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REGIONAL PLANNING AND AN APPLICATION OF LINEAR PROGRAMMING METHODOLOGY

A ROBSON

UNIVERSITY OF DURHAM

THESIS SUBMITTED FOR THE DEGREE OF MASTER OF ARTS, 1974

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ABSTRACT

The thesis* demonstrates an application of linear programming methodology for use in regional and sub-regional (structure) planning. This proposed use is in response to observed deficiencies of analysis considered to exist in those studies and strategies produced so far. These are mostly concerned with the financial and real resource aspects of plan making with special reference to the public sector provision of new infrastructure.

Introduction Presents a brief background of the present regional planning organisation and their responsibility for producing studies and strategies.

Chapter 1 Looks at the Regional Role in the control and allocation of Public Expenditure with special reference to the framework of advice from central government as to how regional bodies should take into account the resource implications of regional studies and strategies.

Chapter 2 Introduces some theoretical aspects on what constitutes a preferred strategy and examines the general form and content of studies and strategies so far produced in the context of these theoretical considerations and the advice from central government referred to in the previous chapter.

Chapter 3 Discusses a role for linear programming in strategy making and sets out the basic premises for its use. Previous uses of LP in planning are referred to with special reference to the problem of suitable objective functions.

Chapter 4 Describes the constructions of an LP matrix and, in some detail, how the estimates of the matrix coefficients were derived.

Chapter 5 Discusses the use of the model for planners, examines its achievement in relation to the requirements of Chapters 1 and 2 and presents examples of output from runs of the model.

Chapter 6 Suggests further development work required to bring the model up to full operational status.

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INTRODUCTION

In 1965 a quickening interest in the need for effective regional policies to counteract the growing disparities between parts of the United Kingdom led to the recognition that these very differences of problems and potential required long-term economic and physical strategies for each planning region. [1] To do this new planning machinery was created. In each region the work of government departments, each with specific functions, was provided with co-ordinating machinery in the shape of the Regional Economic Planning Boards. It was also considered desirable to have available the advice of a body of people in each region outside the Government service, with knowledge and experience relevant to all the main sections of the region's life, and this was provided by the setting up of regional Economic Planning Councils. From 1965 to 1969 the overall responsibility for coordinating work on regional planning lay with the Department of Economic Affairs, from 1969-70 with an enlarged Ministry of Housing and Local Government and, since 1970, with the Department of the Environment.

During their existence the planning work by the councils and boards has formalised into :-

i. giving ad hoc advice on the impact of national government decisions on the region and its parts. This has usually been concerned with capital spending but has also included employment, the distribution of industry etc.

ii. Identifying particular regional problems and making appropriate recommendations to central government.

iii. Bringing together central government interests and local authority structure planning by the production of regional studies/strategies.

iv. Giving a technical service to local planners by making forecasts and analysing data which are best handled at a national and regional level.

It is with function iii that this paper is mostly concerned. The first wave of regional studies produced hurriedly in the sixties [2] were mainly concerned with identifying the characteristics, potentialities and problems of each region and were in no sense plans or even strategies i.e. central government was presented with a "shopping list" of areas on which action was required with little attempt at determining priorities or appraising resource aspects.

The analytical base of these studies was invariably rudimentary involving little more than the collection and collation of information about each region's needs and problems. They were however to provide an essential data base for subsequent work on the production of regional strategies whose aims were more ambitious. These regional strategies were regarded as the proper output from a regional study and were commonly viewed as having three purposes. [3]

i. To set out a realistic assessment of the best use, in regional terms, of the resources likely to be available and related to the range of issues (generally combining economic, environmental, physical and social perspectives) which should be looked at in a regional context.

ii. To set a context within which local planning authorities could frame structure plans and

iii. To provide a framework for major decisions on investment and development by central and local government and public corporations.

To date three regional strategies have been produced; for the South-East and West Midlands Region and North-West Region.[4] One is in course of preparation; for East Anglia, and a further one is being set up in the Northern Region. The commissioning authorities for strategies are central government represented by the Department of the Environment (whose regional director is also chairman of the Planning Board), the Economic Planning Council and the Planning Authorities' Standing Conference. It should be realised that the central and local government support for strategy-making does not necessarily imply an automatic translation of subsequent strategy proposals into executive action. In fact the strategy body performs an agency role with advisory functions only, and strategy making is, at present, an exercise in indicative planning.

Implementation of proposals is a matter for central and local government in the exercise of their statutory and planning functions. In this context, evidence is hard to find of regional studies or those strategies produced so far having affected central and local decision-taking in a manner commensurate with the effort of their production.

To find out why, it would be useful as a first step to consider the advice given by central government to the regional and local authority level planning bodies on the production of plans and to compare this with the form of the studies and strategies which have followed. Leaving aside physical planning and control aspects, which are not the concern of this paper, this advice had invariably concentrated on financial and real resource considerations. The conceptual lineage for the strategy and structure planners' brief in considering the "best use" of resources can be traced back to the recommendations of the Plowden Committee and the subsequent setting up of the Public Expenditure Survey Committee Procedure.

CHAPTER 1

THE CONTROL AND ALLOCATION OF PUBLIC EXPENDITURE AND THE REGIONAL ROLE

In 1961 the Plowden Committee [5] stressed the value of using the aggregate of expenditure as a basis for efficient decision making. "Regular surveys should be made of public expenditure as a whole over a period of years ahead and, in relation to prospective resources, decisions involving substantial future expenditure should be taken in the light of these surveys". A similar statement was made by the Chancellor of the Exchequer in the same year. "We need increasingly to look at all public expenditure together instead of piece-meal and to look at it for a period of years in relation to prospective resources". [6]

In accordance with the recommendation of the Plowden Report, annual surveys of public sector expenditure have been taking place since 1961. These are conducted by the PESC procedure whereby information is provided about the estimated cost of carrying out the government's policies for five years ahead and at the same time an assessment is made of the likely economic growth and of demands which will arise from exports, private investment and private consumption. It is then possible for the forecast public sector expenditure to be examined and, if need be, modified in relation to other likely demands on available resources.

Once the total has been fixed, decisions are taken on the levels of the resources to be allocated to each service, given the government's social and economic priorities. Where necessary, adjustments are then made in the forward plans of the responsible department to accommodate the alterations in the resources available for its programmes. The way in which my particular changes are implemented depends upon current priorities for expenditure within the programmes. The determination has been a national decision and has been necessarily related to the way in which the national economy is developing.

Similarly, changes in the levels of major individual programmes (e.g. roads, education) have been national decisions and have been taken by the Government in the light of its own view of relative national priorities.

The Regional Role

In 1966 a new dimension was added to the process when the Regional Economic Planning Councils were invited to advise the Government on the regional considerations which apply to the Government's proposals for future public investment. To aid them in this task the Councils have been supplied annually with regional figures of past and forecast public expenditure for new building and construction, the forecast covering a five year period. In this way they have been made aware of the general lines of public sector development with the region. They have been able to take it into account in the development of their planning and to comment both upon the priorities within the region for future investment and upon the economic effects on the region of the projects to which the planned expenditure related.

This has not involved a scrutiny of the expenditure by individual local authorities, which it is the local authority's responsibility to coordinate, but it has involved taking a broad view of the pattern within the region. The emphasis within this broad assessment and the factors which needed to be given particular weight were matters for each Planning Council to decide for itself in the light of the stage it had reached in developing a regional strategy.

However the data possessed some major limitations :-

a. The forecasts were, and are still, based on a five year forward look. For many capital programmes this period is relatively short. It takes at least 5 years to plan and develop major schemes such as road improvements, new hospitals etc. Thus if economic implications of the expenditure programmes for the kind of project are to be properly studied they need to be examined in relation to the longer planning and development period than 5 years.

b. None of the planning associated with the expenditure forecasts had any direct connection with the population of the region and therefore did not reveal the nature of the economic strains to which a region is subject. (In general terms a region with a rapidly growing population experiences different strains from one with a less rapidly growing or static population. There are, for example, greater demands in the former for, say, housing and education to meet the requirements of the population.)

c. The share which is borne by the private sector is thus important to the planning of the region, not only in relation to the provision it makes towards meeting the regional needs, but also in regard to the fact that it competes for the resources of the construction industry. The fact that no forecasts of private investment in new construction and works were given was a severe deficiency for analytical purposes.

Nevertheless within the limitations the Councils were asked to give consideration to the following questions :-

a. Within the region, what are the respective contributions which could best be made by public and private investment?

b. What are the construction industry implications for the region of the current and forecast levels of public investment?

c. Given that phasing of public investment is inescapable, do the programmes achieve the best value for money, or could some alternative phasing of the existing resources available to the region be expended with better effect?

d. What will be the long term consequences for the region of the existing programmes?

e. Could the distribution between the different programmes of new works be improved?

The usual Treasury homily was invariably added that because resources were limited the search for better value for money becomes essential and demands for additional expenditure unrealistic.

The account above reflects the knowledge gained by the candidate as a working member of the Planning Council staff and which is not generally available in any publication. However there is a more overt source of advice on financial and real resource planning available through the Department of Environment's advice to structure planning authorities on structure plan production. Since one function of a regional strategy is to provide a context for structure plans then the advice should parallel that given to regional bodies. Since the demise of the DEA the role of the EPC's has become more blurred and therefore the advice given to structure planning authorities gives a current indication of central government thinking.

Central government advice to structure planning authorities is contained in the development plan manual and structure planning advice notes issued to the authorities from time to time. [7] The following are extractions from them.

SPN 6/72 indicated that in the documentation (of the plans) the DOE would need to have material prescribed so that it could be satisfied that :-

"The priorities for investment between major programmes are appropriate for the area"

and in SPN 9/72

"significant relationships between major expenditures in different sectors"

be taken into account, and further :-

"The use a local planning authority propose to make up resources will be reflected in the policy and general proposals they put forward in their plan and will amount to a decision not to use those resources in other ways; their plans will need to take account of the costs inherent in the policy and proposals selected in preference to other possibilitities considered over the relevant period of time. The plan should therefore provide an occasion for local planning authorities to bring out the order of priorities and the grounds for it".

The advice so far has concentrated on the evaluation of alternative strategies and proposals and the best use of resources as opposed to the way in which local authorities should assess priorities for investment between major programmes i.e. between transport and education. To date no local authority has attempted to look at resources in this way.

Advice given in the Development Plan Manual makes the following points :-

- "The Minister and the public will need some measure of the feasibility of the structure plan to see if it is realistic in the light of constraints imposed by the likely availability of resources and to see if it makes the most efficient use of those resources".

- "The Minister will wish to examine the implications of the plan in general terms. It should contain, therefore, an explanation of the methods used to examine the economic and financial viability of the plan, and how the authority have resolved the conflicting demands for resources .....".

- "In addition the report should provide a financial estimate for the main headings of the plan for the ten years following submission. Although particular attention should be paid to the key aspects of public investment in the plan such as housing, highways, education etc the programme should not be limited to finance but should cover other relevant features including changes expected during the period in, for example, population, employment and the availability of constructional manpower. The purpose of the ten year programme is to aid the assessment of the feasibility and soundness of the plan, particularly in terms of comparisons with past trends and broad estimates of future resources."

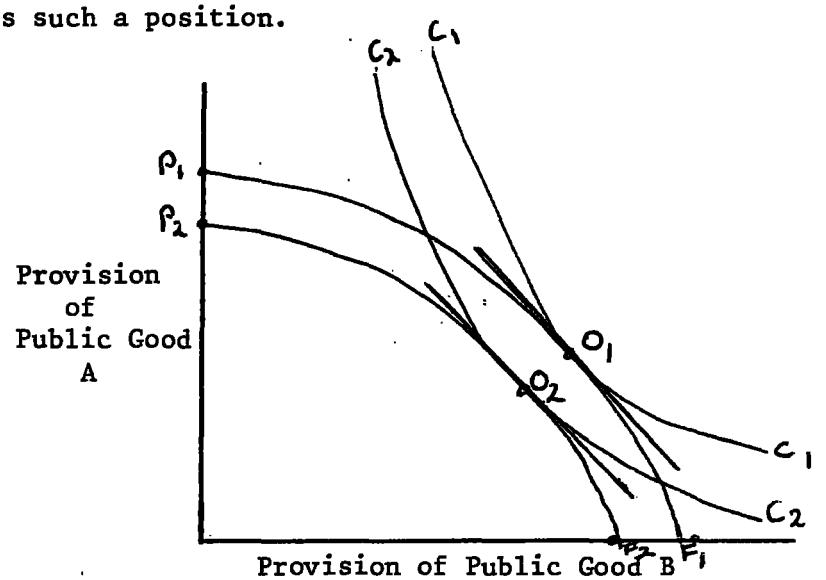
The requirements of the Development Plan Manual and associated SPN's are very clear; and when linked to the advice given to EPCs for regional strategy-making it becomes clear that central government can be specific about what strategies and structure plans should be required to do in testing the financial and real resource feasibility of their proposals. However there is a conspicuous lacuna regarding advice as to the appropriate methodological procedures and the obvious data difficulties. This has been reflected in the form of the studies and strategies submitted. The next section considers the form of these studies and strategies produced.

CHAPTER 2

THE FORM AND CONTENT OF REGIONAL STUDIES AND STRATEGIES : SOME THEORETICAL CONSIDERATIONS

Before comparing the advice discussed in the previous section with the actual form and content of regional studies and so far submitted to central government, it would be helpful to consider briefly the definition of a preferred strategy.

In standard terminology a preferred strategy would be that which fully employed the resources available and allocated them, at least opportunity cost, as between competing objectives in a manner which fully reflected the preferences of the regional community. The following diagram represents such a position.



CF Curves are indifference functions each representing the different combinations of A and B which would offer the same level of total satisfaction to the community. PF Curves represent the total amount of resources expected to be made available and their shape is determined

by the trade-off rate between alternatives A and B i.e. the opportunity cost of one alternative in terms of another. At the tangency points of CF Curves to PF (O_1O_2) we have for given levels of resources the preferred strategy points. At these points the community is allocating resources between A and B in a manner which reflects both the technical conditions of the production function and the preferences of the community. [8]

The usefulness of this standard analysis is shown when the actual form of studies and strategies is considered. An overriding impression (see below) is that they have tended to concentrate their analytical base on describing the CF curves with little attention being given to the PF curve. This is strange, since discovering the prevailing preferences is exceedingly difficult if not impossible while generating production possibilities in terms of public and private expenditure on new works is difficult but possible. A further digression is required to highlight the conceptual difficulties of a strategy formulation based predominantly upon a preference function technique.

In such cases the strategy alternatives would be presumably generated directly from an interpretation of the regional community preference function which in practice would be reflected by the form of the operational objectives adopted. A basic problem immediately arises - how to provide a mechanism for the individual preferences of members of the regional community as between formulated strategy alternatives? In addition some method must be introduced for aggregating individual preferences to provide the required regional community preferences. It is well known that there are serious analytical questions to be faced regarding the latter problem because situations can arise, even

after making quite sensible axiomatic requirements for the formulation of a community preference function, when rational and transitive individual choices can provide irrational and intransitive group choices particularly where there are dissimilarities in rankings of choices with respect to the former. [9] Many writers have found a solution to the problem in some generalisation of the unanimity condition i.e. some form of majority voting. [10] Nevertheless the assumption of similarities in individual preference functions, if justified from investigation at the regional level, would imply a degree of unanimity on the long term mixture of objectives to be pursued. However in view of potential dissimilarities in the rankings of individual choices, particularly if the real income and capital redistributions involved were known, it is perhaps dangerous to imply even weak degrees of unanimity for regional community preference formulations. In other words, it would be misleading to assume that the aggregated regional community function would take on the characteristics of that of a team.

Such problems, however, have usually been disregarded in regional studies and strategies (see below) since no explicit mechanism has been visibly invoked for electing individual or sub-groups preferences beyond a vague representative level composed of the membership of the study/strategy body itself. It also comes as no surprise, in view of the scope of studies and strategies,that the range of objectives is usually comprehensive (perhaps so as to obtain agreement to their content). These are now discussed below.

Regional Studies/Strategies

The typical procedure for formulating a regional strategy has usually been an initial statement of general goals for the region which cannot be defined with precision, recede into the infinite, and lie forever beyond reach. [11] Thus we see statements of the desire of the strategy to maximise social welfare* in the region. Following upon this, some statement of broad objectives is usually made i.e. specific statements identifying attainable steps towards the distant goals. The words differ from study to study but they are all variants of "to increase on a continuing basis the health, wealth and happiness of the people of the region". †

There has then invariably followed a review of the existing situation in each objective area and a comparison between a future situation expected from the continuation of existing trends and policies with the view of the desired state as exemplified by the stated objectives. Analytical work, of which there are two main variants, is then mounted to assess the consequences of alternative policies. These are :-

---

* The Outline Specification for the northern Regional Strategy [3] states that the ultimate goal of the study is to "assist in the process of improving quality of life .....".

† Again the Outline of Specification [3] states the study will seek "to create conditions in which (people) would enjoy a reasonable choice of homes, jobs and education opportunities etc. Their health and welfare would be safeguarded, they would be able to travel about safely and conveniently and their surroundings would be pleasant, safe and healthy".

(a) The "shortfall" approach *

This approach is typical of the regional studies as opposed to strategies published to date. [2]

This requires for the basic aggregates such as employment, housing, roads, schools etc a calculation of their current values in physical terms together with two forecasts. As before, one requires an extrapolation of what would occur to these aggregates if current policies were continued up to the terminal study date. This forecast is usually based on the figures of a past period, and the policies of that particular period are extrapolated. The other forecast indicates what would occur to the same aggregates if various packages of investment (selected in some way) are undertaken as an act of policy in order to improve the position at the terminal study date. The current values of the basic aggregates, plus additions, minus deductions from existing policies, would be related to the need at the terminal date or any intervening date to indicate the "shortfall" between supply and need. For example, in the case of housing, after calculation of existing quantities to which are applied additions and deductions from current policies which, when related to need, give for every aggregate a shortfall (or excess). Given a shortfall, the approach considers whether and how far the need should be met through additional policy proposals. A similar calculation for all selected aggregates is made.

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* The appellation is mine.

It is then necessary to review the list of shortfalls and make judgements upon them. Because the concept of need is so elastic, and depending on the bench mark chosen, shortfalls can easily and arbitrarily be converted into excesses, and vice versa. If, as is usual, a long list of shortfalls is generated, consideration is then given to what extent each shortfall is met. Thus if a were the shortfall in labour demand, b the shortfall in school provision, and c the shortfall in new housing, various packages of investment would be considered whereby the shortfall in employment would be met by adding x additional jobs, y new houses, and z new schools. In many of the regional studies e.g. "Challenge of the Changing North", [2] this is where the process stops and the recipients of the study, i.e. central government, have been presented with a shopping basket of items for action. Consideration of priorities, and therefore trade offs, between items was not attempted, the inter-relationships between activities ignored, and no budgetary or other constraints imposed. In later studies and strategy documents the question of priorities and trade offs between items, and therefore the assessment of alternative packages, was in fact tackled. Firstly it is necessary to take the shortfall approach to a possible conclusion. From the above example x, y and z provisions could attain any figure between zero and the size of the respective shortfall as determined in each category isolated. To decide what particular items should appear in each investment package and the proposed level of investment of each item it is necessary to make judgements as to which are the important items, and to introduce some criterion or criteria to choose between investment packages. The number of alternative packages can be very large because they can be differentiated not only in terms of items but also for quantities. One possible package would be that which

met all the shortfalls and would be the limiting case. Nothing constrains the composition or size of the package quantitatively because no explicit constraints have been produced. The question also arises of adapting a criterion or criteria. This could be done by introducing an explicit priority rating which in effect is an objective function or functions, indicating the value judgements of the decision makers and is a group welfare function, the decision making group acting on behalf of "regional society". Alternatively such a function could be made more social by attempting to discover inductively the regional view, say by a widely cast questionnaire. Either method would then serve to offer a preference rating as between Package I (X, Y, Z) or Package II (X_2, Y_2, Z_2) or Package III (X_3, Y_3, Z_3) etc. Since each package could contain physically dissimilar things and each heterogeneous package selected to enter the preferences needs to be compared with every other, it would be necessary to introduce a common term to aid the comparison. This could be done by adopting a weighting system or points system by which to evaluate each package. This would involve the allocation of weights to each item within a package and perhaps some points to the package as a whole. By this means a "preferred" package would emerge. In fact, in some later strategies, something like the above progression of the shortfall approach was carried out - the Coventry-Solihull-Warwickshire [4] study is the most notable example. The most widely adopted technique of this type is called the goals achievement account method.

(b) Goals achievement account method

The origin of this approach is to be found in Morris Hill's paper "Goals Achievement Matrix for Evaluating Alternative Plans".[12]

Hill begins from the premise that Cost/Benefit Analysis emphasises economic efficiency in the social sense excessively and that other objectives get short shift because of the way the problem is structured. In this he implicitly rejects the traditional CB use of the maximisation of social welfare as a single goal and also the substitution of this single goal by community goals, since he feels that the latter will be different in kind and not necessarily additive, and therefore the simultaneous fulfilment of a number of goals would be neither useful or informative. The question which then arises is how can the decision-maker "Weigh alternative courses of action against each other, particularly where it is not possible to aggregate and compare costs and benefits?" The answer in the goals achievement method is a weighting system. As before, the strategy body provides itself with a statement of regional operational objectives interpreted variously in money, quantitative or qualitative terms. Each alternative strategy considered would fulfill the objectives to different extents and these then have to be compared to the weights given to the objectives as determined by some system. (Though most proponents of the method insist that the weighting system should be based on an inductive investigation, in practice it appears that the subjective views of the strategy body have usually stood proxy for such investigations.) However, given the weights and the operational objectives, it would be possible to "trade off" the extent of the achievement of objectives and thus select the most preferred plan, for differences in achievement, objective by objective, and plan by plan, given the weights, will normally ensure such a result. Obviously, the weighting system adopted provides the basis of the trade-off between the achievement of objectives since it provides the terms of transformation with fixed coefficients. Although the weights could remain the same during the

planning period, nothing precludes the adoption of different values for weightings through time in order to cope with anticipated changes in economic events. That is, the anticipated achievement of a particular objective could serve to reduce its relative weight. A variant would be to combine the weights of the objectives into a single overall index, the preferred strategy being that which provides the highest index. This variant, however, requires additional intuitive assumptions about how the weights are to be related in view of the fact that objectives measured in different units of account have to be combined.

Three serious flaws in the combined "shortfall"/goals achievement approach are evident :-

(a) Given the need gap in each sector or aggregate as selected, a target is set which determines the extent of required fulfilment of need which, of course, become the "objective" for that sector defined in terms which are appropriate to that sector. However, each objective can be fulfilled, once selected, to different extents, and it is still necessary, assuming interdependence, to compare composite investment combinations which make different quantitative contributions to each objective. At this stage it is necessary to ensure that each composite investment combination is feasible both in financial and real resource terms as required by central government. The methods presently used do not do this explicitly or systematically.

(b) The introduction of a priority rating procedure necessitates the investigation of certain quantitative interdependencies between items. Morris Hill admits that "a major disadvantage of the goals achievement matrix method of evaluation is that interaction and interdependence between objectives is not registered".

(c) The basis of trade/off provided by the weighting system is that along the preference function and is not the same as that implied by the economists' usage of the term "opportunity costs".

When comparing these deficiencies of analysis with the advice of central government to Planning Councils and Structure Planning authorities it is clear that the central theme of both briefs has not been met. It would not be unfair therefore to attribute some of the reasons for the muted government reaction (see below) to studies and strategies to the failure of analysis recounted above. In fact it is the premise of this thesis that this has been a major contributing factor. It is difficult to put forward evidence of central government's disquiet on the form of strategies and studies received since "political" considerations usually demand the kind of reply that goes "the Secretary of State thanks the strategy and study body for the hard work they have done in elucidating the problems of the region and promises that the proposals will be considered carefully". However, in a technical addendum to his reply on the Coventry-Solihull-Warwickshire Strategy (the first to use the goals achievement method in a systematic way) it was noted that "the consideration of real costs is neglected in the study ..... and there is no comprehensive attempt to determine the cost of using resources in one particular way rather than another". [13] Further, in the Government's reply to the

Yorkshire and Humberside Regional Strategy it was noted "The Council rightly draw attention to the fact that the general objectives in the strategy can be achieved only within the limits that financial and other constraints are likely to impose, and some breakdown and quantification would have been welcomed. The Government are particularly anxious that the implications of the strategy in terms of investment should be followed up by the Council as soon as possible. The feasibility of the strategy should be demonstrated by simple tests related to the availability of finance as indicated by experience in the recent past".

How then to meet this deficiency? A mechanism is needed which meets certain requirements.

(a) It should be capable of incorporating financial and real resource constraints.

(b) It should be capable of allowing the interdependencies between objectives to be registered.

(c) It should be capable of measuring trade/off in real terms.

Such a mechanism could be interpolated in the present form of strategy making between the initial "shortfall" stage of analysis and the application of value judgements at the preferred strategy stage.

The remainder of the thesis examines the possibility of using linear programming methodology in performing such a role.

CHAPTER 3

REGIONAL PLANNING AND LINEAR PROGRAMMING

It is assumed here that the overall strategy is defined by determining activity levels (X_js) for the programmes (js) designed to form the regional plan. Each programme is considered to be a consumer of regional, central and/or private resources, a means of satisfying statutory demands, and of meeting prima facie regional aims. Assuming linearity*, then any strategy should conform to the conditions :

$$(1) \qquad \sum_{j=1}^{n} aijXj \quad \leq \quad bi$$

Where bi is the availability of the i^{th} resource
and aij is the consumption ,, ,, ,, ,,
by the j^{th} programme per unit input

$$(2) \qquad \sum_{k=1}^{m} akjXj \quad \geq \quad bk$$

Where bk is the demand for the k^{th} service
and akj is the extent to which the j^{th}
programme can satisfy the k^{th} demand per unit

---

*This assumption of linearity is, of course, continued throughout the subsequent analysis.

$$(3) \qquad \sum_{l=1}^{p} a_{lj}X_j \quad \begin{matrix} \leq \\ = \\ \geq \end{matrix} \quad b_i$$

Where b_l is an "acceptable" level for the l^{th} aim a_{lj} being a measure of the extent to which the j^{th} programme can satisfy the l^{th} aim.

The use of linear programming in regional and urban planning has been limited but is not new. However, its major contribution has been in urban land use planning (see for example 14, 15, 16), although more general uses have been attempted (17, 18). In most cases the question of a suitable objective function has been avoided by using a neutral function such as total or public cost, justifying the use of the technique by stating that it considers interdependencies and develops viable plans in line with regional needs. Steger (17) and Ben-Shahar (18) are among the few authors who have directly faced the difficulty (but see also Chadwick (19), Chapter 6). Steger suggests a number of alternatives :

(i) Combining objectives "somehow" into a super goal

(ii) to promote one goal* as being "most important", incorporating others as constraints

(iii) dispensing with an objective function and treating all goals as constraints to be satisfied.

---

*Steger's and Chadwick's goals can be equated with regional aims or objectives in the terminology of strategy making. 11

The first is equivalent to developing the community preference function of the last section. The last seems akin to the general practice of avoiding the issue by choosing some neutral function such as cost. The second has more merit, especially if a region has a clearly identifiable and over-riding single need which would tend to dominate policy. Ben-Shahar, on the other hand, suggests a mechanism that is developed and used in the model to be described here. He suggests that the decision-making body should be presented with a "loci of efficient plans". This loci being an n-dimensional surface consisting of plans which for given values of the (n - 1) criteria (regional aims) provides the maximum feasible value for the n^{th}. The development suggested is that this mapping of the transformation surface should be dynamic, the decision-making body developing the given values for the (n - 1) criteria from evaluation of earlier solutions. Ideally, the process would involve using the maximum feasible value of the r^{th} criterion as a constraint, when finding the maximum value for the $r - 1^{th}$ criteria. This mechanism would be most efficient but not dependent on defining a ranking of criteria, so that criteria of lower rank and importance are optimised within the constraints of maximum values of higher ranking criteria. The method may be summarised as the wish to satisfy.

$$\sum_{m=1}^{n} \sum \text{Cmj Xj} \quad = \sum \text{preferred}$$

where the Cmjs are measures for the j programmes of the extent to which they satisfy the m^{th} regional aim or criterion. The aim being to define Xjs such that the sum of the values for a range of objectives produces a solution which is "preferred" by the decision-making body acting as a surrogate for the community.

However, the initial requirement is to demonstrate that exogenously determined projections of employment, population, housing, road construction etc are feasible in terms of certain budgetary and resource limitations. It should be stressed that the exogenous projections, while they can be construed as needs or demands, should not be interpreted as the objectives of the model. They are *prima facie* needs or demands by society that local or central government are obliged, in some case by statute, to satisfy. The presumption is that the level of these needs or demands is a projection of historical trends. As the programmes are interdependent, a matrix formulation provides a general framework to describe and simulate movements along an approximation of the regional production function. Because of this ability to consider programme interdependencies the matrix formulation avoids the fault of a partial, compartmentalised assessment of regional needs which is one of the main criticisms mentioned by Hill [12].

CHAPTER 4

THE CONSTRUCTION OF THE MATRIX

It should be made clear at this stage that the main concern of this paper is to investigate and test a possible structure of a model and to simulate a limited kind of production function relating to the provision of new construction. The quality of the data employed, though important, has not been allowed (by its scarcity, in some cases) to detract from the conceptual problems of the model structure. Though it is considered that empirical feasibility is demonstrated it is clear that more resources devoted to the problem of the quality of inputs would be needed to build a model of operational and practical value. Even so, the data requirements for the limited approach employed here were considerable. However, where possible, the further requirements for full operational use are explored and discussed.
In constructing the matrix the planning horizon date was taken as 1981. The matrix has a single time period of ten years. The programmes included relate only to the whole range of public and private capital expenditure on new buildings and also include repairs to existing buildings and the replacement of those outworn. Revenue expenditures are not included, but later developments, data permitting, could possibly be designed to include such an extension with interesting possibilities of measuring the trade off between capital and revenue expenditure (see Chapter 6).

The rows of the matrix refer :-

(i) to the projections of population and employment contained in the model

(ii) to incremental changes in those variables and

(iii) to needs and demands determined exogenously, arising from the mixed requirement of replacing outworn infrastructure, meeting new standards of provision, and where no obvious causal relationships can be established to a simple projection of past trends.

The constraint limitations included in the model can be classified as :-

(iv) budgetary on public sector activities (the private sector activities being allowed to run free)

(v) the availability of manpower, disaggregated by categories of skills, in the construction industry

(vi) the general availability of manpower as identified by the pool of unemployed

(vii) the amount of mobile industry estimated to be available nationally

(viii) the remaining constraints refer to those which reflect the upper and lower levels of needs and demands identified for certain activities.

The matrix formulation appears in Figure 1 in the ~~Appendix~~ sleeve.

What follows is a description of the way in which the coefficients of the matrix were derived.

Section (i) The Population/Employment Sub-Matrix

The population/employment sub-matrix is a basic motivator within the model. Expenditure on real resource activities such as housing, education and roads (the determinants of which are population and employment factors) itself is a determinant which affects population via employment changes - the whole process developing circular characteristics. Coupled with regional development policy inducements to new industry, additional employment is created directly in basic industries (defined here as primary, secondary and construction industries) and indirectly in both basic and non-basic industries (the latter are the service industries) through the operation of the regional multiplier employment (see Section (I.e)). As total employment rises, unemployment and outward migration fall. The latter affecting subsequent population levels. The increase in population creates further needs/demands on population-related infrastructure expenditure with consequent employment effects - and so on. Here we have a complex of cyclical interrelationships which need to be incorporated into the model. This is essential if the goal is to ensure a balance of resources such that any regional strategy proposals can be shown to be prima facie feasible.

What are the information requirements of this sub-matrix? They can be listed as follows :-

(i) Population projections disaggregated by age groups with special emphasis on population of working age and Labour Supply

(ii) Employment (Labour Demand) projections

(iii) Estimation of the Labour Supply/Demand relationship
The interdependence of Labour Demand / and Supply exhibits itself through what may be called the "balancing" variables e.g. the unemployment, activity and net migration rates

(iv) The Regional Employment Multiplier

(v) The Relationship of Population and Employment to Expenditure on new construction and works

The remainder of this section discusses both the theoretical and practicable aspects of requirements (i) - (iv), whilst (v) is discussed separately under the appropriate capital expenditure headings in a later section (Section (ii)).

General

It has still not proved possible up to the present to make reliable forecasts of population, still less of employment. Even given the excellent contribution of Professor Brown in the analysis of regional economic systems [20] we are still far from a full understanding of the forces that determine changes in regional economies. One major difficulty is the interdependence of regional labour supply and demand. In the national context changes in the number of people seeking work are due mainly to demographic factors such as changes in the number of working age and to social factors such as the increased willingness of married women to work, or the rising number of students. [20] In the regional context, however, flows of migration are a major source of

regional variations in the number of persons of working age and these are in the large run greatly influenced by changes in the number of jobs in different regions. The labour supply in the Northern region, for instance, depends crucially on the demand for labour there in the long run, but it is uncertain how quickly any change in the regions of relative prosperity would be reflected in a reduction of net migration southwards. [21] Similarly, the reason why female activity rates are low in the Northern region is because the traditional industries are male employing, but it is again uncertain how quickly any increase in the demand for female labour would be reflected in a narrowing of the difference between the regional activity and that for the rest of the country since the social pattern of life reflects the comparative absence of suitable employment opportunities for married women. [2]

Research is in hand to clarify these relationships (within Government Departments) but though the relevant approaches will be referred to, the requirements of the model have necessitated a simpler and more pragmatic approach at this time.

Sub-section (i.a) Population Projections

Of all the social indicators the projection of population trends is the most well documented [22] and will not be presented in great detail here

The regional population projections used in the model were prepared by the Office of Population Censuses and Surveys [23] and are consistent

with and constrained by the 1971-based national projections of the total population prepared by the Government's Actuaries Department in association with OPCS. The 1971 population on which these projections were based took into account the preliminary results of the 1971 Census and are presented both on a natural increase and with migration basis. For the purposes of the model the figures are further disaggregated by age to give the numbers of working age and educational age groups (see Table I).

Sub-section (i.b) Labour supply

The total number of insured employees at 1981 was derived simply by applying to the OPCS 1981 with-migration projection of working age an activity rate which assumes a maintenance of the differential between the regional and national (Registrar, general quarterly return 1st quarter 1973) activity rate to 1981 (see Table II). The assumptions at the national level are discussed below under Labour demand projections. It should be noted that this simple projection does not reflect possible changes in the region's differential demand vis a vis the nation as may be effected, for instance, by the new regional policies brought in over the 1970-72 period. However, the assumption of a stable differential appears reasonable in the light of past trends. Over the past 15 years all regional activity rates have moved in sympathy with national trends. [24]

Sub-section (i.c) Employment Projections

Ideally the regional projection of labour demand would be based upon some disaggregation of a national econometric model. The first stage would then involve estimating the likely growth in "productive potential" (i.e. changes in labour supply and productivity over the whole economy) and thus to forecast the growth in GDP in the target year. The classes of final expenditure (exports, consumer demand, investment, stockbuilding and public expenditure) would be estimated from this forecast. These categories could then be split to show the demands upon the social accounting matrix (SAM) industries. An input-output model taking account of inter-industry transactions could at this stage be used to produce estimates of gross output in each SAM industry necessary to satisfy the demands referred to above. Employment estimates for each SAM industry would be derived from the estimates of output and output per head. Some policy controlled categories, of course, would be fed in directly (i.e. agriculture, energy industry, aircraft manufacture, transport and communications, health, education, public administration and defence). Informed opinion adjustments would probably need to be made to the output and output per head estimates for other industries, e.g. when the answer provided by the model appeared unreasonable. It is known that something akin to the above has been carried out for central planning exercises such as the "Task Ahead" Document prepared by the Department of Economic Affairs in 1969. [25]

With national projections derived as above, disaggregation by regions could then be ensured perhaps by use of methods such as the "components of change" technique. [26] Under this technique it would be necessary

to estimate over a past period three components for each region, i.e. national, structural and differential.

(i) The "national" component measures the change which would have occurred in a particular industry if the regions percentage of total employed and growth rate had been the same as the national

(ii) The "structural" component is derived by using the actual percentage of total employed for that industry in a region, but again applying the national average growth rate.

(iii) The "differential" component measures the actual performance of the industry in the region minus the national and structural component.

Given future estimates of national employment changes by industry the national and structural components can be applied to the regional figures at the base date. The difficulty would be in assessing the future contribution of the "key" differential component, and it is in this area that the local input of knowledge would be applied based probably on industry surveys and even "local feel".

With present knowledge, and allowing for obvious deficiencies, the above account represents the best that could probably be achieved in the field of employment forecasting. Without the resources or time to mount an exercise of the type above, this paper necessarily adopts a simpler approach to estimating regional labour demand. For the purposes of the model the following method was adopted :-

The total national working population for 1981 was obtained from Department of Employment published sources [27] as was estimates of Armed Forces and the percentage of self-employed (see Table III).

By deduction of Armed Forces, the total Civilian Labour Force was obtained and by deduction of self-employed plus employers, the total number of employees was arrived at. Assuming high and continuous demand to 1981 what are considered reasonable estimates of the level of wholly unemployed* were made (i.e. Males 3.0%; Females 0.85%) to give an estimate of the total number of employees in employment nationally at 1981. The breakdown of employees in employment into broad sections was done on the basis of examination of trends for primary, manufacturing and services with construction being treated as a residual. The results did not appear unreasonable though the spurious accuracy implied by the figures should be ignored. The breakdown of the national figures is given in Table III.

The projections of employment for the Northern region were done by regression analysis of the regional share of employment in a given sector (employees in employment Northern Region per 1,000 employees in employment in GB) against time and the national unemployment rate (the latter to take into account cyclical movements). This was done for males and females separately for the years 1959-71 and for sectors

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* These estimates are based on an interpretation of Department of Employment pressure of demand assumptions used in their projections of total working population. These assumptions, however, are quoted in vacancies rather than unemployed.

primary, manufacturing, construction and services. The 1981 projected values for each sector were then multiplied by the national projection for that sector in 1981. A consolidated table is appended (Table IV and Graphs I - VIII) giving details of the regression equations used, tests of significance and the projected 1981 values.

Sub-section (i.d) Labour Supply/Labour Demand Balance

The difficulty of the interdependence of Labour Supply and Demand was referred to above. It was also stated that the indicators of interdependence are the unemployment, migration and economically active rates. These are the variables which balance labour supply and demand, though the term 'balance' is probably a misnomer. It is used here in the context of the allocation of the job deficiency (or excess) which invariably arises when the projections of labour supply and demand confront each other. Thus a projected excess (deficiency) of supply over demand could result in (a) a rise (decrease) in the numbers of wholly unemployed; (b) a decrease (rise) in the economically active rate; (c) an increase (decrease) in net outward migration, or a combination of two or of all three. To be more accurate, it is the first differences which are important, that is, ceteris paribus, only an increase (or decrease) in the projected excess of supply over demand would induce a change in the existing levels of the "balancing" variables. The time scale is almost certainly an important factor, sudden increases in the "job gap" would probably affect the wholly unemployed first, then, with some lags, the activity and net migration rates. Important also for the migration rate are the demand/supply positions in other regions. It is clear that the analytical problem posed here for the model builder is difficult indeed.

Ideally, given the data base regression analysis along the following lines might prove a useful starting point :-

$$\Delta U = \Delta S - \Delta E$$

$$\Delta M = \Delta S - \Delta E$$

where ΔU = change in wholly unemployment over, say, 1959-71 by annual increments

ΔM = change in net migrants

ΔS = change in labour supply

ΔE = change in employees in Employment

Here the changes in the Activity rate would be treated as a residual.

It is also highly probable that regional policy will have affected these variables and therefore any residual movements unexplained by the regression equations could be tested by fitting dummy variables, e.g. the application of intensified regional policy after '66 could have the effect of shifting the regression line and hypotheses could be tested by applying the dummy variable zero in pre-1966 years and 1 post-1966.

Alternatively to the above, which ignores pressure of demand outside the region, the following line of analysis could be pursued. Given national forecasts of Labour demand, and forecasts of the national unemployment and activity rates, then the movement of regional differentials in respect of these rates could provide the focus for analysis. Thus the question to be answered is, how have regional

unemployment relativities moved in relation to labour demand relativity changes? Similarly for activity rate relatives.

Thus $\Delta Ur = f \Delta Er$

$\Delta Ar = f \Delta Er$

where ΔUr = change in unemployment rate relative

ΔAr = change in activity rate relative

ΔEr = change in labour demand relative.

(Here the net migration effect is treated as a residual).

It must now be said that these approaches must, for the present, remain speculative at the regional level. Sufficiently "clean" data in the time series required to allow a statistically respectable analysis to be made was unobtainable. Ideally, material would be required on a sub-annual basis and census material, for example, is only provided quinquennially. Further, to provide year to year estimates of natural increase in labour supply and net migration rates would imply a degree of reworking of census material as to be outside the scope of this thesis. Further, the publication of activity rate analysis has now been discontinued by the Department of Employment because of the gross inaccuracies of estimation which were subsequently discovered.[28]

The approach for model purposes was therefore somewhat different :- For the years 1961 to 1971 the changes over the whole period in natural increase in labour supply and in total employees in employment were confronted. In Northern region over the ten year period there had

been an increase in labour supply and a decrease in labour demand with the result of an increase in job gap. The changes in wholly unemployed rates, activity rates, and net migration rates were then measured (for these years the requisite data was available).

It was found that the increase in the "job gap" could be explained by increases in the wholly unemployed and numbers of net migrants and a decrease in the regions economically active population. The "apportionment" of the job gap increase in this way was approximately 33% to each (see Table II and calculations appended).

For working purposes it was assumed that any increase in the job gap for the model period 1971-81 could be allocated in the same proportions. In the event an increase in the job gap for the model period would be artificially induced i.e. from labour demand forecasts for 1981 new mobile employment (see Section V) expected to arise within the region over this period plus construction employment was removed, along with an additional amount equal to the estimated size of the regional employment multiplier (see Sub-section i.e)). These elements of labour demand would be "reconstituted" within the model as a result of the operation of regional policy and expenditure on new construction and works. Thus for unitary decrease in job gap the technical coefficients operating on the unemployment and net migration levels would be 0.33 in both cases. (Activity rates being treated as a residual). In this way the model, albeit in a grossly simplified manner, could at least demonstrate the interdependent nature of labour demand and supply. Further, the increases in total population resulting from a decrease in net migration would allow the effects of increased demands upon new construction in those activities, where population is a determinant, to be demonstrated also.

It should also be noted that the initial population and employment levels in the model are the "reduced" form of the original 1981 projections and that the right-hand side demands, where these factors are determinants, have been reduced accordingly (see Section II and Table VII).

The model, though an essentially static one, had thus by this means been given an element of dynamism.

Section (i.e) Regional Multiplier

The definition and estimation of regional multipliers is a difficult area and has been the subject of much discussion.[29] Indeed, it is tempting to apply the term multiplier generally to any relationship between a primary and secondary change. Thus we have income multipliers, output multipliers, export-base multipliers, investment multipliers, or a combination of all, the super multiplier. It is not the intention of this study, nor would it be the place to document the various arguments on this subject. What is known, however, is that multiplier effects, even if they are small in magnitude, do exist at the regional level [20]. Further, if they do exist, how can they be incorporated into the Population/Employment Sub-matrix? Sub-section (i.d) referred to the artificial widening of the "job-gap" between Labour demand and supply by the removal of (a) new mobile employment expected from the operation of regional Policy to 1981, and (b) construction employment, from the employment projections as they would be reconstituted within the model. In terms of the income/employment multiplier any primary removal of income earners in this way would, via

local consumption effects, have secondary effects on employment. Conversely, the reconstitution of the primary employment within the model would redress these effects. In the event, by recourse to A.J. Brown's work on multipliers [20], which concluded that the local multiplier probably lay between 1.15 and 1.35, a median income/employment multiplier of 1.25 was adopted for use in allowing the secondary effects of both the removal and reconstitution of the new mobile and construction employment to be taken into account. For this purpose, primary, manufacturing and construction employment are classed as basic and service industries (Department of Employment definition) as non-basic, the multiplier acting through additions to the basic sector on the non-basic sector. (Chapter 6 on further refinements to the model discusses the possibility of incorporating an output/employment multiplier.)

Section (i.i) Capital Expenditure Programmes *

The ensuing sections are concerned with the estimation of the needs and/or demands which form the determinants of the right-hand side values of the matrix. Thus values are required for the amounts of housing, schools and roads etc which are projected to be needed to 1981. It has been stressed earlier (Chapter 3) that these projections are made exogenously to the model and should not be interpreted at this stage as strategy objectives. To repeat, they are *prima facie* the

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* This section should be read in conjunction with Section i.v which is concerned with the Construction Industry.

needs/or demands of the regional community which, in respect of public sector activities, local and central government are obliged, in some cases by statute, to satisfy and, in respect of the private sector, simply projections of historical trends. In a real strategy situation the data demands for the estimation of these right-hand side values is considerable and commensurately the staff resources devoted to this task is large. For the purposes of model testing it has therefore been necessary, as elsewhere, to lean heavily on existing sources for the determination of these values. Nevertheless, some space is given, where possible, to discussion of methods of estimation which would need to be applied in a full strategy context.

The most important single source of data for these sections has been the Economic Development Committee for Building and Civil Engineering's Forecasts of the value of contractors' output in the Northern Region to 1977,[30] without which the estimation of reasonable values for some of the activities of the matrix would have proved extremely difficult, and in one or two cases impossible.

Sub-section (ii.a) Housing

(In the matrix separate values are included for public new and replacement houses and private new and replacement houses.)

With regard to the methods of forecasting new housing, a distinction needs to be drawn between the social concept of housing need and the economic concept of effective housing demand.

"Need" approach

This is defined here as the measurement of difference between an arbitrarily or conventionally fixed standard for a specific amenity or set of amenities, applied to a given group of users, and the situation existing at a given time in respect of the said amenity. No account is taken of the household's ability to pay, or of the type of dwelling required (i.e. size, tenure, tastes). Further possible changes in demand or in the economic situation nationally and regionally are disregarded. The determinants of the housing "need" approach are :-[31]

(i) Household formation rates* (i.e. numbers of existing households and those expected to form over the period of study) *see Housing Statistics No 14

(ii) Assessment of Vacancy Reserve (i.e. the number of houses which it is estimated need to be available to allow adequate mobility)

(iii) Trends in "second home" ownership

(iv) Assessment of "unfitness" (i.e. the number of unfit dwellings, slum clearance rates, rate of dwellings becoming unfit)

(v) Replacement need (replacement of dwellings lost through slum clearance programmes).

Many of these factors are subject to the vagaries of the value judgement and political orientation, and consequently the need concept is an elastic one.

The alternative approach is :-

Effective Demand Forecast

Effective demand depends on both the willingness and the ability to pay, with attention being given to the interaction between the public and the private housing sectors and the variables relevant to these, such as the impact of mortgage society policies and the heterogeneous aspect of the housing market itself.

The determinants of the approach have been documented by Holmans [32] and include mainly :-

(i) New household formation

(ii) Assessment of movement between tenures and the tenures of new households

(iii) Changes in disposable income, house price charges, prevailing mortgage rates.

Whilst this approach is more attractive to economists, its applicability at the regional level is thwarted by the usual data problems operating at the local market level.

The EDC for Building and Civil Engineering [30] have considered both approaches and concluded that in most regions need (apart from replacement need) gives a reasonable indication of demand.

The housing demand forecasts used in the model are taken directly from the EDCs forecasts for the period 1971-77, which give an annual requirement of house-building, extrapolated in the model to 1981.

The consolidated account for new dwellings (excluding replacement) is given below :-

	000's
Potential households in 1977	1,171
Plus vacancy reserve	41
Plus second homes	25
Plus miscellaneous losses (71-77)	10
	1,247
Minus Stock December 1971 (AGB Survey March 1970)	1,167
New Dwellings demand 1971-77	80
Yearly average	13
Replacement need (based on indicators of age and condition of housing stock	122
Rate of replacement (per annum)	7
(Slum clearance has fluctuated between 5,330 and 7,543 houses per annum 1967-71)	

Total forecast is therefore for 20,000 dwellings, made up of 13,000 for new additional dwellings and 7,000 for replacement - a total demand of 200,000 dwellings for the period 1971-81. The breakdown between public and private sectors for the purposes of the model was obtained by applying the ratio of Public to Private completions (11:9)* [33] for the years 1966-71 to the 200,000 forecast, giving a projected 110,000 Public to 90,000 Private.

*See "Housing Statistics No. 24"

The average costs and prices of public and private sector houses used in the model are the averages for England and Wales and ignore regional differentials. This is due to the lack of material on regional construction costs for public sector housing. Since some national data was available for the public sector, though dated, it was thought that consistency demanded that average purchase price for private sector dwellings should also be estimated as England and Wales averages. The method of Estimation was as follows :-

Average Purchase Price - Private Sector

From the annual survey of building society mortgages (MHLG, now DOE) the second quarter 1966 [34] average purchase price of £4,250 for dwellings of all types and size was derived. By second quarter 1971 the equivalent figure (from the same source) was £5,750, an increase of some 28%. [35]

Average Unit Costs - Public Sector

From the Treasury publication "A Selection of unit costs, in public expenditure" 1968, [36] the total cost of all LA dwellings in England and Wales was an average of £3,200 per dwelling (exclusive of fees and site works and land costs). Assuming that unit costs of construction have risen in step with the average purchase price in the private sector (i.e. 28%) then the equivalent 1971 unit cost would be £3,200 x 28% = £4,500.

Migration Coefficients

The requirement for 200,000 new and replacement houses to 1981 is based on the OPCS with-migration projection for that year. The net migration assumption contained in the forecast is 83,000 (Table I). It will be recalled that the increase in "job gap" induced by the removal of new mobile and construction employment from the employment projections gave an initial population level in the "decreased" form due to the net outward migration effects resulting from the decreased employment. As the new mobile and construction employment is re-constituted within the model (up to the limit of the original OPCS "with-migration forecast") then to avoid double counting the housing requirement to 1981 needs to be made consistent with the decreased form of the population forecast. As the population is reconstituted as a consequence of running the model, then the housing requirement returns to the original 200,000 level. Thus within the matrix a coefficient is required which links unitary reduction in net outward migration to the demand for new houses (replacement houses are excluded from the migration effect). From the Mobility in the North Survey 1967 [37] the average number of households per 100 out-migrants of 15.0 was derived. The application of this to the induced net migration figure in the model (132,000, Table II) gave the "reduced" form of housing requirements, 180,200 average housing units (rounded to 180,000). The demands upon the private and public sector were split in the same proportion as the ratio of Public to Private new houses above (11.9, see above). From this coefficients linking housing to net migration of .082 and .068, respectively, were obtained.

Sub-section (ii.b) Education

Educational need was assessed in terms of the number of places requiring to be provided by extension or new construction 1971-81. An element was also added to take account of the desirability of replacing outworn buildings and reducing staff/pupil ratios.

The method was as follows. The number of places was disaggregated by educational range, thus :-

	Age
Day nursery	2 - 4 years
Primary	5 - 11 years
Secondary	11 - 16 years
and proportion	16 - 18 years
Further education (including Polytechnics and Universities)	18 - 21 years

The change in population for these age ranges was taken from the OPCS "with-migration" forecasts to 1981 (Table I).

Day Nursery Education

The calculation of demand for Day Nursery Education is based on the numbers of three and four year olds in the population at 1981 with the following assumptions :-

90% four year olds, of which

1/6% Full-time

5/6% Part-time

33% three year olds, of which

1/3rd % Full-time

2/3rd % Part-time [38]

From the 1981 3-4 year old population of 129,000 (for working purposes equally split between 3 and 4 year olds), the above breakdowns give a full-time equivalent of 47,000 places required.

Primary Education

The OPCS with-migration forecasts to 1981 show a decrease in the population of primary school age to 1981 of some 60,000. However, an examination of the age of maintained primary school buildings in the Northern Region [39] at 1968 shows 106,000 children still housed in pre-1902 built accommodation. Further, the staff-pupil ratio for the region was 27.9 compared with the national average of 27.6. [39] To rehouse pupils in pre-1902 buildings and to eliminate the staff-pupil ratio differential would require the provision of 110,000 new primary school places. Allowing for the decrease of 60,000 primary age population, the net need for new primary places to 1981 was estimated for working purposes to be 50,000.

Secondary Education

The OPCS with-migration forecasts show a static situation in the numbers of secondary age population to 1981. One of the main factors

which will affect the demand for new school places is the raising of the school leaving age to 16. At January 1971 only 50% of 15 year olds were staying on at school,[40] and with an estimated 15 year old population of 55,000 the number of new places required due to this factor will be approximately 27,500. Further, at 1971, with a secondary school population of 236,000 and a staff/pupil ratio of 18.6 compared with the UK average of 17.7, to reduce the differential would require the provision of approximately 13,500 new places. Another factor influencing the need for places is the trend for those remaining in secondary education to stay beyond the statutory leaving age. Between 1959 and 1967, those staying for an extra year (16-17 years) doubled from 7.9% to 15.4%, and those staying for a further year (17-18 years) rose from 3.0% to 5.2%.[40] Extrapolation to 1981 would raise demand for extra places by another 6-7,000. In addition to the above demands, the secondary sector also faces the task of replacing sub-standard schools wherever possible and of meeting the requirements of comprehensive system development. It has not proved possible to quantify these extra requirements. In the event, a final demand for secondary school places of 70,000 was postulated on the basis of an expenditure on major works comparison 1966-1970[39] which showed a ratio of 7:5 in favour of secondary schools. This would give a figure of 22,000 school places (in addition to those above) arising from the need to replace outworn buildings and meet the requirements of comprehensive education developments. The figures do not appear unreasonable.

Further Education and Universities

The quantification of demand for places in further education and Universities for 1981 is even more tentative than that for primary and secondary schools. Briefly, all that could be done was to examine the

numbers of students in public sector and assisted establishments of Further Education at 1971.[40] These were numbered 23,300. Since 1961 there has been a national rise of 85% in the University population and a massive 200% in Advanced Further Education Establishments, including Colleges of Education. There have been increasing indications that this rate of expansion will not continue in the 1970s and that the emphasis of expenditure during this period will be switched to the primary and secondary sectors. With this in mind, tentative figures of 5,000 extra places for Universities/Polytechnics and 5,000 extra places in Further Education establishments are included in the model for working purposes. This represents a rise for Universities/Polytechnics of approximately one-third, and for Further Education of approximately two-thirds, retaining a similar proportion for the 1961-71 period, but on a greatly reduced basis.

Costs per place

The Department of Education work to cost-limits, i.e. ceilings in respect of the new provision of places in the different educational establishments. These ceilings are raised from time to time in accordance with the rate of inflation. However, the Department of Education kindly provided the following capital costs per place, as at the end of 1971, for the categories listed above. These are country-wide averages and therefore can only be regarded as approximates.

	cost per place[38]
Day nursery	£450
Maintained Primary	450
Maintained Secondary	800
Further Education (non-advanced)	2000
University/Polytechnic	3250

Migration Effect on the demand for places

Migration coefficients, relating the effects of reduced migration on population, and therefore the demand for school places, are included in the matrix. From the difference between the 1981 "natural increase" population and the 1981 "with-migration" population (see Table II), approximately three-eighths in equal proportions fell in the Day, Primary, and Secondary Educational Age ranges (see Table I). (It was assumed that the demand for Further Education would not be sensitive to net-migration movements.) A coefficient of .125 (in each case), relating a unitary reduction of net outward migration to the demand for day nursery, primary and secondary places, was, therefore, adopted. The demand for places was then related to the reduced population figure. Subsequently, as population was reconstituted within the model, the number of places required would also be reconstituted to the levels estimated in the previous sections.

Sub-section (ii.c) Roads

The determinants of road investment in a region are :-

(1) Population growth and the changing distribution between residential and workplace areas

(2) State of the existing investment in relation to the above

(3) Personal income growth in relation to car ownership rates

(4) The inter-action between local programmes and the national programme

(5) Regional Policy developmental aspects.

In Northern region (4) and (5) have been important in determining the level of road investment since 1963. In that year the introduction of the "Hailsham Plan" [41] inaugurated a period of intensive activity (which is still continuing) in the improvement of Northern region's road network. This level of activity would not have been justified by determinants (1) - (3) above alone and it is difficult to establish any meaningful relationship between population and expenditure on roads in Northern region for model use. A practical first step to test such a relationship would ordinarily involve establishing a time series for vehicles registered in particular areas, supplementing this with traffic count data, establishing the expenditure of these areas on local roads throughout the same time series and ascertaining the relationship between vehicle population and expenditure. Even this, if achieved, would disregard the inter-action between local programmes and the national programme. In the event, all that could be achieved was to plot a graph (Graph IX) showing local authority investment for England and Wales at constant prices over the period 1954-70 together with numbers of all vehicles and cars over the same period. From this it can be seen that an orderly relationship between vehicle population and expenditure seems to have persisted until 1964 but after that point the relationships become erratic. In the absence of any stable relationship it was not possible or considered justifiable to establish a link with the "reduced" to the "original" population movement that occurs during the running of the model. Instead, data concerning road construction was obtained directly from the Divisional Road Engineer of the Department of the Environment. [42] This was the Northern region's forward programme of road construction up to 1981 and was formulated in terms of national and local programmes, programmed years, whether firm programme or preparation pool, total estimated cost, length of schemes, whether rural, urban or semi-urban, and standard of construction, i.e. :-

single 2 lane (S_2)

single 3 lane (S_3)

dual 2 lanes (D_2)

dual 3 lanes (D_3)

Motorway 3 lanes (M_3)

The analysis consisted simply of adding up schemes by type, totalling the cost, and dividing the number of quarter-mile units in each type to obtain average costs per quarter mile (see right-hand side "Roads" Figure I). Quarter-mile units were adopted to enable a finer grain analysis to be pursued. Thus the right-hand side figuresin the matrix refer to quarter-mile units for each road type. The construction man-power coefficients were made compatible with this level of disaggregation (see Section iv).

Sub-section (ii.d) New Industrial Building

The determinants of new industrial building in a region are :-

(1) The level of manufacturing industry employees (as a proxy for level of demand)

(2) Regional Industrial Structure (since building rates per head vary between industries, this is important)

(3) Development Area Policies

(4) Quality and condition of existing stock.

The forecasts of new industrial building work in the Northern region contained in the Building and Civil Engineering EDC's construction

forecasts were based on a regression analysis using variables based upon the above determinants.[30] The equations derived by the EDC gave satisfactory predictions with both the average levels and turning points being successfully indicated (Graph V). For use in the model the EDC's forecasts of the value of contractors' orders to 1977 were included, together with actual building orders per head 1965 to 1970 (Section iv). The total value for the years 1971-77 was projected proportionately to 1981. From the actual building orders per head, 1969 to 1970, an average value of orders per head was obtained. The ratio of the "reduced" form of basic employment (i.e. minus the jobs expected from new mobile employment (see Section V) to the original basic employment projection was then applied to the 1981 industrial building forecast to give the initial right hand side formulation for the value of that proportion of new industrial building consistent with the initial "reduced" basic employment level.

The formulation of the model thus ensures the restoration of the original EDC based forecast, as new mobile employment is reconstituted. This is done incrementally, via the average industrial building orders, by value, per new mobile job.

Unit Costs

Since the EDC forecast includes new building work for factories, warehouses, chemical works, oil refineries etc., the concept of a single unit cost was not an appropriate measure. In this type of case the alternative which was adopted was to use the average value of contractors' orders per construction worker employed (ten year period) as a surrogate cost in the cost row (see Section IV and Table V).

Sub-section (ii.e) Other Commercial and Public Construction Works

The remaining rows of the matrix in respect of Other Commercial and Public Construction Works (excluding derelict land programme - see below) were derived directly from the Building and Civil Engineering EDC's forecasts to 1977.[30]

These are :-

(a) Offices
(b) Shopping
(c) Health Services
(d) Entertainment Services
(e) Commercial other services
(f) Public Corporations
(g) Sewerage
(h) Water supply
(i) Other public services

(Table VI lists the definitions of these headings.)

In all cases the EDC's forecasts to 1977 were generally extrapolated pro rata to give the matrix right-hand side needs/demand levels for 1981 (Table VII). Except for Offices and Shops, the criterion used is total expenditure on new construction in each field. This was necessary because of the prevailing lack of disaggregation of activity areas which include considerable variations of provision (Table VI). For Offices and Shops the projected demands are in '000 sq. ft. (additions to existing stock and replacement). In order to make the

initial right-hand side needs/demands consistent with the initial "reduced" population and employment levels, the EDC based forecasts were reduced by a proportion equal to either the ratio of the "reduced" to "original" population forecast or the "reduced" to "original" employment forecast, i.e. offices, shopping, entertainment services, other commercial services, public corporations were linked to employment movements where, for the purposes of this model, employment changes stand proxy for regional pressure of demand levels. Health services, water services and other public services were linked to population movements where, again for the purposes of the model, population was considered to be the prime determinant of needs/demands. The incremental addition to the initial "reduced" right hand side levels were on either an average expenditure per additional employee basis (in the case of offices and shops, additional average square footage per additional employee) or an average expenditure per additional head of population.

Unit Costs

Excepting offices and shops, unit costs were not appropriate for activities containing such diverse constituents. In these cases (see Section IV) the average value of contractors' orders per construction worker employed (ten year period) was used as a surrogate cost in the cost row. For offices and shops an average expenditure on new office and shop construction per 1,000 sq. ft. of provision was used by simply dividing square footage provided in the past by the expenditure at current (1971) prices. (Table VII gives a consolidated account of the arithmetic calculations involved.)

Sub-section (ii.f) Sewerage

Sewerage expenditure is a special case in the matrix. From data drawn from H.M. Treasury's "A selection of unit costs in public expenditure 1968"[36] sewerage expenditure is estimated to average 2½% of total expenditure on all other construction and works activities excluding roads, repair and maintenance and derelict land.

Sub-section (ii.g) Repair and Maintenance

Expenditure on repair and maintenance is a considerable component of total expenditure on construction and works and is a function of the existing stock of buildings and plants, roads etc within the region, and its age and condition, and under this heading house improvements are included but not disaggregated. In the complete absence of information on the split between public and private sector, the purely arbitrary public/private ratio of 7:4 was adopted, which reflects the ratio of EDC's forecast public to private expenditure on new construction and works with some additional weighting for repair and maintenance assumed to the public sector. (See Table VII).

Unit Costs

Again the average value of contractors' orders per worker employed (ten year period) was used as a surrogate cost in the cost row.

Sub-section (ii,h) Derelict Land

Derelict land is included in regional new construction and works because the labour content involved is, in many cases, drawn from the construction employment pool as is the plant involved in earth moving equipment etc.

The acreage in the Northern region considered to be derelict and worthy of restoration was given in the Derelict Lands Survey 1971 (for the DOE) as 14,948 rounded for model purposes to 15,000 (Table VIII). Since Table IX from the same survey estimates the amount to be restored for the year 31 December 1971 to 31 December 1972 as 2,153 acres, it is apparent that the restoration of 15,000 acres at present derelict represent a reasonable target for the ten-year period 1971-81.

Unit Costs

The average gross restoration costs per acre have been estimated by dividing the acres restored in 1969-70 by the gross eligible cost for that year (Table X). This gave an average cost per acre of £1,880. For the 1971 period this cost is rounded to £2,000 per acre, disregarding the "after value". *

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*This is the value of the land after reclamation and before its final use.

Section (iii) Estimation of total public expenditure on new construction and works in the region 1971-81

In the model the estimate of Total Public Expenditure on new construction and works for the period 1971-81 is used as though it were the Regional Capital Expenditure Budget for that period i.e. it represents the financial resources estimated to be available. It provides, therefore, a prime constraint for feasibility testing and ensures that total strategy packages do not imply financial demands out of line with those indicated by recent trends in the expenditure concerned.

It should be said here that there are some who regard the regional level in public expenditure as an entirely artificial concept. The North-West Strategy Report [4] for instance holds this view and states in Chapter 4 on Resources that since central government does not consciously allocate a particular sum or percentage to each region, regional figures therefore are simply aggregates of the detailed allocation of funds by particular government departments or public agencies. The report adds that the total to which these separate allocations aggregate is accidental and regional totals year to year reflect mainly the impact of current national priorities. To accept this view would imply that the exercise requested of the Economic Planning Councils in connection with the regional PESC figures (Chapter I) is bogus. Even if this were true it would still remain a valid exercise for the strategy-maker to behave as though the total funds available could be used in the way determined by the analysis of his particular region. This approach is supported by the question asked by central government of both the Planning Councils and the Structure Plan authorities "could the distribution between the

different programmes of new works be improved?" (see Chapter 1). This in turn implies the idea of trading/off between programmes and the most appropriate context for this procedure is to assume flexibility in the allocation of public funds.

It is held here, therefore, that the assumption of a regional capital expenditure budget for analytical purposes is not only valid in the technical sense but also "politically" if regional participation is to proceed effectively.

In the event the estimation of the capital expenditure budget, or more correctly the expenditure on new construction and works budget had to be determined in a simplistic manner. The PESC projections to 1977 unfortunately carry a "confidential" classification and recourse was made to the 1968-72 outturn figures which were obtained from the Department of the Environment. These figures relate to the expenditure programmes of the Department of the Environment, Department of Education and Science, Department of Health and Social Security, the Home Office, Ministry of Agriculture, Fisheries and Food, and a small unanalysed amount for other Government departments. Locally determined schemes (local authority discretionary expenditure) were also included. Excluded were expenditure by public corporations and expenditure on repair and maintenance which are included in the Matrix. The outturn expenditure for the four years 1968-72 at 1971-72 survey views were converted to an average annual figure which was multiplied by 10 to give a 1971-81 total. To this total was added the forecasts of expenditure on new construction for public corporations and repair and maintenance obtained from the EDC for Building and Civil Engineering Report.[30] Finally, a sum for derelict land restoration was included

by simply multiplying the acreage for restorage by the unit cost per acre. A small allowance for real growth in available finance was then made to derive the final regional public expenditure on new construction and works budget. The real growth rate chosen was 1½% per annum and was compatible with the assumptions made in the financial sections of the Tyne/Wear Plan [43] and the Teesside Structure Plan.[44] (Table XI gives the PESC expenditure figures and the arithmetic calculations.)

Section (iv) The Construction Industry

For the purposes of the model the major real resource constraint assumed to be operating is the capacity of the Construction Industry. Ideally this capacity would be defined in terms of the forecast availability of manpower, plant, and materials over the period with which the model is concerned i.e. 1971-81. Further, in order to determine the resource quantities required in new construction work, the formulation of conversion constants (technical coefficient) is required in order to interpret the impact of varying output structures on the demand for resources. Unfortunately, data is not yet available to enable the effect of changes in the volume and structure of output on the incremental requirements for plant and materials to be estimated. However, work carried out at the Building Research Station (BRS) Garston, Watford, on site labour requirements for new construction work [45] provided the basis for technical coefficients in respect of manpower to be derived. The extension of this work to cover the use of plant and material which is being carried out at BRS will be vital if a valid appreciation of total capacity is to be obtained. At this stage the analysis of capacity must necessarily be confined

to manpower, but at least this allows the demonstration of a methodology which can be extended to take account of further material when it becomes available.

It is also necessary to point out that the manpower analysis described below contains some deficiencies and these will be identified later in this section.

Estimation of Construction Coefficients (see Tables V and XII)

The twelve main areas of new construction work identified and classified in Section (ii) were :-

Housing
Road Building
Education
Industrial Building
Offices
Shopping
Health Services
Entertainment Services
Commercial Other Services
Public Corporations
Sewerage Services
Water Services

Added to this list were the two other expenditure areas which make demands upon the available construction employment :-

Repair and maintenance
Derelict Land

Within the constraints of data availability, further subdivision was possible in the fields of Housing, Education, and Road Building, Repair and Maintenances e.g. Housing was subdivided into public and private and further categorised into new and replacement. These activities can be classed as those involved directly with the allocation of real resources - in this case, construction manpower.

In each of these activities the first step was the estimation of the average value of contractors' orders per construction worker employed. From work carried out by the BRS . on public sector construction contracts for all construction work [45] a figure of an average 60 man-days per £1,000 of contract value (this took into account the range of types of construction and sizes of contract) was obtained. Since a man-year is defined by BRS as 264 man-days, then on this basis, nationally, an average annual expenditure on new construction of £4,200 will employ one construction worker for one year. However, it has been estimated that Northern regional productivity in construction may be on average only 70% of that prevailing nationally [46]. Thus, for the model, an average contract value per employee per year of £2,900 was adopted. Since the matrix covers the period 1971-81 the average contract value per employee per ten-year period would be £29,000. The next step was to ascertain inter-activity differences. The BRS . had carried out analysis of contracts in the following public sector fields : Schools, Roads, Public Corporations, Public Housing, Water, Sewerage, Health and Public Other, including some offices.[45(b.c.d)] Information was also available on some Industrial Building. Inter-activity differences for these activities were then estimated by multiplying the average contract value per employee (ten-year period) by the ratio of the average man/days per specific activity to the average man/days

for all activities (Table V). For private sector activities, recourse again was made to estimations made of the crude productivity differences between all public sector construction work and all private sector construction work [46]. Thus, in the case of private Housing, the difference ratio was applied to public housing. For other private sector activities such as shops and entertainment services no information was available and a make-do approach was adopted in that shopping construction was equated to offices, and entertainment services to the average of schools and offices, as a typical construction type.

At this stage it was now possible to obtain the total construction manpower demand arising from total public and private expenditure on new construction and works. The next stage was therefore to estimate the trade element coefficients per employee per activity. Again, the necessary data was obtained from BRS analysis of construction contracts. [45(a)] In the BRS analysis these included disaggregations by construction type i.e. Traditional brick, Steel framed traditional and non-traditional, and concrete framed. There were also variations by contract size. A weighted average of all contracts per activity, taking into account construction types and contract sizes, was thus necessary for the purposes of the model. Fortunately this had been done by BRS. Again, for private sector activities shopping and entertainment, an approximation to the closest public sector construction type was taken. The BRS trade element breakdown was highly disaggregated including 28 different trades. Taking into account the necessary estimation of availability of Trades and the attendant data difficulties, trade elements were aggregated to six logical groupings i.e. Structure, Carpenters, Services, Finishers, Unskilled/semi-skilled. Thus a typical breakdown for the purposes of the matrix became :-

Public Housing	1971 Prices
Average contract value per employee (ten year period)	£26,000

Trade element coefficient

Structure	0.19
Carpenters	0.16
Services	0.14
Finishers	0.13
Unskilled/Semi-skilled	0.32
Supervision	0.12
	1.00

See Table XII

In those cases where average unit costs were available, the average value of contractors' orders per man employed was used to estimate the construction employment requirement per unit of provision. Thus in public Housing the average new unit cost of £4,500 gave the following Trade Element Coefficients for matrix purposes :-

Structure	0.36
Carpenters	.03
Services	.027
Finishers	.025
Unskilled/Semi-skilled	.061
Supervision	.023

Similar coefficients were derived for those activities where unit costs could be properly applied (Figure I). For those construction

activities where unit costs were not appropriate the average contract value per employee (ten year period) was used as a surrogate cost in the cost row. This approximation was required in activities such as public corporations, water services, public and private other etc where clearly unit costs at the level of aggregation used was not appropriate (Table VI).

The final step was to estimate the availability of construction manpower over the ten year period in terms of the aggregated Trade element structure. The definition of construction employment for the purposes of the model was that used by the Department of Employment.* The estimate of availability on a regional basis is the part of the analysis most fraught with difficulties. Regional DE figures for construction do not, and can not, reflect total labour availability in the region for the following reasons :-

a. The industry is more flexible than most industries. A sizeable labour force follows major projects around the country and a proportion of this will undoubtedly find its way to major regional developments such as the Redcar Steel Complex, Kielder reservoir etc. It would also disappear when these projects are completed.

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*This is in many ways a spurious definition since DE classifies employees to construction on the basis of the principal activity of the establishment concerned. The alternative, which appears preferable, is to identify all operatives and all administrative, professional, technical and clerical staff employed in construction work. It is not always the case in the DE definition. However, since employment in the population/employment generator is by necessity based on DE standard Industrial Classification Order Groups, it is perhaps better to remain consistent.

b. The extent of self-employment, the "lump", is excluded from DE figures and is impossible to quantify.

c. It is known that unemployment figures in the industry, because of a and b do not adequately reflect the true reserve of labour.

Nevertheless certain working assumptions can be made :-

a. That nationally the construction industry will be working at full capacity in 1981. This is consistent with the assumption of a national supply/demand balance contained in the forecasts for all employment from which the regional forecast was derived (Table III).

b. The regional share of national construction employment will remain constant to 1981.

c. The availability of trades and their relative proportions of total regional construction manpower will be the same as the national trade element structure forecast by BRS for the years 1973-74-75. [45a]

Given these assumptions, which are not unreasonable for working purposes, the estimate of the availability of regional construction manpower by aggregated trade categories was obtained by applying to the projection of construction employment for 1981 (obtained by share analysis (see Table IV) the same percentage incidence of broad trade categories as evidenced by the BRS national forecasts for 1973-74-75 (see Table XIII).

Section (v) Regional Industrial Development - New Mobile Employment

Within the model, new mobile employment coming into the region is treated in a special way, the validity of which is arguable. The assumption within the model is that there is a share of the new mobile employment which is expected to arise nationally to 1981 which will come to the Northern Region and, in line with current levels of investment grants/allowances, building grants REP and other operational grants operating, will incur exchequer expenditure. This is opposite to supposing there is a supply function of new mobile industry related to the price in terms of inducements, which the government is prepared to pay. There is evidence that the supply of new mobile industry is more obviously mainly related to the pressure of demand prevailing in the economy and comes about mainly from the needs of firms to expand output. An inquiry into location attitudes of firms considering opening a new plant in a new location carried out by the Department of Trade and Industry [47] obtained the following answers to the question :-

"What caused you to consider opening a new plant in a new location?"

Answers	Major Reason	Outstanding Single Reason
To permit an expansion of output (linked to restriction of expansion in sites - IDC Policy)	83	20
Inadequate existing premises	50	8
Unsatisfactory Labour supply	40	15
Financial inducements (government)	20	2

This result lends some support to the treatment of new mobile industry in the model. This is to treat the "available" share of new mobile employment as a resource to meet the unemployment objectives contained in the right-hand column. By virtue of the relative cheapness of the exchequer expenditure incurred for each new mobile job in relation to the costs per construction job created through capital expenditure on new infrastructure (see note to this section) the model ensures that each run reabsorbs the total available share. It also allows through the interdependency relationships with net migration, and therefore population, the infrastructure costs imposed by new mobile employment coming into the region to be assessed.

The actual estimations of the numbers of new jobs expected to arise nationally was necessarily based on rough and ready estimation. The only reliable information covering all movement of more than 18-20 miles is that relating to 1945-65. The published data [48] showed that movement during the 21 years from 1945-65 fluctuated widely from year to year with a total of 870,000 jobs in all at the end of 1966. Making an allowance for the fact that moves taking place in the last part of the period would not have reached maturity by the end of 1966, employment from the 1945-65 moves would ultimately reach about 928,000 total or an average of 44,000 over the period. Movement in 1960-65 alone resulted in 223,000 jobs by the end of 1966, and by the same method of grossing up to take account of their remaining growth potential they could be expected to employ 275,000 eventually. Clearly the upward adjustment forms a proportionately larger element in the case of 1960-65 alone than in the case of 1945-65, but the employment total of 46,000 total for each year on average over 1960-65 is only modestly above the figure for 1945-65 as a whole and appears

fully plausible. A simple extrapolation of this trend for the years 1971-81 gives a national total of approximately 500,000 jobs arising over this period. The Report on long-term population distribution[49] mentions the prospective claimants for these jobs as New and Expanded Towns, Development Areas, Intermediate Areas, and Northern Ireland, and a percentage breakdown of need as 32% New towns, 42% Development Areas, 18% Intermediate Areas and 8% Northern Ireland. This would give a total of 210,000 jobs expecting to accrue to development areas. Since the proportion going to Northern Region has averaged just over one-third, then the figure of 75,000 jobs adopted in the model appears to have reasonable justification.

Note on Cost per job

The most important current use of the concept of cost per job is as an administrative working rule to set limits to delegated authority under the Local Employment Acts, and now under the Industrial Development Executive. In this case the measure relates "a once and for all" expenditure (loan or grant) to the creation of a long-standing source of new employment associated directly with the investment attracting the assistance. Another cost per job concept (which is adopted in the model) concerns the impact on employment of infrastructure expenditure.

It should be noted that the above measures are far from being the true costs per job in opportunity cost terms i.e. Exchequer cost, whether gross or net of savings in unemployment benefit etc, does not measure the real burden imposed on the community by the policy in a way which can meaningfully be compared with the benefits of the policy. The

relevant measure of job creation is the net addition to employment, relative to what it would have been otherwise attributable to the policy measure. Actual measurement is hampered by "confidentiality" restrictions on government data. A hypothetical table can be drawn up which is instructive about the orders of magnitude that might emerge from a cost benefit analysis of incentives to manufacturing firms. The table contains (on optimistic or pessimistic positions) a pessimistic to optimistic range.

Hypothetical Cost/Benefit Table

Assumed resource gains from employing a unit of unemployed labour. Postulated rates of return on capital employed and the government's net assistance which would then be warranted per unit of labour employed.

Annual Resource Gain from employing One unit of Labour in assisted Areas	Present Value of Resource Gain over 10yrs Discounted at 10% (nearest £'000)	Government Assistance Warranted per Unit of Labour* : it varies with Loss per cent on Capital Employed in Unassisted compared with Assisted Areas					
		0%	2½%	5%	10%	12%	20%
		£	£	£	£	£	£
0	0	0	0	0	0	0	0
250	1,500	Infinite	5,000	2,500	1,250	1,000	625
500	3,000	,,	10,000	5,000	2,500	2,000	1,250
750	4,500	,,	15,000	7,500	3,750	3,000	1,875
1,000	6,000	,,	20,000	10,000	5,000	4,000	2,500
1,250	7,500	,,	25,000	12,500	6,250	5,000	3,125

*It is assumed that the average amount of assistance to industry in the form of grants, taxation concessions etc is roughly 50% of capital employed in Development Areas 50.

The table opens up the possibility of endless speculation. A simple start can be made by looking across the row that begins in the left hand column with a resource gain of £1,000 for creating one new job in a Development Area and considering the implication if the rate of profit on capital for that job is 10% less in the DA compared with the unassisted areas.

All the table then says is that a resource gain of £1,000 would compensate capital expenditure of £10,000 if the loss on that capital was 10% or £1,000. As Government subsidies are about 50% of capital invested, the cost to the government at present would then be £5,000 per job. This is the cost per job included in the matrix for each of 75,000 jobs expected to arise from Regional Policy over the ten year period.

The average cost figure is provided purely as the device by which the programme will automatically absorb the available supply of new mobile employment. However, further development would enable costs derived on this basis to be compared with some deliberate policy measure using infrastructure expenditure as a means of creating direct employment in DAs. The comparison of costs per job of either subsidies to private investment or additional public sector (infrastructure) expenditure could then be compared. For the latter the approach might be as follows :-

(a) In standard national income accounting terms the value of infrastructure works (i.e. the output) can be measured by the sum of :-

a - value added by capital,

b - value added by labour which would otherwise be unemployed, "inactive" or unproductively employed,

c - value added by labour which would otherwise have migrated,

d - value of intermediate inputs.

(b) In their turn these intermediate factors would be produced by :-

e - factors which would otherwise have been unemployed, "inactive" or unproductively employed,

f - factors which would otherwise have been employed in the non DAs having migrated from the DAs (i.e. labour),

g - factors which would otherwise have been employed in the non-DAs and which are indigenous there.

From this it can be seen that the production of infrastructure has involved the sacrifice of the following alternative outputs (assuming that all capital was a "scarce" factor as it would be in the medium term).

$$a + c + f + g = Z$$

This is the cost of the Infrastructure (Z). As mentioned above, it would be usual to say that the benefits from the infrastructure equal the sum of items a to d (= Y). However, it is suggested that infrastructure projects may be undertaken with the prime object of stimulating the regional economy so that the benefits to be derived from the use of the infrastructure may be less than they would be elsewhere, thus, just as the apparent cost overstates the real cost, so may the apparent benefits overstate the real benefit. For this

reason it may be wise to mark down the benefits by a factor $>|<$ 0 to give the actual benefits (=X). (In cases where the infrastructure expenditure enabled the regional economy to "take off" there may be a case for marking the apparent benefit up i.e. by a factor $>$ 1).

$$\text{Thus} \quad \text{Cost} \quad Z = a + c + f + g$$

$$\text{Benefit} \quad Y = a + b + c + e + f + g$$

$$X = >|< \ 0 \ (Y)$$

$$Z = Y-(b + e)$$

If b and e could be found from shadow wage calculation, then deriving both X and Z the cost per job becomes $\frac{Z-X}{n}$

(This does not allow for any gains to productive potential through the operation of the multiplier.)

CHAPTER 5

USING THE MODEL

It has been stated that the main purpose of this paper was to propose and describe a means to ameliorate certain deficiencies of analysis observed in previous strategies and studies. Chapter 1 referred to the advice given to Economic Planning Councils when DEA was in existence and which indicated the thinking on public expenditure analysis in terms of regional strategy-making. In the same chapter the advice given to structure planning authorities through the Department of the Environment was said to indicate current thinking.

It will be recalled that from these requirements upon strategy and structure plan production the most important recurring themes were :-

(i) "The need for some measure of the overall feasibility of the Plan". (The model incorporates a financial and real resource parameter (Sections iii and iv).

(ii) "Significant relationships between major expenditures in different sections should be recorded". (This has been attempted through the employment to population relationships (Section i).

(iii) "The priorities for investment between major programmes should be appropriate to the area". (The description of estimation of needs/demands under expenditure levels does this (Section ii and sub-sections).

(iv) "What are the construction implications for the region of the current and forecast levels of public investment". (The demands upon construction manpower under each expenditure level are included and broken down by trade groupings (Section iv).

(v) "Expenditure programmes need to be examined in relation to a larger planning and development period than five years". (The model has a ten year planning horizon).

(vi) "The planning associated with the expenditure forecasts should have a direct connection with the population of the region". (This is attempted within the model through the "reduced" to "original" population mmovement that occurs when the model is run (Section i).

(vii) "The competition of the private sector for construction resources should be registered". (Private Investment in new construction and works is included within the model, Section ii and sub-sections).

(viii) "There should be a facility for examining redistribution between different programmes of new works". (The use of a total regional "new construction" budget allows this flexibility (Section iii).

The remainder of this chapter explains the derivation of a base solution for the model and the information available to planners contained within it. This is presented in terms of the requirements discussed above. Examples of the kind of output available from post optimal analysis is given with special reference to the facility of the approach for parametric programming.

The derivation of the base solution

It has been previously explained that in the construction of the matrix certain population and employment levels were exogenously derived for each of the expenditure variables. The resource constraints, it will be recalled, were those of the "new construction" (including repair and maintenance to existing stock) budget and the capacity of the construction industry expressed in employment terms. In running the model,* the initial requirement was that a solution be sought which fulfilled the requirements expressed by the right-hand side values (those in respect of unemployment, migration levels, housing, education etc) and could be contained within the resources provided for their attainment. This is called the base solution and is efficient but not necessarily desirable. Further, the base

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* The model was solved using MPSX(360), a standard algorithm. For full description see I.B.M. :- MPSX/360 Application Description (H20/0136) or I.B.M. :- Introduction to Linear Programming (E20/8171).

solution must not only meet the requirements of the initial right-hand side formulation but the additional needs and demands imposed by the fact of their achievement through the various relationships and interdependencies built in to the matrix e.g. the reconstitution of employment decreases migration, raises home population which makes incremental demands upon housing and educational and other infrastructure programmes.

The base solution was obtained by first using as an objective function the minimisation of the total cost of meeting the requirements. Since the model is constrained to re-attain the original population and employment levels through the built-in relationships, it seeks to do this by reconstituting the necessary employment to allow this, but at least cost and within the constraints imposed by the right-hand side formulation of the new construction requirements. It was found in this case that the model achieved optimality readily within the new construction budget proposed and the construction manpower projected to be available. But some easing of the unemployment and net migration requirements had to be made since the construction manpower demand fell below that estimated in the original employment projection. This will be discussed further below. It is useful first to discuss the form of the basic solution and the information contained therein.

Examples of Output

The base solution is considered to be the coherent and feasible starting point from which to examine the effects of marginal changes of emphasis in public expenditure. Below is listed a representation of the kind of output obtained in the base solution.

	Activity level	(Initial right-hand side)	Input Cost	Dual Activity
Total Cost	£3,623m			
Public Expenditure on New Works	£2,451	(2,550)	-	-
Total Population	3,326,000	(3,195,000)	-	-
Total Employment	1,300,000	(1,053,000)	-	-
Net Outward Migration	88,000	(215,000,000)	-	-
Total Unemployment	63,000	(141,000)	-	-
Public Sector				
New housing (units)	61,011	(50,000)	4.5	.823
Replacement housing (units)	50,000	(50,000)	5.0	.90
ROADS :-				
Rural single (1/4 miles)	248	(248)	84.0	38.0
Rural single 3 lane	31	(31)	106.0	46.87
Urban single	20	(20)	115.0	51.49
Rural dual	96	(96)	193.0	87.88
Urban dual 2 lane	239	(239)	345.0	156.66
Urban dual 3 lane	37	(37)	1,172.0	530.33
Education				
Day nursery (places)	47,625	32,000	.45	.017
Primary	50,625	35,000	.45	.017
Secondary	70,625	55,000	.80	.152
Further Education	5,000	(5,000)	2.00	.489
University	5,000	(5,000)	3.25	.658
Private Sector				
New housing (units)	69,075	(60,000)	5.0	.997
New shop floor space ('000 sq ft)	4,495	3,850	6.0	1.467
New office floor space ('000 sq ft)	4,227	3,500	9.0	2.313

Construction Capacity		Slack Activity
Structural Works	18,245	1,915
Carpenters/Joiners	14,995	2,605
Service trades	12,590	2,530
Finishing trades	14,791	1,589
Unskilled/Semi-skilled	43,171	7,239
Supervisory staff	5,850	450
TOTAL :	109,642	16,348

The above presentation displays in terms of the requirements listed at the beginning of this chapter :-

(a) the relationship of population and employment to expenditures

(b) the share borne by the private sector

(c) the implications for the construction industry

(d) a financial estimate for the main expenditure headings for a ten year period

(e) the key aspects of public investment e.g. housing, highways, education

(f) an assessment of the feasibility and soundness of the plan in terms of comparisons with past trends and future resources.

To a large extent, therefore, a significant presentational gain has already been made. However, much more information can be gleaned from the base solution.

There is also information regarding the relative importance of public to private expenditure on new construction over the ten year period. In the above example it can be seen that the private expenditure on new construction is projected to be approximately 33% of total expenditure or approximately 50% of public sector expenditure. The relationship of private to public sector expenditure has been an underevaluated aspect of regional plans.

The effect on infrastructure requirements from increased population is also shown by comparing the activity level column with the initial right-hand side demands. It will be recalled that this arises from the movement within the model from the "reduced" to "original" population and employment levels as a result of the reconstitution of employment from construction and regional policy incentives to manufacturing industry. It is possible from the data to adduce an infrastructure cost of increasing population by a marginal increment. The dual activity for decreasing migration by one unit is £33,000. It should be stressed that this is a particular measure of the change in the overall demands upon new construction requirements as a result of the population being raised or lowered by one person. It is apparent that the form of the model makes this measure of infrastructure cost very sensitive to the size of the basic/non basic multiplier postulated. Thus, as infrastructure expenditure has to be generated to employ one construction worker for ten years and through the employment/migration relationships population is increased, then the apparent infrastructure cost will vary greatly with the ease with which that employment is generated e.g. a basic/non-basic multiplier of 1.25 is adopted in the model - if a coefficient of 1.15 were adopted, then more infrastructure expenditure would need to be generated to raise total employment and

therefore to increase population via the migration relationship. This is an important weakness in the present form of the model but at least the attention of the strategy-maker is drawn to the importance of the multiplier effect in his calculation and to the need for an accurate derivation.

The base solution also provides a check on the validity of the exogenously determined projections e.g. employment. From the above table it can be seen that there is some slack activity in construction manpower. It will be recalled (Table IV) that the total employment for construction to 1981 was based essentially on an extrapolation of 1959-71 time series. Graph III shows a considerable spurt in construction activity from 1964-70 and then a levelling off. These years were a period of intense road-building in the North-East following the Hailsham Plan [41] and is unlikely to be repeated in the future. The model figure of 109,642 appears a more reliable indication of the likely demand for construction manpower than the 126,000 indicated by the exogenous projection and further runs of the model adopted the lower base solution figure as the construction capacity constraint. The effect of lower construction employment is, of course, to reduce the total population and employment figures slightly below the original projections (Table II), and that is why the unemployment and net outward migration base solution levels are higher than the initial right-hand side levels as formulated in Figure I. In an operational situation there would be some significance in this for the strategy-maker since it would cast doubts on the original with-migration population forecast. (Inter-regional migration movements are mostly held to be related to inter-regional differences in the demand for labour.)

A major information guide is given by examining the dual activities (expressed in money terms*). As presented above they represent the change in total cost (over and above the nominal input cost) for a unit change in a row activity level. Thus from the above, taking new housing then, at the activity level given, an increase or decrease of one housing unit will increase or decrease total costs by £827 in addition to the incurring of, or saving on, the nominal input cost. This is the additional total infrastructure cost arising from the provision of an extra house and arises from the employment effects of house building. The dual activity values can be examined to determine the direction of desired trade/off. There is also information on the range of provision for which the dual activity value of £827 holds, e.g. from the output the lower activity was 400,924 and the upper activity 74,999. This information is repeated in the output for each of the expenditure headings.

Having examined the base solution and made the necessary adjustments† an examination of the effects of changes in the base solution expenditure pattern which are held to be desirable rather than merely efficient can now be made. All that has been done at this stage is to verify the

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*The dual activities could be formulated alternatively in terms of employment.

†For instance, construction capacity was constrained in later runs to near base solution levels.

general feasibility of exogenously derived demands upon each expenditure heading and it has been stated that these cannot be construed as objectives of the strategy-maker (Chapter 2). However, at this stage objectives in policy areas can now be introduced. Significantly, however, an increase in provision along one expenditure heading can now only be achieved if others are relaxed at the same time to release the necessary resources. If it is later felt that the desired increases in certain nominated expenditure headings have unacceptable consequences elsewhere, then at least those constraints which must be overcome are indicated and these can then be allowed to influence the policy proposals.

Assuming that an objective of the strategy-maker was to maximise the provision of public new housing, then the print-out example below shows the effect of this with special reference to the construction industry.

	Limits	Base Solution	Maximum Public Housing
Total Cost	-	£3,623m	£3,665m
Public Expenditure	£2,550m	£2,451m	£2,495m
Housing			
New Public	50,000	61,011	70,676
New Private	60,000	69,075	69,179
Structural Workers	18,750	18,245	18,565
Carpenters/Joiners	15,500	14,995	15,500
Service Trades	13,000	12,590	12,800
Finishing Trades	15,250	14,791	15,115
Unskilled Workers	44,000	43,171	43,791
Supervisors	6,000	5,850	5,980

From this it can be seen that an extra £44m of public expenditure would allow the provision of a further 9,665 new public housing units

within the new limits on construction capacities. The marginal increase in private sector new housing units results from the inter-dependency effects on population of building the additional public housing. When the objective function is the maximisation of housing provision, the dual activities relate to the provision of houses. For example, it can be seen from the above that the use of carpenters and joiners is at a capacity limit and since the dual activity for this trade element was 31.9 it suggested that each additional unit in this trade element would enable a further 32 houses to be constructed, all other resources remaining constant. If the prime aim was to maximise new public housing, then by tightening all other constraints and relaxing that on carpenters and joiners, a point could be reached with all trade elements constraining, thus giving the most suitable pattern of construction employment for maximum housing provision. Alternatively, housing could now be fixed at a higher level than in the base solution and another expenditure heading maximised, thus developing in an order of the strategy-makers' priorities the maximum values of these within the resource constraints. For instance, the strategy-maker may now wish to ascertain the maximum value for the provision of secondary education places whilst retaining the values for other variables at the base solution level. In this run the following output was derived with the limit on construction manpower as for maximum new public housing.

	Limit	Base Solution	Maximum New Secondary Education Places
Total Cost	-	£3,623m	3,640
Public Expenditure	£2,550	£2,451m	£2,468m
New Secondary Education	55,000	70,625	84,420
Nursery	32,000	47,625	47,667
Primary	35,000	50,625	50,643
Structural Workers	18,750	18,245	18,462
Carpenters/Joiners	15,500	14,995	15,109
Service/trades	13,000	12,590	13,000
Finishing Trades	15,250	14,791	14,942
Unskilled Workers	44,000	43,171	43,253
Supervisors	6,000	5,850	5,847

Again it can be seen that an extra £17m of public expenditure will enable some 14,000 more secondary school places above the base solution level. The dual activity for secondary school places indicated that some £12m of this figure would be a charge on the education capital account, the remaining £5m being the result of the employment effect of building these places (all other values being held equal to, or greater than, the base solution level). The marginal increase in the demand for primary and nursery places is a consequence of the interaction between extra employment creation and net migration effects. In the above solution it is service trades which are at their capacity limit and in this run the dual activity for service trades relates to the provision of new secondary school places. The value obtained of 133,4 suggests that a unit increase in service trades would permit a further 133 secondary school places to be provided, all other resources remaining constant. Similarly for housing, if the prime aim was to maximise the provision of new secondary school places, then by tightening all other constraints and relaxing that on service trades a point could be reached with all

trade elements constraining, thus giving the most suitable pattern of construction employment for maximum secondary education provision. Similar runs, maximising other activities in turn, would eventually provide a Ben-Shahar type transformation surface (Chapter 3).

A further example of information which might prove illuminating is the application of parametrics. Parametric programming is an efficient procedure for resolving the problem with a new right hand side rather than, say, re-optimising since the problem is not then sent infeasible. It is also a convenient tool if there is uncertainty of the relative weight to be given to two different objectives. In the following example the technique is applied to the maximised new housing solution with a view to examining the trade-off between, say, roads and new public houses.

Adjusting the forward road building programme thus :-

Road type	Initial form 1/4 miles	Reduced form 1/4 miles
Rural two lane	248	218
Rural three lane	31	31
Urban two lane	20	20
Rural dual carriageway	96	86
Urban dual carriageway	239	209
Urban six lane carriageway	37	27

The result of these cuts in road building on the new public housing programme and the demands upon construction employment is as follows :-

	Limit	Maximum Public Housing Solution	Reduced Roads Solution
Total Cost	-	£3,657m	£3,647m
Public Expenditure		£2,495m	£2,485m
Housing :-			
New public	50,000	70,676	74,476
Structural Workers	18,750	18,565	18,605
Carpenters/Joiners	15,500	15,500	15,500
Service Trades	13,000	12,800	12,893
Finishing Trades	15,250	15,115	15,214
Unskilled Workers	44,000	43,791	43,287
Supervisors	6,000	5,980	5,960

By imposing cuts on the road building programme obviously further public sector new housing units can be provided. From the dual activities it was suggested that for every quarter-mile reduction in rural two lane road a further 2.6 houses could be constructed, while a reduction of a quarter mile of urban dual carriageway would release sufficient resources for 183 houses to be constructed. However, it is apparent that the release of construction resources from the road building programme for house building is inefficient in terms of construction employees. Whilst the road building programme has been cut by 12-13%, the provision of public new houses has only increased by 4.5% and there has been an actual decrease in total public expenditure. A comparison of the trade element co-efficients for roads and new housing helps to explain the reason.

Average Trade Labour Requirements for new construction 1972

(see Table XII)

	Roads %	New Public Housing %
Structural Workers	1.0	20.0
Carpenters/Joiners	4.0	14.0
Service Trades	1.0	9.0
Finishing Trades	1.0	16.0
Unskilled Workers	87.0	36.0
Supervisory Staff	6.0	5.0

The policy implications are interesting. At those times when the capacity of the construction industry is at a limit, a switch in emphasis from road building to public sector new housing, indicated by the willingness to divert financial resources, would not be paralleled by a commensurate switch in real resources of the required composition and the resulting outturn effect could be an autonomous decrease in public expenditure by inability to fulfill the required targets for public new housing.

This alone is a good example of the power of the methodology to focus attention on the real constraints that face the strategy-maker. It is clear that a continuous dialogue is possible between a planning body and a model of this type such that the question "what if we do this?" is answered by "this will be the effect on expenditure, implies reductions in these fields and the trade off cost becomes .....". The model can be developed so that it can acquire explicit information through changes in the activity levels and dual activities of the implications of following alternative paths. The output generated can help to define the range of acceptable and desirable alternatives along the range of regional "new works" production possibilities.

The model in its present stage of development contains gross over-simplifications and even at this primitive level the data problems have been considerable. Whilst the application of more resources would assist its development to an operational level (Chapter 6), it is recognised that the proposed methodology retains many limiting features. The choice of the preferred solution, for example, is still a matter for the value judgements of the planning body and, on reflection, this may be "politically" correct. There is no evidence that the "proper" division of public expenditure in welfare terms between schools, houses, roads etc can be resolved by economic techniques alone. Within programmes the use of rates of return on capital for the selection between alternative items is as yet limited to items like roads, and even this limited exercise is subject to criticism of the criteria used. In this context the statement by Morris Hill[12] that "economic efficiency in its social sense need not be given an honoured status" only reflects the inadequacy of appropriate analytical techniques.

The particular application of LP methodology to regional and structure plan making which has been the subject of this paper does not point to a preferred strategy. In a narrow sense, with given resources, and for any level of attainment of aims, it can point to alternative combinations while constraining them to the feasible set.

In no sense are all possible and desirable solutions proposed, nor is there really a search after the best which either does not exist or is unrecognisable as such. What has been proposed and demonstrated is simply a way of generating feasible and coherent alternative paths, often the most difficult task which, hopefully, will help guide planners in their choice of priorities and enable them to structure their objectives in a realistic setting.

CHAPTER 6

FURTHER REFINEMENT AND DEVELOPMENT OF THE MODEL

This paper has concentrated mainly on problems of general structure and has sought in the first instance to demonstrate the potential of the methodology. Even with this limited aim the data and computational problems with limited resources have been considerable. To be fully operational as an aid to decision taking and policy analysis, further development is necessary and possible given manpower and data availability.

The remainder of the paper indicates some of the ways in which the practical aspects of the method might be enhanced.

A) FINANCIAL RESOURCES

An essential development for an operational model would require the demands upon the sources of finance to be specified. The total new construction budget employed in the model does not specify who actually pays the tax payer or rate payer, but merely indicates the order of expenditure involved. Public sector expenditure may be broadly divided into six categories :- (a) capital expenditure and (b) current expenditure which is the responsibility in each case of (i) central government (ii) local government (iii) nationalised industries and public corporations. The model as presently structured is concerned only with capital expenditure on new construction but there "are important relationships between

capital and current expenditure since capital expenditure by the public sector is almost always financed by borrowing and the debt interest becomes a claim on revenue expenditure. As well as the overall control exercised by the Treasury on the level of public sector borrowing, the consequent debt servicing claims in revenue spending are themselves an important restraint on such borrowing. The more a local authority borrows to finance capital projects the more it has to raise in rate income to service that debt, in addition to providing for its current expenditure services. The future revenue implications of capital expenditure in terms of both debt servicing and the physical upkeep of capital projects can therefore act as a brake on local authority investment". [4]

The local authorities are the largest spenders of public money in the region. Their three main existing sources of finance are the rate support grant and specific grants (both raised centrally through taxes) and rates which are of course raised locally. It would greatly add to the usefulness of the model to have the facility of measuring the impact of activity level on the implicating for :-

(a) the loan charges consequent on capital expenditure

(b) the scale of other recurrent expenditure which was implied by the capital expenditure

(c) the prospective levels of rate support grant and other relevant grants from central government

(d) the prospective growth in both the level of rates and rateable values, domestic and non-domestic.

B) FURTHER DISAGGREGATION

(1) By sex :-

The model overview, to retain simplicity of presentation, has adopted a unisex approach to population and employment changes. Further refinement would involve disaggregating by sex and to enable a "proper" assessment of the effects of industrial change on male and female employment.

(2) By sub-region :-

Again for the reasons outlined, the paper has only been concerned with regional aggregates and thus we have been concerned initially in attempting to simulate a rather special kind of regional production function, in terms of capital expenditure on new and replacement construction work. It has been assumed that the probable states of the major variables from this output would act as parameters for sub-regional distribution in relation to the locational strategy adopted and the spatial constraints considered to be operating. It should be noted, however, that the treatment of programmes can be widened to include, for example, in the case of housing, the sub-regional implications of alternative housing locations, each alternative locating being treated as a different policy dimension of general housing activity.

(3) By programme :-

In the approach adopted some activities have taken a general form e.g. public "other" activities, and these include other transport-ation forms i.e. railways, car transport, port and harbours. It

would obviously be desirable for investment in these fields to be distinguished. Further, in the case of housing, for example, the effect of house improvement on need or demand levels has been ignored. These and other developments are patently a necessary refinement.

(4) Employment :-

The sub-matrix on regional industrial incentives to new mobile industry, Figure 2, (in sleeve) demonstrates how the treatment of employment and industry may be further disaggregated. Construction employment in a model purporting to demonstrate feasibility patterns of various activity programmes is a prime constraint and the trade element breakdown in the model is still highly aggregated i.e. structure, services etc. Further questioning of relevant sources has shown, however, that a much greater refinement of site labour requirements may be possible. It should also be possible, on recent data developments at the BRS, to determine the plant and materials used in various types of building and civil engineering contracts with a view to determining more fully the impact of varying output structures on the demand for resources.

C) TIME PHASING

The model as presented displays no lapse time between expenditure and output over the planning period adapted. It would nevertheless be possible to introduce the element of time phasing. In this case it would be useful to run the model on an incremental basis to ascertain where activity build-ups diverge in their effects and to distinguish the policy consequences associated with these divergencies.

D) THE TREATMENT OF UNCERTAINTY

In the model the problem of uncertainty centres on the exogenous projection and interdependency coefficients used. In practical terms the effect of this uncertainty is to require proposals based on the output of the model to possess a degree of flexibility consistent with the degree of uncertainty of the underlying data base. One way to approach this problem in the model would be to apply parametric programming techniques to the "uncertain" variables and examine the accompanying sensitivity of output changes. Where sensitivity is shown to be high, consideration would then need to be given to incorporating maximum flexibility into subsequent proposals. Monitoring of results is one accepted safeguard against uncertainty and the form of the model is well suited to facilitating monitoring procedures.

TABLE I POPULATION PROJECTIONS (ALL PERSONS) TO 1981 ON NATURAL INCREASE AND WITH MIGRATION BASIS

'000

Year	0-4 yrs	5-9 yrs	10-14 yrs	15-19 yrs	Population of Working Age 15+	Total
1971	263.5	286.1	273.5	241.9	2,477.6	3,300.7
1981 (Natural Increase)	268.3	243.3	284.7	259.5	2,638.7	3,410.5
1981 (with Migration)	258.7	232.9	273.6	249.9	2,586.6	3,327.3
Difference : Natural increase - with Migration	-9.6	-10.4	-11.1	-9.6	-52.1	-83.2

Source : OPCS. Regional Demography Unit London and Statistics Programming Unit, Tubfield Hants, November 1972

NOTE : EDUCATIONAL RANGES are somewhat different from above. The procedure for deriving these was to take a proportion of the next age group. Thus for primary education 5-10, one-fifth of the 10-14 total was added and one-fifth of the 5-9 subtracted.

TABLE II POPULATION EMPLOYMENT SUB/MATRIX - DERIVATION OF UNEMPLOYMENT, MIGRATION AND ACTIVITY RATE COEFFICIENTS

Population of Working Age 15 and over	Employees in Employment	Average total Unemployment	Economically Active Rate	Annual Average Net outward Migration
Col 1	Col 2	Col 3	Col 4	Col 5
'000	'000	'000	%	'000
1961				1961-66
2,430	1,277	32.0	53.5	6.5
1971				
2,520	1,242	77.0	51.8 @ 1968	

SOURCE : Abstract of Regional Statistics for 1966, 1969, 1972

TABLES 1-12

Assumptions

1. The annual average net outward migration level between 1961-66 of 6,500 was assumed to continue for the period 1966-71
2. The 1971 Population of Working age was derived by adding back into the actual 1971 population that proportion of net migrants of working age, i.e. five-eighths of 65,000
3. The 1971 economically active rate was taken as at the last publication of the rate (Department of Employment definition) for 1968

Under these assumptions the change in job gap 1961-71 becomes :-

(1971 Population of Working Age - 1961 Population of Working Age) +

(1961 Employees in Employment - 1971 Employees in Employment)

= (2,520 - 2,430) + (1,277 - 1,242)

= 123,000

And from TABLE II :-

a) Increase in average total unemployment 1961-71 = 45,000

b) Decrease in economically active = 1.7% x 2,475,000 (Average of 1961 and 1971 Populations of Working Age) = 42,000

c) Net outward movement of Migrants of Working Age = $^{5}/_{8}$ x 65,000 = 40,000

Total Job Gap explained = 127,000

The 123,000 job gap is thus explained largely by movements in the balancing variables, the small difference being attributed to residual estimation error.

The share of explanation of the job gap between the balancing variables is almost equally divided, and therefore the adoption of .33 coefficients for both unemployment and net migration appears not unreasonable for working purposes. (Activity rates are treated as a residual within the matrix.)

INITIAL POPULATION/EMPLOYMENT LEVELS

The removal of 251,000 jobs (i.e. new mobile industry jobs, construction employment plus multiplier) from the employment projections increases the 1981 job gap by the same number. Using the above coefficients, the 1981 projected unemployment rates and migration rates of 58,000* and 83,000 (TABLE I) respectively rise to the initial model figures of 141,000 and 215,000 respectively (FIGURE I). The initial population total falls by 83,000 x $^{8}/_{5}$† = 132,000 to 3,195,000 and initial total Employment becomes 1,053,000 (see FIGURE I).

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*Assumes a maintenance of regional relative unemployment to 1981, e.g. the 1971 June relative was 186, whilst the assumed total National unemployment rate at 1981 is 2.3% (see TABLE III).

∴ 1981 Northern Region Total Unemployment rate = 2.3% x $\frac{186}{100}$ = 4.3% =

1,303.8 x 4.3% = 58,000

†Since 83,000 refers to migrants of working age only

TABLE III ESTIMATES OF GB EMPLOYEES IN EMPLOYMENT AT 1981

Derivation of Employees in Employment by steps	1981 Male '000	1981 Female '000
Total Working Population	16,262	9,770
from which are deducted :-		
(a) Armed Forces	334	16
(b) Civilian Labour Force	15,928	9,754
(c) Self-employed (and employers)	1,300	350
to give :-		
Total "employees including unemployed"	14,628	9,404
from which is deducted :-		
Wholly unemployed (male 3% and female 0.85%)	439	80
to give :-		
Total Employees in employment	14,189	9,324
which is then disaggregated by :-		
(a) Primary employment	540	60
(b) Manufacturing employment	5,950	2,400
(c) Construction employment	1,431	113
(d) Service employment	6,358	6,751

Assumptions for TABLE III :-

(a) The total national working population for 1981 is drawn from the DE Gazette, August 1971

(b) The Civilian labour force is taken as in DE Gazette, March 1972, and hence Armed Forces by subtraction

(c) Self-employed obtained by examination of past figures plus some freehand amendment to take account of new policies :-

(1) The abolition of SET should reduce this class

(2) The introduction of VAT may possibly also reduce self-employed

(3) Finance Act 1971 clamps down on the 'lump' with attendant effects on self-employed workers.

(d) The Wholly unemployed percentages are guesses which do not appear unreasonable. They are based on an interpretation of Department of Employment pressure of demand assumptions as used for their total work population projections - one difficulty is that they now quote pressure of demand in vacancy terms rather than in unemployment terms (DE Gazette, August 1971)

(e) The breakdown of "employees in employment" into broad sectors was done on the basis of examination of trends for primary, manufacturing and services, with construction being treated as a residual. The results did not appear ridiculous, but the spurious accuracy implied by the figures should be ignored.

TABLE IV PROJECTIONS OF LEVELS OF EMPLOYEES IN EMPLOYMENT BY SECTOR - NORTHERN REGION AT 1981

Sector	Model used in Projection	Correlated Coefficient	Overall F Value	Duban Watson Statistic	Estimated Ratio	Std Error of Estimated Ratio	Projected Values at 1981 National Projections	Northern Region Projections	Std Error of Northern Region Projections
1	2	3	4	5	6	7	8	9 =(6)x(8)-1000	10 =(7)x(8)-1000
							000's	000's	000's
Males :									
Primary	Y=284.3-2.2T-4.0GBU-1	0.97	84.3	1.5	93.7	5.0	450	42.2	2.3
Manufacturing	Y=55.9	-	-	-	55.9	1.6	5,950	332.6	9.5
Construction	Y= -19.5-1.3T	0.90	47.0	0.9	84.6	4.0	1,431	121.0	5.7
Services	Y=65.3-0.3T	0.93	71.4	2.2	44.7	0.6	6,358	284.2	3.8
Total							14,189	780.1	
Females :									
Primary	Y=178.6-1.8T	0.96	117.1	1.8	30.4	3.6	60	1.8	0.2
Manufacturing	Y= -7.2+0.7T+0.9MGB4	0.98	128.3	0.9	56.2	1.5	2,400	134.9	3.6
Construction	Y=50.9	-	-	-	50.9	1.7	113	5.0	0.3
Services	Y=54.0+0.9MGBU(-1)	0.72	11.5	1.7	56.6	0.6	6,751	382.1	4.1
Total							9,324	524.6	
All :									
Primary							510	44.0	
Manufacturing							8,350	467.5	
Construction							1,544	126.0	
Services							13,109	666.3	
Grand Total							23,513	1,303.8	

TABLE V AVERAGE CONTRACT VALUES PER CONSTRUCTION WORKER

Activity Area	Average Man Days per £1,000 Contract	Average Contract Value per Construction Worker per ten year period £'000	Comments
All new work	60.0	*29.0	BRS Report[46c] "Site Labour Requirements for Government Contracts"
Housing	67.5	25.7	BRS Report[46b] "Site Labour Requirements for LA Housing Construction". Same value assumed for private construction
Education : Primary and Nursery	60.0	29.0	BRS Report "Site Labour Requirements for Government Contracts
Secondary and Further	65.0	26.8	
Shopping Offices Entertainment Commercial Other Public Other	60.0	29.0	No specific data available yet on these activities. The average value is therefore assumed
Industry	44.2	39.4	BRS Report[46e] "Site Labour Requirements for Industrial Building"
Public Corp	44.2	39.4	Assumed as for Industry
Health	67.3	25.8	BRS Report[46d] "Site Labour Requirements for hospital building"
Roads) Water) Sewerage) Derelict Land)	44.0	40.0	No specific data available. Assumption of high capital intensity in these works is reasonable. Values adopted at the private industrial level
Repair and Maintenance	79.5	21.9	Obtained by taking the average value for extension and alteration works from the BRS reports above

*Average man/year taken as 264 days (to be read in conjunction with Section IV) The average contract value is estimated by multiplying the average contract value for all new work i.e. £29,000 by the ratio of average man-days per £1,000 contract for all new work to the average man-days per 1,000 per particular activity.

TABLE VI TYPES OF NEW CONSTRUCTION WORK

Sector	Units in matrix	Examples of work covered
Public Housing	Average unit cost per average housing unit	Local authority housing schemes.
Private Housing	,, ,, ,,	All privately owned building for residential use
Roads	Average cost per ¼ mile provision per road category	Public roads, pavements, bridges, tunnels, flyovers, fencing etc
Education	Average cost per place per category	All work to state schools or colleges. All works for universities including halls of residence, research establishments etc
Industry	Average cost per average square footage per employee	Factories : warehouses, depots and all other works and buildings for the purpose of, and ancillary to, commercial or industrial production or processing
Offices	Average cost per '000 square foot	Office buildings except when they are purely ancillary
Shops	Average cost per '000 square foot	All buildings for retail distribution such as shops, department stores, markets, showrooms etc
Entertainment	Surrogate Cost (average value of contractors' orders per construction work employed). Estimated expenditure taken as the demand	Theatres, concert halls, cinemas clubs, hotels, public houses, restaurants, cafes, dance halls, swimming pools, stadiums etc
Commercial other	As entertainment	All work not clearly covered by any other heading, e.g. farms, garages, private airfields etc

Continued overleaf .....

TABLE VI Continued

Sector	Units in matrix	Examples of work covered
Public other	As entertainment	Harbours, waterways, Police, prisons, libraries, museums etc
Public Corporations	As entertainment	Works at public steelworks, gas works, power stations, railways, airports etc
Health	As entertainment	Hospitals, including medical schools, clinics, surgeries etc
Sewerage	On analysis of past expenditure taken as 2½% of total expenditure on new construction	Sewage disposal works, laying of sewers and surface drains etc
Water	As entertainment	Reservoirs, purification plants, dams, aqueducts, wells, conduits etc

TABLE VII ESTIMATION OF COEFFICIENTS FOR "OTHER" COMMERCIAL AND PUBLIC NEW CONSTRUCTION AND WORKS

1971 current prices

Activity	Base Expenditure Level	EDC Forecast Growth	1971-81 Total Value of Contractors' Orders	1971-81 Reduced Forecast Employment Linked *	1971-81 Reduced Forecast Population Linked †	Average Value Per Capita Empl. or Popn. as appropriate	Unit or Surrogate Costs from Table V
	£m		£m	£m	£m	£	£'000
Health Services	12.0 (1971)	£14,000 p.a. 1971-77 £8,000 p.a. 1977-81	115.0	-	110.0	34.0	25.0
Entertainment Services	5.8 (1965-71) (average)	2.0%	63.0	52.0	-	48.0	24.7
Commercial "Other"	5.7	1.5%	60.0	-	58.0	18.0	24.7
Public Corporation	14.7 (1968-71) (average)	7.0%	240.0	200.0	-	180.0	34.0
Water Services	No figures obtainable	Approx. £50m to 1977, reduced thereafter to 1981	70.0	-	68.0	21.0	26.0

Continued overleaf.....

TABLE VII (Continued)

1971 current prices

Activity	Base Expenditure Level	EDC Forecast Growth	1971-81 Total Value of Contractors' Orders	1971-81 Reduced Forecast Employment Linked *	1971-81 Reduced Forecast Population Linked †	Average Value Per Capita Empl. or Popn. as appropriate	Unit or Surrogate Costs from Table V
	£m		£m	£m	£m	£	£'000
Other Public Services	19.6 (average) (1969-70)	Erratic historical trends ten year period av. of Col.1 adopted	196.0	-	190.0	60.0	26.0
	sq.ft.m		sq.ft.m	sq.ft.m		sq.ft.	£'000 per '000 sq ft net increase
Offices	*12.1	3.5%	4.15	3.5	-	3.2	*9.0
Shopping	*40.3	1.0%	4.4m	3.85	-	3.8	*6.0

TABLE VII (Continued)

† "Reduced" to "Original" Employment Ratio $\frac{1.053}{1.304}$

"Reduced" to "Original" Population Ratio $\frac{3.195}{3.327}$ (See TABLE II)

* The base level for Offices and Shopping was drawn from the Abstract of Regional Statistics 1972 (Table 39) and the Unit Costs per 1,000 sq.ft. was estimated on the basis of 1967-68 expenditure divided by net increase in floorspace pver that period.

NOTE : Except where stated the above data is based largely on the forecasts of the value of contractors' orders 1971-77 carried out by the EDC for Building and Civil Engineering.[30] The data base of the individual activity forecasts vary greatly in detail and firmness and are only to 1977.

In some cases i.e. Health, Water Services, the EDC forecasts included vague statements hinting that post 1977 orders may well decline. In others e.g. public corporations and public "other" services, the historical trends show extreme variation (e.g. public corporations 1968 - 5.7m, 1970 - £21.6m). On this basis the 1971-81 totals are, at least, extremely tentative. However, for the purpose of testing model structure, it is only required that the figures have a degree of reasonableness. Given the difficulties, a certain amount of interpolation is inevitable and an impression of spurious accuracy is avoided, therefore, by gross roundings.

One further complication is that the EDC forecasts on which the estimates are based were obtained prior to publication and these have since undergone revision. The published version (March 1973) contains, in some cases, considerable variation e.g. the announcement of the Kielder programme affects water services. Again the events have to some extent overtaken the railways element of the public corporation forecasts with the announcement of a massive investment programme. Such events in an operational situation would be taken into account by monitoring procedures.

TABLE VIII TOTAL DERELICTION AT 31 DECEMBER 1971

Administrative Counties and County Boroughs	Spoil Heaps		Excavation and Pits		Other forms of dereliction		Totals	
	Total Acreage	Proportion of total acreage justifying restoration	Total Acreage	Proportion of total acreage justifying restoration	Total Acreage	Proportion of total acreage justifying restoration	Total Acreage	Proportion of total acreage justifying restoration
Cumberland	813	592	810	231	499	407	2,122	1,230
Carlisle	-	-	26	26	8	8	34	34
Durham	3,106	2,487	2,014	667	5,012	4,226	10,132	7,380
Darlington	-	-	-	-	-	-	-	-
Gateshead	11	11	-	-	36	36	47	47
South Shields	-	-	-	-	76	76	76	76
Sunderland	81	81	26	26	271	256	378	363
Hartlepool	-	-	-	-	61	61	61	61
Northumberland	1,208	1,044	845	417	4,258	3,218	6,311	4,679
Newcastle upon Tyne	-	-	8	8	73	60	81	68
Tynemouth	-	-	2	2	4	4	6	6
Westmorland	6	-	3	3	17	17	26	20
Yorkshire - North Riding	201	108	58	34	398	328	657	470
Teesside	306	256	114	114	114	114	564	514
Northern Region	5,732	4,579	3,906	1,528	10,857	8,841	20,495	14,948

DERELICT LAND

TABLE IX AMOUNT OF DERELICT LAND TO BE RESTORED BETWEEN 31 DECEMBER 1971 AND 31 DECEMBER 1972

Administrative Counties and County Boroughs	Spoil Heaps Acreage to be restored	Excavation and Pits Acreage to be restored	Other forms of dereliction Acreage to be restored	Total Acreage to be restored
Cumberland	182	46	64	292
Carlisle	-	-	8	8
Durham	316	15	394	725
Darlington	-	-	-	-
Gateshead	11	-	31	42
South Shields	-	-	-	-
Sunderland	81	26	168	275
Hartlepool	-	-	20	20
Northumberland	160	1	515	676
Newcastle upon Tyne	-	-	18	18
Tynemouth	-	-	-	-
Westmorland	11	9	29	49
Yorkshire - North Riding	-	-	25	25
Teesside	-	-	25	25
Northern Region	761	117	1,275	2,153

TABLE X RECLAMATION OF DERELICT LAND 1979-70 - NORTHERN REGION

No of schemes	Acreage	Gross eligible cost	Aftervalue	Net eligible cost
i	ii	iii	iv	v
22	554.8	1,043,655	75,131	968,524

Source : DOE "Derelict Land Survey 1971"

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TABLE XI SUMMARY OF TOTAL PUBLIC EXPENDITURE ON NEW CONSTRUCTION AND WORKS (1968-1972)

1971-1972 SURVEY PRICES (Excludes Nationalised Industries)

	1968/69	1969/70	1970/71	1971/72
Department of the Environment				
Motorways and Trunk Roads	32.1	38.2	36.1	19.8
Principal Roads	14.4	12.6	14.8	12.6
Ports	0.9	1.2	2.6	5.6
Public Housing Investment	59.6	52.7	49.4	38.6
Water Supply and Sewerage	9.7	8.4	8.9	8.8
Other	9.9	9.6	11.4	10.4
Department of Education and Science				
Schools	13.0	10.8	12.9	20.4
Further Education	3.6	2.9	3.3	3.6
Other Education and Science Services	0.1		0.1	0.1
Department of Health & Social Security				
Hospitals and other Health and Social Services	8.4	7.9	8.5	11.5
Other Departments				
Locally determined schemes	14.4	15.0	17.0	14.9
REGIONAL TOTAL:	172.2	164.9	169.3	152.5

Four Year Average = £164.75m, say, £165m

Ten Year Total @ 1968-71 average 1971-81	£1,650m
plus : (a) *Public Corporations	200m
(b) *Repair and Maintenance	350m
(c) Derelict Land	30m
Initial Regional Total	£2,230m
plus allowance for 1½% † p.a. growth in real terms	
Final Regional Total	£2,550m

Source :- Regional Public Expenditure Survey Committee (unpublished)

*EDC Forecasts for Building and Civil Engineering [30]

† See Sub-section(ii.h)

TABLE XII ESTIMATES OF TRADE LABOUR REQUIREMENTS FOR NEW CONSTRUCTION 1975 GREAT BRITAIN

Man years

	New Housing		Schools	Roads	Health	"Other" Public	Water	Sewer-age	Public Corpor-ations	Private		Total new work
	Public	Private								Industrial	Commercial	
Structure	23,520 (20%)	31,660 (21%)	6,740 (31%)	280 (1%)	3,000 (12%)	7,340 (13%)	110 (3%)	280 (2%)	2,850 (11%)	19,690 (23%)	13,600 (13%)	109,300 (16%)
Carpenter	16,550 (14%)	19,790 (13%)	9,410 (19%)	800 (4%)	4,020 (17%)	8,650 (15%)	480 (13%)	1,630 (2%)	3,830 (15%)	10,940 (13%)	16,030 (15%)	93,060 (14%)
Services	9,900 (9%)	13,700 (9%)	8,300 (17%)	110 (1%)	6,080 (25%)	9,220 (16%)	-	-	3,620 (14%)	12,580 (15%)	17,080 (16%)	80,900 (12%)
Finishers	18,540 (16%)	31,650 (21%)	6,040 (12%)	230 (1%)	3,070 (13%)	5,930 (11%)	-	140 (1%)	2,340 (8%)	9,020 (10%)	10,980 (11%)	88,100 (13%)
Semi- and Unskilled	41,740 (36%)	47,770 (31%)	15,660 (32%)	17,890 (87%)	6,820 (28%)	20,930 (37%)	3,030 (82%)	11,480 (84%)	11,620 (44%)	29,690 (34%)	38,780 (37%)	261,310 (40%)
Supervision	5,220 (5%)	7,610 (5%)	2,860 (6%)	1,150 (6%)	1,110 (5%)	3,930 (7%)	70 (2%)	190 (1%)	1,440 (6%)	4,790 (6%)	7,290 (7%)	36,720 (5%)
All Trades	115,520 (100%)	152,180 (100%)	48,740 (100%)	20,460 (100%)	24,100 (100%)	56,000 (100%)	3,690 (100%)	13,720 (100%)	25,700 (100%)	86,710 (100%)	103,760 (100%)	669,390 (100%)

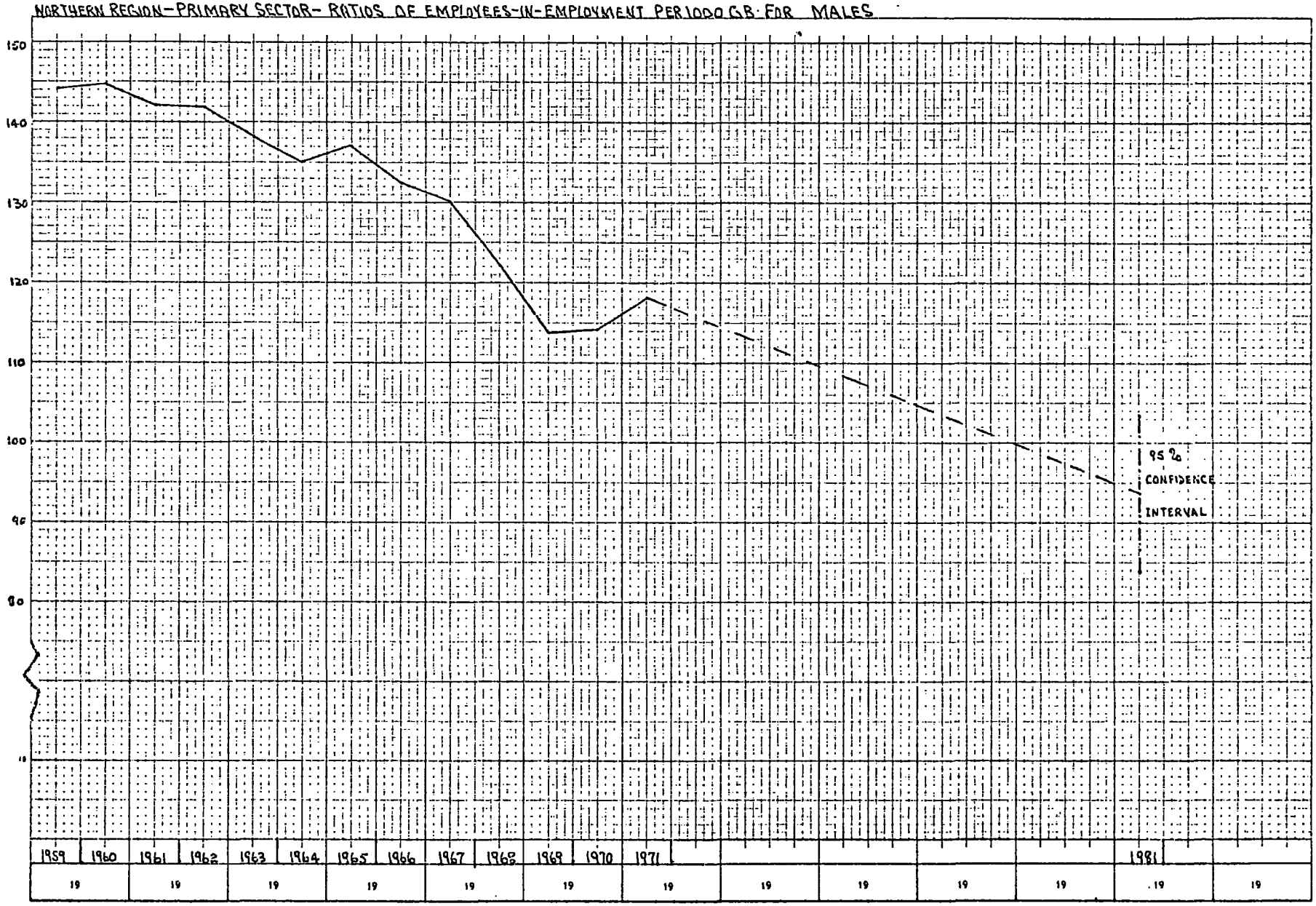
Source : Building Research Station, Garstan Herts.

TABLE XIII AVAILABLE CONSTRUCTION MANPOWER BY TRADE ELEMENT

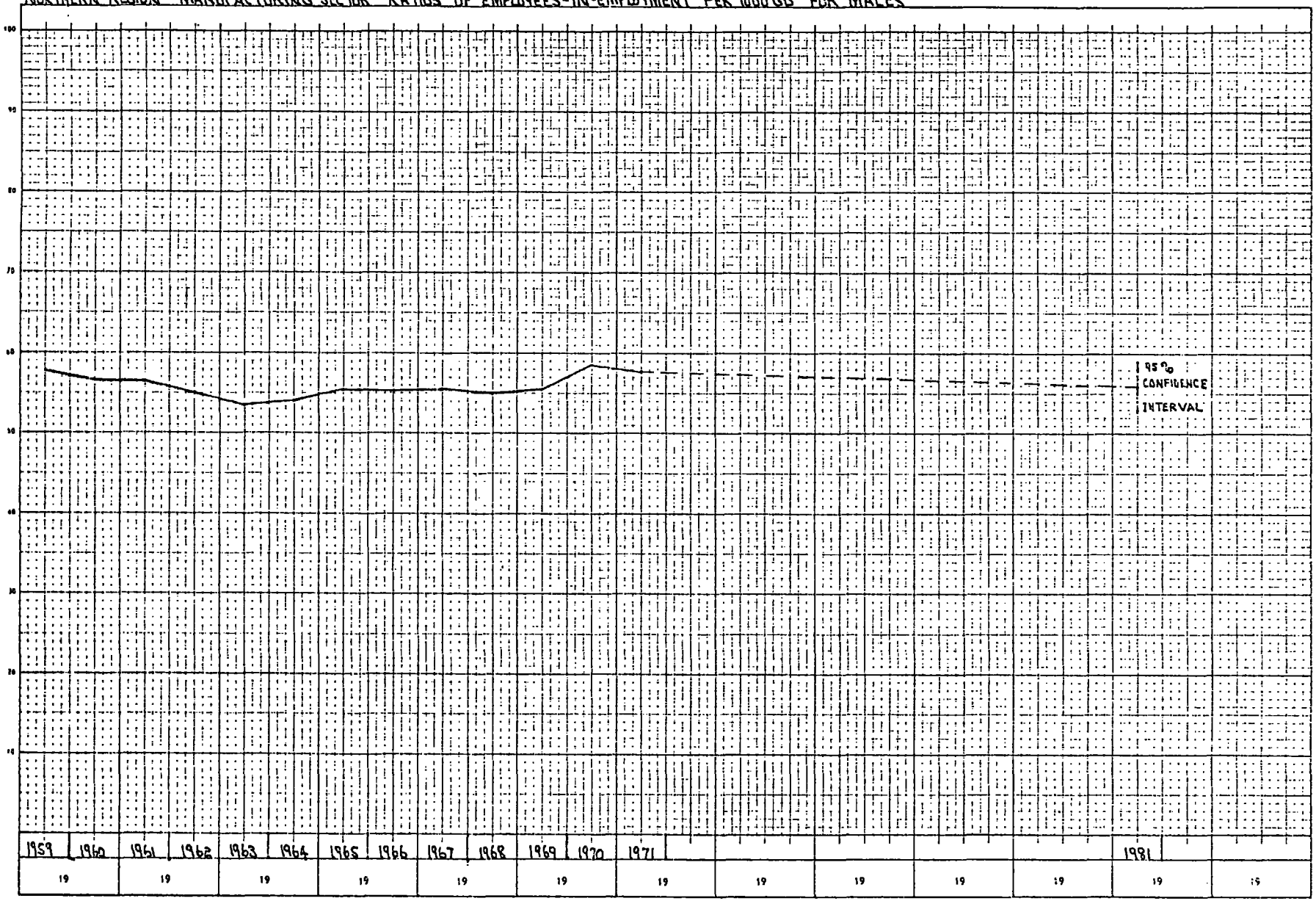
Trade Element	% BRS Estimates of Incidence of all Trades in all New work 1976 [46a]	Previous Column x 126,000 †
Structural Workers	16%	20,160
Carpenters and Joiners	14%	17,600
Service Trades	12%	15,120
Finishing Trades	13%	16,380
Unskilled/semi-skilled Workers	40%	50,400
Supervisory Staff	5%	6,300
TOTAL		125,988 *

*Totals less than 126,000 due to rounding errors

†Table IV refers (Construction employment projection figure)

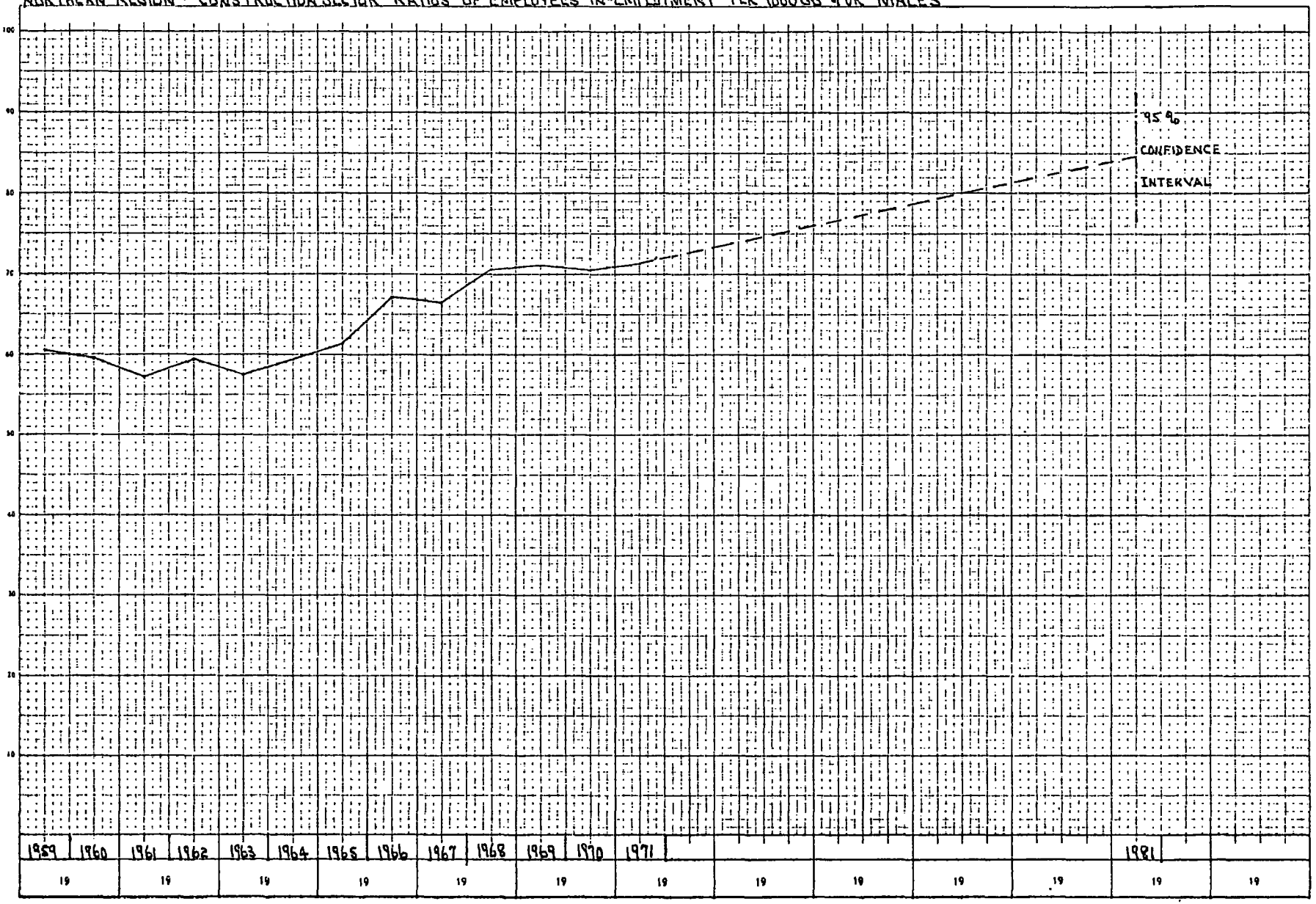

NORTHERN REGION–PRIMARY SECTOR– RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR MALES
150
140
130
120
110
100
90
80
10
95 %
CONFIDENCE
INTERVAL
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1981
19

NORTHERN REGION - MANUFACTURING SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR MALES



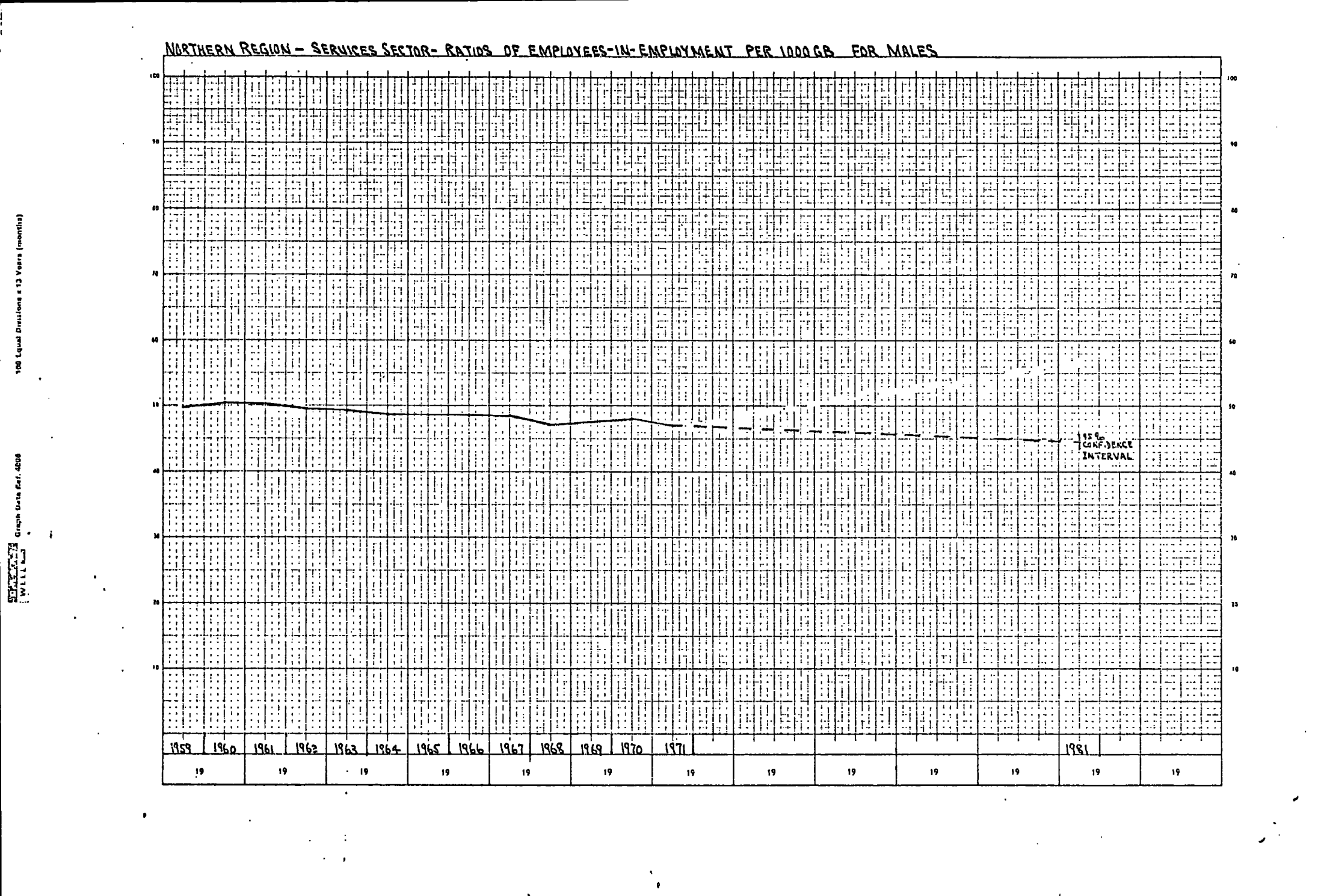
150 Equal Divisions x 13 Years (months)
Graph Data Ref. 4606

NORTHERN REGION - CONSTRUCTION SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB *FOR MALES

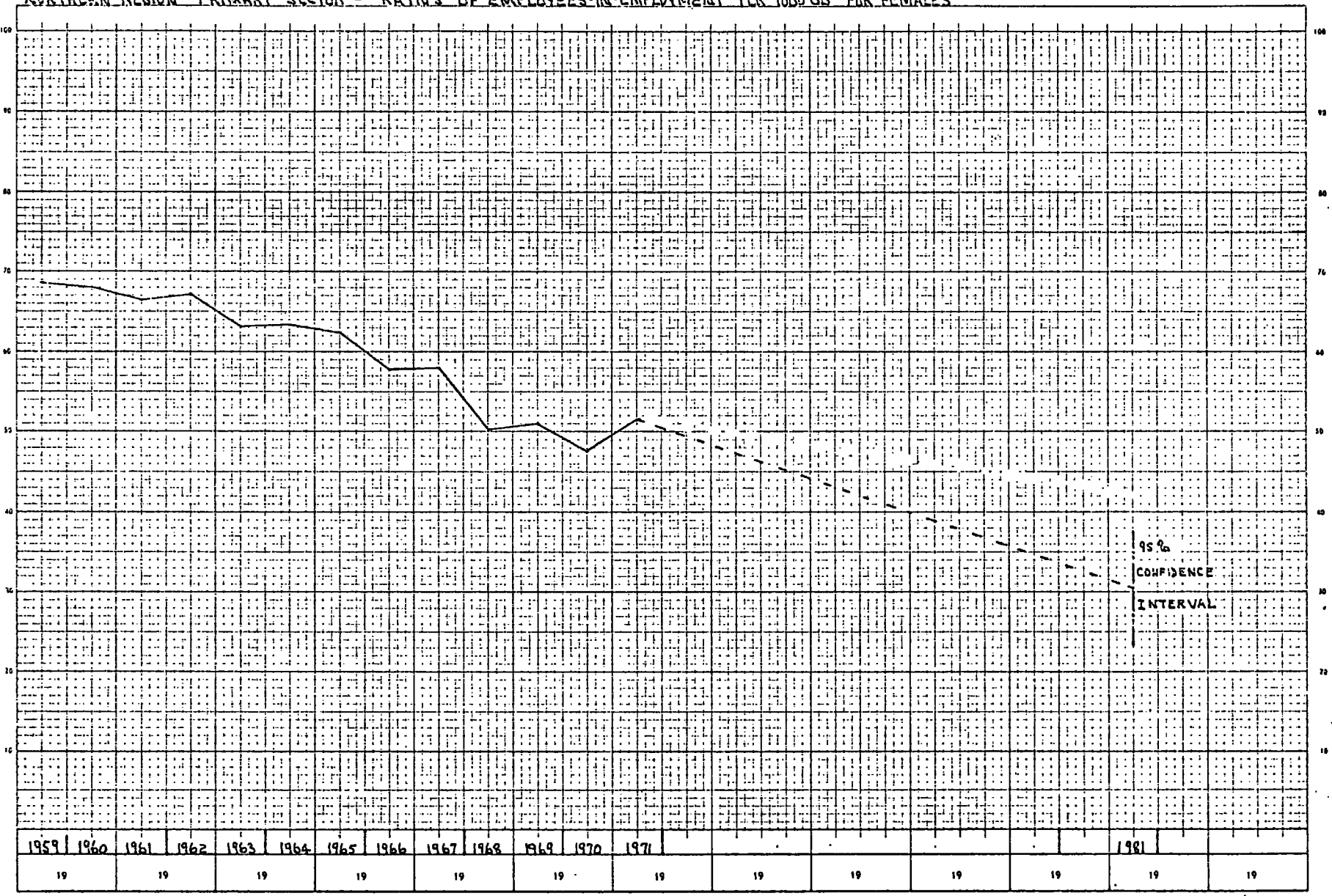


100 Equal Divisions x 10 Years (months)

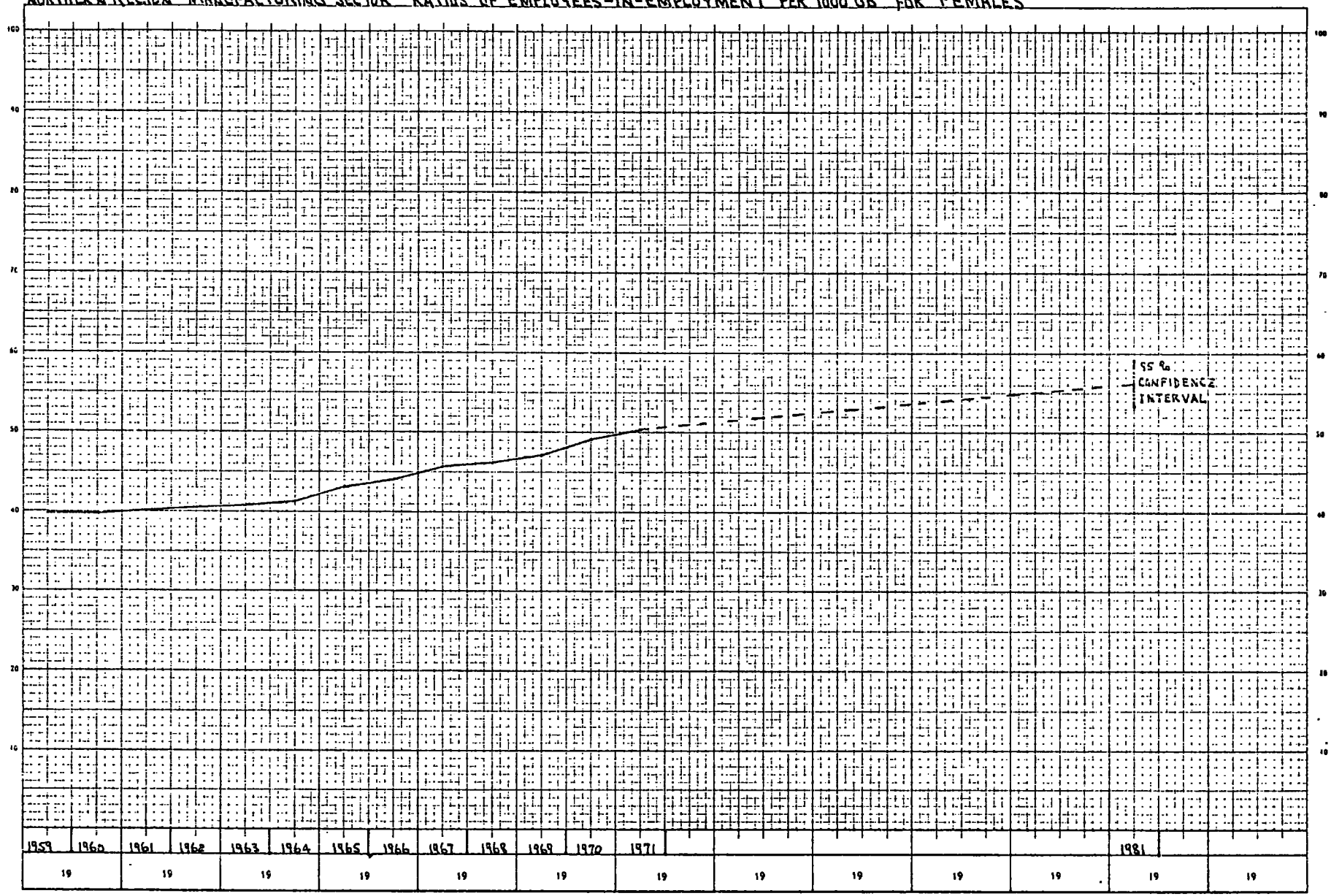
Graph Data ref. 4006


NORTHERN REGION – SERVICES SECTOR- RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR MALES
95% CONF. INTERVAL
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1981
19

NORTHERN REGION - PRIMARY SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR FEMALES

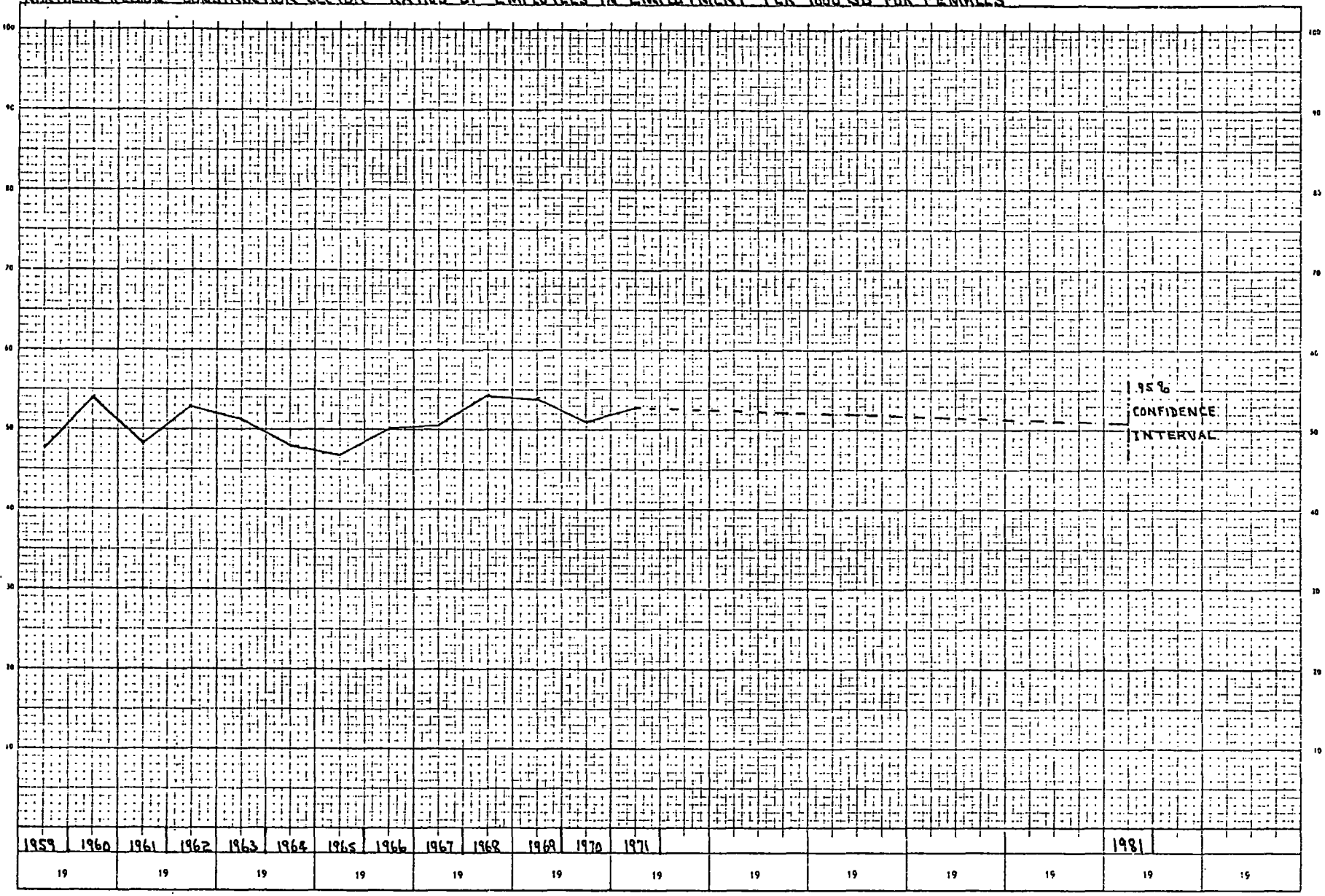


NORTHERN REGION - MANUFACTURING SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR FEMALES



100 Equal Divisions x 13 Years (Lunchie)
Graph Data Ref. 4606

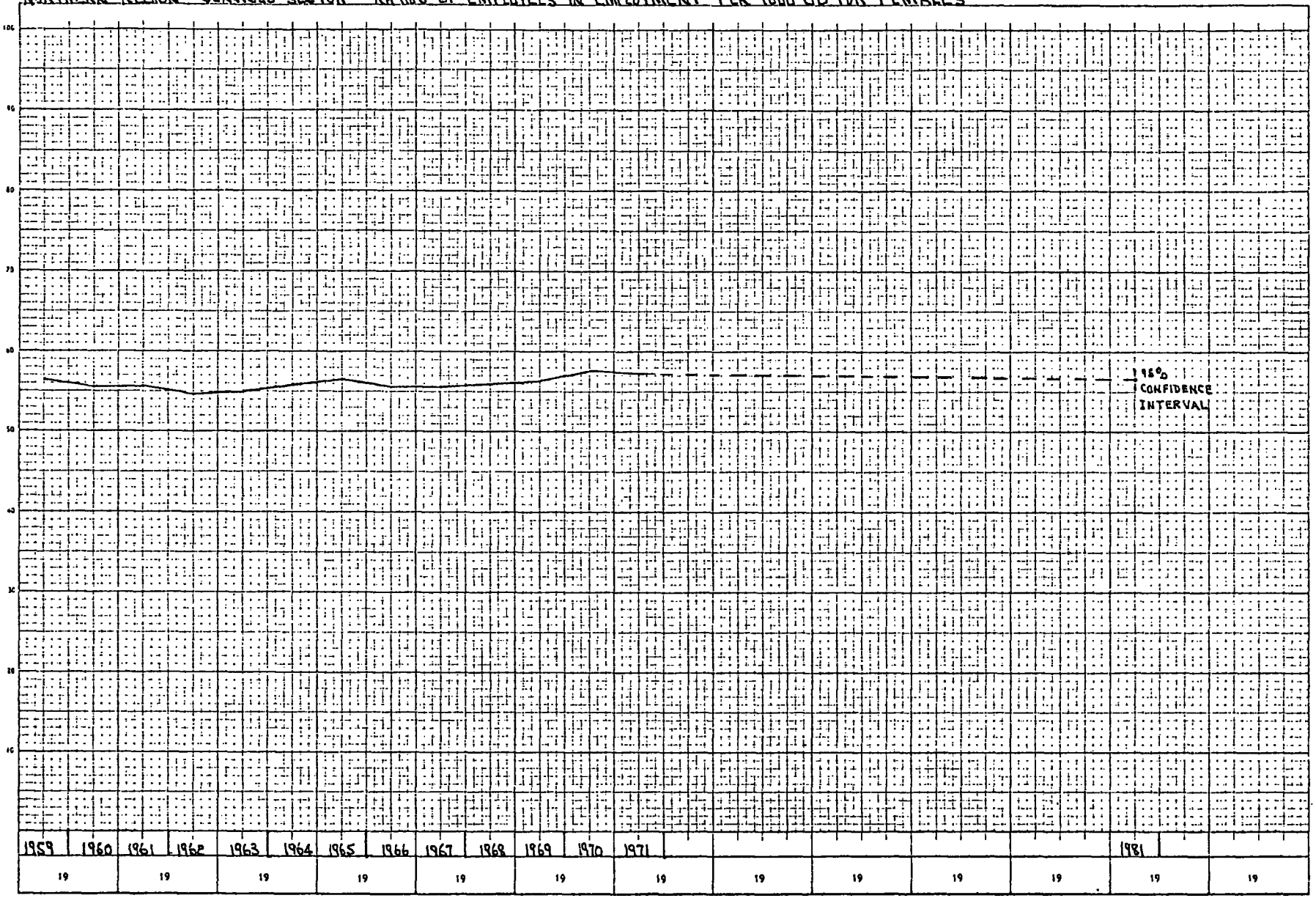
NORTHERN REGION - CONSTRUCTION SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR FEMALES



100 Equal Divisions x 13 Years (months)

Graph Data Ref. 4068

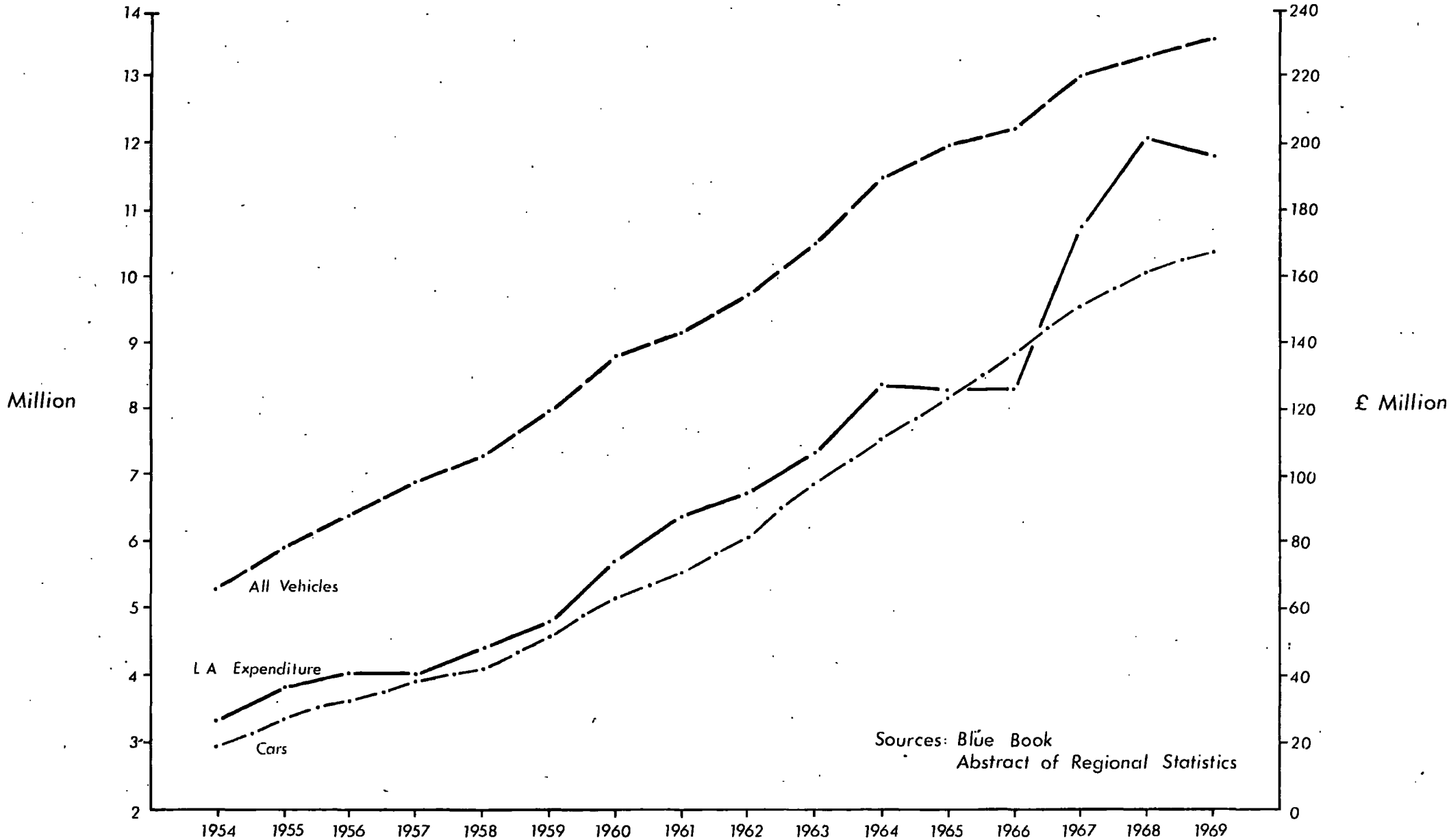
NORTHERN REGION - SERVICES SECTOR - RATIOS OF EMPLOYEES-IN-EMPLOYMENT PER 1000 GB FOR FEMALES



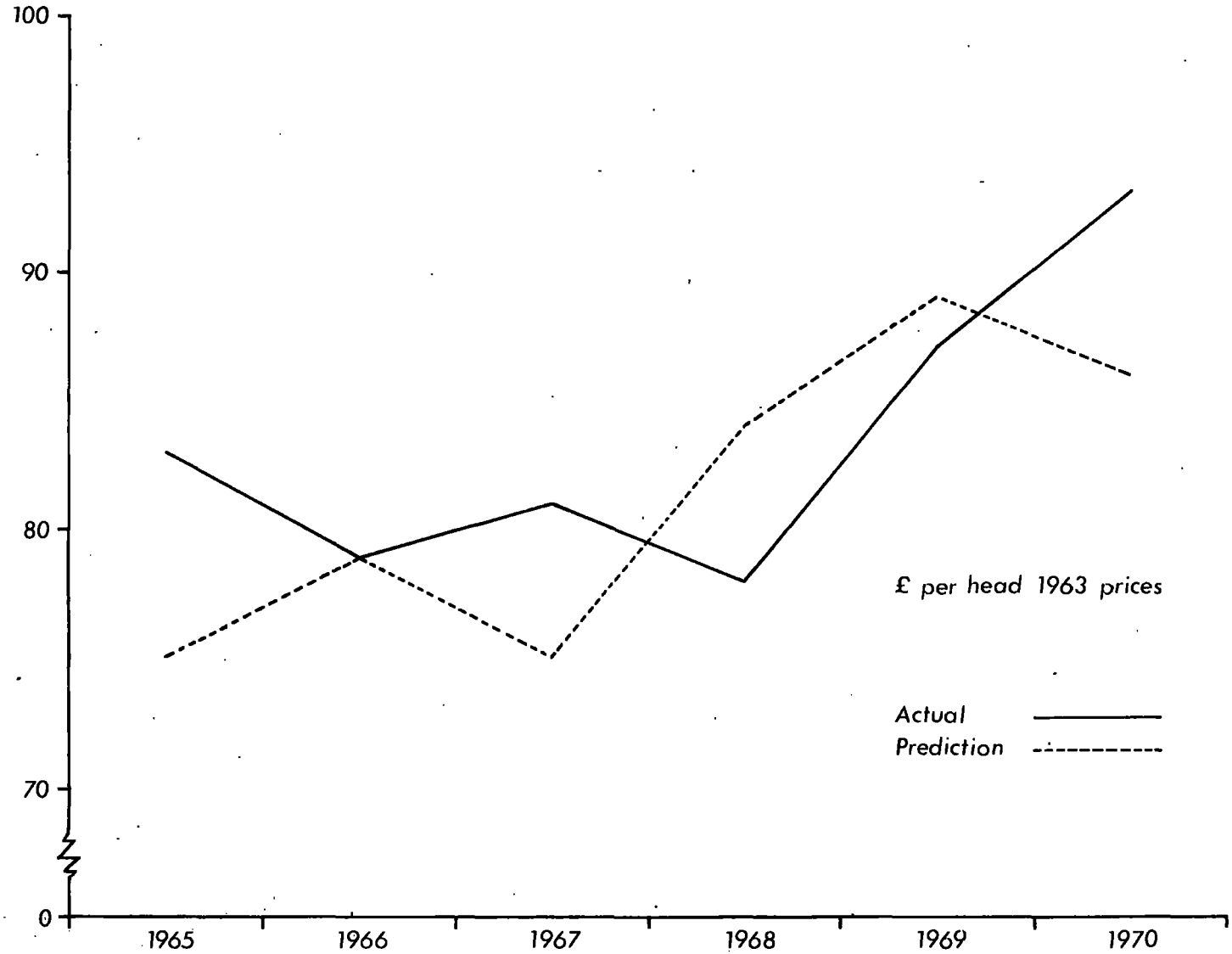
100 Equal Divisions x 12 Years (Logistic)
Graph Data Ref. 6006

LOCAL AUTHORITY ROAD INVESTMENT, Nos. OF VEHICLES, Nos. OF CARS

ENGLAND AND WALES 1954-'69 CONSTANT 1969 PRICES



INDUSTRIAL BUILDING ORDERS PER HEAD — ACTUALS AND PREDICTIONS FROM DERIVED EQUATIONS 1965 — 1969 AND FORECAST EQUATION 1970



Source: EDC's for Building and Civil Engineering — Regional Forecasts[30]

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Figure 2

REGIONAL INDUSTRIAL INCENTIVES TO NEW MOBILE INDUSTRY

EXAMPLE OF MATRIX EXPANSION

ROWS \ COLUMNS	TOTAL MIGRATION (NET)	BASIC EMPLOYMENT INPUT m	NON-BASIC EMPLOYMENT INPUT m	TOTAL EMPLOYMENT INPUT m	NON-BASIC EMPLOYMENT EARNINGS m	TOTAL EMPLOYMENT INPUT + EARNINGS m	INDUSTRY 1	INDUSTRY 2	INDUSTRY 3	INDUSTRY n	Incremental Population Correlated Activity Levels e.g. Housing	Incremental Employment Correlated Activity Levels e.g. New Industrial Building	RIGHT-HAND SIDE
COST							C_1	C_2	C_3	C_n	C_H	C_{IB}	= 0
BASIC EMPLOYMENT INPUT m		−1					Im_1	Im_2	Im_3	Im_n			= 0
NON-BASIC EMPLOYMENT INPUT m			−1				Im_1	Im_2	Im_3	Im_n			= 0
TOTAL EMPLOYMENT INPUT m		1	1	−1									= 0
NON-BASIC EMPLOYMENT EARNINGS m			1	Em−1	−1								= 0
TOTAL EMPLOYMENT				Em		−1							= 0
TOTAL MIGRATION (NET)	−1					a							= 0
TOTAL UNEMPLOYMENT						a							= 0
TOTAL POPULATION	1												= 0
Incremental Population Correlated Activity Levels e.g. Housing	c										−1		≥ v
Incremental Employment Correlated Activity Levels e.g. New Industrial Building		d										−1	≥ v
AVAILABILITY OF NEW MOBILE EMPLOYMENT :−													
INDUSTRY 1							1						≤ v
INDUSTRY 2								1					≤ v
INDUSTRY 3									1				≤ v
INDUSTRY n										1			≤ v

Symbols:−

C = Unit Cost

Im = Input multiplier

Em = Earnings multiplier

a = Employment/Migration/ Unemployment relationship

c = Migration change − Housing need relationship

d = Basic employment change − New Industrial Building relationship

v = Right-hand side values

Figure 1

REGIONAL STRATEGY MATRIX (AN OVERVIEW)

COLUMNS / ROWS

| | INITIAL TOTAL POPULATION | INITIAL TOT. POP. WORKING AGE | INITIAL TOTAL EMPLOYMENT | INITIAL BASIC EMPLOYMENT | INITIAL NON-BASIC EMPLOYMENT | FINAL TOTAL POPULATION | FINAL TOT. POP. WORKING AGE | FINAL TOTAL EMPLOYMENT | FINAL BASIC EMPLOYMENT | FINAL NON-BASIC EMPLOYMENT | △ BASIC EMPLOYMENT | △ NON-BASIC EMPLOYMENT | △ TOTAL EMPLOYMENT | INITIAL TOTAL MIGRATION (NET) | INITIAL TOT. MIGRATION WORKING AGE | FINAL TOTAL MIGRATION (NET) | △ TOTAL MIGRATION (NET) | △ TOT. MIGRATION WORKING AGE | △ TOTAL POPULATION | △ TOT. POP. WORKING AGE | INITIAL TOTAL UNEMPLOYMENT | FINAL TOTAL UNEMPLOYMENT | △ TOTAL UNEMPLOYMENT | NEW HOUSING (AVERAGE HOUSE UNITS) PUBLIC NEW | PUBLIC REPLACEMENT | PRIVATE NEW | PRIVATE REPLACEMENT | ROAD BUILDING (1/4 MILE UNITS) RURAL SINGLE TWO LANE | RURAL SINGLE THREE LANE | URBAN SINGLE TWO LANE | RURAL DUAL TWO LANE | URBAN DUAL TWO LANE | URBAN DUAL THREE LANE | EDUCATION NEW AND REPLACEMENT (NOS. OF PLACES) NURSERY | PRIMARY | SECONDARY | FURTHER | UNIVERSITY | INDUSTRIAL BUILDING (sq.footage) | OFFICES (sq. footage) | SHOPPING (sq. footage) | | HEALTH SERVICES (BY EXPENDITURES) | | | | COMMERCIAL OTHER SERVICES (BY EXPENDITURES) | | PUBLIC CORPORATIONS (BY EXPENDITURES) | | SEWERAGE SERVICES (RELATED COSTS) | WATER SERVICES (TOT. EXP.) | | OTHER PUBLIC SERVICES (TOT. EXP.) | | REPAIR AND MAINTENANCE :— PUBLIC | REPAIR AND MAINTENANCE :— PRIVATE | DERELICT LAND (ACRES) | △ INDUSTRIAL BUILDING | REGIONAL INDUSTRIAL INCENTIVES TO NEW MOBILE INDUSTRY (AVERAGE EXCHEQUER EXPENDITURE PER NEW JOB) | | | |