STUDIES IN THE STRUCTURE AND GROWTH OF THE REGIONS IN THE UNITED KINGDOM

by

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ABSTRACT

The thesis attempts to develop and test a number of hypotheses relating to the structure and growth of manufacturing industry in the regions of the U.K., over the period 1958-1968.

After a brief discussion of the extent and measurement of specialisation, an attempt is made to test for relationships between specialisation patterns, and alternative measures of comparative and absolute advantage. Patterns of structural change in relation to comparative unit labour costs are also studied.

The neo-classical model of economic growth is used to examine the determinants of regional productivity growth. A C.E.S. production function is applied to assess the variability in techniques between regions, and to estimate the degree of returns to scale. These estimates are then used in a 'cross-sectional' context to examine inter-regional differences in the 'efficiency parameter' of the C.E.S. function.

The determinants of inter-regional differences in the rate of employment growth are discussed. Beginning with a 'shift-share' analysis of employment growth, basic relationships between the growth rates of output, employment and capital accumulation are then examined.

The growth experience of regions is further explored with the aid of the Harrod-Domar model of economic growth.

Finally, some of the major findings of the thesis are highlighted with the aid of Kaldor's model of regional economic growth.

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CHAPTER 1

INTRODUCTION

The thesis consists of a collection of interrelated papers concerned with the structure and growth of the manufacturing sector in the regions of the United Kingdom over the period 1958 to 1968. In the main the thesis is based upon the regional tables of the 1963 and 1968 (provisional) Census of Production reports.[1]

The thesis begins with a consideration of the industrial structure of regions, interpreted as 'patterns of specialisation', and then moves on to examine structural change. The central sections of the study are concerned with evaluating the determinants of inter-regional differences in the level, and growth rates, of labour productivity within a production function framework. The final part of the thesis is devoted to an analysis of the relative growth rates of the supply and demand for labour, together with a discussion of the policies required to correct any imbalance between these two rates of growth. The dominant theme throughout all chapters is the variety of regional experience, especially when the phenomena are viewed in a growth, rather than in a static, context.

The essential unity of the thesis is maintained, above all else, in its subject matter, in that it consists of a series of studies based upon Census of Production data. The insight gained into the functioning of the regional economies from the study of this data, has only been obtained at certain costs. These costs are particularly associated with the restrictive assumptions used at various stages of the analysis. These assumptions are necessitated by data deficiencies, especially the absence of capital and price data for the regions. Indeed an essential part of

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1. Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133, and "Area Analyses of the provisional results of the Census of Production for 1968", Board of Trade Journal, Vol.199, 1970, pp.488-496.

any study of regional phenomena at the present time, and this thesis is no exception, must be concerned with the development and espousal of methods which attempt to overcome data limitations. These methods may embrace a wide range from a 'simple' reformulation of the problem at hand, or the judicious use of assumptions, to attempts to generate additional data from that which is available.

As a result of the limitations described above we will be repeatedly forced to work within a restrictive set of assumptions. This entails the application of economic models which (although 'fully' worked out in theory) appear, when confronted with limited data, to be incomplete and unable to bear the heavy burden which is placed upon them. This is a particularly pressing problem because assumptions, which are used as an aid to abstraction and model building in theory, are being used to 'force' the data into a straight-jacket. Whenever possible, we have attempted to deal explicitly with 'crucial assumptions',[1] even at the risk of some repetition.

As has been indicated above, the basic themes of the thesis emphasise regional growth and regional variety. We have attempted, within the framework of growth economics, to study the varieties of regional experience and to discuss the policy implications of the findings. In this regard two particular techniques of analysis have been employed; the neo-classical model of economic growth, and mathematical techniques related to the analysis of variance. It may be of some benefit to discuss at this early stage the use to be made of these techniques and their relationship to the themes of 'regional growth' and 'regional

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1. c.f., Solow's comment in R.M. Solow, "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economics, Vol.70, 1956, p.65.

variety'.

On the theme of regional economic growth and the application of models of economic growth there are two fundamental views which have shaped the approach adopted in this thesis. Firstly, the approach is influenced, not only by the belief that a growth viewpoint is desirable, but also by the conviction that a growth viewpoint is necessary (as Domar long ago observed)[1] because of the nature of the phenomena with which we are concerned. The real benefits to be gained from adopting a growth oriented approach are to be found in the perspective it affords into the functional relationships between key economic variables, and the differing policy conclusions it yields as compared with those derived from a static analysis.[2] This viewpoint is doubly important because much of the discussion of regional inequalities and policy in the U.K., whilst fundamentally concerned with regional economic growth, has largely taken place outside the context of research which embodies growth models.

The second point relating to the use of growth models within a regional context (and an important one in terms of the techniques to be encountered in the present work) is that, paradoxically, many models of economic growth may be used to great effect in the study of differences between regions at a point in time. This is in addition to the study of the movements in key economic variables within a given region over time. We are able to employ this 'cross-sectional' approach because in many growth models (as distinct from dynamic models)[3] 'time' neither shapes the

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1. E. Domar, "Capital Expansion, Rate of Growth and Employment", Econometrica, Vol.14, 1946, p.147.

2. An excellent demonstration of this view is provided in J.R. Sargent, Out of Stagnation, Fabian Tract No.343 (London, Fabian Society, 1963).

3. c.f. J.A. Schumpeter, History of Economic Analysis (London, George Allen and Unwin, 1954), p.1160, and J.R. Hicks, Capital and Growth (Oxford, Clarendon Press, 1965), p.6.

analysis nor determines the mathematical technique to be employed. Indeed 'time' often appears only in the form of subscripts which are added almost as an afterthought. The application of the neo-classical model to compare different economies (states) at the same point in time, rather than to study processes through time, is particularly advantageous, since many of the recent criticisms of the model are directed towards its use in the study of processes rather than states.[1] It is indeed strange, given the limitations of data, that previous work in regional economics should have overlooked the potential of the theory of economic growth to explain regional differences at a point in time. The realisation and application of this insight is an important aspect of the work contained in the thesis.

Regional variety, or inter-regional differences, have also played their part in shaping the techniques used in the thesis. The realisation that these differences are the raison d'être of regional economics[2] necessitates the adoption of a mathematical, or statistical, technique whereby we can measure these differences and evaluate their sources.

A common technique adopted is the 'shift-share' approach which attempts to decompose inter-regional differences (usually between a region and the nation), into 'composition' and 'rate' differences. Whilst this technique has its uses, it also has its limitations: firstly there are the problems (common to all indexes) of deciding which 'weights'

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1. On this point see J.R. Hicks, ibid., p.294, and G.C. Harcourt, Some Cambridge Controversies in the Theory of Capital (Cambridge, C.U.P., 1972).

2. A.J. Brown, 'Surveys of Applied Economics: Regional Economics, with Special Reference to the United Kingdom", Economic Journal, Vol.79, 1969, p.760.

are appropriate,[1] and difficulties arising from the extent of the industrial aggregation. Secondly, the results are often difficult to interpret because the method does not deal explicitly with functional (i.e. causal) relationships. The main purpose for which the technique is employed, in this work, is to inform us of the extent to which we may focus our attention upon relationships between changes in 'macro-economic' variables, to the neglect of changes in the structure of industry.

Another technique which may be used to measure and assess interregional differences is the Analysis of Variance. This technique, which is very useful in the context of regression analysis, may be used to summarise information contained within a data matrix. In particular, it provides us with a method which enables us to assess the importance (and significance) of industrial, vis-à-vis regional, sources of variation. An additional advantage of the method is that it is amenable to statistical tests of significance, since it evaluates deviations from the arithmetic mean.

For many purposes however, a weighted mean (specifically a 'national rate'), rather than the arithmetic mean, is a more meaningful benchmark; especially in regional studies. As a result of this we need to develop a technique which will decompose, and evaluate, the variability in a series of regional deviations about a weighted mean. To avoid confusion with analyses involving variances, we will refer to the decomposition of deviations from the weighted mean as an 'evaluation of inner products'; the variance of a series being a specific type of inner product.[2] The

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1. This matter will be discussed, at some length, in Chapter Seven.

2. H. Scheffé, The Analysis of Variance (New York, John Wiley and Sons, 1959), p.375.

mathematics of the technique bears many similarities to variance analysis, especially as it is applied in regression models.[1] Since in using this approach we are not concerned with deviations from the arithmetic mean, the statistical tests of significance normally associated with the analysis of variance are inapplicable. It is hoped that in the development and application of this technique at various points in the work, some small contribution will have been made to the 'tool-kit' of regional economists.

As we have indicated earlier, the subject matter of the thesis is restricted to manufacturing activities only. In confining attention to the manufacturing sector it is not intended to convey the impression that the study of this sector is, by itself, sufficient to fully comprehend the problems of the regions. The concentration upon manufacturing activities has been determined largely by expediency, in that the Census of Production data provides a consistent set of regions and industries, over a minimum acceptable length of time, necessary for the types of analysis which we shall employ. Notwithstanding this, the manufacturing sector is a large and important component of the regional economies and thus efforts devoted to the study of this sector would seem to be not entirely wasted.

Insofar as the thesis studies the manufacturing sector in isolation, there is some evidence from input-output studies (with reference to 'bloc-independence') which may indicate that in restricting our attention to this sector the injustice to reality, albeit considerable, may be less than appears at first sight.[2]

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1. J. Johnston, Econometric Methods (New York, McGraw-Hill, 1963).

2. D. Simpson and J. Tsukui, "The Fundamental Structure of Input-Output Tables, An International Comparison", Review of Economics and Statistics, Vol.47, 1965, pp.434-446.

An additional defect is related to the relatively high levels of sectoral and regional aggregation for which adequate data is available. This must introduce an element of uncertainty into many of the conclusions arrived at on the basis of this information.

It has been emphasised above that a large portion of the thesis is concerned with inter-regional differences in productivity levels and industrial structure. The following section attempts to explain the importance of these factors, and attempts to justify the selection of these two aspects of the regional economies for extensive examination.

The Importance of Labour Productivity

The role of labour productivity in determining, at least in part, the demand for labour may be seen as soon as it is realised that the inverse of labour productivity is labour input per unit of output (unit labour requirements). In a later section of the thesis we will assess the quantitative importance of inter-regional differences in the rate of productivity growth, as a source of differences in the rates of growth of regional employment. For the moment we will accept this rationale for the analysis of labour productivity to be self-evident.

Differences in labour productivity are also likely to be important, because as they are a prime determinant of regional variations in output per head of population. As a result of work at the National Institute for Economic and Social Research,[1] we are able to assess the quantitative importance of these differences as they effect regional differences in Gross Domestic Product per capita.

Following Woodward,[2] we can define GDP per capita in each region as,

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1. V.H. Woodward, Regional Social Accounts for the U.K. 1961 and 1964, N.I.E.S.R. Regional Occasional Paper No.1 (Cambridge, C.U.P., 1970).

2. Ibid., p.80.

$$\frac{GDP}{P} = \frac{W}{P} \cdot \frac{N}{W} \cdot \frac{GDP}{N} \tag{1.1}$$

where: $\frac{GDP}{P}$ = Gross Domestic Product at factor cost per head of total population;

$\frac{W}{P}$ = Proportion of total population which is of working age;

$\frac{N}{W}$ = Proportion of population of working age which is 'economically active';

$\frac{GDP}{N}$ = Productivity of Employed work force.

Since an identical relationship will hold for the nation as a whole, we may divide the regional value of GDP per capita by the national figure to yield:

$$y = w.n.r \tag{1.2}$$

where: y = Index of GDP per capita;

w = Index of potential work force relative to total population:

n = Index of activity rates;

r = Index of labour productivity.

Table 1.1 below reports Woodward's estimates of these indices for the U.K. regions in 1961.

One procedure, by which we might assess the importance of differences in labour productivity as a determinant of differences in GDP per capita, is to calculate the Sum of Squares, or the variation, of GDP per capita (y'y), and to relate this in some way to the sum of squares of each of the elements (w, n and r), which together determine y.

Whilst this is feasible where relationships are additive, it is not so easy when dealing with multiplicative relationships. The variance of

Table 1.1

Regional Variations in GDP per head at factor cost, 1961

Region[1]	y	w	n	r
N	0.900	0.994	0.920	0.989
E & WR	1.000	1.009	1.007	0.981
NW	0.990	1.003	1.026	0.959
NM	1.020	1.003	0.980	1.041
M	1.080	1.015	1.040	1.018
SEE	1.110	1.005	1.043	1.055
SW	0.880	0.985	0.931	0.960
W	0.880	1.003	0.884	0.994
S	0.860	0.978	0.960	0.907
NI	0.640	0.940	0.887	0.770
UK	1.000	1.000	1.000	1.000

1. A complete list of regions and their abbreviations is presented in the appendix.

Source: V.H. Woodward, Regional Social Accounts for the U.K. 1961 and 1964, N.I.E.S.R., Regional Occasional Paper No.1, (Cambridge, C.U.P., 1970,) p.80.

the vector y, in equation (1.2) is equal to;

$$var(y) = var(w.n.r.) \qquad (1.3)$$

which is difficult to expand and evaluate. If we desire to evaluate the importance of each term on the R.H.S. of that equation in determining the variation in the vector y, some method must be found which will linearise the relationships contained in equation (1.2). Equation (1.2) may be linearised either by expressing the function in its Logarithmic form, or alternatively by an expansion in terms of first differences. Consider first the logarithmic form.

Taking logarithms of both sides of equation (1.2) yields;

$$\lg y = \lg w + \lg n + \lg r. \qquad (1.4)$$

We note that this is already in deviation form. Since each element is an index of the regional to the national figure, finding the logarithm of the index is equivalent to finding the differences in the logarithms of the numerator and denominator of the index.

If we square the deviations in equation (1.4), we find,

$$(\lg y)^2 = (\lg w)^2 + (\lg n)^2 + (\lg r)^2 + 2(\lg w)(\lg n) + 2(\lg w)(\lg r) + 2(\lg n)(\lg r). \qquad (1.5)$$

Summing over regions yields an expression for the total sum of squares of the logarithm of GDP per capita, as

$$\Sigma(\lg y)^2 = \Sigma(\lg w)^2 + \Sigma(\lg n)^2 + \Sigma(\lg r)^2 + 2\Sigma(\lg w)(\lg n) + 2\Sigma(\lg w)(\lg r) + 2\Sigma(\lg n)(\lg r). \qquad (1.6)$$

The components of the total sum of squares (T.S.S.), as expressed in equation (1.6), were computed using the data contained in Table 1.1. The results of this decomposition, or evaluation of inner-products, are reported in Table 1.2.

Table 1.2 shows that the most important sources of variation in the logarithm of GDP per capita are: variations in the logarithm of labour

Table 1.2

Decomposition of the inner product of the logarithm of Regional GDP per capita : 1961

Source of Variation	Sum of Squares	Proportion of T.S.S. (%)
$\Sigma(\text{Lg } w)^2$	0.003	6.1
$\Sigma(\text{Lg } n)^2$	0.009	16.9
$\Sigma(\text{Lg } r)^2$	0.016	30.2
$2\Sigma(\text{Lg } w)(\text{Lg } n)$	0.003	6.1
$2\Sigma(\text{Lg } w)(\text{Lg } r)$	0.007	12.7
$2\Sigma(\text{Lg } n)(\text{Lg } r)$	0.015	28.0
$\Sigma(\text{Lg } y)^2$	0.053	100.0

productivity (30.2% of T.S.S.); variations in the logarithm of activity rates (16.9%); and the interaction between these two sources of variation (28.0%). These results support the conclusions of Brown and Woodward,[1] arrived at after an examination of the range of variation in the absolute indexes. It is also interesting to note that all of the interaction terms are positive, indicating that negative (positive) deviations on one variable tend to be associated with negative (positive) deviations on all other variables.

An alternative method of linearising equation (1.2) is to apply the differential method.[2]

Taking the total differential of equation (1.2) gives:

$$\Delta y = \Delta w.n.r. + \Delta n.w.r. + \Delta r.w.n. + R, \qquad (1.7)$$

where the remainder (R) represents the higher powers of the Taylor series.

The differences represent deviations from the national average to which we have assigned, by taking indexes, a fixed value of unity in each case; i.e. $\Delta y = (y - 1)$.

Computation of the sum of the first three elements in the R.H.S. of equation (1.7) revealed that this sum bore a close approximation to the actual deviations of GDP per capita. As a result we have neglected to specify the higher powers of the series (R), and will regard the first order components as providing a reasonable approximation.

We may then square both sides of equation (1.7) and sum over regions

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1. A.J. Brown et al, "Regional Problems and Regional Policy", National Institute Economic Review, Vol.46, 1968, p.47; and V.H. Woodward, op.cit., p.79f.

2. W.E. Demming, Some Theory of Sampling (New York, John Wiley and Sons, 1950), p.130.

to yield an expression for the total sum of squares, as;

$$\Sigma(\Delta y)^2 = \Sigma(\Delta w.n.r.)^2 + \Sigma(\Delta n.w.r.)^2 + \Sigma(\Delta r.w.n.)^2 + 2\Sigma(\Delta w.n.r.)(\Delta n.w.r.) + 2\Sigma(\Delta w.n.r.)(\Delta r.n.w.) + 2\Sigma(\Delta n.w.r.)(\Delta r.w.n.) + (\text{terms involving } R). \quad (1.8)$$

The components of the total sum of squares as expressed in equation (1.8) were calculated using the data presented in Table 1.1. The results are reported in Table 1.3.

The usefulness of the first-order approximation may be judged by the fact that 88.8% (100.0-11.2) of the total sum of squares of GDP per capita, is accounted for by the first-order terms alone.

The sources of variation in GDP per capita which are assigned a major importance using the differential method are the same as those indicated by the logarithmic formulation, namely; productivity differences, differences in activity rates, and the interaction between these factors. Again, this is in substantial agreement with the conclusions arrived at by Brown and Woodward,[1] except that in the present analysis more importance is assigned to productivity differences as a source of total variation. To some extent, however, this is due to the inclusion of Northern Ireland which exhibits a relatively large deviation for labour productivity.

The Industrial Structure of the Regions

A number of studies in the U.K. have demonstrated the importance of the industrial composition of regions as a determinant of regional performance.

'Shift-share' calculations have revealed that the industrial structure of regions is an important determinant of regional performance

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1. See the references cited earlier, p.12, note 1.

Table 1.3

Decomposition of variation in GDP per capita using the differential method

Source of Variation	Sum of Squares	Proportion of T.S.S. (%)
$\Sigma(\Delta w.n.r)^2$	0.003	1.6
$\Sigma(\Delta n.w.r)^2$	0.037	18.9
$\Sigma(\Delta r.n.w.)^2$	0.057	29.1
$2\Sigma(\Delta w.n.r)(\Delta n.w.r)$	0.012	6.1
$2\Sigma(\Delta w.n.r)(\Delta r.n.w)$	0.020	10.2
$2\Sigma(\Delta n.w.r)(\Delta r.n.w)$	0.045	22.9
Terms involving R	0.022	11.2
$\Sigma(\Delta y)^2$	0.196	100.0

vis-à-vis the nation, with respect to a number of indices. Thirlwall,[1] and later Harris and Thirlwall,[2] have demonstrated that industrial composition is an important determinant of 'sensitivity' of regional unemployment rates to changes in the national rate.[3] In addition recent work at the N.I.E.S.R.[4] had demonstrated that the industrial composition of regions is a major determinant of female activity rates. These are themselves an important source of variation in total activity rates between regions,[5] which in turn (as we have already seen) are responsible for a sizeable proportion of differences in the levels of GDP per capita in the U.K. regions.

In a similar vein, studies using analysis of variance based on data classified by industry and region, have demonstrated that inter-industry differences account for a significantly large portion of variations in such variables, as productivity and average earnings,[6] female activity rates,[7] and unemployment rates.[8]

It would appear therefore, that a necessary step towards under-

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1. A.P. Thirlwall, "Regional Unemployment as a Cyclical Phenomenon", Scottish Journal of Political Economy, Vol.13, 1966, pp.205-219.

2. C.P. Harris and A.P. Thirlwall, "Interregional Variations in Cyclical Sensitivity to Unemployment in the U.K., 1949-1964", Bulletin of the Oxford University Institute of Economics and Statistics, Vol.30, 1968, pp.55-66.

3. An 'evaluation of inner products' reveals that 47.0% of the variations in cyclical sensitivity between regions, is due to 'rate differences', 28.3% is attributable to 'composition differences', and 24.7% reflects the interaction of these two factors.

4. A.J. Brown et al, op.cit., p.43.

5. J. Bowers, The Anatomy of Regional Activity Rates, N.I.E.S.R., Regional Occasional Papers No.1 (Cambridge, C.U.P., 1970).

6. V.H. Woodward, op.cit., p.89.

7. J. Bowers, op.cit., p.33.

8. A.J. Brown, Op.cit., p.769.

standing inter-regional variations over a wide range of indices, is to make some attempt to explain the industrial structure of the regions, and changes in this structure over time.

A second motive for attempting a study of the industrial composition of regions reflects our interest in the criteria of economic efficiency. To the extent that patterns of regional specialisation are unrelated to alternative measures of regional comparative advantage, it may be possible to conclude that there exists a welfare loss to the region arising from the possible mis-allocation of resources. Similarly, if it can be demonstrated that industries do not tend to locate in regions which possess an absolute advantage in that activity, it may be that there is a resultant welfare loss to the nation as a whole.

Given the above, it seems reasonable to conclude that the study of patterns of regional specialisation in relation to alternative measures of comparative and absolute costs, is a worth-while task. Similarly, it is also desirable to study the direction of change of specialisation and location patterns in relation to these cost factors.

An Outline of the Chapters

Immediately following the Introduction, Chapter Two considers regional specialisation and trade. After a brief discussion of the extent and measurement of specialisation, an attempt is made to test for relationships between specialisation patterns in each region, and alternative measures of regional advantage. Hypotheses related to comparative advantage are tested first, including an indirect test of the Heckscher-Ohlin theorem, together with tests involving the Classical comparative advantage measures; relative labour productivities and unit labour costs. Consideration is also given to the hypothesis, that trade and specialisation are determined by absolute, rather than comparative, advantage. As a result of the analysis we are led to reconsider the role of relative price differences in determining the allocation of resources. Some evidence on the extent and effectiveness of resource re-allocation within regions is also presented.

Unlike Chapter Two, which is essentially static in character, Chapter Three attempts to examine the relationships between changes in industrial structure, and measures of comparative and absolute costs. It attempts to bridge the gap between the static analysis of industrial structure in the preceding chapter and the analysis of regional growth which follows. Particular attention is given to the development of alternative measures of structural change.

Chapter Four examines the determinants of productivity growth within the regions over the period 1958-1968. It combines the approach used by Solow,[1] utilising the Cobb-Douglas production function, with techniques which attempt to make up for the absence of data on regional capital stocks. These methods are extended to enable a comparison of results generated under alternative assumptions. The relative importance of capital accumulation, intra-regional resource shifts and the 'residual' as determinants of productivity growth is examined. It is argued that inter-regional differences in the rate of productivity growth are due (in the main) to differences in the rate and effectiveness of capital deepening, and not (as one might expect from other studies of technical change) to differences in the rate of neutral technical advance. We also estimate the contribution of resource shifts to regional and national productivity

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1. R.M. Solow, "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol.39, 1957, pp.312-320.

growth over the period.

Consideration of the assumptions made in Chapter Four leads to an attempt to estimate the degree of returns to scale and the elasticity of substitution in U.K. manufacturing. Also in Chapter Five we provide an alternative proof of the C.E.S. side-relation, which relates the value of the elasticity of substitution, to the relative growth rates of labour productivity and the wage rate. Problems of estimation and interpretation of the results are also discussed.

The estimates obtained in Chapter Five, for the aggregate manufacturing sector, are utilised in Chapter Six to examine inter-regional differences in the 'efficiency parameter' of the C.E.S. function. This chapter is thus, in one sense, a static (or cross-sectional) counterpart to the analysis presented in Chapter Four. Chapter Six emphasises the applicability of growth theory to the study of differences between regions, at a point in time. A technique is developed whereby differences in the efficiency parameter may be ascertained without recourse to data on the capital-labour ratio. We question the relevance of the doctrine of 'inherent', or 'locational', disadvantage,[1] and extend the method of the 'evaluation of inner products' to reveal the importance of variations in the capital-labour ratio, as a determinant of inter-regional differences in the level of labour productivity. We are also able to evaluate the importance of returns to scale as a source of productivity differences between regions.

Chapter Seven has as its subject matter, the growth rates of employment in the regions. Beginning with a 'shift-share' analysis of

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1. e.g. G. McCrone, Regional Policy in Britain (London, George Allen and Unwin, 1969), pp.169-180.

employment growth, we then set out basic relationships between the growth rates of output, employment, productivity, and capital accumulation. With the aid of the estimates of capital deepening obtained earlier (Chapter Four), an evaluation of inner products reveals the differing importance of these factors as determinants of inter-regional differences in the growth rate of employment.

The growth experience of regions is further explored in Chapter Eight, which attempts to apply the Harrod-Domar model to isolate the causes of persistent unemployment in the problem regions. A marked diversity of regional experience is discovered.

The final chapter highlights some of the major findings of the thesis with the aid of Kaldor's model[1] of regional economic growth. It also attempts to indicate some implications of the results for further research in the area of regional employment growth.

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1. N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-348.

Appendix Table 1.A1

Regional Abbreviations

(a) New Standard Regions.

N	North
YH	Yorkshire and Humberside
EM	East Midlands
EA	East Anglia
SE	South East
SW	South West
WM	West Midlands
NW	North West
W	Wales
S	Scotland
NI	Northern Ireland
UK	United Kingdom

(b) Old Standard Regions.

E&WR	East and West Riding
NM	North Midlands
M	Midlands
L&SE	London and South East
E&S	East and South
SEE	South East England (L&SE + E&S)

Appendix Table 1.A2

Standard Industrial Classification Order Numbers (1963)[1]

III	Food, Drink and Tobacco
IV	Chemicals and Allied Industries
V	Metal Manufacture
VI	Engineering and Electrical Goods
VII	Shipbuilding and Marine Engineering
VIII	Vehicles
IX	Metal Goods n.e.s.
X	Textiles
XI	Leather, Leather Goods and Fur
XII	Clothing and Footwear
XIII	Bricks, Pottery, Glass and Cement etc.
XIV	Timber, Furniture, etc.
XV	Paper, Printing and Publishing
XVI	Other Manufacturing Industries

1. Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1968), Part 1, Introductory Notes.

Chapter Two

Regional Specialisation and the Location of Manufacturing Industries in the United Kingdom: 1958 and 1963

This chapter is concerned with an examination of regional specialisation and the location of industry. The chapter is comprised of two parts; one dealing with the level (or degree) of specialisation and localisation, and one dealing with patterns of specialisation and localisation. The first part offers a brief discussion of measures of the level of regional specialisation and the localisation of industry, together with a description of these magnitudes for the manufacturing industries and regions of the U.K. in the years 1958 and 1963. The second part of the chapter deals with the patterns of specialisation and location, and attempts to explain these patterns with the aid of hypotheses derived from the theory of international trade.

Inter-regional differences in the level and patterns of industrial composition are of interest for two main reasons. Firstly, because a number of studies have revealed that differences in industrial structure between regions, or 'composition differences', are an important source of inter-regional differences with respect to a number of important economic phenomena.[1] Given that one of the tasks of the regional economist is to explain these differences,[2] it follows that a necessary step towards this end is to account for these 'structural differences'. The second reason for examining the industrial structure of the regions

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1. cf. the discussion in Chapter One, pp.14-16, and the references cited therein.

2. A.J. Brown, "Surveys of Applied Economics: Regional Economics, with Special Reference to the United Kingdom", Economic Journal, Vol.79, 1969, p.760.

concerns the relationship that might be expected to hold between specialisation patterns, and comparative or absolute costs. Given that there may be gains to the regions from specialisation and trade, it is of some interest to inquire into the association between cost and specialisation patterns. Such a study should also provide evidence on the possibility of increasing productivity levels within the regions, by intra-regional resource shifts.

The Extent of Regional Specialisation and Industrial Localisation.

A convenient measure of the degree to which the industrial composition of employment in any one region differs from that of all other regions taken together, is the 'Coefficient of Regional Specialisation'.[1, 2] Using the national composition of employment as a benchmark, the coefficient measures the extent to which the proportional distribution of industrial employment in any region, differs from the corresponding distribution in all regions taken together.

The Coefficient of Regional Specialisation (CRS) for any region (j) is defined as:[3]

$$CRS_j = \tfrac{1}{2}\Sigma_i \left| \frac{L_{ij}}{L_j} - \frac{L_i}{L} \right| \qquad (2.1)$$

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1. P.S. Florence, Investment, Location and Size of Plant, N.I.E.S.R. Economic and Social Studies VII (Cambridge, C.U.P., 1948), pp.34-7.

2. On alternative measures and their inter-relatedness, see W. Isard (et al), Methods of Regional Analysis (Cambridge, Mass., MIT Press, 1960), pp.232-308; A.P. Thirlwall and C.P. Harris, "Measuring the Localisation of Industry", Manchester School, Vol.35, 1967, pp.55-68.

3. W. Isard (et al), op.cit., p.271; C.E.V. Leser, "Industrial Specialisation in Scotland and in Regions of England and Wales", Yorkshire Bulletin of Economic and Social Research, Vol.1, 1948, pp.19-30; A.P. Thirlwall, "Weighting Systems and Regional Analysis: A Reply to Mr. Cunningham", Oxford Economic Papers, Vol.21, 1969, pp.128-133.

where L_{ij} = Employment in industry i in region j;

L_j = Total manufacturing employment in region j;

L_i = Employment in all regions in industry i;

L = Total manufacturing employment in all regions.

If the industrial distribution of manufacturing employment in any region was identical with that of the nation, the value of the coefficient would be zero. The maximum degree of divergence, which would occur if the region had no employment in common with the nation, would be reflected in a value for the CRS of unity.

Calculations of the proportion of each region's manufacturing work force employed in different industries in the years 1958 and 1963 are presented in the Appendix to this chapter, Tables 2.A1 and 2.A2. Data on the proportion of national manufacturing employment in each industrial order are presented in the Appendix Table 2.A6.[1]

Regional values of the Coefficient of Regional Specialisation for the years 1958 and 1963 are reported in Table 2.1. Of the regions it appears that Northern Ireland, Wales, and East Anglia, tend to be the most specialised; in other words, the industrial structure of these regions is most unlike that of all regions taken together. In contrast; Scotland, the South East, and the North West, appear to possess the least specialised industrial structures.

In some sense, the size of the Coefficient of Regional Specialisation is related to the importance of inter-regional trade to the regional economy. It is of some interest to examine the relationship between the

1. Ideally we would prefer a classification based on Minimum List Headings, but sufficient data is unavailable. Even at the SIC order level data is unavailable for two industries in Wales and Northern Ireland.

Table 2.1

Coefficients of Regional Specialisation[1] 1958 and 1963[2, 3]

Region	1958	1963
N	0.279	0.237
YH	0.217	0.183
EM	0.218	0.162
EA	0.287	0.238
SE	0.155	0.184
SW	0.233	0.214
WM	0.280	0.294
NW	0.178	0.110
W	(0.295)	(0.276)
S	0.168	0.128
NI	(0.343)	(0.314)

1. Includes Manufacturing industries only.

2. $CRS = \frac{1}{2}\sum_i \left|\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right|$

3. Brackets (..); indicate calculations based upon insufficient data.

Source: Calculated from data presented in Appendix: Tables 2.A1, 2.A2 and 2.A6.

(apparent) importance of the trade sector and the size of the region. Some idea of this relationship may be obtained from measuring the extent to which there is an association between the CRS, and the proportion of national manufacturing employment concentrated in each region. A rank correlation coefficient, between the coefficient of Regional Specialisation (ranked from highest to lowest), and the percentage distribution of national manufacturing employment (also ranked from highest to lowest), was computed for each year. In 1958 the value of the rank correlation coefficient was ($\rho=$) - 0.760, which is significantly less than zero at the 1 per cent level: for 1963 the correlation coefficient was -0.553, which is significantly less than zero at the 5 per cent level of significance. We may conclude therefore that the degree of specialisation decreases as the size of the region increases.[1]

A similar coefficient to the CRS may be calculated for each manufacturing industry, measuring the extent to which the percentage distribution of a particular industry between regions differs from that of manufacturing as a whole. This is termed the Coefficient of Localisation (CL) and is measured by;[2]

$$CL_i = \tfrac{1}{2}\sum_j \left| \frac{L_{ij}}{L_i} - \frac{L_j}{L} \right| \qquad (2.2)$$

The values of the coefficient of localisation for each manufacturing order in the years 1958 and 1963, are presented in Table 2.2. Textiles (X), Metal Manufactures (V), and Shipbuilding and Marine Engineering (VII);

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1. In part this may be due to a statistical illusion, in that more 'weight' is given to the larger regions in the calculation of national percentages. We would therefore expect, a priori, the larger regions to show evidence of less specialisation vis-à-vis the nation.

2. W. Isard (et al), op.cit., pp.249-254; A.P. Thirlwall and C.P. Harris, op.cit., p.55f.

Table 2.2

Coefficients of Localisation by Industry:[1] 1958 and 1963[2]

Industry	1958	1963
III	0.102	0.112
IV	0.192	0.184
V	0.367	0.362
VI	0.092	0.085
VII	(0.351)	(0.329)
VIII	(0.216)	(0.177)
IX	0.271	0.250
X	0.414	0.416
XI	0.100	0.099
XII	0.146	0.145
XIII	0.129	0.116
XIV	0.174	0.161
XV	0.244	0.230
XVI	0.167	0.140

1. $CL = \frac{1}{2}\sum_i \left| \frac{L_{ij}}{L_i} - \frac{L_i}{L} \right|$

2. Brackets (..); indicate calculations based upon insufficient data.

Source: Calculated from data presented in Appendix: Tables 2.A3, 2.A4 and 2.A5 are the most localised of the industry groups. The least localised industries appear to be; Engineering and Electrical Goods (VI), Food, Drink and Tobacco (III), and Leather, Leather Goods and Fur (XI).

Unlike the CRS, the degree of localisation appears to be unrelated to the total size of the industry in question. The coefficient of rank correlation between the Coefficient of Localisation and the proportion of the national work force employed in each industry (both ranked from highest to lowest), was (ρ=) 0.267 in 1958, and 0.196 in 1963; neither of which is significantly different from zero at the 5 per cent level of significance.

It has been claimed that there exists an association between the average plant size in each industry and the degree of localisation. In Lösch's theory of location, industries differ in the extent to which increasing returns prevail. Technical factors may determine the scale (relative to the market) at which diminishing returns set in, or alternatively, transport costs may offset the potential influence of decreasing production costs. Differences in the size of 'market areas' (reflected in average plant size) thus effect the dispersion of industry.[1] Florence[2] tends to place the emphasis upon transport costs, including the effect of localised resources, together with differing demand conditions. In Lösch's model, it is primarily the degree of returns to scale which explains the different sizes of market areas, and thus the spatial dis-

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1. A. Lösch, The Economics of Location (New York, John Wiley and Sons, 1967). For an excellent discussion of Lösch's model, see S. Valavanis, "Lösch on Location", American Economic Review, Vol.45, 1955, pp.637-44; W. Isard, Location and Space Economy (Cambridge, Mass., MIT Press, 1956), pp.42-50; and B.J.L. Berry, Geography of Market Centres and Retail Distribution (Englewood Cliffs, Prentice-Hall, 1967).

2. P.S. Florence, op.cit., pp.45-54.

persion of industry. Leaving to one side the differing patterns of urbanisation within each region, and the influence of 'resource location', the major variables accounting for differences in localisation would appear to be economies of scale and demand conditions.

Data on the average size of plant by industry is presented in Table 2.3. Average size is measured by the average number of employees per establishment (AEE) in each industry, i.e.

$$AEE_i = \frac{L_i}{E_i} \qquad (2.3)$$

where E_i = Number of establishments in industry i in the U.K.[1]

An inspection of a scatter diagram of AEE and CL for each industry in 1958 and 1963, revealed little evidence of any relationship between the two,[2] although there does appear to be a tendency for highly localised industries to have an above average size of plant. The coefficient of rank correlation between average employees per establishment, and the Coefficient of Localisation (both ranked from highest to lowest), was (ρ=) 0.334 in 1958, and 0.379 in 1963. Although both coefficients are positive, neither is significantly greater than zero at the 5 per cent level of significance.

Elsewhere in the thesis we have derived estimates of the degree of returns to scale in each industry in 1958 and 1963.[3] Assuming that these estimates reflect the scale at which decreasing returns set in,

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1. Strictly speaking 'establishments' do not necessarily correspond to 'plants', being more akin to 'firms'. See Board of Trade, Report on the Census of Production 1963, Introductory Notes (London, H.M.S.O., 1968), p.4.

2. This may be due to the high level of aggregation.

3. See Chapter Five, pp. 191-9, on the estimation of the degree of returns to scale.

Table 2.3

Average Number of Employees per Establishment by Industry; U.K.: 1958 and 1963

Industry	1958	1963
III	80	107
IV	125	130
V	200	186
VI	117	113
VII	220	158
VIII	342	390
IX	45	49
X	100	105
XI	28	31
XII	55	60
XIII	58	61
XIV	26	28
XV	57	57
XVI	73	77
U.K.	84	89

Source: Board of Trade, Report on the Census of Production 1963, (London, H.M.S.O., 1970), pp.133/8-133/35.

they may be used to test the hypothesis that localisation is related to the extent of economies of scale (internal to the industry). The rank correlation coefficient between the degree of returns to scale, and the Coefficient of Localisation (both ranked from highest to lowest), was ($\rho=$) 0.386 in 1958 and -0.500 in 1963. The latter is significantly less than zero at the 5 per cent level of significance. It would appear as though highly localised industries tend to be those experiencing decreasing returns, and highly dispersed industries tend to be those experiencing increasing returns. If we accept the estimates of the degree of returns to scale, this result can only be reconciled with Lösch's model if oligopoly, transport costs, demand patterns, and economies of agglomeration (external to the industry),[1] are taken into account. It appears as though the existence, and degree, of returns to scale are relatively unimportant as a determinant of localisation patterns in U.K. manufacturing industries. The broad conclusions of Florence,[2] regarding the relationship between average establishment size and localisation seem to be supported, although we appear to be bereft of an explanation for them.

Turning our attention to changes in specialisation and localisation over the period,[3] two measures of change suggest themselves. One

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1. Although the perverse results noted above may be considered to be evidence of diseconomies of agglomeration, there is likely to be little association between these two sources of economies.

2. P.S. Florence, op.cit., pp.37-45, and also P.S. Florence, Post-War Investment, Location and Size of Plant, N.I.E.S.R. Occasional Papers XIX (Cambridge, C.U.P., 1962), p.6f. See also, R.J. Nicholson, "The Regional Location of Industry: An Empirical Study Based on the Regional Tables of the 1948 Census of Production", Economic Journal, Vol.66, 1956, p.472f.

3. Unfortunately the detailed tables of the 1968 Census have not been released at this time. As a result comparisons are restricted to the period 1958 to 1963.

measure of change is simply to calculate the difference in magnitude between the Coefficients of Specialisation (and Localisation), between 1958 and 1963. An alternative is to compute a 'redistribution' coefficient directly. We may define the Coefficient of Regional Redistribution (CRR)[1] as:

$$CRR_j = \tfrac{1}{2}\Sigma_i \left| \frac{L_{ij}}{L_j}63 - \frac{L_{ij}}{L_j}58 \right| \qquad (2.4)$$

The coefficient will have a value ranging between zero (no change in the distribution of regional employment over the period) and unity (complete re-allocation of resources).

The values of these two coefficients over the period are reported, for each region, in Table 2.4.[2] There was a tendency in most regions for their industrial composition to converge towards the national industrial structure. Only the South East and the West Midlands increased their degree of specialisation relative to the nation. Redistribution was greatest in East Anglia and the North West, and least in the West Midlands and the South East. The data may therefore be interpreted to mean that other areas of the country were altering their industrial structure, over the period, such as to duplicate that of the South East and West Midlands.

The convergence of the industrial composition of regions, noted above, may be due, to a large extent, to the influence of government policy as it effects the movement of industry. Since it operates to divert the expansion of firms from the South East and Midlands to the

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1. W. Isard (et al), Methods of Regional Analysis, p.275.

2. The coefficient of rank correlation between these two measures is 0.715, which is greater than zero at the 5 per cent level of significance.

Table 2.4

The Change in the value of the Coefficient of Regional Specialisation;[1] and Coefficients of Regional Redistribution;[2] 1958-1963[3]

Region	ΔCRS	CRR
N	-0.042	0.061
YH	-0.034	0.030
EM	-0.056	0.051
EA	-0.049	0.082
SE	0.029	0.036
SW	-0.019	0.044
WM	0.014	0.020
NW	-0.068	0.075
W	(-0.019)	(0.044)
S	-0.040	0.046
NI	(-0.029)	(0.056)

1. $CRS = CRS_{63} - CRS_{58}$

2. $CRR = \frac{1}{2}\sum_i \left| \frac{L_{ij}}{L_j}63 - \frac{L_{ij}}{L_j}58 \right|$

3. Brackets (..); indicate calculations based upon insufficient data.

<u>Source</u>: Calculated from data presented in Table 2.1 and Appendix: Tables 2.A1 and 2.A2

peripheral areas, it is thereby transferring the industrial structure of the centre to the periphery. Whilst there is no discernible association between the change in the Coefficient of Regional Specialisation and measures of industrial movement between regions over the period, this is not true of the Coefficient of Regional Redistribution. The Coefficient of Rank Correlation between CRR_j and the proportion of total moves going to each region, over the period 1960-66, is 0.555. The correlation coefficient between CRR_j and the 'Propensity to Attract Moving Firms'[1] for each region, is 0.562. Both coefficients are greater than zero at the 5 per cent level of significance.

We would expect that relatively rapid employment growth could provide the potential for resource re-allocation; in addition, we would expect resource re-allocation to be reflected in relatively high levels of productivity growth. It must be reported that there is no association between the levels of redistribution undertaken in the regions, and the magnitude of employment or productivity growth over the period. The rank correlation coefficient between the CRR, and the rate of growth of employment over the period (disregarding the sign of employment growth), is 0.072; between the CRR and the rate of growth in labour productivity it is 0.183. Neither of the correlations is significantly different from zero.[2]

Measures of locational change may also be computed for each industry. The Coefficient of Industrial Redistribution (CIR) becomes;[3]

1. Details of the computation and sources of the movement data may be found in Chapter Three, pp. 101-4.

2. These relationships will be explored further in Chapter Four.

3. W. Isard (et al), <u>op.cit.</u>, p.254.

$$CIR_i = \tfrac{1}{2}\Sigma_j \left| \frac{L_{ij}}{L_i}63 - \frac{L_{ij}}{L_i}58 \right| \qquad (2.5)$$

The values of this coefficient, together with the magnitude of the changes in the Coefficient of Localisation over the period, are presented in Table 2.5.

Most industries, with the exception of Food, Drink and Tobacco (III), and Textiles (X), revealed a tendency to become more dispersed over the period.[1] Locational change was greatest in Shipbuilding and Marine Engineering (VII), and Textiles (X).

As with the CRR, there is little association between the Coefficient of Industrial Redistribution and either employment or labour productivity growth rates. The rank correlation coefficient between the CIR and the rate of growth in employment (disregarding sign) is 0.140; with productivity growth it is 0.175. Neither coefficient is significantly different from zero at the 5 per cent level of significance.

Thus far we have described the <u>degrees</u> of regional specialisation and industrial localisation, together with the magnitude of changes in these measures over the period 1958 to 1963. It has been shown that there is little or no relation between these measures and various 'explanatory' variables (which we would expect to be associated with them), such as plant size, returns to scale, productivity growth etc.

The next section of this chapter will be concerned with attempts to explain the <u>pattern</u> of specialisation and localisation with reference to hypotheses derived from the theory of international trade.

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1. These findings are broadly in agreement with those of A.P. Thirlwall and C.P. Harris, <u>op.cit.</u>, p.60.

Table 2.5

The Change in the value of the Coefficient of Localisation by Industry;[1] and Coefficients of Industrial Redistribution:[2] 1958-63[3]

Industry	ΔCL	CIR
III	0.010	0.028
IV	-0.008	0.032
V	-0.005	0.039
VI	-0.007	0.015
VII	(-0.002)	(0.063)
VIII	(-0.039)	(0.050)
IX	-0.021	0.029
X	0.002	0.056
XI	-0.001	0.031
XII	-0.001	0.016
XIII	-0.013	0.020
XIV	-0.013	0.019
XV	-0.014	0.014
XVI	-0.027	0.035

1. $\Delta CL = CL_{63} - CL_{58}$

2. $CIR = \frac{1}{2} \Sigma_i \left| \frac{L_{ij}}{L_i}63 - \frac{L_{ij}}{L_i}58 \right|$

3. Brackets (..); indicate calculations based upon insufficient data.

Source: Calculated from data presented in Table 2.2.

Patterns of Regional Specialisation and Trade in the United Kingdom: A Test of Some Hypotheses.

As indicated at the beginning of this chapter, this section will be concerned with patterns of specialisation and localisation rather than the level, or degree, of specialisation and localisation.

Regional economists have devoted little attention to the empirical study of the basis of regional specialisation and industrial location. One major exception is the work of R.J. Nicholson for the U.K.[1] based upon the 1948 Census of Production. Another exception is the stimulating paper by J.R. Moroney and J.M. Walker[2] which considers the ability of the Heckscher-Ohlin theorem to account for the observed pattern of specialisation in the south of the United States. One part of the present study represents an attempt to extend the work of Moroney and Walker, using U.K. data, and to generalise their model to a multi-region system. Besides the Heckscher-Ohlin theorem, an attempt will also be made to test various other hypotheses of the basis of regional specialisation, in particular hypotheses derived from the classical theory of international trade.

The purpose of this section is therefore twofold. Firstly, we are interested in explaining particular patterns of specialisation and localisation. Towards this end we will specify and test alternative hypotheses as to the determinants of trading and location patterns.

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1. R.J. Nicholson, "The Regional Location of Industry: An Empirical Study based on the Regional Tables of the 1948 Census of Production", Economic Journal, Vol.66, 1956, pp.467-481. It is important however to read, in conjunction with the above, the comments by A.J. Brown, "Surveys of Applied Economics: . . .", op.cit., pp.775-7.

2. J.R. Moroney and J.M. Walker, "A Regional Test of the Heckscher-Ohlin Hypothesis", Journal of Political Economy, Vol.74, 1966, pp.573-86.

Secondly, we are also interested in assessing, according to various criteria, the 'efficiency' of resource allocation within and between regions. In the latter case the particular determinants of allocative and locational decisions are immaterial; we are simply interested in the outcome of these forces, as reflected in the prevailing pattern of specialisation, and its relationship with certain 'efficiency' criteria, such as labour productivity. In the event that prices reflect opportunity costs and are correctly perceived (and this led, in turn, to an appropriate adjustment in resource allocation), these two interests would merge into one. As will readily become apparent it is necessary, at the outset, to make these assumptions and to treat the two problems as identical. At some point in the analysis however, it may be necessary to reconsider this assumption.

Whilst the main concern of this section is with explaining the observed pattern of regional specialisation, it is possible, given certain assumptions, to derive inferences about regional trading patterns from the observed pattern of regional specialisation. Assuming that differences in the composition of demand do not offset the ordering of regional advantages as determined by supply conditions, the industrial composition of regional trade may be considered to be arrayed in the same order as the industrial composition of regional specialisation in production.

The major assumption upon which the analysis is based is that the pattern of resource allocation, and the quantity composition of trade, are determined by differences in relative prices. It is the determinants of relative price differentials which alternative theories, of the basis of trade, seek to explain.[1]

In order to derive appropriate measures of regional advantage, it is also necessary to make an assumption about whether specialisation and trade are determined by comparative, or absolute, advantage. That is, assumptions must be made regarding the mobility (or 'specifity') of resources. We will assume, in the first instance, that regions specialise according to their comparative, rather than absolute, advantage; in other words that resources are regional specific.

If none of the hypotheses, as to the basis of relative price differences, appears to account successfully for the observed patterns of regional specialisation, it may be necessary to question the validity of the assumptions which underly the analysis. For the moment however, the discussion will proceed on the assumptions; that comparative advantage is the appropriate measure of regional advantage, and that patterns of specialisation and trade[2] in manufactures reflect relative price differences.

Consideration will be given initially to the ability of the two-factor variant of the Heckscher-Ohlin theorem to account for the observed pattern of regional specialisation.[3] This is followed by a test of the

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1. For a detailed discussion of the methodology of empirical studies of patterns of trade see J. Bhagwati, "The Pure Theory of International Trade: A Survey", Economic Journal, Vol.74, 1964, pp.4-17.

2. For an extremely interesting discussion of the relationships between specialisation, trade and industrial location see W. Isard, Location and Space Economy (Cambridge, Mass., MIT Press, 1956).

3. Whilst this is tantamount to a 'reversal' of the doctrinal order of things it is prompted by two factors. Firstly, the analysis which follows was stimulated by the Moroney and Walker paper, and in that sense the Heckscher-Ohlin model was the starting point for the analysis of this chapter. Secondly, the formulation and test of the H-O theorem is relatively straightforward compared with the classical hypotheses, especially in the light of Nicholson's confusing analysis, referred to above.

classical comparative labour costs hypothesis, consideration being given to comparative labour productivities, and comparative unit labour costs, as possible determinants of specialisation patterns. Examination of the latter alternative was prompted by a recent paper by Kaldor,[1] in which he stresses the possible importance of efficiency wage differences as a determinant of regional export and growth performance. The penultimate section of the chapter considers the possibility that the observed pattern of specialisation may reflect differences in absolute, rather than comparative, regional advantage. We begin with a discussion of the measure of the pattern of specialisation within each region.

The Measure of Regional Specialisation

The pattern of specialisation within each region is measured by the Employment Location Quotient (ELQ).[2] For each industry (i) in region (j), the ELQ is defined as being equal to;[3]

$$ELQ_{ij} = \frac{L_{ij}}{L_i} \Big/ \frac{L_j}{L} = \frac{L_{ij}}{L_j} \Big/ \frac{L_i}{L} \qquad (2.6)$$

If the value of the ELQ is greater than unity, then the region is considered to be specialised in that industry relative to all other regions; if it is less than unity, the region is assumed not to

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1. N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-48.

2. Specialisation may be measured in terms of employment or output. Since the rank correlation coefficient between these two measures is positive and significant at the 1 per cent level for all regions, it should make no substantial difference to the results which measure is used.

3. The ELQ is thus equivalent, in terms of ratios, to the components (expressed in terms of differences) of the measure of the level of regional specialisation or industrial localisation; cf. Equations (2.1) and (2.2).

specialise in that activity. A matrix may be derived consisting of (i) rows and (j) columns, the elements of which are the calculated ELQ_{ij}'s. The matrices for the years 1958 and 1963 are presented in the Appendix Tables 2.A7 and 2.A8. Assuming that a region will export the products of those industries in which it is relatively specialised, and import the products of industries for which the ELQ is less than unity, the column vectors of ELQ's can be regarded as a proxy for the trading pattern of each region.[1] If the ELQ's across any row are ranked from highest to lowest, the rankings should correspond to ordering the regions by an exportation-importation scale for the products of that industry.[2]

The major defect of the Location Quotients approach, as it effects the present study, is that it would be possible for all regions to be net importers of one product and net exporters of another. Yet, the ELQ measure must show some regions with an ELQ greater than unity in the first case, and an ELQ less than unity in the second, thus possibly reversing the actual rankings within a region.[3] This defect is mitigated by two factors; firstly, the qualitative rather than quantitative use to be made of the quotients, and secondly, the fact that the

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1. It should be emphasised that attention is confined to manufacturing activities.

2. Emphasis is placed upon "rankings" and "ordering" rather than absolute magnitudes for a number of reasons. It has been argued that the theory of comparative advantages predicts orderings rather than magnitudes. R.W. Jones, "Factor Proportions and the Heckscher-Ohlin Theorem", Review of Economic Studies, Vol.24, 1956-7, pp.1-10.

3. Recently an attempt has been made to take account of this and to apply the Location Quotients to measure regional exports and imports. F.J.B. Stilwell and B.D. Boatwright, "A Method of Estimating Inter-regional Trade Flows", Regional and Urban Economics, Vol.1, 1971, pp.77-87.

U.K. as a whole is a net exporter of the products of those industries with which we are concerned.[1] We turn now to a discussion of the Heckscher-Ohlin theorem.

Relative Factor Endowments and the Pattern of Regional Specialisation

Briefly stated the Heckscher-Ohlin hypothesis is; that economies will export those goods which require in their production relatively large quantities of the most abundant factor in that economy, and import the products of those industries which are intensive in the relatively less abundant factor. Following extensive discussion in the literature over the influence of the composition of demand, and the resultant distinction between physical and 'economic' abundance,[2] the theorem has been modified to predict production rather than trading patterns. Given the 'strong factor intensity' assumption, the theorem may be modified slightly to state that; "Ordering the commodities with respect to the capital-labour ratios employed in production is to rank them in order of comparative advantage".[3] Since the data we have available refers to specialisation in production, rather than trade, the problem imposed by demand factors may be side-stepped.[4]

Moroney and Walker[5] examined the relationship between the relative

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1. Central Statistical Office, Input-Output Tables for the United Kingdom 1963, Studies in Official Statistics No.16 (London, H.M.S.O., 1970), p.9f.

2. In particular, S. Valavanis-Vail, "Leontief's Scarce-Factor Paradox", Journal of Political Economy, Vol.62, 1954, pp.523-528.

3. R.W. Jones, op.cit., p.6.

4. An excellent review of tests of the Heckscher-Ohlin hypothesis, and the advantages of regional tests, will be found in J.R. Moroney and J.M. Walker, op.cit., pp.573-586.

5. Ibid., pp.573-86.

capital intensity of (two-digit) manufacturing industries in the United States, and the degree of specialisation in those industries in the South. Given that the South is a relatively low wage (labour abundant) region, the two-factor version of the Heckscher-Ohlin theorem predicts that the South should specialise, vis-à-vis the remainder of the U.S., in relatively labour intensive industries. The particular hypothesis tested by Moroney and Walker was that; "there is an inverse rank ordering between capital-labour ratios and location quotients".[1] Since rank correlation measures indicated that the region was specialising in relatively capital intensive industries in 1949 and 1957, they rejected the hypothesis.

The Heckscher-Ohlin hypothesis was tested for the regions of the United Kingdom in 1958 and 1963, based upon the procedure adopted by Moroney and Walker. Capital-labour ratios were calculated for the thirteen manufacturing orders in the U.K.[2] in 1960, using estimates made as part of the Cambridge Growth Project.[3] The industrial orders were then ranked from highest to lowest on the basis of the estimated capital-labour ratios. Assuming that the order of these rankings would be preserved in each region,[4] the rankings of the industries in terms of capital intensity were correlated with the rankings of the column vectors of the ELQ's (Tables 2.A7 and 2.A8), and Spearman's coefficient of rank

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1. Ibid., p.581.

2. S.I.C. Orders XI and XII, were combined.

3. G. Pyatt, Capital, Output and Employment 1948-1960, A Programme for Growth, Vol.4 (Cambridge Department of Applied Economics, 1964). Data refers to the value of capital stock per employee and is reported in the Appendix to this Chapter, Table 2.A9.

4. This amounts to the 'strong factor intensity assumption'.

correlation (RCC) was computed.[1]

The estimates of the rank correlation coefficient are given in Table 2.6, together with an index of average earnings per employee in total manufacturing in each region. On the basis of a one-tailed test, none of the estimates was found to be significantly different from zero at the 5 per cent level of significance.

It is of some interest, however, to find that the correlation coefficient for Northern Ireland is negative in both years, indicating that there is some tendency for the low-wage region to specialise in relatively labour intensive industries. The coefficient for Wales, a high wage region, is positive in both years, reflecting the tendency for resources to be concentrated in capital intensive industries in that region. The coefficient for the South East, however, also a high wage region (and a region which suffers from a chronic shortage of labour), is negative in both years - a result which is inconsistent with the predictions of the Heckscher-Ohlin model. Similarly, as we progress from regions with the lowest, to regions with the highest, wage level, we do not find a smooth transition from negative coefficients (indicative of specialisation in labour intensive industries), to high and positive coefficients (indicative of specialisation in capital intensive industries). However, the evidence for particular regions is more favourably inclined towards the Heckscher-Ohlin hypothesis than were the results of Moroney and Walker's study of the Southern United States.

We should note that the associations we have measured may arise from many factors. Indeed, it could be argued that the relationship

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1. A discussion of the coefficient and significance tests may be found in P.G. Hoel, Elementary Statistics (N.Y., John Wiley and Sons, Second Edition, 1966).

Table 2.6

Relationship between Relative Capital Intensity and Regional Specialisation Patterns: 1958 and 1963

Region	1958		1963	
	RCC[1]	WI[2]	RCC	WI
N	+0.01	1.03	-0.09	1.00
YH	+0.33	0.95	+0.35	0.93
EM	+0.14	0.96	+0.23	0.92
EA	-0.35	0.95	-0.32	0.93
SE	-0.30	1.08	-0.23	1.07
SW	-0.40	1.01	-0.32	1.01
WM	+0.11	1.04	+0.01	1.03
NW	+0.10	0.93	+0.30	0.96
W	+0.27	1.08	+0.33	1.08
S	+0.30	0.96	+0.27	0.95
NI	-0.31	0.75	-0.28	0.76

1. Rank correlation coefficients between capital-labour ratios and ELQs for thirteen manufacturing industries in each region, both ranked from highest to lowest. (Due to insufficient data only eleven industries are included for Wales and Northern Ireland.)

2. Index of earnings per employee in manufacturing in each region (U.K. = 1.00).

<u>Source</u> of earnings data; Board of Trade, <u>op.cit.</u>, pp.133/6 and 133/7.

between average wage rates (earnings) and specialisation is due, not to a causal relationship from wage level to technique but, to a relationship from technique to a 'productivity based' wage.

The analysis was repeated substituting Nicholson's estimates[1] of the capital-labour ratio in ten industry groups for 1961, for the Cambridge data. Essentially the same results were observed using Nicholson's data as were found with the Cambridge capital measures. To some extent the results appear to be insensitive to alternative measures of the capital-labour ratio.

Two explanations for the insignificant results suggest themselves; one refers to the possibility of 'factor-reversal', the other refers to excluded variables.

It may be that the assumption, that the ordering of capital-labour ratios is identical between regions, is invalid. Remaining within the neo-classical framework, this would occur if the elasticity of substitution of capital for labour was not identical between industries. This would imply that industries could not be ranked uniquely in terms of their capital intensiveness.[2] Estimates of the elasticity of substitution at the SIC order level in U.K. manufacturing (using a Constant Elasticity of Substitution Production Function)[3] indicate that there are significant differences in the estimated elasticity of substitution between industries.[4]

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1. R.J. Nicholson, "Capital Stock, Employment and Output in British Industry 1948-1964", Yorkshire Bulletin of Economic and Social Research, Vol.18, 1966, p.81.

2. B.S. Minhas, An International Comparison of Factor Costs and Factor Use (Amsterdam, North Holland, 1963).

3. K. Arrow (et al), "Capital-Labour Substitution and Economic Efficiency", Review of Economics and Statistics, Vol.43, 1961, pp.225-250.

4. The estimates, and the estimation procedure, are discussed in Chapter Five.

In addition factor reversal, which is made possible by differing elasticities, is quite likely, as one-quarter of the industries appear to operate under conditions of fixed coefficients, and two-thirds under conditions approximating a Cobb-Douglas technology.[1] Given these results the Heckscher-Ohlin theorem is untenable, or at least untestable, even if all the other assumptions of the model are fulfilled.

It is also possible that more than two factors of production must be considered. Natural resources are often thought to be important as a determinant of comparative advantage, and their exclusion from the analysis is often cited as the major contributor to poor results.[2] With manufacturing industries this is not likely to be an importantfactor, although there are some exceptions, especially Textiles and Metal Manufactures.

At least one writer[3] has argued that differences in the 'quality' and 'efficiency' of labour are an important variable which should be taken into account explicitly. Indeed it may be claimed that the hypothesis should be revamped to make differences in the 'efficiency of labour', the proximate determinant of comparative advantage. This has the advantage of retaining (implicitly) the importance of capital-intensity as a variable, but regards it as only one determinant of differences in the 'efficiency wage', and thus indirectly as a determinant of comparative advantage and trading patterns. This approach,

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1. See Tables 5.2 and 5.6.

2. Moroney and Walker use this explanation; op.cit., pp.581-4. Mention should also be made of market imperfections and returns to scale.

3. A.J. Brown, "Professor Leontief and the Pattern of World Trade", Yorkshire Bulletin of Economic and Social Research, Vol.9, 1957, pp.63-75.

which is essentially 'classical' in outlook, will be the subject of the remaining sections of this chapter.

Comparative Labour Costs as a Basis for Specialisation

A number of studies of the pattern of international trade have found some empirical support for the classical hypothesis; that differences in trading patterns, or shares in export markets, can largely be explained by differences in comparative labour costs.[1] In addition the importance of efficiency wage differences, as a determinant of regional growth rates, has recently been emphasised by Kaldor.[2] The particular problem encountered in this study was associated with the measurement of comparative labour costs, in a manner consistent with the classical hypothesis.[3]

A 'naive' version of the classical hypothesis, which holds that there is a relationship between specialisation and comparative labour productivity, was tested for 1958 and 1963. The method used to construct vectors of comparative labour productivity in manufacturing industries, for each region in both years, will be described in some detail.

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1. G.D.A. MacDougall, "British and American Exports: A Study suggested by the Theory of Comparative Costs", Economic Journal, Vol.61, 1951, pp.687-724 and Vol.62, 1952, pp.487-521; R. Stern, "British and American Productivity and Comparative Costs in International Trade", Oxford Economic Papers, Vol.14, 1962, pp.275-296; B. Balassa, "An Empirical Demonstration of Classical Comparative Cost Theory", Review of Economics and Statistics, Vol.45, 1963, pp.231-238. A critical evaluation of these papers may be found in J. Bhagwati, "The Pure Theory of International Trade: A Survey", Economic Journal, Vol.74, 1964, pp.1-84.

2. N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-48.

3. A similar approach, to that adopted here, may be found in, A.J. Brown, The Framework of Regional Economics in the United Kingdom, N.I.E.S.R. Economic and Social Studies XXVII (Cambridge, C.U.P., 1972), pp.158-160.

A matrix of i rows (industries) and j columns (regions) of comparative labour productivity was constructed by the following method. Firstly, the value of net output per employee was calculated for each industry in each region, from the regional tables of the 1963 Census of Production.[1] This yields a matrix of actual labour productivities in each region. Secondly, for each industry (row) in turn, labour productivity in each region was expressed as a proportion of the national 'average' productivity in that industry. The derived matrices of comparative labour productivities are presented in the Appendix to this chapter, Tables 2.A10 and 2.A11.

Regional comparative advantage is assumed to lie in the products of those industries for which regional productivity is highest, relative to the nation. If, therefore, regions specialised according to their comparative labour productivities, we would expect to find a significantly positive correlation between the rankings of the ELQ's and the ranking of the productivity indices (both ranked from highest to lowest), down the corresponding columns of the matrices.[2, 3]

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1. Net Output is defined as ". . . the value added to materials . . . obtained by deducting from the Gross Output the cost of purchases adjusted for stock changes, payments for work given out to other firms, and payments for transport". (Board of Trade, op.cit., p.ii). 'Employees' includes; operatives, administrative, technical, and clerical employees. Net Output is measured in value terms as regional price indices are unavailable.

2. An alternative method is to deflate each column by the regional average and then compare the relevant rows. The procedure outlined in the text was preferred on intuitive grounds, and also to facilitate 'absolute cost' comparisons at a later stage of the argument.

3. This amounts to a test of what Stigler has labelled a 'predictive' labour theory of value; G.J. Stigler, "Ricardo and the 93 Per Cent Labor Theory of Value", American Economic Review, Vol.48, 1958, pp.357-367. It appears as though the classical economists were not alone in this view, as recent comments on the 'neo-classical' parable demonstrate; P. Garegnani, "Heterogeneous Capital, the Production Function and the Theory of Distribution", Review of Economic Studies, Vol.37, 1970, pp.407-436.

The results of the test, correlation being measured by Spearman's rho, are set out in Table 2.7. Only one region, the North, exhibits a significantly positive relationship. This result is not unexpected as prices depend, not only upon factor productivity, but also on the cost of inputs. Differences in wages may offset, or more than offset, differences in labour productivity between regions, and between the industries within each region.

A recent study by Woodward[1] revealed, as a result of an analysis of variance on U.K. data for 1961, that average product differs significantly between industries, but does not exhibit any significant inter-regional differences. Average earnings, however, exhibited significant inter-industry, and inter-regional, differences. It seems desirable therefore to allow for this source of variation in the measure of comparative labour costs. The next section of the chapter will deal with the formulation, and tests, of the hypothesis that differences in efficiency wages are able to account for the observed pattern of regional specialisation.

<u>The Classical Hypothesis II: Efficiency Wage Differences</u>

Unit labour costs were calculated, for each industry in each region, by dividing the wage and salary bill[2] by the value of net output. This has a particular advantage in that differences in taxes, overtime payments, hours of work etc., are automatically included. Comparative

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1. V.H. Woodward, <u>Regional Social Accounts for the United Kingdom</u>, N.I.E.S.R. Regional Papers 1 (Cambridge, C.U.P., 1970), p.89.

2. Wages and Salaries are defined as "amounts paid to operatives and to administrative, technical and clerical employees", ". . . no deduction is made for income tax, insurances, contributory pensions etc." (Board of Trade, <u>op.cit.</u>, p.iii).

Table.2.7

Relationship between Comparative Labour Productivity and Regional Patterns of Specialisation: 1958 and 1963[1]

Region	ρ 58	ρ 63
N	+.570[1]	+.508[1]
YH	+.311	+.323
EM	-.049	+.059
EA	-.096	-.134
SE	-.084	+.086
SW	+.242	+.165
WM	-.234	-.130
NW	+.148	+.119
W	+.131	-.189
S	+.191	-.086
NI	+.183	-.042

1. Indicates significantly different from zero at the 5 per cent level.

unit labour costs were derived, for each industry in each region, in the same manner in which the matrix of comparative labour productivities were derived; i.e. by dividing each row element by the corresponding national 'average' unit labour cost.[1] Ranking the indices down each column, from lowest to highest, is equivalent to ordering the industries in each region in terms of the opportunity cost, to the region, of using labour in each particular industry, since net output is measured in value terms. The lowest unit labour cost industry, relative to the nation, represents the industry in which regional comparative advantage is greatest.

If regions specialised according to their comparative advantages, as determined by relative efficiency wages, we would expect to find a positive and significant correlation between the rankings of the ELQ's (ranked from highest to lowest), and the rankings of the efficiency wage indices (ranked from lowest to highest), down the corresponding columns of the matrices. Results of the correlation test are set out in Table 2.8.

The results indicate that only one region, the South West in 1958, was specialising in industries in which it had a comparative advantage according to the classical criterion. Two regions were specialising in industries in which they had a comparative disadvantage, i.e. East Anglia and Wales; and the remaining regions show no statistically significant relationship. The hypothesis, that regional comparative advantage is determined by differences in efficiency wages, must therefore be rejected.

It may be of some interest to examine the changes which occurred in the degree of association, between specialisation and comparative unit

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1. The matrices of comparative unit labour costs are presented in the Appendix, Tables 2.A12 and 2.A13.

Table 2.8

Rank Correlation Coefficients between the Patterns of Regional Specialisation and Comparative Unit Labour Costs; 1958 and 1963[1]

Region	ρ1958	ρ1963
N	+.248	+.194
YH	-.022	-.065
EM	-.130	-.350
EA	-.701**	-.557*
SE	-.321	-.045
SW	+.501*	+.130
WM	-.365	-.415
NW	+.105	+.048
W	-.161	-.570*
S	+.262	+.048
NI	-.094	-.355

1. * - indicates significant at the 5 per cent level.

** - indicates significant at the 1 per cent level.

labour costs, over the period 1958 to 1963. With the exceptions of East Anglia and the South East, all regions exhibited a decline in this association over the period.[1]

As a first approximation we may consider the change in the degree of association over the period to be the result of two distinct, though inter-related, influences. On the one hand wage rates and the productivity of labour may alter, signalling the need for a re-allocation of the resources within each region. On the other hand (possibly as a result of this change), resources may be re-allocated in each region, altering the pattern of specialisation. An attempt has been made to isolate these two influences using a 'hybrid' correlation coefficient (rho*); arrived at by comparing the rankings of the ELQ's for each region in 1958, with the rankings of comparative unit labour costs in 1963. Rho* thus measures the degree of association which would have been found, if the pattern of regional specialisation remained unaltered, as unit labour costs varied over the period. The difference between the value of the hybrid rank correlation coefficient and the actual degree of association in 1958, measures the effect of changing unit labour costs over the period - holding the pattern of specialisation constant. The difference between the actual coefficient for 1963, and the hybrid coefficient, allows us to assess the effect of changes in the pattern of

1. It should be emphasised that the discussion contained in the remainder of this section is of the nature of an aside from the main argument. In the main text the rank correlation coefficient is used as an aid to test hypotheses, and thus statistical tests of significance are applied. The remainder of the present section is concerned with the use of the rank correlation coefficient merely as a descriptive statistic, summarising information contained in the samples. Statistical significance or insignificance aside, this information is worthwhile as descriptive information in its own right, conveying information about the sample.

regional specialisation in the light of unit labour costs ruling in the final period.

Thus,

$$\left[\mathrm{Rho}(63) - \mathrm{Rho}(58)\right] = \left[\mathrm{Rho}^{*} - \mathrm{Rho}(58)\right] + \left[\mathrm{Rho}(63) - \mathrm{Rho}^{*}\right] \qquad (2.7)$$

By this means we are able to decompose the total change in the coefficient over the period into a 'competitiveness', and 're-allocation' component, respectively.

The estimates of these components are presented in Table 2.9. In the regions for which the degree of association increased over the period (EA and SE), a favourable movement in the competitive component was an important contributor.

Estimates of the reallocation component also indicate that in three regions in particular (EW, SW and W), structural changes occurred over the period which (perhaps in response to market forces), tended to mitigate against unfavourable changes in competitiveness, although with varying success. Scotland stands out as a region where unfavourable structural changes were a major determinant of the lesser degree of association, between specialisation and comparative costs, over the period. This is also true to some extent of the West Midlands region. Once these perverse results are noted, the table as a whole reveals the expected rigidity of allocative patterns, vis-à-vis relative price changes.

It was noted earlier that comparative unit labour costs appear unable to account for the observed pattern of regional specialisation. Efficiency wages may be considered, however, to be a good proxy for relative prices,[1] and therefore it seems desirable to question the assumptions under which the hypothesis was brought to test. In particular we must consider the

1. cf. J. Bhagwati, op.cit., pp.12-17.

Table 2.9

Components of Change in the Association between Unit Labour Costs and Specialisation between 1958 and 1963

Region	Total Change in RCC[1]	Competitiveness Component[2]	Re-allocation Component[3]
N	-0.054	-0.038	-0.016
YH	-0.043	-0.060	+0.017
EM	-0.220	-0.370	+0.150
EA	+0.144	+0.121	+0.023
SE	+0.276	+0.281	-0.005
SW	-0.371	-0.418	+0.047
WM	-0.050	+0.005	-0.055
NW	-0.057	-0.065	+0.008
W	-0.409	-0.499	+0.090
S	-0.214	-0.062	-0.152
NI	-0.261	-0.269	-0.008

1. Total Change = rho (63) minus rho (58), from Table 2.8.

2. Competitive Component = rho* minus rho (58).

3. Re-allocation Component = rho (63) minus rho*.

possibility that the pattern of regional specialisation and trade is based not upon comparative, but rather on absolute, cost differences. It is possible, owing to the method by which the matrix of efficiency wages was derived, to test this proposition.

Industrial Localisation and Absolute Unit Labour Costs

If regions specialised according to their absolute advantage (that is, resources were industry, not regional, 'specific') and each industry was relatively concentrated in regions with the lowest absolute unit labour costs,[1] we would expect to find a significantly positive correlation between the ELQ's and the Unit Labour Cost indices, ranked across each corresponding row of the matrices. Since we derived the indices by deflating the elements in each row by a constant, the initial ordering of absolute costs (across each row) is preserved.

The results of the absolute advantage test, relating specialisation and absolute unit labour costs by region for each industry, are set out in Table 2.10. There is some evidence that, to the extent to which resources are mobile inter-regionally, for many industries the degree of regional specialisation is related to absolute disadvantage, rather than advantage. We must therefore reject the hypothesis that the pattern of regional specialisation is determined by absolute advantage, as reflected in unit labour costs.

A major defect of the analysis would appear to be the level of aggregation of the industry groups. Rank correlation coefficients were

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1. Alternatively, it is possible to test the Heckscher-Ohlin hypothesis within the context of inter-regional mobility of resources. Correlation coefficients could be computed between the ELQ's and regional wage rates within each industry. We would expect to find, if the Heckscher-Ohlin theorem were correct, that the coefficient would be positive for capital intensive industries and negative for labour intensive industries.

Table 2.10

Rank Correlation Coefficients between ELQs and Unit Labour Costs by Industry; 1958 and 1963

Industry	1958	1963
III	+.227	+.298
IV	+.405	+.041
V	+.314	-.048
VI	+.064	-.525*
VII	-.308	-.500
VIII	-.104	+.348
IX	-.357	-.636*
X	-.295	-.634*
XI	+.257	+.831**
XII	+.032	-.570*
XIII	-.557*	-.551
XIV	-.057	-.250
XV	-.388	-.020
XVI	-.066	+.527*

computed for absolute unit labour costs using the 'across rows' method for twenty-four minor industry groups in 1963. Without detailed knowledge of all groups it is difficult to perform the regional (i.e. the 'down columns') test in a dis-aggregated form. The results are reported in Table 2.11. The conclusions drawn previously from the aggregative data are not contradicted. Of the twenty-four correlation coefficients derived, only two are significantly different from zero at the 5 per cent level, one positive and one negative.[1]

An alternative test of the effects of the high level of aggregation is to compare, where possible, the coefficient obtained for the aggregate (i.e. Order level), with the coefficients of the MLH industries which comprise that order. The nearest we can get to this is for 'Metal Manufactures' (V), for 1963. The correlation at the Order level for that industry was (ρ=) -0.048 (from Table 2.10). Three of the four MLH components of that industry exhibited coefficients of (ρ=) -0.160 (MLH-311); 0.540 (MLH-313); and -0.020 (MLH-321/2/3).[2]

Whilst the high level of aggregation is a major defect of the analysis there is some indication that the conclusions, arrived at on the basis of SIC order data, would be sustained if a more dis-aggregated analysis were possible.

Implications of the Results

If we accept the assumptions set out in the introduction to this paper, then we must reject the hypothesis that efficiency wages are

1. These being MLH-489, 'General Printing, Publishing, Bookbinding etc.', and MLH-473, 'Bedding and Soft Furnishings', respectively.

2. Owing to data deficiencies we cannot calculate the coefficient for the other sub-group of this industry, MLH-312.

Table 2.11

Rank Correlation Coefficients between ELQs and Absolute Unit Labour Costs for M.L.H. Industries: Great Britain[1], 1963

M.L.H. No.	Industry	RCC
271(3)	General Chemicals	0.427
332	Metal-working Machine Tools	0.436
336	Contractors' Plant and Quarrying Machinery	-0.352
339	Misc. (Non-elec.) Machinery	-0.175
341	Industrial Plant and Steelwork	-0.309
349	General Mechanical Engineering	0.498
351	Scientific, Surgical and Photographic Instruments etc.	-0.212
369	Misc. Electrical Goods	0.266
381	Motor Vehicle Manufacture	0.530
399	Misc. Metal Manufactures	-0.318
417	Hosiery and other Knitted Goods	0.085
442	Men's and Boys' Tailored Outwear	0.536
444	Overalls and Men's Shirts, Underwear, etc.	-0.558
445	Dresses, Lingerie, Infants' Wear, etc.	0.175
450	Footwear	0.314
463	Glass	0.015
471	Timber	-0.282
472	Furniture and Upholstery	0.030
473	Bedding and Soft Furnishings	-0.621*
483	Misc. Manufactures of Paper and Board	0.257
486	Print. and Publ. of Newspapers etc.	-0.506
489	General Printing, Publishing etc.	0.596*
491	Rubber	-0.303
494	Toys, Games and Sports Equipment	0.109

1. Excluding Northern Ireland.

able to account for the pattern of regional trade in the United Kingdom. It has been demonstrated that this result is not due to an unrealistic assumption as to the basis for trade (i.e. absolute rather than comparative advantage). Were it possible, however, to argue that efficiency wages are a good proxy for relative prices, then the implication of the findings would be that patterns of trade and specialisation, are not determined by relative price differences.

There seem to be two grounds upon which it can be argued that efficiency wages reflect relative prices, and against the objection that the negative results are due to other costs, particularly capital costs, offsetting the unit labour cost differences.

Firstly, what matters is not the absolute difference in capital cost between regions, but rather the comparative industrial rankings of capital costs for all industries in one region compared with another. We may expect these differences to be slight, the situation being analagous to the argument put forward by Taussig in response to Cairne's question of 'non-competing' groups,[1] although the evidence of the variability in the elasticity of substitution between industries, discussed earlier, may support this objection.

Secondly, numerous studies of locational decision making support the view that the minimisation of production costs is not accorded high priority, in the evaluation of alternative locations, by industry decision makers.[2]

It may be concluded, therefore, that if we cannot reject the

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1. This is discussed in S.J. Wells, International Economics (London, George Allen and Unwin, 1969), pp.30-33.

2. e.g. G. McCrone, Regional Policy in Britain (London, George Allen and Unwin, 1969), pp.169-181, and the references cited therein.

proposition that efficiency wage differences are able to account for differences in relative prices; then we must reconsider the proposition that relative price differences determine the 'quantity composition' of regional trade, and spatial patterns of resource allocation. Non-economic, or at least non-price determined models, appear to be necessary if we are to understand the pattern of regional specialisation and the location of industry in the United Kingdom.

The most likely factor affecting the results is that of locational inertia.[1] Colin Clark, in a slightly different context, has put the matter this way:

> "The essential concept of a free market is trial and error . . . But can we say that this is a valid method of control in matters where you may have to wait two centuries before all the consequences of a decision are apparent."[2]

Given the element of inertia in resource allocation it would seem desirable to examine the relationship between structural or locational change and unit labour costs. This is the subject of the following chapter.

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1. This is the explanation adopted by Moroney and Walker, op.cit., pp.581-3.

2. C. Clark, "Industrial Location and Economic Potential", Lloyds Bank Review, No.82, 1966, p.2.

Appendix Table 2.A1

Proportions of Regional Manufacturing Employment by Industry Groups[1]: 1958

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI
III	7.2	8.6	7.2	22.3	9.7	15.1	6.0	8.9	6.3	12.4	14.8
IV	14.0	5.2	3.3	5.5	5.5	2.6	1.9	8.9	9.8	4.9	0.7
V	14.1	13.7	7.7	0.9	1.9	1.5	12.8	3.1	30.3	8.7	0.1
VI	22.6	17.0	19.1	30.7	29.0	20.2	22.8	19.4	13.3	20.1	11.7
VII	14.8	1.2	0.0	2.0	2.4	5.7	0.0	2.9	-	9.9	-
VIII	3.0	4.8	11.9	1.4	11.8	21.1	18.2	7.3	-	5.4	-
IX	2.4	7.1	2.8	1.4	5.0	2.3	16.9	3.9	8.0	3.6	0.8
X	3.8	23.3	20.3	2.8	1.6	4.2	3.3	22.3	6.1	14.1	30.6
XI	0.3	0.7	0.9	1.0	0.8	0.9	0.5	0.8	0.6	0.5	0.3
XII	6.6	6.9	14.7	11.7	7.2	6.8	1.9	7.4	4.3	4.1	14.1
XIII	3.9	3.6	3.3	3.9	3.2	2.6	7.6	3.5	4.2	3.0	2.3
XIV	2.6	2.6	2.7	5.6	5.1	4.2	1.9	2.1	2.6	3.1	2.2
XV	3.2	4.1	4.4	8.5	12.5	9.1	2.6	5.6	3.2	7.8	3.1
XVI	1.5	1.2	1.8	2.3	4.3	3.6	3.6	3.9	4.1	2.4	0.8
Total[2,3]	100	100	100	100	100	100	100	100	100	100	100

1. Any element (e_{ij}) equals $e_{ij} = \frac{L_{ij}}{L_j} \times \frac{100}{1}$

2. Columns might not sum exactly to 100 due to rounding errors.

3. (-) indicates data unavailable.

Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), pp.133/8-133/35.

Appendix Table 2.A2

Proportions of Regional Manufacturing Employment by Industry Groups[1]: 1963

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI
III	7.5	9.4	7.1	21.4	8.8	16.0	6.1	10.0	6.4	13.4	16.6
IV	14.3	5.2	3.6	4.5	5.7	2.2	1.7	8.5	8.0	4.9	1.4
V	13.0	13.6	7.5	0.7	2.2	1.5	12.7	2.9	30.6	7.4	0.2
VI	24.6	17.9	21.4	30.1	30.9	22.4	21.2	16.1	22.6	14.8	22.3
VII	10.1	0.9	0.1	1.7	2.0	5.2	0.2	2.3	-	6.8	-
VIII	2.4	4.6	8.8	7.8	10.9	18.2	18.1	9.2	-	5.2	-
IX	2.5	7.4	3.8	2.1	5.4	2.3	16.9	4.2	6.6	3.7	1.3
X	4.9	21.5	20.5	2.1	1.3	4.2	2.8	16.9	6.2	14.3	27.7
XI	0.4	0.7	0.8	0.7	0.8	0.9	0.5	0.7	0.5	0.5	0.4
XII	7.3	6.4	13.1	8.7	6.2	5.8	1.8	7.1	4.0	4.1	14.1
XIII	3.8	3.6	3.4	4.2	3.1	3.1	7.0	3.6	3.7	3.0	2.9
XIV	2.9	3.0	2.6	4.3	5.0	4.1	1.8	2.3	2.3	3.1	2.6
XV	3.6	4.3	4.4	8.7	12.6	9.5	2.7	6.6	3.6	8.6	3.7
XVI	2.9	1.5	2.8	2.8	4.9	4.5	4.1	4.4	4.7	2.5	1.2
Total[2,3]	100	100	100	100	100	100	100	100	100	100	100

1. Any element (e_{ij}) equals $e_{ij} = \frac{L_{ij}}{L_j} \times \frac{100}{1}$

2. Due to rounding errors some columns may not sum to exactly 100.

3. (-) indicates data unavailable.

Source: Board of trade, op.cit.

Appendix Table 2.A3

Proportions of Industry Work Force, by Region[1]: 1958

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI	Total
III	4.1	9.7	5.3	3.9	28.1	7.0	8.8	15.8	2.3	11.5	3.5	100
IV	12.9	9.6	4.0	1.6	26.2	1.9	4.6	25.8	5.7	7.4	0.3	100
V	10.1	19.7	7.2	0.2	6.9	0.9	23.8	7.0	13.9	10.3	0.0	100
VI	5.3	8.0	5.9	2.3	35.2	3.9	13.9	14.5	2.0	7.8	1.2	100
VII	22.0	3.6	0.1	0.9	18.5	7.0	0.2	13.6	-	24.4	-	100
VIII	1.6	5.0	8.1	0.2	31.6	9.1	24.6	12.0	-	4.6	-	100
IX	2.1	12.3	3.1	0.4	22.1	1.6	37.8	10.8	4.4	5.1	0.3	100
X	1.8	22.4	12.7	0.4	3.8	1.7	4.1	33.8	1.9	11.2	6.2	100
XI	2.4	10.5	8.5	2.4	31.8	5.5	10.1	18.2	2.9	6.6	1.1	100
XII	5.1	10.6	14.9	2.8	28.5	4.3	3.7	18.0	2.1	5.3	4.6	100
XIII	5.3	9.6	5.8	1.6	22.2	2.9	26.2	14.8	3.6	6.7	1.3	100
XIV	4.2	8.5	5.7	2.8	41.9	5.6	8.0	10.8	2.7	8.3	1.5	100
XV	2.4	6.2	4.3	2.0	48.6	5.7	5.1	13.5	1.5	9.7	1.0	100
XVI	2.4	4.0	3.8	1.2	36.5	4.9	15.3	20.5	4.3	6.5	0.5	100

1. Any element (x_{ij}) equals $x_{ij} = \frac{L_{ij}}{L_i} \times \frac{100}{1}$

Source: Board of Trade, *op.cit.*

Appendix Table 2.A4

Proportions of Industry Work Force, by Region[1]: 1963

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI	Total
III	3.9	10.2	5.2	4.4	25.9	7.4	9.0	16.7	2.4	11.3	3.7	100
IV	12.8	9.7	4.4	1.6	28.6	1.7	4.3	24.2	5.1	7.0	0.5	100
V	9.0	19.6	7.2	0.2	8.5	0.9	24.8	6.4	15.1	8.2	0.1	100
VI	5.1	7.7	6.1	2.4	35.8	4.1	13.7	14.0	2.4	7.5	1.3	100
VII	19.8	3.5	0.2	1.3	22.0	8.9	1.0	14.4	-	21.6	-	100
VIII	1.2	4.8	6.1	1.5	30.6	8.0	25.4	14.8	-	4.1	-	100
IX	1.9	12.0	4.1	0.6	23.4	1.6	37.1	10.5	3.7	4.6	0.4	100
X	2.5	23.4	14.9	0.4	3.9	1.9	4.2	28.3	2.3	12.1	6.1	100
XI	2.4	10.2	8.4	2.2	34.1	5.7	9.5	16.5	2.8	6.5	1.2	100
XII	5.8	10.7	14.5	2.7	27.7	4.0	4.1	18.1	2.3	5.3	4.8	100
XIII	4.9	9.6	6.1	2.1	22.6	3.5	25.4	14.7	3.4	6.2	1.6	100
XIV	4.3	9.3	5.5	2.5	42.3	5.5	7.7	11.2	2.5	7.4	1.7	100
XV	2.5	6.1	4.2	2.3	47.8	5.7	5.1	14.3	1.7	9.4	1.1	100
XVI	3.8	4.0	5.2	1.4	36.3	5.2	15.2	18.6	4.4	5.3	0.7	100

1. Any element (x_{ij}) equals $x_{ij} = \frac{L_{ij}}{L_i} \quad \frac{100}{1}$

<u>Source</u>: Board of Trade, <u>op.cit.</u>

Appendix Table 2.A5

Proportions of Total U.K. Manufacturing Employment within each Region: 1958 and 1963.[1]

Region	1958	1963
N	5.3	5.0
YH	10.5	10.3
EM	6.9	6.9
EA	1.6	1.9
SE	27.0	27.9
SW	4.3	4.4
WM	13.6	14.0
NW	16.6	15.9
W	3.3	3.5
S	8.7	8.0
NI	2.2	2.1
UK	100.0	100.0

1. Element equals $= \frac{L_j}{L} \cdot \frac{100}{1}$

<u>Source</u>: Board of Trade, op.cit., Table 21.

Appendix Table 2.A6

Proportions of Total U.K. Manufacturing Employment within each Industry: 1958 and 1963.[1]

Industry	1958	1963
III	9.5	9.3
IV	5.6	5.7
V	7.2	7.3
VI	24.1	22.3
VII	2.6	3.5
VIII	10.0	10.1
IX	6.4	6.1
X	9.5	10.9
XI	0.7	0.7
XII	6.2	6.8
XIII	3.9	3.9
XIV	3.3	3.3
XV	7.3	7.0
XVI	3.8	3.2
U.K.	100.0	100.0

1. Element equals $= \frac{L_i}{L} \cdot \frac{100}{1}$

Source: Board of Trade, op.cit.

Appendix Table 2.A7

Employment Location Quotients[1]: 1958[2]

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI
III	76	91	76	235	102	159	63	94	66	131	156
IV	250	93	59	98	98	46	34	159	175	88	13
V	196	190	107	13	26	21	178	43	421	121	1
VI	94	71	79	127	120	84	95	80	55	83	49
VII	569	46	0	76	92	219	0	112	-	380	-
VIII	30	48	119	14	118	211	182	73	-	54	-
IX	38	111	44	22	78	36	264	61	125	56	13
X	40	245	213	29	17	44	35	235	64	148	322
XI	43	100	129	143	114	128	71	114	86	71	43
XII	106	111	237	189	116	110	31	119	69	66	227
XIII	100	92	85	100	82	67	195	90	108	77	59
XIV	79	79	82	170	154	127	58	64	79	94	67
XV	44	56	60	116	171	125	36	77	44	107	42
XVI	39	32	47	61	113	95	95	103	108	63	21

1. $ELQ_{ij} = \left[\frac{L_{ij}}{L_j} \bigg/ \frac{L_i}{L} \right] \times \frac{100}{1}$

2. (-) indicates data unavailable.

Source: Calculated from data presented in Tables 2.A1-2.A6.

Appendix Table 2.A8

Employment Location Quotients[1]: 1963[2]

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI
III	78	99	75	232	93	168	64	105	69	141	176
IV	256	94	64	84	103	39	31	152	146	88	24
V	180	190	104	11	30	20	177	40	431	103	5
VI	102	75	88	126	128	93	98	88	69	94	62
VII	396	34	3	68	79	202	7	91	-	270	-
VIII	24	47	88	79	110	182	181	93	-	51	-
IX	38	117	59	32	84	36	265	66	106	58	19
X	50	227	215	21	14	43	30	178	66	151	290
XI	58	99	121	116	122	130	68	104	80	81	57
XII	116	104	210	142	99	91	29	114	66	66	229
XIII	98	93	88	111	81	80	181	92	97	78	76
XIV	86	90	80	132	152	125	55	70	71	93	81
XV	50	59	61	121	171	129	36	90	49	118	52
XVI	76	38	75	74	130	118	109	117	126	66	33

1. $ELQ_{ij} = \left[\frac{L_{ij}}{L_j} \bigg/ \frac{L_i}{L} \right] \times \frac{100}{1}$

2. (-) indicates data unavailable.

Source: Calculated from data presented in Tables 2.A1-2.A6.

Appendix Table 2.A9

Estimates of Capital-Labour Ratios in U.K. Manufacturing Industries: 1960[1]

Industry	Ratio[2]
III	1.8
IV	3.6
V	2.4
VI	1.0
VII	0.7
VIII	1.3
IX	1.0
X	2.0
XI) XII)	0.5
XIII	1.2
XIV	0.7
XV	1.6
XVI	1.2

1. Source: G. Pyatt, op.cit., p.23 and 27.

2. Ratio equals value of capital in 1954 prices (£'000's) per employee.

Appendix Table 2.A10

Indices of Comparative Net Output per Employee: 1958[1]

Industry	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI
III	84	83	110	84	106	116	98	101	83	105	88
IV	114	91	78	83	105	80	81	106	86	92	80
V	102	98	101	62	102	73	91	93	129	93	41
VI	104	100	99	100	100	95	95	102	100	103	77
VII	113	102	162	112	96	89	98	109	-	95	-
VIII	65	95	90	317	109	93	107	86	-	87	-
IX	95	95	112	138	116	89	92	99	96	102	91
X	105	111	107	93	119	135	114	88	211	94	69
XI	96	94	120	78	105	113	75	96	110	101	84
XII	91	88	108	100	119	98	102	90	88	88	72
XIII	95	111	102	107	119	90	74	115	100	101	86
XIV	92	88	89	94	113	88	95	92	75	88	94
XV	89	87	81	89	110	93	86	93	93	88	75
XVI	85	83	107	67	96	142	102	103	102	93	58

1. Element $= \left[\frac{NO_{ij}}{L_{ij}} \Big/ \frac{NO_i}{L_i} \right] \times \frac{100}{1}$

where NO = Net Output
L = Employment

Source: Board of Trade, op.cit., pp. 133/8-133/35.

Appendix Table 2.A11

Indices of Comparative Net Output per Employee: 1963[1]

Industry	N	YH	EM	EA	SE	SW	WM	NW	W	S	NI
III	85	87	107	98	101	107	96	101	92	113	97
IV	112	82	75	112	105	83	78	107	82	99	122
V	91	95	106	92	100	88	97	92	118	97	92
VI	92	95	107	84	105	98	96	92	113	99	92
VII	99	95	126	87	107	100	164	111	-	91	-
VIII	69	82	69	110	118	97	101	89	-	96	-
IX	93	97	107	120	111	102	95	94	96	98	86
X	175	104	97	103	115	157	117	83	201	92	77
XI	91	109	111	91	107	125	71	93	103	91	65
XII	101	88	107	92	112	122	94	94	91	90	71
XIII	99	104	105	109	119	90	76	112	100	100	93
XIV	95	93	95	96	110	87	93	94	86	90	89
XV	85	84	82	93	112	88	83	94	107	87	73
XVI	95	88	90	86	98	120	109	101	99	98	58

1. Element $= \left[\frac{NO_{ij}}{L_{ij}} \Big/ \frac{NO_i}{L_i}\right] \times \frac{100}{1}$

2. Source: Board of Trade, op.cit., pp. 133/8-133/35.

Appendix Table 2.A12

Indices of Comparative Unit Labour Cost: 1958[1]

Industry	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI
III	105	110	93	120	103	90	105	98	110	90	103
IV	95	103	110	115	93	118	118	98	120	105	78
V	100	104	98	80	102	138	107	102	89	100	182
VI	98	97	100	93	100	98	105	97	92	97	111
VII	90	100	65	84	106	106	97	94	-	103	-
VIII	134	93	108	54	98	103	97	106	-	106	-
IX	102	102	117	83	91	107	103	102	103	97	78
X	90	95	98	103	93	103	102	111	64	98	108
XI	109	105	89	138	100	92	100	98	89	97	117
XII	102	105	102	109	95	103	89	103	108	109	105
XIII	110	95	97	114	95	110	112	93	100	97	88
XIV	100	105	105	97	100	103	98	102	117	103	71
XV	93	100	97	98	100	102	102	103	93	102	91
XVI	93	108	86	95	102	75	105	100	92	107	97

1. Element = $\left[\frac{W_{ij}}{NO_{ij}} \Big/ \frac{W_i}{NO_i}\right] \times \frac{100}{1}$

where W = Wage and Salary Bill.

2. Source: Board of Trade, op.cit., pp. 133/8-133/35.

Appendix Table 2.A13

Indices of Comparative Unit Labour Cost: 1963[1]

Industry	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI
III	108	105	92	103	108	97	103	95	100	82	95
IV	97	114	111	94	94	117	126	97	129	100	86
V	102	104	95	98	104	114	102	104	96	93	88
VI	109	100	95	107	96	98	105	109	84	104	93
VII	99	103	68	103	97	99	79	93	-	105	-
VIII	127	107	127	76	92	103	103	105	-	95	-
IX	102	102	94	85	96	94	104	106	104	100	96
X	64	100	102	94	96	72	98	117	68	98	104
XI	111	98	102	93	94	91	111	107	98	106	148
XII	93	107	105	108	97	90	97	102	90	102	107
XIII	102	100	96	106	94	107	111	98	100	100	96
XIV	102	100	98	100	98	107	98	98	105	102	97
XV	102	104	100	104	98	106	106	104	85	102	102
XVI	90	98	106	96	98	88	100	104	94	106	121

1. Element $= \left[\frac{W_{ij}}{NO_{ij}} \Big/ \frac{W_i}{NO_i} \right] \times \frac{100}{1}$

Source: Board of Trade, op.cit., pp.133/8-133/35.

Chapter Three

Relative Costs as a Determinant of Changes in the Pattern of Regional Specialisation and Industrial Location

Whereas the previous chapter attempted to examine possible explanations of specialisation and location patterns at a point in time, the present chapter takes as its subject matter, the association between unit labour costs and the observed alterations in patterns of specialisation and industrial location, over the period 1958 to 1963.

It has already been demonstrated that there was little association between comparative labour productivities and unit labour costs, and the observed pattern of regional specialisation and industrial location in the years 1958 and 1963. It has also been shown that the 're-allocation component' of the total change in the degree of association (between regional specialisation and comparative unit labour costs) over the period, was not only relatively unimportant as a determinant of the magnitude of the total change, but also tended to move in an unfavourable direction in some regions.

The evidence of the preceding chapter, however, referred to the existing pattern of specialisation and location. This would reflect decisions made in past periods - in the light of prices, factor availability and technology, then ruling, or as expected to rule. In contrast to this, the determinants of resource allocation, and the 'decision rules' or economic models which explain allocation, refer to a 'planning function' (or 'book of blue-prints') which lists only the 'best practice' decisions in each current period.[1] In an examination of the spatial structure of industry as it exists at the present, we are really contemplating the

1. J.A.S. Schumpeter, History of Economic Analysis (London, George Allen and Unwin, 1954), pp.1026-1053.

fossilised history of the regions. There is thus a clear analogy between models of locational structure and change, and the vintage approach to the study of economic growth. The viewpoint embodied within such models is best revealed in the following quotation from W.E.G. Salter (one of the pioneers of the vintage approach to economic growth); "An economy in the process of growth is, so to speak, sandwiched between its past history and its expected future. From the past it has inherited a capital stock, the physical form of which reflects past investment and technique decisions. From the future expectations are thrown back about new techniques, variations in factor prices and new demand conditions. And, in the present itself, new technical knowledge, new savings and perhaps new labour, are available to be incorporated into the economy."[1]

Leaving aside the consideration of static efficiency at any point in time, it is reasonable that any test of the relationship between relative costs and resource allocation should refer to current allocative decisions, rather than to the total existing resource 'mix'.[2] In an attempt to remove the influence of 'history', this chapter investigates the relationship between current labour costs and the pattern of resource re-allocation, together with the assignment of 'new' resources. This should provide a more appropriate vehicle for the test of hypotheses pertinent to locational decision making.

Considerable attention will be given, in this chapter, to alternative measures of structural and locational change. Accordingly, the hypothesis;

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1. W.E.G. Salter, 'Productivity Growth and Accumulation as Historical Processes', in E.A.G. Robinson (ed.), Problems in Economic Development (London, Macmillan, 1965), p.266f.

2. V.R. Fuchs, 'Statistical Explanations of the Relative Shift of Manufacturing Among Regions of the United States', Regional Science Association Papers and Proceedings, Vol.VIII, 1962, p.105.

that differences in unit labour costs accurately reflect relative price differences, will be accepted. The task of the chapter is to consider if any association can be found between various measures of the pattern of locational change within industries, or specialisation changes within regions, and the observed pattern of unit labour costs.

Any study of these relationships cannot neglect the role of expectations and time lags in decision making. Allocation decisions, to the extent that they reflect relative prices and costs, are based upon expected economic conditions as much as, if not more than, existing or past economic conditions. Since we cannot observe 'expected' economic conditions this presents a problem. One solution would be to accept an 'extrapolative-expectations' model, which implies that recent experience is a dominating factor in shaping expectations as to the future. If this hypothesis were acceptable, it would then be valid to consider locational change as somehow related to economic conditions as they presented themselves in the base period. In this case, base-period costs would be used as a proxy for expected cost relationships, and we could reasonably test for the existence of a relationship between structural change over the period 1958 to 1963 and cost conditions prevailing in 1958 (the earliest year for which comparable data on labour costs is available). The existence, and length, of the time lags between market signals, arriving at a decision and the eventuality of the decision, negates the use of this hypothesis. To the extent that a relationship may be established between observed market conditions and structural change, the time lag is of considerable importance. Experience with industrial movement has led the Board of Trade to indicate that the lag is likely to be in excess of one or two years.[1] Data on industrial

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1. Board of Trade, The Movement of Manufacturing Industry in the United Kingdom 1945-65 (London, H.M.S.O., 1968), p,13.

building area approved, and completed, also supports this conclusion in that there appears to be a lag of 12 to 18 months between peaks and troughs in the 'approvals' series and peaks and troughs in 'completions'.[1] This would imply that allocation changes in any period are related, via extrapolated expectations, to economic conditions experienced some three to four years prior to the observed structural change. Since the data on structural change at our disposal refers to the period 1958 to 1963, the above discussion indicates that the relevant economic conditions would be those prevailing in the period 1954 to 1959. Unfortunately the earliest comparable cost data which is available, refers to the year 1958; a period which is too late to justify the use of an extrapolated expectations model.

The only reasonable alternative is to assume that current cost conditions, in 1958 and 1963, accurately reflect the conditions which were expected to prevail in those years. In other words, we will reverse the expectations hypothesis and assume that expectations, as represented by cost conditions prevailing after the decision is made, were fulfilled.

The relatively short time period, namely five years, which the study encompasses and the highly aggregative nature of the industries considered, are dictated by the availability of data for consistent region and industry definitions, and the operation of the 'disclosure rule' by the Board of Trade.[2]

An additional problem is that the relevant costs to be considered,

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1. Data on industrial building area approved and completed may be obtained from Central Statistical Office, Monthly Digest of Statistics (London, H.M.S.O.)

2. Data is not reported where the information disclosed would refer to an individual enterprise. Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1968), Part 1, 'Introductory Notes', p.6.

in a study of structural and locational change, should be those costs facing new firms, rather than the average cost conditions of established firms. Consequently, it will be assumed that the existing cost ratios for all established firms, within an industry, adequately reflect the cost ratios of marginal plants. Strictly speaking it is not necessary, in order to obtain this result, to assume that 'marginal' plants possess cost curves which are identical to established plants within each industry and region, but only that the difference between the two is in the same proportion between industries and regions; such that the relative rankings of cost ratios are preserved.

It is the aim of this chapter, bearing in mind the data limitations and assumptions outlined above, to examine the patterns of structural and locational change over the period. Hopefully, it is in the study of allocative change that an adequate assessment can be made of the importance of relative costs and prices, in influencing the allocation of resources between industries and regions. Both comparative and absolute costs are examined, for these reflect different assumptions as to the 'specifity' of resources, that is, whether resources are mobile between regions or between industries within a given region. Assumptions as to the nature of resource mobility are likely to be crucial when structural change is being considered.

The following section will examine the degree of association between comparative unit labour costs prevailing in 1958 and 1963, and the pattern of structural change within the manufacturing sector of the regions, over the intervening period. Considerable attention will be given to the development of alternative measures of regional structural change.

Specialisation Change and Comparative Unit Labour Costs

The studies of this section are based upon the hypothesis that resources are regional specific. In particular it considers the hypothesis; that resources were re-allocated within each region over the period 1958 to 1963 in the light of comparative unit labour costs as prevailing, or as expected to prevail, at both the beginning and end of the period.[1] As in the previous chapter, the degree of association between the two variables, patterns of specialisation change and relative unit labour costs, will be measured by the rank correlation coefficient (Spearman's rho).

The static analysis of the previous chapter considered specialisation to be measured by the employment location quotient (ELQ_{ij}); i.e.

$$ELQ_{ij} = \frac{L_{ij}}{L_i} \Big/ \frac{L_j}{L} \qquad (3.1)$$

where L_{ij} = Employment in the ith industry in the jth region;

L_i = Total employment in industry i;

L_j = Total employment in region j;

L = Total employment in all regions (industries).

It would seem natural, in the first instance, to consider specialisation change as measured by the absolute change in the location quotient between the beginning and end of the period, i.e.

$$\Delta ELQ_{ij} = ELQ_{ij}^{t+n} - ELQ_{ij}^{t} \qquad (3.2)$$

If the extent and direction of re-allocation within each region is based upon the pattern of comparative unit labour costs[2] (as a proxy for relative prices), and the pattern of re-allocation is adequately reflected

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1. An alternative procedure would be to relate changes in specialisation to <u>changes</u> in comparative labour costs over the period. The existence of time lags renders this hypothesis untenable. Insofar as allocative change is concerned, absolute differences, rather than differences in the rate of change, in comparative costs are likely to be more important.

2. An explanation of the method of calculation of comparative unit labour costs may be found in Chapter Two, pp. 50-2 and Tables 2.A12 and 2.A13.

in the array of first-differences in the Employment Location Quotients, we would expect to find a positive rank correlation between the ordering of comparative unit labour costs in the industries of each region (ranked from lowest to highest), and the ordering of changes in the Location Quotient (ranked from highest to lowest).

The coefficients of rank correlation between these two measures are presented in Table 3.1. In general the results are not inconsistent with the hypothesis. Only four out of the twenty-two cases considered (eleven for each year) exhibit a negative correlation, and it is only in one of these (Yorkshire and Humberside) that the coefficient is significantly less than zero at the 5 per cent level of significance.[1] All of the remaining eighteen coefficients are positive, although in only four of these is the coefficient significantly greater than zero.

The general tenor of the results is such that it may be concluded that there is some evidence in favour of the hypothesis; that the re-allocation of resources within each region, as measured by the absolute change in the location quotients over the period, was positively associated with the pattern of comparative unit labour costs.

Absolute differences in Employment Location Quotients are difficult to interpret in terms of relative rates of employment growth. An important defect of the measure is that a re-ordering, of the size of the absolute change in location quotients, may arise simply due to a change in the base ratio, that is, in the proportion of the national

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1. This is mainly due to the region expanding its employment, relative to other regions in industries in which it has extreme comparative disadvantages, namely: Food, Drink and Tobacco (III), Timber, Furniture etc. (XIV) and Other Manufacturing Industries (XVI); and because it is reducing its employment relatively faster than other regions in an industry in which it has a comparative advantage, namely Textiles (X).

Table 3.1

Rank Correlation Coefficients between Changes in Location Quotients[1] within each Region and Comparative Unit Labour Costs[2] : 1958-1963[3]

Region	1958	1963
N	0.193	0.315
YH	-0.470*	0.183
EM	0.075	0.250
EA	0.492*	0.198
SE	0.040	0.155
SW	0.440	0.138
WM	0.077	0.243
NW	-0.150	-0.065
W	0.549*	0.718**
S	0.501*	-0.192
NI	0.227	0.102

1. <u>i.e.</u> $ELQ_{ij}^{t+n} - ELQ_{ij}^{t}$; ranked from highest to lowest.

2. Ranked from lowest to highest.

3. * - indicates significantly different from zero at the 5 per cent level.

   ** - indicates significantly different from zero at the 1 per cent level.

work force employed within the region. This may be demonstrated as follows:

Totally differentiating the ELQ as defined in equation (3.1) yields;[1]

$$\Delta ELQ_{ij} = dL_{ij}\left(\frac{1}{L_j}.\frac{L}{L_i}\right) - dL_i\left(\frac{L_{ij}}{L_j}.\frac{L}{L_i^2}\right) + dL\left(\frac{L_{ij}}{L_i}.\frac{1}{L_j}\right) - dL_j\left(\frac{L_{ij}}{L_i}\,\frac{L}{L_j^2}\right) \qquad (3.3)$$

Consider the effect upon the magnitude of the location quotient if, with L_{ij} and L_i held constant, L and L_j are allowed to vary:

Assuming $dL_{ij} = dL_i = 0$

$$\Delta ELQ_{ij} = dL\left(\frac{L_{ij}}{L_i}.\frac{1}{L_j}\right) - dL_j\left(\frac{L_{ij}}{L_i}.\frac{L}{L_j^2}\right)$$

$$= \left(\frac{dL}{L_j} - \frac{dL_j}{L_j}.\frac{L}{L_j}\right)\frac{L_{ij}}{L_i} \qquad (3.4)$$

It is clear from equation (3.4) that it is possible for the measure of specialisation to change simply because of a change in the base ratio (i.e. $\frac{L}{L_j}$). Furthermore the effect of this variation will differ between the industries within the region. Although the term inside the brackets of equation (3.4) will adopt the same value for all the industries of a given region, the term outside the brackets ($\frac{L_{ij}}{L_i}$) will not. It follows that the rankings of specialisation, and specialisation change, as measured by first-differences in the Employment Location Quotient, will not be invariant with respect to changes in the ratio of regional to national employment; the degree of sensitivity depending upon the proportion of each industry's employment to be found in the region.

The difficulty may be overcome by using proportionate changes in the Location Quotient, instead of absolute changes, as the measure of structural change.

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1. Assuming that higher powers of the expansion may be neglected.

Dividing both sides of equation (3.3) by the value of the Employment Location Quotient as defined in equation (3.1), yields;

$$\frac{\Delta ELQ_{ij}}{ELQ_{ij}} = \frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i} + \frac{dL}{L} - \frac{dL_j}{L_j} \qquad (3.5)$$

A change in the base ratio (i.e. $\frac{dL}{L} \gtrless \frac{dL_j}{L_j}$) will leave the rankings of structural change unaltered, since this term is constant between the industries of a given region.[1]

Given the above discussion, it would appear that a more acceptable test of the existence of a relationship between specialisation change and comparative unit labour costs, would be to consider the percentage change in location quotients as the appropriate measure of structural change.

Rank correlation coefficients were calculated between the percentage change in location quotients of the industries within each region (ranked from highest to lowest), and comparative unit labour costs (ranked from lowest to highest). These coefficients are reported in Table 3.2.

Broadly speaking the evidence in Table 3.2 is even more favourable to the hypothesis, than the results reported in Table 3.1. With the exception of Yorkshire and Humberside, which retains the negative correlation coefficient for 1958 (although it is not significant), all of the coefficients are positive. Of the twenty-two coefficients more than one-quarter are significantly greater than zero at the 5 per cent level of significance.

It may be concluded therefore, that there is some evidence of a

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1. This is presumably what Moroney and Walker are referring to when they indicate that ". . . the rankings [of L.Q.s] and the rankings of percentage changes are . . . not affected by the change in base." J.R. Moroney and J.M. Walker, "A Regional Test of the Heckscher-Ohlin Hypothesis", Journal of Political Economy, Vol.74, 1966, p.583n.

Table 3.2

Rank Correlation Coefficient between Proportionate Changes in the Location Quotients[1] within each Region and Comparative Unit Labour[2] Costs : 1958-1963

Region	1958	1963
N	0.318	0.498*
YH	-0.341	0.150
EM	0.257	0.269
EA	0.530*	0.178
SE	0.085	0.304
SW	0.210	0.320
WM	0.506*	0.713**
NW	0.066	0.489*
W	0.432	0.967**
S	0.345	0.325
NI	0.110	0.239

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

fairly close and positive relationship between changes in the pattern of regional specialisation, and regional comparative advantage as measured by comparative unit labour costs.

Given the expression for the proportionate change in the location quotient as defined in equation (3.5), it is clear that differences in the magnitude of this measure between the industries of a region, arise, not because of differences in the magnitude of the relative rates of growth of regional vis-à-vis national employment in all manufacturing, but rather because of differences in the relative rate of expansion of each individual industry in the region, and in all regions taken together. In other words ranking the industries in each region according to the magnitude of the proportionate change in the location quotient, is equivalent to ranking industries according to the magnitude of the term $(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i})$ in equation (3.5).

The favourable degree of association revealed earlier, between the proportionate change in location quotients and comparative unit labour costs, may therefore have its origins in either a close relationship between comparative costs and the individual rates of growth in the region itself $(\frac{dL_{ij}}{L_{ij}})$, or, in a close relation between relative rates of growth $(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i})$, and comparative unit labour costs.

Table 3.3 presents rank correlation coefficients for each region, which relate the ordering of rates of growth of employment within each industry in the region $(\frac{dL_{ij}}{L_{ij}})$, and comparative unit labour costs. These coefficients may be compared with the estimates presented in Table 3.2, which measure the degree of association between the <u>relative</u> rates of growth in each industry within the region $(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i})$, and comparative unit labour costs.

Table 3.3

Rank Correlation Coefficients between the rates of growth of industry employment within each Region[1] and Comparative Unit Labour Costs[2] : 1958-1963

Region	1958	1963
N	0.275	0.270
YH	-0.410	0.392
EM	-0.100	0.112
EA	0.569*	0.214
SE	0.100	-0.032
SW	0.361	0.111
WM	0.140	0.325
NW	-0.106	0.025
W	0.511*	0.818**
S	0.417	-0.208
NI	0.283	0.472

1. Ranked from Highest to Lowest.

2. Ranked from Lowest to Highest.

The majority of the coefficients presented in Table 3.3 are smaller in magnitude than the corresponding estimates presented in Table 3.2. The estimates in Table 3.2 may be considered to reflect 'standardised' growth rates, in that the national rate of expansion or decline for each industry is taken into account. The coefficients provided in Table 3.3, however, do not allow for expansion or contraction in the national market. A comparison of the two results indicates that the association between comparative advantage and structural change is reflected, not only in different rates of expansion within the region (i.e. vis-à-vis the regional average), but also in different relative rates of expansion of industries within the region and the industry as a whole. In other words, the structural change which has taken place has not only taken the form of intra-regional differences in growth rates, but also reflects intra-industry (i.e. inter-regional) differences in growth rates. This finding; that not only rates of industrial growth within the region, but also differential rates of growth, are associated with the pattern of comparative unit labour costs; is very favourable to the hypothesis.

Differential (or relative) rates of growth, as the above discussion indicates, are highly associated with the pattern of comparative advantage in each region. The differential rate of growth may be viewed as introducing both the influence of changing market size (as measured by the national rate of employment growth within each industry), and the influence of changing regional shares of that market (as measured by the difference between regional and national rates of growth within a given industry). It must be recognised however, that by itself the differential rate of growth (i.e. $\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right)$) is an inadequate measure of structural change. It is unsatisfactory, in that two industries within a region may be experiencing the same rate of growth, yet, because of differences in their absolute size, they may be making vastly different claims upon the amount of resources which are available within the region. The larger the proportion of the regional work force in any industry, the greater will be the re-allocation (or assignment) of regional manpower resources, for any given rate of industrial growth. We are thus led to consider structural change as measured, not simply by relative rates of growth but, by the weighted relative rate of growth; in other words, the relative rate of growth, weighted by the proportion of regional employment engaged in that activity in the base year.

The weighted relative rate of growth for any industry (i) in a region (j), thus becomes;

$$WRG_{ij} = \frac{L_{ij}}{L_j}\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right) \qquad (3.6)$$

This measure has a great deal of affinity with the differential or rate component in a 'shift/share' model. It is of some interest to enquire further into this relationship.

Shift-share models adopt, as their starting point, a definitional relationship involving three terms; the national rate of growth, the rate of growth in an industry within the region, and the rate of growth of the industry in all regions taken together, i.e.

$$\frac{dL_{ij}}{L_{ij}} = \frac{dL_{ij}}{L_{ij}} + \frac{dL}{L} - \frac{dL}{L} + \frac{dL_i}{L_i} - \frac{dL_i}{L_i} \qquad (3.7)$$

Rearrangement of the above terms yields;

$$\frac{dL_{ij}}{L_{ij}} - \frac{dL}{L} = \left(\frac{dL_i}{L_i} - \frac{dL}{L}\right) + \left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right) \qquad (3.8)$$

The last term on the R.H.S. of equation (3.8) is the unweighted relative rate of growth referred to earlier in the discussion on the percentage growth in the location quotient.[1]

Multiplying through, by the proportion of employment in region j engaged in industry i, and summing over industries yields;

$$\sum_i \left(\frac{L_{ij}}{L_i} \cdot \frac{dL_{ij}}{L_{ij}}\right) - \sum_i \left(\frac{L_{ij}}{L_j} \cdot \frac{dL}{L}\right) = \sum_i \frac{L_{ij}}{L_j}\left(\frac{dL_i}{L_i} - \frac{dL}{L}\right) + \sum_i \frac{L_{ij}}{L_j}\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right) \qquad (3.9)$$

Notice that, since the sum of the weights $\sum_i \left(\frac{L_{ij}}{L_j}\right)$ is unity and $\left(\frac{dL}{L}\right)$ is a constant, the second term on the L.H.S. may be written as;

$$\sum_i \left(\frac{L_{ij}}{L_j} \cdot \frac{dL}{L}\right) = \frac{dL}{L} \cdot \sum_i \frac{L_{ij}}{L_j} = \frac{dL}{L}$$

Note also that;

$$\frac{dL}{L} = \sum_i \left(\frac{L_i}{L} \cdot \frac{dL_i}{L_i}\right)$$

and similarly;

$$\sum_i \left(\frac{L_{ij}}{L_j} \cdot \frac{dL_{ij}}{L_{ij}}\right) = \frac{dL_j}{L_j}$$

Substitution of the above into equation (3.9) gives;

$$\left(\frac{dL_j}{L_j} - \frac{dL}{L}\right) = \sum_i \frac{dL_i}{L_i}\left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right) + \sum_i \frac{L_{ij}}{L_j}\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right) \qquad (3.10)$$

This is the basic shift-share equation as used by Perloff and associates[2] (although they deal with absolute differences rather than rates of growth), and A.P. Thirlwall,[3] amongst others.

The term within the brackets on the L.H.S. of equation (3.10) measures the difference between the regional and national rates of

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1. See over, p.87.

2. H.S. Perloff, E.S. Dunn, E.E. Lampart and R.F. Muth, Regions, Resources and Economic Growth (Baltimore, John Hopkins Press, 1960), p.71n.

3. A.P. Thirlwall, "A Measure of the 'Proper Distribution of Industry'", Oxford Economic Papers, Vol.19, 1967, pp.46-58.

growth in manufacturing employment, and represents, in terms of growth rates rather than absolute differences, the 'total shift'. The first term on the R.H.S. is a measure of the influence of industrial structure, and is variously titled the 'mix', or 'composition', effect. The last term on the R.H.S. represents the effect of different rates of growth for individual industries and is known as the 'differential shift', or alternatively the 'rate', or 'competitiveness', component.[1]

Regional employment may grow rapidly, relative to the nation, as a result of two forces. Firstly, it may specialise in industries which are expanding rapidly in the nation as a whole. Secondly, the region's 'share' of individual industries may be increasing, as its rate of growth in these industries exceeds the corresponding national growth rate (i.e. $\frac{dL_{ij}}{L_{ij}} > \frac{dL_i}{L_i}$). It is this last term which is of particular interest at this point, since what may be called the 'differential shift component' for the region (i.e. $DSC_j = \sum_i \frac{L_{ij}}{L_j}\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right)$, which is the sum of the individual 'differential components' for each industry in the region) is identical to the sum of the 'weighted relative rate of growth' terms for the region (equation (3.6) above).

Perloff and his associates claim that; "The differential effect arises out of the fact that some regions gain, over time, a differential

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1. It must be emphasised that the measures of the components as characterised in equation (3.10) represent only one of a number of possible methods of decomposition. The discussion immediately following does provide some grounds for regarding the expression for the 'rate component' in equation (3.10) as having some basis in theory. The measurement of the 'composition component' and the possible inclusion of an interaction term, whilst important in another context, is immaterial to the present discussion. For a discussion of these issues the reader is referred to: N.J. Cunningham, "A Note on the 'Proper Distribution of Industry'", Oxford Economic Papers, Vol.21, 1969, pp.122-127, and A.P. Thirlwall, "Weighting Systems and Regional Analysis: A Reply to Mr. Cunningham", Oxford Economic Papers, Vol.21, 1969, pp.128-133.

advantage (vis-à-vis other regions) in their <u>access</u> to important markets and inputs for each of one or more specific activities".[1] Later they explain that ". . . when we speak of access . . . we refer . . . to all the cost elements inherent in the production of the commodity".[2] Other authors[3] also indicate that the differential effect is a reflection of 'locational advantage' for the region.

An examination of the degree of association between the differential components within the region and the pattern of comparative unit labour costs is therefore of particular interest. Such an examination facilitates a test of the hypothesis; that the differential, or 'rate', effect, as measured in a shift-share framework, does indeed reflect 'competitiveness' - and as such may be interpreted as an indicator of regional advantage or disadvantage in location.

Alternatively the differential shift component may be viewed as a measure of structural change, and simply interpreted as the 'weighted relative rate of growth' for each industry in the region.

To the extent that the 'differential shift component' for each industry reflects comparative advantages, we would expect to find a positive correlation between the differential shift component (or the weighted relative rate of growth), calculated for each industry in the region (ranked from highest to lowest), and comparative unit labour costs (ranked from lowest to highest).

The actual values of the differential component, for each industry

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1. H.S. Perloff, et al, <u>op.cit.</u>, p.74.

2. <u>Ibid</u>., p.87.

3. For example, G. McCrone, <u>Regional Policy in Britain</u> (London, George Allen and Unwin, 1969), Ch.VII.

in each region, over the period 1958 to 1963, are set out in the Appendix (Table 3.A2) to this chapter. The rank correlation coefficients between these components and the pattern of comparative advantage, in each region, are reported in Table 3.4.

There is some evidence that the differential component and thus resource re-allocation as measured by the weighted relative rate of growth, does reflect the pattern of regional comparative advantage. Four of the twenty-two coefficients are significantly greater than zero at the 5 per cent level of significance, although Yorkshire and Humberside still presents evidence of a negative relationship.[1] There is also some justification for the claim that the differential growth component, of a shift-share analysis, reflects the operation of what may loosely be termed 'competitiveness factors'. Given the exclusion of variables such as transport costs, and also the coarseness of the industrial classification, the relationships are quite favourable to this hypothesis.

The following section of this paper will be concerned with an examination of the relationship between changes in the pattern of industrial location over the period, and absolute unit labour costs.

Locational Change and Absolute Unit Labour Costs

To the extent that resources, especially new resources and allocative decisions, are industry or national specific (and as such are mobile between regions), we would expect to find that allocative

1. This is largely due, not to factors associated with the Textile Industry (X), but, to the relatively low rates of expansion (allowing for the influence of size) of two industries in which unit labour costs were very low relative to other regions, Engineering and Electrical Goods (VI), and Vehicles (VIII).

Table 3.4

Rank Correlation Coefficients between Industry Differential Components in each Region[1] and Comparative Unit Labour Costs[2]: 1958-1963

Region	1958	1963
N	0.240	0.543*
YH	-0.446	0.050
EM	-0.057	0.142
EA	0.190	0.077
SE	0.217	0.280
SW	0.424	0.196
WM	0.359	0.340
NW	-0.012	0.500*
W	0.565*	0.669*
S	0.118	0.240
NI	0.235	0.383

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

changes within any industry should favour those areas where absolute unit labour costs are lowest relative to other regions.

Consider first the relationship between locational change within each industry, as measured by the absolute difference in the Employment Location Quotient, and the pattern of unit labour costs prevailing in that industry in 1958 and 1963.

With first-differences in the Location Quotient ranked from highest to lowest, and unit labour costs ranked from lowest to highest, a favourable relationship would be indicated by a positive rank correlation between the variables.

The rank correlation coefficients between these two variables are presented for each industry, in Table 3.5. Of the twenty-eight coefficients five are negative, although not significantly so. Of the remainder, four are significantly greater than zero at the 5 per cent level.

It has already been demonstrated that the percentage change in the location quotient is likely to be a more satisfactory measure of re-allocation, than the absolute change in location quotients.[1]

As before, the proportionate change in the location quotient may be expressed as

$$\frac{\Delta ELQ_{ij}}{ELQ_{ij}} = \frac{dL_{ij}}{L_{ij}} - \frac{dL_j}{L_j} - \frac{dL_i}{L_i} + \frac{dL}{L} \qquad (3.5)$$

Ranking the percentage change of the location quotients across regions within an industry is equivalent to ranking the differential rates of growth of the industry in each individual region (compared with the rate of growth of all industries in that region), since the

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1. See over, pp. 83-85.

Table 3.5

Rank Correlation Coefficients between the Change in Location Quotients[1] and absolute unit labour costs[2] for each Industry : 1958-1963

Industry	1958	1963
III	0.291	0.535*
IV	0.863**	0.464
V	0.081	-0.135
VI	-0.036	0.334
VII	0.227	0.376
VIII	0.528	0.500
IX	0.336	0.500
X	0.691*	0.723*
XI	-0.223	-0.374
XII	0.035	0.293
XIII	0.264	0.260
XIV	0.082	0.412
XV	0.007	0.156
XVI	0.229	-0.044

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

last term on the R.H.S. of the above equation will be a constant within any industry group. It follows, that in examining the relationship between the proportionate change in the location quotients and absolute advantages, a relationship is being sought between differential rates of growth in each region and unit labour costs.

To the extent that the proportionate change in the location quotient is an adequate measure of locational change, and that these changes are related to the pattern of unit labour costs, we would expect to find a positive correlation between the rate of growth in location quotients (ranked from highest to lowest) and absolute unit labour costs (ranked from lowest to highest).

The results of this exercise are set out in Table 3.6. Seven of the twenty-eight coefficients are negative, although only one is significantly so. Five coefficients are significantly greater than zero.

Considering the unstandardised growth rates in each region (i.e. $\frac{dL_{ij}}{L_{ij}}$) and their association with the rankings of unit labour costs, many of the rank correlations are found to be negative. These coefficients are presented in Table 3.7. Over one quarter of the coefficients are negative and only four are significantly greater than zero at the 5 per cent level of significance. Sixteen of the twenty-eight rank correlations are higher than their counterpart in Table 3.6. In other words, in sixteen cases there is a higher degree of association between the regional growth rates in each industry and absolute unit labour costs, than is apparent between the differential growth rates of employment and the pattern of absolute unit labour costs.

Ordering the unadjusted rates of growth (i.e. $\frac{dL_{ij}}{L_{ij}}$) across regions within an industry, is equivalent to ranking regions by their performance

Table 3.6

Rank Correlation Coefficients between Percentage Changes in Location Quotients[1] and Unit Labour Costs[2] for each Industry : 1958-1963

Industry	1958	1963
III	0.205	0.275
IV	0.752**	0.580*
V	-0.613*	-0.127
VI	-0.140	0.185
VII	0.072	0.466
VIII	0.625*	0.467
IX	0.506	0.520
X	0.650*	0.438
XI	-0.222	-0.417
XII	0.072	0.140
XIII	0.260	0.215
XIV	0.223	0.338
XV	0.180	-0.040
XVI	0.564*	-0.172

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

Table 3.7

Rank Correlation Coefficients between rates of growth of Employment[1] and Unit Labour Costs[2] for each Industry : 1958-1963

Industry	1958	1963
III	-0.528	0.293
IV	0.512	0.960**
V	-0.485	0.023
VI	-0.500	0.695*
VII	0.141	0.482
VIII	0.697*	0.546
IX	0.321	0.524
X	-0.529	0.181
XI	-0.177	-0.265
XII	-0.148	0.310
XIII	-0.014	-0.469
XIV	0.661*	0.412
XV	-0.244	-0.150
XVI	0.315	0.131

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

relative to the national total for that industry. That is, it is equivalent to ranking regions according to the magnitude of the relative rate of growth measured as $\left(\frac{dL_{ij}}{L_{ij}} - \frac{dL_i}{L_i}\right)$, which, as we have already seen, is highly related to regional comparative advantages.[1] The results of this section, given that the method is unable to discriminate between regional re-allocation and industrial re-location, are consistent with the hypothesis that re-allocation was primarily regional in character,[2] and related to comparative advantages as reflected in comparative unit labour costs.

Movement Patterns and Unit Labour Costs

With regard to the decision to re-locate in another region the basis for decision making is relatively clear. To the extent that location decisions reflect cost conditions, it is absolute costs, rather than comparative costs, which are important.

An analysis of the relationships between movement patterns and labour costs, should enable more precise conclusions to be drawn as to the importance of unit labour costs as an element affecting locational decisions, and also of the implications for economic efficiency of diverting firms from central locations to sites in the peripheral areas.

As part of a research programme at the Board of Trade, into the movement of manufacturing industry over the period 1945 to 1965,[3] data was collected (although not published) with reference to the number of establishments and the associated employment in each industry, which

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1. See over, pp. 85-87.

2. Some evidence on the magnitude of intra-regional, vis-à-vis inter-regional, labour mobility may be found in: A.J. Brown, The Framework of Regional Economics in the United Kingdom (Cambridge, C.U.P., 1972), p.218.

3. Board of Trade, The Movement of Manufacturing Industry in the United Kingdom 1945-1965 (London, H.M.S.O., 1968).

'moved' from one area to another over the period.[1] A 'move' is defined in the Report as ". . . the opening of new manufacturing establishments in new locations . . . in which the firm in question had not manufactured previously".[2] The Department of Trade and Industry have supplied data which provides a breakdown, by industry and region of destination, of the number of establishments[3] involved in moves over the period 1960-65. This data is summarised in the Appendix to this chapter (Table 3.A3).

The particular hypothesis to be considered here refers to the degree of association between the regional pattern of 'destinations', within an industry, and the ordering of regions by the magnitude of unit labour costs in existing establishments in that industry, in 1958 and 1963.

Consider first, the pattern of movement as measured by the proportion of the total number of moves in each industry destined for each region (M_{ij}); where,

$$M_{ij} = \frac{M_{ij}}{M_i}$$

M_{ij} = number of 'moves' in industry (i) with destinations in region (j);

M_i = total number of 'moves' in industry i.

To the extent that this is an adequate measure of the pattern of movement within an industry, we would expect to find a positive association between the order of 'movement proportions' (M_{ij}), ranked from highest to lowest across the regions for each industry, and the ordering

1. The data to be considered in this section includes intra-regional moves.

2. Board of Trade, op.cit., p.3.

3. Unfortunately, a sufficiently detailed breakdown of 'moves' measured in terms of employment is unavailable.

of unit labour costs between regions, ranked from lowest to highest. The Rank correlation coefficients between these measures are reported in Table 3.8.

Of the twenty-eight coefficients slightly more than one half are negative. In addition, only two coefficients are significantly different from zero at the 5 per cent level of significance, one positive and one negative. Clearly there is little association between patterns of movement, as reflected in this measure, and absolute unit labour costs.

The absence of the relation noted above may be due to deficiencies in the measure of movement patterns, in that it does not allow explicitly for the different 'size' of regions. A more satisfactory measure of movement patterns may be obtained if the data is 'standardised', for the total levels of movement to each region. That regions differ in their ability to attract mobile establishments is evident from Table 3.9, which presents evidence on the intensity of movement into each region, both as a proportion of total moves over the period and relative to the number of establishments already existing in the region. The latter term is measured by the 'propensity to attract establishments', which standardises the number of moves according to the initial 'size' of the region.

In an attempt to account for the influence of size 'movement location quotients' were calculated. These express the regional proportion of moves in each industry as deflated by the regional proportion of all moves over the period.

$$MLQ_{ij} = \frac{M_{ij}}{M_i} \Big/ \frac{M_j}{M} \qquad (3.12)$$

where; M_j = Total number of establishments in all industries moving to destinations in region j;

M = Total number of moves in the U.K.

Table 3.8

Rank Correlation Coefficients between Regional Proportions of total moves in each Industry[1] and Unit Labour costs[2] : 1958 and 1963

Industry	1958	1963
III	-0.185	-0.184
IV	0.050	0.432
V	-0.236	-0.377
VI	0.238	0.134
VII	-0.517	-0.216
VIII	-0.175	0.718*
IX	-0.116	-0.161
X	-0.384	-0.578*
XI	-0.185	0.275
XII	0.020	0.380
XIII	0.048	0.063
XIV	-0.223	-0.378
XV	-0.295	0.120
XVI	0.200	0.037

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

Table 3.9

Estimates of the 'Propensity of Regions to Attract Establishments' : 1960-65

Region	Proportion of Total Moves[1]	Propensity to Attract[2]
N	6.9	2.16
YH	4.1	0.41
EM	4.4	0.68
EA	7.2	3.62
SE	25.4	0.72
SW	8.6	1.92
WM	6.9	0.59
NW	12.3	0.90
W	7.3	2.81
S	12.8	1.76
NI	4.4	2.09

1. Proportion of total Moves = $\frac{M_{.j}}{M}$

2. Propensity to Attract Establishments = $\frac{M_{.j}}{M} \Big/ \frac{E_{.j}}{E}$

where M_j = No. of moves to Region j.

M = Total number of moves in the U.K.

E_j = Number of establishments in the region in 1963.

E = Total number of establishments in the U.K. in 1963.

Source: Table 3.9 and, Board of Trade, Report on the Census of Production 1963, London, H.M.S.O., 1970, Part 133, p.133/6.

The estimates of the Movement Location Quotients are set out in the Appendix, Table 3.A4.

To the extent that there exists a relationship between the pattern of movement within an industry, as measured by the movement location quotients, and the pattern of unit labour costs, we would expect to find a positive rank correlation between the movement location quotients (ranked from highest to lowest) and absolute unit labour costs (ranked from lowest to highest).

The rank correlation coefficients so derived, are presented in Table 3.10. In general there appears to be little association between the two measures. Nineteen of the twenty-eight coefficients are negative, although none is significantly less than zero at the 5 per cent level.

It must be concluded that there is little apparent relation between movement patterns and unit labour costs, with the resultant loss of efficiency which this entails.

The regional allocation of movement within any industry is likely to be affected by government policy, a factor which has not been given sufficient attention in the above discussion. Broadly speaking this policy operated (between 1960 and 1966) to create a division between the 'development districts', and the rest of the country. Government policy, although an important influence upon the decision to locate within or outside the development districts, should be relatively neutral in its impact on the location decision within the development districts. Given the decision to locate within a scheduled area, which will be

Table 3.10

Rank Correlation Coefficient between 'Movement Location Quotients'[1] (1960-65) and Unit Labour Costs[2] : 1958 and 1963

Industry	1958	1963
III	-0.182	0.201
IV	0.124	0.395
V	-0.326	-0.354
VI	-0.336	0.301
VII	-0.520	-0.221
VIII	-0.374	0.503
IX	-0.165	-0.065
X	-0.262	-0.375
XI	-0.475	0.240
XII	-0.463	0.345
XIII	-0.215	-0.375
XIV	0.137	-0.297
XV	-0.065	0.014
XVI	-0.097	-0.036

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

influenced to some extent by government policy,[1] the choice of location within the development districts should be influenced to a large extent by cost considerations.

The remainder of this section will be concerned with repeating the tests undertaken above, but confining attention to comparisons between the 'development districts' (which we loosely take to include the Northern region, Wales, Scotland, and Northern Ireland[2]), in the hope that this will remove the influence of government policy from the relationships between movement patterns and labour costs.

Table 3.11 reports the values of the rank correlation coefficient between 'movement proportions' (i.e. m_{ij}) and unit labour costs, in these four regions. Only one coefficient is significantly different from zero, being negative.

Rank correlations between the rankings of Movement Location Quotients and unit labour costs in the four regions are presented in Table 3.12. The majority of the correlations are negative.

Insofar as this procedure makes allowance for the effects of government policy upon locational choice, it is apparent that there is little relation between the pattern of movement and unit labour costs.

It may be that unit labour costs are a poor proxy for relative profitability, although it might be expected that they are an important

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1. Policy mainly took the form of I.D.C. control, financial assistance and building grants. After 1963 cash grants for new plant and machinery were also provided. For a discussion of policies in this period see G. McCrone, op.cit., pp.121-136, and R. Dowie, Government Assistance to Industry: A Review of the Legislation of the 1960s (Ashford Study Paper II, University of Kent at Canterbury, 1968).

2. Data is unavailable for the Scheduled Areas alone.

Table 3.11

Rank Correlation Coefficients between Regional Proportions of Total Moves in each Industry[1] and Absolute Unit Labour Costs[2]; 'Development Districts' only.[3]

Industry	1958	1963
III	0.80	0.40
IV	-0.20	-0.80
V	0.25	-0.70
VI	0.80	0.20
VII	..	..
VIII	..	..
IX	-0.40	-0.40
X	-0.80	-1.00*
XI	..	..
XII	-0.40	0.20
XIII	-0.20	-0.45
XIV	-0.40	-0.40
XV	-0.45	-0.65
XVI	0.00	0.80

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

3. .. indicates insufficient data.

Table 3.12

Rank Correlation Coefficients between Movement Location Quotients[1] and Absolute Unit Labour Costs[2] in each Industry; Development Districts only.[3]

Industry	1958	1963
III	0.80	0.40
IV	-0.80	-0.80
V	0.25	-0.70
VI	-0.40	0.60
VII	..	..
VIII	..	..
IX	-0.20	-0.20
X	-0.40	-0.80
XI	..	..
XII	-0.80	0.40
XIII	-0.80	-0.85
XIV	-0.40	-0.40
XV	-0.45	-0.65
XVI	0.40	0.40

1. Ranked from highest to lowest.

2. Ranked from lowest to highest.

3. .. indicates insufficient data.

decision variable to the firm. On the other hand, the low degrees of association found in this section are consistent with the evidence of surveys into the movement of industry, in that relative costs are apparently given little consideration in the location decision.[1]

The main implication for economic growth of the discussion in both this chapter and the previous chapter would appear to be that there exists a great potential for productivity gains arising from intra-regional resource re-allocation. This potential may not be exploited without more flexible policies on the part of government, and will probably necessitate substantial investment within the regions.

From the policy viewpoint, the main implication would apparently encompass the need to be more selective in the operation of location policy, or else continuing subsidisation must be seriously contemplated. Structural change, in the light of a realistic appraisal of the viability and growth prospects of industries must be an important aspect of regional and national policy.

The defects of the analysis presented in this and the preceding chapter must not be overlooked. Apart from limitations such as the level of aggregation, and the relatively short time period, which arise in the main from data limitations, the main reservations of the analysis are related to three important assumptions: the assumption that relative prices and profitability are reflected in unit labour costs; the assumption that observed unit costs adequately reflect expectations as to these costs; and the assumption that average cost conditions of existing firms

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1. In particular: W.F. Luttrell, Factory Location and Industrial Movement (London, N.I.E.I.R., 1962), Ch.V; G.C. Cameron and B.D. Clark, Industrial Movement and the Regional Problem (Edinburgh, Oliver and Boyd, 1966), Ch.6, and B.J. Loasby, "Making Location Policy Work", Lloyds Bank Review, No.83, January 1967, pp.34-47.

are 'representative' of new entrants. Similarly, many relevant factors have been inadequately represented, demand conditions, transport costs, externalities and especially the location of other firms. To some extent the standardisation procedures may have compensated for some of these factors, especially those associated with the size of the region.

Despite these defects, the methods of analysis and the conclusions we have drawn, appear to be both reasonable, and supported by other evidence from the surveys of industrial movement.

Appendix 3.A1

Average Annual Rate of Growth of Employment 1958-1963

I \ R	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI	UK
III	0.1	1.8	0.2	3.3	-0.8	2.0	1.4	1.8	1.6	0.3	1.7	0.8
IV	-0.3	0.1	2.3	0.0	1.7	-2.2	-1.3	-1.1	-2.6	-1.2	14.9	-0.1
V	-2.1	0.2	0.2	0.0	4.4	0.8	1.0	-1.5	1.8	-4.2	8.4	0.2
VI	1.2	1.2	2.8	3.5	2.3	2.7	1.6	1.3	5.4	1.4	4.4	2.1
VII	-7.9	-6.4	0.0	0.8	-2.6	-1.4	30.6	-4.9	-	-8.3	-	-6.0
VIII	-4.9	-0.4	-5.3	46.4	-0.2	-2.4	0.9	4.5	-	-2.0	-	0.3
IX	0.0	1.0	6.9	12.9	2.7	0.7	1.1	0.8	-1.6	-0.4	11.1	1.5
X	4.3	-1.5	1.0	-1.7	2.1	0.2	-2.1	-5.7	2.0	-0.7	-2.3	-2.2
XI	2.9	-0.7	-0.5	-1.6	1.2	0.0	-1.2	-1.9	-1.3	-0.6	3.1	-0.3
XII	0.7	-1.2	-1.8	-2.0	-1.8	-2.6	0.6	-1.1	0.0	-1.2	-0.3	-1.2
XIII	-1.3	0.2	1.4	5.1	0.6	3.8	-0.4	0.2	-0.7	-1.2	4.1	0.3
XIV	1.0	1.6	0.0	-1.1	0.8	0.3	0.0	1.6	-0.9	-1.7	3.0	0.7
XV	2.1	0.9	0.7	4.4	1.2	1.6	1.6	2.7	4.5	0.7	3.1	1.5
XVI	13.7	4.1	10.8	8.1	4.0	5.1	3.9	2.1	4.2	0.4	10.1	4.0
Total	-0.6	0.1	0.6	3.9	1.0	0.6	1.0	-0.4	1.6	-1.1	-0.4	0.5

Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970).

Appendix 3.A2

Regional Differential Effects : by Industry
1958-1963

I \ R	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI
III	-.05	.09	-.04	.47	-.16	.18	.04	.09	.05	-.06	.16
IV	-.03	.01	.08	.01	.10	-.07	-.02	-.09	-.25	-.05	.11
V	-.32	.00	.00	.00	.08	.01	.10	-.05	-.48	-.38	.01
VI	-.20	-.15	.13	.43	.06	.12	-.11	-.15	.44	-.14	.39
VII	-.28	-.01	.00	.14	.08	.26	.00	.03	-	-.23	-
VIII	-.16	-.03	-.67	.65	-.06	-.57	.11	.31	-	-.12	-
IX	-.04	-.04	.17	.16	.11	-.02	-.07	-.03	-.25	-.07	.08
X	.26	.16	.65	.01	.00	.10	.00	-.78	.26	.21	-.03
XI	.01	-.01	.00	-.01	.02	.00	-.01	-.01	-.01	.00	.01
XII	.13	.00	-.09	-.09	-.04	-.10	.03	.01	.05	.00	.13
XIII	-.06	-.01	.04	.19	.01	.09	-.05	.00	-.13	-.05	.09
XIV	.01	.02	-.02	-.10	.01	-.02	-.01	.02	-.04	-.07	.05
XV	.02	-.03	-.04	.33	-.04	.01	.00	.03	.10	-.06	.08
XVI	.15	.00	.12	.09	.00	.04	.00	-.07	.01	-.11	.05
Total	-.57	.26	.33	2.26	.21	.05	.00	-.70	.72	-1.14	.95

Differential Effect for an Industry

$$= \frac{L_{ij}}{L_j} (\ell_{ij} - \ell_i)$$

Total Differential Effect

$$= \sum_i \frac{L_{ij}}{L_j} (\ell_{ij} - \ell_i).$$

Source: Board of Trade, Report on the Census of Production 1963, (London, H.M.S.O., 1970), Part 133.

Appendix 3.A3

Number of Firms in each industry moving into the Regions[1]
1960-65.*
(i.e. No. of Cases)

I \ R	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI	Total
III	4	7	4	8	13	2	6	7	2	12	4	69
IV	4	2	2	8	30	3	5	11	6	7	3	81
V	2	2	2	1	3	2	5	7	0	6	0	30
VI	23	8	20	26	122	42	15	37	24	41	17	375
VII	0	0	0	0	2	1	0	0	0	0	0	3
VIII	7	0	4	6	16	3	2	6	5	12	2	63
IX	3	5	2	6	25	12	22	5	11	10	4	105
X	2	6	3	2	1	3	2	17	9	9	12	66
XI	1	0	1	2	4	2	0	3	0	0	0	14
XII	7	7	7	3	15	12	4	13	13	29	3	113
XIII	8	4	3	2	9	5	5	6	2	9	1	52
XIV	5	1	1	6	17	7	6	7	4	4	0	58
XV	7	3	2	5	21	5	3	10	5	3	1	65
XVI	8	3	1	10	22	2	6	16	5	8	4	85
Total	81	48	52	85	300	101	81	145	86	150	52	1181

1. Enumerated by Region of Destination.

* <u>Source</u>: Data supplied by the Department of Trade and Industry.

Appendix 3.A4

Movement Location Quotients 1960-65[1]

I \ R	N	Y	EM	EA	SE	SW	WM	NW	W	S	NI
III	0.83	2.46	1.30	1.61	0.46	0.25	1.26	0.82	0.30	1.37	1.29
IV	0.71	0.61	0.57	1.38	1.46	0.43	0.90	1.11	1.01	0.68	0.84
V	0.97	1.63	1.52	0.46	0.39	0.78	2.42	1.89	0.00	1.57	0.00
VI	0.88	0.51	1.20	0.96	1.28	1.30	0.58	0.80	0.88	0.86	1.02
VII	0.00	0.00	0.00	0.00	2.59	3.95	0.00	0.00	0.00	0.00	0.00
VIII	1.61	0.00	1.43	1.32	1.00	0.56	0.46	0.77	1.08	1.49	0.73
IX	0.42	1.17	0.43	0.79	0.94	1.33	3.03	0.39	1.44	0.75	0.86
X	0.43	2.22	1.02	0.42	0.06	0.52	0.43	1.93	1.86	1.07	4.14
XI	1.03	0.00	1.61	1.99	1.13	1.66	0.00	1.74	0.00	0.00	1.61
XII	0.90	1.51	1.41	0.38	0.52	1.23	0.51	0.93	1.58	2.02	0.61
XIII	2.23	1.88	1.32	0.53	0.68	1.12	1.39	0.93	0.52	1.36	0.43
XIV	1.75	0.41	0.38	1.43	1.15	1.41	1.49	0.98	0.95	0.54	0.00
XV	1.57	1.12	0.71	1.07	1.27	0.89	0.67	1.25	1.05	0.36	0.34
XVI	1.36	0.85	0.27	1.64	1.02	0.28	1.03	1.54	0.81	0.74	1.07

1. $MLQ = \frac{M_{ij}}{M_i} \Big/ \frac{M_j}{M}$

Source: Calculated from the data in Table 3.A3.

Chapter Four

An Analysis of the Determinants of Productivity Growth in the Regions of the United Kingdom: 1958-1968

In contrast to the previous chapters which were essentially 'static', or 'comparative static', in character, the present chapter attempts to examine regional economic growth. An attempt will be made to estimate, and assess the importance of, various determinants of productivity growth in regional manufacturing. A distinction is drawn between the effects of capital deepening on the one hand, and what may loosely be called 'technical progress' on the other. Given this distinction, an attempt is made to incorporate techniques developed by Johansen (and extended by the present author) for estimating the rate of capital deepening, into the neoclassical model. An attempt is also made to measure the contributions of returns to scale, and resource shifts, to regional productivity growth.

Solow's Analysis of Productivity Growth

The neoclassical approach to the determinants of productivity growth[1] is so designed as to isolate two components of the growth in output per employee. The first component refers to that portion of the growth in labour productivity associated with an increase in the degree of capital intensity. The second component, the remainder (or residual),[2] is that

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1. R.M. Solow, "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol.39, 1957, pp.312-320; J.E. Meade, <u>A Neo-Classical Theory of Economic Growth</u> (London, George Allen and Unwin, Revised Edition 1962); M. Brown, <u>On the Theory and Measurement of Technological Change</u> (Cambridge, C.U.P., Revised Edition 1968).

2. ". . . some sort of measure of our ignorance . . .": M. Abramovitz, "Resource and Output Trends in the United States since 1870", <u>American Economic Review: Papers and Proceedings</u>, Vol.46, 1956, p.11.

portion which arises from all other sources.

Solow[1] begins his analysis by postulating a two-factor aggregate Cobb-Douglas production function.[2] Technical progress is assumed to be Hicks neutral[3] and disembodied.

Thus,

$$Y_t = A_t K_t^{\beta} L_t^{\alpha}$$

Output per unit of labour may be expressed as;

$$Y_t / L_t = A_t K_t^{\beta} L_t^{\alpha - 1}$$

Given constant returns to scale the exponents sum to unity, which implies that $(-\beta)$ may be substituted for $(\alpha - 1)$, as the exponent on the labour input term in the above equation. Output per worker may therefor be expressed as;

$$q_t = A_t x_t^{\beta} \qquad (4.1)$$

where; $q_t = Y_t / L_t$;

$x_t = K_t / L_t$.

If we totally differentiate the above with respect to time, assuming that the exponents are constant, we obtain:[4]

$$\dot{q} = \dot{A} x^{\beta} + \dot{x} \beta A x^{\beta - 1}$$

Dividing both sides by q_t, gives;

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1. R.M. Solow, op.cit., passim.

2. P.H. Douglas, "Are There Laws of Production?", American Economic Review, Vol.38, 1948, pp.1-41.

3. J.R. Hicks, The Theory of Wages (London, Macmillan, Second Edition 1963), pp.121-3; R.G.O. Allen, Macro-Economic Theory (London, Macmillan, 1967), pp.236-258.

4. Where 'dots' indicate derivatives with respect to time.

$$\frac{\dot{q}}{q} = \frac{\dot{A}x^{\beta}}{Ax^{\beta}} \quad \frac{\dot{x}\beta Ax^{\beta-1}}{Ax^{\beta}}$$

which simplifies to,

$$\frac{\dot{q}}{q} = \frac{\dot{A}}{A} + \beta\frac{\dot{x}}{x}$$

or

$$r = a + \beta m \qquad (4.2)$$

where; r = rate of growth of labour productivity;

m = rate of growth of capital per worker;

a = rate of neutral technical change.

The two terms on the R.H.S. of equation (4.2) correspond to Solow's two components of productivity growth; the contribution of capital deepening (βm), and the contribution of technical progress (a).

Given the additional assumptions of profit maximisation, perfect competition, and marginal productivity factor pricing, the elasticity of output with respect to capital (β) will be equal in value to the share of profits in total income. Equation (4.2) may therefore be rewritten as,

$$r = a + w_k m \qquad (4.3)$$

The appearance of a parameter, β or w_k, (which effectively deflates the rate of capital deepening in order to assess the contribution of this factor to labour productivity growth) may be rationalised in terms of production or income relationships. As a production parameter, it is interpreted as the proportional increase in output resulting from a given proportional increase in the stock of capital utilised in the productive process.[1] The contribution of a given increase in the amount of capital per worker, is determined by deflating the standardised rate of accumulation by the elasticity of output with respect to

1. Both output and capital are 'standardised' with respect to labour.

capital (β). The parameter may also be interpreted as an income, or distribution, coefficient, representing the weighting given to capitalist's income in total income. If the value of property in the hands of capitalists were to increase, the effect of this upon total income would depend upon the proportion which capitalist's income bears to total income, that is on the share of profits in total income (w_k).

Given data on the observed values of labour productivity, the share of capital, and the levels of capital intensity, it is possible to compute the rate of neutral technical change as a residual,

$$\text{i.e.} \qquad a = r - w_k m \qquad (4.4)$$

Using data for private non-farm G.N.P. in the United States over the period 1909-1949, together with estimates of employed capital per worker and the profit share, Solow was able to calculate the rate of technical change for each year (a_t), and was thereby able to construct an index of the technological parameter (A_t). A comparison of base and final year values for the series revealed the overwhelming importance of technical progress as a determinant of productivity growth.

The general applicability of the method may be seen if we compute average annual rates of growth of productivity and capital per worker using Solow's data.[1] The corresponding rates of growth (% p.a.), and the share of capital, are set out below;

$$r = 1.70$$

$$m = 0.50$$

$$w_k = 0.35$$

Using equation (4.4), the average rate of technical progress may be

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1. Three year averages are used as base period and final period estimates of output per man and capital per man, as a correction for cyclical influences. R.M. Solow, op.cit., Table 1, p.315.

calculated as;

$$a = 1.70 - (0.35)(0.50)$$

$$a = 1.70 - 0.17$$

$$\therefore a = 1.53$$

It appears that the increase in capital per worker contributed on average, one-tenth of the growth in labour productivity ($^{0.17}/_{1.70} = 0.10$); leaving nine-tenths of productivity growth attributable to the residual. These proportions agree with Hogan's 'corrected' estimates.[1]

Solow's analysis is particularly attractive because of its computational simplicity, and also because it may be readily interpreted in terms of shifts in the production function, and changes in technique with a given production function. As an analytical device it requires a prior intellectual commitment to the concept of an aggregate (Cobb-Douglas) production function,[2] together with the usual neoclassical assumptions with respect to factor pricing, etc. As an empirical tool the main requirement is for data on capital per worker, which is difficult to obtain for the U.K. as a whole, and is unobtainable at the regional level.

The remainder of this chapter will be concerned with attempts to ascertain the relative contributions of these two determinants of productivity growth, given the absence of regional data on capital per employee.

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1. W.P. Hogan, "Technical Progress and the Production Function", Review of Economics and Statistics, Vol.40, 1958, pp.407-11.

2. A critical view of the Cobb-Douglas function may be found in: E.H. Phelps-Brown, "The Meaning of the Fitted Cobb-Douglas Production Function", Quarterly Journal of Economics, Vol.71, 1957, pp.546-560; F.M. Fisher, "Aggregate Production Functions and the Explanation of Wages: A simulation experiment", Review of Economics and Statistics, Vol.53, 1971, pp.305-23.

Johansen's Contribution

In 1961 Leif Johansen published a paper in which he demonstrated an alternative method whereby Solow's two components of productivity growth could be estimated.[1] Johansen's rather ingenious method is of particular interest, since it obviates the need for estimates of the capital stock. Whilst Johansen applied his method to cross-section data for several industries, the approach is equally valid when applied to regional cross-section data.[2]

We assume that the prevailing technology in each region (j) may be approximated by a Cobb-Douglas production function;

$$Y_{jt} = A_{jt} K_{jt}^{\beta_{jt}} L_{jt}^{\alpha_{jt}}$$

Given the assumptions of constant returns to scale and Hicks neutral technical progress, labour productivity (q_j) in any period (t) is equal to;

$$q_{jt} = A_{jt} x_{jt}^{\beta_{jt}}$$

Assuming that the exponents are constant over time, the ratio of labour productivity in the final period (q_{jt+n}), to labour productivity in the base year (q_{jt}), may be expressed as;

$$\frac{q_{jt+n}}{q_{jt}} = \frac{A_{jt+n}}{A_{jt}} \left(\frac{x_{jt+n}}{x_{jt}} \right)^{\beta_j} \qquad (4.5)$$

Given constant returns to scale and that factor rewards are equal

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1. L. Johansen, "A Method for Separating the Effects of Capital Accumulation and Shifts in Production Functions upon Growth in Labour Productivity", Economic Journal, Vol.71, 1961, pp.775-82

2. Johansen's method is discussed in: C. Kennedy and A.P. Thirlwall, "Surveys in Applied Economics: Technical Progress", Economic Journal, VOl.82, 1972, p.30f; and G.C. Harcourt, Some Cambridge Controversies in the Theory of Capital (Cambridge, C.U.P., 1972), pp.66-9.

to their marginal products;

$$\alpha_j = \frac{W_{jt}L_{jt}}{Y_{jt}}, \text{ and } \beta_j = \frac{R_{jt}K_{jt}}{Y_{jt}};$$

where W_j = wage rate;

R_j = rental per unit of Capital.

After rearranging the above, we obtain,

$$L_{jt} = \frac{\alpha_j Y_{jt}}{W_{jt}}, \text{ and } K_{jt} = \frac{\beta_j Y_{jt}}{R_{jt}}$$

Capital per worker may therefore be expressed as;

$$x_{jt} = \frac{\beta_j W_{jt}}{\alpha_j R_{jt}}$$

The ratio of final to base period capital per worker is;

$$\frac{x_{jt+n}}{x_{jt}} = \frac{\beta_j W_{jt+n} / \alpha_j R_{jt+n}}{\beta_j W_{nt} / \alpha_j R_{jt}} = \frac{W_{jt+n} / R_{jt+n}}{W_{jt} / R_{jt}}$$

alternatively,

$$\frac{x_{jt+n}}{x_{jt}} = \frac{W_{jt+n} / W_{jt}}{R_{jt+n} / R_{jt}} = w_j. \tag{4.6}$$

[1]

Substitution of equation (4.6) into (4.5) yields,

$$\frac{q_{jt+n}}{q_{jt}} = \frac{A_{jt+n}}{A_{jt}} \left(w_j \right)^{\beta_j} \tag{4.7}$$

Taking logarithms of equation (4.7) gives;

$$\text{Lg} \frac{q_{jt+n}}{q_{jt}} = \text{Lg} \frac{A_{jt+n}}{A_{jt}} + \text{Lg } w_j(\beta_j) . \tag{4.8}$$

Given the assumption that the relative increase in wages (w_j) is the same for all regions, and that Lg $\frac{A_{jt+n}}{A_{jt}}$ is uncorrelated with β_j, it

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1. Johansen describes the term w_j as ". . . the relative increase in wages", op.cit., p.776.

is possible to estimate Lg w as the coefficient in the regression equation;

$$Lg \frac{q_{jt+n}}{q_{jt}} = Lg \frac{\hat{A}_{jt+n}}{A_{jt}} + Lg\ \hat{w}\ (w_{kj}) + u$$

where, $w_{kj} = \beta_j$ (by assumption);

u = error term.

The estimate for the relative increase in wages (which is equal to the increase in capital intensity), may be substituted into equation (4.7), and the contributions of capital deepening and technical progress to the growth in labour productivity, may be computed.

Johansen performed this calculation upon the basis of cross-section data for twenty-eight industries over the period 1928-1950. His general conclusion is that capital deepening is more important, as a determinant of productivity growth in the U.K., than Solow's evidence for the United States would suggest.

Two particular comments may be made upon Johansen's analysis. Firstly, the discussion relating to the use of the 'relative increase in wages' as a proxy for the increase in capital per man is, given data deficiencies, redundant. It is equally valid to estimate a logarithmic transformation of equation (4.5) directly; this then becomes:

$$Lg \frac{q_{jt+n}}{q_{jt}} = Lg \frac{A_{jt+n}}{A_{jt}} + Lg \frac{x_{jt+n}}{x_{jt}} \beta_j. \qquad (4.9)$$

Given the assumption that the increase in capital per worker is the same in all regions, equation (4.9) may be estimated as,

$$Lg \frac{q_{jt+n}}{q_{jt}} = \hat{\lambda}_1 + \hat{\lambda}_2 \beta_j + u. \qquad (4.10)$$

where $\hat{\lambda}_2 = Lg \frac{\hat{x}_{t+n}}{x_t}$.

In the absence of data for the 'relative increase in wages', nothing is lost from the analysis by formulating the estimation procedure in this manner.

Secondly, it should be noted that it is not necessary to restrict the analysis, as Johansen does, to the case where the increase in capital per worker is assumed to be the same in all regions. The analysis can be generalised to encompass the case where the rate of neutral technical progress is assumed to be constant, thus leaving the growth of capital per employee in each region free to assume any value.

If we divide both sides of equation (4.9) by β_j, we obtain

$$^1/_{\beta_j} \; Lg \frac{q_{jt+n}}{q_{jt}} = Lg \frac{x_{jt+n}}{x_{jt}} + Lg \frac{A_{jt+n}}{A_{jt}} \; ^1/_{\beta_j} \qquad (4.11)$$

Assuming that $Lg \frac{A_{jt+n}}{A_{jt}}$ is the same in all regions we may rewrite equation (4.11) in the form of an estimating equation:[1]

$$^1/_{\beta_j} \; Lg \frac{q_{jt+n}}{q_{jt}} = \hat{\lambda}_3 + \hat{\lambda}_4 \; ^1/_{\beta_j} + u \qquad (4.12)$$

where $\hat{\lambda}_4 = Lg \frac{\hat{A}_{t+n}}{A_t}$

The extension of Johansen's analysis is of interest, for it not only allows and alternative means of estimating the relative contributions of the two sources of productivity growth, but also enables an assessment to be made of the validity of Johansen's restrictive assumption, that the rate of capital deepening is constant between regions. We would expect, given the assumption that technical progress is neutral and disembodied, that the alternative formulation as expressed in equation (4.12) is both more in keeping with the 'spirit' of the model, and less of an injustice

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1. Since both sides of the estimating equation (4.12) contain a common variable, it is possible - in the event of measurement errors - that the resulting estimates may be biased.

to reality, especially in an inter-regional context.[1]

Estimates of the components of productivity growth for the regions of the U.K.

It has been shown that given the assumptions of; constant returns to scale, Hicks neutral technical progress, and a unitary elasticity of substitution, it is possible to derive two alternative estimating equations for the determinants of productivity growth, both of which obviate the need for capital data.

One equation (that proposed by Johansen), assumes that the increase in capital intensity is the same in all regions. This 'deepening constant' equation may be estimated as

$$\text{Lg}\,\frac{q_{jt+n}}{q_{jt}} = \hat{\lambda}_1 + \hat{\lambda}_2\,\beta_j + u \qquad (4.10)$$

where q_{jt} = real output per employee in region j, at time t;

β_j = elasticity of output with respect to capital in region j;

$\hat{\lambda}_2$ = estimate of $\text{Lg}\,\frac{x_{t+n}}{x_t}$;

$\hat{\lambda}_1$ = regression constant;

u = error term.

A second equation, which assumes that the rate of neutral technical progress is constant between regions, may be estimated as;

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1. In terms of the 'econometrics' of the analysis, assuming that the rate of capital deepening is constant (λ_2 in equation 4.10), when it is really a variable, will lead to bias. Similarly, assuming that the rate of technical progress is constant (λ_4 in equation 4.11) when it is variable, will also introduce bias. We would expect, given the assumed nature of technical progress, that the bias resulting in the second case (λ_4 constant) will be less than the former (λ_2 constant).

$$^{1}/_{\beta_j} \text{ Lg } \frac{q_{jt+n}}{q_{jt}} = \hat{\lambda}_3 + \hat{\lambda}_4 \, ^{1}/_{\beta_j} + u \qquad (4.12)$$

where $\hat{\lambda}_4$ = estimate of Lg $\frac{A_{t+n}}{A_t}$;

$\hat{\lambda}_3$ = regression constant.

An attempt was made to estimate the regression coefficients ($\hat{\lambda}_2$ and $\hat{\lambda}_4$), using data referring to the total manufacturing sector of each region in the U.K., for the years 1958 and 1968.[1]

Description of the Measures Used

The elasticity of output with respect to capital for each region (β_j), is assumed to be equal to the share of non-wage income in net output within each region. Thus;

$$\beta_j = w_{kj} = 1 - \frac{W^m_j}{Y^m_j}$$

where W^m_j = total wage and salary payments in the manufacturing industries of region j in 1963;[2]

Y^m_j = net output in manufacturing industries in each region in 1963, valued at current prices.

The increase in labour productivity in each region is calculated as the ratio between the value of net output per employee in manufacturing in 1968, and the value of net output per employee in manufacturing in each region in 1958. Since regional price indices are unavailable, all data are expressed in terms of current prices. Thus, instead of the increase in real labour productivity ($\frac{q_{jt+n}}{q_{jt}}$), the data refers to the

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1. Data and Sources are presented in the Appendix Table 4.A1.

2. 1963 was chosen as this was the middle year of the period over which we have comparable data on Labour Productivity.

increase in the money value of output per worker ($\frac{q_{jt+n}^{m}}{q_{jt}^{m}}$), where the 'm' superscript indicates that the variable is measured in money, not real terms.

Thus, equation (4.10), for example, is estimated as;

$$\text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}} = \hat{\lambda}_1^{m} + \hat{\lambda}_2^{m}\, w_{kj} + u \qquad (4.10m)$$

whereas the 'true' estimating equation should be,

$$\text{Lg}\,\frac{q_{jt+n}}{q_{jt}} = \text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}} - \text{Lg}\,\frac{P_{jt+n}}{P_{jt}} = \hat{\lambda}_1 + \hat{\lambda}_2\, w_{kj} + u$$

alternatively,

$$\text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}} = \hat{\lambda}_1 + \hat{\lambda}_2\, w_{kj} + \text{Lg}\,\frac{P_{jt+n}}{P_{jt}} + u \qquad (4.10)$$

where P_j = price index of regional output.

The 'true' estimating equation (4.10), may be rewritten in terms of deviation from means (indicated by square brackets) as;

$$\left[\text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}}\right] = \hat{\lambda}_2 \left[w_{kj}\right] + \left[\text{Lg}\,\frac{P_{jt+n}}{P_{jt}}\right] + \left[u\right]$$

Multiplying through by $\left[w_{kj}\right]$ and summing over the observations gives:

$$\sum_j \left[\text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}}\right]\left[w_{kj}\right] = \hat{\lambda}_2 \sum_j \left[w_{kj}\right]^2 + \sum_j \left[\text{Lg}\,\frac{P_{jt+n}}{P_{jt}}\right]\left[w_{kj}\right] + \sum_j \left[u\right]\left[w_{kj}\right]$$

Dividing through by $\left[w_{kj}\right]^2$, and rearranging (assuming that the error term is a random variable) yields;

$$\hat{\lambda}_2 = \frac{\sum_j \left[\text{Lg}\,\frac{q_{jt+n}^{m}}{q_{jt}^{m}}\right]\left[w_{kj}\right]}{\left[w_{kj}\right]^2} - \frac{\sum_j \left[\text{Lg}\,\frac{P_{jt+n}}{P_{jt}}\right]\left[w_{kj}\right]}{\left[w_{kj}\right]^2}$$

It will be seen that the first term on the R.H.S. of the above equation is equal in value to the estimate $(\hat{\lambda}_2^m)$ in equation (4.10m). It follows that;

$$\hat{\lambda}_2^m = \hat{\lambda}_2 + \frac{\sum_j \left[Lg \frac{P_{jt+n}}{P_{jt}} \right] \left[w_{kj} \right]}{\left[w_{kj} \right]^2}$$

$\hat{\lambda}_2^m$ will therefore be an unbiased estimate of $\hat{\lambda}_2$, provided either that $Lg \frac{P_{jt+n}}{P_{jt}}$ is constant (i.e. the rate of inflation is the same in all regions) or, that there is no correlation between the rate of price increase and the share of capital across regions. Whilst the latter seems most likely, it will be convenient at a later stage, to use the assumption that the rate of change in prices is the same in all regions. This might just as well be assumed from the outset.[1] By an analogous argument it will be seen that $\hat{\lambda}_4^m$ is also an unbiased estimate of $\hat{\lambda}_4$ in equation (4.12).

The estimates

When the estimating equation (4.10m) was fitted to regional cross-section data for the period 1958-1968, the result was not in accord with a priori expectations.

The equation as estimated was;

$$Lg \frac{q_{jt+n}^m}{q_{jt}^m} = 1.068 - 0.755\, w_{kj}. \qquad R^2 = 0.032.$$ [2]

1. This assumption, whilst sufficient, is not necessary in the interests of devising unbiased estimates. It does, however, enable the analysis to be carried further at a later stage.

2. Figures in parenthesis refer to standard errors. Superscripts are:
   * - significant at 5 per cent confidence level.
   ** - significant at 1 per cent confidence level.

The regression coefficient (i.e. the estimate of $Lg \frac{x_{t+n}}{x_t}$) is not only insignificant but also of the wrong sign. Taking antilogs. of the coefficient yields an estimated value of $\frac{x_{t+n}}{x_t}$ of 0.461. This, in turn, implies that capital per worker declined at a rate of (-)8.10% per annum over the period.[1]

An inspection of a scatter diagram and the residuals from the above equation, revealed that two observations lay well above, and three well below, the hypothetical regression line. If we accept the production function approach, as providing a meaningful interpretation of events, we are faced with two alternative explanations of this result. We could reject the assumption that the rate of capital deepening was the same in all regions, and accept that in two regions it was much greater, and in three regions much lower, than in the remainder. This would involve the rejection of equation (4.10) as a valid estimating equation. Alternatively, we could argue that the growth in capital per worker was the same in all regions, but that the rate of neutral technical progress differed greatly between regions. In this event, equation (4.10), whilst substantially valid, will yield biased estimates. We will, as did Johansen,[2] tentatively accept the validity of equation (4.10), and assume that the poor fit is due to dissimilar rates of neutral technical progress, rather than differences in the rate of capital deepening.

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1. Since $k_{t+n} = k_t(1+m)^n$, the rate of capital deepening (m) is calculated as

$$m = \sqrt[n]{\frac{k_{t+n}}{k_t}} - 1$$

2. Johansen apparently views the dummy variables as representing the effects of non-constant returns to scale (L. Johansen, op.cit., p.780). If so, this contradicts his use of w_k as the measure of the elasticity of output with respect to capital, and means that the residual is no longer simply a reflection of technical progress.

Since we lack the degrees of freedom necessary to fit separate equations to the data, or to delete the 'nuisance' observations, equation (4.10) was re-estimated using dummy variables.[1, 2]

When re-estimated, the equation was;

$$\text{Lg}\,\frac{q^{m}_{jt+n}}{q^{m}_{jt}} = \underset{}{0.348} + \underset{(0.392)}{0.741\,w_{kj}} - \underset{(0.023)^{**}}{0.125\,d_1} + \underset{(0.025)^{**}}{0.211\,d_2} \qquad R^2 = 0.950 \qquad (4.10')$$

where d_1 = a dummy variable assuming the values;

1 : for N, Y&H and W;

0 : for all other regions.

d_2 = dummy variable assuming the values;

1 : for EM and NI;

2 : for all other regions.

The explanatory power of the equation is greatly enhanced, and the coefficient on w_{kj}, although it remains insignificant, is now in accord with a priori expectations. The estimate of Lg $\frac{x_{t+n}}{x_t}$, (= 0.741), yields an estimated average annual rate of growth of capital per worker of (+) 7.7%.

Since we possess data which enables us to calculate the actual rate of growth of labour productivity, together with the share of capital, we can substitute these, together with the estimate for the

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1. The equations were also re-estimated with the 'outlying' observations deleted. The results, whilst not totally unsatisfactory from the statistical point of view, were not significantly different from those obtained with the dummy variables.

2. On the use of dummy variables see: J. Johnston, Econometric Methods (New York, McGray-Hill, 1963), pp.221-8; and, R.J. Wonnacott and T.H. Wonnacott, Econometrics (New York, John Wiley and Sons, 1970), pp.68-77.

rate of capital deepening, into Solow's equation;[1]

$$r_j = a_j + w_{kj}\, m_j. \qquad (4.3)$$

Given that the rate of capital deepening is the same in all regions, the estimate of this variable, derived from equation (4.10), may be substituted into equation (4.3). It is then possible to compute the 'deepening constant' rate of neutral technical progress within each region, as the residual in the equation;

$$a_j = r_j - w_{kj}\hat{m} \qquad (4.4)$$

Estimates of the 'deepening constant' rate of technical progress for each region are reported in Table 4.1. An inspection of the table reveals the relative importance of capital accumulation as a source of productivity growth. Over the period the average annual rate of growth in labour productivity in manufacturing in the U.K. as a whole was 4.9%, and the share of capital in 1963 was 0.47. Substituting these values, together with the estimate of m derived from equation (4.10')[2], into the above equation (4.4) we find;

$$a_{UK} = 4.9 - (0.47)(7.7)$$

$$a_{UK} = 4.9 - 3.6$$

$$a_{UK} = 1.3$$

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1. As we have already indicated, we only possess data for the rate of growth in output per man at current prices. Given the assumption that the rate of growth in prices is the same in all regions, the rate of growth of real output per worker (r_j) was calculated as:

$$r_j = r_j^m - p.$$

where p = national rate of growth of prices.
Full details are given in the Appendix, Table 4.A1.

2. The national rate of capital deepening is a weighted sum of the regional rates. Given that the regional rates are equal, and that the weights sum to unity, the national rate will equal the (constant) regional rate of capital deepening.

Table 4.1

Estimates of 'capital deepening constant' rates of technical change. 1958-1968

Region	r_j	$\hat{m}$	$w_{kj}.\hat{m}$	a_j [1]
N	3.8	7.7	3.8	0.0
Y&H	3.9	7.7	3.5	1.3
EM	7.2	7.7	3.5	3.7
EA	5.8	7.7	3.8	2.0
SE	4.9	7.7	3.8	1.1
SW	4.6	7.7	3.3	1.3
WM	4.6	7.7	3.3	1.3
NW	5.3	7.7	3.6	1.7
W	3.7	7.7	3.8	-0.1
S	4.8	7.7	3.8	1.0
NI	7.2	7.7	3.5	3.7
UK	4.9	7.7	3.6	1.3

1. $a_j = r_j - w_{kj}\hat{m}$

This indicates that on average, neutral technical progress has accounted for 27% of the growth in output per worker in the U.K. ($0.27 = {}^{1.3}/_{4.9}$); capital deepening having accounted for the remaining 73% of productivity growth (${}^{3.6}/_{4.9}$). These results are not unlike Johansen's, in that they ascribe to capital accumulation a greater role as a determinant of productivity growth, than did Solow's analysis for the United States. Capital deepening appears more important in this study than Matthews' analysis for U.K. manufacturing over the period 1948-1962[1] would suggest. It is also greater than Nicholson's 'implied' estimate for the contribution of deepening over the period 1948-1964; of 47%.[2]

It is also apparent from Table 4.1 that there is a wide variation in the rate of neutral technical progress between regions. The calculations suggest that in Wales the production function has shifted slightly outwards over the period, whilst for the North no discernible shift has taken place. In the East Midlands, East Anglia, and Northern Ireland, technical progress has proceeded at a rate well above the U.K. average.

Both of these results, the relative unimportance of technical progress, and the widely dissimilar rates of technical advance, are in conflict with the work of many previous writers and with a priori expectations; given the disembodied form which technical advance is

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1. Matthews estimates that capital deepening accounted for 26% of the growth in labour productivity in manufacturing, leaving 74% to be accounted for by the residual; R.C.O. Matthews, "Some Aspects of Post-War Growth in the British Economy in Relation to Historical Experience", reprinted in D.H. Aldcroft and P. Frearon (eds.), Economic Growth in Twentieth Century Britain (Macmillan, London, 1969), p.91.

2. R.J. Nicholson, "Capital Stock, Employment and Output in British Industry 1948-1964", Yorkshire Bulletin of Economic and Social Research, Vol.18, 1966, pp.65-85; C. Kennedy and A.P. Thirlwall, op.cit., p.43.

assumed to take. It would seem reasonable therefore to question the assumptions upon which the analysis is based, in particular the assumption that the rate of capital deepening is the same in all regions.

An alternative procedure is to estimate equation (4.12), which embodies the assumption that the rate of neutral technical progress is the same in all regions.

The estimated values for equation (4.12) are;

$$^{1}/_{w_{kj}} \text{ Lg} \frac{q^{m}_{jt+n}}{q^{m}_{jt}} = -0.704 + 1.035 \ ^{1}/_{w_{kj}} \qquad R^2 = 0.214$$

The regression coefficient, whilst insignificant is of the correct sign, unlike the initial estimate of Lg $\frac{x_{t+n}}{x_t}$ in equation (4.10). It should also be noted that the explanatory power of the 'technical change constant' equation (4.12), is much greater than the explanatory power of the 'deepening constant' formulation, as estimated by equation (4.10). The implied rate of neutral technical progress however, is +10.8% per annum, which is too high to be considered a valid estimate of this component of productivity growth.

An inspection of a scatter diagram and the residuals from equation (4.12), revealed a similar situation to that confronted earlier, namely five observations lying well of the hypothetical regression line. Earlier we followed Johansen's lead and investigated the implications of assuming that this was due to uneven rates of technical progress. We will now explore the possibility that the estimate of technological advance ($\hat{\lambda}_4$ in equation (4.12)) is biased, due to uneven rates of capital deepening between regions. Dummy variables were reintroduced to account for this source of bias, and a modified equation (4.12') was estimated.

The equation as re-estimated is;

$$^{1}/_{w_{kj}} \; Lg \frac{q^m_{jt+n}}{q^m_{jt}} = \underset{(0.175)^*}{0.741 + 0.347} \; ^{1}/_{w_{kj}} \; \underset{(0.045)^{**}}{- 0.252 \, d_1} \; \underset{(0.052)^{**}}{+ 0.463 \, d_2} \qquad \underset{R^2 = 0.963}{(4.12')}$$

The explanatory power of equation (4.12') is greater than equation (4.10'). This enhances the belief that the 'technical change constant' formulation (not considered by Johansen) is more credible than the alternative equation, which embodies the assumption that the rate of capital deepening is a constant between regions. This belief is strengthened by the significance of the coefficient on the explanatory variable in equation (4.12').

The estimate of the increase in the technological parameter (Antilog 0.347), yields an implied average annual rate of technical progress of (+) 3.5%.

Given the actual rates of growth of labour productivity for each region, it is possible to substitute the estimate for the (constant) rate of technical change into Solow's equation (4.3), and to compute estimates of the rate of growth of capital per worker as;

$$m_j = \frac{r_j - \hat{a}}{w_{kj}}$$

The resulting estimates of the rate of capital deepening, together with the contribution of this factor to the rate of productivity growth, are given in Table 4.2.

An examination of the estimates reveals the importance of technical progress as a source of productivity growth. If we substitute into the above equation values for manufacturing in the U.K. as a whole, together with the estimate of the rate of technical progress, we find an estimated value of the rate of capital deepening of;

$$m_{UK} = \frac{4.9 - 3.5}{0.47}$$

$$m_{UK} = 3.0$$

Table 4.2

Estimates of the 'technical change constant' rates of capital deepening.
1958-1968

Region	r_j	$\hat{a}$	$w_{kj}m_j$ [1]	m_j [2]
N	3.8	3.5	0.3	0.6
Y&H	3.9	3.5	0.4	0.9
EM	7.2	3.5	3.7	8.0
EA	5.8	3.5	2.3	4.6
SE	4.9	3.5	1.4	2.9
SW	4.6	3.5	1.1	2.6
WM	4.6	3.5	1.1	2.6
NW	5.3	3.5	1.8	3.8
W	3.7	3.5	0.2	0.4
S	4.8	3.5	1.3	2.7
NI	7.2	3.5	3.7	8.0
UK	4.9	3.5	1.4	3.0

1. $w_{kj}m_j = r_j - \hat{a}$

2. $m_j = \dfrac{r_j - \hat{a}}{w_{kj}}$

The estimated contribution of capital deepening to national productivity growth is 1.4% p.a. (4.9 - 3.5). Using this formulation the contribution of technical progress to productivity growth is now 72% of the total ($^{3.5}/_{4.9}$), leaving 28% to be attributed to the effects of capital deepening. These ratios are almost identical with the relative contributions as estimated by Matthews, for the period 1948-1962.[1, 2]

Whilst some of the estimates of the rate of capital deepening appear to be very high, it should be borne in mind that some regions, particularly Scotland and Northern Ireland, exhibited negative rates of growth of employment. Other things being equal, this would tend to inflate the rate of growth of capital per man.

Two major conclusions would seem to follow from the analysis presented in this section.

Firstly, we may conclude that technical progress, or more correctly the 'residual', was an important source of growth in labour productivity in manufacturing industries in the United Kingdom, over the period 1958-1968; accounting for approximately seven-tenths of the total productivity growth.

Secondly, the formulation of the model which embodies the assumption that the rate of technical advance is constant between regions, performs 'better' than the original Johansen formulation, which was based upon the assumption that the rate of capital deepening is a constant. This is of more than theoretical significance, for it indicates that the major source of <u>differences</u> in the rate of productivity growth between

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1. See note 1, p.134. Due to the high R^2 these proportions are the reverse of those mentioned earlier (cf. p.134).

2. Further evidence, in support of the estimates obtained above, will be presented in Chapter Seven, pp.283-6.

regions lies not in different rates of technological advance, but in differences in the rate and effectiveness of capital accumulation between regions.

It follows from the above, that it is a worthwhile exercise to investigate further some alternative measures of the rate of capital deepening.

<u>An approach which rests upon the definition of the elasticity of substitution</u>

The elasticity of substitution (σ) is defined as;

$$\sigma = \frac{d(K/L)}{K/L} \Bigg/ \frac{d\left(\frac{MP_L}{MP_K}\right)}{\frac{MP_L}{MP_K}}$$

Given that factors are rewarded according to the value of their marginal products this can be rewritten as;

$$\sigma = \frac{d(K/L)}{K/L} \Bigg/ \frac{d\left(\frac{W}{R}\right)}{\frac{W}{R}} \qquad (4.13)$$

The numerator of equation (4.13) is, for small changes, equal to the rate of growth of capital per worker, that is, the rate of capital deepening (m).

The denominator of equation (4.13) may be expanded and expressed as;

$$\frac{d\left(\frac{W}{R}\right)}{\frac{W}{R}} = \frac{dW}{W} - \frac{dR}{R}$$

Thus;

$$\sigma = \frac{m}{\frac{dW}{W} - \frac{dR}{R}} \qquad (4.14)$$

Given that the technology of the economy may be approximated by a Cobb-Douglas production function (i.e. $\sigma = 1$), equation (4.14) may be simplified to;

$$m = \frac{dW}{W} - \frac{dR}{R} \tag{4.15}$$

Assuming that the rental per unit of capital is constant, i.e. $\frac{dR}{R} = 0$,[1] the rate of capital deepening (m) may be approximated by the growth in wages per employee.[2]

Solow's equation (4.3) then becomes;

$$r_j = a_j + w_{kj}\left(\frac{dW}{W_j}\right) \tag{4.16}$$

and the rate of technical progress may be calculated as;[3]

$$a_j = r_j - w_{kj}\left(\frac{dW}{W_j}\right) \tag{4.17}$$

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1. This is not to say that rentals are fixed, but rather that the increase in rentals due to technical progress is offset by the decrease in rentals due to capital deepening.

2. L.B. Lave, Technological Change: Its Conception and Measurement (Englewood Cliffs, Prentice-Hall, 1966), p.27.

3. There is a further extension of this approach, which rests upon the relationship between average and marginal products in a Cobb-Douglas function. Marginal Product per worker may be expressed as:

$$\frac{\partial Y}{\partial L} = \alpha A K^{\beta} L^{\alpha - 1} \tag{4.18}$$

Substituting equation (4.1) into (4.18) yields:

$$W = \frac{\partial Y}{\partial L} = \alpha q \tag{4.19}$$

It follows from (4.19), given that the share of labour (α) is constant, that

$$\frac{dW}{W} = \frac{dq}{q} = r \tag{4.20}$$

Substitution of (4.20) into (4.17) gives an alternative expression for the rate of neutral technical change;

$$a_j = (1 - w_{kj})\frac{dW}{W_j} \tag{4.21}$$

Consideration of the elasticity of substitution approach leads therefore, to both an alternative estimate of the rate of capital deepening, and also to an additional means of ascertaining the rate of technical progress for each region.

Estimates of the rates of capital deepening and technical progress in manufacturing industries for the regions of the U.K., 1958-1963.

Since comparable data on wage rates in each region are unavailable for the whole of the period 1958-1968, the application of the analysis based upon the growth in wages will be restricted to the period 1958-1963.[1]

To act as a basis for comparison, we have estimated the rates of capital deepening and the two components of productivity growth over the period, using both equations (4.10) and (4.12).

The results derived from estimating equation (4.10") are set out in Table 4.3. The equation as estimated was;

$$\text{Lg}\,\frac{q^m_{j1963}}{q^m_{j1958}} = \underset{}{0.121} + \underset{(0.194)*}{0.414\,\bar{w}_{kj}} - \underset{(0.008)**}{0.057\,d_3} + \underset{(0.014)**}{0.111\,d_4} \qquad R^2 = 0.952 \qquad (4.10")$$

where d_3 = dummy variable, assuming the values of;

1 : for N, Y&H and W,

0 : for all other regions.

d_4 = dummy variable, assuming the value of;

1 : for NI,

0 : for all other regions.

The estimate of the increase in capital per worker (Antilog 0.414) implies an estimated growth of capital per worker of 8.6% per annum.

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1. Data and sources are detailed in the Appendix Table 4.A2.

Table 4.3 reports the results of computing the residual for each region, assuming that the rate of capital deepening is the same in all regions.

Equation (4.12") was also applied to the observations over the period 1958-1963. The equation as estimated was;

$$ {}^{1}/_{\bar{w}_{kj}} \, Lg \frac{q^{m}_{j1963}}{q^{m}_{j1958}} = \underset{}{0.451} + \underset{(0.084)}{0.104} \; {}^{1}/_{\bar{w}_{kj}} - \underset{(0.017)^{**}}{0.122} \, d_3 + \underset{(0.029)^{**}}{0.269} \, d_4 \qquad \text{(4.12")} \quad R^2 = .973 $$

The latter formulation, the 'technical change constant' equation, yields more satisfactory estimates of the relative contributions of technical progress and capital accumulation to the growth in labour productivity (see Table 4.4). The estimated value of $\frac{A1963}{A1958}$ (= Antilog 0.104) yields an estimated rate of neutral technical progress (constant between regions), of 2.1% per annum. Table 4.4 presents the estimated values for the rate of capital deepening in each region, arrived at by substitution of the estimates derived from equation (4.12") into equation (4.3).

The estimates of the rate of capital deepening, derived from the definition of the elasticity of substitution (equations (4.15) and (4.16)), are set out in Table 4.5, together with the associated estimates of the residual, estimated by equation (4.17).

A comparison of Tables 4.4 and 4.5 indicates that the estimate of the rate of capital deepening, derived via the elasticity of substitution approach (Column 2 of Table 4.5), typically tends to underestimate the rate of capital deepening as determined by equation (4.12"), presented in Column 4 of Table 4.4.[1]

Comparing the estimates of the rate of technical change we find

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1. The square of the correlation coefficient between the two estimates of the rate of capital deepening is (R^2=), 0.405.

Table 4.3

Estimates of the 'capital deepening constant' rates of technical change. U.K. Regions, 1958-1963

	(1)	(2)	(3)	(4)
Region	r_j	$\hat{m}$	$\bar{w}_{kj}\hat{m}$	a_j [1]
N	3.8	8.6	4.1	-0.3
Y&H	3.8	8.6	3.9	-0.1
EM	4.2	8.6	3.8	0.4
EA	5.0	8.6	4.1	0.9
SE	5.0	8.6	4.0	1.0
SW	5.0	8.6	4.0	1.0
WM	4.4	8.6	3.6	0.8
NW	4.7	8.6	4.0	0.7
W	3.7	8.6	4.2	-0.5
S	4.8	8.6	4.0	0.8
NI	6.9	8.6	3.6	3.3
UK	4.6	8.6	3.9	0.7

1. $a_j = r_j - \bar{w}_{kj}\hat{m}$

Table 4.4

Estimates of the 'technical change constant' rates of capital deepening. U.K. Regions, 1958-1963.

	(1)	(2)	(3)	(4)
Region	r_j	$\hat{a}$	$\bar{w}_{kj}m_j$[1]	m_j[2]
N	3.8	2.1	1.7	3.5
Y&H	3.8	2.1	1.7	3.8
EM	4.2	2.1	2.1	4.8
EA	5.0	2.1	2.9	6.0
SE	5.0	2.1	2.9	6.3
SW	5.0	2.1	2.9	6.3
WM	4.4	2.1	2.3	5.5
NW	4.7	2.1	2.6	5.7
W	3.7	2.1	1.6	3.3
S	4.8	2.1	2.7	5.7
NI	6.9	2.1	4.8	11.4
UK	4.6	2.1	2.5	5.6

1. $w_{kj}m_j = r_j - \hat{a}$

2. $m_j = \dfrac{r_j - \hat{a}}{w_{kj}}$

Table 4.5

Rates of Neutral Technical Progress as determined by Equation (4.16)
U.K. Regions, 1958-1963

	(1)	(2)	(3)	(4)
Region	r_j	dW/W_j	$w_{kj}dW/W_j$	a_j [1]
N	3.8	2.2	1.1	2.7
Y&H	3.8	2.9	1.3	2.5
EM	4.2	2.5	1.1	3.1
EA	5.0	3.1	1.5	3.5
SE	5.0	3.0	1.4	3.6
SW	5.0	3.2	1.5	3.5
WM	4.4	3.2	1.3	3.1
NW	4.7	3.5	1.6	3.1
W	3.7	3.2	1.6	3.1
S	4.8	2.7	1.3	3.5
NI	6.9	3.7	1.6	5.3
UK	4.6	3.0	1.4	3.2

1. $a_j = r_j - \bar{w}_{kj}dW/W_j$

that the estimates based upon the elasticity of substitution (Column 4 of Table 4.5) tend to overstate the rate of technical progress as determined by equation (4.10"), presented in Column 4 of Table 4.3.[1]

It should also be noted that, using the estimates presented in Table 4.5, the relative contribution of technical progress to the national growth in labour productivity is $(\frac{a}{r}=)$ 70%. This is almost identical to the estimate made by Matthews, referred to earlier.

The Contribution of Inter-regional Resource Shifts to National Productivity Growth

Up to now we have used the term 'technical progress' to refer to the residual growth in labour productivity, once an allowance has been made for the effects of capital deepening. Massell[2] and others have demonstrated that a portion of the estimated rate of technical progress may be due to changes in the composition of output, associated with a re-allocation of resources.

Since the national residual, estimated separately, is calculated upon the basis of the total resources available to the nation (independent of their distribution between regions), a comparison between the weighted sum of the regional residuals and the national estimate, will reveal the effects of the inter-regional movements of resources. The weights used to derive the predicted national rate of technical change (from the observed regional rates of technical change), are the proportions of national output produced in each region, in the base period.

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1. It appears that the elasticity of substitution approach fares much better as a proxy for technical progress. The square of the correlation coefficient between the two estimates of technical progress is $(R^2 =)$ 0.883.

2. B.F. Massell, "A Disaggregated View of Technical Change", Journal of Political Economy, Vol.69, 1961, pp.547-557.

The 'predicted' national rate, ($\hat{\hat{a}}$), on the basis of the pattern of resource allocation in the base period will therefore equal;

$$\hat{\hat{a}} = \sum_j \left(\frac{Y_{jt}}{Y_t} \cdot a_j \right) \tag{4.22}$$

To the extent that the observed national rate of technical change is greater than the 'predicted' rate, this will be an indication of the extent to which resources have 'moved' from relatively low, to relatively high, productivity regions. The estimate of the contribution of inter-regional resource shifts (CIRRS) is therefore;

$$\text{CIRRS} = a_{UK} - \hat{\hat{a}} \tag{4.23}$$

This component of national productivity growth was calculated for the period 1958-1968, using the estimates reported in Table 4.1, and for the period 1958-1963, using the estimates reported in Tables 4.3 and 4.5. The estimates of the contribution of inter-regional resource shifts, using base-year weights, are reported in Table 4.6.

It is apparent that over the period 1958-1968 the inter-regional movements of resources, resulted in an increase in labour productivity of 0.1 per cent per annum. That is, 2% of the total growth in the productivity of labour in the U.K. may be attributed to this factor.

For the period 1958-1963 the calculations suggest a different story; one measure suggests that inter-regional re-allocation contributed nothing at all to the growth in labour productivity; an alternative measure suggests that national labour productivity grew less slowly than it otherwise might, in the absence of resource shifts. This result, whilst it is at odds with the findings of other authors on the subject,[1] is consistent with an examination of 'static' resource

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1. In particular, B.F. Massell, op.cit., p.555, and R.C.O. Matthews, op.cit., pp.92-5.

Table 4.6

Estimates of the Contribution of Inter-Regional Resource Shifts to National Productivity Growth

Estimate	1958-1968	1958-1963	
	a_1 [1]	a_3	a_5
National rate	1.5	0.7	3.2
$\hat{a}$ [2]	1.4	0.7	3.3
CIRRS [3]	0.1	0.0	-0.1
Proportional Contribution [4]	2%	0%	-2%

1. Subscripts refer to the table number which is the source of the estimate.

2. $\hat{a} = \sum_j \frac{y_{jt}}{y_t} a_j$

3. CIRRS = $a - \hat{a}$

4. Proportional Contribution = $\frac{\text{CIRRS}}{r}$

allocation in the regions, undertaken earlier in the thesis.[1]

Increasing returns to Scale

The analysis undertaken in the previous sections of this chapter did not allow for the possible influence of economies of scale. To the extent that constant returns do not prevail, the use of the constrained form of the Cobb-Douglas Production Function will lead to biased estimates of technical progress.[2] Studies of the degree of returns to scale in U.K. manufacturing industries reveal that increasing returns apparently rule in most industries and in the aggregate.[3]

The existence of increasing returns will effect the estimate of technical progress (and indirectly the estimate of capital deepening) in two ways; firstly it will result in an underestimate of the effect of capital deepening, since capital's share (w_k) will be an underestimate of the elasticity of output with respect to capital (β); secondly, it will result in an overestimate of the residual, in that part of the residual will include the effect of economies of scale.[4] Walters, in

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1. Cf. Chapter Two, pp.53-56.

2. Kennedy and Thirlwall, op.cit., p.26f. Durand was apparently one of the first to criticise the Cobb-Douglas Function along these lines; see D. Durand, "Some Thoughts on Marginal Productivity with Special Reference to Professor Douglas' Analysis", Journal of Political Economy, Vol.45, 1937, pp.740-58; P.H. Douglas, op.cit., passim.

3. M.S. Feldstein, "Alternative Methods of Estimating a CES Production Function for Britain", Economica, Vol.34, 1967, p.391f; C.F. Pratten, Economies of Scale in Manufacturing Industry, Department of Applied Economics, Occasional Paper No.28 (Cambridge, C.U.P., 1971).

4. An additional problem with the constrained Cobb-Douglas function is that the scale of output is (formally) indeterminate. On indeterminacy, see M. Bronfenbrenner, 'Neo-Classical Macro-Distribution Theory', in J. Marschal and B. Ducros (eds.), The Distribution of National Income, I.E.A. (London, Macmillan, 1968), p.483, and A.A. Walters, An Introduction to Econometrics (London, Macmillan, 1968), p.280f.

his study of the influence of returns to scale, found, using Solow's data,[1] that the homogeneity parameter (v) was approximately 1.30.[2] This implies that; "Compared to Solow's 1957 results, the effect of neutral technical change is reduced from an annual rate of improvement of between 1.5 and 1.8% per annum to between 1.0 and 1.25% per annum".[3]

Without detailed estimates of the production function in its unconstrained form, any adjustment to the residuals for the presence of economies of scale, however desirable, must be subject to error. A case in point is Denison's work, which for no apparent reason assumes that one-eleventh of the increase in output in the U.S. was due to economies of scale.[4] He relates the scale economies to total output growth rather than to input expansion,[5] and he also neglects to adjust the 'weights' given to capital and labour for the existence of increasing returns. Obviously, a more formal approach is desirable.

In the analysis presented in the preceding sections, the rate of technical progress was calculated as;

$$a = r - w_k m = g - w_k (k - \ell) - \ell \qquad (4.24)$$

where g = rate of growth of output;

k = rate of growth in capital;

ℓ = rate of growth in labour.

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1. R.M. Solow, op.cit., passim.

2. A.A. Walters, "A Note on Economies of Scale", Review of Economics and Statistics, Vol.45, 1963, p.427.

3. Ibid., p.426.

4. E. Denison, The Sources of Economic Growth in the United States (New York, Committee for Economic Development, 1962), pp.173-81.

5. Apparently technical progress also reaps economies of scale.

If increasing returns prevail the income shares cannot be taken as estimates of the individual elasticities, as the sum of the elasticities ($\alpha + \beta$) now exceeds unity. In this event the 'true' rate of technical progress (a^*) will equal;

$$a^* = g - \beta k - \alpha \ell \qquad (4.25)$$

Given that the sum of the elasticities is equal to the magnitude of the homogeneity parameter ($\alpha + \beta = v$), equation (4.25) may be rewritten as;

$$a^* = g - \beta k - (v - \beta)\,\ell$$

from which it follows that,

$$a^* = g - \beta(k - \ell) - v\ell \qquad (4.26)$$

Instead of estimating the effect of capital deepening as ($w_k(k-\ell)$), as in equation (4.24), the 'true' effect of capital deepening is now ($\beta(k - \ell)$). In addition to this there is now an allowance for increasing returns, in the form of ($v\ell$).[1]

If we add and subtract both ($w_k(k-\ell)$) and (ℓ) to the R.H.S. of equation (4.26), we find

$$a^* = (g - \ell) - w_k(k - \ell) - \beta(k - \ell) + w_k(k - \ell) + \ell - v\ell \qquad (4.27)$$

The first two terms on the R.H.S. of equation (4.27) correspond to the estimate of the residual arrived at via equation (4.24). Substituting equation (4.24) into the above and rearranging, yields;

$$a^* = a - (\beta - w_k)(m) + (1 - v)\,\ell \qquad (4.28)$$

where; $m = (k - \ell)$.

With the aid of equation (4.28), together with estimates of the

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1. The intuitive explanation of this would be that 'scale' effects accrue only to the extent that factors grow in proportion. Given that labour is the slowest growing factor, scale effects cannot occur for growth rates of inputs which exceed the rate at which employment is expanding.

homogeneity parameter (v) and the 'true' elasticity of output with respect to capital (β), it would be possible, given independent data for the rate of deepening, to adjust the estimate of the residual for the effects of increasing returns.

Elsewhere in the thesis we have estimated the degree of returns to scale in U.K. manufacturing, assuming that the production function is common to all regions, as (v=) 1.13 in 1963.[1] The contribution of returns to scale, to the growth in labour productivity (Cv), may be calculated as;[2]

$$Cv_j = (v - 1)\,\ell_j = (0.13)\,\ell_j \qquad (4.29)$$

The estimates of the contribution of this factor to productivity growth in each region, over the period 1958-1968, are reported in Table 4.7, together with the proportion of total productivity growth attributable to this source (PCv).

Negative contributions are found for five regions; North, Yorkshire and Humberside, North-West, Scotland, and Northern Ireland. This is a reflection of the decreasing returns which accrue as employment falls. In these regions the value of the residual would be enhanced above its estimated value, by the introduction of economies of scale. East Anglia, which exhibited a rate of employment growth of 3.4% per annum over the period, realised a rate of growth in labour productivity 0.44 percentage points per annum over and above what might otherwise have been the case. Overall, however, the contribution of returns to scale has been relatively unimportant as a source of productivity growth.

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1. Chapter Five, pp.191-194.

2. This follows if $(1 - v)\ell$ is taken over to the L.H.S. of equation (4.28). data on 'ℓ' is given in the appendix to this Chapter, Table 4.A.1.

Table 4.7

Estimates of the Contribution of Returns to Scale to the Growth in Labour Productivity in the Regions, 1958 to 1968

Region	Cv [1] (% p.a.)	PCv [2] (%)
N	-0.02	-0.5
Y&H	-0.02	-0.5
EM	0.17	1.4
EA	0.44	7.6
SE	0.08	1.6
SW	0.18	3.9
WM	0.11	2.4
NW	-0.12	-2.3
W	0.21	5.6
S	-0.02	-0.4
NI	-0.02	-0.2
UK	0.03	0.6

1. $Cv = (v - 1)\ell_j$

2. $PCv = \frac{Cv}{r_j}$

Adjustments to the Estimates of Capital Deepening

It was demonstrated earlier that, once increasing returns are allowed, the estimates of the contribution of capital deepening to productivity growth will be biased, to the extent that the share of profits in income understates the 'true' elasticity of output with respect to capital.[1]

If returns to scale are neutral in their effects between the factors, it will raise the elasticity of both factors in proportion. Given that the elasticity of substitution is unity, and 'true' technical progress is Hicks neutral, there should be a relation between shares and output elasticities such that the true elasticity is in the same proportion to the homogeneity parameter, as the factor share is to unity. In other words, the 'true' elasticity of output with respect to capital may be estimated as;[2]

$$\beta_j = w_{kj}(v) \qquad (4.30)$$

Earlier,[3] it was argued that the estimates of technical progress and capital deepening, derived from the 'progress' constant formulation of Johansen's method (equation (4.12)), were likely to be more satisfactory than estimates derived from the 'deepening' constant formulation (equation (4.10)). A new 'progress' constant equation was devised which explicitly takes account of increasing returns.

If returns to scale are not constant the Production Function takes the form

$$Y_t = A_t K_t^{\beta} L_t^{\alpha} \qquad (4.31)$$

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1. Cf. pp.149-52 and equation (4.28).

2. In the absence of data on the 'true' elasticity this is probably the most reasonable assumption which can be made.

3. Cf. pp.125f, 135-139.

where: $\alpha + \beta = v \gtrless 1$.

Since $\alpha = v - \beta$, equation (4.31) may be rewritten as;

$$Y_t = A_t K^{\beta} L^{-\beta} L^{v} \qquad (4.32)$$

Output per unit of labour may therefore be expressed as;

$$\frac{Y_t}{L_t} = q_t = A_t (x_t)^{\beta} L_t^{\,v-1} \qquad (4.33)$$

The equation for labour productivity in the final period (t+n) will possess exactly the same form. Under the assumption that the exponents are constant over time, an expression relation final to base period labour productivity can be derived;

$$\frac{q_{t+1}}{q_t} = \frac{A_{t+1}}{A_t} \left(\frac{x_{t+1}}{x_t}\right)^{\beta} \left(\frac{L_{t+1}}{L_t}\right)^{v-1} \qquad (4.34)$$

A logarithmic transformation of equation (4.34) is;

$$Lg\left(\frac{q_{t+1}}{q_t}\right) = Lg\left(\frac{A_{t+1}}{A_t}\right) + \beta Lg\left(\frac{x_{t+1}}{x_t}\right) + (v - 1)\, Lg\left(\frac{L_{t+1}}{L_t}\right) \qquad (4.35)$$

Rearrangement of the above yields;

$$Lg\left(\frac{q_{t+1}}{q_t}\right) - (v - 1)\, Lg\left(\frac{L_{t+1}}{L_t}\right) = Lg\left(\frac{A_{t+1}}{A_t}\right) + \beta Lg\left(\frac{x_{t+1}}{x_t}\right)$$

Dividing both sides of the above by (β) yields the new 'progress' constant formulation of,[1]

$$1/_{\beta_j}\, Lg\left(\frac{q_{t+1}}{q_t}\right) - \left(\frac{v - 1}{\beta_j}\right) Lg\left(\frac{L_{t+1}}{L_t}\right) = Lg\left(\frac{x_{t+1}}{x_t}\right) + 1/_{\beta_j}\, Lg\left(\frac{A_{t+1}}{A_t}\right) \qquad (4.36)$$

Given that the 'true' rate of technical progress is constant between regions, equation (4.36) may be rewritten in the form of an estimating equation;

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1. This may be compared with equation (4.12) which is devised under the assumption of constant returns to scale.

$$Z = \lambda_6 + \lambda_7 \, {}^{1}/_{\beta_j} + u \qquad (4.37)$$

where: Z = the term on the R.H.S. of equation (4.36)

λ_6 = regression constant

λ_7 = estimate of $Lg\left(\frac{A_{t+1}}{A_t}\right)$

The estimated equation (4.37), is;

$$Z = 0.823 + \underset{(0.237)}{0.238}\, {}^{1}/_{\beta_j} - \underset{(0.068)*}{0.232}\, d_5 + \underset{(0.058)**}{0.432}\, d_6 \qquad R^2 = 0.936$$

where: d_5 = 1 for N, W; and 0 for all other regions.

d_6 = 1 for EM, NI; and 0 for all other regions.

The estimate of the coefficient on $({}^{1}/_{\beta_j})$ yields an estimated rate of technical progress of (a*=) 2.42% per annum. Table 4.8 reports the estimated contribution of technical progress to productivity growth, in each region over the period. Expressed as a proportion of productivity growth in manufacturing in the U.K. as a whole over the period, technical progress (adjusted for increasing returns to scale) appears to have contributed one-half of the increase in output per unit of labour.

The contribution of capital deepening to the growth in labour productivity in each region ($\beta_j m_j$) may be calculated as;

$$\beta_j m_j = r_j - a^*_j - (v - 1)\ell \qquad (4.38)$$

These estimates are presented in Table 4.9, together with the proportional contribution of deepening to productivity growth. On average, capital deepening was apparently responsible for one-half of the increase in labour productivity over the period.

Combining the estimated contributions of returns to scale (Table 4.7), adjusted capital deepening (Table 4.9) and technical progress, enables a comparison to be made of inter-regional difference in the source of productivity growth. The rates of productivity growth, and

Table 4.8

Proportional Contribution of Technical Progress (adjusted for increasing returns) to Regional Productivity Growth,[1] 1958-1968

Region	PCa*[2] (%)
N	63.6
Y&H	62.1
EM	33.6
EA	41.7
SE	49.4
SW	32.6
WM	52.6
NW	45.7
W	65.4
S	50.4
NI	33.6
UK	49.4

1. Derived from estimating equation (4.37) in text.

2. $PCa^* = \frac{a_j^*}{r_j}$

Table 4.9

Estimates of the 'True' Contribution of Capital Deepening to Productivity Growth in U.K. Regions ($\beta_j m_j$), 1958-1968[1]

Region	Cm[2] (% p.a.)	PCm[3] (%)
N	1.40	36.8
Y&H	1.50	38.5
EM	4.61	64.0
EA	2.94	50.6
SE	2.40	49.0
SW	2.02	43.9
WM	2.07	45.0
NW	3.02	57.0
W	1.07	28.9
S	2.40	50.0
NI	4.80	66.7
UK	2.45	52.0

1. Derived from estimating equation (4.37) in text.

2. $Cm_j = \beta_j m_j = r_j - (v - 1)\ell_j - a^*_j$

3. $PCm = \frac{Cm_j}{r_j}$

their components, are reported in Table 4.10.

For each region the overall rate of productivity growth (r_j) may be expressed as;[1]

$$r_j = a^*_j + \beta_j m_j + (v - 1)\ \ell_j \qquad (4.39)$$

and similarly for manufacturing in the U.K. as a whole;

$$r_{UK} = a^*_{UK} + \beta_{UK} m_{UK} + (v - 1)\ \ell_{UK} \qquad (4.40)$$

Subtraction of (4.40) from (4.39) yields an equation for regional productivity growth rates, expressed as deviations from the national average;

$$\Delta r_j = \Delta a^*_j + \Delta(\beta_j m_j) + \Delta((v - 1)\ \ell_j) \qquad (4.41)$$

Squaring both sides of equation (4.41) and summing over regions, yields an expression for the 'inner product'[2] of productivity growth rates of;

$$\sum_j \Delta r^2 = \sum_j \Delta a^{*2} + \sum_j \Delta(\beta m)^2 + \sum_j \Delta((v-1)\ell)^2 + R \qquad (4.42)$$

where: R includes all interaction terms and the random component.

Equation (4.42) expresses the total inter-regional variation in productivity growth rates in terms of inter-regional differences in the sources of productivity growth.

The estimates of these components, based upon the data reported in Table 4.10, are presented in Table 4.11. It is apparent that inter-regional differences in the rate, and effectiveness, of capital deepening were the most important source of differences in the rate of productivity growth between regions.

The adjusted rate of technical progress (a*) is, however, an

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1. Derived from equation (4.27).

2. Cf. Chapter One, pp.10-14.

Table 4.10

The Components of Regional Productivity Growth in U.K. Regions, 1958-1968

Region	a*	$\beta_j m_j$	$(v-1)\ell_j$	r_j
N	2.42	1.40	-0.02	3.8
Y&H	2.42	1.50	-0.02	3.9
EM	2.42	4.61	0.17	7.2
EA	2.42	2.94	0.44	5.8
SE	2.42	2.40	0.08	4.9
SW	2.42	2.02	0.18	4.6
WM	2.42	2.07	0.11	4.6
NW	2.42	3.02	-0.12	5.3
W	2.42	1.07	0.21	3.7
S	2.42	2.40	-0.02	4.8
NI	2.42	4.80	-0.02	7.2
UK	2.42	2.45	0.03	4.9

Table 4.11

Decomposition of the 'Inner Product' of Productivity Growth in the Regions,[1] 1958-1968

Source of Variation	Sum of Squares	Proportion of T.S.S. (%)
$\sum_j a^{*2}$	0.00[2]	0.0
$\sum_j \Delta(\beta_{m_2})^2$	19.19	124.7
$\sum_j \Delta(v-1)\ell^2$	0.28	1.8
Residual (Interaction)	-4.08	-26.5
$\sum_j \Delta r^2$	15.39	100.0

1. Excluding Resource Shifts.

2. Assumed to be the same in all regions.

unsatisfactory estimate of this source of productivity growth, since it will still reflect bias due to: (i) incorrect measurement of factor inputs;[1] (ii) interaction effects which have not been made explicit; (iii) it will also include the contribution of intra-regional resource shifts. In the following section of this chapter an attempt will be made to ascertain the magnitude of the latter source of regional productivity growth, and to assess its effect upon the rate of technical progress (a*) as estimated above.

The Contribution of Intra-Regional Resource Shifts to Regional Productivity Growth

The importance of resource shifts as a source of productivity growth has been stressed by various writers.[2] Some authors have attempted to explain the growth 'performance' of different countries and regions largely in terms of the potential for resource shifts, especially between agriculture and manufacturing.[3] In this section we will attempt to evaluate the importance of inter-industry resource shifts (within the manufacturing sector) to the productivity growth of the regions over the period 1958 to 1968, and the sub-period 1958-1963.

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1. Labour inputs are unadjusted for hours or 'quality'. Jorgensen and Griliches claim that a large portion of the unadjusted residual may be due to incorrect measurement of labour and capital input; see D.W. Jorgensen and Z. Griliches, "The Explanation of Productivity Change", Review of Economics and Statistics, Vol.34, 1967, pp.249-83. Whether 'quality' changes should be included under the heading of technical progress or not is a moot point; see C. Kennedy and A.P. Thirlwall, op.cit., pp.28-42.

2. B.F. Massell, op.cit., passim; R.C.O. Matthews, op.cit., pp.92-5; C. Kennedy and A.P. Thirlwall, op.cit., p.41f.

3. G.H. Borts and J.L. Stein, Economic Growth in a Free Market (New York, Columbia University Press, 1964); N. Kaldor, Causes of the Slow Rate of Economic Growth in the United Kingdom (Cambridge, C.U.P., 1966); E.F. Denison, 'Economic Growth', in R.E. Caves (et al), Britain's Economic Prospects (London, George Allen and Unwin, 1968), pp.231-78.

Given estimates of technical change in each industry in each region, it would be possible to estimate the contribution of intra-regional resource shifts using the method proposed by Massell,[1] and adopted in a previous section of this chapter. Since these estimates are unobtainable it is necessary to develop and alternative method.

The relationship between the aggregate output in the region and the output of individual industries of the region is such that;

$$Y_j = \Sigma_j Y_{ij} \tag{4.43}$$

Dividing both sides of equation (4.43) by (L_j), and multiplying by $(\frac{L_{ij}}{L_j})$ yields;

$$\frac{Y_j}{L_j} = \sum_i \frac{Y_{ij}}{L_j} = \sum_i \left(\frac{Y_{ij}}{L_{ij}} \cdot \frac{L_{ij}}{L_j} \right)$$

i.e. $$q_j = \sum_i q_{ij} . N_{ij} \tag{4.44}$$

where: $N_{ij} = \frac{L_{ij}}{L_j}$.

Totally differentiating equation (4.44) yields (for small changes),

$$dq_j = \sum_i dq_{ij} . N_{ij} + \sum_i q_{ij} . dN_{ij} \tag{4.45}$$

Dividing both sides of equation (4.45) by q_j, yields an expression for

1. B.F. Massell, op.cit., pp.547-50.

total productivity growth of;[1]

$$\frac{dq_j}{q_j} = \sum_i \frac{dq_{ij}.N_{ij}}{q_j} + \sum_i \frac{q_{ij}.dN_{ij}}{q_j} \qquad (4.46)$$

The last term on the R.H.S. of equation (4.46) is thus an estimate of the contribution of intra-regional resource shifts (CRS) to regional productivity growth, and is identical to the measure expressed by Denison.[2]

Estimates of the contribution of intra-regional resource shifts to regional productivity growth over the period 1958-1963, calculated on this basis, are given in Table 4.12. The first column of the table reports the estimates of the contribution of inter-industry shifts to regional productivity growth and is equivalent (in 'per annum' terms) to the last term on the R.H.S. of equation (4.46). It is apparent that in two regions (North and Wales) resource shifts were tending to

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1. Since the estimates to be reported in the paper refer to a period of five years, the total growth in productivity (r) per annum is calculated as;

$$r = \sqrt[n]{\frac{q_j + dq_j}{q_j}} - 1$$

and the 'per annum' contribution of resource shifts is calculated as;

$$CRS = \sqrt[n]{\frac{q_j + \sum_i q_{ij}.dN_{ij}}{q_j}} - 1$$

As the contribution of resource shifts is measured applying base period price weights (q_j is the value of output per worker in the base year), it does not require adjustment for price changes, provided the estimate of total productivity growth is adjusted for this factor. (See note 1, p.132).

2. E.F. Denison, The Sources of Economic Growth in the United States, (New York, Committee for Economic Development, 1962), p.225.

Table 4.12

Estimates of the Contribution of Intra-Regional Resource Shifts to the Aggregate Rate of Productivity Growth in the Regions, 1958-1963[1]

Region	CRS[2] (% p.a.)	PCRS[3] (%)
N	-0.1	-2.6
Y&H	0.2	5.3
EM	0.2	4.8
EA	2.6	51.8
SE	0.0	0.0
SW	0.3	6.0
WM	0.0	0.0
NW	0.4	8.5
W	-0.3	-8.1
S	0.2	4.2
NI	0.2	2.9
UK	-0.1	-2.2

1. Manufacturing Industries Only.

2. $CRS_j = \sqrt[n]{\dfrac{q_j + \Sigma_i q_{ij} . dN_{ij}}{q_j}} - 1$

3. $PCRS = \dfrac{CRS_j}{r_j}$

reduce the productivity of labour (in manufacturing as a whole). In two other regions (South East and West Midlands) resource shifts contributed nothing (on balance) to the growth in aggregate labour productivity. These conclusions are broadly in agreement with the findings with respect to changing unit labour costs, referred to earlier.[1]

East Anglia stands out as the region where resource shifts contributed most to the increase in labour productivity over the period, roughly one-half of the total increase in labour productivity being attributable to this source. This may almost entirely be explained by the relatively large expansion of the region's work force in Vehicles (SIC VIII) (from 1.4% to 7.8%) over the period.

With the exception of this region the estimated rates of technical progress over the period (1958 to 1963) are largely unaffected.[2]

The analysis was repeated for the whole of the period 1958 to 1968, using tentative estimates of the allocation of the regional manufacturing work force in 1968.[3] The estimates are marred somewhat by the change in the classification of industries introduced in the 1968 Census,[4] but this is unavoidable.

The estimates of the contribution of intra-regional resource shifts

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1. Cf. Chapter Two, pp.53-56.

2. Although if the rates of technical progress as presented in Tables 4.3 and 4.4 were accepted, this would result in a negative rate of technical progress in East Anglia of -1.7 (0.9-2.6) in Table 4.3, and -0.5 (2.1-2.6) in Table 4.5.

3. This data is reported in Board of Trade, "Area Analyses of the Provisional Results of the Census of Production for 1968", Board of Trade Journal, Vol.199, 1970, pp.488-496.

4. Some details of the changed classification are given in, Board of Trade, op.cit., p.492.

to regional productivity growth over the period 1958 to 1968 are presented in Table 4.13. The relatively high estimate for East Anglia is due primarily to the expansion in the Vehicles industry in that region over the period 1958 to 1963. The high estimate for Scotland is due mainly to the expansion in Metal Manufactures in that region over the period. No single determinant can be cited as responsible for the negative contribution in the North, although the decline in Chemicals and Allied Industries together with Shipbuilding and Marine Engineering may largely account for this result.

The proportional contribution of resource shifts to regional productivity growth also indicates the magnitude of the aggregation problem, inherent in the use of aggregate production functions.[1] This seems to be a minor problem with the exception of East Anglia and the North. In all the other regions the aggregative analysis is able to account for over ninety per cent (100% - PCRS) of productivity growth over the period.[2]

Technical Progress over the Period 1958-1968 Including an Allowance for Intra-Regional Resource Shifts.

It was noted earlier, that the estimated rates of technical progress, even after allowance was made for increasing returns to scale (i.e. a*), will include the effect of intra-regional resource shifts. Given the estimates of the contribution of intra-regional resource shifts (CRS), obtained in the preceding section, some attempt may now be made to take these effects into account. Using the estimates for the period 1958-1968 the rate of technical progress, adjusted for intra-regional resource

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1. B.F. Massell, op.cit., p.549f.

2. It must be emphasised that interaction effects have been neglected.

Table 4.13

Estimates of the Contribution of Intra-Regional Resource Shifts to the Aggregate Rate of Productivity Growth in The Regions, 1958-1968[1]

Region	CRS[2] (% p.a.)	PCRS[3] (%)
N	-0.6	-15.8
Y&H	-0.1	-2.6
EM	0.5	6.9
EA	1.4	24.2
SE	0.2	4.1
SW	-0.1	-2.2
WM	0.1	2.2
NW	0.4	7.5
W	0.1	2.7
S	0.6	12.5
NI	0.5	6.9
UK	0.1	2.0

1. Manufacturing Industries Only

2. $CRS = \sqrt[n]{\frac{q_j + \sum_i q_{ij}.dN_{ij}}{q_j}}$

3. $PCRS = \frac{CRS}{r}$

shifts (a**), may be calculated as;

$$a^{**}_j = a^*_j - CRS_j \qquad (4.47)$$

Table 4.14 reports the estimates of a** for the period 1958-1968.[1] Table 4.15 brings together the estimates of the sources of productivity growth in regional manufacturing over the period 1958-1968, including the contribution of intra-regional resource shifts.

The contribution of each of the components to the differences in productivity growth rates between regions, may be evaluated in a manner analogous to that presented earlier.[2] The total variation in productivity growth rates (expressed as squared deviations from the national rate) may be expressed as;

$$\sum_j \Delta r^2 = \sum_j \Delta a^{**2} + \sum_j \Delta(\beta m)^2 + \sum_j \Delta((v-1)\ell)^2 + \Sigma\Delta(CRS)^2 + R \qquad (4.48)$$

Table 4.16 reports the magnitude of the elements in equation (4.48), and the proportional contribution of each to the total variation in productivity growth rates. It is apparent that once deepening is allowed for, intra-regional resource shifts are the most important source of differences in productivity growth rates. The largest source of differences in the rate of productivity growth between regions, even after adjustments for returns to scale and resource shifts, remains that of differences in the rate and effectiveness of capital accumulation. The major determinant of the level of productivity growth in any region appears to be the rate of technical progress. It must be stressed, that this is likely to be an overestimate of the role of technical progress, as the analysis is based upon a model which assumes that

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1. (a*) is taken from Table 4.10 and (CRS_j) is taken from Table 4.13.
2. Cf. pp.156-161.

Table 4.14

Estimated Rates of Technical Progress, Adjusted for Resource Shifts: U.K. Regions, 1958-1968

Region	a**[1]	PCa**[2]
N	3.02	79.5
YH	2.52	64.7
EM	1.92	26.7
EA	1.02	17.6
SE	2.22	45.3
SW	2.52	54.8
WM	2.32	50.5
NW	2.02	38.1
W	2.32	62.7
S	1.82	38.0
NI	1.92	26.7
UK	2.32	47.4

1. $a^{**} = a^{*} - CRS_j$

2. $PCa^{**} = \frac{a^{**}_j}{r_j}$

Table 4.15

Components of Productivity Growth in the Manufacturing Sector of U.K. Regions, including Resource Shifts, 1958-1968

Region	a**[1]	βm[2]	$(v-1)\ell$[3]	CRS[4]	r_j
N	3.02	1.40	-0.02	-0.6	3.8
Y&H	2.52	1.50	-0.02	-0.1	3.9
EM	1.92	4.61	0.17	0.5	7.2
EA	1.02	2.94	0.44	1.4	5.8
SE	2.22	2.40	0.08	0.2	4.9
SW	2.52	2.02	0.18	-0.1	4.6
WM	2.32	2.07	0.11	0.1	4.6
NW	2.02	3.02	-0.12	0.4	5.3
W	2.32	1.07	0.21	0.1	3.7
S	1.82	0.40	-0.02	0.6	4.8
NI	1.92	4.80	-0.02	0.5	7.2
UK	2.32	2.45	0.03	0.1	4.9

1. From Table 4.14.

2. From Table 4.9.

3. From Table 4.7.

4. From Table 4.13.

Table 4.16

Decomposition of the 'Inner Product' of Productivity Growth in Manufacturing Activities in the Regions, 1958-1968.

Source of Variation	Sum of Squares	Proportion of T.S.S.(%)
$\Sigma_j \Delta a^{**2}$	2.93	19.0
$\Sigma_j \Delta(\beta m_2)^2$	19.19	124.7
$\Sigma_j \Delta(v-1)\ell^2$	0.28	1.8
$\Sigma_j \Delta CRS^2$	2.93	19.0
Residual (Interaction)	-9.94	-64.6
$\Sigma_j \Delta r^2$	15.39	100.0

technical progress is disembodied. Once a vintage approach is adopted (or some other model,[1] perhaps including 'learning', which explicitly recognises that part of 'technical progress' is embodied in capital equipment), the importance of capital accumulation as a determinant, not only of differences in, but also the level of, productivity growth, would be enhanced.

The main conclusions of this chapter may be stated as follows;

1. The 'technical change constant' variant of Johansen's model appears to provide the basis for valid estimates of the components of regional productivity growth, in the manufacturing sector of the U.K. economy.
2. Given the above, it follows that variations in the rate and effectiveness of capital deepening were the major sources of differences in the rates of productivity growth between regions.
3. Although over the period 1958-1968 the inter-regional re-allocation of resources and activities served to slightly increase the national rate of productivity growth, there is some evidence to suggest that over the sub-period 1958-1963 the inter-regional resource shifts tended to reduce the national rate of productivity growth.
4. That intra-regional resource shifts are an important source of differences in productivity growth rates, although they contributed little to productivity growth in any one region.
5. That returns to scale are, in the main, unimportant as a source of levels of, or differences in, the rate of productivity growth in the regions.

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1. For example: W.E.G. Salter, "Productivity Growth and Accumulation as Historical Processes", in E.A.G. Robinson (ed.), Problems in Economic Development, I.E.A. (London, Macmillan, 1965), pp.266-91; R.M. Solow, 'Investment and Technical Progress', in K.J. Arrow et al (eds.), Mathematical Methods in the Social Sciences (Stanford, Stanford University Press, 1960), pp.89-104; C. Kennedy and A.P. Thirlwall, op.cit., pp.31-6.

Appendix Table 4.A1

Data used in the study of productivity growth in the manufacturing sector of the regions: 1958-1968[1]

Region	$q_j 68/q_j 58$[2]	w_{kj}[3]	r_j^m[4]	r_j[5]	ℓ[6]
N	1.80	0.50	6.0	3.8	-0.1
Y&H	1.81	0.46	6.1	3.9	-0.1
EM	2.46	0.46	9.4	7.2	1.3
EA	2.16	0.50	8.0	5.8	3.4
SE	1.99	0.49	7.1	4.9	0.6
SW	1.93	0.43	6.8	4.6	1.4
WM	1.93	0.43	6.8	4.6	0.8
NW	2.06	0.47	7.5	5.3	-0.9
W	1.77	0.50	5.9	3.7	1.6
S	1.97	0.49	7.0	4.8	-0.2
NI	2.46	0.46	9.4	7.2	-0.1
UK	2.03	0.47	7.1	4.9	0.3

1. Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133; "Area analyses of the provisional results of the Census of Production for 1968", Board of Trade Journal, Vol.199, 1970, pp.488-496.

2. Value of net output per employee in 1968, expressed as a proportion of the value of net output per employee in 1958.

3. w_{kj} equals unity minus the share of wages and salaries in net output (i.e. $w_{kj} = 1 - \frac{W_j}{y_j}$) in 1963.

4. Average annual rate of growth of the value of output per employee, 1958-1968.

5. Estimated rate of growth of real output per employee ($r_j = r_j^m - p_j$ where p = average annual rate of growth of wholesale prices of all manufacturing products over the period 1958-1968 - for the U.K. as a whole = 2.2% p.a.)
Source of price data: London and Cambridge Economic Service, The British Economy Key Statistics 1900-1970 (London, Times Newspapers Ltd., 1972), p.8.

6. Average annual rate of growth of employment (% p.a.).

Appendix Table 4.A2

Data used in the study of productivity growth in manufacturing industries in each region of the U.K.: 1958-1963[1]

Region	r^m_j [2]	r_j [3]	dW/W^m_j [4]	dW/W_j [5]	$\bar{w}_{kj}$ [6]
N	5.4	3.8	3.8	2.2	0.48
Y&H	5.4	3.8	4.5	2.9	0.45
EM	5.8	4.2	4.1	2.5	0.44
EA	6.6	5.0	4.7	3.1	0.48
SE	6.6	5.0	4.6	3.0	0.46
SW	6.6	5.0	4.8	3.2	0.46
WM	6.0	4.4	4.8	3.2	0.42
NW	6.3	4.7	5.1	3.5	0.46
W	5.3	3.7	4.8	3.2	0.49
S	6.4	4.8	4.3	2.7	0.47
NI	8.5	6.9	5.3	3.7	0.42
UK	6.2	4.6	4.6	3.0	0.45

1. Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133.

2. Average annual rate of growth in the value of output per employee, 1958-1963.

3. $r_j = r^m_j - p$; where p = average annual rate of growth of wholesale prices of all manufacturing products in the U.K. (1958-1963), p = 1.6%.
Source of price data: London and Cambridge Economic Service, The British Economy Key Statistics 1900-1970 (London, Times Newspapers Ltd., 1972), p.8.

4. Average annual rate of growth of the value of wages and salaries paid per employee in manufacturing.

5. $dW/W_j = \frac{dW^m_j}{W^m_j} - p$; where p = 1.6%

6. $\bar{w}_{kj}$ is the average of the 1958 and 1963 values for the non-wage and salary share in net output $(\bar{w}_{kj} = 1 - \frac{W_j}{Y_j})$.

Chapter Five

The Elasticity of Substitution and the Degree of Returns to Scale in U.K. Manufacturing Industries: 1958 and 1963

At various stages in the previous chapters we have had occasion to refer to estimates of the elasticity of substitution,[1] and the degree of returns to scale,[2] in U.K. manufacturing industries. In this chapter the source and derivation of these estimates will be presented, together with a critical evaluation of the neoclassical model on which they are based. These estimates are not only important in the context of theories of inter-regional trade and economic growth, but are also of some concern to policy makers, especially insofar as they enter into the determination of the demand for labour.[3]

Previous estimates of the elasticity of substitution and the degree of returns to scale, reported by Feldstein,[4] were made upon an inter-industry basis for the years 1954, 1957 and 1960. Feldstein stated, after a brief discussion of the deficiencies of the inter-industry estimates, that; "Unfortunately, no cross-section intra-industry data exist for Britain. This is a serious deficiency."[5] The second section of this chapter presents intra-industry estimates of the elasticity of substitution, and the degree of returns to scale, in U.K. manufacturing industries for the years 1958 and 1963. These estimates are based upon

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1. Especially Chapter Two, p.46f, and Chapter Four, pp.118-126.

2. Especially Chapter Two, pp.29-31, and Chapter Four, pp.149-153.

3. Joan Robinson, The Economics of Imperfect Competition (Second ed., London, Macmillan, 1969), p.257.

4. M.S. Feldstein, "Alternative Methods of Estimating a CES Production Function for Britain", Economica, Vol.34, 1967, pp.384-394.

5. Ibid., p.386.

the Regional tables of the 1963 Census of Production,[1] which affords the opportunity of deriving estimates both for aggregate manufacturing as well as for separate industries. The final section of the chapter attempts to evaluate the validity of the estimates. This is undertaken in the light of a recent paper by Franklin Fisher,[2] in which he questions the propriety of econometric estimation of production function parameters. The first part of the chapter presents a brief discussion of the concept of the elasticity of substitution together with the estimation procedures adopted in this study.

The Elasticity of Substitution

It is possible to distinguish between two 'variants' of the elasticity of substitution; one the 'technical elasticity of substitution', and the other the 'price elasticity of substitution'. The 'technical' elasticity of substitution[3] is a technological parameter which expresses the configuration of the production surface. It is a measure of the 'shape' of an isoquant, and is thus a 'standardised' or 'unit-free' measure of the rate of technical substitution. It (σ_t) may be defined as;

$$\sigma_t = \frac{d(K/L)}{K/L} \bigg/ \frac{dR}{R} \qquad (5.1)$$

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1. Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133.

2. F.M. Fisher, "Aggregate Production Functions and the Explanation of Wages: A Simulation Experiment", Review of Economics and Statistics, Vol.53, 1971, pp.305-325.

3. Joan Robinson refers to this as the more fundamental definition of the two. See J.Robinson, op.cit., p.330n; J.R. Hicks, The Theory of Wages (Second ed., London, Macmillan, 1963), p.117.

where: R = Marginal Rate of Technical Substitution

$$= \frac{MP_L}{MP_K} ;$$

and MP_i = Marginal Product of factor of production i.

It is also possible to conceive of the elasticity of substitution as an economic, rather than a technical, parameter. In this sense the 'price' elasticity of substitution expresses the relationship between a proportionate change in relative factor prices, and the proportionate change in relative factor quantities utilised in the production process. It (σ_p) may be defined as;

$$\sigma p = \frac{d(K/L)}{K/L} \Bigg/ \frac{d\left(\frac{W}{r}\right)}{\frac{W}{r}} \qquad (5.2)$$

where: W = wage rate;

r = rental per unit of capital.

Given that factors are rewarded according to their marginal products, the values of the two elasticities (σ_t and σ_p) are identical. It would then be possible to infer the value of the (unobservable) technical elasticity of substitution, from an estimate of the price elasticity of substitution. This is not possible here however, because the necessary capital and rental data are unavailable. An indirect methodis therefore required if an estimate is to be obtained of the elasticity of substitution.

Arrow, Chenery, Minhas and Solow presented an alternative procedure in 1961.[1] This method makes use of an 'equivalence relation', derived

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1. K.J. Arrow, H.B. Chenery, B.S. Minhas and R.M. Solow, "Capital-Labor Substitution and Economic Efficiency", Review of Economics and Statistics, Vol.43, 1961, pp.225-250.

earlier by R.G.D. Allen,[1] whereby the value of the elasticity of substitution is shown to be equal to the ratio of the proportionate change in output per employee (average product), to the proportionate change in the wage rate (marginal product). This relation, and the conditions under which it will hold, may be demonstrated as follows. We define a 'Cost or Distribution Function' as;[2]

$$Y = wL + rK + \pi \tag{5.3}$$

where: π = (Abnormal) Profit.

Assuming perfect competition and constant returns to scale;[3] dividing both sides by (L), yields;

$$Y/L = w + rK/L$$

$$\text{or,} \quad q = w + rx \tag{5.4}$$

Expressing the total differential of (5.4) as;

$$dq = dw + dr.x + r.dx$$

It follows that;

$$\frac{dq}{dx} = \frac{dw}{dx} + \frac{dr}{dx}.x + r \tag{5.5}$$

If factors are rewarded according to their marginal products (i.e. $r = \frac{dq}{dx}$) it follows from (5.5) that;

$$\frac{dq}{dx} - r = \frac{dw}{dx} + \frac{dr}{dx} \cdot x = 0$$

and thus;

$$\frac{dw}{dx} = -\frac{dr}{dx} \cdot x \tag{5.6}$$

or, alternatively;

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1. R.G.D. Allen, Mathematical Analysis for Economists (London, Macmillan, 1938), pp.340-343.

2. All variables are measured in real terms.

3. i.e. abnormal profits are zero.

$$\frac{dw}{dr} = -x \tag{5.7}$$

Taken together, equations (5.4) and (5.7) imply that the 'Factor Price Frontier' (FPF),[1] for each technique, is a straight line. While this is a reasonable 'parable' in a world of 'jelly' capital, the conditions under which the above equations will hold in a world of heterogeneous capital goods are quite special; specifically, only if each activity has the same 'organic composition' of capital.[2]

Given the above, together with the assumption that there are enough different techniques to generate a smooth FPF 'envelope',[3] we are now in a position to derive the 'equivalence relation' for the elasticity of substitution.

Assuming that the 'price' (σ_p) and technical (σ_t) elasticities are equal in value, the elasticity of substitution (σ) may be written as;

$$\sigma = \frac{dx}{x} \bigg/ \frac{d(\frac{W}{r})}{\frac{W}{r}} \tag{5.2}$$

The denominator or (5.2) may be expanded as follows;

$$\sigma = \frac{dx}{x} \cdot \frac{1}{\frac{dw}{w} - \frac{dr}{r}} = \frac{dx}{x} \cdot \frac{1}{\frac{rdw - wdr}{rw}}$$

and therefore;

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1. As expressed in P.A. Samuelson, "Parable and Realism in Capital Theory: The Surrogate Production Function", Review of Economic Studies, Vol.39, 1962, pp.193-206.

2. See A. Bhaduri, "On the significance of Recent Controversies on Capital Theory: A Marxian View", Economic Journal, Vol.79, 1969, pp.532-9; P. Garegnani, "Heterogeneous Capital, the Production Function and the Theory of Distribution, Review of Economic Studies, Vol.37, 1970, pp.407-36; G.C. Harcourt, Some Cambridge Controversies in the Theory of Capital (Cambridge, C.U.P., 1972), pp.131-149.

3. P. Garegnani, op.cit., passim.

$$\sigma = \frac{dx.w.r}{x.r.dw - d.w.dr} = \frac{w.r}{x.r.\frac{dw}{dx} - x.\frac{dr}{dx}.w} \qquad (5.8)$$

Substitution from (5.6) into the denominator of (5.8) yields;

$$\sigma = \frac{w.r}{x.r.\frac{dw}{dx} + \frac{dw}{dx}.w} = \frac{w.r}{(x.r + w)\,\frac{dw}{dx}} \qquad (5.9)$$

Substitution of (5.4) into (5.9) gives;

$$\sigma = \frac{w.r.}{q.\frac{dw}{dx}}$$

Since, by assumption $r = \frac{dq}{dx}$, the above expression may be rewritten as;

$$\sigma = \frac{w.dq}{q.dw} = \frac{dq}{q} \Big/ \frac{dw}{w}$$

alternatively,

$$\sigma = \frac{d\ Lg\ q}{d\ Lg\ w} \qquad (5.10)$$

It follows from equation (5.10) that one measure of the elasticity of substitution corresponds to the coefficient (b) in the estimating equation;

$$Lg\ q = Lg\ a + b\ Lg\ w + \varepsilon \qquad (5.11)$$

where: ε = error term.

It has been demonstrated elsewhere[1] that the relationship expressed in equation (5.11) can be derived, under the assumptions stated above, from a production function of the following form;

$$Y = \gamma \left[\delta K^{-\rho} + (1 - \delta)\ L^{-\rho} \right]^{-1/\rho} \qquad (5.12)$$

More interesting perhaps is the corollary of the above, namely that a production function of the same form as (5.12) may be derived by integration, under neoclassical assumptions, from the estimating equation (5.11).[2]

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1. K.J. Arrow et al, op.cit., p.230.

2. Ibid., p.228.

The estimating equation (5.11) has the particular advantages of not requiring estimates of the capital stock, and is easily computed. The following section of this chapter will report upon the estimates of the elasticity of substitution arrived at by the application of equation (5.11) to regional cross-section data for the U.K.

The Estimation Procedure

We begin this section with a discussion of the estimation problems associated with equation (5.11). The elasticity of substitution will be estimated by using cross-section data referring to the operations of each industry group, in the regions of the U.K., in the years 1958 and 1963.

If the observations within any industry represent different points on the same representative isoquant, and factor price ratios are variable between regions, a large segment of the representative isoquant may be revealed. There are thus two important conditions in the argument.

One condition requires that the observations reflect points of tangency, or 'optimal' points on isoquants. It is necessary to assume therefore, that the observations of average product and the wage are generated by firms using optimal input combinations given ruling factor prices. This implies that firms conform to neoclassical assumptions as regards profit maximisation, perfect foresight, perfect competition, the absence of 'abnormal' profits and marginal productivity factor pricing.

The other condition entails the assumption that the observations, as points on different isoquants, can be 'collapsed' onto a representative isoquant, exhibiting a Constant Elasticity of Substitution.[1] This condition, that the observations can be treated 'as if' they come from the same isoquant, is dependent upon two assumptions. Firstly, that the production function exhibits constant returns to scale. This implies that the average product of labour depends solely upon the capital-labour ratio.[2] Secondly, it must be assumed that the observations are taken from different points on the same production surface. In other words, that the choice of techniques facing firms in the same industry in different regions, is identical.

It is only if these assumptions hold that it is possible to conceive of, and measure, the elasticity of substitution for an industry using the method proposed.[3] It must be stressed, however, that the existence (or significance) of the relationship embodied in equation (5.11) cannot itself be construed as evidence for the existence of a production function, or that such a function is common to all regions. Nor can it be taken as evidence for the fulfilment of any of the assumptions of the neoclassical model.[4]

It should also be noted that throughout the theoretical discussion and derivation of equation (5.11) all variables were expressed in real

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1. These are the assumptions required for estimation. The equally restrictive assumptions required, in theory, to derive the estimating equation itself were discussed in the first section of the chapter.

2. The consequences of dropping this assumption will be discussed in a later section of this chapter.

3. Assuming also that two 'econometric' requirements are satisfied:
   (i) that the wage rate is exogenous, and
   (ii) that the wage rate does not vary systematically with differences in the efficiency parameter (γ).

4. K.J. Arrow et al, <u>op.cit.</u>, p232. We will return to this point in a later section of this chapter.

terms. Since regional price data is not available for the U.K., all of the estimating equations presented in this chapter are expressed in money, not real, terms.

Thus equation (5.11) is estimated as;

$$Lg\ (^V/_L) = Lg\ a_1 + b_1\ Lg\ (\frac{W}{L}) \qquad (5.13)$$

where: V = value added in money terms;

W = money wage bill;

L = total employment.

Whereas the 'true' estimating equation should be;

$$Lg\ (^V/_L \cdot \frac{1}{P}) = Lg\ a + b\ Lg\ (\frac{W}{L} \cdot \frac{1}{P}) \qquad (5.11a)$$

where: P = regional price series.

Equation (5.11a) is equivalent to;

$$Lg\ (^V/_L) - Lg\ P = Lg\ a + b\ Lg\ (^W/_L) - b\ Lg\ P$$

which may be rewritten as;

$$Lg\ (^V/_L) = Lg\ a + b\ Lg\ (^W/_L) + (1-b)\ Lg\ P \qquad (5.14)$$

Estimating the equation in money, instead of real, terms is equivalent to leaving out the last term ((1-b) Lg P) in the 'true' estimating equation (5.14).

The extent to which our estimate of b ($\hat{b}_1$) will diverge from the true value of b, may be expressed as follows;[1]

$$E(\hat{b}_1) = b + (1 - b) . \beta_{2.3}$$

$$\text{or} \quad E(\hat{b}_1) - b = (1 - b) . \beta_{2.3} \qquad (5.15)$$

where: $\beta_{2.3}$ = simple regression coefficient of Lg $(^W/_L)$ on Lg P.

Note that if the price index is identical for all regions, the

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1. A.A. Walters, An Introduction to Econometrics (London, Macmillan, 1968), p.200f.

coefficient $\beta_{2.3}$ in equation (5.15) is equal to zero, and thus no bias will result. To the extent that prices do vary between regions we would expect $\beta_{2.3}$ to be positive. It follows from equation (5.15), that if the 'true' elasticity of substitution (b) is less than unity, the estimate ($\hat{b}_1$) will be biased upwards. If b is greater than unity, the estimate ($\hat{b}_1$) will be biased downwards. As a result of neglecting the price deflator, there is a built-in bias towards an estimated elasticity of substitution of unity; i.e. the Cobb-Douglas case.[1]

The analysis is complicated further if factor rewards are not equal to their marginal products. Estimation techniques appropriate to this situation have been discussed by Dhrymes,[2] Feldstein[3] and Katz.[4] Since the data necessary to perform such experiments is unavailable the matter will not be pursued further.[5] The analysis will proceed upon the assumption that the 'degree of imperfection' is the same in all regions.

Equation (5.13) was estimated by Ordinary Least Square, using cross-section data for 1958 and 1963, obtained from the Regional tables of the

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1. M. Nerlove, 'Recent Empirical Studies of the C.E.S. and Related Production Functions', in M. Brown (ed.), <u>The Theory and Empirical Analysis of Production</u>, N.B.E.R. Studies in Income and Wealth, Vol.31 (Columbia, Columbia University Press, 1967), p.73f.

2. P.J. Dhrymes, "Some Extensions and Tests for the C.E.S. Class of Production Functions", <u>Review of Economics and Statistics</u>, Vol.47, 1965, pp.357-66; P.J. Dhrymes and P. Zarembka, "Elasticities of Substitution for Two-Digit Manufacturing Industries: A Correction", <u>Review of Economics and Statistics</u>, Vol.52, 1970, pp.115-7.

3. M.S. Feldstein, <u>op.cit.</u>, p.388f.

4. J.M. Katz, <u>Production Functions, Foreign Investment and Growth</u>, (Amsterdam, North-Holland, 1969), pp.70-5.

5. M.S. Feldstein, <u>op.cit.</u>, p.389.

Census of Production.[1] Estimates were obtained for aggregate manufacturing and for all SIC orders in 1958 and 1963, and also for certain Minimum List Headings (MLH) in 1963.[2]

Description of the Data and Estimates

Net Output (V): ". . . represents the value added to materials by the process of production."

Wages and Salaries (w): "These are the amounts paid during the year to operatives, and to administrative, technical and clerical employees, . . . no deduction is made for income tax, insurances, contributory pensions, etc."

Employees (L): Includes all ". . . administrative, technical and clerical employees . . . and . . . all other classes of employees, i.e. . . ., all manual wage earners."[3]

When equation (5.13) was fitted to aggregate data for the years 1958 and 1963, the equations, as estimated, were;[4]

$$(1958):\quad Lg\,(V/L) = 0.756 + \underset{(0.126)^{**}}{1.317}\,Lg\,(W/L) \qquad R^2 = 0.924$$

$$(1963):\quad Lg\,(V/L) = 0.679 + \underset{(0.132)^{**}}{1.089}\,Lg\,(W/L) \qquad R^2 = 0.883$$

1. Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133.

2. Due to the 'disclosure rule' (Board of Trade, op.cit., Part 1), the number of observations varies for different industries, the maximum being eleven. Results are not reported for those MLH Industries for which the number of observations is less than eight.

3. Full descriptions may be found in, Board of Trade, op.cit., pp.11-15.

4. Figures in brackets are standard errors. Asterisks indicate significance levels:

   * - significantly different from zero at the 5 per cent level
   ** - significantly different from zero at the 1 per cent level.

The estimates of the elasticity of substitution do not differ significantly from each other. Whilst the estimated elasticity of substitution is significantly greater than unity (at the 5 per cent level)[1] in 1958, it is not significantly different from unity at the 5 per cent level for 1963.[2] It may be concluded that the Cobb-Douglas production function, as applied in Chapter Four, does provide a reasonable approximation to the prevailing technology at the aggregate level.

The size of the R^2 indicates that over 88% of the variation in labour productivity between regions may be accounted for by variations in the wage rate. If the assumptions of the model are accepted, this result implies that over three-quarters of the differences in labour productivity between regions may be accounted for by differences in the capital-labour ratio.[3]

Estimates of the elasticity of substitution for SIC orders are presented in Table 5.1. Rather surprisingly, Shipbuilding and Marine Engineering (SIC VII), and Vehicles (SIC VIII) appear to have a very high elasticity of substitution.[4] Most of the other estimates are either not significantly different from zero, indicating fixed coefficients, or else grouped around unity - the Cobb-Douglas case. Table 5.2 presents a breakdown of the estimates according to whether

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1. But not at the 1 per cent level of significance.

2. It is interesting to note that the share of wages in the value added in U.K. Manufacturing fell by around 6 per cent over the period 1958-1963.

3. K.J. Arrow et al, <u>op.cit.</u>, p.228. This aspect of the results will be further developed in Chapter Six.

4. This may be a reflection of the level of aggregation.

Table 5.1

Estimates of the Elasticity of Substitution ($\hat{b}_1$) in U.K. Manufacturing Industries: 1958 and 1963 (S.I.C. Order Level)[1]

SIC[2] No.	1958			1963		
	$\hat{b}_1$	s.e.$\hat{b}_1$[3]	R^2	$\hat{b}_1$	s.e.$\hat{b}_1$	R^2
III	1.4252	0.4210**	.560	0.7244	0.4364	.234
IV	0.5004	0.2599	.292	1.7160	0.5822*	.491
V	0.9594	0.3728*	.495	0.6539	0.2227*	.489
VI	1.1972	0.3185**	.611	0.5867	0.4469	.161
VII	2.7070	1.2626	.396	1.1421	0.4748*	.452
VIII	2.1165	0.1583**	.962	1.2263	0.6762	.320
IX	0.5926	0.2247*	.436	1.0285	0.3296*	.520
X	1.4376	0.2399**	.800	1.9164	0.3541**	.765
XI	0.8416	0.4194	.309	1.2937	0.4063*	.530
XII	1.0000	0.1682**	.797	1.0157	0.1942**	.752
XIII	0.8150	0.2009**	.647	1.1944	0.6650**	.839
XIV	0.2952	0.2424	.142	0.9894	0.1830**	.765
XV	0.7694	0.0817**	.908	1.0919	0.2034**	.762
XVI	1.0082	0.1732**	.790	1.2393	0.1940**	.819
Total Man.	1.3172	0.1258**	.924	1.0886	0.1318**	.883

1. Coefficient estimated from equation (5.13) in text.

2. A detailed list of the SIC and MLH abbreviations can be found in the Appendix to this chapter, Table 5.A1.

3. s.e. = standard error of regression coefficient.
   * : indicates coefficient significantly different from zero at the 5 per cent level.
   ** : indicates coefficient significantly different from zero at the 1 per cent level.

Table 5.2

Significance tests on the estimate of σ . ($\hat{b}_1$)
1958 and 1963[1]

Value of	1958		1963		Total	
	No.	%	No.	%	No.	%
σ = 0	4	29	3	21	7	25
σ < 1	1	7	0	0	1	4
σ = 1	8	57	10	71	18	64
σ > 1	1	7	1	7	2	7
Total	14	100	14	100	28	100

1. The 5 per cent significant level is used throughout.

the implied value for the elasticity of substitution is significantly different from zero, or unity; the two values most significant in terms of theory.[1] Out of 28 cases (14 each year) seven are not significantly different from zero, and eighteen of the total are not significantly different from unity. Only three of the industries exhibited values of the elasticity of substitution not equal to zero or one. These were Paper, Printing and Publishing (SIC XV, in 1958), $\sigma < 1$; Vehicles (SIC VIII, 1958), $\sigma > 1$; and Textiles (SIC X, in 1963), $\sigma > 1$.

The next most striking feature is the instability of the estimates. The coefficient of rank correlation between the estimates for 1958, and those for 1963, is -0.200, which is not statistically significant. In particular, Vehicles (SIC VIII), which in 1958 had an implied value of the elasticity of substitution greater than unity at the 1 per cent level of significance, had an elasticity of substitution not significantly different from zero in 1963. In one respect at least (the diversity of results) this study is in accord with the findings of other workers in this field.[2]

It is also clear from Table 5.2 that it cannot be assumed that the elasticity of substitution is identical in all activities. This implies that, in the context of the Heckscher-Ohlin theorem, factor reversals are likely to occur.[3]

The regression equation (5.13) was also fitted to fifty-eight MLH

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1. For an application to U.S. data, see C.E. Ferguson, "Cross-Sectional Production Functions and the Elasticity of Substitution in American Manufacturing", Review of Economics and Statistics, Vol.45, 1963, pp.305-313.

2. M. Nerlove, op.cit., p.58.

3. Cf. the discussion in Chapter Two, p.46f.

industries for which cross-section data is available for 1963. The detailed estimates of these coefficients are reported in the Appendix to this Chapter, Table 5.A2. Table 5.3 presents the results of significance tests upon the estimated values of the elasticity of substitution. Approximately forty per cent of the industries have estimates which are not significantly different from zero. If we are prepared to accept the existence of a C.E.S. production function on a priori grounds, the number of insignificant coefficients would imply that something over one-third of the industries covered in this study (and thus one-sixth of all U.K. manufacturing industries), produce under conditions of fixed coefficients, ($\hat{\sigma} = 0$).

Non-Constant Returns to Scale

If returns to scale are not constant then output per unit of labour is not only dependent on the capital-labour ratio, but also on the level of output.

The estimating equation should therefore be;

$$Lg\,(Y/L) = Lg\ a + b_2\ Lg\ w + b_3\ Lg\ Y \qquad (5.16)$$

It has been demonstrated[1] that given a production function of the form

$$Y = \gamma \left[K^{-\rho} + (1 - \delta)\, L^{-\rho} \right]^{-v/\rho}$$

the coefficient (b_3) in equation (5.16) may be written as;

$$b_3 = \frac{(1 - \sigma)(v - 1)}{v}$$

where: $\sigma = b_2$ = elasticity of substitution;

v = the homogeneity parameter.

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1. J.K. Katz, op.cit., pp.70-2.

Table 5.3

Significance tests on the estimate of σ . $(\hat{b}_1)$
MLH Industries (1963)[1]

Value of	No.	%
$\sigma = 0$	24	41
$\sigma < 1$	1	2
$\sigma = 1$	30	52
$\sigma > 1$	3	5
Total	58	100

1. The 5 per cent level of significance is used throughout.

One estimating equation which allows for the possibility of non-constant returns to scale is;

$$Lg\ (^V/_L) = Lg\ a_2 + \hat{b}_2\ Lg\ (^W/_L) + \hat{b}_3\ Lg\ V \qquad (5.17)$$

Given that the remaining assumptions of the model still hold, and that prices are constant between regions, the degree of returns to scale (v) can be calculated as follows;

$$v = \frac{1 - \hat{b}_2}{1 - \hat{b}_2 - \hat{b}_3}$$

Both Dhrymes[1] and Feldstein[2] have shown that it is possible to estimate a transformation of equation (5.16).

$$Lg\ Y - Lg\ L = Lg\ a_2 + b_2\ Lg\ w + b_3\ Lg\ Y$$

Subtracting Lg Y from both sides gives;

$$-\ Lg\ L = Lg\ a_2 + b_2\ Lg\ w + b_3\ Lg\ Y - Lg\ Y$$

and thus;

$$Lg\ L = -\ Lg\ a_2 - b_2\ Lg\ w + (1 - b_3)\ Lg\ Y \qquad (5.18)$$

where: $b_2 = \sigma$

and: $(1 - b_3) = \dfrac{1 + \sigma\ (v - 1)}{v}$

Equation (5.18) is estimated as;[3]

$$Lg\ L = -\ Lg\ a_2 - \hat{b}_4\ Lg\ (\tfrac{W}{L}) + \hat{b}_5\ Lg\ V \qquad (5.19)$$

where: $\hat{b}_5 = (1 - b_3)$

$\hat{b}_4 = \hat{b}_2 = \sigma$

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1. P.J. Dhrymes, op.cit., passim.

2. M.S. Feldstein, op.cit., p.387f.

3. This is notwithstanding the absence of any explicit reference to the degree of monopoly in the estimating equation.

The degree of returns to scale is calculated as;

$$v = \frac{1 - \hat{b}_4}{\hat{b}_5 - \hat{b}_4} \qquad (5.20)$$

Both equations (5.17) and (5.19) were estimated. The estimated coefficients were, as expected, the same. Because equation (5.19) allowed the homogeneity parameter (v) to be computed more easily, results will only be reported for this estimating equation.

The estimated equations for total manufacturing in the U.K. in 1958 and 1963 were;

$$(1958): \text{Lg } L = -0.982 - \underset{(0.138)^{**}}{1.439} \text{ Lg } (W/L) + \underset{(0.015)^{**}}{1.025} \text{ Lg } V \qquad R^2 = 0.999$$

$$(1963): \text{Lg } L = -0.888 - \underset{(0.148)^{**}}{1.221} \text{ Lg } (W/L) + \underset{(0.016)^{**}}{1.025} \text{ Lg } V \qquad R^2 = 0.999$$

The implied values of the homogeneity parameter are;[1]

(1958) $v = 1.060$

(1963) $v = 1.25$

There is thus some evidence of increasing returns to scale in the aggregate.

Estimates of the elasticity of substitution and the degree of returns to scale (v) are reported for SIC orders in the years 1958 and 1963, in Tables 5.4 and 5.5. When an allowance is made for non-constant returns to scale, the instability in the estimates of the elasticity of substitution, noted earlier, reappears.

Nerlove, in his survey of the field, states that: "The major finding of this survey is the diversity of results: Even slight variations in the period or concepts tend to produce drastically different estimates

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1. Using equation (5.20).

Table 5.4

Estimates of the Elasticity of Substitution ($\hat{b}_4$) and the Degree of Returns to Scale ($\hat{v}$): S.I.C. Orders III-XVI: U.K. 1958[1]

S.I.C. No.	$\hat{b}_4$	s.e.$\hat{b}_4$ [2]	$\hat{b}_5$	s.e.$\hat{b}_5$	R^2	v [3]
III	-1.0366	0.5256	0.9491	0.0428	.989	1.097 b
IV	+0.2155	0.3125	0.9097	0.0311**	.997	1.075 b
V	-0.0451	0.2263	0.8801	0.0216**	.998	1.138 b
VI	-1.5595	0.5972*	1.0223	0.0307**	.998	1.042 a
VII	-2.9593	0.9452*	1.0505	0.0196**	.998	1.027 a
VIII	-2.1284	0.1814**	0.9945	0.0288**	.997	0.995 a
IX	-0.6994	0.2257*	1.0295	0.0214**	.997	0.913 a
X	-1.4338	0.2538**	1.0092	0.0356**	.991	1.022 a
XI	-0.8892	0.3742*	0.9340	0.0360**	.989	2.473 a
XII	-0.9120	0.1823**	0.9727	0.0238**	.996	1.450 a
XIII	-0.7900	0.2165*	0.9860	0.0294**	.993	1.071 a
XIV	+0.4050	0.3383	0.8908	0.0434**	.994	1.064 b
XV	-0.9630	0.1608**	1.0228	0.0166**	.999	0.619 a
XVI	-1.4310	0.3964**	1.0707	0.0599**	.993	1.196 a
Total Man.	-1.4392	0.1384**	1.0248	0.0154**	.999	1.060 a

1. Estimation is described in equation (5.19).

2. See note 3 to Table 5.1.

3. 'v' is calculated as described in the text, pp.193-4.

Table 5.5

Estimates of the Elasticity of Substitution ($\hat{b}_4$) and the Degree of Returns to Scale ($\hat{v}$): S.I.C. Orders III-XVI? U.K. 1963[1]

S.I.C. No.	$\hat{b}_4$	s.e.$\hat{b}_4$	$\hat{b}_5$	s.e.$\hat{b}_5$	R^2	v
III	-0.5450	0.5273	0.9727	0.0146**	.989	1.039 b
IV	-1.7113	0.6196*	0.9969	0.0362**	.990	0.996 a
V	-0.6268	0.3153	0.9982	0.0139**	.999	1.019 b
VI	-0.6446	0.8133	1.0042	0.0477**	.994	1.020 b
VII	-1.3781	0.3386**	1.0679	0.0232**	.997	1.219 a
VIII	-0.6894	1.5649	0.9567	0.1121**	.981	1.074 b
IX	-1.6709	0.3245**	1.0435	0.0147**	.999	1.069 a
X	-1.8729	0.3435**	1.0557	0.0433**	.988	1.068 a
XI	-1.0883	0.3932*	0.9335	0.0405**	.986	0.570 a
XII	-1.1194	0.2491**	1.0242	0.0346**	.993	1.254 a
XIII	-1.1941	0.1876**	0.9999	0.0186**	.997	1.000 a
XIV	-0.7836	0.2817*	0.9833	0.0174**	.999	1.083 a
XV	-1.3750	0.3373**	1.0304	0.0290**	.997	1.088 a
XVI	-1.1765	0.3663*	0.9919	0.0386**	.995	0.956 a
Total Man.	-1.2211	0.1483**	1.0245	0.0156**	.999	1.125 a

1. See notes to Table 5.4.

of the elasticity."[1] It is difficult to rationalise the instability of the estimates. Between 1958 and 1963 the percentage of the work force unemployed rose in almost all industries, yet some of the estimates are higher, some lower. There seems to be no consistency in the direction of movement of the estimates over the period.

The coefficient of rank correlation between the estimates of $(\hat{b}_4)$ for 1958 and 1963 is -0.100, which is not significantly different from zero. The estimate of elasticity of substitution for Vehicles (SIC VIII) again falls from greater than unity in 1958, to zero in 1963; a similar change occurs for Textiles (SIC X). The results of significance tests on the elasticity of substitution coefficient, as estimated in the multiple regression, are given in Table 5.6.

The homogeneity parameter (v) was calculated by two different methods.

(a) If both coefficients in equation (5.19) were significant, v was calculated by the formula;

$$\frac{1 - \sigma}{\hat{b}_5 - \sigma} = \frac{1 - \hat{b}_4}{\hat{b}_5 - \hat{b}_4}$$

(b) If the estimate of the elasticity of substitution $(\hat{b}_4)$ was not significantly different from zero (at the 5 per cent level), the model interprets this as indicative of fixed coefficients. In this event the equation should be re-estimated with the variable Lg $(^W/_L)$ deleted from the regression. In other words the degree of returns to scale (v), in the presence of fixed coefficients, is determined by the magnitude of the elasticity of output with respect to labour $\left(1 / \left(\frac{dL}{L} / \frac{dV}{V}\right)\right)$. If the elasticity of substitution $(\hat{b}_4)$ was not

1. M. Nerlove, op.cit., p.58.

Table 5.6

Significance tests on the estimate of σ . ($\hat{b}_4$)
1958 and 1963.

SIC Order Groups[1]

Value of	1958		1963		Total	
	No.	%	No.	%	No.	%
σ = 0	4	29	4	29	8	29
σ < 1	0	0	0	0	0	0
σ = 1	9	64	9	64	18	64
σ > 1	1	7	1	7	2	7
Total	14	100	14	100	28	100

1. Confidence Limits are at the P. $\leq$ 0.05 level throughout.

significantly different from zero, v was estimated as the coefficient λ in the equation;

$$Lg\ V = \alpha + \hat{\lambda}\ Lg\ L$$

Significant economies of scale appear to rule in most industries, although there is considerable instability in the estimates. Three industries deserve special mention. Vehicles (SIC VIII), contrary to a priori expectations,[1] does not appear to be experiencing significant increasing returns to scale; indeed, on the basis of 1958 data, decreasing returns appear to rule. Leather, Leather Goods, and Fur (SIC XI), which was experiencing considerable increasing returns to scale in 1958 ($v = 2.473$), had somehow altered its production surface in the intervening years such that by 1963 it was experiencing significant (and severe) decreasing returns to scale ($v = 0.570$). A similar, although less spectacular, reversal occurred in Other Manufacturing Industries (SIC XVI). The coefficient of rank correlation for the estimates of v, in 1958 and 1963, is -0.360, which is not significantly different from zero.

The estimating equation (5.19) was also fitted to the fifty-eight MLH industries for which sufficient data is available. The detailed results for each MLH industry in 1963 are reported in the Appendix to this chapter, Table 5.A3.

The estimates of the homogeneity parameter (v) are all quite close to unity, although it should be noted that four industries appear to be experiencing considerable decreasing returns. These are: Bricks, etc. (MLH 461), Timber (MLH 471), Furniture and Upholstery (MLH 472) and General Printing, Publishing etc. (MLH 489).

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1. See C.F. Pratten, Economies of Scale in Manufacturing Industry, (Cambridge, C.U.P., 1971), pp.132-149.

Table 5.7 presents the results of significance tests upon the estimated value of the elasticity of substitution. Approximately sixty per cent of the industries present estimates which are not significantly different from zero in the multiple regression. If we are prepared to accept the existence of a C.E.S. production function on a priori grounds, the number of insignificant coefficients would imply that something over one-half of the industries covered in this study (and thus one-quarter of all U.K. manufacturing industries), produce under conditions of fixed coefficients ($\sigma = 0$). Since the model is constructed under the assumption of a 'representative' isoquant, this implies that the technique of production in all regions is exactly the same in these industries. This rather startling conclusion must lead us to reconsider the validity of the exercise.

In particular, we must question whether the interpretation of insignificant estimates as indicative of fixed technical coefficients (i.e. identical capital-labour ratios in all regions), is warranted. It can only be assumed that fixed technical coefficients is the correct interpretation provided that two prior conditions are satisfied. These are;

(i) That there are substantial a priori grounds for believing that a single production function is a valid interpretation of prevailing technology in those industries; and that the industries operate in a neoclassical environment.

(ii) That there is minimal variation in output per man, within these industries, aside from that which could be expected to result from variable returns to scale or from measurement error. If there really exists fixed coefficients, we should find that different factor price ratios are associated with the same technique, and therefore the same output per man

Table 5.7

Significance tests on the estimate of σ . $(\hat{b}_4)$[1]
MLH Industries 1963

Value of	No.	%
$\sigma = 0$	35	60
$\sigma < 1$	1	2
$\sigma = 1$	19	33
$\sigma > 1$	3	5
Total	58	100

1. Confidence Limits are at the $P \leq 0.05$ level throughout.

(i.e. $(^V/_L)$ or Lg $(^V/_L)$ is a constant for those industries).

If the fixed coefficients interpretation is correct we would expect to find (given the variation in the wage rate), that the variation in Lg $(^V/_L)$ is significantly less in those industries for which the implied elasticity of substitution is zero, than in the industries where the elasticity of substitution is significantly different from zero.

To test for this 'fixed coefficients' effect, the mean, median, and standard deviation <u>of the variance</u> in Lg $(^V/_L)$, were computed for the twenty-four MLH industries which exhibited an implied elasticity of substitution $(\hat{b}_1)$ of zero. These were then compared with the mean, median and standard deviation of the variances in Lg $(^V/_L)$, for the thirty-four MLH industries which exhibited an implied value of the elasticity of substitution $(\hat{b}_1)$ greater than zero.

Mean variance is calculated for each group as;

$$\text{mean var} = \frac{\sum_{i}^{n} \left[\sum_{j}^{m} \frac{(X_{ij} - \bar{X}_{ij})^2}{} \right]}{n - 1}$$

where: X_{ij} = Logarithm of output per man in industry i_1 $(i = 1, 2 \ldots n)$, in region j $(j = 1, 2 \ldots m)$;

$\bar{X}_{ij}$ = Mean of the observations of the Log. of output per man in each industry,

$$= \sum_{j}^{m} \frac{X_{ij}}{m}$$

The results of this exercise are set out, for each group separately, in Table 5.8 below.

Table 5.8

Results of the test for fixed coefficients

	$\hat{\sigma} = 0$	$\hat{\sigma} > 0$
Mean of variances	0.0383	0.0352
Median of variances	0.0230	0.0200
S.D. of variances	0.0390	0.0388

There is no significant difference in the mean variance of Lg $({}^{V}/_{L})$ between the two groups. Indeed, although the standard deviations of the variances are almost identical, the mean and median of the variances in the 'fixed coefficients' group ($\sigma = 0$), are greater than the associated statistics for the variable technique group ($\sigma > 0$).

It would seem on the basis of this test, that the insignificant coefficients in Table 5.A2 are a reflection, not of the absence of variation in output per man (i.e. fixed technical coefficients) but, of an absence of co-variation between the variables Lg $({}^{V}/_{L})$ and Lg $({}^{W}/_{L})$, across regions in those industries.

Given that the estimation procedure is incapable of accurately detecting the industries with fixed coefficients, the use of this procedure to estimate the value of the elasticity of substitution, when technical coefficients are not fixed, must be questioned.

It must be admitted however, that for some industries at least the results are in accord with a priori expectations. But once the operation of the neoclassical forces is denied, it becomes necessary to offer an alternative rationalisation of the 'successful' cases. This is the task of the final section of this chapter.

Interpretation of the Results

In a recent paper Franklin Fisher[1] has demonstrated some disturbing propositions, especially as regards the fitting of aggregate production functions to national (time series) data. Fisher's claims are based on simulation experiments. In the present section we attempt to prove his results using the CES estimating relationship, thus revealing, for this method of estimation at least, the logic of his claim.

Whilst many economists have long held that the concept of an aggregate production function could not be carried over to real world situations, many authors justified their use of such a concept by the apparent success of the aggregate Cobb-Douglas function to account for the 'constancy' of labour's share in National Income. Indeed this success has often been cited as the only evidence in favour of the marginal productivity theory of wage determination. It now appears as a result of Fisher's simulation experiments that not only the recipe, but the (as if) pudding, is incapable of providing such a proof.[2]

One of the main conclusions of his recent paper is that: "An aggregate Cobb-Douglas only works well so long as labour's share is roughly constant."[3] Again: "The suggestion [of the simulation experiments] is clear, however, that labour's share is not roughly constant because the diverse technical relationships of modern economies

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1. F.M. Fisher, op.cit., passim; F.M. Fisher, "The Existence of Aggregate Production Functions", Econometrica, Vol.37, 1969, pp.553-577; Joan Robinson, "Comment", and F.M. Fisher, "A Reply", both to be found in Econometrica, Vol.39, 1971, p.405.

2. P.A. Samuelson, op.cit., p.194, n.2.; M. Friedman, Essays in Positive Economics (Chicago, University of Chicago Press, 1953), pp.3-43.

3. F.M. Fisher, "A Simulation Experiment . . .", op.cit., p.307.

are truly representable by an aggregate Cobb-Douglas, but rather that such relationships appear to be representable by an aggregate Cobb-Douglas because labour's share happens to be roughly constant."[1] He also indicates that these conclusions may be extended to apply to the CES production function.

There are two logically distinct, though related, issues here. One issue refers to the validity of interpreting reduced equations (side-relations) as estimating, or being evidence for the existence of, a production function and its associated parameters.

If we accept that the coefficients (estimated from side-relations) are production function parameters, the second issue is concerned with explaining why, given that labour's share is roughly constant, such estimates appear to indicate that the implied production function is Cobb-Douglas in form.

Attention will be confined initially to the latter claim, based on simulation experiments, that if labour's share is constant the implied production function will be Cobb-Douglas in form. This can be demonstrated with the aid of CES side-relations which we have used to estimate the elasticity of substitution (Equation 5.11).

Consider the estimating equation used to derive values of the elasticity of substitution;

$$Lg\ (Y/L) = Lg\ a + b\ Lg\ (W/L) \qquad (5.11)$$

where: Y = Value Added;

L = Total Labour Input;

W = Total Wage Bill.

As we have shown, under neoclassical assumptions the implied value

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1. Ibid., p.325.

for the elasticity of substitution is equal to the value of the regression coefficient (b) in equation (5.11).

We note first that if the wage share is constant then;

$$\frac{d(\frac{W}{Y})}{W/_Y} = \frac{dW}{W} - \frac{dY}{Y} = 0$$

$$\text{i.e. } \frac{dY}{Y} = \frac{dW}{W}$$

Subtraction of $(\frac{dL}{L})$ from both sides of the above, yields an equivalent condition for the constancy of shares,

$$\frac{dY}{Y} - \frac{dL}{L} = \frac{dW}{W} - \frac{dL}{L} \qquad (5.21)$$

We may rewrite the estimate of the elasticity of substitution (b) in (5.11), as;

$$b = \frac{d\ Lg\ (^Y/_L)}{d\ Lg\ (^W/_L)}$$

$$b = \frac{d\ (^Y/_L)}{^Y/_L} \Big/ \frac{d\ (\frac{W}{L})}{^W/_L}$$

$$b = \frac{\frac{dY}{Y} - \frac{dL}{L}}{\frac{dW}{W} - \frac{dL}{L}} \qquad (5.22)$$

If labour's share is constant, then the R.H.S. and L.H.S. of (5.21) are equal; but note that this equality also implies that the numerator and denominator of (5.22) are equal (i.e. b = 1). If shares are constant, the regression coefficient in the estimating equation (5.11) will have a value of unity, and thus the implied value of the elasticity of substitution will be unity. If shares are not constant, the numerator and denominator of (5.22) are not equal, and thus $b \neq 1$.

In terms of this formulation of the problem, Fisher is correct in his assertions that the implied value of the elasticity of substitution, and thus the form of the production function, depends on the observed constancy, or otherwise, of labour's share. This conclusion can be generalised to the CES class of production functions, both aggregative and dis-aggregative.[1]

The first issue raised by Fisher is whether we can interpret the coefficients in the estimating equations (5.13) and (5.19), as production function parameters. In this section it will be argued that we cannot, both because the notion of a single production function may be invalid for our observations, and because it is unlikely that if such a function did exist, the parameters would be identified in the estimating equations.

If the world was severely neoclassical, and if the dramatic reversals in the estimates which we discovered in the preceding section could be rationalised in terms of technical factors, then it may be possible to consider the estimates presented earlier as parameters of the production function. The world, however, is not in accord with neoclassical assumptions, and the diversity of results cannot be rationalised in terms of technique decisions.[2]

Even if all the neoclassical behavioural assumptions were satisfied, it would still be difficult to consider the results as parameters of the production surface in each industry. The simple explanation is, that the observations do not reflect a production surface; nor is it likely

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1. This discussion also implies that tests of the CES estimate, based upon the comparison between observed and predicted wage shares (such as Ferguson's 'largely independent' test), are in fact not independent in the least. Cf. C.E. Ferguson, op.cit., p.309.

2. Cf. M. Nerlove, op.cit., pp.58-82.

that the observations within each industry come from the same production surface. The two basic assumptions on which the model is based are violated. It is also highly unlikely that the observations are generated by firms using optimal input combinations given the ruling factor prices. Once we admit, as we must, the existence of time and uncertainty, vintages and non-malleability, the concept of a single ex-post production function, is invalid.[1] Given uncertainty and non-malleability, it would only be by chance that the values of the coefficients in the estimating equations correspond to parameters of the production surface. We cannot throw light upon a concept that does not exist.

An additional reason for these negative conclusions is that the assumption, that the wage rate is exogenous, is also likely to be violated. Given the widespread use of payment by results in U.K. industries, in addition to more general productivity agreements, the statistical procedure is incapable of separating out the effects of changes in the wage rate (and thus technique) on average product, from the effects of changes in average product on the wage rate.[2]

E pur si muove

Leaving questions of 'existence' aside, there are also problems of 'identification'. If it can be demonstrated that the estimating

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1. W.E.G. Salter, Productivity and Technical Change, 2nd edition (Cambridge, C.U.P., 1966), pp.13-26; J.A.S. Schumpeter, History of Economic Analysis (London, George Allen and Unwin, 1954), p.1038.

2. R. Agawala and G.C. Goodson, "A Study of Earnings from Employment in British Industries, 1958-1966", Bulletin of Economic Research, Vol.23, 1971, pp.35-41; J.R. Crossley, 'Collective Bargaining, Wage Structure and the Labour Market in the U.K.', in E.M. Hugh-Jones (ed.), Wage Structure in Theory and Practice (Amsterdam, North-Holland, 1966), pp.157-235.

equations we have used are consistent with alternative models containing wage and productivity variables, it may be concluded that the side-relation of the production function has not been identified.

The untransformed version of our estimating equation (5.11) is;

$$Y/L = a\,(W/L)^{b} \qquad (5.23)$$

There appear to be two alternative rationalisations of this relationship. One is as a wage determining equation; the second is a profit or price determining equation.

(a) Wage determination.

We may rewrite (5.23) as follows;[1]

$$W/L = \frac{1}{a}\,(Y/L) \qquad (5.24)$$

Given that Y/L is exogenous, equation (5.24) becomes an expression for wage determination.

Kuh found some evidence for the existence of such a relationship in the U.S. He states that; "Quite apart from its relation to marginal productivity, average productivity placed in a bargaining framework could explain wage movements."[2]

The logarithmic function we have estimated is consistent with this hypothesis.for many industries in the U.K. The finding that the coefficient (b) approximates unity may be indicative of the observations being generated, not by production function relationships, but rather by a wage-determination model.

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1. The exponent has been set equal to unity, as is the case with the 'implied' Cobb-Douglas results.

2. E. Kuh, "A Productivity Theory of Wage Levels - an Alternative to the Phillips Curve", Review of Economic Studies, Vol.34, 1967, p.337. See also R. Agawala and G.C. Goodson, op.cit., passim.

(b) Profit or Price determination.

Alternatively, the relationship can be derived from a pricing theory based on prime costs plus margins. The particular alternative discussed in this section considers margins to be calculated on a 'wage-cost plus' basis, rather than on a 'full prime-cost plus' basis.[1]

Price per unit of output (p) is made up of, the unit wage cost plus unit materials cost plus unit profit, i.e.;

$$p = w.\frac{L}{O} + m.\frac{M}{O} + \pi$$

where: w = wage rate;

O = quantity of output;

m = price per unit of raw materials;

M = quantity of raw materials.

Let profit per unit (π) equal wage cost, times some mark-up (τ) for overheads and earnings,

$$\pi = w.\frac{L}{O}(\tau)$$

The value of gross output (p.O) will be equal to;

$$p.O = O\left[w.\frac{L}{O}(1 + \tau) + m.\frac{M}{O}\right]$$

$$\text{and } p.O = w.L\,(1 + \tau) + m.M$$

Value added equals (p.O - m.M), and thus;

$$p.O - m.M = V = w.L\,(1 + \tau)$$

Dividing both sides by the number of workers yields;

$$V/_L = (1 + \tau)\,\frac{W}{L} \qquad (5.25)$$

This pricing, or distribution, equation (5.25) is also consistent

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1. A. Silberston, "Surveys of Applied Economics: Price Behaviour of Firms", Economic Journal, Vol.80, 1970, pp.511-582.

with the form of the CES estimating equation.[1]

It is difficult to discriminate between these alternative rationalisations of the data, and in this light there are serious problems of identification. It must be concluded, therefore, that the results of estimating the CES side-relation, where they are in apparent agreement with a priori beliefs, cannot automatically be interpreted as production function parameters. Given these important qualifications, the results (interpreted as production function parameters), are not only reasonable in themselves, but may act as a basis for further research into productivity differences between regions.

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1. i.e.; $Lg\ (^{V}/_{L}) = Lg\ (1 + \tau) + \lambda\ Lg\ (^{W}/_{L})$.

Appendix 5.A1

List of Industries Considered[1]

	III Food, Drink and Tobacco
214	Bacon Curing, Meat and Fish Products
215	Milk Products
218	Fruit and Vegetable Products
219	Animal and Poultry Foods
229(2)	Starch and Misc. Foods
231	Brewing and Malting
239(2 & 3)	Soft Drinks, British Wines, Cider and Perry
	IV Chemicals and Allied Industries
263	Lubricating Oils and Greases
271(3)	General Chemicals
272(1)	Pharmaceutical Preparations
274	Paint and Printing Ink
	V Metal Manufacture
311	Iron and Steel (General)
313	Iron Castings (etc.)
321 & 322	Non-ferrous Metals
	VI Engineering and Electrical Goods
331	Agricultural Machinery (except tractors)
332	Metal-working Machine Tools
333	Engineers Small Tools and Gauges
336	Contracts. Plant and Quarrying Machinery
337	Mechanical Handling Equipment
339	Misc. (Non-Electrical) Machinery
341	Industrial Plant and Steel Work
349	General Mechanical Engineering

351 Scientific, Surgical and Photographic Industries etc.

361 Electrical Machinery

364 Radio and Other Electronic Apparatus

396 Miscellaneous Electrical Goods

VIII Vehicles

381 Motor Vehicle Manufacturing

IX Metal Goods n.e.8.

394 Wire and Wire Manufactures

399 Misc. Metal Manufactures

X Textiles

414 Woollen and Worsted

417 Hosiery and Other Knitted Goods

421 Narrow Fabrics

XI Leather, Leather Goods and Fur

431 Leather (Tanning and Dressing) and Fellmongery

XII Clothing and Footwear

442 Men's and Boys Tailored Outwear

443 Women's and Girls Tailored Outwear

444 Overalls and Men's Shirts, Underwear, etc.

445 Dresses, Lingerie, Infant Wear, etc.

449(1,3 &4) Corsets, and Misc. Dress Industries

450 Footwear

XIII Bricks, Pottery, Glass, Cement, etc.

461 Bricks, Fireclay and Refractory Goods

463 Glass

469(2) Misc. Building Materials, etc.

	XIV	Timber, Furniture, etc.
471	Timber	
472	Furniture and Upholstery	
473	Bedding and Soft Furnishings	
474	Wooden Containers and Baskets	
475	Shop and Office Fittings	
479	Misc. Wood and Cork Manufactures	
	XV	Paper, Printing and Publishing
481	Paper and Board	
482	Cardboard Boxes, Cartons and Fibreboard Packing Cases	
483	Misc. Manufactures of Paper and Board	
486	Printing and Publishing of Newspapers and Periodicals	
489	General Printing, Publishing, Bookbinding, Engineering, etc.	
	XVI	Other Manufacturing Industries
491	Rubber	
493	Brushes and Brooms	
494	Toys, Games and Sports Equipment	
496	Plastics Moulding and Fabricating	
499	Misc. Manufacturing Industries.	

1. Source: Board of Trade, op.cit., p.251f.

Appendix Table 5.A2

Estimates of the Elasticity of Substitution ($\hat{b}_1$)
MLH Industries 1963[1]

Ind. No.	$\hat{b}_1$	s.e.$\hat{b}_1$	R^2
214	0.4150	0.4987	.080
215	-0.0393	0.3383	.002
218	1.2942	0.3346**	.652
219	-0.4704	1.0295	.025
229/2	1.5037	0.3518**	.723
231	0.8785	0.6963	.185
239/ 2 & 3	1.3418	0.3478**	.650
263	0.4792	0.6512	.083
271/3	1.0791	0.8383	.175
272/2	1.9746	0.3083**	.872
274	0.7879	0.3918	.366
311	0.2737	0.2523	.144
313	0.7858	0.1703**	.780
321 & 322	-0.6534	0.9390	.065
331	0.0343	1.0276	.000
332	2.4543	0.7308**	.585
333	0.5970	0.2087*	.557
336	1.1103	0.6111	.292
337	0.5318	0.5247	.128
339	1.0033	0.7764	.173
341	1.4432	0.3746**	.650
349	1.1623	0.4592*	.445
351	0.5433	0.2580	.357
361	-0.1043	0.3693	.011
364	1.3832	0.3724**	.663
369	-0.0041	0.8834	.000
381	0.0866	1.5469	.000
394	1.3535	0.5232*	.489
399	1.0245	0.4430*	.401
414	1.9562	0.4902**	.666
417	0.7752	0.8960	.111
421	0.2504	0.6749	.022
431	0.9469	0.4173*	.424
442	0.7123	0.4271	.258
443	1.1769	0.3512*	.652
444	0.7197	0.2566*	.496

(contd.)

Appendix Table 5.A2 (contd.)

Ind. No.	$\hat{b}_1$	s.e.$\hat{b}_1$	R^2	Ind. No.	$\hat{b}_1$	s.e.$\hat{b}_1$	R^2
445	0.6494	0.2589*	.440	479	0.5971	0.2103*	.502
449/1 3 & 4	-0.1723	0.4772	.021	481	1.8541	0.3709**	.838
450	1.7162	0.4837**	.611	482	0.9081	0.4568*	.361
461	1.0151	0.2540**	.727	483	2.0261	0.5757**	.608
463	0.9343	0.3889*	.419	486	0.7423	0.1544**	.743
469/2	0.8906	0.6318	.176	489	1.2249	0.1489**	.894
471	1.2773	0.3303**	.651	491	0.9832	0.2725**	.619
472	1.4084	0.2770**	.764	493	0.8452	0.2744*	.575
473	0.2117	0.2431	.087	494	1.7361	0.5207*	.581
474	0.6043	0.3197	.338	496	1.1666	0.2775**	.716
475	1.0292	0.3371*	.571	499	1.0149	0.3497*	.559

1. See notes to Table 5.1.

Appendix Table 5.A3

Estimates of the Elasticity of Substitution ($\hat{b}_4$) and the Degree of Returns to Scale (v)
MLH Industries 1963[1]

Ind. No.	$\hat{b}_4$	s.e. $\hat{b}_4$	$\hat{b}_5$	s.e. $\hat{b}_5$	R^2	v
214	-0.3306	0.6541	0.9873	0.0572**	.984	1.0136 b
215	+0.2037	0.3759	1.0508	0.0507**	.987	0.9492 b
218	-0.7177	0.4047	0.9240	0.0378**	.994	1.1304 b
219	-0.042	0.6394	0.8025	0.0515**	.973	1.2115 b
229/2	-2.0572	0.3228**	1.1939	0.0705**	.981	1.1583 a
231	-0.8842	1.0903	1.0009	0.1337**	.944	1.0164 b
239/ 2 & 3	-0.8769	0.4027	0.9092	0.0507**	.985	1.1640 b
263	-0.7022	0.4569	0.8381	0.0588**	.978	1.1326 b
271/3	-0.7678	0.8546	0.9412	0.0508**	.981	1.0566 b
272/1	-1.9719	0.5524*	0.9996	0.0648**	.989	1.0000 a
274	-0.8725	0.4509	1.0182	0.0380**	.993	0.9983 b
311	-0.5086	0.3562	1.0341	0.0362**	.996	0.9967 b
313	-0.5859	0.1123**	0.9672	0.0090**	.999	1.0860 a
321 & 2	+0.8866	1.0547	0.9803	0.0321**	.995	1.0039 b
331	+0.4176	1.0845	0.8973	0.0909**	.951	1.0433 b
332	-2.4057	0.5965**	0.9382	0.0276**	.994	0.9579 a
333	-0.6946	0.2361*	1.0155	0.156**	.999	0.9550 a
336	-0.8857	0.6951	0.9159	0.1115**	.913	1.0444 b
337	-0.5245	0.4937	0.9532	0.0338**	.992	1.0401 b
339	-1.0621	0.8313	1.0136	0.0321**	.993	0.9849 b
341	-2.1350	0.6417*	1.0627	0.0483**	.994	1.0585 a
349	-0.4908	0.3615	0.9956	0.0131**	.999	1.0559 b
351	-0.3869	0.3697	0.9786	0.0348**	.995	1.0428 b
361	-0.1799	0.4546	1.0468	0.0443**	.993	0.9578 b

(contd.)

Appendix Table 5.A3 (contd.)

Ind. No.	$\hat{b}_4$	s.e. $\hat{b}_4$	$\hat{b}_5$	s.e. $\hat{b}_5$	R^2	v
364	-1.3612	0.5252*	0.9960	0.6122**	.984	0.9890 a
369	+0.1634	0.8231	0.9591	0.0342**	.991	1.0324 b
381	-0.0990	2.7934	1.0011	0.2018**	.908	0.9126 b
394	-1.3517	0.5598	1.0115	0.0336**	.993	0.9886 a
399	-1.5108	0.6422	1.0256	0.0246**	.998	0.9472 b
414	-1.9322	0.5181**	1.0171	0.0357**	.992	1.0186 a
417	-0.8425	1.0002	0.9825	0.0601**	.983	0.9864 b
421	-0.1380	0.7765	1.0494	0.1200**	.947	0.8952 b
431	-0.7429	0.6042	0.9690	0.0625**	.985	1.0710 b
442	-0.1900	0.4183	0.9245	0.0427**	.991	1.0834 b
443	-1.2531	0.4067*	1.0175	0.0357**	.994	1.0743 a
444	-0.5185	0.3572	0.9620	0.0458**	.991	1.0776 b
445	-0.1926	0.3844	0.9478	0.0343**	.996	1.0661 b
449/1 3 & 4	+0.1932	0.5537	0.9851	0.1313**	.929	0.9267 b
450	-1.6405	0.4973*	0.9746	0.0285**	.994	0.9618 a
461	-1.0095	0.2936*	0.9966	0.0568**	.984	0.7364 a
463	-0.6699	0.5781	0.9762	0.0372**	.995	1.0511 b
469/2	-0.3900	0.7749	0.9638	0.0382**	.992	1.0413 b
471	-1.1311	0.2850**	0.9587	0.0196**	.997	0.7604 a
472	-1.1289	0.3219**	0.9852	0.0285**	.995	0.7751 a
473	-0.2116	0.2493	1.0600	0.0771**	.964	0.9063 b
474	-0.6344	0.3424	1.0243	0.0461**	.988	0.9715 b
475	-1.3131	0.4963*	1.0394	0.0494**	.992	1.1440 a
479	-0.3923	0.3317	0.9615	0.0475**	.992	1.0784 b
481	-1.6546	0.2514**	0.9614	0.0160**	.998	0.9443 a
482	-1.3520	0.5096*	1.0985	0.0645**	.984	1.3886 a

(contd.)

Appendix Table 5.A3 (contd.)

Ind. No.	$\hat{b}_4$	s.e. $\hat{b}_4$	$\hat{b}_5$	s.e. $\hat{b}_5$	R^2	v
483	-2.0129	0.6089*	1.0222	0.0537**	.982	1.0224 a
486	-0.4911	0.2790	0.9638	0.0336**	.997	1.0892 b
489	-1.0422	0.2236**	0.9828	0.0157**	.999	0.7104 a
491	-1.0349	0.4944*	1.0047	0.0363**	.996	1.1556 a
493	-0.9033	0.3503*	1.0274	0.0899**	.961	0.7792 a
494	-1.7680	0.5386*	0.9641	0.0494**	.983	0.9553 a
496	-1.1544	0.3063**	0.9955	0.0245**	.996	0.9717 a
499	-1.3836	0.6011*	1.0877	0.1230**	.959	1.2964 a

1. See notes to Table 5.4.

Chapter Six

Inter-Regional Differences in the 'Efficiency' or 'Technological' Parameters : 1958 and 1963

Whereas Chapter Four dealt with the sources of regional productivity differences over time, this chapter attempts to examine the source of inter-regional differences in productivity, at a point in time. In particular, the chapter is concerned with estimating regional 'efficiency parameters'[1] using a Constant Elasticity of Substitution Production Function. It is necessary, as a preliminary to the main sections of this analysis, to demonstrate the specific interpretation which can be placed upon the estimates obtained in the preceding chapter.

Derivation of the CES side-relation

Assuming constant returns to scale, the CES production function may be specified as;[2]

$$Y = \gamma \left[\delta K^{-\rho} + (1 - \delta) L^{-\rho} \right]^{-1/\rho} \qquad (6.1)$$

where: γ = (neutral) efficiency parameter;

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1. The 'efficiency parameter' of the CES production function is similar to the 'technological parameter' (A) in the Cobb-Douglas function. Changes in the 'efficiency parameter' give rise to an equi-proportional increase in output, for any given quantity of inputs. See D.F. Heathfield, Production Functions (London, Macmillan, 1971), p.56; M. Brown, On the Theory and Measurement of Technological Change (Cambridge, C.U.P., 2nd edition, 1968), p.54.

2. Derivations of the CES function may be found in K.J. Arrow, H.B. Chenery, B.S. Minhas and R.M. Solow, "Capital-Labor Substitution and Economic Efficiency", Review of Economics and Statistics, Vol.43, 1961, pp.225-250; M. Brown and J. de Cani, "Technological Change and the Distribution of Income", International Economic Review, Vol.4, 1963, pp.289-309; M. Brown, op.cit., pp.43-62; C.E. Ferguson, The Neoclassical Theory of Production and Distribution (Cambridge, C.U.P., 1969). For an application of the CES function to U.S. regional data see E. Olsen, International Trade Theory and Regional Income Differences (Amsterdam, North-Holland, 1971).

δ = distribution parameter;

ρ = substitution parameter.

Output per unit of labour may be expressed as;

$$Y/L = \gamma \left[\delta(K/L)^{-\rho} + (1 - \delta)\right]^{-1/\rho} \qquad (6.2)$$

Raising both sides of equation (6.2) to the power ρ, and dividing through by γ^{ρ}, gives;

$$Y/L^{\rho}\gamma^{-\rho} = \left[\delta(K/L)^{-\rho} + (1 - \delta)\right]^{-1} \qquad (6.3)$$

To establish the marginal product of labour, assumed to be equal to the wage rate, we partially differentiate equation (6.1) with respect to labour, to yield;

$$w = \frac{\partial Y}{\partial L} = \gamma\ (1 - \delta)\left[\delta\ (K/L)^{-\rho} + (1 - \delta)\right]^{-1/\rho^{-1}} \qquad (6.4)$$

Substitution of (6.2) into (6.4) gives;

$$w = Y/L\ (1 - \delta)\left[\delta\ (K/L)^{-\rho} + (1 - \delta)\right]^{-1} \qquad (6.5)$$

Substitution of (6.3) into (6.5) yields;

$$w = Y/L\ (1 - \delta)\ Y/L^{\rho}\gamma^{-\rho} \qquad (6.6)$$

It follows from (6.6) that;

$$(Y/L)^{1+\rho} \equiv w\ (1 - \delta)^{-1}\gamma^{\rho} \qquad (6.7)$$

Taking logarithms of both sides and dividing through by $(1 + \rho)$ gives;[1]

$$\text{Lg}\ (Y/L) = \frac{1}{1 + \rho}\ \text{Lg}\left[\gamma^{\rho}\ (1 - \delta)^{-1}\right] + \frac{1}{1 + \rho}\ \text{Lg}\ w \qquad (6.8)$$

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1. Alternative proofs may be found in; C.E. Ferguson, "Time series Production Functions and Technological Progress in American Manufacturing Industry", Journal of Political Economy, Vol.73, 1965, pp.135-137; J.M. Katz, Production Functions, Foreign Investment and Growth (Amsterdam, North-Holland, 1969), p.43.

In the previous chapter[1] we saw that the ratio

$$\frac{\partial \ Lg \ ^{Y}/_{L}}{\partial \ Lg \ w} = \sigma \qquad (6.9)$$

where: σ is the elasticity of substitution between capital and labour.

It follows that;

$$\sigma = \frac{1}{1 + \rho} \qquad (6.10)$$

Equation (6.9) may therefore be rewritten as;

$$Lg \ (^{Y}/_{L}) = \sigma \ Lg \left[\gamma^{\rho} \ (1 - \delta)^{-1} \right] + \sigma \ Lg \ w \qquad (6.11)$$

Equation (6.11) is of the same form as the estimating equation used in the previous chapter, i.e.

$$Lg \ (^{Y}/_{L}) = a_1 + b_1 \ Lg \ (^{W}/_{L}) \qquad (6.12)$$

It follows that the coefficients, a and b (in equation 6.12), may be interpreted as;

a_1 = estimate of $\sigma \ Lg \left[\gamma^{\rho} \ (1 - \delta)^{-1} \right]$

b_1 = estimate of σ.

The relationships expressed in equations (6.11) and (6.12) form the basis for the estimates of the following section of this chapter.

Inter-Regional Differences in the Efficiency Parameter

Assuming that the distribution parameter (δ) and the substitution parameter (ρ) are constant between regions, the logarithm of output per worker, in any region (j), may be expressed as;[2]

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1. Chapter Five, pp.177-181.

2. From equation (6.11).

$$Lg\,(^{Y}/_{L})_{j} = \sigma\, Lg\left[\gamma^{\rho}{}_{j}\,(1-\delta)^{-1}\right] + \sigma\, Lg\,(^{W}/_{L})_{j} \qquad (6.13)$$

This may be expanded as follows;

$$Lg\,(^{Y}/_{L})_{j} = \rho\sigma\, Lg\,\gamma_{j} - \sigma\, Lg\,(1-\delta) + \sigma\, Lg\,(^{W}/_{L})_{j} \qquad (6.14)$$

and then rearranged to provide an expression for the efficiency parameter in any region (γ_j);

$$Lg\,(\gamma_{j}) = \frac{Lg\,(^{Y}/_{L})_{j} - \sigma\, Lg\,(^{W}/_{L})_{j} + \sigma\, Lg\,(1-\delta)}{\sigma\rho} \qquad (6.15)$$

Data for output per worker and earnings per worker are available for the regions from the Census of Production.[1] Estimates of the elasticity of substitution and, by implication, the substitution parameter were derived earlier.[2] Without data on the distribution parameter there are still two unknowns (γ and δ) in equation (6.15). If the distribution parameter is constant between regions, it is possible to obtain a solution for the efficiency parameters.

The logarithm of the efficiency parameter, for any region, when the distribution parameter is a constant, may be expressed as;[3]

$$Lg\,(\gamma_{j}) = \frac{Lg\,(^{Y}/_{L})_{j} - \sigma\, Lg\,(^{W}/_{L})_{j}}{1-\sigma} + \frac{Lg\,(1-\delta)}{\rho} \qquad (6.16)$$

Similarly for the U.K. as a whole the logarithm of the efficiency parameter will equal;

$$Lg\,(\gamma)_{UK} = \frac{Lg\,(^{Y}/_{L})_{UK} - \sigma\, Lg\,(^{W}/_{L})_{UK}}{1-\sigma} + \frac{Lg\,(1-\delta)}{\rho} \qquad (6.17)$$

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1. Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133.

2. Chapter Five, pp. 186-187.

3. Since $\sigma = \frac{1}{1+\rho}$ (6.10), it follows that $\sigma\rho = 1 - \sigma$.

Subtraction of (6.17) from (6.16) yields;

$$Lg(\gamma_j) - Lg(\gamma)_{UK} = \frac{(Lg(^Y/_L)_j - Lg(^Y/_L)_{UK}) - \sigma(Lg(^W/_L)_j - Lg(^W/_L)_{UK})}{1-\sigma} \quad (6.18)$$

Let: $\Delta Lg(^Y/_L)_j = Lg(^Y/_L)_j - Lg(^Y/_L)_{UK}$

$\Delta Lg(^W/_L)_j = Lg(^W/_L)_j - Lg(^W/_L)_{UK}$

Equation (6.18) may then be rewritten as;

$$Lg\left(\frac{\gamma_j}{\gamma_{UK}}\right) = \frac{\Delta Lg(^Y/_L)_j - \sigma\,\Delta Lg(^W/_L)_j}{1-\sigma} \quad (6.19)$$

Given the assumption that the substitution and distribution parameters are constant,[1] it is possible, given estimates of the elasticity of substitution and data on output, wages and employment in each region, to estimate the value of the 'relative efficiency parameter' ($^{\gamma j}/_{\gamma UK}$) as the anti-logarithm of the estimate obtained in (6.19).[2]

There is a less tortuous way of arriving at this result (equation (6.19)), although it is correspondingly less rigorous. In the previous chapter, it was shown that the ratio of the growth rates of average and marginal products (wage rate) is equal to the value of the elasticity of substitution;

$$d\,Lg(^Y/_L) = \sigma\,d\,Lg(^W/_L) \quad (6.20)$$

Turning our attention to the determinants of the growth in average,

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1. ACMS also make use of this assumption; K.J. Arrow et al, <u>op.cit.</u>, pp.233-6.

2. This is an interesting situation for it means that the assumption that a parameter is of constant value, without actually specifying at which value it is constant, is equivalent in outcome to being able to specify its actual value.

and marginal, products, it is clear that they are related in some way to the rates of technical progress and capital deepening. That is;

$$d \; Lg \; (^{Y}/_{L}) = d \; Lg \; \gamma + \Phi_1 \; (d \; Lg \; (^{K}/_{L})) \qquad (6.21)$$

and,

$$d \; Lg \; (^{W}/_{L}) = d \; Lg \; \gamma + \Phi_2 \; (d \; Lg \; (^{K}/_{L})) \qquad (6.22)$$

Applying the 'chain-rule',[1] it follows from (6.20) and (6.22) that;

$$\frac{\partial \, Lg \; (^{Y}/_{L})}{\partial \, Lg \; (^{K}/_{L})} = \frac{\partial \; Lg \; (^{Y}/_{L})}{\partial \; Lg \; (^{W}/_{L})} \cdot \frac{\partial \; Lg \; (^{W}/_{L})}{\partial \; Lg \; (^{K}/_{L})} = \sigma \cdot \Phi_2 \qquad (6.23)$$

Equation (6.23) may be substituted into (6.21) and rearranged, to yield;

$$d \; Lg \; \gamma = d \; Lg \; (^{Y}/_{L}) - \sigma\Phi_2 \; (d \; Lg \; ^{K}/_{L}) \qquad (6.24)$$

From equation (6.22) we see that;

$$\Phi_2 \; (\; d \; Lg \; (^{K}/_{L})) = d \; Lg \; (^{W}/_{L}) - d \; Lg \; \gamma$$

Substitution of the above into equation (6.24) gives;

$$d \; Lg \; \gamma = d \; Lg \; (^{Y}/_{L}) - \sigma \; (d \; Lg \; (^{W}/_{L}) - d \; Lg \; \gamma)$$

This may be simplified to yield;

$$d \; Lg \; \gamma = \frac{d \; Lg \; (^{Y}/_{L}) - \sigma \; d \; Lg \; (^{W}/_{L})}{1 - \sigma} \qquad (6.25)$$

If the variables in equation (6.25) are treated, not as rates of growth over time,[2] but rather as differences in the logarithm of $(^{Y}/_{L})$ between regions at a point in time,[3] equation (6.25) immediately becomes

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1. R.C.D. Allen, <u>Mathematical Analysis for Economists</u> (London, Macmillan, 1938), p.298f.

2. i.e. $d \; Lg \; (^{Y}/_{L}) = Lg \; (^{Y}/_{L})_{t+n} - Lg \; (^{Y}/_{L})_{t}$

3. i.e. $\Delta \; Lg \; (^{Y}/_{L}) = Lg \; (^{Y}/_{L})_{j} - Lg \; (^{Y}/_{L})_{i}$

equation (6.19), i.e.;

$$\Delta \text{ Lg}_{\ j} = \frac{\Delta \text{ Lg } (^Y/_L)_j - \sigma \, \Delta \text{ Lg } (^W/_L)_j}{1 - \sigma} \qquad (6.19)$$

Equation (6.19) makes explicit use of the fact that if the elasticity of substitution (σ) is not equal to unity, capital deepening will effect average and marginal products differently. This may be used to isolate the 'deepening component' of productivity differences and, given that technical progress is Hicks neutral, enable the rate of technical progress to be calculated as a residual. If the production function is Cobb-Douglas in form, the rates of growth in the average and marginal products will be identical (i.e. $d \text{ Lg } (^Y/_L) = d \text{ Lg } (^W/_L)$); hence knowledge of these two rates of growth is not sufficient to determine the rate of capital deepening.

It is of particular interest that this approach enables an evaluation of the source of inter-regional differences, at a point in time. The model, and its counterpart the Cobb-Douglas production function, have usually been restricted to examining the sources of productivity differences over time. There is no reason in principle, why models of 'economic growth' should not be seen as relevant to the 'cross-sectional' situation, especially given the existing deficiency of consistent regional data over any length of time.[1] Surely it is as interesting and important to understand the sources of differences in regional productivity at a point in time, as it is to understand the sources of productivity growth, in any given region, over time.

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1. Olsen's analysis in particular suffers from a paucity of observations for each region; but could well be carried out on an inter-regional basis with the data he has available. E. Olsen, op.cit., pp.103-160.

Estimates of the Relative Efficiency Parameter for Regional Manufacturing in the years 1958 and 1963.

It has been demonstrated above that the efficiency parameter in each region, relative to the nation, may be calculated as;

$$Lg\left(\frac{\gamma_j}{\gamma_{UK}}\right) = \frac{\Delta\, Lg\,(Y/L)_j - \sigma\,\Delta\, Lg\,(W/L)_j}{1-\sigma} \qquad (6.19)$$

Data for output per worker and average earnings is available for 1958 and 1963, and is reported in the Appendix to this chapter, Table 6.A1. The estimates of the elasticity of substitution, derived in Chapter Five, are;[1]

1958: $\hat{\sigma} = 1.317$

1963: $\hat{\sigma} = 1.089$

Table 6.1 reports the estimates of the Relative Efficiency Parameter calculated under the assumption of constant returns to scale for the manufacturing sector of the regions in 1958 and 1963, using the formula presented in equation (6.19).

As a comparison Table 6.2 reports indices of labour productivity in the manufacturing sector of the regions, in 1958 and 1963.[2] Wales is perhaps the most interesting region, with labour productivity well above average in both years, but presenting evidence of an efficiency parameter which is well below average. This implies that the level, and/or effectiveness, of the capital stock is relatively high in this region.[3] The reverse appears to be the case with the West Midlands

1. Chapter Five, p.186.

2. U.K. = 1.000.

3. Support for this hypothesis may be found in E. Nevin, A.R. Roe and J.I. Round, The Structure of the Welsh Economy, Welsh Economic Studies, No.4 (Cardiff, University of Wales Press, 1966), pp.2-6.

Table 6.1

Estimates of the Relative Efficiency Parameter in the Manufacturing Sector of U.K. Regions: 1958 and 1963[1]

Region	1958	1963
N	0.937	0.668
YH	0.939	1.180
EM	1.600	1.120
EA	0.863	0.540
SE	1.080	0.817
SW	1.010	0.885
WM	1.270	2.340
NW	0.922	1.030
W	0.786	0.632
S	0.942	0.668
NI	1.030	0.935
UK	1.000	1.000

1. Calculated using equation (6.19) from the data reported in Appendix Table 6.A1.

Table 6.2

Indices of Labour Productivity in Manufacturing:[1] 1958 and 1963[2]

Region	1958	1963
N	1.090	1.050
YH	0.945	0.915
EM	0.928	0.912
EA	0.975	0.992
SE	1.079	1.105
SW	1.000	1.022
WM	0.970	0.960
NW	0.943	0.963
W	1.182	1.135
S	0.965	0.978
NI	0.678	0.760
UK	1.000	1.000

1. Index $= \dfrac{(Y/L)_j}{(Y/L)_{UK}}$

2. Calculated from data in Appendix Table 6.A1.

region which has efficiency parameters well above average, but labour productivity which is a little below average. The rank correlation coefficient between the values of the Relative Efficiency Parameter and the labour productivity indices in 1958, is -0.400; a value which is not significantly less than zero at the 5 per cent confidence level. For 1963, the rank correlation coefficient is -0.650, which is significantly different from zero at the 5 per cent confidence level.[1]

It appears that whilst there are significant differences in the magnitude of the efficiency parameter between regions, differences in this parameter are being offset by differences in the level and effectiveness of capital per worker.

A transformation of equation (6.2) into logarithms, yields an expression for the logarithm of labour productivity in each region;

$$Lg\ (^Y/_L)_j = Lg\ \gamma_j - {}^1/_\rho\ Lg\left[\delta\ (^K/_L)_j^{-\rho} + (1-\delta)\right] \qquad (6.26)$$

Similarly, for the nation;[2]

$$Lg\ (^Y/_L)_{UK} = Lg\ \gamma_{UK} - {}^1/_\rho\ Lg\left[\delta\ (^K/_L)_{UK}^{-\rho} + (1-\delta)\right] \qquad (6.27)$$

Subtraction of (6.27) from (6.26) yields;[3]

$$\Delta\ Lg\ (^Y/_L)_j = \Delta\ Lg\ \gamma_j + \Delta\ Lg\ (\phi(^K/_L)_j) \qquad (6.28)$$

where: $\Delta\ Lg\ \gamma_j = Lg\ \gamma_j - Lg\ \gamma_{UK}$

1. The coefficient of rank correlation between the estimates in 1958 and 1963 is +0.640, which is significant at the 5 per cent level.

2. Retaining the assumption that the substitution and distribution parameters are constant between regions.

3. Since the substitution and efficiency parameters are assumed to be constant, the source of differences in the last term on the R.H.S. of equation (6.22) will be that of variations in the capital-labour ratio itself.

$$\Delta \text{ Lg } (\phi(^{K}/_{L})_{j}) = -^{1}/_{\rho} \text{ Lg} \left[\delta(^{K}/_{L})_{j}^{-\rho} + (1 - \delta) \right] + \; ^{1}/_{\rho} \text{ Lg} \left[\delta(^{K}/_{L})_{UK}^{-\rho} + (1 - \delta) \right]$$

The last term on the R.H.S. of equation (6.28) expresses the relative importance of differences in the capital-labour ratio between regions, as a source of differences in labour productivity. Since we have estimates of (Δ Lg $(^{Y}/_{L})_{j}$), reported in Table 6.2, and estimates of (Δ Lg γ_j), reported in Table 6.1, the last term on the R.H.S. of equation (6.28) may be calculated as;

$$\Delta \text{ Lg } (\phi(^{K}/_{L})_{j}) = \Delta \text{ Lg } (^{Y}/_{L})_{j} - \Delta \text{ Lg } \gamma_{j} \qquad (6.23)$$

Since equation (6.28) is explicitly expressed in the form of deviations from the national average, it is possible to ascertain the importance of the terms on the R.H.S. of that equation in determining differences in labour productivity between regions. Squaring both sides of equation (6.22) and summing over regions, yields an expression for the inner product of productivity differences in terms of its sources;[1]

$$\sum_{j} (\Delta \text{ Lg } (^{Y}/_{L})_{j})^{2} = \sum_{j} (\Delta \text{ Lg } \gamma_{j})^{2} + \sum_{j} (\Delta \text{ Lg } (\phi(^{K}/_{L})_{j}))^{2} + 2 \sum_{j} ((\Delta \text{ Lg } \gamma_{j})(\Delta \text{ Lg } (\phi(^{K}/_{L})_{j})) \qquad (6.29)$$

Equation (6.29) decomposes the variation in the logarithm of labour productivity between regions into three components; that part which is due to differences in the efficiency parameter between regions; that part which is due to differences in capital intensity; and that part

1. The method for the decomposition of the inner product has been discussed in Chapter One, pp.10-14, and Chapter Four, pp. 156-159.

due to the interaction between these factors.[1]

The results of these calculations are reported in Table 6.3, for the years 1958 and 1963. In both years, differences in capital intensity were more important than differences in the efficiency parameters in determining variations in labour productivity between the regions. The residual, or interaction, term is quite high in both years. Perhaps more important than its size is the negative sign of this term, indicating that differences in capital intensity tend to offset, or more than offset, differences in the efficiency parameter between the regions.

It must be emphasised that these results depend crucially upon the assumption that the efficiency parameter does not vary systematically with the wage rate.[2] If in fact it does, then part of the contribution of the efficiency parameter to labour productivity, will be reflected in the magnitude of the estimated elasticity of substitution and thus included in the contribution of capital deepening. In short, the analysis presented above is likely to underestimate the contribution of 'efficiency' differences to productivity differences, although the relative magnitudes of the efficiency parameters should be a reasonable approximation.

An additional defect of the analysis presented above, is that it is premised on the assumption of constant returns to scale. It may be that this factor is an important source of inter-regional differences in labour productivity.

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1. This will also include a random component.

2. Chapter Five, pp. 183-4.

Table 6.3

Components of Inter-Regional Differences in Labour Productivity: 1958 and 1963

Component	1958	1963
$\sum_j (\Delta \text{ Lg } \gamma_j)^2$	0.154	1.738
$\sum_j (\Delta \text{Lg } (\phi(K/L)_j))^2$	0.451	2.123
Residual (Interaction)	-0.396	-3.740
$\sum_j (\Delta \text{ Lg } (Y/L)_j)^2$	0.209	0.121

The C.E.S. Production Function with an Allowance for Increasing Returns to Scale.

If returns to scale are not constant the CES Production Function will take the form;[1]

$$Y = \gamma \left[\delta K^{-\rho} + (1-\delta) L^{-\rho} \right]^{-\frac{v}{\rho}} \qquad (6.30)$$

where: v = homogeneity parameter.

Differentiation of equation (6.30) with respect to labour yields an expression for the marginal product of labour (assumed to equal the wage rate);

$$w = \frac{\partial Y}{\partial L} = v\,\gamma(1-\delta)\, L^{-\rho-1} \left[\delta K^{-\rho} + (1-\delta) L^{-\rho} \right]^{-(\frac{v}{\rho})-1} \qquad (6.31)$$

Substitution of (6.30) into (6.31) yields;

$$w = v\,(1-\delta)\, L^{-\rho-1}\, Y \left[\delta K^{-\rho} + (1-\delta) L^{-\rho} \right]^{-1} \qquad (6.32)$$

From equation (6.30) we also find that;

$$Y^{\rho/v}\ \gamma^{\rho/v} = \left[\delta K^{-\rho} + (1-\delta) L^{-\rho} \right]^{-1} \qquad (6.33)$$

Equation (6.32) may therefore be rewritten as;

$$w = v\gamma^{-\rho/v} (1-\delta)\, L^{-\rho-1}\, YY^{\rho/v} \qquad (6.34)$$

Multiplying both sides by (Y^{ρ}) gives;

$$Y^{\rho} w = v\gamma^{-\rho/v} (1-\delta)\, L^{-(1+\rho)}\, Y^{1+\rho}\, Y^{\rho/v} \qquad (6.35)$$

Rearranging and dividing both sides by Y^{ρ} yields;

$$w = v^{-\rho/v} (1-\delta)\, (Y/L)^{1+}\ Y^{(\rho/v)-\rho} \qquad (6.36)$$

1. M. Brown and J. de Cani, op.cit.; M. Brown, op.cit., pp.45-60; J.M. Katz, op.cit., pp.70-3; J.M. Katz, "'Verdoorn Effects', Returns to Scale and the elasticity of factor substitution", Oxford Economic Papers, Vol.20, 1968, pp.343-353; P.J. Dhrymes, "Some Extensions and Tests for the CES Class of Production Functions", Review of Economics and Statistics, Vol.47, 1965, pp.357-366.

It follows that;

$$({}^{Y}/_{L})^{1+\rho} = \gamma^{\rho/v} v^{-1} (1 - \delta)^{-1} w Y^{\rho-(\rho/v)} \qquad (6.37)$$

Now;

$$\rho - {}^{\rho}/_{v} = \rho(1 - {}^{1}/_{v}) = \rho(\frac{v - 1}{v})$$

Taking logarithms of equation (6.37) and dividing through by $(1 + \rho)$ gives;

$$Lg\ ({}^{Y}/_{L}) = \frac{1}{1 + \rho} Lg \left[\gamma^{\rho/v} (1 - \delta)^{-1} v^{-1} \right] + \frac{1}{1 + \rho} Lg\ w + (\frac{\rho}{1 + \rho})(\frac{v - 1}{v})\ Lg\ Y \qquad (6.38)$$

Since $(\frac{1}{1 + \rho})$ is equal to the elasticity of substitution (equation (6.10)), the above may be rewritten as;[1]

$$Lg\ ({}^{Y}/_{L}) = \sigma\ Lg \left[\gamma^{\rho/v} (1 - \delta)^{-1} v^{-1} \right] + \sigma\ Lg\ w + \frac{(1 - \sigma)(v - 1)}{v}\ Lg\ Y \qquad (6.39)$$

The efficiency parameter (γ_j) for any region may therefore be expressed as;[2]

$$Lg\ \gamma_j = \frac{Lg\ ({}^{Y}/_{L})_j - \sigma\ Lg\ w_j - \frac{(1 - \sigma)(v - 1)}{v}\ Lg\ Y_j}{\sigma\ {}^{\rho}/_{v}} + \frac{Lg\ v + Lg\ (1 - \delta)}{{}^{\rho}/_{v}} \qquad (6.40)$$

In the previous section of this chapter the national efficiency parameter was taken as the base for the measurement of the relative efficiency parameter for each region. This approach cannot be adopted in the present section owing to the appearance of the scale term $(Lg\ Y_j)$ in equation (6.40). If the national parameter were taken as the base, the 'scale deflator' would be;

$$\frac{(1 - \sigma)(v - 1)}{v} (Lg\ Y_j - Lg\ Y_{UK})$$

---

1. This is equivalent to the estimating equation (5.16) used in the previous chapter.

2. The assumption that the distribution, substitution and homogeneity paramenters do not differ between regions, is maintained.

Since the nation is the aggregate of all regions, this expression is always negative. This would result in extremely high values of the relative efficiency parameter for all regions. To counter this effect the mean of all regions is taken as the relevant benchmark. Subtraction of the 'mean' efficiency parameter from the efficiency parameter for each region, assuming that the distribution parameter is identical in all regions, will yield;[1]

$$\text{Lg}\,\gamma_j - \text{Lg}\,\gamma_x = \frac{\Delta\,\text{Lg}\,(Y/L)_j - \sigma\Delta\,\text{Lg}\,(W/L)_j}{(\frac{1-\sigma}{v})} - (v-1)\,\Delta\text{Lg}\,Y_j \qquad (6.41)$$

where: $\Delta\,\text{Lg}\,(Y/L)_j = \text{Lg}\,(Y/L)_j - \text{Lg}\,(Y/L)_x$

$\Delta\,\text{Lg}\,(W/L)_j = \text{Lg}\,(Y/L)_J - \text{Lg}\,(Y/L)_x$

$\Delta\,\text{Lg}\,Y_j = \text{Lg}\,Y_j - \text{Lg}\,Y_x$

The use of regional means facilitates the calculation of an 'Adjusted Relative Efficiency Parameter',[2] for each region.

Estimates of the elasticity of substitution and the degree of returns to scale were reported in Chapter Five, for the years 1958 and 1963.[3] These were;

1958: $\hat{\sigma} = 1.439$

$\hat{v} = 1.060$

1963: $\hat{\sigma} = 1.221$

$\hat{v} = 1.125$

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1. Where the (x) subscript indicates the mean value for all regions.

2. 'Adjusted' for the effects of increasing returns to scale.

3. Chapter Five, p.194.

Table 6.4 reports estimates of the adjusted efficiency parameter for each region (relative to the mean values for all regions) in 1958 and 1963, using the estimates of the production function parameters reported above. Again there is little association between the estimates of the efficiency parameters and labour productivity indices, in each year. The coefficients of rank correlation between the estimates of the adjusted relative efficiency parameters and productivity indices in 1958 and 1963, are -0.150 and -0.452 respectively.[1, 2]

As was the case with the constant returns formulation, it is possible to estimate the importance of the different sources of productivity growth, as determinants of variations in labour productivity between regions. The deviation of the logarithm of labour productivity in any region (j) from the mean of all regions, may be expressed as;

$$\Delta \text{ Lg } ({}^{Y}/_{L})_{j} = \Delta \text{ Lg } \gamma_{j} + \Delta \text{ Lg } (\psi({}^{K}/_{L})_{j}) + \Delta g \text{ Lg } (Y_{j}) \qquad (6.42)$$

where: g = elasticity of labour productivity with respect to output.[3]

The second term on the R.H.S. of equation (6.42), which measures the effect of differences in capital intensity, is calculated as;

$$\Delta \text{ Lg } (\psi({}^{K}/_{L})_{j}) = \Delta \text{ Lg } ({}^{Y}/_{L})_{j} - \Delta \text{ Lg } (\gamma)_{j} - \Delta g \text{ Lg } (Y)_{j}$$

Squaring both sides of equation (6.37) and summing over regions

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1. Neither is significantly different from zero at the 5 per cent confidence limit.

2. The rank correlation coefficient between the estimates reported in Table 6.1, and Table 6.4 are; 0.985 in 1958, and 0.970 in 1963.

3. From equation (6.33) it will be seen that;

$$g = \frac{(1 - \sigma)(v - 1)}{v}$$

Table 6.4

Estimates of the Relative Efficiency Parameter in each Region with Adjustments for Returns to Scale: 1958 and 1963[1]

Region	1958	1963
N	0.991	0.931
YH	0.934	1.040
EM	1.050	1.060
EA	0.969	0.895
SE	1.010	0.828
SW	1.050	1.070
WM	1.180	1.470
NW	0.913	0.946
W	0.907	0.970
S	0.943	0.832
NI	1.040	1.040

1. Calculated using equation (6.41), from the data in Appendix Table 6.A1.

yields an expression for the total sum of squares in labour productivity;

$$\sum_j (\Delta \text{ Lg } (^Y/_L)_j)^2 = \sum_j (\Delta \text{ Lg } _j)^2 + \sum_j (\Delta \text{ Lg } (\psi(^K/_L)_j))^2 + \sum_j (\Delta g \text{ Lg } (Y)_j)^2 + R \qquad (6.43)$$

where: R = interaction terms (co-variances) together with a random component.

The components of the total sum of squares in labour productivity are reported, for 1958 and 1963, in Table 6.5. It appears that differences in the scale of output account for a very small part of the differences in labour productivity between regions. Differences in capital intensity between regions remains the major single source of differences in labour productivity between the regions.

Regional Efficiency Parameters and the Doctrine of General Locational Disadvantage

It is clear from the form of the CES Production Function that the efficiency parameter (γ) determines the 'position', or distance from the origin in the production surface, of a representative isoquant for each region. If we compare the CES function

$$Y = \gamma \left[\delta K^{-\rho} + (1 - \delta) L^{-\rho}\right]^{-1/\rho} \qquad (6.1)$$

with the Cobb-Douglas function,

$$Y = AK^{\beta} L^{\alpha} \qquad (6.44)$$

it is easily seen that the efficiency parameter (γ), in the CES Function, performs a role analogous to that of the 'technological parameter' (A), in the Cobb-Douglas Function.[1] Expressed in terms of labour productivity rather than output, we find for the CES function that;

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1. C.E. Ferguson, The Neoclassical Theory of Production and Distribution, (Cambridge, C.U.P., 1969), p.103; D. Heathfield, op.cit., p.56, and M. Brown, op.cit., p.54.

Table 6.5

Decomposition of the Total Sum of Squares of the Logarithm of Labour Productivity: 1958 and 1963

Component	1958	1963
$\sum_j (\Delta \text{ Lg } \gamma_j)^2$	0.066	0.242
$\sum_j (\Delta \text{ Lg } (\psi({}^K/_L)_j))^2$	0.352	0.484
$\sum_j (\Delta \text{ g Lg } (Y)_j)^2$	0.002	0.010
R	-0.220	-0.616
$\sum_j (\Delta \text{ Lg } ({}^Y/_L)_j)^2$	0.198	0.110

$$Y/_{L} = \left[\delta(K/_{L})^{-\rho} + (1 - \delta)\right]^{-1/_{\rho}} \qquad (6.45)$$

Inter-regional differences in the efficiency parameter will be reflected, ceteris paribus, in inter-regional differences in labour productivity.

In this section of the chapter it will be argued that differences in the efficiency parameter between regions, reflect the general environment of production within each region. To the extent that there are ". . . significant differences between the economy of a region . . . and the whole of the United Kingdom as environments of manufacturing industries . . .",[1] these differences should be reflected in the magnitude of the regional efficiency parameters.

The notion that the 'efficiency' of production is relatively lower in the peripheral regions,[2] and that this in turn reflects general or locational disadvantages specific to that region, will be referred to as 'the doctrine of inherent, or locational, disadvantage'.[3] This doctrine has had an important influence upon economic policy, in that the application of the 'Regional Employment Premium' presumably reflects at least in part, this notion.[4]

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1. P.E. Hart and A.I. MacBean, "Regional Differences in Productivity, Profitability and Growth: A Pilot Study", Scottish Journal of Political Economy, Vol.8, 1961, pp.1-11.

2. In particular: Northern Ireland, Scotland, Wales and the North. Although these do not correspond exactly with the 'development areas'.

3. A stimulating discussion of these views may be found in: G. McCrone, Regional Policy in Britain (London, George Allen and Unwin, 1969), pp.169-180; G. McCrone, "The Location of Economic Activity in the United Kingdom", Urban Studies, Vol.9, 1972, pp.369-375.

4. Department of Economic Affairs and H.M. Treasury, The Development Areas: A Proposal for a Regional Employment Premium (London, H.M.S.O., 1967); A.J. Brown, H. Lind and J. Bowers, "The 'Green Paper' on the Development Areas", National Institute Economic Review, No.40, 1967, pp.26-33; N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-348.

Specific references to the doctrine of locational disadvantage are often found, not in studies explicitly of a 'production function' genre, but rather in 'Shift and Share' analyses.[1] It is often claimed for example that, ". . . the generally poorer industry-by-industry performance [vis-à-vis employment growth] of the development areas in comparison with the country as a whole reflects general locational disadvantages . . .".[2]

General locational disadvantages may reflect many factors including perhaps climate, transport costs, labour quality, managerial ability, the age and quality of capital equipment, and many others.[3] Provided that these factors do not vary systematically with the wage rate between regions, the estimates of the efficiency parameters derived above, should refelct the operation of these factors within the regions.

Referring to the estimates of the 'relative efficiency parameter', reported in Table 6.1, it will be seen that there is some evidence that the peripheral regions (N, W, S and NI) do exhibit relatively low efficiency parameters. Similarly as inspection of the estimates of the 'adjusted efficiency parameter', reported in Table 6.4, indicates that even when returns to scale are taken into account, the peripheral

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1. A.J. Brown et al, op.cit., passim; A.J. Brown, "Surveys of Applied Economics: Regional Economics, with Special Reference to the United Kingdom", Economic Journal, Vol.79, 1969, pp.765-768; T.W. Buck, "Shift and Share Analysis - A Guide to Regional Policy?", Regional Studies, Vol.4, 1970, pp.445-450; F.J.B. Stilwell, "Further Thoughts on the Shift and Share Approach", Regional Studies, Vol.4, 1970, pp.451-458; G. McCrone, op.cit., pp.169-180.

2. A.J. Brown et al, "The 'Green Paper' on the Development Areas", National Institute Economic Review, No.40, 1967, p.29.

3. P. Hart and A.I. MacBean, op.cit., p.2. Their analysis has been critically discussed in R.L. Smyth, "A Note on Regional Differences in Productivity, Profitability and Growth", Scottish Journal of Political Economy, Vol.8, 1961, pp.246-250; G. Fisher, "Further Calculations on Regional Differences in Profitability and Growth", Scottish Journal of Political Economy, Vol.9, 1962, pp.147-158.

regions (with the exception of Northern Ireland) continue to exhibit a relatively low estimate of the efficiency parameter. This is particularly true of Scotland.

It is also of interest to consider how other regions, in particular the 'intermediate areas',[1] fare in this regard. If returns to scale are disregarded, the NW, YH and the SW show a relatively low efficiency parameter in only one, of the two years studied.[2] If returns to scale are included explicitly in the analysis, as in the case with the estimates reported in Table 6.4, the South West exhibits an above average efficiency parameter in both years. Yorkshire and Humberside remains below average in one year and above average in the other. The North West, on the other hand, exhibits an efficiency parameter which is well below average in both years. There is little to distinguish between regions which are representative of the development areas, and the intermediate areas, in this regard. Taken together, most of these regions tend to exhibit 'low' efficiency parameters relative to the average. This is not to say that the causes, or effects, of the relatively low efficiency parameter may not differ between the two regional groupings, or even between regions within a given grouping. This result would seem to indicate the need for a flexible regional policy consisting of a spectrum of policy instruments, rather than a rigidly discriminatory policy based upon only two or three regional

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1. In particular, North West, Yorkshire and Humberside, and the South West. Department of Economic Affairs, The Intermediate Areas: Report of a Committee under the Chairmanship of Sir Joseph Hunt, Cmnd.3998 (London, H.M.S.O., 1969), p.1.

2. The estimates are reported in Table 6.1.

groupings.[1]

Some idea of the relationship between the 'differential' ('rate') component of Shift-Share studies, and the relative levels of the efficiency parameter for each region, may also be established. In Chapter Three one measure[2] of the differential, or rate, component of employment growth was discussed, and estimates of this component were reported for each industry in each region, over the period 1958 to 1963.[3] The estimates totals of this component for each region are reported in Table 6.6. To the extent that the sign and magnitude of the differential component reflects general locational factors, we would expect to find some association between the values of the differential component between regions, and the corresponding values of the regional efficiency parameters. The particular hypothesis to be considered is, that there is a positive rank correlation between the regional ordering of the estimated efficiency parameters in 1958 and the ordering of regions according to the magnitude of the differential component of their employment growth over the period.[4]

Neither of the estimates of the efficiency parameter, reported in Tables 6.1 and 6.4, are positively correlated with the differential

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1. A.J. Brown, 'Note of Dissent', in Department of Economic Affairs, The Intermediate Areas, op.cit., pp.155-165; H.W. Richardson, "The Hunt Report", Yorkshire Bulletin of Economic and Social Research, Vol.22, 1970, pp.54-64.

2. There are a number of alternative measures depending upon the weighting system used. The estimates referred to in Chapter Three used regional weights in the calculation of the differential component.

3. The estimation procedure is discussed in Chapter Three, pp.90-93, and the results are reported in an Appendix to that chapter, Table 3.A2. We are interested only in the total for each region.

4. Both ranked from highest to lowest.

Table 6.6

The Differential Component of Regional Employment Growth: 1958-1963[1]

Region	Component
N	-0.57
YH	0.26
EM	0.33
EA	2.26
SE	0.21
SW	0.05
WM	0.00
NW	-0.70
W	0.72
S	-1.14
NI	0.95

1. Source: Chapter Three, Appendix Table 3.A2.

component of employment growth. The coefficient of rank correlation using the Relative Efficiency Parameters (Table 6.1) is -0.090; using the Adjusted Relative Efficiency Parameters (Table 6.4), it is -0.014. Neither of these coefficients differs significantly from zero. It is interesting to note, that those regions which exhibited a negative differential component over the period[1] also exhibited an efficiency parameter which was below average. To this extent at least, general locational disadvantage appears to be associated with the differential component of employment growth.[2]

Conclusion

An attempt has been made to demonstrate that economic models which are usually contemplated in the context of change through time, may also be applied to the analysis of regional differences at a point in time. The relationship between regional efficiency parameters and labour productivities has been elucidated with the aid of the CES production function. The relationship between regional variations in efficiency (and thus labour productivity) and employment growth has been touched upon, but this is properly the subject of a separate chapter.

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1. That is: North, North West, and Scotland.

2. Alternative estimates of the differential (rate) component, for each region, are discussed in Chapter Seven. The above conclusions are also applicable to the alternative measures.

Appendix Table 6.A1

Output per Worker and Average Earnings in the Manufacturing Sector of U.K. Regions: 1958 and 1963. (£'s).

Region	Net Output per Worker[1]		Average Earnings[2]	
	1958	1963	1958	1963
N	1095	1425	597	725
YH	955	1245	538	670
EM	937	1240	546	665
EA	985	1345	540	675
SE	1090	1495	615	770
SW	1010	1390	571	725
WM	980	1305	590	741
NW	953	1310	540	695
W	1195	1540	615	775
S	975	1350	547	680
NI	685	1035	427	556
UK	1010	1362	573	718

1. Net Output in each region divided by total employment.

2. Total wages and salaries divided by total employment.

Source: Board of Trade, Report on the Census of Production 1963, (London, H.M.S.O., 1970), Part 133, p.6f.

Chapter Seven

The Proximate Determinants of Employment Growth in Regional Manufacturing

The concern of this chapter is with explaining the determination of regional employment growth. This is of particular interest since variations in regional unemployment rates are directly related to the growth of labour demand, together with the growth of the regional work force.

In the first section of the chapter a 'shift-share' analysis of employment growth is undertaken. This facilitates an assessment of the relative importance of changes in the composition, rather than in the level, of output as a determinant of employment growth. The remaining sections of the chapter adopt a macroeconomic viewpoint, concentrating directly upon explanatory relationships derived from the mainstream of economic theory.

Shift and Share Analyses of Employment Growth

Shift and Share studies of employment growth attempt to isolate at least two components of regional, vis-à-vis national, growth rates. These may be referred to as the 'rate' (differential growth) component, and the 'composition' (mix) component.[1] The rate component indicates that regional employment may grow faster than national employment, even if it possesses the same industrial structure as the nation, because employment in each industry expands at different rates between regions.

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1. In this chapter we will adopt the self-explanatory nomenclature of Harris and Thirlwall. See C.P. Harris and A.P. Thirlwall, "Interregional Variations in Cyclical Sensitivity to Unemployment in the U.K. 1949-1964", Bulletin of the Oxford University Institute of Economics and Statistics, Vol.30, 1968, pp.55-66.

Alternatively, industries may grow at the same rate in all regions but, depending upon the proportion of each region's work force engaged in each activity, these individual rates of growth will imply differing rates of growth in the aggregate.[1] It is possible to derive a number of alternative measures of these components.

For each region (j), total employment will equal the sum of employment in each of the industries (i) in that region;

$$L_j = \sum_i L_{ij} \qquad (7.1)$$

where: L_{ij} = employment in industry (i) in region j;

L_j = total employment in region j.

Similarly for the nation (all regions taken together);

$$L = \sum_j L_i = \sum_j L_j = \sum_i \sum_j L_{ij} \qquad (7.2)$$

where: L = total national employment;

L_i = total employment in industry (i).

The ratio of regional to national employment in any period will equal;

$$\frac{L_j}{L} = \frac{\sum_i L_{ij}}{\sum_i L_i} \qquad (7.3)$$

Totally differentiating equation (7.3) yields an expression for the change in the ratio of regional to national employment;

$$\Delta\left(\frac{L_j}{L}\right) = \sum_i \Delta L_{ij} \cdot \frac{1}{L} - \sum_i \frac{\Delta L_{ij}}{L} \cdot \frac{L_j}{L} \qquad (7.4)$$

Dividing both sides by the ratio of regional to national employment, yields an expression for the relative rates of employment growth;[2]

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1. Cf. the discussion in Chapter Three, pp.90-93.

2. Multiplying each of the terms on the L.H.S. by $\frac{L_{ij}}{L_{ij}}$ and $\frac{L_i}{L_i}$, respectively.

$$\frac{\Delta\left(\frac{L_j}{L}\right)}{\frac{L_j}{L}} = \frac{\Delta L_j}{L_j} - \frac{\Delta L}{L} = \sum_i \frac{\Delta L_{ij}}{L_{ij}}.\frac{L_{ij}}{L_j} - \sum_i \frac{\Delta L_i}{L_i}.\frac{L_i}{L} \qquad (7.5)$$

Equation (7.5), which expresses the difference in the aggregate growth rates in terms of differences in the weighted sums of the industry growth rates, is the basic starting point of a shift-share analysis.

If we arbitrarily add and subtract the term $\sum_i \frac{\Delta L_i}{L_i} \cdot \frac{L_{ij}}{L}$ from the R.H.S. of equation (7.5), we find (after rearrangement) that;

$$\frac{\Delta L_j}{L_j} - \frac{\Delta L}{L} = \sum_i \frac{L_{ij}}{L_j}\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) + \sum_i \frac{\Delta L_i}{L_i}\left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right) \qquad (7.6)$$

This is the expression for relative employment growth used by Perloff[1] and his associates, and Thirlwall.[2] The first term on the R.H.S. of equation (7.6) is a measure of the 'rate' (differential growth) component, and the second term is a measure of the 'composition' (mix) component.

These components of employment growth were calculated for the manufacturing sector in each region, over the period 1958 to 1963.[3] The components are reported in Table 7.1.[4] It is possible, using the technique for the 'evaluation of inner products', to obtain some idea of the importance of these components as determinants of inter-regional

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1. H.S. Perloff et al, Regions, Resources and Economic Growth (Baltimore, John Hopkins Press, 1960), p.71n.

2. A.P. Thirlwall, "A Measure of the Proper Distribution of Industry", Oxford Economic Papers, Vol.19, 1967, pp.46-58.

3. Data refers to the SIC order level, Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), part 133.

4. The components are measured as annual average rates of growth. Base year weights are applied throughout.

Table 7.1

Estimates of the Composition and Rate Components of Employment Growth, U.K. Regions: 1958-1963[1]

Region	Rate Component[2]	Composition Component[3]	Total
N	-0.57	-0.53	-1.10
YH	0.26	-0.66	-0.40
EM	0.33	-0.23	0.10
EA	2.26	1.14	3.40
SE	0.21	0.19	0.40
SW	0.05	0.05	0.10
WM	0.00	0.50	0.50
NW	-0.70	-0.20	-0.90
W	0.72	0.38	1.10
S	-1.14	-0.46	-1.60
NI	0.95	-1.85	-0.90

1. Estimated from equation (7.6)

2. Rate component = $\sum_i \frac{L_{ij}}{L_j} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right)$

3. Composition component = $\sum_i \frac{\Delta L_i}{L_i} \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right)$

differences in employment growth.

Equation (7.6) may be rewritten as follows;

$$\Delta \ell_j = RRC_j + NCC_j \qquad (7.7)$$

where: $\Delta \ell_j = \frac{\Delta L_j}{L_j} - \frac{\Delta L}{L}$;

RRC = Rate component estimated using regional weights;

NCC = Composition component estimated using national weights.

Squaring both sides of equation (7.7) and summing over regions, yields an expression for the total sum of squares of regional growth rates of employment;

$$\sum_j (\Delta \ell_j)^2 = \sum_j RCC_j^2 + \sum_j NCC_j^2 + R_1 \qquad (7.8)$$

where: R_1 = interaction and random components.

The values for each of the terms in equation (7.8) were calculated from the data contained in Table 7.1, and are reported in Table 7.2. The results indicate that inter-regional differences in the growth rates of individual industries are the major source of differences in the rate of aggregate employment growth between regions.

It should be noted however, that equation (7.6) was derived quite arbitrarily from equation (7.5). Instead of introducing the term $(\sum_j \frac{\Delta L_i}{L_i} \cdot \frac{L_{ij}}{L})$ we could add and subtract $\sum_j \frac{\Delta L_{ij}}{L_{ij}} \cdot \frac{L_i}{L}$ from the R.H.S. of equation (7.5). This will yield an alternative expression for the rate and composition effects;[1]

$$\frac{\Delta L_j}{L_j} - \frac{\Delta L}{L} = \sum_i \frac{L_i}{L} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) + \sum_i \frac{\Delta L_{ij}}{L_{ij}} \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right) \qquad (7.9)$$

This expression is similar to equation (7.6), except that national

1. N.J. Cunningham, "A Note on the 'Proper Distribution of Industry'", Oxford Economic Papers, Vol.21, 1969, pp.122-127.

Table 7.2

Source of Inter-Regional Differences in Employment Growth Rates: 1958-1963[1]

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j RRC^2$	8.87	47.5
$\sum_j NCC^2$	6.18	33.0
Residual	3.70	19.5
$\sum_j (\Delta \ell_j)^2$	18.75	100.0

1. Calculated from equation (7.8) using the (mixed weight) estimates reported in Table 7.1.

weights are now used to calculate the 'rate' effect, and regional weights are used to calculate the 'composition' effect. The values of the rate and composition effects for the period 1958-1963, using this alternative weighting system, are reported in Table 7.3. The extreme values for East Anglia are due mainly to the rapid growth of employment in Vehicles (SIC VIII) in that region. Similarly the estimate for the West Midlands reflects the expansion of Shipbuilding and Marine Engineering (!) in that region.[1] A comparison between Tables 7.1 and 7.3 reveals striking dissimilarities in the estimates of the rate and composition effects. These dissimilarities arise solely from the use of alternative weighting systems.

The contribution of the rate and composition effects to inter-regional differences in employment growth, may be assessed in a manner analogous to that conducted earlier.

Equation (7.9) may be rewritten as;

$$\Delta \ell_j = NRC_j + RCC_j \qquad (7.10)$$

where: NRC = Rate Component calculated using national weights;

RCC = Composition Component calculated using regional weights.

Squaring both sides of equation (7.10) and summing over regions, yields an expression for the total sum of squares of regional growth;

$$\sum_j (\Delta \ell_j)^2 = \sum_j NRC_j^2 + \sum_j RCC_j^2 + R_2 \qquad (7.11)$$

The sources of inter-regional differences in aggregate employment growth, using this method of computation, are reported in Table 7.4.

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1. A.J. Brown, "Surveys of Applied Economics: Regional Economics, with Special Reference to the United Kingdom", <u>Economic Journal</u>, Vol.79, 1969, p.780.

Table 7.3

Alternative Estimates of the Composition and Rate Components of Employment Growth, U.K. Regions: 1958-1963[1]

Region	Rate Component[2]	Composition Component[3]	Total
N	0.23	-1.33	-1.10
YH	-0.06	-0.34	-0.40
EM	0.93	-0.83	0.10
EA	7.48	-4.08	3.40
SE	0.34	0.06	0.40
SW	0.45	-0.35	0.10
WM	1.06	-0.56	0.50
NW	0.05	-0.95	-0.90
W	1.70	-0.60	1.10
S	-1.10	-0.50	-1.60
NI	1.34	-2.24	-0.90

1. Estimated from equation (7.9)

2. Rate Component = $\sum_i \frac{L_i}{L} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right)$

3. Composition Component = $\sum_i \frac{\Delta L_{ij}}{L_{ij}} \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right)$

Table 7.4

Sources of Inter-Regional Differences in Employment Growth Rates: 1958-1963[1]

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j NRC_j^2$	64.21	354.0
$\sum_j RCC_j^2$	26.19	138.0
Residual	-71.65	-392.0
$\sum_j (\Delta \ell_j)^2$	18.75	100.0

1. Calculated from equation (7.11) using the (alternative mixed weight) estimates reported in Table 7.3.

Whilst the residual (interaction) term is large, the results are similar to those for the alternative weighting system (Table 7.2), in that differences in the growth rates of individual industries between regions dominate over structural differences, as a source of variation in aggregate employment growth.

It is clear, however, that the choice of weighting systems is quite arbitrary and in addition the use of mixed weights (as in equations (7.6) and (7.9)) introduces an element of inconsistency. Several authors have shown that a consistent weighting system yields a third component of employment growth, which may be of particular interest in itself.[1] Applying regional weights to both the rate and composition terms we find an alternative expression for the relative rate of aggregate employment growth;

$$\frac{\Delta L_{.j}}{L_{.j}} - \frac{\Delta L}{L} = \sum_i \frac{L_{ij}}{L_{.j}} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_{i.}}{L_{i.}}\right) + \sum_i \frac{\Delta L_{ij}}{L_{ij}} \left(\frac{L_{ij}}{L_{.j}} - \frac{L_{i.}}{L}\right) - \sum_i \left[\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_{i.}}{L_{i.}}\right)\left(\frac{L_{ij}}{L_{.j}} - \frac{L_{i.}}{L}\right)\right] \qquad (7.12)$$

The interaction term (the last term on the R.H.S. of the above equation) will reflect any correlation between rate and composition differences.[2]

Table 7.5 reports the value of these components of relative employment growth for each region over the period 1958 to 1963. Only one region, the South East, demonstrates positive values for both the rate

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1. A.J. Brown, op.cit., p.766f; N.J. Cunningham, op.cit., pp.122-127; C.P. Harris and A.P. Thirlwall, op.cit., p.56f; A.P. Thirlwall, "Weighting Systems and Regional Analysis: A Reply to Mr. Cunningham", Oxford Economic Papers, Vol.21, 1969, pp.128-133.

2. The interaction term is identical to Cunningham's 'rho'. N.J. Cunningham, op.cit., p.124.

Table 7.5

Estimates of the Rate, Composition and Interaction Components of Employment Growth in U.K. Regions: 1958-1963[1]

Region	Rate Component[2]	Composition Component[3]	Interaction Component[4] (minus)	Total
N	-0.57	-1.33	-0.80	-1.10
YH	0.26	-0.34	0.32	-0.40
EM	0.33	-0.83	-0.60	0.10
EA	2.26	-4.08	-5.22	3.40
SE	0.21	0.06	-0.13	-.40
SW	0.05	-0.35	-0.40	0.10
WM	0.00	-0.56	-1.06	0.50
NW	-0.70	-0.95	-0.75	-0.90
W	0.72	-0.60	-0.98	1.10
S	-1.14	-0.50	-0.04	-1.60
NI	0.95	-2.24	-0.39	-0.90

1. Estimated from equation (7.12), using regional weights.

2. Rate component = $\sum_i \frac{L_{ij}}{L_i} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i} \right)$

3. Composition component = $\sum_i \frac{\Delta L_{ij}}{L_{ij}} \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L} \right)$

4. Interaction term = $\sum_i \left[\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i} \right) \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L} \right) \right]$

and composition components. Of those regions where the aggregate relative employment growth was negative, three exhibit negative values for the rate and composition components. Each region with a negative total effect showed evidence of a negative, and sizeable, composition component.

It is clear from the specification of the interaction term in equation (7.12) that the sign, and magnitude, of this component may be interpreted as a reflection of trends in regional specialisation.[1] The interaction component will be negative if regions are tending to expand faster in those industries in which they are least specialised, vis-à-vis the nation. In other words, the interaction component will be negative if there is some tendency for regional industrial structures to converge. This has indeed been the case in most regions; as the measures of specialisation change discussed earlier in the thesis indicate.[2]

It is possible to assess the importance of each of these components in determining the variation in aggregate employment growth between regions. Equation (7.12) may be rewritten as;

$$\Delta\ell_j = RRC_j + RCC_j - \rho_j \qquad (7.13)$$

where: ρ_j = interaction term in equation (7.12).

Squaring both sides of equation (7.13) and summing over regions, yields an expression for the total sum of squares in regional employment growth;

$$\sum_j (\Delta\ell_j)^2 = \sum_j RRC_j^2 + \sum_j RCC_j^2 + \sum_j \rho_j^2 + R_3 \qquad (7.14)$$

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1. N.J. Cunningham, op.cit., p.125; A.P. Thirlwall, op.cit., pp.129-131.

2. Chapter Two, pp.31-34.

Estimates of these components are reported in Table 7.6. In this formulation the importance of rate differences as a source of variation in aggregate growth of employment, is very slight. The importance of differences in industrial structure as a source of variation in employment growth is enhanced.

It has been argued that the interaction term, or 'joint particle', should not be considered as a component of employment growth in its own right, but rather should be assigned equally to the rate and composition components.[1] This is especially desirable when the sources of inter-regional differences in aggregate employment growth are being considered.

If the joint particle (in equation (7.12)) is distributed equally between the rate and composition components, the new rate term (JRC_j) will become:

$$JRC_j = \sum_i \frac{L_{ij}}{L_j} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) - \tfrac{1}{2} \sum_i \left[\left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right)\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) \right] \qquad (7.15)$$

Expanding the last term on the R.H.S., equation (7.15) may be rewritten as;

$$JRC_j = \sum_i \frac{L_{ij}}{L_j} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) - \tfrac{1}{2} \sum_i \frac{L_{ij}}{L_j} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) + \tfrac{1}{2} \sum_i \frac{L_i}{L} \left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right)$$

Simplifying the above yields;

$$JRC_j = \tfrac{1}{2} \sum_i \left[\left(\frac{L_{ij}}{L_j} + \frac{L_i}{L}\right)\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) \right] \qquad (7.16)$$

This may be rewritten as;

$$JRC_j = \sum_i \left[\left(\tfrac{1}{2} \left(\frac{L_{ij}}{L_j} + \frac{L_i}{L}\right)\right)\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) \right] \qquad (7.17)$$

Assigning part of the joint particle to the rate component is

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1. C.P. Harris and A.P. Thirlwall, op.cit., p.57; A.P. Thirlwall, op.cit., p.129.

Table 7.6

Sources of Inter-Regional Differences in Employment Growth Rates: 1958-1963[1]

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j RRC_j^2$	8.87	47.5
$\sum_j RCC_j^2$	26.19	138.0
$\sum_j \rho_j^2$	31.33	169.4
Residual	-47.64	-254.9
$\sum_j (\Delta \ell_j)^2$	18.75	100.0

1. Estimated from equation (7.14), using estimates presented in Table 7.5.

therefore equivalent to calculating the rate component using the mean of regional and national weights.[1]

If a similar operation is carried out on the composition component of equation (7.12), we find that;

$$JCC_j = \sum_i \left[\left(\tfrac{1}{2} \left(\frac{\Delta L_{ij}}{L_{ij}} + \frac{\Delta L_i}{L_i} \right) \right) \left(\frac{L_{ij}}{L_j} - \frac{L_i}{L} \right) \right] \tag{7.18}$$

The total difference between the regional and national growth rates of aggregate employment becomes;

$$\frac{\Delta L_j}{L_j} - \frac{\Delta L}{L} = JRC_j + JCC_j \tag{7.19}$$

The estimates of each of these components for regional manufacturing over the period 1958-1963, are presented in Table 7.7.

Since almost all of the interaction terms were negative, the subtraction of part of this term from the original rate components (the majority of which are positive), tends to increase the size of the rate component. Similarly, since most of the original composition components were negative, the subtraction of negative interaction components results in a reduction in the (absolute) size of the composition component.

These changes are reflected in the evaluation of the sources of regional differences in employment growth. Squaring both sides of equation (7.19) and summing over regions, yields an expression for the total sum of squares of regional employment growth rates;

$$\sum_j (\Delta \ell_j)^2 = \sum_j JRC_j^{\,2} + \sum_j JCC_j^{\,2} + R_4 \tag{7.20}$$

The estimates of these components are reported in Table 7.8. If these results are compared with those presented in Table 7.6 it is seen that the assignment of the joint particle results in an increase in the

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1. A.P. Thirlwall, op.cit., p.129.

Table 7.7

Estimates of the Rate and Composition Components of Regional Employment Growth: 1958-1963[1]

Region	Rate Component[2]	Composition Component[3]	Total
N	-0.17	-0.93	-1.10
YH	0.10	-0.50	-0.40
EM	0.63	-0.53	0.10
EA	4.87	-1.47	3.40
SE	0.28	0.12	0.40
SW	0.25	-0.15	0.10
WM	0.53	-0.03	0.50
NW	-0.33	-0.57	-0.90
W	1.21	-0.11	1.10
S	-1.12	-0.48	-1.60
NI	1.14	-2.04	-0.90

1. Estimated from equation (7.19), assigning the joint-particle equally between rate and composition components.

2. Rate Component $= \frac{1}{2}\sum_i \left[\left(\frac{L_{ij}}{L_j} + \frac{L_i}{L}\right)\left(\frac{\Delta L_{ij}}{L_{ij}} - \frac{\Delta L_i}{L_i}\right) \right]$

3. Composition Component $= \frac{1}{2}\sum_i \left[\left(\frac{\Delta L_{ij}}{L_{ij}} + \frac{\Delta L_i}{L_i}\right)\left(\frac{L_{ij}}{L_j} - \frac{L_i}{L}\right) \right]$

Table 7.8

Sources of Inter-Regional Differences in Aggregate Employment Growth Rates: 1958-1963[1]

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j JRC_j^2$	28.70	149.7
$\sum_j JCC_j^2$	8.32	46.9
Residual	-18.27	-96.6
$\sum_j (\Delta \ell_j)^2$	18.75	100.0

1. Calculated from equation (7.20) using the estimates reported in Table 7.7

importance of rate differences, over composition differences, as a source of inter-regional differences in employment growth.

In concluding this section it must be emphasised that the analysis has been confined to a relatively high level of industrial aggregation. Since the results are likely to be sensitive to the level of aggregation[1] the main conclusions of this study must be concerned with the techniques of decomposition, rather than with the specific estimates obtained for particular regions.

It has been demonstrated that the use of different weighting schemes, at times yields very different results. It has also been demonstrated that the technique for the evaluation of inner-products may be usefully combined with the shift and share equations. When this is done it is apparent, in the majority of formulations, that the major source of inter-regional differences in the rate of aggregate employment growth lies in inter-regional differences in the growth rates of individual industries, and not in differences in industrial structure between regions.

To some extent the size and importance of the composition component is a measure of the 'aggregation problem', which would be present if an analysis of employment growth were to neglect the influence of industrial structure.[2] The evidence of this section is that composition effects, whilst not the most important source of employment differences, are sizeable. In other words, an aggregation problem is likely to be present if the analysis is conducted in entirely macroeconomic terms,

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1. T.W. Buck, "Shift and Share Analysis - A Guide to Regional Policy?", Regional Studies, Vol.4, 1970, pp.445-450.

2. B.F. Massell, " A Disaggregated View of Technical Change", Journal of Political Economy, Vol.69, 1961, p.549f.

without explicit reference to structural change.

A Macroeconomic View of Employment Growth

The major shortcoming of the Shift and Share analysis of employment growth is, that it does not consider deterministic relationships derived from the main body of economic theory. Rather, it is an exercise in classification with little analytical content. In the following sections of the chapter emphasis will be placed upon the economic determinants of employment growth.

There are three propositions, or principles, which together shape the analysis of employment growth. The first notion, which is both ancient and respectable, is that the demand for labour is a derived demand in that ". . . labour is a factor of production, and is thus demanded (as a general rule) not because the work to be done is desired for and by itself, but because it is to be used in the production of some other thing which is directly desired."[1]

In an industrialised society the essential productive function of labour lies in its complementary relationship with capital equipment: labour is essentially used to 'man' capital. This is the second proposition, which will become clearer as the analysis proceeds.

Finally, the demand for labour and the level of unemployment cannot be completely understood without reference to the tools of economic growth. As Domar says: "One does not have to be a Keynesian to believe that employment is somehow dependent on national income, and that national income has something to do with investment. But as soon as investment comes in, growth cannot be left out, because for an individual

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1. J.R. Hicks, The Theory of Wages (London, Macmillan, Second Edition 1963), p.1.

firm investment may mean more capital and less labour, but for the economy as a whole (as a general case) investment means more capital and not less labour. If both are to be properly employed, a growth of income must take place."[1]

It is the aim of the remaining sections of the chapter to investigate the major 'economic' determinants of the rate of growth of manufacturing employment, in the regions of the U.K. over the period 1958 to 1968. The main variables considered are Harrod's ". . . three fundamental elements, viz. (1) man power (2) output or income per head and (3) quantity of capital available."[2] Structural change and the effect of the initial industrial structure upon employment growth will be neglected. Since the ultimate objective is to explain why the rate of unemployment in particular regions increased or decreased over the period, the importance of structural change in reducing the level of employment is not directly relevant. What is relevant however is to explain why changes in the level of unemployment due to composition effects, were not offset or reabsorbed by growth effects. This is not to deny that the structural characteristics of the unemployed may have an important bearing upon the extent of reabsorption.[3] The mere existence of a 'composition effect' does not, by itself, preclude a macro-economic analysis of employment growth in the region as a whole.

It is implied in the above quotation from Domar, that once accumulation

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1. E.D. Domar, "Capital Expansion, Rate of Growth and Employment", Econometrica, Vol.14, 1946, p.147.

2. R.F. Harrod, Towards a Dynamic Economics (London, Macmillan, 1948), p.20.

3. For an analysis of regional unemployment in terms of 'structural' and 'demand-deficient' components see A.P. Thirlwall, "Types of Unemployment: with Special Reference to 'Non-Demand Deficient' Unemployment in Great Britain", Scottish Journal of Political Economy, Vol.16, 1969, pp.20-49.

and technical progress are present, growth in labour productivity takes place. It is important to realise that output per worker (labour productivity) is simply the inverse of labour input per unit of output (unit labour requirements). An increase in labour productivity necessarily implies a decrease in unit labour requirements. To prevent a decline in employment in an economy experiencing productivity growth, the level of output must expand at least in proportion to the growth in labour productivity.

Given the above, the clearest formulation of the determinants of employment growth may be developed either in terms of labour-output relationships (the requirements approach), or in terms of labour-capital relationships (the manning approach).

In terms of the labour requirements approach, the demand for labour is viewed simply as being determined by the level of output, in conjunction with the average product of labour. That is;

$$L_j = \left(\frac{L}{O}\right)_j O_j = {}^{1}/_{AP_{Lj}} O_j \tag{7.21}$$

where: L_j = employment in region j;

O_j = output in region j;

AP_{Lj} = Average Product of Labour in region j.

In terms of a Cobb-Douglas production function (with constant returns to scale) this becomes;

$$L_j = A_j^{-1} (x_j)^{-\beta} O_j \tag{7.22}$$

where: A_j = technological parameter;

x_j = capital-labour ratio;

β_j = elasticity of output with respect to capital.

Totally differentiating equation (7.21), and dividing through by the level of employment, yields an expression for the rate of growth of employment;

$$\frac{\Delta L}{L} = \frac{\Delta O}{O} - \frac{\Delta ({}^{O}/_{L})}{({}^{O}/_{L})}$$

or;

$$\ell_j = g_j - r_j \qquad (7.23)$$

where: ℓ_j = rate of growth in employment;

g_j = rate of growth in output;

r_j = rate of growth in labour productivity.

In a sense, the model us 'demand driven' in that the rate of growth of aggregate regional demand (and thus the rate of growth of output) determines, via technical conditions, the rate of growth in labour demand.[1] The model is 'Keynesian' in that the rate of growth of the demand for labour is the dependent variable.

Equation (7.23) is similar in form to Harrod's conception of the 'natural rate of growth' (g_n) which he defines as, ". . . the maximum rate of growth allowed by the increase of population, accumulation of capital, technological improvement and the work-leisure preference schedule, supposing that there is always full employment in some sense."[2] Harrod's equation for the full-employment growth rate of output may be

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1. In terms of the Cobb-Douglas production function, the rate of growth in employment may be expressed as;

$$\ell_j = \frac{g_j - \beta_j k_j - a_j}{\alpha_j} \qquad (7.24)$$

where: k_j = rate of growth in capital stock;

α_j = elasticity of output with respect to labour.

2. R.F. Harrod, "An Essay in Dynamic Theory", Economic Journal, Vol.49, 1939, p.30.

expressed as;

$$g_n = n + r \qquad (7.25)$$

where: n = rate of growth of the work force.

The similarities between equations (7.23) and (7.25) are readily apparent; although in equation (7.25) the rate of growth of the work force is an independent variable.

It should be borne in mind that the rate of productivity growth may be thought of as the 'rate of labour saving'. This term will include the effects of technical change (which means that less inputs are required to produce a given output), and also the effects of the substitution of capital for labour.

Table 7.9 reports the rates of growth of output, employment and labour saving in the manufacturing sector of U.K. regions over the period 1958 to 1968. Since the original data was expressed in current prices, rather than in real terms, the rates of growth of output and of labour productivity have been adjusted to allow for this factor. As regional price indices are unavailable it is assumed that the rate of inflation was the same in all regions, and consequently the 'money' growth rates were deflated by the national rate ofprice increase over the period.[1]

In all regions which experienced a rate of growth of manufacturing employment below the national average over the period 1958-1968,[2] employment declined in absolute terms. The North West in particular experienced

1. The estimated annual average rate of increase in the wholesale price of all manufactured items was 2.2% over the period.

2. The beginning (1958) and terminal (1968) years are similar in that in both years unemployment was high and rising, although the level of unemployment was higher in 1968 (2.5%) than in 1958 (2.2%). The two years do seem to represent similar positions in the business cycle.

Table 7.9

Average Annual Growth Rates of Employment, Output and Labour Productivity in the Manufacturing Sector of the Regions: 1958-1968[1, 2]

Region	ℓ_j	g_j	r_j
N	-0.1	3.7	3.8
YH	-0.1	3.8	3.9
EM	1.3	8.5	7.2
EA	3.4	9.2	5.8
SE	0.6	5.5	4.9
SW	1.4	6.0	4.6
WM	0.8	5.4	4.6
NW	-0.9	4.4	5.3
W	1.6	5.3	3.7
S	-0.2	4.6	4.8
NI	-0.1	7.1	7.2
UK	0.3	5.2	4.9

1. Source: Board of Trade, Report on the Census of Production 1963 (London, H.M.S.O., 1970), Part 133.
Board of Trade, "Area Analyses of the Provisional Results of the Census of Production for 1968", Board of Trade Journal, Vol.199, 1970, pp.488-496.

2. Price deflator obtained from: London and Cambridge Economic Service, The British Economy: Key Statistics 1900-1970 (London, Times Newspapers Ltd., 1972), p.8.

a relatively heavy fall in employment over the period. In five regions, which together account for over four-tenths of the total manufacturing employment in the U.K., the rate of labour saving was in excess of the rate of growth of output. In a study of the fortunes of the peripheral areas over the nineteen-fifties and sixties, McCrone also found this to be the case. He remarks that; "It is in many ways ironic to find that, during a period when the United Kingdom as a whole was suffering from labour shortage so that the growth of output had very largely to come from productivity increases, the regions with surplus labour resources actually achieved faster productivity growth."[1]

It is not immediately apparent from the data presented in Table 7.9 that the major source of inter-regional differences in the rate of employment growth lies in differences in the rate of labour saving. Nor is it obvious that high rates of labour saving are incompatible with high rates of growth of employment. An 'evaluation of inner products' may provide some insight into these questions. An equivalent expression for employment growth to that presented in equation (7.23) will apply to the nation; i.e.;

$$\ell_{UK} = g_{UK} - r_{UK} \qquad (7.26)$$

An expression for the deviations of regional employment growth rates from the national rate may be obtained by subtracting equation (7.26) from (7.23), to yield;

$$\Delta\ell_j = \Delta g_j - \Delta r_j \qquad (7.27)$$

where: $\Delta\ell_j = \ell_j - \ell_{UK}$;

$\Delta g_j = g_j - g_{UK}$;

$\Delta r_j = r_j - r_{UK}$.

1. G. McCrone, <u>op.cit.</u>, p.160.

Squaring both sides of equation (7.27) and summing over regions, yields an expression for the total sum of squares of regional employment growth;

$$\sum_j (\Delta \ell_j)^2 = \sum_j (\Delta g_j)^2 + \sum_j (\Delta r_j)^2 - 2 \sum \left[(\Delta g_j)(\Delta r_j) \right] \qquad (7.28)$$

Table 7.10 reports the magnitude of the components of the total sum of squares using the data presented in Table 7.9. The most important single source of inter-regional differences in employment growth was that of differences in the rate of growth of output. The interaction between output growth and rates of labour saving served to reduce the differences in employment growth between regions. This implies that relatively high (low) rates of labour saving tend to be positively associated with relatively high (low) rates of output growth.[1] This positive association between output and productivity growth has become known as 'Verdoorn's Law'.[2] Kaldor describes Verdoorn's Law as, ". . . the empirical relationship between the growth of productivity and the growth of production."[3] The relationship between these two phenomena in the U.K. has been investigated by a number of writers, especially Salter[4] and Beckerman.[5]

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1. The negative sign of the interaction term indicates that the terms inside the square brackets of equation (7.28) are positively correlated.

2. P.J. Verdoorn, "Fattori che regolano lo sviluppo della produttività del lavoro", L'Industria, Vol.1, 1949, pp. 45-53.

3. N. Kaldor, Causes of the Slow Rate of Economic Growth of the United Kingdom (Cambridge, C.U.P., 1966), p.10.

4. W.E.G. Salter, Productivity and Technical Change (Cambridge, C.U.P., 1960; Second Edition with an Addendum by W.B. Reddaway, 1966).

5. W. Beckerman, The British Economy in 1975, N.I.E.S.R. Economic and Social Studies XXIII (Cambridge, C.U.P., 1966). See also J.M. Katz, "'Verdoorn Effects', Returns to Scale and the Elasticity of Factor Substitution", Oxford Economic Papers, Vol.20, 1968, pp.342-352; N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-348; K.A. Kennedy, Productivity and Industrial Growth (Oxford, Clarendon Press, 1971), pp.105-115, 154-222.

Table 7.10

Sources of Inter-Regional Differences in Employment Growth: 1958-1968

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j (\Delta g_j)^2$	36.41	237.5
$\sum_j (\Delta r_j)^2$	15.40	96.7
$-2 \sum_j \left[(\Delta g_j)(\Delta r_j)\right]$	-35.86	-234.2
$\sum_j (\Delta \ell_j)^2$	15.95	100.0

The importance of the 'Verdoorn effect' for employment growth depends not upon the mere existence of a relationship between r and g, but upon the precise magnitude of the relationship. To the extent that increasing returns exist, this implies that the rate of labour saving is positively related to the growth of output. If a given proportional increase in output yields a greater than proportional increase in labour productivity, then the absolute level of employment will decline. If the 'Verdoorn coefficient' is less than unity this need not be the case.

The Verdoorn relationship may be specified as;

$$r_j = r_{aj} + \lambda g_j \qquad (7.29)$$

where: r_a = rate of 'autonomous' productivity growth;

λ = Verdoorn coefficient, assumed to be the same in all regions.

Substitution of equation (7.29) into (7.23) yields an expression for the rate of growth in employment;

$$\ell_j = g_j - r_{aj} - \lambda g_j$$

$$\text{or} \quad \ell_j = g_j (1 - \lambda) - r_{aj} \qquad (7.30)$$

The absolute level of employment will increase or decrease depending upon whether $g (1 - \lambda) - r_a \gtrless 0$.

The importance of the magnitude of the Verdoorn coefficient (λ) is easily demonstrated[1] by assuming that the 'autonomous' rate of productivity growth is zero ($r_a = 0$). In that event;

$$\ell_j = (1 - \lambda) g_j \qquad (7.31)$$

and $\ell_j \gtrless 0$; as $(1 - \lambda) \gtrless 0$.

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1. Assuming that λ, r, g > 0.

Employment will rise, as a consequence of increased output, if the Verdoorn coefficient is less than unity.[1] The level of employment will fall (i.e. $\ell_j < 0$) if the Verdoorn coefficient is greater than unity.

It is also possible to examine the relationship between the Verdoorn coefficient and the degree of returns to scale in a Cobb-Douglas production function. It was demonstrated earlier,[2] that if the production function is not homogeneous of degree one, then the rate of growth of output may be specified as;

$$g_j = a_j + \beta_j (k - \ell) + v\ell \qquad (7.32)$$

where: a_j = rate of neutral technical progress;

v = degree of returns to scale.

Assuming that 'autonomous' productivity growth is equal to the rate of technical progress plus the effects of capital deepening, and that these are equal to zero, equation (7.32) simplifies to;

$$g_j = v\ell_j$$

and $$\ell_j = \frac{1}{v} g_j \qquad (7.33)$$

Comparing equation (7.33) and (7.31) yields a relation between λ and v, such that;

$$(1 - \lambda) = \frac{1}{v} \text{ and therefore; } \lambda = 1 - {}^{1}/_{v} \qquad (7.34)$$

If technical progress and capital deepening were autonomous, and there were constant returns to scale ($v = 1$), then the Verdoorn coefficient would be zero. The coefficient (λ) would be unity if the degree of

1. It would, however, rise less than if there were no association between productivity and output growth.

2. Chapter Four, p.151.

returns to scale were infinitely large (as $v \to \infty$; $\lambda \to 1$) or if part of technical progress and capital deepening were induced. Most empirical studies of the Verdoorn coefficient yield an estimate of λ in the region of 0.4 to 0.5. For this to be due solely to the influence of increasing returns to scale, the homogeneity parameter (v) would have to assume a value between 1.66 and 2.0. These values are unrealistic. It follows, that the Verdoorn coefficient cannot be interpreted simply as increasing returns to scale in the conventional sense, but must also include the effects of induced technical progress and capital deepening.[1]

If autonomous productivity growth is positive, and output is increasing, then employment will increase or decrease according to whether $(g - r_a) - \lambda g \gtreqless 0$; or $(g - r_a) \gtreqless \lambda g$.

Kaldor has estimated, for the manufacturing sectors of twelve O.E.C.D. countries, that;[2]

$$r_a = 1.04$$
$$\lambda = 0.48$$

This implies that the average rate of growth of output necessary to prevent employment from falling, is (setting $\ell_j = 0$);

$$g\,(0.52) - 1.04 = 0$$
$$\therefore \quad g = \frac{1.04}{0.52} = 2.0$$

The actual growth rate of output for the U.K. over the period considered by Kaldor, was 3.2 per cent per annum.[3]

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1. This is the interpretation adopted by Kaldor; N. Kaldor, op.cit., pp.8-14; N. Kaldor, "The Irrelevance of Equilibrium Economics", Economic Journal, Vol.82, 1972, pp.1237-1255.

2. N. Kaldor, op.cit., p.12. It is interesting in the light of the present discussion, that he finds for the agricultural sector that $\lambda = 1.04$; $r_a = 2.70$. N. Kaldor, op.cit., p.37.

3. Ibid., p.12.

Using regional data for the U.K. the estimate of the Verdoorn coefficient (equation (7.29)) is;[1]

$$r_j = 2.116 + \underset{(0.147)^{**}}{0.512}\, g_j \qquad R^2 = 0.573$$

There is evidence of a Verdoorn effect, as the coefficient on output growth is significantly different from zero at the 1 per cent confidence limit. The coefficient is also significantly less than unity at the 1 per cent confidence limit. It is interesting to note that the (average) rate of 'autonomous' productivity growth (r_a) is estimated as 2.12% per annum. The national rate of productivity growth in manufacturing over the period, was in the order of 4.90% per annum.[2] This implies that approximately one-half of national productivity growth is autonomous, and one-half is induced by the growth in output. In an earlier chapter we estimated the components of national productivity growth to be;[3]

$$r = a^* + \beta m + (v - 1)\ell \qquad (7.35)$$

and $a^* = 2.42$

$\beta m = 2.45$

$(v-1)\ell = 0.03$

That part of productivity growth attributable to increasing returns (in the production function sense) is clearly an induced component of productivity growth, implying that the autonomous component is concealed in the joint effects of technical progress and capital deepening. Since these terms together account for a rate of growth of labour productivity

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1. Using the data on g_j and r_j from Table 7.9.

2. Cf. Chapter Four, p.174.

3. Chapter Four, p.160.

labour productivity of 4.87% per annum, this implies that just under one-half of the rates of technical progress and capital deepening are 'autonomous', and over one-half is induced by the growth of output.[1]

It follows from the above, that the contribution of inter-regional differences in the rate of growth of output is likely to be more important, as a source of inter-regional differences in the rate of employment growth, than the calculations of Table 7.10 would suggest. This is because part of the variation in productivity growth, which is treated there as a separate component, should be attributed to the variations in output growth. A 'deterministic' equation for employment growth in each region would therefore be;[2]

$$\ell_j = g_j - r_{aj} - \lambda g_j \qquad (7.36)$$

where: $\hat{\lambda} = 0.57$

$$r_{aj} = r_j - \lambda g_j$$

And, for the nation;

$$\ell_{UK} = g_{UK} - r_a - \lambda g_{UK} \qquad (7.37)$$

The values of the components of equations (7.36) and (7.37) are reported in Table 7.11. Since an expansion of output now induces some labour saving, the contribution of output growth to the growth of employment is correspondingly reduced.

The contribution of each of the components, to inter-regional differences in the growth of employment, may be assessed by applying the technique for an evaluation of inner products. Subtracting equation

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1. The autonomous proportion is equal to $\left(\frac{r_a}{a^* + \beta m}\right) = \frac{2.12}{4.87} = 0.44$.

2. Assuming that the 'Verdoorn coefficient' (λ) is the same in all regions.

Table 7.11

The Determinants of Employment Growth in U.K. Regions with an explicit allowance for the 'Verdoorn Effect': 1958-1968[1]
(% per annum)

Region	$g_j(1-\lambda)$	r_{aj}	ℓ_j[2]
N	1.8	1.9	-0.1
YH	1.9	2.0	-0.1
EM	4.2	2.9	1.3
EA	4.6	1.2	3.4
SE	2.7	2.1	0.6
SW	3.0	1.6	1.4
WM	2.6	1.8	0.8
NW	2.2	3.1	-0.9
W	2.6	1.0	1.6
S	2.3	2.5	-0.2
NI	3.5	3.6	-0.1
UK	2.5	2.2	0.3

1. Calculated from the data reported in Table 7.9.

2. $\ell_j = g_j(1-\lambda) - r_{aj}$

(7.37) from (7.36) yields an expression for deviations of regional data from the national average;

$$\Delta \ell_j = \Delta g_j - \Delta r_{aj} - \lambda \Delta g_j \qquad (7.38)$$

where: $\lambda \Delta g_j = \lambda g_j - \lambda g_{UK}$.

Squaring both sides of equation (7.38) and summing over regions, yields an expression for the total sum of squares in employment growth rates;

$$\sum_j (\Delta \ell_j)^2 = \sum_j (\Delta g_j)^2 + \sum_j (\Delta r_{aj})^2 + \sum_j (\lambda \Delta g_j)^2 + R_5 \qquad (7.39)$$

where: R_5 = Residual and Interaction Terms.

These estimates are reported in Table 7.12. The inclusion of an allowance for the 'Verdoorn effect' enhances the contribution of differences in output growth to inter-regional differences in employment growth, compared with the estimates of Table 7.10.

The 'Manning Ratio' approach to the demand for labour

In adopting this view of labour demand, we are proposing that employment should be viewed as the use of labour to operate, or 'man', capital equipment. The demand for labour is therefore determined by the capital stock in use and the 'manning ratio', i.e.;

$$L = \frac{L}{K_a} K_a \qquad (7.40)$$

where: K_a = actual capital stock in use.

Expressed in terms of relative rates of growth, equation (7.40) may be rewritten as;

$$\ell_j = k_{aj} - m_j \qquad (7.41)$$

where: m_j = rate of growth in the capital-labour ratio.

In Chapter Four we derived estimates of the contribution of capital deepening to productivity growth, and also (using estimates of the

Table 7.12

Sources of Inter-Regional Variation in the Rate of Employment Growth: 1958-1968[1]

Source of Variation	Sum of Squares		Proportion of TSS (%)	
$\sum_j (\Delta g_j)^2$	36.41		237.5	
$\sum_j (\lambda \Delta g_j)^2$	8.80	45.21	55.3	292.8
$\sum_j (\Delta r_{aj})^2$		6.45		40.5
Residual		-35.71		-233.3
$\sum_j (\Delta \ell_j)^2$		15.95		100.0

1. Calculated using equation (7.39) from the data reported in Tables (7.10) and (7.11).

elasticity of output with respect to capital) estimates of the rate of capital deepening in each region.[1]

To use these estimates in the present context we must accept that the estimated rates of capital deepening reflect the rate of growth of the 'active' capital stock, and not the rate of growth of the available capital stock. It is usual in studies of economic growth for the capital data to refer to the quantity of capital in existence. As a result, it is common practice to find the capital data being adjusted by some index of capacity utilisation to arrive at estimates of the 'active' capital stock. Estimates of the rate of capital deepening were derived earlier, from data referring to the <u>actual</u> values of output per worker and the actual share of capital. Since the estimates were derived from observations of actual, and not potential, output, the estimated rates of capital deepening refer to the <u>actual</u> rate of growth of capital per worker <u>in use</u>. It is this estimate, rather than an estimate of the growth of the <u>existing</u> capital stock, which is relevant to the determination of the level of employment. Given these estimates of the rate of capital deepening, together with the rate of growth of employment, the rate of growth of the 'active' capital stock may be calculated, as;

$$k_{aj} = m_j + \ell_j. \qquad (7.42)$$

These estimates are presented in Table 7.13.

It is interesting to note that the estimated national rate of growth in the active capital stock is 3.3 per cent per annum. The

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1. Chapter Four, pp.136-138. This is an additional advantage of using the 'progress constant' formulation of Johansen's technique. An alternative approach may be found in J. Taylor, "A Surrogate for Regional Estimates of Capital Stock", <u>Bulletin of the Oxford University Institute of Economics and Statistics</u>, Vol.29, 1967, pp.289-299.

Table 7.13

Estimated rates of capital deepening, growth in the Active Capital Stock and Employment: 1958-1968

Region	m_j [1]	k_{aj} [2]	ℓ_j
N	0.6	0.5	-0.1
YH	0.9	0.8	-0.1
EM	8.0	9.3	1.3
EA	4.6	8.0	3.4
SE	2.9	3.5	0.6
SW	2.6	4.0	1.4
WM	2.6	3.4	0.8
NW	3.8	2.9	-0.9
W	0.4	2.0	1.6
S	2.7	2.5	-0.2
NI	8.0	7.9	-0.1
UK	3.0	3.3	0.3

1. Obtained from Chapter Four, Table 4.2, p.137

2. $k_{aj} = m_j + \ell_j$

'Blue Book' estimates of the value of the capital stock[1] in manufacturing in the U.K. yield an average annual rate of growth of capital of 3.2 per cent, over the period 1958-1968.[2] In this light the estimates of the rate of growth in the capital stock (in Table 7.13) may be regarded to be a reasonable approximation.[3]

Another question is whether the estimates provide a reasonable approximation to the relative ranking of regions according to their rates of capital accumulation. The best available 'proxy' for the utilised capital stock is probably that of electricity consumption by industrial users, in the Electricity Generating Board Regions.[4] The ranking of regions according to the rate of growth in electricity supplied to industrial users over the period 1960-68, was compared with the ranking of regions according to the estimated rate of growth of their active capital stock (1958-68). Excluding Northern Ireland the rank correlation coefficient is (+)0.650; with Northern Ireland included the rank correlation is (+)0.545; both coefficients are significantly greater than zero at the 5 per cent confidence level. In the absence of 'hard' data on regional capital stocks, the estimates

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1. At 1963 prices.

2. Data was obtained from London and Cambridge Economic Service, The British Economy: Key Statistics, 1900-1970 (London, Times Newspapers Ltd., 1972), p.12.

3. Matthews gives a figure for the average annual rate of growth of the capital stock in manufacturing (1948-1962) of 3.1%. R.C.O. Matthews, op.cit., p.91. Feinstein's data indicates that the capital stock (in manufacturing and construction) increased at a rate of 3⅓% per annum, over the period 1955-1965. C.H. Feinstein, National Income Expenditure and Output of the United Kingdom 1855-1965 (Cambridge, C.U.P., 1972), Table 44, p.T100.

4. The data refers to Electricity Board Areas which, even after aggregation, only approximate the New Standard Regions. Data for Northern Ireland included both commercial and industrial users. Department of Trade and Industry, Digest of Energy Statistics (London, H.M.S.O., 1971).

again seem to provide a very good approximation.

The estimates reported in Table 7.13 indicate that in five regions the fall in the manning ratio ($^L/_K$) more than offset the employment creating effects of an increase in the active capital stock. This was particularly the case in the North West.[1]

The relative importance of differences in the proportional rate of change in the manning ratio and the growth of the active capital stock, as a source of inter-regional differences in the rate of growth in employment, may be judged from an evaluation of inner products.

Given the relationships between capital deepening, capital accumulation and employment growth expression in equation (7.41), it follows that;

$$\Delta \ell_j = \Delta k_{aj} - \Delta m_j \qquad (7.43)$$

where: $\Delta k_{aj} = k_{aj} - k_{aUK}$;

$\Delta m_j = m_j - m_{UK}$.

Squaring both sides of equation (7.43) and summing over regions, yields an expression for the total sum of squares of employment growth rates;

$$\sum_j (\Delta \ell_j)^2 = \sum_j (\Delta k_{aj})^2 + \sum_j (\Delta m_j)^2 - 2 \sum_j \left[(\Delta k_{aj})(\Delta m_j) \right] \qquad (7.44)$$

Table 7.14 reports the estimates of the components of equation (7.44). It is evident from the table that differences in the rate of growth of the active capital stock and of the manning ratio, served to

1. This may be a reflection of regional policy which discriminated in favour of more capital intensive techniques. A.J. Brown, 'Impact of Investment Grants on Capital-Intensive Industry', in Department of Economic Affairs, The Intermediate Areas, Cmnd.3998 (London, H.M.S.O., 1969), Appendix J, p.237f.

Table 7.14

Sources of Inter-Regional Differences in Employment Growth in terms of 'Manning Ratios': 1958-1968[1]

Source of Variation	Sum of Squares	Proportion of TSS (%)
$\sum_j (\Delta k_{aj})^2$	96.03	607.0
$\sum_j (\Delta m_j)^2$	70.95	446.0
$2\sum_j \left[(\Delta k_{aj})(\Delta m_j)\right]$	-151.03	-953.0
$\sum_j (\Delta \ell_j)^2$	15.95	100.0

1. Calculated from equation (7.44) using the data reported in Table 7.13.

make for extensive differences in the rate of employment growth between regions. The single most important source of variation was the interaction component. The negative sign of this component indicates that the term within the square brackets of equation (7.44) is positive. This implies that relatively high (low) rates of accumulation were also associated with a relatively excessive ('deficient') switch to capital intensive techniques. Capital accumulation was undertaken primarily as a substitute for, rather than a complement to, employment growth.[1] As a result the expansion of employment in rapidly accumulating regions was lower, and in slowly accumulating regions it was higher, than might otherwise have been the case.

The absolute level of the capital stock in use is determined by the level of output and the capital-output ratio. The rate of growth in the active capital stock may therefore be expressed as;

$$k_{aj} = g_j + d_{aj} \qquad (7.45)$$

where: d_{aj} = rate of growth in the actual (as distinct from the desired) capital-output ratio.

The rate of growth in the (actual) capital-output ratio may be estimated as;

$$d_{aj} = k_{aj} - g_j \qquad (7.46)$$

Table 7.15 reports the estimates of the determinants of the rate of capital accumulation over the period 1958-1968. It is interesting that the rate of growth of the capital-output ratio is negative in many regions, but positive in the East Midlands and Northern Ireland.[2] In

1. In other words, accumulation was primarily 'deepening', rather than 'widening', in form.

2. As we shall see in the next chapter, the behaviour of the capital-output ratio over time is an important indicator of macroeconomic conditions.

Table 7.15

Growth Rates of the Active Capital Stock, Output and the Capital-Output Ratio, U.K. Regions: 1958-1968

Region	g_j	d_{aj}[1]	k_{aj}
N	3.7	-3.2	0.5
YH	3.8	-3.0	0.8
EM	8.5	0.8	9.3
EA	9.2	-1.2	8.0
SE	5.5	-2.0	3.5
SW	6.0	-2.0	4.0
WM	5.4	-2.0	3.4
NW	4.4	-1.5	2.9
W	5.3	-3.3	2.0
S	4.6	-2.1	2.5
NI	7.1	0.8	7.9
UK	5.2	-1.9	3.3

1. $d_{aj} = k_{aj} - g_j$

most regions the presence of technical progress apparently more than offset the tendency for diminishing returns to set in, as a result of deepening. In the East Midlands and Northern Ireland, the tendency for diminishing returns, as a result of capital deepening, was not entirely offset by technical progress. Alternative explanations, in terms of biased technical progress or differences in the utilisation rate, may also account for these results.

It has been demonstrated that inter-regional differences in employment growth have resulted mainly from differences in the rate of growth of output, on the one hand, and from inter-regional differences in rates of capital accumulation, on the other. These findings are not inconsistent, and imply that there is a close association between rates of output growth and capital accumulation. This relationship will be dealt with in the following chapter.

It remains to undertake two tasks; firstly, to relate the rate of growth in employment, determined by the forces we have discussed above, to the rate of growth of the work force. Secondly, to explain any discrepancies between these two rates, and to account for the differing experience of regions in this respect.

The Relationship between the Growth Rates of Employment and the Work Force

As a matter of definition, the unemployment rate (U) may be expressed as;

$$U = \frac{N - L}{N} = 1 - \frac{L}{N} \qquad (7.47)$$

where: L = Employment;

N = Work Force;

U = Proportion of the work force which is unemployed.

It follows that the rate of growth in the proportion of the work force unemployed, is determined by the relative growth rates of employment and of the work force. The rate of growth of the proportion of the work force employed (1 - U) may be expressed as;

$$\frac{\Delta\ (1 - U)}{(1 - U)} = \frac{\Delta L}{L} - \frac{\Delta N}{N} = \ell - n \qquad (7.48)$$

where: ℓ = rate of growth of employment;

n = rate of growth of the work force.

The proportion of the work force unemployed will be steadily falling over time, if the rate of growth of employment exceeds the growth in the work force.

It is difficult to ascertain the particular relationships between these variables over the period with anything approaching complete accuracy. Data for the 'manufacturing work force' is unobtainable and consequently, the 'work force' is defined as, the number of employees in manufacturing plus the number 'unemployed in manufacturing'. In addition to this problem, there was a change in regional boundaries over the period and comparable unemployment estimates are unavailable for many regions. This has been allowed for by using data pertaining to years where the two systems of classification overlap.[1] In addition, the rates of growth were calculated using base (1958) and final (1968) year estimates only. It is likely that some cyclical influences will be reflected in the series.

The resultant estimates of the rates of growth in the work force, employment, and the proportion of the work force employed, are presented in Table 7.16. The largest disparities between the growth rates of labour supply and of demand are apparent in the North and the West

1. Details of the sources and adjustment procedures are given in the Appendix, Table 7.A2.

Table 7.16

Rates of Growth of Employment, Work Force and the Proportion of the Work Force Employed, in the Manufacturing Sector of U.K. Regions: 1958-1968

Region	ℓ_j	n_j [1]	z_j [2]
N	-0.1	0.1	-0.2
YH	-0.1	-0.1	0.0
EM	1.3	1.2	0.1
EA	3.4	3.4	0.0
SE	0.6	0.6	0.0
SW	1.4	1.4	0.0
WM	0.8	0.9	-0.1
NW	-0.9	-1.1	0.2
W	1.6	1.5	0.1
S	-0.2	-0.2	0.0
NI	-0.1	-0.2	0.1
UK	0.3	0.4	-0.1

1. Details of the calculation of the work force data are presented in the Appendix (7.A2) to this chapter.

2. $z_j = \ell_j - n_j = \frac{\Delta(1-u)}{(1-u)}$

Midlands (rising unemployment), and in the North West (falling unemployment). It may be noted that all of these tendencies are evident in the published data for the total registered unemployed (in all industries over the period).[1]

It would appear that for the purposes of studying the relationship between the growth rates of labour supply and of demand, the regions fall into three groupings: firstly, those which exhibit growing unemployment (N and WM); secondly, those which are experiencing growth with 'steady' unemployment (YH, EA, SE, SW and S); and lastly, those which are experiencing falling unemployment (EM, NW, W and NI). It should be emphasised that these groupings cut across the conventional 'centre/periphery' regional classification.

It is doubtful that any single explanation of regional economic behaviour could account for the differing fortunes of the regions over the period. This chapter has used 'tautological' or 'definitional' statements to <u>indicate</u> the relationships between key economic variables in the regions. The following chapter will seek to use the Harrod-Domar growth model to <u>explain</u> these relationships.

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1. Department of Employment and Productivity, <u>British Labour Statistics: Historical Abstract 1886-1968</u> (London, H.M.S.O., 1971), p.328f. The estimates are also in broad agreement with Brechling's estimate of the 'structural component of regional unemployment'. F. Brechling, "Trends and Cycles in British Regional Unemployment", <u>Oxford Economic Papers</u>, Vol.19, 1967, pp.11-16.

Appendix Table 7.A1

Net Output, Employment and Productivity Growth Rates in Manufacturing, U.K. Regions: 1958-1968

Region	g_m[1]	ℓ[2]	r_m[3]
N	5.9	-0.1	6.0
YH	6.0	-0.1	6.1
EM	10.7	1.3	7.4
EA	11.4	3.4	8.0
SE	7.7	0.6	7.1
SW	8.2	1.4	6.8
WM	7.6	0.8	6.8
NW	6.6	-0.9	7.5
W	7.5	1.6	5.9
S	6.8	-0.2	7.0
NI	9.3	-0.1	9.4
UK	7.4	0.3	7.1

1. g_m = average annual rate of growth of the value of net output.

2. ℓ = average annual rate of growth of employment.

3. r_m = average annual rate of growth of the value of net output per employee.

Source: Board of Trade, Report on the Census of Production 1963, (London, H.M.S.O., 1970), Part 133, p.133/6f.

Appendix 7.A2

Calculations of the Work Force in Manufacturing in U.K. Regions: 1958 and 1968

(a) 1968

Total Registered as Unemployed in Manufacturing Industries by Region: 1968 ('000's).[1]

N	16.6			
YH	16.0			
EM	7.6			
L&SE[2]	23.1		EA	3.0
E&S	13.3		SE	33.5
SW	6.3			
WM	22.9			
NW	24.4			
W	8.2			
S	24.0			
GB[3]		162.4		
NI[4]	8.2			
UK		170.6		

1. Data for the regions of Great Britain are monthly averages calculated from unpublished data assembled by Dr. A.P. Thirlwall.

2. Alterations to the geographical boundaries resulted in the area made up of (Old Standard Regions) L&SE and E&S being apportioned between the New Standard Regions, EA and SE. The total number unemployed in manufacturing in the Old Standard Regions (36.5) was distributed between the New Standard Regions in proportion to their share of total unemployment in the two regions in 1968. (Data for the total unemployed in that year was obtained from Department of Employment and Productivity, British Labour Statistics: Historical Abstract 1886-1968 (London, H.M.S.O., 1971), p.329.)

3. The estimated total register for manufacturing (170.6) corresponds favourably with D.E.P. estimates of the number wholly unemployed in manufacturing in 1968 of 164.0 (D.E.P., op.cit., p.341).

Appendix 7.A2 (contd.)

4. The total registered as unemployed in NI in all industries was 37.2 in 1968 (D.E.P., op.cit., p.329). In 1969 manufacturing unemployment represented 22% of the total in that year. The figure for manufacturing unemployed in NI in 1968 was calculated as 22% of 37.2.

(b) 1958

For 1958 two direct sets of estimates are available; one set refers to May and another to June of that year. This data is set out below:[1]

	May 1958			June 1958		
N	9.3			10.4		
EWR	19.0	YH	22.8	21.3	YH	21.1
NM	15.1	EM	11.3	10.5	EM	10.7
L&SE[2]	22.2	EA	3.0	24.6	EA	3.6
E&S	11.8	SE	31.0	11.6	SE	32.6
SW	5.8			5.9		
WM	15.2			17.6		
NW	41.8			43.8		
W	15.3			14.8		
S	31.1			33.5		
GB		186.0			194.0	
NI[3]	9.6			9.6		
UK		197.6			203.6	

1. Estimates for the regions of GB were calculated from unpublished data assembled by Dr. A.P. Thirlwall.

2. Estimates for the SE and EA were derived in the same manner as for 1968. A similar adjustment was made to obtain YH and EM from the total of EWR and NM.

3. NI was estimated in the same manner as for 1968 except that the ratio of manufacturing to total unemployment in 1960 was used to deflate the data for total unemployment in 1958.

Appendix 7.A2 (contd.)

The estimate for the total register in the UK of around 200.0 is far greater than the D.E.P. evidence for wholly unemployed in manufacturing in that year (145.0) would suggest (D.E.P., op.cit., p.337).

An alternative set of estimates was generated by accepting that the total register in manufacturing in GB was around 150.0 in 1958. This total was then apportioned between the regions on the basis of their share of manufacturing unemployment in June of that year. This procedure yields the following set of estimates which were used in the calculations of the work force;

N	8.2
YH	16.6
EM	8.2
EA	2.9
SE	25.4
SW	4.5
WM	13.7
NW	34.1
W	11.5
S	26.1
NI	9.6
UK	161.0

Chapter Eight

The Growth Experience of the Regions, 1958-1968: An Harrodian Interpretation

This chapter attempts to examine the growth rates of output and employment, in the manufacturing sector of the regions, in terms of the Harrod-Domar[1] model of economic growth.

Harrod's analysis is concerned with the relationships between three rates of growth of output: that rate of growth consistent with the full employment of labour (gn); that rate of growth consistent with 'full employment' of the capital stock (gw); and the actual rate of growth of output which takes place (g). To understand the relationship between the demand and the supply of labour over time, it is necessary to examine the precise relationships between these three rates of growth; the 'natural rate', the 'warranted rate', and the 'actual rate'.

It is Harrod's contention that there exists no mechanism in the private sector which will ensure that all of these growth rates concide.[2] A large portion of the theory of economic growth has been concerned with this claim, and therefore with attempts to examine

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1. R.F. Harrod, "An Essay in Dynamic Theory", Economic Journal, Vol.49, 1939, pp.14-33; R.F. Harrod, Towards a Dynamic Economics (London, Macmillan, 1948); R.F. Harrod, Economic Dynamics (London, Macmillan, 1973); E.D. Domar, "Capital Expansion, Rate of Growth and Employment", Econometrica, Vol.14, 1946, pp.137-147; E.D. Domar, Essays in the Theory of Economic Growth (New York, Oxford University Press, 1957); R.F. Harrod, "Domar and Dynamic Economics", Economic Journal, Vol.69, 1959, pp.451-464.

2. "I am confident that the theory that the 'warranted' equilibrium growth rate of laissez-faire capitalism, without management or interference, is unstable, stands firm; and that this is the fundamental explanation of the business cycle." R.F. Harrod, Economic Dynamics (London, Macmillan, 1973), p.45.

mechanisms which may ensure equality between two, or all three, of these rates of growth. These theories may be broadly characterised as being either neo-classical or Keynesian in outlook.[1]

Neo-classical models are primarily concerned with the relationship between the warranted and the natural rates of growth.[2] In these models equality between the warranted and natural rates of growth occurs through changes in the capital-output ratio, resulting from variations in the rate of interest and the wage rate. The Cambridge, or Keynesian, School[3] has been more concerned with the relationship between the actual and warranted rates of growth, and claims to demonstrate that ". . . when a steady rate of growth is actually going on, the 'share' of saving adapts to it."[4] Keynesian models differ from neo-classical in that,

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1. Excellent surveys of the field may be found in: F.H. Hahn and R.C.O. Matthews, "The Theory of Economic Growth: A Survey", Economic Journal, Vol.74, 1964, pp.782-811; A.K. Sen, 'Introduction', in A.K. Sen (ed.), Growth Economics, Penguin Modern Economics Readings (Harmondsworth, Penguin, 1970), pp.9-40; K.S. Frearson, "Recent Developments in the Theory of Economic Growth", Australian Economic Papers, Vol.3, 1964, pp.1-24; J.A. Kregel, The Theory of Economic Growth (London, Macmillan, 1972).

2. T.W. Swan, "Economic Growth and Capital Accumulation", Economic Record, Vol.32, 1956, pp.334-361; R.M. Solow, "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economics, Vol.70, 1956, pp.65-94; J.E. Meade, A Neo-Classical Theory of Economic Growth (London, George Allen and Unwin, Revised Edition, 1962); R.M. Solow, Growth Theory: An Exposition (Oxford, Clarendon Press, Second Edition, 1971).

3. N. Kaldor, "Alternative Theories of Distribution", Review of Economic Studies, Vol.23, 1955-56, pp.83-100; Joan Robinson, Essays in the Theory of Economic Growth (London, Macmillan, 1962); Joan Robinson, Economic Heresies (London, Macmillan, 1971), pp.109-125; Joan Robinson, "Harrod After Twenty-one Years", Economic Journal, Vol.80, 1970, pp.731-7; R.F. Harrod, "A Comment", Economic Journal, Vol.80, 1970, pp.737-741; Joan Robinson, "A Reply", Economic Journal, Vol.80, 1970, p.741.

4. Joan Robinson, "A Reply", Economic Journal, Vol.80, 1970, p.741.

". . . even if all the other conditions are fulfilled, growth at the natural rate will not be realised if firms lack the energy to carry it out. There is no law of nature that the natural rate of growth should prevail."[1]

In the present context these models differ in their explanation of the source and behaviour of unemployment over time. In a neo-classical model unemployment would be explained either in terms of 'frictions',[2] which prevent adjustment mechanisms operating, or in terms of the slow speed of adjustment. Adoption of the Cambridge approach would imply that the behaviour of unemployment should be explained in terms of decisions to accumulate, subject to the constraints imposed by the supply of labour and the real wage rate.[3]

The modern theory of economic growth regards the behaviour of output and of unemployment over time as determined by two fundamental relationships; the relationship between the warranted and natural rates, and the (unstable) relationship between the actual and the warranted rate. Since we are ultimately interested in the behaviour of unemployment, it is convenient to begin the study with a description of the relationship between the actual and the natural rates of growth.

The interpretation of this relationship depends, not only upon the relative rates of growth of employment and the work force, but also upon the initial conditions prevailing in the regions. Table 8.1 presents some evidence on these initial conditions, derived from data referring

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1. Joan Robinson, Economic Heresies (London, Macmillan, 1971), p.118.

2. M. Dobb, Political Economy and Capitalism (London, Routledge and Kegan Paul, Second Edition, 1940), pp.185-222.

3. Joan Robinson, Essays in the Theory of Economic Growth (London, Macmillan, 1962), pp.34-59.

Table 8.1

Estimates of the Excess Supply of Labour[1] and the Relative Growth Rates of Employment and the Work Force: 1958-1968

Region	Excess Supply of Labour[2]	$(\ell_j - n_j)$[3]
N	1.3	-0.2
YH[4]	-0.3	0.0
EM[5]	-0.5	0.1
EA) SE)	-0.2	0.0
SW	0.0	0.0
WM[6]	-0.4	-0.1
NW	0.5	0.2
W	1.5	0.1
S	1.6	0.0
NI[7]	-	0.1

1. Thirlwall's estimate of the average rate of 'Demand-Deficient' Unemployment in all industries. A.P. Thirlwall, op.cit., p.35.
2. Negative sign indicates an excess demand for labour.
3. Source: Chapter Seven, Table 7.16.
4. Data in the first column refers to the Old Standard Region, E and WR.
5. " " " " " " " " " " , NM
6. " " " " " " " " " " , M
7. Thirlwall does not provide estimates for this region.

to all industries, including manufacturing, over the period 1949-1966.[1] Table 8.1 also reports estimates of the rate of growth in the proportion of the work force employed. If the rate of growth of employment exceeds that of the work force, this is an indication that the actual rate exceeds the natural rate, and vice-versa. The relationships between g and gn, implied by the estimates reported in Table 8.1, are given in Table 8.2.

It is apparent from Table 8.1 that the regions may be divided into three groups, depending upon the behaviour of unemployment over time. Firstly, those regions where employment is increasing faster than the work force. With the exception of the East Midlands, these were all regions with an initial reserve of unemployed labour. Mrs. Robinson has dubbed a state such as this, a 'limping golden age'.[2] The situation of $g > gn$ must be a transient phase, for either the 'animal spirits' will be dimmed before full employment is reached, or the rate of growth of the work force will become an effective constraint. Secondly, there are the regions where the rates of growth of the work force and of employment are roughly equal. Most areas in this category are experiencing a 'golden age',[3] by maintaining minimum unemployment rates over time. Scotland is another example of a 'limping golden age' where, although employment and the work force are falling at the same rate, there is a high level of unemployment. Lastly, there are two regions where the unemployment rate is rising over time. The North, where employment is declining

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1. A.P. Thirlwall, "Types of Unemployment: with Special Reference to 'Non-Demand-Deficient' Unemployment in Great Britain", Scottish Journal of Political Economy, Vol.14, 1969, pp.20-49.

2. Joan Robinson, Essays (op.cit.), p.53.

3. Ibid., p.52f.

Table 8.2

The Relationship Between the 'Actual' and 'Natural' Rates of Growth in Regional Manufacturing: 1958-1968

Region	g : gn[1]
N	g < gn
YH	g = gn
EM	g > gn
EA	g = gn
SE	g = gn
SW	g = gn
WM	g < gn
NW	g > gn
W	g > gn
S	g = gn
NI	g > gn

1. g = actual rate of growth.

   gn = 'natural' rate of growth.

faster than the work force, an example of a 'leaden age';[1] and the West Midlands, where the excess demand for labour is slowly giving way to an excess supply, another 'limping golden age'.

Whilst the unemployment experience of regions may be described in this way, it cannot be explained solely in terms of the relationship between the natural and actual rates. As we have already noted, the decision to accumulate is of crucial importance in determining the pattern of regional growth rates. To explain regional growth patterns it is necessary to introduce the concept of a 'desired'[2] or 'warranted'[3] rate of growth - for Harrod's model embodies the notion that it is the relationship between the 'warranted' and actual rates, which ultimately determines the path of employment growth.

Harrod defines the warranted rate of growth (gw) as ". . . that overall rate of advance which, if executed, will leave entrepreneurs in a state of mind in which they are prepared to carry on a similar advance".[4] It is that rate of growth which maintains the equality between the growth rates of output and capacity.

We may postulate an investment function of the form;

$$I = v_r(\Delta Y) \qquad (8.1)$$

where: I = current investment demand;

ΔY = change in output;

v_r = desired or 'optimum' incremental capital-output ratio.

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1. Ibid., p.54.

2. Ibid., p.49.

3. R.F. Harrod, Towards a Dynamic Economics (London, Macmillan, 1948), p.81f.

4. Ibid., p.82.

and a 'net withdrawals' function of;

$$S - (X - M) = (s - b)\,Y \tag{8.2}$$

where: S = current savings;

X = exports;

M = imports;

s = propensity to save;

b = net 'balance of trade', expressed as a proportion of Y;

Y = output.

In equilibrium, desired withdrawals and injections are equalised, i.e.;

$$v_r(\Delta Y) = (s - b)\,Y \tag{8.3}$$

It follows, that the equilibrium growth rate of output will equal;

$$\frac{\Delta Y}{Y} = gw = \frac{(s - b)}{v_r} \tag{8.4}$$

The actual rate of growth (g) may be expressed as;[1]

$$g = \frac{(s - b)}{v} \tag{8.5}$$

The relationship between the 'actual' and 'desired' I.C.O.R. may be expressed as;[2]

$$v_r = \theta v \tag{8.6}$$

where (θ) is a measure of capacity utilisation.

Given decisions to accumulate, if output growth is such as to satisfy entrepreneurs, then capacity will be neither in excess nor deficient (i.e. $\theta = 1$). If there is excess capacity, that is current investment is 'too high', then v will be greater than v_r, and θ will be

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1. Where 'v', measures the actual incremental capital-output ratio.

2. For an analysis of equilibrium growth with less than 'full capacity working' see R. Eisner, "Underemployment Equilibrium Rates of Growth", American Economic Review, Vol.42, 1952, pp.43-58.

less than unity. If current additions to the capital stock are less than desired ($v < v_r$), θ will exceed unity.

It follows from equation (8.6) that $v = \frac{1}{\theta}.v_r$. If this expression is substituted into the equation for the actual rate of growth (8.5), then;

$$g = \theta.\frac{(s - b)}{v_r} = \theta gw \qquad (8.7)$$

If the actual rate of growth exceeds the rate warranted by thriftiness and technical conditions, then capacity will be deficient ($\theta > 1$), expectations will be revised upwards, the rate of accumulation will increase, and the actual rate of growth will rise. If the warranted rate exceeds the actual rate, then excess capacity will build up ($\theta < 1$). Instead of feeling that they were pessimistic in their previous expectations, entrepreneurs will feel that they were optimistic, expectations will be revised downwards, and a further divergence from the warranted rate will occur. These deviations are likely to be amplified by the influence of the degree of capacity utilisation (θ) upon investment demand.

There is a large body of empirical evidence[1] to support a theory of investment demand which embodies a 'flexible' accelerator; that is, the Capital Stock Adjustment Principle.[2] In a situation of deficient capacity, not only will expectations of output growth be revised upwards, but the desired level of investment demand (relative to any expected rise

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1. A.D. Knox, "The Acceleration Principle and the Theory of Investment: A Survey", Economica, Vol.19, 1952, pp.269-297; D. Smyth, "Emprical Evidence on the Acceleration Principle", Review of Economic Studies, Vol.34, 1964, pp.185-202; M.K. Evans, Macroeconomic Activity: Theory, Forecasting and Control (New York, Harper and Row, 1969), pp.80-86.

2. R.C.O. Matthews, The Trade Cycle (Cambridge, C.U.P., 1959), pp.40-43; R.G.D. Allen, Macro-Economic Theory (London, Macmillan, 1967), pp.68-73.

in output) will also increase. This introduces more instability into the system.[1] When gw exceeds g the presence of excess capacity will result in a reduction in the desired level of new investment, over and above that reduction arising out of a downward revision of expectations.[2] If we intend to explain the trends in regional unemployment over the period, it is necessary to examine the relationship between gw and g.

Since we have no direct information on the warranted rate, we must infer the relationship between gw and g either from indirect evidence, or alternatively through the judicious use of assumptions.

We could assume that the warranted and actual rates are equal. The Cambridge model suggests that any steady rate of growth will, after a time, become warranted, but this rests upon adjustment mechanisms which should themselves be subjected to test. Another possibility is to assume that gw equals gn. Again this is an 'unwarranted' assumption which should be subject to empirical verification.

Alternatively, it may be hypothesised that, in the event of a divergence between g and gw some observable phenomena are effected in a predictable direction, or that some adjustment mechanism comes into play. Evidence on the affected variable, or on the adjustment mechanism itself, could then be used to deduce the implied relationship between gw and g. There are two possible sources of evidence, both based upon Harrod's proposition that a divergence between gw and g will be reflected in variations in the degree of capacity utilisation.

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1. R.C.O. Matthews, <u>op.cit.</u>, pp.237-241.

2. Harrod pays little attention to short-period variations in the warranted rate, perhaps due to his assumption that technical progress is neutral with respect to the capital-output ratio. See R.F. Harrod, "An Essay in Dynamic Theory", <u>Economic Journal</u>, Vol.49, 1939, pp.26-29; R.F. Harrod, <u>Towards a Dynamic Economics</u> (London, Macmillan, 1948), p.83n.

The theory of instability implies that if g exceeds gw there is deficient capacity ($\theta > 1$); if gw exceeds g there is excess capacity ($\theta < 1$). In terms of the distinction between the 'active' capital stock (ka) and the capital stock in existence (ke), an inequality between g and gw implies an inequality between ka and ke. That is, if g exceeds gw then ka 'exceeds' ke,[1] and if gw exceeds g then ke exceeds ka. If investment decisions do reflect the Capital Stock Adjustment Principle, where the accelerator is flexible, this tendency should be quite marked.

In the previous chapter[2] it was argued that our estimates of capital accumulation refer to the active capital stock (Ka), rather than the capital stock in existence (Ke). Various methods, which are commonly used to derive estimates of the active capital stock from the estimates of the existing capital stock, were mentioned in the previous chapter. It may be that one of these methods could be used to adjust the estimates of the active capital stock to arrive at estimates of the existing capital stock. The two rates of growth could then be compared to provide evidence on the relationship between gw and g.

The capital stock in use at any moment in time may be defined as;

$$Ka = \theta Ke \tag{8.8}$$

where: ka = active capital stock;

θ = utilisation coefficient;

Ke = existing capital stock.

The rate of growth of the active capital stock may therefore be

1. Assuming there is always some margin of excess capacity; cf. J.R. Hicks, A Contribution to the Theory of the Trade Cycle (Oxford, O.U.P., 1950), p.53; A.K. Sen, op.cit., p.13f.

2. Chapter Seven, pp. 281-283.

expressed as;

$$ka = ke + c$$

$$\text{where: } c = \frac{\Delta\theta}{\theta}$$

$$ke = \frac{\Delta Ke}{Ke}$$

It follows that;

$$ke = ka - c \qquad (8.10)$$

The problem in estimating ke, given the estimates of ka, lies in obtaining some proxy for the rate of change in the utilisation of capital. One approach is to assume that capital is unemployed in the same proportion as the labour force,[1] i.e.;

$$\theta = (1 - u) \qquad (8.11)$$

where: u = proportion of the work force unemployed.

Given this assumption, equation (8.10) may be rewritten as;

$$ke = ka - \frac{\Delta\,(1 - u)}{(1 - u)} = ka - (\ell - n) \qquad (8.12)$$

Estimates of the rate of growth of the existing capital stock are presented in Table 8.3. The implied relationships between g and gw are reported in Table 8.4.

If the rate of growth of the existing capital stock exceeds that of the active capital stock, then this is indicative of excess capacity and implies that g is less than gw. Similarly, an increase in the degree of utilisation (ka exceeds ke) implies that g exceeds gw.

Assuming that the capital stock is under-utilised in the same proportion as labour, is tantamount to assuming that the warranted rate

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1. R.M. Solow, "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, Vol.39, 1957, pp.312-20; cf. D.W. Jorgenson and Z. Griliches, "The Explanation of Productivity Change", Review of Economic Studies, Vol.34, 1967, pp.249-283.

Table 8.3

Estimates of the Rate of Growth of the Existing Capital Stock (ke) in Regional Manufacturing: 1958-1968

Region	ka[1]	$(\ell - n)$[2]	ke[3]
N	0.5	-0.2	0.7
YH	0.8	0.0	0.8
EM	9.3	0.1	9.2
EA	8.0	0.0	8.0
SE	3.5	0.0	3.5
SW	4.0	0.0	4.0
WM	3.5	-0.1	3.6
NW	2.9	0.2	2.7
W	2.0	0.1	1.9
S	2.5	0.0	2.5
NI	7.9	0.1	7.8

1. Average annual rate of growth in the active capital stock (ka): data obtained from Chapter Seven, Table 7.13.

2. Rate of growth in the proportion of the work force employed: data obtained from Chapter Seven, Table 7.16.

3. $ke = ka - (\ell - n)$. (Equation (8.12) in text)

Table 8.4

The Relationship Between the Warranted (gw) and Actual (g) Rates of Growth Implied by the Estimates of the Proportionate Change in Capacity Utilisation[1]

Region	g : gw
N	g < gw
YH	g = gw
EM	g > gw
EA	g = gw
SE	g = gw
SW	g = gw
WM	g < gw
NW	g > gw
W	g > gw
S	g = gw
NI	g > gw

1. Cf. Table 8.3.

of growth is equal to the natural rate of growth. That is, regions with g greater than gn (Table 8.2) exhibit g greater than gw (Table 8.4).

The use of the proportion of the labour force employed as a proxy for the utilisation of capital, may be criticised on a number of grounds.[1] It is particularly hazardous where labour may be hoarded, which is likely to be the case in many U.K. regions.[2] In this event the proportion of capital under-utilised will be under-estimated, particularly in areas where labour is in short supply. Those regions with an excess demand for labour on average (YH, EM, EA, SE, WM) would probably have experienced a rate of growth in the existing capital stock greater than the estimates of Table 8.3 imply. In other words, the tendency for gw to exceed g would be greater than is implied in Table 8.4. (Although it should be noted that this argument would not effect the estimate of the relationship between gw and g for the West Midlands - it would only enhance the inequality in the same direction.)

An alternative approach to obtaining an assessment of the relationship between gw and g, is to examine the capital-output ratio. Once Harrod's theory of divergent growth is accepted, it follows that deviations of g from gw will be reflected, via the utilisation coefficient, in variations in the Incremental Capital-Output Ratio (ICOR). If capacity is deficient ($g > gw$) the actual ICOR should be relatively low. If there is excess capacity ($g < gw$), the actual ICOR should be relatively

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1. C. Kennedy and A.P. Thirlwall, "Surveys in Applied Economics: Technical Progress", Economic Journal, Vol.82, 1972, p.29f.

2. C.P. Harris and A.P. Thirlwall, "Interregional Variations in Cyclical Sensitivity to Unemployment in the U.K. 1949-1964", Bulletin of the Oxford University Institute of Economics and Statistics, Vol.30, 1968, p.63.

high.

Earlier in the thesis estimates were reported for the rate of growth of the capital-output ratio (d) where;

$$d = (\frac{\Delta Ka}{Ka} - \frac{\Delta Y}{Y}) \qquad (8.13)$$

If the rate of growth in the capital-output ratio is positive, then $(\frac{\Delta Ka}{Ka})$ exceeds $(\frac{\Delta Y}{Y})$; in other words if 'd' is positive;

$$\frac{\Delta Ka}{\Delta Y} > \frac{Ka}{Y} \qquad (8.14)$$

Assuming that the extent of the divergence of the actual ICOR from the Average Capital-Output Ratio, reflects variations in the degree of capacity utilisation, these estimates may be used to obtain information about the relationship between g and gw, within each region. Relatively high values of 'd', as in equation (8.14) will reflect relatively high values of the ICOR (v) and relatively low values of g. Relatively low values of 'd' may reflect relatively low values of the ICOR, which could be indicative of deficient capacity (i.e. g exceeds gw).

Table 8.5 reports the estimates for the rate of growth of the capital-output ratio (d), together with the implied relationship between gw and g.[1] It is interesting to note that in the two regions where the unemployment rate is growing over time (N and WM), g apparently exceeds gw. This does not augre well for the long term prospects of those regions.

There are however, a number of problems with the approach adopted above. To use a single 'benchmark' (the national rate) to measure relatively high or low values of d, is to assume that the warranted rate

1. 'Excessive' or 'deficient' values of 'd' are judged with respect to the national average, which was estimated as -1.9 over the period. Cf. Chapter Seven, Table 7.15.

Table 8.5

Estimates of the Rate of Growth in the Capital-Output Ratio and the Implied Relationship Between the 'Actual' and 'Warranted' Rates of Growth

Region	d[1]	g : gw
N	-3.2	g > gw
YH	-3.0	g > gw
EM	0.8	g < gw
EA	-1.2	g < gw
SE	-2.0	g > gw
SW	-2.0	g > gw
WM	-2.0	g > gw
NW	-1.5	g < gw
W	-3.3	g > gw
S	-2.1	g > gw
NI	0.8	g < gw

1. $d = (\frac{\Delta K}{K} - \frac{\Delta Y}{Y})$. Data was obtained from Chapter Seven, Table 7.15.

is the same in all regions. Also, it may be argued that the use of a single 'benchmark' does not take adequate account of those factors, specific to each region, which effect the 'optimum' capital-output ratio; such as technical progress, variations in techniques, etc. 'Excessive' or 'deficient' accumulation must be measured in terms of deviations of the actual rate of growth of the capital-output ratio, from that rate which would occur (in each region) when an allowance is made for those factors.

For these reasons the above interpretation of inter-regional differences in variations in the capital-output ratio must be rejected. An alternative approach must take into account inter-regional differences in the 'optimum' rate of growth in the capital-output ratio, and which recognises that the data for the rate of capital accumulation refers to the rate of growth in the active capital stock, and not to the desired rate of accumulation.

This alternative approach rests on the assumption that initially all regions were faced with excess capacity. This is a reasonable assumption, given that the base year of this study (1958) was a recession year. Given this, rates of growth of output in excess of the growth in the active capital stock ($d < 0$) reflect increasing degrees of utilisation, and therefore a tendency for the actual rate to exceed the warranted rate. An excess of the growth of the capital stock over that of output ($d > 0$), will reflect growing excess capacity and thus gw in excess of g.

The relationship between the rates of growth of the capital stock and of output has already been mentioned in Chapter Seven, where a high positive correlation was observed between g and ka.[1] This relation-

1. Chapter Seven, pp.288-290.

ship was also implicit in the discussion of the 'Verdoorn' coefficient.[1]

The importance of technical progress and input substitution in determining the capital-output ratio, has been formalised by Professor Kaldor in his 'Technical Progress Function'.[2] This function may be construed as establishing a relationship between the rate of capital accumulation and the rate of growth of output; although in its latest version the analysis is cast in terms of investment and output.[3] The relationship is such that increases in the rate of growth of the capital stock are associated with increases in the rate of growth of output, although at a diminishing rate. The Function is depicted graphically in Figure 8.1. At some rate of growth the capital-output ratio is constant, and thus Harrod's requirement for steady growth[4] is satisfied. The economy will be in long period equilibrium at point P in the diagram. At any other point on the curve the economy will be in short period equilibrium,[5] for, although the warranted rate of growth is not constant, the capital stock is fully employed. Kaldor also indicates that, due to lags in the adjustment of the capital stock in the short run, ". . . periods of accelerating growth are likely to be periods in which the

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1. Chapter Seven, pp.273-278.

2. N. Kaldor, "A Model of Economic Growth", Economic Journal, Vol.67, 1957, pp.591-624; N. Kaldor, "Economic Growth and the Problem of Inflation", Economica, Vol.26, 1959, pp.212-226 and 287-298; N. Kaldor, 'Capital Accumulation and Economic Growth' in F.A. Lutz and D.C. Hague (eds.), The Theory of Capital, I.E.A. (London, Macmillan, 1961), pp.177-222.

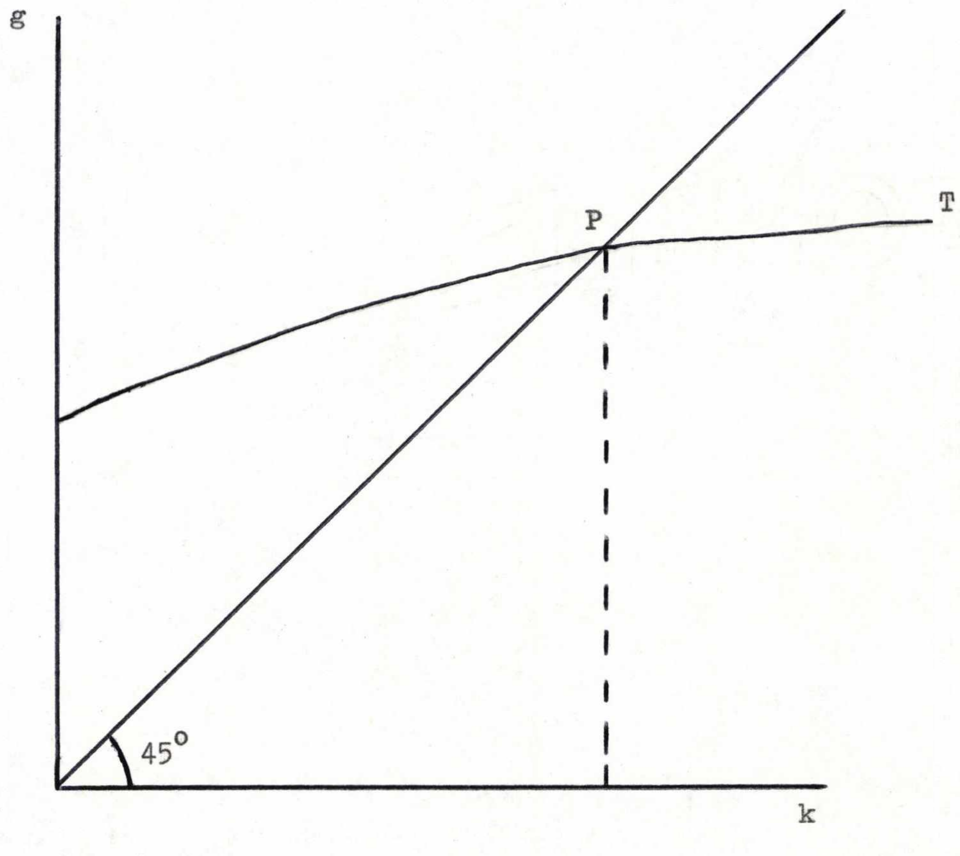
3. N. Kaldor and J.A. Mirrlees, "A New Model of Economic Growth", Review of Economic Studies, Vol.29, 1961-2, pp.174-190.

4. That is, a constant 'v_r'. See H. Uzawa, "Neutral Inventions and the Stability of Growth Equilibrium", Review of Economic Studies, Vol.28, 1961, pp.117-124.

5. N. Kaldor, "A Model of Economic Growth", op.cit., p.609.

Figure 8.1

The Relationship Between the Equilibrium Rates of Growth of Output and the Capital Stock



capital/output ratio is falling, and periods of decelerating growth are those in which the capital/output ratio is rising."[1] In other words if g exceeds gw (accelerating growth) the output/capital ratio is likely to be greater than that predicted by the Technical Progress Function. If gw exceeds g (decelerating growth), the reverse will be the case.

If the Technical Progress Function for each region could be observed, then the actual rate of growth of output could be compared with that 'predicted' by the Function. This would enable us to infer the relationship between gw and g. If output growth in any region was greater than that 'predicted', this would imply accelerating growth, and g in excess of gw.[2] Similarly, if the rate of growth of output was less than that predicted on the basis of the prevailing rate of accumulation, then gw exceeds g in that region. This is the substantive part of the argument to be adopted.

The problem is that, due to insufficient data, we cannot observe the 'Technical Progress Function' for each region. To assume that the Technical Progress Function is the same in all regions, would retain the 'spirit' of the analysis presented in Chapter Four.[3] It could then be argued that each region, in the light of its own factor supplies and quality of entrepreneurship, 'selected' a position on the common 'Technical Progress Function'.[4]

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1. Ibid., p.623n.

2. Given the assumption of excess capacity initially in all regions, it is possible for the growth rate of output to exceed the rate of growth of capacity (g > gw).

3. Cf. Chapter Four, pp.125f, 134-139.

4. A Technical Progress Function is not necessarily inconsistent with the assumption of a Cobb-Douglas Production Function. See H.A.J. Green, "Growth Models, Capital and Stability", Economic Journal, Vol.70, 1960, pp.57-73; J. Black, "The Technical Progress Function and the Production Function", Economica, Vol.29, 1962, pp.166-170; C. Kennedy, "Induced Bias in Innovation and the Theory of Distribution", Economic Journal, Vol.74, 1964, p.547.

Given these assumptions, the Technical Progress Function was estimated, in linear and non-linear form, for the U.K. regions over the period 1958-1968. Whilst the results do not differ substantially, the non-linear form is preferred on theoretical grounds.

The estimate of the (non-linear) Technical Progress Function is;[1]

$$g = 3.383 + \underset{(0.304)^{*}}{0.603k} - \underset{(0.029)}{0.003k^2} \qquad R^2 = 0.897$$

Although the estimate on the quadratic term (k^2) is insignificant there is a slight trace of diminishing returns in the function.

It has been argued that values of output growth (g) in excess of that predicted by the function (gw), reflect rising profit rates as capacity is more heavily utilised; and thus an excess of g over gw. Actual growth rates of output less than that predicted by the function, imply that gw is in excess of g. Table 8.6 reports the deviations of the actual rate of growth of output from the predicted rate over the period. If the interpretation of these deviations is correct, a positive deviation is indicative of higher degrees of capacity utilisation, and that g exceeds gw. Similarly, a negative deviation indicates a falling degree of capacity utilisation, and that gw exceeds g.

We would expect the observations for the regions with growing excess capacity ($g < gw$), to lie closer to the hypothetical regression line, than do the observations for those regions where g is in excess of gw. This is because it is easier to operate on the function when there is spare capacity, than it is when there is deficient capacity. Thus, we expect the 'mean absolute value' of the negative deviations to be less than the 'mean absolute value' of the positive deviations. The

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1. Data was obtained from Chapter Seven, Table 7.15.

Table 8.6

Deviations of the Actual Rate of Growth of Output (g) from that Predicted upon the basis of the Technical Progress Function ($\hat{g}$)

Region	$g > \hat{g}$	$g < \hat{g}$
N	0.02	
YH		-0.06
EM		-0.24
EA	1.18	
SE	0.04	
SW	0.25	
WM		-0.05
NW		-0.70
W	0.72	
S		-0.27
NI		-0.86

mean absolute value of the negative deviations is |0.363|, whilst for the positive deviations it is |0.442|. On both theoretical and empirical grounds, this approach appears to yield meaningful results.

The implied value of the relationship between the warranted and actual rates of growth, using this method,[1] are reported in Table 8.7, together with the relationship between g and gn derived earlier.

The South East is apparently experiencing relatively steady growth with warranted, actual and natural rates equal, and with minimum unemployment on average. An example of a Robinsonian 'Golden Age' if ever there was one! The North West and Northern Ireland have desired and actual growth rates in excess of the natural rate. This phase can only be transitory, for either the 'animal spirits' will be dimmed before full employment is reached, or the constraints of full employment will reduce the actual rate of growth. Scotland and Yorkshire and Humberside appear to be experiencing growth at the natural rate, but with an excess of the desired rate of accumulation over the actual rate.[2] Apparently there are constraints, either in the form of structural factors or in financing investment, which prevent growth from proceeding at a higher rate. The constraint in Yorkshire and Humberside is likely to be the labour supply. Scotland, however, has a chronic labour surplus which indicates that the constraint is probably involved with the financing of investment or with the structural characteristics of the unemployed. The East Midlands and Wales appear to be experiencing a transitory phase, with growth in excess of the natural rate, but less

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1. Where the deviation did not exceed 0.05 the two rates were assumed to be equal.

2. A 'restrained golden age' in Mrs. Robinson's terminology.

Table 8.7

Estimates of the Relationships Between the 'Natural' (gn), 'Actual' (g) and 'Warranted' (gw) Rates of Growth

Region	g : gw[1]	g : gn[2]
N	g = gw	g < gn
YH	g < gw	g = gn
EM	g < gw	g > gn
EA	g > gw	g = gn
SE	g = gw	g = gn
SW	g > gw	g = gn
WM	g = gw	g < gn
NW	g < gw	g > gn
W	g > gw	g > gn
S	g < gw	g = gn
NI	g < gw	g > gn

1. Obtained from Table 8.6: $g > \hat{g}$ implies $g > gw$.

2. Obtained from Table 8.2.

than that warranted by thriftiness and technical conditions. East Anglia and the South West are experiencing full employment (of labour) growth, in excess of the warranted rate. In the North and the West Midlands steady growth is proceeding at the warranted rate,[1] but at a rate less than sufficient to maintain the work force fully employed.

The preceding analysis not only provides an interpretation of the 'growth experience' of any single region, but also enables us to establish a number of points about regional economic growth in general. Firstly, it has been demonstrated that steady growth[2] does not appear to rule in any of the regions, although some appear to be operating in conditions of short run producers equilibrium ($g = gw$). Secondly, in many regions it is apparent that the rate of accumulation effectively determines the rate of growth, and not the operation of bottlenecks associated with labour supply.

If any single conclusion can be drawn, it is that the regions exhibit a bewildering array of 'growth postures'. In particular the contrast between the North and the West Midlands, and the southern regions must be noted.

In the context of Harrod's model these differences are extremely significant, for they demonstrate that short-term national economic policy is bound to exacerbate the problems of particular regions. The real dilemma of regional policy lies not in treating different areas differently, whilst attempting to achieve national policy objectives in the short term, but in recognizing the importance that short term policy

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1. This finding that $gw = g$ is interesting in the light of Thirlwall's (unexpected) finding that the North is a 'cyclically insensitive' region. A.P. Thirlwall, "Regional Unemployment as a Cyclical Phenomenon", Scottish Journal of Political Economy, Vol.13, 1966, p.210f.

2. That is, with a constant capital-output ratio (v_r).

decisions may have for longer term regional economic growth and stability. In bringing together the concepts of the 'Technical Progress Function' and 'Verdoorn's Law', it is possible to formalise these contradictions in the context of Kaldor's model of divergent regional economic growth. The concluding chapter of this thesis will be concerned with a discussion of Kaldor's model, and with highlighting the findings in this and the previous chapters.

Chapter Nine

Concluding Remarks

This chapter highlights some of the major findings of the thesis with the aid of Kaldor's model of regional economic growth.[1] Since this model has provided a theoretical basis (or justification) for certain regional policies, it should prove a convenient vehicle for drawing the main results together.

Kaldor's model is addressed to the problem of ". . . what causes differences in regional growth rates".[2] Kaldor contends that the ". . . principle of cumulative causation - which explains the unequal incidence of industrial development by endogenous factors resulting from the process of historical development itself rather than by exogenous differences in resource endowment - is an essential one for the understanding of the diverse trends of development as between different regions."[3, 4]

The centre of the argument is that the major exogenous component of regional economic growth is the demand for exports. Regions which gain an initial competitive advantage find that the operation of the 'Verdoorn effect' increases their competitive advantage still further. Due to the mobility of labour and institutional factors, differences in labour productivity between regions are not offset by differences in

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1. N. Kaldor, "The Case for Regional Policies", Scottish Journal of Political Economy, Vol.17, 1970, pp.337-347.

2. Ibid., p.337.

3. Ibid., p.343.

4. Cf. G. Myrdal, Economic Theory and Underdeveloped Regions (London, Methuen, 1963).

the wage rate. As a result of this process an initial competitive advantage, or disadvantage, is continually reinforced.[1] Since individual regions do not possess a mechanism for exchange rate adjustment, national policies must be introduced to offset any competitive advantage or disadvantage. One solution is to subsidise labour costs in the lagging regions (equivalent to a devaluation). This has the additional advantages of being financed mainly from outside the region and of subsidising a factor in excess supply.[2]

The dynamic properties of Kaldor's model may be formalised with the aid of difference equations. For any region we may specify four 'structural equations' which determine the growth rates of output, exports, domestic prices and productivity.[3]

$$g = \mu x \qquad (9.1)$$

$$x = \eta p + z + \zeta cp \qquad (9.2)$$

$$p = w - r + \tau \qquad (9.3)$$

$$r = r_a + \lambda g \qquad (9.4)$$

where: μ = elasticity of regional output with respect to exports;

η = price elasticity of the demand for exports;

ζ = 'cross-elasticity' of the demand for exports;

λ = 'Verdoorn' coefficient,

and all other variables refer to rates of growth;

g = regional output,

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1. Similar views may be found in: N. Kaldor, "Conflicts in National Economic Objectives", Economic Journal, Vol.81, 1971, pp.1-16; E. Olsen, "Regional Income Differences within a Common Market", Papers and Proceedings of the Regional Science Association, Vol.14, 1965, pp.35-41.

2. Cf. R.G. McCrone, "The Location of Economic Activity in the United Kingdom", Urban Studies, Vol.9, 1972, pp.369-375.

3. Assuming that the region may be treated 'as if' it were a single fully-integrated firm.

x = exports,

p = prices,

z = index of world demand for the products of the region,

cp = competitor's prices,

w = wage rate,

r = productivity of labour,

τ = 'mark-up',

r_a = autonomous productivity growth.

Equation (9.1) expresses the growth of (total) regional output as a function of the growth in export production. Assuming that there is excess capacity,[1] the rate of growth of export production will be determined by the growth in the demand for exports. The export demand function is assumed to be multiplicative in form, which yields an additive relationship when expressed in terms of growth rates (equation (9.2)). Prices are assumed to be set by a mark-up on unit labour costs.[2] Equation (9.4) expresses the 'Verdoorn' relationship.[3]

Consider a simple dynamic process, where output responds to a change in demand only after a lag of one period has elapsed, i.e.;

$$g_t = \mu x_{t-1} \qquad (9.5)$$

Given that all other variables respond instantaneously, equations (9.2)-(9.4) may be substituted into (9.5), to yield an expression for current output growth;

$$g_t = \mu \left[\eta \ (w - r_a + \tau) + z + \zeta cp \right] - \mu\lambda\eta g_{t-1} \qquad (9.6)$$

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1. N. Kaldor, op.cit., p.342.

2. Cf. Chapter Five, p.210.

3. Chapter Seven, pp.273-281.

Equation (9.6) is a 'first-order non-homogeneous difference equation',[1] of the form;

$$g_t = \alpha g_{t-1} + \beta \qquad (9.7)$$

The time path of the growth rate in any region depends crucially upon the value of α, in equation (9.7).[2] Since we would expect the product of the coefficients μ, λ and η, in equation (9.6) to be negative, α will assume a value greater than zero. The system will therefore be non-oscillatory.

In the unlikely event that α equals unity, the growth rate will increase at a steady rate over time. If α exceeds unity, the growth rate will explode towards $+\infty$ or $-\infty$, depending upon the initial conditions. If the value of α lies between zero and unity, the growth path will converge towards an equilibrium value (ge). The equilibrium path will be determined as;

$$ge = \frac{\mu\left[\eta\ (w - r_a + \tau) + z + \zeta cp\right]}{1 + \mu\lambda\eta} \qquad (9.8)$$

We would expect that this latter alternative (convergent growth) is most likely to be the case, given reasonable values for λ and η. It follows that to explain why there are ". . . persistent differences in growth rates . . ."[3] between regions, we must explain why the 'equilibrium' growth path will differ between regions. This will depend primarily upon

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1. D.S. Huang, Introduction to the Use of Mathematics in Economic Analysis (New York, Wiley, 1964), pp.147-151. W.J. Baumol, Economic Dynamics (London, Macmillan, Third Edition, 1970), p.180f.

2. The discussion follows the mathematical format of D.S. Huang, op.cit., pp.148-151.

3. N. Kaldor, op.cit., p.337.

two factors;[1] wage and price behaviour, and inter-regional differences in industrial structure. As we have seen, Kaldor does attempt to explain why wages rates will not differ substantially between regions. Little attention, however, is devoted to price formation (τ). The structure of industry is likely to be important, not only in determining the values of the parameters, but also through its influence upon the magnitude of z, the rate of growth in world demand for the products of the region.

The model rests upon a number of propositions which warrant further consideration. For example, it is hypothesised: that growth is 'demand-led', rather than constrained by factor supplies; that export demand is determined by relative prices, themselves determined by relative unit labour costs; and that productivity growth is endogenous, determined according to 'Verdoorn's Law'.

Since the model may be characterised as one variant of theories known as 'export-base' models,[2] it is open to many of the criticisms of such models.[3] These are, that the growth process should be viewed in terms of factor supplies rather than in terms of demand considerations;[4]

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1. Assuming that r_a and cp do not differ substantially between regions.

2. D.C. North, "Location Theory and Regional Economic Growth", Journal of Political Economy, Vol.63, 1955, pp.243-258.

3. C.M. Tiebout, "Exports and Regional Economic Growth", Journal of Political Economy, Vol.64, 1956, pp.160-164; H.W. Richardson, Regional Economics (London, Weidenfeld and Nicolson, 1969), pp.336-339.

4. This is the approach implicit in many works of regional economic growth: G.H. Borts and J.L. Stein, Economic Growth in a Free Market (New York, Columbia Universith Press, 1964); J.T. Romans, Capital Exports and Growth Among U.S. Regions (Connecticut, Wesleyan University Press, 1965); H. Siebert, Regional Economic Growth: Theory and Policy (Scranton, International Textbook Co., 1969).

and that exports are not the sole, or even the major, autonomous component of regional demand.

The view that economic growth is constrained by factor supplies is clearly not applicable to the lagging regions of the U.K. These areas are characterised by an excess supply of labour and, in general, by excess productive capacity.[1] The notion that a 'demand-constrained' model is relevant for these regions is supported by research at the N.I.E.S.R., which demonstrates that to understand the regional problem, ". . . differences in [the] pressure of demand are of key importance".[2] Unemployment is high in certain regions ". . . basically, and predominately, because these regions suffer from a deficiency of effective demand, which is persistent rather than periodic."[3] Clearly, for these regions, a model which emphasises the growth rate of demand, rather than factor supplies, is the most relevant.[4]

A more substantial criticism refers to Kaldor's claim that ". . . from the point of view of any particular region, the 'autonomous component of demand' is the demand emanating from <u>outside</u> the region."[5] The major problem here would seem to be about the role of 'autonomous investment'.

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1. Chapter Eight, pp.308-323.

2. A.J. Brown et al, "Regional Problems and Regional Policy", <u>National Institute Economic Review</u>, No.46, 1958, p.42.

3. Ibid., p.45.

4. In Kaldor's world of 'increasing returns forever' it is doubtful if factor supplies could ever provide an effective constraint: N. Kaldor, "The Irrelevance of Equilibrium Economics", <u>Economic Journal</u>, Vol.82, 1972, pp.1237-1255.

5. N. Kaldor, "The Case for Regional Policies", <u>op.cit.</u>, p.342.

which is of great importance in Hicks' model of the trade cycle.[1, 2] The notion that the term 'autonomous investment' is a misnomer has a long history in Kaldor's writings,[3] indeed the Technical Progress Function may itself be construed as supplying Kaldor's reply to this notion.[4] It is implicit in Kaldor's model that capital accumulation is endogenous to the system.[5]

Kaldor can be criticised for giving insufficient attention to the role of the government and tertiary sectors. The neglect of the government sector is explained largely in terms of the methodology of economic theorising in general, which concentrates upon behaviour in a system without a government sector in order to contemplate better the role of government policy. This neglect is also explained by the belief, implicit in a major part of economic theory, that the behaviour of the government sector cannot itself be explained in terms of behavioural (causal) relationships. Given the absence of a satisfactory theory of government behaviour, it is difficult to include this sector in the model other than in the role of a 'deus ex machina'.

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1. J.R. Hicks, "Mr. Harrod's Dynamic Theory", Economica, Vol.16, 1949, pp.106-121; J.R. Hicks, A Contribution to the Theory of the Trade Cycle (Oxford, O.U.P., 1950).

2. It is interesting that a recent 'Hicksian' model of regional economic growth does not include an 'autonomous investment' component; L.M. Hartman and D. Seckler, "Towards the Application of Dynamic Growth Theory to Regions", Journal of Regional Science, Vol.7, 1967, pp.167-173.

3. N. Kaldor, "Mr. Hicks on the Trade Cycle", Economic Journal, Vol.61, 1951, p.842.

4. Cf. Chapter Eight, pp.316-319; the estimate of the Technical Progress Function for the regions indicates that ninety per cent of the growth in the capital stock may be 'explained' by the growth in output.

5. N. Kaldor, "The Case for Regional Policies", op.cit., p.339.

The absence of an analysis of the tertiary sector is a reflection of Kaldor's belief (substantiated by some evidence),[1] that ". . . the prevailing distribution of real income . . . is largely to be explained . . . by the unequal incidence of development in industrial activities."[2]

We turn now to a discussion of the 'Verdoorn effect'. It has been emphasised that this relationship should be viewed in terms of a 'Technical Progress Function', given Kaldor's view that the growth in the capital stock is endogenous. Earlier, a significant relationship was established between the rates of growth of output and of productivity in the regions,[3] although there may be some argument over 'identification' and the direction of causation. Similarly, the estimates for the 'Technical Progress Function'[4] and the Cobb-Douglas production relations,[5] are consistent with the 'Verdoorn' hypothesis. Of particular importance in this regard are the findings, that approximately one-half of productivity growth is autonomous,[6] and that it is reasonable to assume that neutral technical progress proceeds at roughly the same rate in all regions.[7] It has also been found that inter-regional differences in the 'efficiency parameter' explain little of the variation in labour

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1. N. Kaldor, Causes of the Slow Rate of Economic Growth in the United Kingdom (Cambridge, C.U.P., 1966). Cf. G.C. Archibald, 'On Regional Economic Policy in the U.K.', in M. Peston and B. Corry (eds.) Essays in Honour of Lord Robbins (London, Weidenfeld and Nicolson, 1972), pp.224-245.

2. N. Kaldor, op.cit., p.339.

3. Chapter Seven, p.278.

4. Chapter Eight, p.319.

5. Chapter Four, passim.

6. Chapter Seven, p.278f.

7. Chapter Four, pp.125f, 134-139.

productivity between regions.[1] Taken together, these findings imply that the 'position' of the Technical Progress Function, which is indicative of the rate of disembodied technical progress, is roughly the same for all regions. Differences in the level and growth of productivity appear to be due mainly to the rate at which 'technical progress' is embodied in capital equipment,[2] which is primarily determines by the rate of output growth.[3]

The real advantage of adopting a 'growth-oriented' approach lies in understanding the significance of the 'Verdoorn effect' for employment growth. From the point of view of productivity growth (and thus the standard of living of the employed population), the aim of policy must be to induce higher rates of labour saving. The effect of these measures upon the rate of employment growth will depend upon the particular slope of the Technical Progress Function, and the rate of growth of output. The higher the rate of autonomous productivity growth and the closer the 'Verdoorn coefficient' is to unity, the larger will be the rate of labour saving. Output will have to expand proportionately faster if growth at the natural rate is to be achieved. National policies which aim for higher rates of disembodied productivity growth may, in the absence of demand expansion in the lagging regions, have serious effects upon employment prospects in the peripheral areas.

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1. Chapter Six, passim.

2. Chapters Four and Six.

3. Emphasis on the endogenous nature of observed productivity growth, does not preclude the application of policy measures which aim to 'shift' or 'bend' the Technical Progress Function. This would be in addition to policies aimed towards inducing a movement along the function.

These policies increase the rate of autonomous productivity growth (labour saving) in all regions, without at the same time giving a competitive advantage to the peripheral areas.[1] For growth with full employment, the higher rates of labour saving must be matched by policies to increase the demand for the products of the lagging regions - in Verdoorn's world one must run in order to stand still!

It should be emphasised that up to this point, the discussion has assumed that the rate at which productivity growth is induced (the magnitude of the Verdoorn coefficient) is the same in all regions. This may not be the case. To the extent that excess capacity, slow growth, and the outmigration of labour and enterprise[2] tend to diminish technical dynamism, the cumulative process (outlined by Kaldor) will become even more accentuated. Paradoxically these shifts in the Technical Progress Function will act to reduce the rate at which labour is saved, and thus (ceteris paribus) reduce the rate of decline in employment.[3]

The extent of the change in output and employment associated with an 'autonomous' change in demand, will depend upon three coefficients: the initial multiplier effects of the change in aggregate demand upon regional output; the size of the 'Verdoorn effect', which may induce a further expansion of regional exports; and the rate of autonomous productivity growth. If policy measures designed to effect the rate

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1. This process may be exacerbated as (demand) induced labour saving in the rapidly growing regions is passed on autonomously (probably in disembodied form) to producers in the lagging regions.

2. G. Myrdal, op.cit., p.27.

3. Chapter Seven, pp.279-282.

of growth of demand combine with measures to increase the rate at which technical progress is induced, then the cumulative forces will themselves be strengthened. If this were adopted as a policy measure there may be some conflict between the objective of rapid productivity growth and that of increased employment, unless the rate at which demand expands is sufficiently rapid.

It follows that the expansion of demand is of prime importance to the lagging regions, although it must be remembered that the required rate of demand expansion is, itself, dependent upon the rate at which labour saving is induced by the expansion in output. Whether, as Kaldor claims, the required expansion in demand may be brought about as a result of subsidies is another matter.

As Kaldor recognises, the growth of exports depends upon two factors, the rate of growth of world demand for the regions' products, and on the 'competitiveness' of the region.[1] It is hypothesised that 'competitiveness' is determined by movements in the 'efficiency wage' in the producing region, relative to other regions. Our earlier analysis of the relationship between various measures of comparative advantage and industrial <u>structure</u>, throws some doubt upon the hypothesis that efficiency wages (operating through relative prices) determine the patterns of regional specialisation.[2] Contrary to this hypothesis, it was found that specialisation tended to be related more to productivity alone than to the efficiency wage.[3]

Some evidence was found to indicate that the industrial pattern of

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1. N. Kaldor, "The Case for Regional Policies", <u>op.cit.</u>, p.342.

2. Chapter Two, pp.48-57.

3. Chapter Two, Tables 2.7 and 2.8.

expansion is related, for some regions, to comparative unit labour costs.[1] In particular, it was seen that the 'differential components' in each region appear to be related to the pattern of comparative unit labour costs.[2] Although this may reflect the influence of growth upon productivity, rather than that of productivity upon exports, it does appear as though changes in market shares are related to efficiency wage levels, To the extent that the causal direction is from efficiency wage units to market shares, a subsidy to labour will (cet.par.) effect the growth of regional exports. This assumes of course that the subsidy is reflected in price changes. To the extent that it is absorbed in increased margins or wages, or its importance diminishes as inflation proceeds (because the payment is fixed in money terms), it cannot begin to have the desired effect.[3] It appears however, that changes in market shares are of relatively minor importance as a determinant of output and employment trends. The 'rate component' in a 'shift-share analysis' may be interpreted as reflecting the influence of changing market shares on regional employment growth.[4] In Chapter Seven we noted that this factor has been dominated by the 'composition' and interaction components, especially in determining growth differentials between regions.[5] It is unlikely, given the scale of payment, that the effect of the R.E.P. upon market shares will offset the influence of trends in the size of markets

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1. Chapter Three, pp.80-89.

2. Chapter Three, pp.89-95.

3. Cf. B. Moore and J. Rhodes, "Evaluating the Effects of British Regional Economic Policy", Economic Journal, Vol.83, 1973, pp.87-110.

4. Cf. H.S. Perloff et al, Regions, Resources and Economic Growth (Baltimore, John Hopkins Press, 1960), pp.63-96.

5. Chapter Seven, pp.248-265.

as a whole. It is here that structural factors are extremely important, for an increased share of a declining market is likely to mean little in terms of sustained regional growth. The major impact of the labour subsidy is likely to be seen in a reduction in the rate at which labour is made redundant, rather than in the generation of long term employment prospects.[1] The subsidy itself does not discriminate in favour of 'growth industries', indeed it tends to favour relatively labour intensive industries.[2] If it were paid on a more selective basis, and at a sufficiently high rate, it would serve (given Kaldor's assumptions) to offset the deleterious influence of industrial structure.

Given the model outlined by Kaldor, there are three direct means of inducing a higher rate of sustained growth.[3] Firstly, labour subsidies, which have already been discussed. Secondly, efficiency wages, and thus exports, may be affected by increasing the rate of autonomous productivity growth in the lagging regions. In Kaldor's model the effect of this upon output growth will be the same as for a labour subsidy, although the rate of labour saving will be increased and employment growth correspondingly slower. A third measure, already discussed, would be to increase the rate at which productivity growth is induced. This will increase the rate of output growth, but will also tend to lower the rate of growth of employment.

In practice the use of both the R.E.P. and differential allowances to investment indicates that government policy is operating on all three

1. R.R. MacKay, "Employment Creation in the Development Areas", Scottish Journal of Political Economy, Vol.19, 1972, p.288.

2. A latter-day 'transformation' problem!

3. Kaldor neglects policies for 'import substitution'.

of these variables.[1] We have already seen that the substitution of capital for labour was an important factor in explaining the relatively low employment growth in many of the lagging regions.[2]

An additional criticism of Kaldor's model, and a feature implicit in British regional policy, is that it views regional economic growth as 'competitive'. The notion that growth may be induced by altering market shares implies that growth in the lagging regions must be at the expense of other regions.[3] To some extent the prophecy is self-fulfilling in that, mainly as a result of government policy, growth has partly been at the expense of the (so-called) 'intermediate areas'.[4] There is no evidence that this need be the case. Indeed there is no evidence that growth of the (already) prosperous regions <u>need</u> be at the expense of the peripheral regions.[5] It should be the role of policy to concentrate upon the 'spread effects'[6] to ensure that growth is transmitted and diffused throughout the system. If these policies do not have the desired effect then fiscal policy, applied discriminatingly between areas, should be resorted to.

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1. The effect of government policy upon the 'capital-intensity' of production is discussed in A.J. Brown, 'Impact of Investment Grants on Capital-Intensive Industry', <u>op.cit.</u>, p.237f.

2. Chapter Seven, pp.286-288.

3. Regional economic growth as a 'competitive' process is discussed in J.H. Cumberland, <u>Regional Development: Experiences and Prospects in the United States of America</u> (The Hague, Mouton, 1971), pp.135-145.

4. Department of Economic Affairs, <u>The Intermediate Areas</u>, Cmnd.3998 (London, H.M.S.O., 1969);D.F. Lomax, "Some Thoughts on Regional Policy", <u>National Westminster Bank Quarterly Review</u>, August 1972, p.49.

5. Cf. A.G. Frank, <u>Capitalism and Underdevelopment in Latin America</u> (Harmondsworth, Penguin, 1971), pp.32-36.

6. G. Myrdal, <u>op.cit.</u>, pp.31-33.

'backwash' and 'spread' effects requires detailed empirical and theoretical analysis. Without this information regional policy measures may be self-defeating.

The major area for further work appears to involve the study of labour demand, particularly in the context of growth models. The significance of the 'Verdoorn effect' for understanding employment growth, and for policies towards reducing unemployment, cannot be questioned. It is undoubtedly in this area that further study is likely to prove most beneficial, for the dynamic inter-relationships between output and productivity growth are an important determinant of employment prospects.

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