow</td>
<td>1,413</td>
<td>360 3/</td>
<td>38,724</td>
<td>40,497</td>
<td>-</td>
</tr>
<tr>
<td>Prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ratio (2)/</td>
<td>0.941</td>
<td>0.2676</td>
<td>0.9095</td>
<td>0.8915</td>
<td>-</td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the appraisal at shadow prices therefore, the figure of $40,497 thousand represents project capital costs. Project maintenance costs at market and shadow prices are shown as time streams in Annex Table 2 (last two columns).

1/ The direct breakdown for construction is obtained by aggregating up the first row of Table 1.

2/ This means that converting the construction cost into world prices directly, by applying the SCF to the entire cost, in this case gives an answer much the same as applying different conversion factors (shadow prices) to different components of the cost.

3/ Rural land shadow priced at zero (see para 5.6), urban land at market price times SCF.
Vehicle Operating Costs (VOC) at World Prices

5.19 Although the average level of tariff protection in Malaysia is not particularly high (SCF of 0.90), it happens to be the case that the protection given to the motor vehicle assembly industry is rather high. Import duties vary from 34 percent of CIF value (for motorcycles and trucks) to 49 percent (for passenger cars). Prevailing domestic prices for motor vehicles (net of local sales tax) appear to be correspondingly higher than CIF prices.

5.20 The nominal tariff rates applicable to motor vehicles do not necessarily provide an indication of the protection received by the assembly industry. 1/ We need to consider effective tariffs for this. An effective tariff measures the protection given to value-added, i.e. to returns to the primary factors. 2/ The effective tariff rate for an industry is defined as follows: value-added in the industry at domestic prices (in the presence of tariffs) minus value-added in the industry at world prices (in the absence of tariffs), all as a percentage of value-added at world prices. 3/

5.21 The Malaysian tariff structure is such that completely knocked down (CKD) packs of vehicles are imported virtually free of customs duties, 4/ whereas completely built units (CBU) are presently charged import duties between 34 and 49 percent depending on the vehicle type. Furthermore, very little real value is added to the CKD packs domestically when they are completely built up in Malaysia. For these reasons we would expect the effective rate of protection to be a good deal higher than the nominal rate.

5.22 In a thesis 5/ submitted to the University of Malaya, estimates have been made of the effective protection afforded to the motor vehicle assembly industry. It was estimated that the effective tariff on motor vehicle assembling was a staggering 611 percent in 1968, compared to nominal tariffs on vehicles then between 22 and 37 percent. Considering passenger cars separately from commercial vehicles, it was demonstrated that passenger car assembling showed negative value-added at world prices. Negative value-added means that the cost of inputs exceeds the value of output. Measured at world prices, passenger car assembling subtracted about M$2.5 million from GDP in 1968.

1/ Nominal tariffs only indicate the protection received by the industry's products.

2/ It is therefore considered a better indicator of the incentives affecting resource allocation.


4/ There are only two intermediate inputs not exempt from import duties: tires and batteries.

5.23 Commercial vehicle assembling was shown to be relatively more efficient than passenger car assembling. At least it added positive value at world prices. However, the effective protection it received was still as high as 112 percent. This is much higher than the effective protection received by other industries with which comparisons were made. For instance, battery manufacturing received an effective tariff of only 33 percent. The overall results of the thesis suggest that the Malaysian tariff structure has probably misallocated resources into the motor vehicle assembly industry.

5.24 Resource allocation based on a distorted domestic price structure can lead to economic losses not just in the industry whose prices are distorted, but in other industries as well. Valuing motor vehicles in Malaysia at domestic prices will tend, ceteris paribus, to discourage those investments which utilize motor vehicle services as input (e.g., the road transport industry), and to encourage those investments which save (e.g., highways), or produce (e.g., the assembly industry), motor vehicle services as output. Therefore it is important to value vehicles at their true economic cost to the economy. These are their cif prices in Malaysia, since foreign supply is elastic at these prices. In computing VOC we have valued vehicles at cif prices (Annex Table 1).

5.25 The same principle also applies to other ingredients of VOC. Fuel, tires and engine oil are all tradeables. Thus, they have also been valued at border prices. Other elements of VOC are non-tradeables such as the salvage value of a vehicle, crew wages, insurance, and vehicle maintenance (Annex Table 1). We convert these costs into world prices by applying the SCF.

5.26 Average vehicle operating costs at world prices are shown in Annex Table 1. They were calculated from the HPU table (see para 3.1) by substituting border prices (cif or fob) for domestic prices in the case of tradeables, and by applying the SCF in the case of non-tradeables. Given the composition of traffic expected on the new Ipoh-Kuala Kangsar road (row 28 of Annex Table 1), VOC per-mile for the 'typical' vehicle traveling on this road will be M$0.2509 at world prices.

1/ The customs duty on gasoline was M$1.40 per imperial gallon; on diesel oil M$0.20 per imperial gallon; on engine oil M$17 per ton; and on motor car tires M$1.80 per lb.
6. RESULTS OF THE LITTLE-MIRFLEES APPRAISAL

6.1 We now present the results of the LM appraisal of the project. The results are discussed in terms of the internal rate of return rather than the net present value. Even though the correct parameter for decision-making is the net present value, the internal rate of return is an easier parameter to grasp. In any case, since we did not encounter multiple rates and since we are not choosing between competing projects, the internal rate-of-return decision rule is equivalent to the net-present-value decision rule.

The Cut-off Rate of Discount

6.2 Since the value of $s$ has been assumed constant at unity during the life of the project, the rate of discount may be taken as either the consumption or the accounting rate of interest (see para 4.9). The consumption rate of interest can be shown to equal the elasticity of the social marginal utility function multiplied by the growth rate of per capita consumption, neglecting "pure" time preference. It is very unlikely to exceed 10-12 percent in Malaysia. Even with the rather high values of 2 for the elasticity of the social marginal utility function, and 6 for the projected percentage growth rate of per capita consumption, the CRI will be just 12 percent. With smaller values of the elasticity parameter or of the growth rate of per capita consumption, the CRI, or discount rate, will be lower than 12 percent.

6.3 Another way of getting at the discount rate is to consider values for the accounting rate of interest. Malaysia is creditworthy enough to be able to borrow foreign exchange in international capital markets at competitive rates of interest. The marginal cost of such borrowing for Malaysia is unlikely to exceed 10-12 percent. This implies an upper bound of 10-12 percent for the accounting rate of interest. Hence the same upper bound for the consumption rate of interest, or discount rate.

Best Estimates

6.4 The best estimate internal rate of return 1/ to the project between 1972 and 1996 was computed as 17.06 percent when all business time is valued fully. In transport project appraisal, however, there has been a tendency to distinguish between savings in paid-crew time and other business time. Because of the practical difficulties in estimating the value of other business time savings 2/, it has been suggested to exclude time savings benefits for journeys not carried out as the specific occupation of the driver and/or passengers. We define as our base case the exclusion of all time savings benefits other than those for paid crews. The base case LM rate of return for the 25-year period (1972-96) is 16.41 percent. 3/

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1/ The best estimate internal rate of return is the rate of return corresponding to the best estimate (i.e. most likely estimate) values of the variables.

2/ Paid drivers' and vehicle crews' time has been included in VOC at 100 percent of the wages paid. See the item for Annual Wages in Annex Table 1.

3/ The base case net present value of the project, discounted at 10 percent to 1972, is M$ 22,023,000.
6.5 It must be admitted that the assumption of a 25-year (1972-96) economic life of project is really quite arbitrary. There is no reason why net benefits of the project should suddenly halt in 1996. Even if a capacity traffic figure is reached in 1996, net benefits should be projected as constant thereafter. Projecting net benefits for a further 10 years after 1996 at the constant level of that year raises the rate of return from 16.41 to 17.32 percent. The difference is not very large because the rate of return is already high in the base case.

**Sensitivity Analysis**

6.6 A sensitivity analysis was conducted around the best estimate values of the variables. The purpose of this analysis is to identify the key variables on which the project rate of return depends. With construction cost overruns of +10, +20 and +30 percent, the rate of return dropped from 16.41 to 15.19, 14.06 and 13.08 percent, respectively. With a maintenance cost overrun of 25 percent, the rate of return fell negligibly. With every 1 percentage point increase in the predicted rate of growth of traffic, the rate of return increased by roughly 1 percentage point. The latter is due to the fact that gross benefits are proportional to traffic and hence grow at the same rate as traffic, and that net benefits are very close to gross benefits in this project.

**Risk Analysis**

6.7 It must be recognized that capital costs for this project were estimated from preliminary engineering data. As such their final values are uncertain, and at this stage are really only knowable as random variables. Furthermore, given uncertainties in forecasting and errors in measurement, values for base-year traffic and traffic growth rates are also only estimable as random variables. So far we have conducted the analysis using the best or most likely 1/ estimates of project variables. While individual variations around these estimates have been considered, we have little idea as to the likelihood of the combined effect of these variations. The latter would allow us to estimate the uncertainty involved in the outcome of the project as a whole.

6.8 It might be felt unnecessary to estimate the uncertainty surrounding the outcome of an individual project in a bundle of several typically undertaken by the government each year. The reason is, very roughly, that there is a large number of independent projects in the annual investment portfolio of the government, and the probability of a poorer than average outcome for one project cancels out with that of a better than average outcome for another. Essentially, the law of large numbers implies that it might be appropriate for the government to decide on an individual project on the basis of its expected return.

6.9 Although this criterion appears to be valid from the vantage point of the Malaysian Government, it need not be so from that of an independent institution like the Bank. It is perfectly reasonable for a

1/ The most likely estimate of a random variable is the mode of its probability distribution, assuming the distribution is unimodal.
lending agency to want to be rather certain of success in those projects that it does finance in a country. Since the number of such projects is likely to be small, risks on individual projects do not get pooled from the viewpoint of its total lending program to the country. It is therefore relevant for the Bank, in appraising this project, to estimate the likelihood of it turning out to be 'poor'. This can be done through risk or probability analysis.

6.10 In risk analysis, we specify subjective probability distributions for all the random variables of the project and compute a corresponding probability distribution for the project's rate of return. Formally, this means calculating the joint probability distribution of the internal rate of return by combining the probability distributions of the individual variables. It is not possible to determine the joint probability distribution analytically, since the internal rate of return is not an explicit function of these variables. The Monte Carlo technique has been applied instead to simulate the joint probability distribution by repeated sampling (300 picks) of the individual probability distributions.

6.11 Subjective probability distributions for project variables were constructed after considerable discussion with the Consultants. This involved an attempt to narrow down the nature of uncertainty concerning each variable, and to specify the possible effect that this uncertainty might have on its probability distribution. When different subjective distributions were presented for the same variable by different individuals, an attempt was made to bring the individuals together to 'explain' their reasons for the difference. This usually resulted in a revision of the prior distribution by one or both individuals, and an agreement on its final shape.

6.12 For ease both of specification and of computation, we restricted the set of permissible distributions to discrete ones. Four key project variables were randomized: construction costs, base-year traffic, traffic growth rates, and unit operating costs. Step-rectangular distributions were specified for each of these variables, and they are shown as figures A, B, C, D in the Annex. The distributions for the base-year traffic count and traffic growth rates are symmetric, while the distributions for unit operating costs and construction costs are skew.

6.13 All the four probability distributions were assumed statistically independent in the risk analysis. This assumption appears very reasonable for every pair of distributions except possibly the pair comprising base-

1/ Note that risk analysis serves a different purpose from sensitivity analysis. Although it attaches probabilities to specified changes in variables, risk analysis is unable to isolate the key variables which affect the project's rate of return.

2/ This reflects symmetric error possibilities in measurement and forecasting.

3/ The final subjective distribution for construction costs was modified in the light of the actual ('objective') frequency distribution of cost overruns on a sample of previous Bank-financed highway projects. A frequency distribution of final construction costs around appraisal cost estimates was computed from a sample of 134 contract sections in 26 Bank/IDA highway projects since January 1, 1968.
year traffic and traffic growth rates. Although some inverse correlation might exist between these two, it is extremely hard to specify and harder still to program it. Unsatisfactory though it may be, the two variables have been assumed statistically independent in this exercise.

6.14 The results of the risk analysis are presented in Figure 1 as a cumulative probability distribution of the LM rate of return. The distribution ranges from 8.16 to 22.18 percent, with a mean of 15.06 percent and a standard deviation of 2.76. The modal value of the distribution is 16.15 percent. Not surprisingly, this is different from the rate of return of 16.41 percent corresponding to the modal values (best estimates) of the distributions of the individual variables. There is only a 4% chance that the rate of return will fall below 10 percent, and a 15% chance that it will fall below 12 percent. At the same time there is a 50% chance that it will exceed 15 percent. This element of risk is clearly tolerable with a cut-off rate in the 10-12 percent range 1/, and we judge the project to be economically acceptable.

1/ The decision rule implicit in considering only the worst outcomes of a project is overly risk averse. A more rational decision rule would involve specifying a 'risk profile' over the entire range of possible outcomes, and considering favorable outcomes with a lower (but not necessarily zero) weight than unfavorable outcomes.
<table>
<thead>
<tr>
<th>VEHICLE DATA</th>
<th>Motorcycle</th>
<th>Passenger Car</th>
<th>Taxi</th>
<th>Bus</th>
<th>Light Van</th>
<th>Medium Truck</th>
<th>Heavy Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fuel Type</td>
<td>Petrol</td>
<td>Petrol</td>
<td>Diesel</td>
<td>Diesel</td>
<td>Petrol</td>
<td>Diesel</td>
<td>Diesel</td>
</tr>
<tr>
<td>2. Average Engine Size (c.c.)</td>
<td>90</td>
<td>1,350</td>
<td>2,000</td>
<td>6,000</td>
<td>6,000</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>3. Seating Capacity (incl. driver)</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>44</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4. Annual Mileage (miles)</td>
<td>14,000</td>
<td>10,000</td>
<td>60,000</td>
<td>45,000</td>
<td>10,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>5. Life (years)</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>6. New Value excl. tires(c.i.f.)/$</td>
<td>1,800</td>
<td>5,700</td>
<td>10,500</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>7. Salavge Value $/</td>
<td>10</td>
<td>1,500</td>
<td>3,000</td>
<td>5,200</td>
<td>1,100</td>
<td>1,500</td>
<td>2,700</td>
</tr>
<tr>
<td>8. Tire cost (f.o.b.) per 0.001 mile</td>
<td>0.053</td>
<td>0.220</td>
<td>0.907</td>
<td>0.393</td>
<td>0.468</td>
<td>0.537</td>
<td>0.694</td>
</tr>
<tr>
<td>9. Tire wear 0.001% per mile</td>
<td>0.0455</td>
<td>0.0219</td>
<td>0.051</td>
<td>0.201</td>
<td>0.030</td>
<td>0.052</td>
<td>0.048</td>
</tr>
<tr>
<td>10. Fuel price per gallon (c.i.f.)/</td>
<td>2.30</td>
<td>2.24</td>
<td>2.36</td>
<td>2.59</td>
<td>2.53</td>
<td>2.62</td>
<td>2.72</td>
</tr>
<tr>
<td>11. Fuel consumption (gallons per mile)</td>
<td>0.032</td>
<td>0.032</td>
<td>0.028</td>
<td>0.050</td>
<td>0.033</td>
<td>0.067</td>
<td>0.091</td>
</tr>
</tbody>
</table>

**Fixed Annual Costs**

| 12. Capital Recovery Factor (CRF) at 10% | 0.2056 | 0.198 | 0.1638 | 0.1628 | 0.1618 | 0.1648 | 0.1628 |
| 13. Sinking Fund Factor (SFF) at 10% | 0.1056 | 0.1048 | 0.1048 | 0.1047 | 0.1048 | 0.1048 | 0.1048 |
| 14. Annual Depreciation plus Interest (new value x CRF + Salavge Value x SFF) | 103 | 843 | 1,284 | 2,087 | 3,014 | 3,753 | 5,145 |
| 15. Annual Wages $/ | - | - | - | - | 1,100 | 1,500 | 2,700 |
| 16. Annual Overhead & Supervision Costs $/ | - | - | - | - | 450 | 700 | 1,700 |
| 17. Annual Insurance Costs $/ | 0.045 | 0.106 | 0.167 | 0.200 | 0.290 | 0.400 | 0.600 |
| 18. Total Fixed Costs per year (item 19 + 24) | 223 | 4,018 | 20,160 | 9,032 | 12,335 | 15,010 | 21,395 |
| 19. Total Fixed Costs per mile (item 18 x 10^-3) | 0.0312 | 0.0433 | 0.1023 | 0.3077 | 0.2487 | 0.3610 | 0.4111 |

**VARIABLE COSTS PER MILE**

| 20. Fuel (items 10 to 11) | 0.0032 | 0.0408 | 0.0156 | 0.0260 | 0.0189 | 0.0368 | 0.0436 |
| 21. Engine Oil | 0.0002 | 0.0079 | 0.0030 | 0.0050 | 0.0010 | 0.0020 | 0.0020 |
| 22. Tires (items 8 & 9) | 0.0013 | 0.0439 | 0.0023 | 0.0046 | 0.0200 | 0.0464 | 0.0878 |
| 23. Maintenance $/ | 0.0050 | 0.0475 | 0.0272 | 0.0475 | 0.0270 | 0.0765 | 0.1054 |
| 24. Total Variable Costs (items 15 to 23) | 0.0867 | 0.0421 | 0.0188 | 0.0283 | 0.0681 | 0.1379 | 0.2079 |
| 25. Total Cost per vehicle-mile (items 19 + 24) at World Prices | 0.2597 | 0.2665 | 0.2665 | 0.2665 | 0.2665 | 0.2665 | 0.2665 |
| 26. Total Cost per vehicle-mile at domestic prices excluding taxes $/ | 0.0599 | 0.0886 | 0.1205 | 0.2000 | 0.2555 | 0.3000 | 0.3760 |
| 27. Total Cost per vehicle-mile at domestic prices including taxes $/ | 0.0660 | 0.0980 | 0.1210 | 0.2100 | 0.2600 | 0.3080 | 0.3900 |

**Percentage Composition of Traffic**

| 28. | 36.1 | 37.2 | 14.8 | 14.8 | 9.3 | 15.9 | 6.6 |

*Note: This table is similar to that complied by Messrs. J. de Nolle and W. Way for the Highway Planning Unit (HPU), Malaysia (Average Vehicle Operating Costs on Paved Roads in West Malaysia) in 1972. These values have been converted into 1982 dollars (in 1982, World Prices). All the data are taken directly from that table.*
### ANNEX TABLE 2

**MAINTENANCE COST STREAMS**

(in M$ thousand)

<table>
<thead>
<tr>
<th>Year</th>
<th>Combined Maintenance Costs on old road (without project) at Market Prices</th>
<th>Combined Maintenance Costs on old and new roads (with project) at Market Prices</th>
<th>Additional Maintenance Costs (with project) at Market Prices</th>
<th>Additional Maintenance Costs (with project) at Shadow Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>336</td>
<td>366</td>
<td>+ 30</td>
<td>+ 25</td>
</tr>
<tr>
<td>1978</td>
<td>467</td>
<td>499</td>
<td>+ 32</td>
<td>+ 26</td>
</tr>
<tr>
<td>1979</td>
<td>1,188</td>
<td>1,228</td>
<td>+ 40 (periodic)</td>
<td>+ 39</td>
</tr>
<tr>
<td>1980</td>
<td>572</td>
<td>436</td>
<td>- 136</td>
<td>- 113</td>
</tr>
<tr>
<td>1981</td>
<td>263</td>
<td>297</td>
<td>+ 34</td>
<td>+ 28</td>
</tr>
<tr>
<td>1982</td>
<td>388</td>
<td>426</td>
<td>+ 38</td>
<td>+ 31</td>
</tr>
<tr>
<td>1983</td>
<td>281</td>
<td>315</td>
<td>+ 34</td>
<td>+ 28</td>
</tr>
<tr>
<td>1984</td>
<td>296</td>
<td>321</td>
<td>+ 25</td>
<td>+ 21</td>
</tr>
<tr>
<td>1985</td>
<td>306</td>
<td>326</td>
<td>+ 20</td>
<td>+ 17</td>
</tr>
<tr>
<td>1986</td>
<td>319</td>
<td>334</td>
<td>+ 15</td>
<td>+ 12</td>
</tr>
<tr>
<td>1987</td>
<td>333</td>
<td>339</td>
<td>+ 6</td>
<td>+ 5</td>
</tr>
<tr>
<td>1988</td>
<td>484</td>
<td>857</td>
<td>+ 373</td>
<td>+ 309</td>
</tr>
<tr>
<td>1989</td>
<td>439</td>
<td>1,765</td>
<td>+ 1,326 (periodic)</td>
<td>+ 1,280</td>
</tr>
<tr>
<td>1990</td>
<td>576</td>
<td>565</td>
<td>- 11</td>
<td>- 9</td>
</tr>
<tr>
<td>1991</td>
<td>1,286</td>
<td>1,286</td>
<td>0 (periodic)</td>
<td>0</td>
</tr>
<tr>
<td>1992</td>
<td>668</td>
<td>499</td>
<td>- 169</td>
<td>- 140</td>
</tr>
<tr>
<td>1993</td>
<td>360</td>
<td>362</td>
<td>+ 2</td>
<td>+ 2</td>
</tr>
<tr>
<td>1994</td>
<td>486</td>
<td>485</td>
<td>- 1</td>
<td>- 1</td>
</tr>
<tr>
<td>1995</td>
<td>385</td>
<td>373</td>
<td>- 12</td>
<td>- 10</td>
</tr>
<tr>
<td>1996</td>
<td>396</td>
<td>384</td>
<td>- 12</td>
<td>- 10</td>
</tr>
<tr>
<td>Total</td>
<td>9,829</td>
<td>11,463</td>
<td>+ 1,634</td>
<td>+ 1,540</td>
</tr>
</tbody>
</table>

1. The shadow price for routine maintenance is 0.828 and for periodic resurfacing 0.965 (see Table 2).

Source: Valentine, Laurie and Davies, Consulting Engineers: *Malaysia Highway Feasibility Study, Route 1, West Malaysia, April 1972, Volume 5C - Computer Printout Section III.*
<table>
<thead>
<tr>
<th>YEAR</th>
<th>BENEFITS (in M$ thousands)</th>
<th>COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>445</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>3,373</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>12,226</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>12,226</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>12,226</td>
</tr>
<tr>
<td>6</td>
<td>6,346</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>6,895</td>
<td>26</td>
</tr>
<tr>
<td>8</td>
<td>7,064</td>
<td>39</td>
</tr>
<tr>
<td>9</td>
<td>7,142</td>
<td>-113</td>
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<td>10</td>
<td>7,862</td>
<td>28</td>
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<td>11</td>
<td>8,291</td>
<td>31</td>
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<td>12</td>
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<td>13</td>
<td>9,232</td>
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<td>14</td>
<td>9,740</td>
<td>17</td>
</tr>
<tr>
<td>15</td>
<td>10,275</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>10,738</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>11,221</td>
<td>309</td>
</tr>
<tr>
<td>18</td>
<td>11,726</td>
<td>1,280</td>
</tr>
<tr>
<td>19</td>
<td>12,254</td>
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<td>20</td>
<td>12,805</td>
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<td>21</td>
<td>13,381</td>
<td>-140</td>
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<tr>
<td>22</td>
<td>13,983</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>14,613</td>
<td>-1</td>
</tr>
<tr>
<td>24</td>
<td>15,270</td>
<td>-10</td>
</tr>
<tr>
<td>25</td>
<td>15,957</td>
<td>-10</td>
</tr>
</tbody>
</table>

Rate of Return = 16.41%
Optimum Investment Time = 1977
Present Value Discounted at (0.100 *100) Percent = 22,022.8

*Annual VOC savings in 1977 = VOC savings per mile x mileage savings
  x vpd x 365 days per year = .2509 x 12.6
  x 5,500 x 365 = M\$ 6,346 thousands
CUMULATIVE PROBABILITY DISTRIBUTION OF LITTLE-MIRRLEES RATE OF RETURN

- Distribution Mean = 15.06
- Standard Deviation = 2.7552
MAP OF PROPOSED NEW ROUTE
BETWEEN IPOH AND KUALA KANGSAR

LEGEND
EXISTING RD. E
DEVIATION D
SCALE: 1:250,000

FEDERAL COUNTING STATION 13
NEW SITE

FEDERAL COUNTING STATION 13
OLD SITE

SOUTH BOUND TRAFFIC STATION AND CLASSIFIED COUNT AT MILE 13

NORTH BOUND TRAFFIC STATION AT MILE 10.5M

FEDERAL COUNTING STATION 16

TAIPING
CT. JERING
PG. RENGAS
S. CHEMPIAS
KUALA KANGSAR
CHEMOR
IPOH
S. SIPUT

D7

TO GRIK

Scale: 1:250,000
Figure A

PROBABILITY DISTRIBUTION FOR PROJECT CONSTRUCTION COSTS

LM Best Estimate: M$ 40,497,000
Figure B

PROBABILITY DISTRIBUTION FOR BASE-YEAR TRAFFIC COUNT

Variation from Best Estimate (percent)

Best Estimate 5,500

World Bank — 7400
Figure C

PROBABILITY DISTRIBUTION FOR UNIT OPERATING COSTS

LM Best Estimate: M$ 0.2509 per vehicle-mile
Figure D

PROBABILITY DISTRIBUTION FOR TRAFFIC GROWTH RATES

Variation from Best Estimate (percent)

Best Estimate 1977-85 5.5 percent
1986-96 4.5 percent

World Bank – 7401