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Motorway Investment and Regional Growth in Developed Countries

by

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THIS PAPER is concerned with the impact of major highway construction on regional development in developed economics. In Britain, at least, major road investments are currently appraised by means of the tool of cost-benefit analysis. Cost benefit analysis involves the estimation and valuation of all the social costs and benefits of a road project, to whoever they accrue, so that these social costs and social benefits can then be compared and discounted to yield the net present value, or the internal rate of return, of the project in social welfare terms. Maximisation of net present value will then maximise economic efficiency, though the project may also have equity implications which the policy maker may regard as desirable or undesirable.

Cost-benefit appraisal of inter-urban highway investments has been developed to a stage at which the benefits to the road users on the new highway and on the pre-existing road network can usually be measured. It is, however, sometimes alleged that major road investments will also give rise to further external and secondary benefits which ought to be included within the cost-benefit evaluation but which usually cannot be so included because of difficulties which arise in their measurement and valuation. Many of these so-called secondary benefits arise because of the nature of freight transport as an intermediate good, a factor of production used in the production of final goods. It is argued that the demand by hauliers for freight transport cannot accurately reflect the valuation of the finally produced goods by the economy. In particular, it is argued that transport investments will have an impact on the economic development of the regions which they serve which will generate further benefits over and above their benefits to traffic.

One attempted approach to the evaluation of such secondary benefits is that adopted by both Tinbergen, and Bos and Koyck,[1] who, employing arithmetical examples, attempted to calculate the increase in National Income which would follow a particular road investment in an imaginary economy. Making various assumptions about the demand and supply functions for the products they were considering, they both showed that the change in the value of output, or National Income, measured at final prices, would be greater than the conventional measure of benefits to existing and generated road traffic, as measured by the area under the demand curve for transport between old and new freight costs.

This may well be the case in practice, but it does not follow that the change in National Income correctly measures the change in welfare which results from the road investment. Before the investment we would have a certain pattern of relative prices and of production and consumption, so that National Income could be measured by

$$\sum_{i=1}^{n} p_1 q_1,$$

where the p's and q's are the initial prices and quantities of all the n goods in the economy entering into final output. If there is then a transport investment which lowers transport costs, then, assuming that some of the reductions in factor prices are passed on to consumers, there will be a lowering of some of the product prices within the economy and hence a reallocation of resources and redistribution of income, so that we will have a new set of relative prices and a new pattern of production. We could then multiply the new quantities of the products by their new prices to get a measure,

$$\sum_{i=1}^{n} p_2 q_2,$$

of National Income at final year prices; this could then be compared with

$$\sum_{i=1}^{n} p_2 q_1,$$

the measure of pre-investment outputs valued at post-investment relative prices. However, we are faced here with an index number problem, since there is no objectively correct set of relative prices which we can use to value the different bundles of goods which make up National Income before and after the investment. As a result of the investment, relative prices and the distribution of

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income within the economy will change, so that neither the pre- nor the post-investment prices are in any sense objectively "correct" indices of the weighting we should give to different goods in the valuation of National Income. It follows that we have no objective way of determining the change in welfare which follows a given change in our measure of National Income.

We can only measure welfare changes by abandoning the general equilibrium approach, and employing the partial equilibrium tool of consumers' surplus. For private travel between two points, A and B, consumers' surplus can be measured by the area under the demand curve for travel between A and B. This measures the maximum amount of money which all travellers together would be prepared to pay, given their existing income levels, rather than forego travel between A and B completely. Similarly, for freight transport, the area under the demand curve for freight transport between A and B will indicate the maximum amount which consignors of goods would be prepared to pay rather than cease to consign goods between A and B. The demand for freight transport arises because of final demands, and associated consumers' surpluses, by consumers of the final products which the transport is used to produce. In consequence, the demand for freight transport is a derived demand. It can be shown that, in a world of perfect competition, the area under the derived demand curve for freight transport accurately reflects the value of the transport to the community in producing final goods.[2] It follows that, in this type of world, if we wish to measure the net level of benefits of a road investment to the community as a whole, we can do this by accurately measuring the transport user benefits to both existing and generated freight and passenger road users.[3] This is the approach currently adopted by the British Department of the Environment.[4]

In a non-perfectly competitive world, problems of second best arise.[5] However, there seems to be no feasible way of taking account of this particular aspect of a problem which applies to all applications of cost-benefit analysis. In Britain, but less so elsewhere, the road haulage industry does approximate in many ways to the perfectly competitive model, and so the approach seems more justified than it might do in other developed economies. However, it is very difficult to see what alternative approach could be adopted in practice to the measurement of benefits of transported goods where the road haulage industry is not competitive, and, in the absence of contrary evidence that such a method under- or over-states final benefits, it seems reasonable to continue to use it.

Thus, if we are concerned only with the net level of benefits to the community as a whole, then these benefits can be measured accurately purely by measuring the traffic benefits. One difficulty in doing this is in predicting the impact of transport improvements on generated freight traffic. There would seem to be two possible ways in which reduced transport costs might increase freight traffic levels;

(a) Lower transport costs might cause firms to substitute transport for other inputs.[6] Thus, if there are economies of scale in production, a transport cost reduction might cause firms to locate their plants further apart than before in order to take advantage of reduced distribution costs. Although this process might have some relevance for trades like wholesale distribution, its application elsewhere seems rather limited because of the very high costs of relocation in relation to transport cost changes.

(b) Transport costs have been traditionally stressed in location theory, and if we accept that transport costs are a significant determinant of differences in regional growth rates, then a reduction in transport costs between two regions will give these two regions a relative advantage over all other regions, and hence cause them to grow faster. It follows that if output and employment are growing relatively fast, so too will be freight transport, since there appears to be a close relation between output or employment levels and freight traffic volumes. Thus, if we can derive a relationship between changes in transport costs and changes in regional growth rates, we might be able to gauge the importance of this generated traffic element.

There are, however, two, more important, reasons why the investigation of such a relationship between changes in transport costs and regional growth rates would be fruitful;

(a) From a planning point of view, it is important to be able to predict the future growth of employment, population, etc. in an area in order to be able to plan for future housing, education, local transport, and other needs in that area.

(b) Governments may be concerned not only with the net level of benefits from an investment project, but also with the distribution of benefits between the different regions of the country. This is certainly the case in Britain, where the Development Area policies have attempted to stimulate growth and reduce unemployment in the less developed areas of the country. If road investment

is held to be an instrument of regional development policy, then it is important that more knowledge be gained of what the effects of such investment on regional growth rates are.

Thus, what we have argued in this section is that the net level of benefits of highway investments can be measured by a correct evaluation of the traffic benefits to the passenger and freight users of the highway (allowing also for repercussions on traffic on other roads). However, this does not mean that highways will not have effects on the relative growth rates of the areas through which they pass, and the second half of this paper will be concerned with the possible effects of one such road, the British M62 motorway, on industrial transport costs and employment growth in the areas through which it passes or will pass.

A Case Study: The British M62 Motorway

The M62 motorway will eventually run across Northern England from the West Coast at Liverpool to the East Coast at Hull, linking the conurbations of Merseyside, South East Lancashire, West Yorkshire and Humberside. The existing section runs from Eccles near Manchester over the Pennine Hills to Lofthouse, near Wakefield. For our purposes we have divided Northern England into 30 separate zones, with a minimum employment size of 40,000.

Industrial Transport Costs

We first consider the measurement of the transport costs which will be incurred by firms located in our zones of the North of England. These can be measured by a term known as access cost, which is an index of the average cost of freight transport for an area's industries.

The access cost of any area i is a measure of the probable average costs of transporting a given quantity of freight to or from that area. This average cost will be a function of the freight transport costs to each of the other areas, muliplied by the probability of the consignment originating or terminating in each of these areas. Thus, we can write access cost in area i, Ci, as equal to:

$$C_i = p_{i1}\,c_{i1} + p_{i2}\,c_{i2} + \cdots + p_{in}\,c_{in} = \sum_j p_{ij}\,c_{ij} \qquad (1)$$

where p_{ij} = the probability that the trip will be to, or from, area $j (\sum_j p_{ij} = 1)$

c_{ij} = freight transport costs between areas i and j for a given sized consignment.

The form of the probability function can be derived from the gravity model, i.e., we assume that inter-zonal freight flows can be explained by a model which takes the form:

$$T_{ij} = G\frac{E_i E_j}{c_{ij}^{\alpha}} \qquad (2)$$

where T_{ij} = freight flow between zones i and j

E_i, E_j = total employment in areas i and j respectively

G, α = constants found in the calibration of the model

Thus, it follows that:

$$p_{ij} = \frac{T_{ij}}{\sum_j T_{ij}} = \frac{G\frac{E_i E_j}{c_{ij}^{\alpha}}}{\sum_j G\frac{E_i E_j}{c_{ij}^{\alpha}}} = \frac{\frac{E_j}{c_{ij}^{\alpha}}}{\sum_j \frac{E_j}{c_{ij}^{\alpha}}}$$

So therefore access cost for area i, C_i, is given by:

$$C_i = \sum_j \left[\left(\frac{\frac{E_j}{c_{ij}^{\alpha}}}{\sum_j \left[\frac{E_j}{c_{ij}^{\alpha}} \right]} \right) c_{ij} \right] = \sum_j \left[\frac{\frac{E_j}{c_{ij}^{\alpha-1}}}{\sum_j \left[\frac{E_j}{c_{ij}^{\alpha}} \right]} \right]$$

Hence equation (4) gives us the probable average transport costs involved in location at point i.

Access costs were estimated for our 30 zones of the North of England. For this purpose the remainder of Great Britain was divided into a further 36 areas covering the rest of the country. The inter-zonal transport cost function used took the form:

$$C_{ij} = a + b\sqrt{d_{ij}} \qquad (5)$$

where C_{ij} = cost of transporting a 1 cwt. consignment of a 'neutral' commodity between zones i and j

d_{ij} = road distance between zones i and j

a, b = constants

This function was regarded as giving the best approximation to actual inter-zonal freight transport costs. Since values of the impedence exponent, α, vary from study to study, the access cost indices were computed with alternative values of α lying between 1.0 and 3.0. Subsequently, it was found that changing the value of the exponent had practically no effect on the relative rankings of access cost values in the different zones.

Access costs were initially computed for our 30 zones using the inter-zonal cost function described above. This gave us pre-M62 access costs for each zone.

We then adjusted each inter-zonal transport cost by the percentage fall in that cost which would result from the construction of the M62, and re-computed the access cost in each zone to derive post-M62 access costs for each zone. This enabled us to compare pre- and post-M62 transport costs for each area, allowing for the diversion of trips so as to substitute lower cost M62 trips for relatively higher cost trips to areas unaffected by the construction of the M62. Thus, if we assume that the cost exponent, α, has a value of 1.8, we can consider the probable impact of the M62 on transport costs in different zones by reference to table I. This indicates the pre-M62 and post-M62 access costs, and the proportionate fall in access costs due to the M62, in each of our 30 areas.

The percentage fall in access costs is greatest in Huddersfield (—3.65%) with Bradford next (—3.59%). Transport costs might also be expected to fall by more than 3% in Dewsbury and Rochdale. They could be expected to fall by between 2.5% and 3% in Warrington, Wigan, Liverpool, Oldham, Ashton, Halifax, Leeds, and the Five Towns; by between 2% and 2.5% in Bury, Leigh, Wakefield, and Birkenhead; by between 1.5% and 2% in Manchester, Stockport and Bolton; and by less than 1% in Preston and Blackpool.

From these results the areas which can primarily be expected to gain from reduced transport costs are those closest to the M62 in West Yorkshire, namely Huddersfield, Dewsbury and Bradford, together with Rochdale in Lancashire. The next group of areas to gain, but by rather less, are those areas close to the M62 but located towards either end of it; i.e., Liverpool, Warrington and Wigan in the West, and Leeds, Halifax and the Five Towns in the East, together with Ashton and Oldham. Many areas in South East Lancashire, which might be expected to gain most from the M62 because of their position near its centre, are in a half-way category, with gains of cost reductions of between 1.5% and 2.5%. Finally, the areas with most difficult access to the motorway, i.e. Preston and Blackpool will, as would be expected, gain least (apart from those areas more or less completely unaffected by the M62).

It seems from this analysis that the areas in West Yorkshire will gain relatively more from the M62 than will the areas in Lancashire. This means that the relative advantage from the transport cost point of view of the latter areas in South East Lancashire will be relatively diminished, though by no means fully eroded. It should also be noted that the percentage reductions in transport costs are not large. If, on average, transport costs represent 9% of the value of net output of manufacturing industry in Great Britain, as has been suggested recently by S. L. Edwards,[7] then a 3.5% reduction in transport costs in Huddersfield would represent a reduction in total costs of manufacturing output in that area of the order of ⅓%. Total costs would be reduced by smaller percentages than this in all other areas.

Transport Costs and Regional Growth

In the previous section we looked at the impact of the M62 motorway on industrial transport costs in the area through which it passes. These changes in transport costs can, accepting conventional location theory, be expected to change the different areas' comparative advantages, and thereby affect the relative rates of growth of output and employment in these areas. The difficulty is, of course, in deriving a statistical relationship between transport costs and regional economic growth, particularly because of the multitude of factors affecting relative growth rates in different areas. For the North of England we developed a model relating employment growth in each of our 30 areas to access costs, and to other variables intended to reflect the relative strength of the demand for labour in different areas. Our index of employment growth was intended to reflect the interaction of the demand by firms for labour, and the supply available.[8] We give this index the term "attractiveness."

For each area, i, attractiveness, A_i, was regressed against access costs, C_i, an index reflecting the quality of the area's industrial structure, S_i, and a density dummy, D_i, intended to reflect the effects of congestion in the largest urban areas.[8] The resultant relationship for access costs with a cost exponent, α, of 1.8 was:

$$A_i = -0.51 + 0.60S_i - 6.84D_i - 0.18C_i \qquad (6)$$
$$(2.97)\ (-2.57)\ (-2.24)$$
$$F = 4.34;\ r^{-2} = 0.26;\ CD = 0.80$$

The signs of the independent variables in the equation conform with theoretical expectations. S_i, structure, has a positive effect on growth; areas with better structures grow faster. The sign of the density variable, D_i, is negative, indicating a relatively low rate of growth in the very high density areas. Access cost, C_i, has the expected negative sign, indicating faster growth with lower transport costs.

The overall equation is significant at the 97.5% level, but not at the 99%

level. The individual industrial structure and density variables are significant at the 99% level, and the access cost variable is significant at the 97.5% level.

The value of r^{-2} is low, at 0.26.

This result would appear to indicate that, considering the overall employment growth of each area, transport costs do appear to have some influence on relative rates of employment growth. However, most of this influence in the model which has been described was due to a relatively small number of areas, on the periphery of the industrial North of England, which appear to suffer from locational disadvantages because of relatively high transport costs.

Given that the relationships between employment growth and access costs which were derived are not strong, the empirical analysis which follows is intended to indicate an approach to the study of motorway impact which would be more legitimate with better quality data and statistical results. The actual numerical results which are presented may, however, suggest the most probable maximum orders of magnitude of employment change on the basis of present knowledge.

Putting equation (6) in the first difference terms, and assuming industrial structure, density, and the natural increase of the working population,[9] are constant, we can derive a relationship between changes in an area's access costs and changes in its rate of growth of employment, i.e.

$$dE_i = -0.18dC_i \qquad (7)$$

where dE_i = change in area i's percentage growth rate of employment

dC_i = change in area i's access cost

Changes in each area's access costs as a result of the M62 were discussed above. Using equation (7), they can be used to derive changes in each area's rate of growth of employment, and hence changes in each area's absolute employment levels, as a result of the construction of the M62. These changes in absolute employment levels (over a five year period) are shown in column (4) of Table I.

This approach to employment growth rate changes, however, would imply that if a motorway network were built throughout the country, so that access cost fell in all areas, then employment growth would be faster in all areas as a result. Although anything which improves a country's international competitiveness might increase the national growth rate, and thereby reduce the net outflow of population by emigration, it seems more reasonable to assume that total employment in the whole country will be invariant with respect to changes in areal transport costs. In these circumstances, we might regard the employment growth figures in Table I as representing absolute maximum changes. Even so, the figures do not appear large; a maximum additional increase in employment of about 2,900 per annum in a region with a total employed population of 3,400,000 does not appear very great.

In addition, the employment increases are those due solely to the M62. Thus, we might expect some of these expected employment increases in our area due to the M62 to be counterbalanced by the effects of the construction of other motorways which increase other areas' locational attraction.

Finally, it will be clear that one serious problem with this type of model is that it is not directly testable. We are not attempting to predict the actual employment growth in an area over a period of future time, which we will eventually be able to observe ex post, but the most probable change in an area's employment due solely to a particular change in that area's relative position in the transport network.

We now briefly consider the framework for the valuation of the effects of a transport investment on regional development. A conventional cost-benefit appraisal of an investment project will sum all monetary benefits, to whoever they accrue, to yield the net present value of the project. This involves an implicit acceptance, both of the existing distribution of income, and of any changes in income distribution which the project itself may create. Alternatively, several writers have suggested that we should apply a system of weights intended to reflect different valuations of gains to different groups within society. In a regional context we might weight income gains to low income regions higher than gains to more prosperous regions. In addition, Governments may specifically have employment objectives so that we might also wish to weight income gains, and employment gains, in a particular region separately.[10] Any gain in employment in a given region, as a result of a transport investment, could then be weighted by a weight reflecting the Government's valuation of employment increases in that particular region. It might be possible to observe such weights by looking at past Government expenditure on regional policy, and its employment generating effects, though clearly there is a danger in so doing which may arise when Governments' expectations about the effec-

TABLE I
THE EFFECT OF THE M62 MOTORWAY ON ACCESS COSTS AND EXPECTED EMPLOYMENT GROWTH

Area	(1) Pre-M62 access costs (new pences)	(2) Post-M62 access costs (new pences)	(3) Percentage change in access costs %	(4) Expected employment increase due to the M62 (five yr. period)
Leeds	97.5	95.0	—2.56	1406
Bradford	97.5	94.0	—3.59	1547
Wakefield	96.5	94.5	—2.07	258
Halifax	96.5	94.0	—2.59	490
Huddersfield	96.0	92.5	—3.65	657
Dewsbury	97.0	94.0	—3.09	566
Five Towns	99.0	96.5	—2.53	274
Barnsley	96.5	96.5	0	0
Sheffield	96.0	96.0	0	0
Doncaster	98.5	98.5	0	0
Stockport	94.0	92.5	—1.60	199
Ashton	94.0	91.5	—2.66	336
Oldham	94.0	91.5	—2.66	500
Rochdale	95.0	92.0	—3.16	365
Manchester	92.0	90.5	—1.63	2244
Bury	94.5	92.5	—2.12	221
Bolton	95.0	93.5	—1.58	389
Leigh	96.0	94.0	—2.08	279
Wigan	96.5	94.0	—2.59	358
Warrington	95.5	93.0	—2.62	382
Blackburn	99.0	99.0	0	0
Burnley	99.0	99.0	0	0
Preston	100.0	99.0	—1.00	229
Blackpool	106.5	106.0	—0.47	149
Barrow	119.0	119.0	0	0
Lancaster	106.5	106.5	0	0
Liverpool	97.5	95.0	—2.56	3288
Birkenhead	98.0	96.0	—2.04	476
Workington	121.5	121.5	0	0
Carlisle	116.5	116.5	0	0

Note: Access cost measures the cost of transporting 1 cwt. of a "neutral" commodity from each area, weighted by the probable destinations of the consignment derived from the gravity model function with an impedence exponent, α, of 1.8.

tiveness of their regional policy measures prove to be incorrect.

Conclusions

We can now attempt to summarise some broad conclusions which arise from this paper. If we are concerned only with the net level of benefits from a transport investment to the economy as a whole, then these will be correctly measured by a correct evaluation of the traffic benefits of the project. However, major transport investments may be expected to have an effect on the regional distribution of benefits by influencing differential regional growth rates. Our study of a particular major highway investment indicated, however, that the impact of this investment on the total costs of manufacturing production would reach only ⅓% of such total costs in one area, and would be less in other areas. An attempt to relate areal employment growth rates to transport cost differences was only partially successful; but there appears to be some relationship between transport costs and employment growth. Finally, if we assume that the employment growth model is valid, the maximum increases in employment in the areas affected by the M62 do not appear to be very great. This would appear to indicate, as has been suggested elsewhere,[11] that the effectiveness of transport policy in stimulating regional growth may be somewhat limited and uncertain in relation to other, more direct, regional policy measures.[12] It should be noted that this conclusion relates to developed economies; it may well be the case that in developing countries, where transport facilities are inadequate, lack of transport facilities may provide a bottleneck to regional or national growth.[13]

More work is clearly needed to back up these interim conclusions. The employment growth model is an aggregated model. In practice, different industries will be affected differently by transport

cost differences, and so the broad averaging of the model discussed briefly in this paper may have concealed important effects. However, once we attempt to predict employment growth, sector by sector, in each area, we will experience considerable problems arising from the interaction of the demand for labour in each sector with the total supply available in that area. In addition, statistics of employment at the local level in Great Britain are somewhat inaccurate when disaggregated. This makes development of a more complex (and more realistic) model rather difficult; in the meantime, the broad overall approach may provide some useful pointers.

APPENDIX

A Model of Employment Growth

In any area, the growth of employment over a period of time will be determined by the interaction of the demand by firms for labour and the supply available. The growth over time in the demand for labour is likely to depend on such factors as the quality of the area's industrial structure, the relative transport cost advantages of the area, the availability of land, and the possibility of agglomeration economies or diseconomies. Growth of supply is likely to depend on the natural increase of the population of working age, and on changes in net migration, commuting patterns, activity rates and unemployment rates. These two factors, of demand and supply, interact to produce actual employment growth; e.g. an increase in labour demand will cause firms to offer relatively high wages, and so will increase in-migration and/or commuting into the area.

A number of empirical studies of the factors affecting the location and growth of industry in Britain have argued that labour supply has been a major constraint to employment growth within a region. We therefore proceed by assuming that employment in an area will grow at least as fast as the natural increase of the working population in that area, and then consider actual divergeences from this "expected" employment growth rate. In other words, we take the availability of labour as the most important factor influencing employment growth, and then consider other factors which might also influence growth rates.

The overall employment change in an area over a given time period can be split into a number of component parts; i.e.

$$\triangle E = \Sigma_i a_i \triangle P_i + \Sigma_i a_i M_i + \triangle C + \Sigma_i \triangle a_i P_i + \triangle U \qquad (8)$$

where $\triangle E$ = total employment change in the area

a_i = base year activity rate for age/sex group i

$\triangle P_i$ = natural increase in population in age/sex group i

M_i = net migration into or out of the area of age/sex group i

$\triangle C$ = net change in commuting to or from the area

$\triangle a_i$ = change in activity rate for age/sex group i

$\triangle U$ = net change in numbers unemployed.

The term $\Sigma_i a_i \triangle P_i$ is the natural increase in the working population of the area (to be termed the "expected increase" in employment), and the value of this term can be predicted in advance from the base year population figures for each age/sex group, and from activity and death rates. If we assume that firms in the area will employ all the available labour in this area at the existing wage rate, then all of this "expected increase" would be employed. However, if an area is in a relatively favourable position from the point of view of economic growth, then it can be assumed that the consequent pressure of firms' demand for labour will be reflected in the local/national wage ratio. If the local/national wage ratio has a value greater than one (e.g. because the area has a high proportion of its employment in industries which are nationally fast-growing, and consequently high-wage, industries, or because the area has lower transport costs so that firms are prepared to pay relatively high wages to attract labour), then we can expect this to increase the supply of labour to the area via increased in-migration and inward commuting so that there will be additions to total employment above the expected natural increase. On the other hand, if the area is less attractive to firms than other areas, then the local/national wage ratio will be less than one, and some of the expected natural increase in the working population will be lost to other areas. It follows that the term:

$$\triangle E - \Sigma_i a_i \triangle P_i = \Sigma_i a_i M_i + \triangle C + \Sigma_i \triangle a_i P_i + \triangle U \qquad (9)$$

will be the employment change due to the relative intensity of demand for labour in that area vis-a-vis other areas (i.e. if the term is positive, it indicates that demand for labour in the area is causing net in-migration and increased commuting to the area, and is persuading or enabling those not employed to enter the labour market from the pool of inactive or unemployed persons). This is the index of the strength

of labour demand in an area, expressed as a percentage of the area's base year employment and given the label "attractiveness," which was used in this paper.

Industrial Structure

The index of industrial structure which was used to indicate whether a particular area had a relative high or low proportion of its employment in nationally fast growing industries took the form:

$$S_i = \Sigma_K W_{Ki} g_K$$

where S_i = index of quality of industrial structure in area i

W_{Ki} = proportion of total employment in area i in industry K

g_K = percentage growth or decline nationally of employment in industry K

Congestion

A dummy variable was used to represent density, which in turn was intended to represent the influence of agglomeration diseconomies in congested areas. The two highest density areas, Liverpool and Manchester, were given a value of 1.0, and other areas a value of zero.

FOOTNOTES

1 J. Tinbergen, "The appraisal of road construction; two calculation schemes," Review of Economics and Statistics, August 1957; H. C. Bos and L. M. Koyck, "The appraisal of road construction projects; a practical example," Review of Economics and Statistics, February 1961.

2 See: J. S. Dodgson, "External effects and secondary benefits in road investment appraisal," Journal of Transport Economics and Policy, May 1973; D. M. Winch, "Analytical welfare economics," London, 1971, see pp. 154-6.

3 Where the transport investment brings into use resources which were formerly unemployed, these resources should be treated as having zero opportunity costs.

4 See, G. A. C. Searle, "COBA; a computer programme for the economic assessment of road schemes," Traffic Engineering and Control, December 1972.

5 R. C. Lipsey and R. K. Lancaster, "The general theory of second best," Review of Economic Studies, 1956.

6 H. Mohring and H. Williamson, "Scale and 'industrial reorganisation' economics of transport improvements," Journal of Transport Economics and Policy, September 1969.

7 S. L. Edwards, "Transport cost in British Industry," Journal of Transport Economics and Policy, September 1970.

8 For a discussion of these indices, see the appendix.

9 See the appendix.

10 For an attempt to do this see C. B. McGuire and H. Garn, "The integration of equity and efficiency criterion in public project selection," Economic Journal, December 1969.

11 See; A. Peaker, "Transport policy and regional development," Bankers Magazine, November 1971; M. R. Straszheim, "Researching the role of transportation in regional development," Land Economics, August 1972.

12 See B. Moore and J. Rhodes, "Evaluating the effects of British regional economic policy," Economic Journal, March 1973.

13 For case studies of this type see G. W. Wilson, et. al. "The impact of highway investment on development," Brookings Institution, 1966.