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Employment Creation, Technological Efficiency, and Distributional Judgements; a case study in road construction

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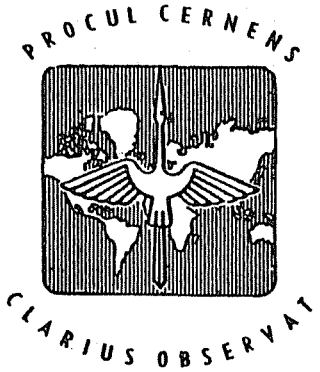

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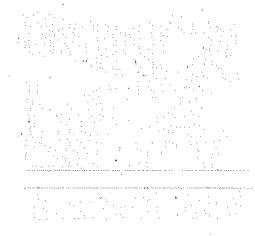


Summary

The present article is concerned with the relationship between distributional and efficiency criteria and the objective of employment creation in a single sector, that of road construction. The work is based on a series of case studies carried out in Iran,±) one such study being presented here, in which the potential for substituting labour for equipment is explored and techniques of social benefit-cost analysis applied to determining technology selection. Optimal factor use and hence employment is shown to depend, inter alia, on explicit judgements concerning income distribution.

±) The study was initiated by the International Labour Office, Geneva, as part of the World Employment Programme, and the case study work carried out at the request of the Government of Iran. A full account of the work carried out is to be found in I.L.O., (1973 a) Roads and Redistribution, A Social Cost Benefit Study of Labour Intensive Road Construction Methods in Iran, WEP 2-22, Geneva, October 1973. The author is indebted to Prof. A.K. Sen, Prof. Gustav Ranis, and Mr. Charles Cooper for comments and criticisms.

Introduction

Road construction has a certain natural attraction to those concerned with employment promotion at the sectoral level. Strategically positioned to intercept the flow of rural poor to the increasingly overcrowded urban centres of much of the Third World, an expanding road construction sector should, it is argued, make a significant contribution to providing extra jobs for the unskilled. But, except in the case of a few select countries, road construction appears to be predominantly an equipment intensive activity whose total contribution to employment creation is small. Such findings are reported by Muller (1970), IBRD/IDA (1971), and ILO (1973 b).

At the simplest level of analysis, the main aspects of the problem can be characterised in the following manner. Given that road construction is found to be equipment-intensive, how far is technically feasible to substitute men for machines?; i.e., the iso-product map for a specific road product needs to be drawn in order to enquire whether a labour-intensive alternative to present technology might be more efficient at market prices or, if markets are thought to be imperfect, at some set of prices which more accurately reflect opportunity costs of factor use. In such a framework, the employment problem is treated as one of allocative efficiency, major emphasis being given to the operation of the price mechanism.

Any enquiry into efficiency, however, raises questions of distribution since a given set of price relatives can only be deemed efficient in relation to some distributional plan prescribing how consumption is to be shared out amongst different individuals and through time. One may thus argue that problems of employment creation are ultimately problems about distributional preferences, the onus being on Government having once determined such preferences, to follow a set of policies consistent not merely with improving allocative efficiency in a given sector but in all sectors. Such is the basic schema adopted in the present study.

To be sure, the discussion which follows focuses on a limited area of the problem. General equilibrium aspects of allocative efficiency - such as for example whether Government can plan the composition of investment and output (particularly of wage goods) in a manner consistent with meeting distributional objectives - is ignored. So too are problems of valuation of existing capital stock; all investment decisions are taken to be of an ex ante nature. At a more practical level, detailed discussion of important issues - such as institutional biases in technological innovation and choice in road construction, the relative potential for switching technology in the case of roads having different terrain characteristics and design standards, secondary employment generation effects, the organisational and management problems raised by the adoption of new technology, etc. - is omitted here. Primary emphasis is given to illuminating the relationship between distributional judgements, factor pricing, and employment creation through the application of cost-benefit techniques to a given case study.

In Section I, the basis of the cost-benefit framework is set out and estimates derived for the various aggregate or sector level parameter values specific to the present situation in Iran. These then serve, in Section II, as the set of basic datum required to translate market prices for substitutable factors of production in road

construction into social aggregate consumption costs. The first part of Section III is concerned with determining the technical rates of substitution between equipment and labour - the shape of the iso-product curve so to speak - in the case of constructing a particular road, which is in this case a major highway project. Section III concludes with a concise diagramatic illustration of the relationship between distributional objectives and employment generation through the selection of a more labour intensive factor mix. The relative merits of alternative policy instruments which might be used to effect such a change are discussed and general policy implications of the analysis summarised.

1 A. The Social Cost Benefit Framework

The present section sets out in general terms the method which has been followed in pricing factors of production between which substitution is technically feasible. The social pricing conventions used follow, to a large extent, those set out in the UNIDO (1972). [1] The UNIDO approach has been followed both because it was felt that the explicit treatment accorded to the valuation of class and regional distribution of consumption benefits was more satisfactory (given the particular relevance of such problems in the Iranian context), and because under existing conditions of data availability in the country, the breakdown of all items of consumption into tradeable commodities and their valuation at border prices which an OECD type approach have required seemed altogether too hazardous an exercise.

1 B. Central Parameter Values for Iran

Table 1 sets out estimates derived for key parameter values used in valuing substitutable factors of production in terms of aggregate consumption claims on the national economy. It will be convenient briefly to discuss the basis of derivation of each of these items.

The aggregate yield on a unit of investment at the margin is measured by estimating both the first round direct consumption out of extra real income generated by that unit, and the indirect consumption generated in subsequent rounds by re-investment out of savings; all expressed in terms of present consumption. If q_1 is the amount of consumption generated next year by one unit of investment today, then the present value of q_1, or q_o, can be written $q_1/(1+i)$ where i is the social marginal rate of time preference.

Alternative discrete values of the social rate of time preference have been posited, [2] (as shown in Table 1). The estimate of the parameter q, the marginal rate of return to investment for the economy as a whole, has been calculated from the national income account projections for the Vth Plan period, [3] according to the definition:

$$q = (\bar{y} - \bar{w1})$$

where $\bar{y}$ is equal to value added per unit planned investment and $\bar{w1}$ to the wage bill per unit planned investment over the period 1972-77. Marginal rates of savings, for the economy as a whole (S) and out of private capitalist profits (S^{cap}) have also been derived from these figures. In the case of S, it has been convenient to use the predicted change in total savings as a proportion of GDP as a basis of estimation, some allowance being made for a possible shortfall in the expected contribution of the balance of payments to aggregate savings and the fact that Iran's savings-investment ratio has historically been less than 1. The estimate of S^{cap} is based on the predicted post tax savings rate for the modern urban sector; as this sector includes both high income households and companies, the use of an average figure as a proxy for saving out of profit is biased to the degree that household incomes are both an important proportion of the total and

Table 1 : Central Parameter Values for Iran

1.	Shadow price of investment	$p^{inv}_{i=.15}$	3.2
		$p^{inv}_{i=.10}$	14.1
2.	Social rate of discount	i	.15,.10
3.	Marginal rate of return to investment for economy as a whole	q	0.33
4.	Marginal rate of savings/ investment for economy as a whole	S	0.25
5.	Marginal saving out of capitalist profits	s^{cap}	0.25
6.	Marginal propensities to save		
	(i) Government	s^{G}_{P}	0.375
	(ii) Private	s_{SL}	0.15
	(iii) Skilled labour	s^{f}	0.08
	(iv) Farm sector (±)		0.12
7.	Foreign exchange premium	ø	0.20
8.	Weights on objectives		
	(i) Aggregate consumption	θ^{Σ}_{f}	1
	(ii) Rural consumption	θ^{r}	0→4.0
	(iii) Regional consumption		-
9.	Skilled labour premium$^{+}_{-}$	χ	0.50
10.	Shadow wage rate	SWR	-

average household savings significantly lower than those of the company sector.

Given estimated values for q and S, and given alternative assumptions for i, the premium on investment corresponding to a given value of i is given by the expression:

$$p^{inv} = (1 - S)q/(i - Sq)$$

Only in the case of i = q, that is to say where the social marginal rate of time preference is judged to be equal to the marginal rate of return on investment, will a unit of present investment be judged as being equivalent in value to a unit of present consumption ($p^{inv} = 1$). Such a hypothesis has been excluded by the choice $.10 \leq i \leq .15$, given that q is found to be greater than .15.

Other parameter values shown in Table 1 are calculated as follows. Government's marginal savings propensity is estimated by taking total projected change in Government savings over the Plan period as a proportion of the projected increase in receipts. The average savings ratio is found to move from 30% to 33% over this period, and the marginal savings ratio is calculated to be 37.5%. The all urban household average savings ratio is currently 15%, and is estimated to remain unchanged over the Plan period. (The marginal ratio is thus equal to the average.) Skilled wages do not figure as a separate category in the available data for the Plan period, but low income urban households have been used as a proxy for this category. A marginal figure of 8% has been derived. Savings for the small farm sector over the relevant period do not figure separately in the data; nor can any proxy be used. Rural household budget studies for this sector suggest an average savings ratio in the range of 5-8%. [4] Such studies, however, are likely to be misleading in that only monetised savings are considered, the importance of non-monetised savings in the rural sector having been pointed out by various authors. [5] Drawing upon the conclusions of other work, the inclusion of all forms of savings for rural farm families whose recorded savings ratio is in the region of 6-7% would bring the figure up to 12%.

A premium on foreign exchange is included in the analysis. The absence of an overall payments deficit cannot be treated as prima facia evidence for correct valuation of the exchange rate, given the high tariff barriers which Government has found necessary to erect in order to encourage import substitution, unless existing protection levels be said to be 'optimal'. Protection has in many cases, moreover, encouraged the domestic manufacture of luxury consumer goods which themselves have a high import content, and thus merely led to a change in the composition of imports rather than in an overall reduction of the import bill. It is therefore assumed that the price of foreign exchange relevant to the present exercise exceeds its nominal price. The magnitude of such a premium is measured by the ratio of the trade weighted index of domestic clearing prices for imports to their c.i.f. prices. The present average effective rate of tariff protection has been taken as an estimate of this ratio. [6]

Beyond the objective of maximising the present value of aggregate consumption, an objective which requires some value judgement to be made with respect to the inter-temporal distribution of consumption (the parameter i), planners may want to introduce some further

judgement with respect to the weighting to be accorded to consumption by different income groups. [7] For present purposes, aggregate consumption has been accorded a neutral weight of 1, while a premium of θ_f has been given to rural consumption. Rather than setting a fixed value on this premium, it is treated as a variable in the analysis. Optimal technology choice will thus be seen to depend, inter alia, on an explicit judgement of policy makers concerning both inter-temporal and inter-class (sectoral) distribution.

2 A. Translating Market Prices into Social Aggregate Consumption Values

The present section outlines the method by which cost data taken from private company accounts is translated into social aggregate consumption costs.

Table 2 sets out the account for a typical item of equipment (a Caterpillar D7). Purchase price (c.i.f. Teheran), effective, duty, and dealer mark-up are shown explicitly. Depreciation has been calculated on the basis of a 12,500 hour total life allowing for the scrap value of the asset, and an average interest charge of 13% on depreciation value included. Maintenance charges have been estimated, over the life of the asset, to match depreciation, and all items of running costs have been set out including operator wages. Costs per hour and per ton-hour are shown both in Rials and, for convenience, in US dollars. [8]

Some types of equipment cannot be replaced by labour. Those groups for which labour can be substituted have been designated 'key groups'. In order to express costs of key items of equipment in terms of social aggregate consumption, it will be necessary first to recast private firm accounts (figure 2) in a form relevant to calculation at national planning level, and then to apply the various adjustment factors discussed above. Table 3 demonstrates the basis on which the first step is accomplished. All forms of expenditure are now shown on a yearly flow basis.

The column in Table 3 labelled 'composition' shows the assumptions which have been made with regard to the form in which the consumption claim accrues. Purchase takes place in year zero, and is entirely a foreign exchange claim. 'Special items', 'tyres and tracks', 'fuel and lubrication' and 'scrap value' have also been treated as consisting entirely of claims on foreign exchange (positive or negative), while it is assumed that in the 'dealer markup' and 'maintenance expenditure', only 50% of expenditure finds its way abroad. As a distinction has already been drawn between aggregate social consumption and skilled worker consumption, the approximate portion of 'maintenance expenditure' and 'operator charges' assumed to accrue as skilled wages has also been distinguished.

Certain items which the private entrepreneur would count as 'costs' must now be omitted from the national accounting framework, notably effective duty and depreciation and interest charges. Effective duty is not a cost to society, but a transfer between private and public sectors. Depreciation is an accounting convention which allows the entrepreneur to set aside funds for replacement of equipment while normally obtaining tax concessions from Government for doing so. Capital is maintained 'intact' not by including

Table 2 : Private Firm Financial Account for Typical Item Heavy Equipment
(Bulldozer D7.PS, 180 HP, 18 tons)
(1 US$ = 67.5 Rials)

	US$	Rlsx10^6	Rls/hr	$/hr	Rls/ton-hr	$/ton-hr
I. Breakdown of capital cost						
1. Purchase price ex-works	51,575					
2. Price cif Iran	52,025					
3. Effective duty (8%)	4,126	0.279			1.24	0.02
4. Dealer markup (15%)	8,423					
5. Cost to customer	64,574	4.359				
II. Contractor accounts						
1. Depreciation on 12.500 hr life allowing for 10% scrap value	58.117	3.924	314	4.65	17.44	0.26
2. Interest (½ cost x 13% ÷ 2500)			105	1.55	5.83	0.09
3. Maintenance			314	4.65	17.44	0.26
4. Special items (shank protection, blades, etc.)			50	0.74	2.78	0.04
5. Tyres and tracks			66	0.98	3.67	0.05
6. Fuel			83	1.23	4.61	0.07
7. Lubrication (20% fuel cost)			17	0.25	0.94	0.01
8. Driver			160	2.37	8.89	0.13
TOTAL			1109	16.42	61.60	0.91

Note: total utilisation 12.500 hours
annual utilisation 2.500 hours
market interest rate: 13%

Table 3 : National Account for Typical Item Heavy Equipment at Market Prices

Expenditure	Composition	(year) 0	1	2	3	4	5	6
I.								
1. c.i.f. price	100% FE*	$ 52,025						
2. Duty	transfer	(4,126)						
3. Dealer markup	50% FE	8,423						
II. Operating costs								
Maintenance	50% FE, 50% skilled worker consumption		3,877	7,731	11,625	15,520	19,181	
Special items	100% FE		1,850	1,850	1,850	1,850	1,850	
Tyres/trucks	100% FE		2,450	2,450	2,450	2,450	2,450	
Fuel and Lubrication	100% FE (potential experts foregone)		3,700	3,700	3,700	3,700	3,700	
Operator charges	skilled worker consumption		5,925	5,925	5,925	5,925	5,925	
Scrap value	100% FE							-6,457
Present value at	PV at	60,448	17,802	21,656	25,550	29,445	33,106	-6,457

Present value at	$	$/ton-hr±	PV at	$	0	1	2	3	4	5	6
10%	150,794	0.67	10%	150,796	60,488	16,184	17,899	19,198	20,114	20,559	-3,646
15%	139,652	0.62	15%	139,652	60,488	15,481	16,376	16,802	16,837	16,460	-2,792

± 18 tons; 12,500 hrs. total use

* FE: foreign exchange

depreciation costs, but rather by allowing for proper maintenance. [9] 'Interest' is omitted as not representing a cost of using capital in the sense defined earlier. All columns are now summed, and represent dated consumption claims at market prices (minus any allowance for the future consumption foregone by tying up capital in equipment purchase). Alternative present values of the stream of claims are obtained according to the value chosen for the social marginal rate of time preference, i. Alternative cost estimates are therefore derived which are shown both in total terms, and on a cost per tonne-hour basis.

The next step in the exercise requires expenditure, valued above at market prices, to be re-expressed in terms of social prices. In particular, expenditure accruing as foreign exchange claims or skilled workers wages, which has already been singled out, must be adjusted by applying the respective premiums set out above. Once expenditure has been valued at social prices, there remains the problem of translating expenditure into aggregate consumption claims. It is thus necessary to determine how the expenditure associated with the purchase and use of equipment is apportioned between different major sectors, and estimate the savings (reinvestment) propensities of each sector, to arrive at a final estimate of the stream of aggregate consumption claims which such expenditure represents. [10]

Estimated savings propensities for each major sector have been set out in Table 1, as has the estimated value of P^{inv} corresponding to alternative assumptions about the social marginal rate of time preference. Conversion factors are now calculated translating expenditure (valued at social prices) flows for each major group - Government (G), private entrepreneurial (P) and skilled workers (SL) - into social aggregate consumption claims. Such estimates are presented in Table 4:

Table 4: Aggregate Consumption Adjustment Factors

Group	Parameter	Social rate of time preference	
		0.10	0.15
Government	μ^G	5.92	1.83
Private	μ^P	2.97	1.33
Skilled Labour	μ^{SL}	2.05	1.18

The two major steps described - the conversion of expenditure valued at market prices into expenditure valued at social prices, and the conversion of the latter into an aggregate social consumption equivalent - are summarised in Table 5.

Such an exercise could, in principle, be carried out at a much finer level of definition tracing the flow of consumption and saving/re-investment through successive rounds. [11] Suffice to say that a first round approximation to the measurement of aggregate consumption value (consumption plus savings) of expenditure will be considered satisfactory for present purposes and serves to illustrate the contrast between the treatment of the price of investment in a full social

accounting framework and conventional private accounting practice. At the bottom right of Table 5 are shown the final estimates of aggregate social consumption cost of a typical item of equipment for alternative marginal rates of social time preference (i = .10, i = .15). The above exercise is now generalised to cover all items of equipment for which labour can be substituted in road construction. Table 6 contrasts average cost to the contractor and average social aggregate consumption value at alternative marginal rates of social time preference for each of the 10 key equipment groups which figure in the analysis.

2 B. Calculation of the Shadow Wage Rate

The shadow wage rate (SWR) for unskilled labour is defined for the purposes of the present exercise to include all real costs to society associated with the hiring of an extra worker. These costs are first estimated at market prices. Then, using adjustment factors given in the table of central parameter values, a range of estimates of the SWR is derived, bearing in mind that - just as in the case of equipment - the social cost of labour depends, inter alia, on judgements about intertemporal and inter-class distributional weights.

Table 7 sets out, at market prices, cost estimates for items associated with the use of an extra worker. All estimates relate to the area in which the study was carried out, notably, the Azarbijan region of Iran. The nominal wage for unskilled labour in road construction is estimated to be Rls. 16.00 per hour ($ 0.24), a figure which contrasts with the going wage rate for casual labour in agriculture of Rls. 8.75 per hour. Net costs of transferring a worker from agriculture to road construction are itemised. These are claims which would not otherwise be borne, and which must be met either by the worker or his employer. The operative assumption is that the resulting benefits are wholly reflected in the estimated productivity coefficients for labour entering the production function. [12] Incremental food costs are estimated to involve an increase in calorific expenditure of 4.2 Kcals per day costed at Rls. 5.86 per Kcal, and met by a proportional increase of all items in the present rural food bundle. Costs of extra housing are estimated as corresponding to approximately 10% of the nominal wage. Once-and-for-all journey costs are reasoned to constitute a negligible proportion of the total wage bill, and are therefore omitted from the analysis. Supervisory costs have been estimated from data on the required ratio of different grades of supervisory staff to unskilled labour, and costed at their respective wage rates, while extra administrative charges have been derived from interview data.

The general form of the shadow wage rate (SWR) adopted is: [13]

$$SWR = (z + c)\ (1 + f\emptyset) + \{P^{inv} - 1)\ (S^{cap} - rS^{f})$$

$$- \theta^{f}\ \underline{/}\ (P^{inv} - 1)rS^{r} + 1\ \underline{/}\ \}w + (P^{inv} - 1)S^{cap}{}_{c}$$

where: z = net agricultural product foregone

Table 5 : Final Social Account for Typical Item of Heavy Equipment Valued at Aggregate Consumption Cost (SACE)

			Aggregate Consumption Adjustment	Social Pricing Adjustment	Present Value at 10%	Present Value at 15%	0	1	2	3	4	5	6
CLAIMS ON FOREIGN EXCHANGE	1. Private Sector (Industry) 1 cif price 2. 50% dealer markup 3. 50% maintenance 4. Special items 5. Tyres and Trucks 6. Fuel and Lubrication 7. Scrap Value	Social Discount Rate	v^P {2.97 / 1.33	$\phi = .2$ $(1+\phi)$			52025 4212	1939 1850 2450 3700	3866 1850 2450 3700	5813 1850 2450 2700	7760 1850 2450 3700	9591 1850 2450 3700	-6457
							56237	9939	11864	13813	15760	17591	-6457
		10%	368,880	124,202	103502		56237	9036	9807	10383	10766	10924	-3646
		15%	156,258	117,487		97906	56237	8643	8973	9087	9012	8746	-2792
CLAIMS ON DOMESTIC CONSUMPTION AND INVESTMENT	2. Private Sec. (Industry) 1. 40% dealer markup 2. Duty (-)		v^P {2.97 / 1.33	nil			3369						
		10%	-2248				- 4126						
		15%	-1007		- 757	- 757	- 757						
	3. Government 1. 10% dealer markup 2. Duty		v^G {5.92 / 1.83	nil			843 4126						
		10%	29,416		4969	4969	4969						
		15%	9093										
	4. Skilled Workers 1. Operator Charges 2. 50% Maintenance		v^{SL} {2.05 / 1.18	$\chi = .50$ $(1+\chi)$				5925 1939	5925 3866	5925 5813	5925 7760	5925 9591	
								7864	9791	11738	13685	15516	
		10%	132,360	64,566	43044			7149	8092	8820	9348	9635	
		15%	66,379	56,253		37502		6839	7404	7719	7825	7715	
	TOTAL AGGREGATE CONSUMPTION COST AT ALTERNATIVE SOCIAL DISCOUNT RATES	10%	528,408	$\simeq$	AGGREGATE CONSUMPTION COSTS PER TON-HR [÷ (12500 x 18)]					10%	2.35		
		15%	230,723							15%	1.03		

Table 6 : Average Social Aggregate Consumption Values for Key Equipment Groups for Alternative Values for i (1 US$ = 67.5 Rials)

Group	$ per tonne-hr		
	Private Cost	Aggregate Social Costs	
		i = .10	i = .15
I. A. Bull dozers	0.91	2.35	1.03
B. Traxcavators	0.95	2.45	1.07
C. Wheel loaders	0.96	2.48	1.08
D. Motor graders	0.95	2.45	1.07
E. Lorries	0.81	2.09	0.92
F. Farm tractors & trailers	0.77	1.99	0.87
G. Wheel Barrows & hand tools	0.30	0.77	0.34
II.H. Stone cutters	0.59	1.52	0.67
I. Compressors	2.49	6.42	2.81
K. Screening plant	0.80	2.06	0.90

Table 7 : Elements of the Wage at Market Prices

	Symbol	Rls/day	Rls/hr	$/hr
1. Average Wage of Casual Agricultural labour	W_a	70	8.75	0.13
2. Average Unskilled Worker's Wage in Road Construction (Nominal)	W	128	16.00	0.24
3. Costs of Transfer of which:	C	67	8.38	0.12
(a) food	C_a	25	3.12	0.05
(b) housing	C_b	13	1.63	0.02
(c) transport	C_c	-	-	-
(d) supervision& administration (±)	C_d	29	3.63	0.05
4. Actual Cost to Employer of Unskilled Worker	$W+C_d$ $=(W')$	157	19.63	0.29
5. Transfer Cost borne by worker	$C-C_d$	38	4.75	0.07

± Borne by employer

c = net costs of transfer from agriculture to road construction

F = the import (or potential export) content of workers' consumption

$\emptyset$ = the foreign exchange premium

p^{inv} = the premium on investment at a given social time preference rate

s^{cap} = the marginal savings rate of capitalists

r = the proportion of workers' wages remitted to the agricultural sector

s^{f} = the marginal savings rate of the agricultural sector

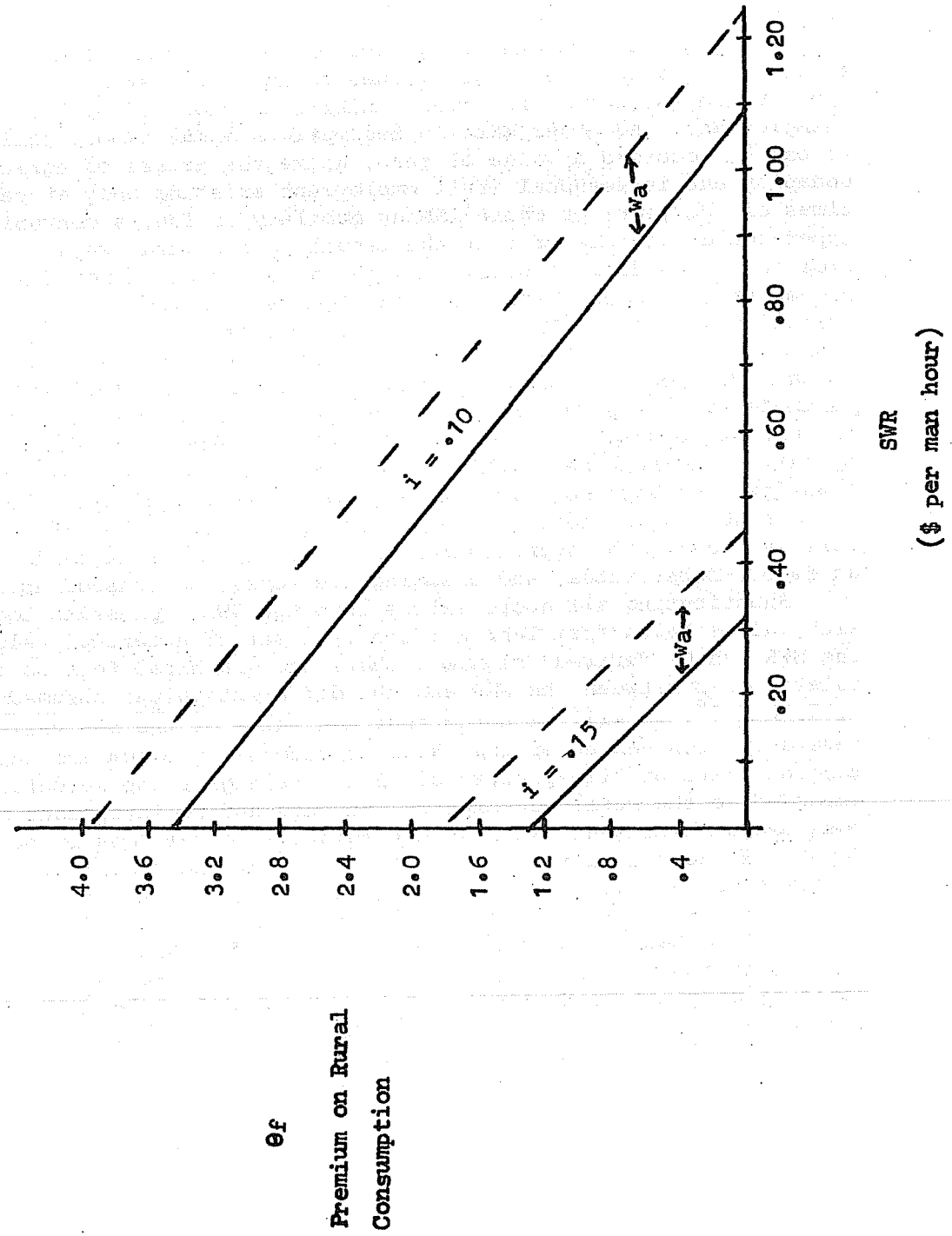
θ^{f} = the premium on workers' consumption

w = the effective money wage

Net product foregone in agriculture as a result of migration, z, is not treated as a single-valued parameter; instead, lower and upper bound estimates are given. Under conditions of open rural unemployment, and under certain assumptions about labour mobility, it can be accorded a value of zero. Where the nature of agricultural unemployment is seasonal (full employment existing only at certain times of the year) or where labour mobility is low, a convenient upper-bound estimate of z if the casual agricultural wage rate (w_a). From interview data, a value of 0.15 has been determined for the parameter r, the proportion of the wage remitted to the rural agricultural sector. This accords with observations of remittance behaviour of wage workers in other studies, as with logical inferences to be made about rational wage market behaviour based on other parameter values given above. [14] The proportion of foreign exchange in current consumption claims of unskilled workers, F, has been derived by taking the average of the proportion of extra food claim in total transfer cost together with the average of the total extra food claim if a product equivalent to the casual agricultural wage is foregone. This is found to be approximately 60%, all food claims being treated as import-substitutes, and assuming the worker to consume no imports. [15]

Substituting all above values into the SWR expression together with values taken from Tables 1 and 7, a set of numerical values for the SWR can be derived. Figure 1 shows the graphical form of the relationship between the SWR and the different values assumed for z, i, and θ^{f}. It will be noted that the value of the SWR varies inversely with values of the rural consumption premium and the social marginal rate of time preference; i.e. the higher the weighting accorded to the rural consumption, savings and re-investment made possible by hiring an extra worker relative to the loss in private capitalist consumption and savings, the lower the social wage cost in terms of aggregate consumption. Similarly, the higher the value of the social marginal rate of time preference, the smaller is the value of the SWR. The extreme sensitivity of the SWR calculation to changes in the latter parameter, i, follows from the relatively high rates of marginal productivity of investment and saving out of extra income which have been observed for Iran. Future consumption claims

Figure 1 : The SWR as a Function of Inter-class (θ_f) and Inter-temporal (i) Distributional Weights on Consumption



are thus seen to play an important role in the SWR valuation, and the question of whether or not present output foregone resulting from migration is zero ($0 \leq z \leq w_a$) assumes lesser importance in the present context.

3 A. The Rezayeh Highway Study: Example of the Applied Analysis

In the case of the Rezayeh-Mahabad highway, which is presently under construction, eight basic operations have been observed in which it is judged feasible to substitute labour for equipment. Technical coefficients for the productivity of equipment and various grades of labour have been estimated, taking into account the specified design characteristics of the road and general climatic and environmental factors. Calculations of the change in equipment and labour use corresponding to an alternative technology in the case of each particular operation are then derived from a series of exogenous parameters; viz. volume and weight of earth to be moved, transport distances, volume and type of gravel required, thickness of each layer of road base, compaction ratio, etc.

Table 8 sets out, for each of the above mentioned operations, the factor proportions used under present technology and recommended for the alternative labour-intensive technology. Row 1 gives an itemised breakdown of all classes of equipment which figure in the substitution bundle for each operation in turn. [16] Row 2a and 2b show the total value and total tonne-hours respectively of all such equipment, while row 2c gives the average market price of such equipment weighted by relative importance in substitution. [17] Rows 3 and 4 give total equipment tonne-hours for each operation for present (ΣE_j) and alternative technologies respectively, the reduction in equipment use under the labour-intensive technology defined for each operation (ΔE_j) being shown in row 5. Similarly, change in total unskilled labour use for the jth operation (L_j) is shown in row 8, as derived from row 6 (L_j) and row 7. The average rate of technical substitution ($ARTS_j$) for each operation is shown in row 9. Row 10 gives the ranking order of operations by their ARTS.

Co-ordinates for each segment of the aggregate iso-product curve can now be calculated and the curve itself plotted as shown in Table 9 and Figure 2 respectively (note that operation D, which is found to have a very high ARTS, has been dropped from the analysis at this stage). At this level of aggregation, average rates of technical substitution (ARTS) are treated as marginal (MRTS). From this information an employment function is derived as shown in Figure 3. Total direct employment generation per 10 km. road is plotted against the marginal rate of technical substitution of labour for equipment as given by each segment of the aggregate iso-product curve. [18] This total refers to employment generated per unit length over the whole of road construction time. As total construction time will vary as a function of several factors besides length - road class, design standard, terrain, etc. - comparison employment functions for different roads on such a basis will be misleading. A further function is therefore derived which is standardised with respect to time, [19] and this is shown by the dotted line in Figure 3.

Table 8 : Basic Calculations for Rezayeh Highway

Row	Equipment Group	Average Market Price ($/tonne-hours)	A Cut & Fill		B Crushing Rock		C Cut & Fill short dist.		D Drilling Rock		E Rock trp. short dist.		F Rock trp. long dist.		G Base layer c.t.c.		H Trimming of slopes		TOTAL
			Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	Tonne-hrs or man-hrs	Value ($)	
1	I A	.91	18690	17008			10800	9828			4350	3959	5010	4559			500	455	
	B	.95															1500	1425	
	C	.96	29370	28195	11000	10500							5511	5291	23235	22306			
	D	.95													24234	23022	1200	1140	
	E	.81	32040	25952	2000	16200							10020	8116	40452	32766	1200	972	
	F	.77	*(31520)	24270									(9020)	6945	(45168)	34779	(2000)	1540	
	G	.30	(1576)	473	(6750)	2025	(1820)	546	(2850)	855	(609)	183	(451)	135	(3943)	1183	(100)	30	
	II H	.59			25000	14750													
	K	.80													6835	5468			
	I	2.49							3990	9935									
2a	Total value			95898	——	43535	——	10374	——	10790	——	4142	——	25046	——	119524	——	5562	314871
2b	Total tons		113196	——	44750	——	12620	——	6840	——	4959	——	30012	——	143867	——	6500	——	362814
2c	Average Cost ($)																		0.87
3	Total Equipment tonne-hrs under present technology (ΣE_j)		80100		38000		10800		3990		4350		20541		94756		4400		256937
4	Total Equipment tonne-hrs under labour intensive technology (ΣL_j)		33096		6750		1820		2850		609		9471		49111		2100		105807
5	row(3) - row(4) [ΔE_j]		47004		31250		8980		1140		3741		11070		45645		2300		151130
6	Total man-hrs labour under present technology (ΣL_j)		2670		3000		400		5700		145		334		6196		500		18945
7	Total man-hrs labour intensive (unskilled)		354600		540000		104120		285000		24360		49610		505200		19500		1882390
8	row(7) - row(6) [ΔL_j]		351930		537000		103720		279300		24215		49276		499004		19000		1863445
9	(8)/(5) [$ARTS_j$]		-7.51		-17.18		-11.55		-245.0		-6.47		-4.45		-10.93		-8.26		
10	rank		3		7		6		8		2		1		5		4		

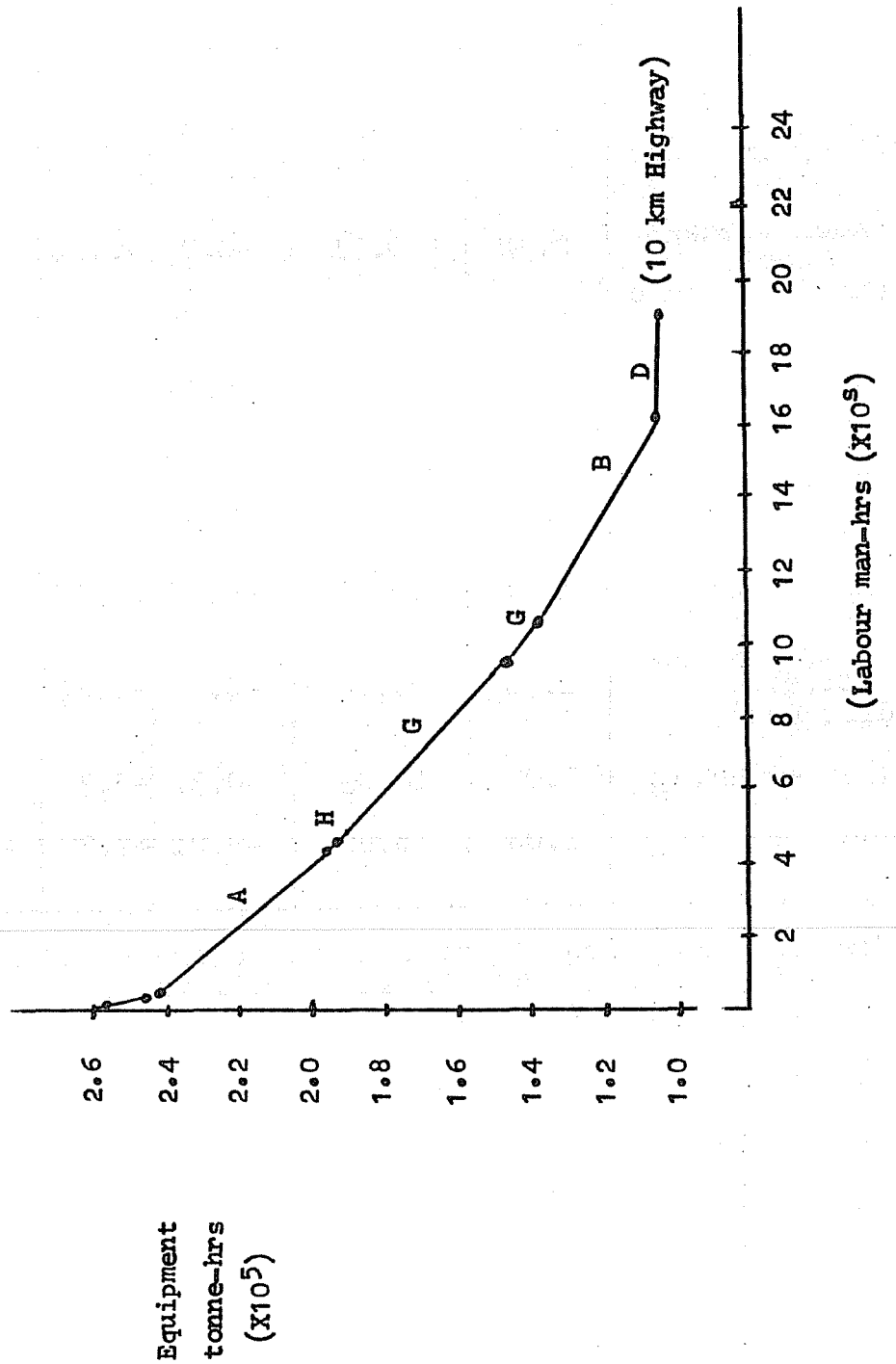
* brackets indicate E used in L intensive activty

Table 9 : Rezayeh Highway: Iso-product Curve Co-ordinates

Activity Code	Activity	Total E used [tonne hrs x 10^5]	Total L used [man hrs x 10^5]	ΔE	ΔL	Marginal Rate of Technical Sub. (MRTS) ±
-	Present Technology	2.57	0.18	-	-	
F	Rock transport; (long distance)	2.46	0.67	-0.11	+0.49	- 4.45
E	Rock transport; (short distance)	2.42	0.91	-0.04	+0.24	- 6.47
A	Earth cut and fill (long distance)	1.95	4.44	-0.47	+3.54	- 7.51
H	Trimming slopes	1.93	4.63	-0.02	+0.19	- 8.26
G	Base layer	1.47	9.62	-0.46	+4.99	-10.93
C	Earth Cut and fill (short distance)	1.38	10.66	-0.09	+1.04	-11.55
B	Rock crushing	1.07	16.03	-0.31	+5.37	-17.18
D	Rock Drilling	1.06	18.82	-0.01	+2.79	-245.00

± MRTS calculated from figures above before rounding to two decimal places; $\Delta L / \Delta E$ shown will therefore only approximate MRTS given.

Figure 2 : Rezayeh Highway: Iso-product curve per 10 km. Road Constructed over given Period



The exercise can now be summarised analytically with the aid of a final diagram. Figure 4 illustrates the basis on which optimal technology selection, the employment objective, and distributional judgements are related. Total direct employment generation is shown on the left-hand vertical axis, the function relating employment to the marginal rate of technical substitution (MRTS) which is shown on the bottom log-scale. At the top of the diagram, the equipment/labour price ratio (log-scale) is shown in relation to the premium on rural consumption, θ_f, which appears vertically on the right. Price ratio have been plotted for discrete pairs of values for the parameters i and z. The condition for optimisation requires the factor price ratio to be equated to the MRTS; the employment generation implications of optimal technology in the case of the particular road chosen can therefore be seen for combinations of i, z, and θ_f determining the social aggregate consumption costs of equipment relative to labour. [20]

The vertical line c/w' represents the market price ratio. The Figure shows that at market prices the private entrepreneur will not find it profitable to switch to a more labour-intensive technology. Moreover, for the range of values assumes for the marginal rate of social time preference, substitution of labour for equipment will never be socially profitable if no premium is placed on rural consumption vis-à-vis consumption of other sectors, ($\theta_f = 0$). If, however, some positive value is placed on θ_f, then (all other things being equal) the technology chosen will depend on the nature of unemployment in the rural sector (the value of z), and on the value accorded to future relative to present consumption claims. The more highly future consumption claims are discounted, the less costly in terms of savings and therefore future consumption foregone will be a redistribution from profits to wages entailed by a switch to labour-intensive techniques. Just how important society's (or policy makers') value judgement with respect to the inter-temporal aspect of distribution is in the case of the present exercise is illustrated by the vertical distance between the pairs of curves corresponding to the different assumptions for the value of i, a point which has already been noted in discussing the derivation of the SWR.

Since inter-temporal and inter-class distribution weights on consumption have been treated as explicit value judgements in the case of the present study, it is not possible to make a final recommendation about the extent to which labour should be substituted for equipment. Rather, the analysis serves to bring out the fact that pursuing employment creation objectives in this or any other sector will entail a set of judgements about both dimensions of the distributional question. [21]

3 B. Implementing Optimal Technology Selection

Suppose that Government, on the basis of the results presented above, were to choose to increase employment in the road construction up to an amount N^* per unit standard output. For a given value of i, the implicit weight accorded to total consumption can be read from Figure 4.

Figure 3 : Rezayeh Highway: Employment Functions [f(N)] for Total and Standardised Unit Construction Time

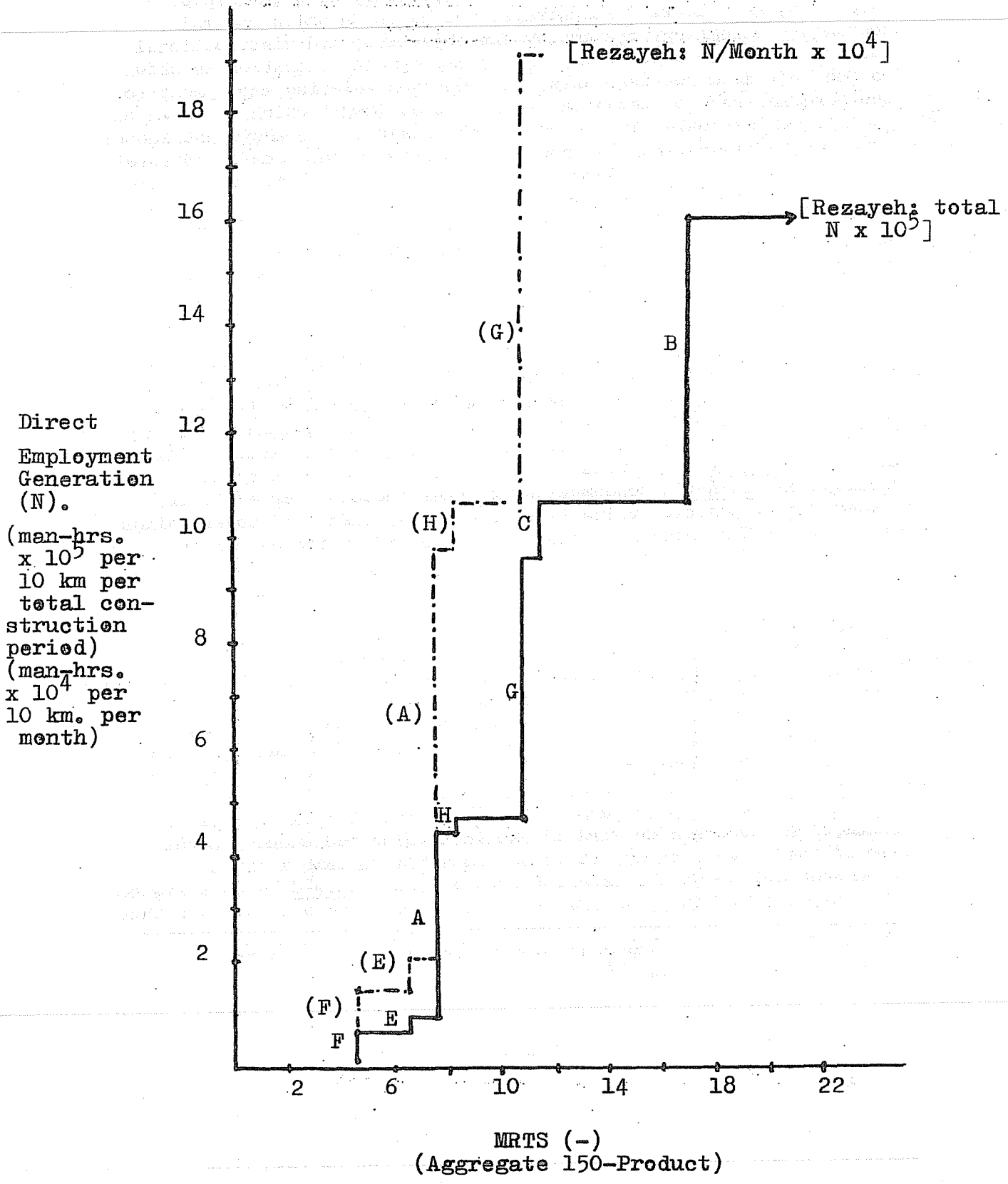
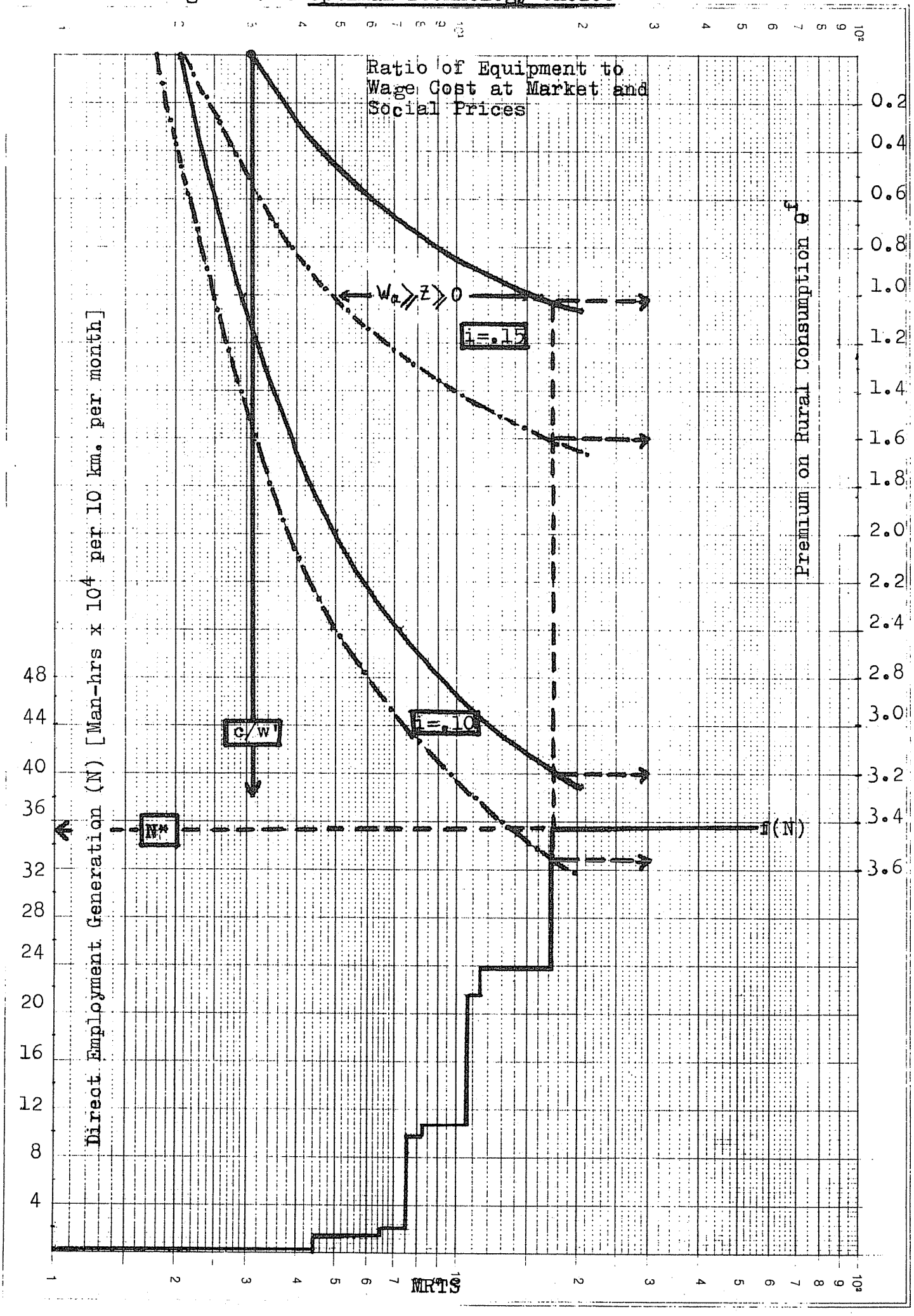


Figure 4 .: Optimal Technology Choice



If Government were able to fix all factor prices ruling in the market, no problem would arise, as market price relatives could be brought into line with social price relatives, and entrepreneurs would presumably adopt the new technology of their own accord. Such an assumption, however, is hardly realistic given the extent to which most Governments are effectively able to intervene in controlling resource allocation decisions. Typically, enforcement of a change in present resource allocation needs to be encouraged using some form of subsidy; i.e., a financial transfer from public to private sector. If no such transfer is made, then private sector resources will simply shift out of road construction into more profitable sectors. Note that such a transfer is, by definition, one which Government should be willing to finance since it is instrumental to the realisation of a social welfare gain. The form in which it is financed, however, will depend upon Government adopting a consistent set of social valuations applicable to all resources over which it has command and all benefits to which these potentially give rise. In the present case, Government may resort to one or a combination of measures to enforce a change in technology including an increase in the nominal price of equipment through tax, tariff, or quantity restriction measures, or more directly, a subsidy on the wage, or direct intervention in the road construction market acting as entrepreneur. In all cases Government will bear the financial costs of the subsidy, either directly or indirectly. [22]

The argument concerning the relative merits of specific tariffs, quantity restrictions and wage subsidies does not turn, therefore, on any simple notion of economies in Government finance. The issue is basically one of ease of administration and relative efficiency of the measure or set of measures adopted. Prima facie, tariffs or quantity restrictions would appear to have a certain appeal as they would appear to be more easily administrable than a direct wage subsidy. However, tariffs or quantity restrictions will not, by themselves, guarantee the adoption of changed technology, it being possible that entrepreneurs will simply pass extra costs onto Government without any significant substitution of labour for equipment taking place. In this case, no social welfare gain would be realised, the whole exercise merely resulting in increased private sector contractor profits. Exactly the same argument applies to wage subsidy.

Clearly, a condition of any set of measures being successful is that they be carefully supervised. In this respect, consulting engineers will have a critical role to play, for it is on this part of the market which the responsibility for specification and supervision of the new technology under existing conditions will largely depend, particularly in the light of the critical role of major highway construction in employment generation in Iran. A first priority will be for Government to ensure that terms of reference for feasibility studies and detailed engineering design are suitably couched to encourage the further investigation of factor substitution potential along the lines discussed above. The same considerations will apply to the award of supervision contracts. It will then be necessary to supplement such measures by specific provision at contract level, possibly in the form of a 'minimum employment' contract making specific reference to the amount of labour to be used in the construction of a particular road. [23]

An equally important question concerns the rate at which the new technology is adopted. Undoubtedly, there will be 'learning costs' involved in switching technologies for all parties concerned, but accruing ultimately to society in the form of construction delays, extra contract negotiations, higher engineering fees, and so forth. Maximising the potential welfare gain would appear to dictate that, once the decision is made to switch to a socially preferred technology, such a technology should be applied across the board to all road construction projects. Institutional constraints on available Government finance for subsidy notwithstanding, the generalised adoption of labour-intensive methods would mean that all firms would bear learning costs simultaneously. It would thus seem preferable to make provision for 'learning by doing' in a small number of individual cases, allowing the results of such experience to accrue as external economies to all firms subsequently called upon to apply new methods.

Viewed from this dimension, the use of a direct wage subsidy as part of a 'package contract' involving both consultant engineers and contractors will probably be preferable to any specific measure or combination of measures directed to raising the effective price of equipment. The wage subsidy will be appropriate to apply on a contract by contract basis while alternative measures will not. [24] Equally, there will be severe, if not insurmountable, difficulties in operating specifically on the price of equipment entering into substitution in road construction, as some items of key equipment referred to in the above analysis are used in other activities besides road construction.

The notion of the 'wage subsidy' is defined in general terms, and relates to the required transfer of financial resources from Government to private sector. Increase in private cost associated with a switch in technology can be expressed as a proportion of the total wage, that is, the subsidy (S) per unit wage can be written simply as:

$$S = (\Delta Lw' - \Delta Ec)/\Delta L$$

or: $$S = w' - \Delta Ec/\Delta L$$

where: ΔL: change in labour per unit output

ΔE: change in equipment per unit output

w': effective market wage

c : effective cost of equipment

While it will be useful to bear in mind that the subsidy element in the wage needs to be calculated at the margin and will gradually rise to the full amount of the wage, it will be more convenient to speak in terms of an average rate of subsidy. In the case of the Rezayeh highway, the figure corresponds to 71% of the effective wage. On the assumption that the Rezayeh case study can be treated as representative of all highway construction over the coming plan period, and on the further assumption that Government will consider switching

to the most labour-intensive methods of highway construction shown at the margin in Figure 4, some preliminary calculations can be made for total employment generation potential of Iran's highway programme over the coming Plan period, and total subsidy required.

Planned new highway starts to be completed over the Vth Plan period total some 2,900 km., at a total cost of Rls. 28,700 million. It is estimated that average annual extra employment from adopting maximum labour-intensive techniques in this sector alone would be 32,500 man-year equivalents, or just under 10% of average annual total open unemployment for the whole of Iran estimated for the Vth Plan period. The corresponding total average annual subsidy required to create this extra employment over the whole of the planned highway programme is Rls. 1253 millions, which adds approximately 22% to the average annual allocation for the 2,900 km. in question. This is equivalent to a financial cost to Government of approximately Rls. 40,000 per extra full year equivalent job created, a figure which contrasts favourably with correspinding financial costs of job creation in the modern industrial sector. [25]

The question of how best to finance the wage subsidy element implicit in the choice of a given strategy can only be considered here in very general terms. Although such a subsidy is, formally speaking, a transfer payment from public to private sectors, such a transfer will have repercussions on real resource use. A central principle applicable therefore to the choice of means of finance is that Government, having decided to encourage the adoption of a new factor mix in the road construction sector on the basis of some assessment of social price relatives as derived from the above analysis, should be consistent in applying the same basic principles of pricing to resource use in all sectors. The aggregate consumption values of equipment and labour have been shown to depend both on a set of judgements about inter-sectoral and inter-temporal distribution weights attached to consumption, and on derived estimates of sectoral savings propensities, the average yield on investment, the consumption cost of foreign exchange, etc. Whether Government will in practice realise the full amount of social savings derived on this basis depends, interalia, on whether present consumption and investment foregone in other sectors as a result of effecting a transfer of resources from Government to workers is the same as would result from a similar transfer from private entrepreneurs to workers. For this to be the case, Government would need to recover the full amount of the subsidy taxing the incomes of that class whose consumption carries a neutral weight carefully.

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Footnotes

1. It cannot be said a priori that the adoption of an alternative set of conventions - viz. the use of free foreign exchange (savings) in the hands of Government rather than consumption as numeraire as recommended in OECD (1968) or Little and Mirrlees (1974) - would lead to identical results. For a critical discussion of issues involved here, see 'Symposium on the Little-Mirrlees Manual...', Bulletin of the Oxford University Institute of Economics and Statistics, February 1972. Dasgupta's (1972) article in particular demonstrates that under particular conditions the two approaches will not necessarily lead to similar conclusions.

   A recent expert group meeting held by UNIDO and IADB (Washington, 28th March 1973) has concluded, however, that divergences between results generated by each method may not be as significant as originally thought.

2. The range so defined, it should be noted, encompasses the private commercial borrowing rate, and that the results of the analysis will not be at variance with those derived on the basis of the more conventional assumption that such a rate is the best available estimator of social time preference.

3. In the absence of the final English version of the Vth Plan, it has been necessary to rely on the national income account projections prepared by the ILO Mission. See ILO, (1973 b), Supplementary Volume C. These are supplemented by such Vth Plan statistics as were made available in English while the ILO Mission on road construction was in Iran.

4. See Iran Statistical Centre (1971), Rural Household Expenditure Survey, Teheran, 1971.

5. See P. Panikar 'An Essay on Rural Savings in India' in T. Shulka (1969) (ed.), Economics of Underdeveloped Agriculture, Bombay, 1969. Also A. Rosenthal (1970) 'Sources and Uses of Funds in Thai Agriculture', Economic Development and Cultural Change, April 1970.

6. Since Iran has largely resorted to tariff-based protection rather than quota restrictions and import licences, most domestic markets will be cleared at a price equivalent to the c.i.f. price plus the effective tariff rate. See: ECAFE, (1972), ILO (1973 b), Iran Plan Organisation (1973).

7. Indeed, the assumption that a unit of consumption is to be regarded as having the same value regardless of its distribution between classes implies the judgement that the marginal utility of additional consumption is constant.

8. The current official exchange rate of Rls. 67.50 to $1.00 has been used in this and all subsequent tables.

9. Note that maintenance has here been costed such that the non-discounted flow of expenditure over time rises in linear fashion, and is equivalent in total value to depreciation.

10. Let SAC_i and SC_i represent respectively the aggregate social value of consumption (i.e. allowing for savings/re-investment) and the social value of consumption (before allowing for savings/re-investment) for the ith sector. Then:

$$SAC_i = u_i SC_i$$

and: $u_i = \{(1 - S^i) + S^i p^{inv}\}$

where S^i is the marginal savings propensity of the ith sector, p^{inv} is the premium on investment, and u_i is derived as a conversion factor to be applied to SC_i.

11. Note that in the table shown all items have been broadly reorganised under two headings, 'Claims on Domestic Consumption and Investment' and 'Claims on Foreign Exchange'. The breakdown of expenditure flow by the major group to which it accrues is then shown under each heading separately. This allows a first set of adjustments ('social pricing adjustment' column) to be made in which corrections are applied for the valuation of foreign exchange and skilled labour. Then, immediately to the left of this column (under 'aggregate consumption adjustment'), the conversion factors set out in Table 5 are applied for each group respectively. Note that 10% of dealer markup (profits) is assumed to accrue to Government in the form of tax. Also note the treatment of 'duty' which is subtracted from the Private sector but added to the Government sector. Because of the differential marginal savings propensities of these sectors, transfers cannot be omitted entirely from the analysis.

1) The returns to the extra work involved, however, would need to be demonstrated to significantly affect the conclusions of the exercise.

12. Extra food costs are not counted as conferring an extra consumption benefit to the worker per se; extra housing costs are assumed to be net (i.e. no housing capacity is released in agriculture as a result of migration, a reasonable assumption as migration is of a relatively short-term nature). Supervision and administration costs are also net; that is to say, they take into account the release of such resources as substitution takes place for equipment. The skilled labour element in supervision is net in the sense that skilled labour has been included on both sides of the equation.

13. The use of this form assumes that:

(1) in addition to net agricultural production forgone, all costs of transfer are treated as claims on the migrant's current consumption and are net claims on society of a once and for all nature.

(2) One dollar's (Rial) worth of present savings is more valuable than one dollar's (Rial) worth of present consumption; i.e. there is a premium on investment.

(3) The adverse effects on investment of employing extra labour in road construction cannot be assumed to be offset by compensating Government fiscal policies, and therefore must be charged to the project.

(4) There is significant remittance out of wage income to the farm sector and thus both private capitalist and farm sector savings propensities are relevant to the calculation of future consumption claims.

(5) Though different sectoral savings propensities are calculated, no sectoral differentiation is made with respect to the premium on investment.

(6) A distinction is made between society's valuation of rural and non-rural aggregate consumption.

14. See, for example, G. Pfefferman (1968), Industrial Labour in Senegal, Praeger, 1968, p. 166; G.E. Johnson and W.E. Whitelaw, (1970), 'Urban-Rural Income Transfers in Kenya; an Estimated Remittances Function', IDS, Nairobi (mimeo), 1970.

    From Table 7, it will be noted that if the worker is assumed to equate retained earnings, $(1-r)w$, to his offer price, $w_a + (c-c_d)$, the respective values obtained are \$0.204 and \$0.200 per hour.

15. $c_a/c + (c_a/c + w_a/w_a) = 62\%$; this figure matches that given by Iran Statistical Centre, (1971) Rural Household Expenditure Survey, for proportion of food expenditure in total expenditure.

16. For item corresponding to each group (viz. I, A; II, K) see Table 6. For each operation, present equipment use (tonne hours per 10 km.) is shown. Items in brackets are equipment groups used under the labour-intensive technology. Values are quoted at market prices.

17. $2c = \Sigma 2a \div \Sigma 2b$. This 'weighted average' price now becomes the market price of equipment (c) appearing in Figure.

18. From the function given in Figure 3 can easily be seen the relative importance of different operations in contributing to employment creation. Earth cut and fill (A), laying of the primary road base (G), and rock and stone crushing (B) are clearly critical, all other operations for which labour can be substituted contributing relatively little to the total. But short and long distance transport of rock materials (F, E) using farm tractors and wagons appear to require relatively little extra labour per unit decrease in net equipment use compared to present methods, and so figure amongst the first operations for which it may be socially profitable to alter technology. 'Short distance' is defined as less than 150 meters, while the longest distance considered in the present case is 3000 meters. For very short distances, wheelbarrows have been assumed to be used; otherwise, a small farm tractor is ued in conjunction with two wagons one of which is loaded while the other is being used for transport.

19. f(N/month) is derived from f(N) by dividing through by the number of months' construction time needed per 10 km.

20. Thus, choice of a technology of construction generating total employment N^* implies values of θ_f of 1.02, 1.60, 3.20 and 3.56 corresponding respectively to the assumptions i = .15 (z = 0. z = w_a) and i = .10 (z = 0, z = w_a).

21. While this diagramatic form of presentation is a useful way of summarising key aspects of the study, it raises certain difficulties which need to be noted.

    Referring back to Figure 2, the aggregate isoquant from which the employment function in Figure 4 is derived it will be seen that what is being measured along the vertical axis at the '10 km. highway' level of aggregation is a bundle of equipment the composition of which changes according to which point on the isoquant is selected. Thus, one cannot speak of a unique 'price of equipment'. To get round this problem, a weighted average price of equipment entering into substitution over the whole range of the isoquant has been used. But, ideally, one would need to cost each point (or vertex) on the isoquant as a separate exercise.

22. High rates of tax on equipment use, or high tariffs on equipment import would ultimately be passed on to Government in the form of higher contract prices. QR's would also have the effect of raising market prices, and thus contract prices. In this case, however, it is likely that large contractors would almost certainly benefit at the expense of small contractors whose bargaining position for a place in the queue would be weakest.

23. In this respect, the use of 'labour only' contracts should be noted in the East African context; see ILO (1973 c), Employment Incomes and Equality, Geneva 1973 (Chap. II); also, E. Epstein and J. Monat, (1973), 'Labour Contracting and its Regulation', International Labour Review, May 1973.

24. It is difficult to see how tariffs or QR's could be made 'contract specific' unless an elaborate set of arrangements were made to allow some contractors to 'reclaim' extra costs in certain cases. Even so, the underlying principle at issue is whether subsidy is attached directly to factors, or directly to contracts.

25. Incremental Capital/Labour Ratios 1952-70 (Rls./job)

Whole Industrial Sector				Modern Sector	
	I		II		III
1962-64	60,553				
		1965	223,000		
1964-66	247,831	1966	250,000	1965	455,000
1966-68	411,524	1967	405,000		
		1968	403,000		
		1969	491,000	1968	989,000
		1970	949,000	1969	2,554,000

Source: ILO (1973 b).