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Aggregate Employment: Demand and Supply in the U.K. Engineering Industry.

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Summary

The thesis aims to explain the determination of employment at the industry level - in particular, the S.I.C. Orders of the U.K. engineering industry. The traditional demand-orientated approach is examined theoretically and empirically. Many developments are made to the models, but implausible and unstable estimates are generally found. More major developments are attempted, modelling desired output and the relationship between investment and employment with some success, but without a generally acceptable model of aggregate employment emerging.

The view is taken that a major reason for this is likely to be the neglect of supply factors. Initial attempts to allow for the tightness of the labour market indicate some effect, though incorrectly specified. The second half of the thesis undertakes a more rigorous and original analysis, involving the specification of an industry labour supply function, to be analysed in conjunction with the demand function. The appropriate methods of analysis and estimation depend upon assumptions about the interaction of demand and supply and the role of wages.

Three stages of development are considered with increasing realism of assumptions, but increasing complexity of analysis and difficulty of estimation. The first assumes flexibility of wages, equilibrating sectors of the labour market and enabling simultaneous estimation of aggregate demand <u>and</u> supply. The second assumes a degree of inflexibility of wages, but homogeneity of the sectors, so that aggregate demand <u>or</u> supply is observed and 'regime' estimation is possible. The third stage allows for non-homogeneity of sectors so that <u>neither</u> aggregate demand <u>nor</u> supply may be observed. Constrained estimation, via programming methods, results. Exogenous data is used to assess the extent of excess demand and supply in the labour market.

Whilst the empirical results are limited, they do indicate the need for supply factors to be modelled and included in the analysis of employment.

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Acknowledgments

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Declaration

An initial survey of the 'employment functions' literature appeared as Roberts (1972); Section 1.3 is based on this, with substantial changes. An earlier version of Chapter 3 of the thesis appeared as Roberts (1974), though it has also been considerably changed since. However, the work for it was undertaken whilst registered for the Ph.D. (part-time) and was intended as part of the thesis. The small amount of joint work included is clearly indicated in the text.

1. The Theory of Employment Functions

1.1 Introduction

The importance of being able to explain the level of employment for a sector or industry aggregate is illustrated by the large amount of work which has been done on this subject over the last decade. This work, whilst generally theoretically based, has been essentially empirically-orientated. As a consequence, the approach can be used not only to explain past levels of employment but also to predict the future path. Derivations are now used as integral parts of macroeconomic forecasting models.[(1)]

However, for an area of economic study to be widely accepted as fully developed, it must be shown to be solidly based on acceptable theory and to yield plausible and stable empirical results. This, as will be seen, is not the case for the 'employment functions' area. The empirical consideration will be fully studied in the following two chapters. In this chapter the theoretical grounding of the models is considered. Section 1.2 develops a theoretically 'ideal' employment function and this serves as a benchmark with which to assess the merits or shortcomings of major works in the area. This assessment is carried out in section 1.3.

1.2 An 'ideal' employment function

A full specification of the theoretical determination of employment is an exceedingly complex matter and, in a practical /

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(1) For example, see McLean (1974) and Shepherd et al (1974) for its use in the Treasury Model.

practical situation, many simplifications have to be made. However, it would be a useful exercise to try to postulate a theoretically adequate model of employment determination before proceeding to look at the various simplifying theories which have been put forward. The aim of these is to capture the essentials of the determination process whilst keeping a form which can be empirically estimated and tested. The 'pure' theory will serve as a benchmark to illustrate what assumptions and simplifications are being made and to assess their importance. Even within this theoretical framework several assumptions will be made, the validity of which may be questioned.

Before proceeding to the theory, consideration should be given to the 'aggregation problem'. This problem derives from the fact that, whilst the theory is formulated at the microeconomic level of the firm, empirical analysis is generally carried out at the industry or sector level of aggregation. Much has been written, particularly with reference to production functions(2), about the validity of aggregate versions of microeconomic relationships. The conditions under which aggregate specification and estimation is consistent with micro formulation have been shown to be very restrictive indeed. The general requirement is that the determinants of each microeconomic relationship be additively separable.(3)

Many of the studies in the employment functions area formulate /

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(2) See, for example, Fisher (1969)

(3) See Green (1964) for a survey of 'aggregation'. However, if efficient allocation between firms can be assumed, then the conditions for aggregation are much less severe .

formulate an expression, to be estimated in aggregate, which is linear in logarithmic form. At first sight these would appear to be additively separable. However, for this to be the case it would be necessary for each aggregate variable to be measured as the sum of the logs of the equivalent micro variable. In fact, data is usually available in aggregate form as the sum of the (unlogged) micro variables. The usual practice, then, is to take the log of the aggregate variable which is <u>not</u> equivalent to the aggregate of the logs. Consequently, such aggregate estimation will contain measurement or specification errors and will be biased and inefficient because of them.[(4)]

However, whilst the theoretical inadequacy of such formulations is undeniable, the relative merits of macro and micro level application is much less definite in actual empirical use. Grunfeld and Griliches (1960) have shown that aggregate estimation can provide a greater degree of 'explanatory power' than a composite of micro estimations. This apparent contradiction to the theoretical findings can be easily explained. The theoretical derivations assume that the micro relationships are perfectly specified. In empirical work this implies that all important variables are included and that available data accurately measures the required concepts. This is seldom true in practice. Microeconomic relationships are frequently formulated for the 'typical' micro /

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(4) See Theil (1954)

micro unit neglecting individual differences and interdependencies. In this sense, the theory may be more macroeconomic than it first appears. Also the quality of disaggregated data is often doubtful with inaccuracy due to human errors of collection. Thus microrelationships are likely to contain mis-specification and measurement errors which will lead to biased estimates if they are estimated. On summing the microrelationships to obtain a macrorelation these biases are unlikely to cancel each other out. On the other hand, if the data is aggregated before estimation then measurement errors are likely to cancel each other out to a large extent, reducing the degree of errors in variables. Furthermore, micro interdependencies may be captured by the corresponding aggregate variable and so the macro relation may not suffer from this particular mis-specification.

In conclusion, the practical superiority of macro or micro estimation depends on the relative magnitude of aggregation errors and specification errors. The optimal answer to this dilemma may well be to use better specification and data, in disaggregated studies. However, aggregate studies based on theories of typical microeconomic behaviour have a valuable and potentially reliable role to play, where it is the behaviour of the aggregate dependent variable which is of interest, for policy or forecasting purposes.

In proceeding with the development of the theory the following path is pursued. First, the relationship between desired output and desired inputs is examined, i.e. the /

the production function. This is the relationship which would be observed if the firm were in long-run steady state or equilibrium with all its outside influences constant. Then the determination of the desired level of output is considered, with particular reference to product demand. Finally, actual levels of inputs and output are determined in relation to the desired levels and in the face of changing product demand, by a cost minimising process.

(a) The production function

Firstly, desired inputs and output are related by means of a production function. This represents the maximum output which can be achieved with different combinations of inputs, given the present state of technology. As such it represents the most efficient means of production and the firm will aim to move towards the production function. In the long-run, if exogenous factors remain constant, it will operate on the production function, so the production function can be said to represent the relationship between desired output and desired inputs. In the short-run there is no necessity for producers to operate on the production function. As we will see shortly, such behaviour does not necessarily indicate bad management but may be perfectly rational in a situation where outside influences are not steady over time. Consequently, a production function does not represent the relationship between actual output and actual inputs. At best, it represents the most efficient frontier of such observations and it may be that no actual observations are fully efficient in the long-run sense.

The /

The level of aggregation at which a production function is meaningful is a much debated question. Ideally, the function relates the output of one type of good to the different types of labour, capital and material inputs which are used in its production. Thus a consideration of just one firm would involve a large number of these production functions and empirical investigation would require an intricate mass of data to explain how employment is determined. For exposition purposes and in keeping with most of the 'employment functions' literature, it is assumed that a meaningful production function can be postulated at the firm level of aggregation and that within this function different products, labour skills and types of capital can be added together and referred to as output, labour and capital respectively.

Consequently, the relationship between desired output and desired inputs can be specified but analysis of how these desired levels are determined, i.e. at what level the production function should be operated, is now required.

(b) The determination of desired output

The main determinant of desired output will be the market demand for the product. As this is influenced by the price of the product and as price will also influence the amount of the good which the firm desires to produce, it follows that the price of the good is important to the determination of desired output. The extent to which the firm can influence its selling price depends on the structure /

structure of the market. If it is perfectly competitive then the firm has to accept the price determined by the market and so price is exogenous to its desired output decision. But if the market is oligopolistic or even monopolistic then the firm will have some discretion to determine a target selling price as well as a production target. Consequently, desired price and desired output will be jointly determined.

From the point of view of explaining employment, it may be reasonable to assume that desired price is fixed independently of existing input stocks or of the costs involved in changing these stocks to meet the demand which corresponds to the desired price. This would reduce the connection between the product and labour markets, implying that desired price, and hence desired output, was exogenous to the determination of desired inputs, and simplifying the analysis considerably. The rationale for this assumption could be that prices are set on a rigid 'cost-plus markup' basis, where costs are some measure of production costs, not including adjustment costs, or that separation of decision-making in large firms between sales and production departments leads to lags in reactions, which reduce or remove the endogeneity of price determination.

A profit-maximising firm should take into account not only potential revenue but also the present scale of operation and availability of inputs since profits are the difference between revenue and <u>all</u> costs. Costs, as will be emphasised shortly, include the various adjustment costs /

costs involved in changing the scale of operation. Provided that the demand curve facing the firm is known and that all the costs involved in production are recognised, it should be possible to derive the optimal level of desired output.

(c) Cost minimizing process

Furthermore, the optimal paths of inputs, output (and price) over time can be derived by assuming that the firm is a cost minimiser. It should be noted that product demand is not constant or steady over time. It is known to have considerable seasonal and cyclical fluctuations, in addition to its trend, and actual output and inputs are bound to follow these fluctuations to some extent. However, their paths should be determined in order to minimize all the costs involved. Careful consideration of these costs must be made.

Some of the costs, which are necessarily involved in production, would be present even if demand did not fluctuate and inputs and output had achieved a steady state. On the labour input side there are all the costs associated with employing a number of employees to work a standard number of hours per week. These payroll costs will be dependent on the level of employment, the level of normal hours and the standard wage per hour[5] - the latter two being considered exogenous to the firm. On the capital input side there are all the costs associated with the operation of a stock of capital at a 'normal' rate. These include maintenance, depreciation and rental costs - the only determinant of these costs endogenous to the /

(5) This assumes that the average wage per hour is a minimum at the standard level of hours.

the firm is considered to be the level of capital stock at which the firm chooses to operate. Finally, the cost of holding a level of inventories due to lags between production and delivery or to meet 'normal' random fluctuations in demand would be a further element of 'steady-state' costs. However, this cost may be taken as minimal in a steady-state and inventory costs are much more relevant to the costs of fluctuating demand which is now considered.

There are three 'pure' strategies which a firm may follow when demand, and hence desired output, changes:-

i) It may adjust its labour force and/or capital stock sufficiently to meet the new level of demand, whilst maintaining normal working hours and inventory levels.

(ii) It may adjust the hours that labour and capital work to meet the new level of demand, maintaining labour force, capital stock and inventory levels constant.

iii) It may adjust the level of inventories and/or the backlog of orders-on-hand (negative inventories) and/or the product price, whilst maintaining a constant level of production and hence of labour and capital inputs.

Each of these three strategies involves its own particular costs:-

i) To increase or decrease the labour force affects payroll costs but more crucially it causes 'hiring and firing' costs. Hiring costs include recruitment, personnel and training costs. Firing costs include redundancy payments and loss of worker morale. The cost of increasing capital /

capital stock are similar. New investment will incur appraisal, installation and training costs. The laying-up or scrapping of capital stock, whilst it may be relatively costless in itself, is likely to increase the capital cost per unit of output to the firm.

ii) To increase the number of hours worked by labour will cause over-time costs thereby increasing the average wage per hour cost. To decrease the number of hours of labour will also cause wage costs per hour to rise with guaranteed wages or salary schemes in operation. Similarly, greater than normal use of capital will cause higher maintenance and depreciation costs whilst under-utilization will raise the 'rental' cost per production hour.

iii) To increase the level of inventories when demand is low incurs costs of storage, interest charges on the working capital tied-up etc. A reduction in the level of inventories below 'normal' increases the likelihood of order backlog, queueing and poor customer service which will incur the less tangible cost of lost custom. Lowering the product price when demand is low will reduce the profit margin and raising the price, when demand is high, will lose custom and goodwill.[6]

Thus it can be seen that each of the strategies which a firm has available to it when faced with a change in demand incurs /

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(6) In practice firms do not seem to use price variations as a strategy - perhaps suggesting that the associated costs are high. See, for example, Hague (1971).

incurs costs.[7] The choice of strategy will depend upon the magnitude of the demand change, whether the change is likely to be permanent or temporary and the magnitude and shape of the various cost curves involved. The rational firm will estimate the cost curves of the various strategies and forecast the expected path of demand. It will then minimize the total costs involved over time subject to the demand path and then adopt the appropriate strategy or mix of strategies. Holt et al (1960) find that an unexpected change in demand should be met, initially mainly by a change in the inventory level. When the costs of this strategy become too high and the change in demand persists then production should be altered by a change in the number of hours worked per week, allowing inventory costs (or lost sales) to fall. Finally, when the change in demand can be seen to be long-lasting then employment (and capital stock) take up the adjustment to new desired levels.

From the account given above it can be seen that it is a complex matter to explain the level of employment and changes in that level, involving the simultaneous determination of output, capital utilization, hours of work and inventory levels and requiring a detailed knowledge of all the associated costs. Few if any of the cost function parameters would seem to be measurable in aggregate and certainly no data series of adjustment costs are available to the author's knowledge.

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(7) Thomas and Deaton (1977) enumerate a large number of possible strategies open to a firm when faced with a shortage and the likely costs of and constraints on such actions. However, it is felt that the three strategies detailed will provide the main options, whilst keeping the model viable.

Consequently the above formulation, though having much to recommend it theoretically, is very unlikely to be operational in explaining aggregate employment. Grossly simplifying assumptions will have to be made to make estimation possible and various attempts to do this are considered in the next section. Before doing so it should be noted that the above formulation for all its complexities encompasses some possibly unrealistic assumptions. Firstly, as was pointed out there is a problem of aggregation particularly in connection with the production function both within the firm and between firms when considering production at the industry level.

Secondly, the above discussion has centred on the firm's demand for labour. No attention has been paid to the supply of labour nor to the existence of trade unions. The implicit assumption has been made that when a firm needs to make adjustments, particularly to the labour input, it will be able to do so. When over-time is required it is assumed that the firm can get as much as it wants and when extra employees are required it is assumed that the required number can be recruited. Both of these actions involve costs but these are taken to be insufficient to deter the firm. This may seem reasonable for one firm but, if all the firms in an industry or in the whole of manufacturing wish to expand their labour force, the expansion may not be possible because it is restricted by supply limitations.

Little, if any, regard has been paid in the literature

to /

to the effect of labour supply on the determination of employment. The assumption is that firms can obtain the employees they desire. To remedy this deficiency is one of the aims of this thesis and its importance and effect are analysed in Chapters 6-10. For now, we confine ourselves to an analysis of what has been done to explain employment and the strengths and weaknesses of the work, within the above 'demand-orientated' framework.

1.3 A survey of employment functions

It is unrealistic to expect any employment function formulation, capable of empirical application, to cope with all the complexities discussed in the previous section. However, the most important features can be categorized into four headings and then the literature can be analysed to see how well each model formulation deals with these aspects. In doing this, the approach of Killingsworth (1970) is followed to some extent.

The first point to note is that the labour input, L, has two dimensions - the number of employees, E, and the average number of hours worked per employee, H. If we wish to explain E then it is not sufficient to determine L, we must consider the choice between E and H as well. In particular, changes in the labour input may have different effects on output and costs according to which dimension of labour input is changed. The costs are discussed in the next paragraph but the effect on output should be noted. If E and H have different elasticities /

elasticities with respect to output then they should be specified separately in any production function formulation[8]. The same reasoning can be applied to the capital services input. This has the dimensions of capital stock, K, and its rate of utilization, U, but its treatment in employment studies is limited.

The second point to note is that there are different costs associated with different aspects of labour input. These costs were discussed fully in the previous section and the description need not be repeated except to emphasise that there are different costs associated with the level of employment, with the number of hours of work per employee and with changes in the level of employment. Again a similar consideration can be, but seldom is, given to the costs of the capital input.

The third point to note is that these costs cause actual levels of labour input (and capital and output) to generally differ from the desired levels which would be achieved in a steady-state. This deviation of observations from the production function will take the form of an adjustment process towards the desired levels, and this adjustment process should take explicit account of the various costs which determine it.

In fact, most studies published do not attempt to make the adjustment process explicitly dependent on these costs. The main reason for this is the lack of statistical /

(8) Feldstern (1967) and Craine (1972) justify and find empirical evidence for this difference. However, more recent evidence from Leslie and Wise (1980) suggests that the elasticities may in fact be equal.

statistical information on relevant costs. The usual procedure is to acknowledge the existence of adjustment costs and to assume that they cause actual levels, in particular employment, to approach desired levels with some lag structure. This assumption seems reasonable but when estimation is undertaken the type of lag structure specified is often very restrictive. The most common lag structure postulated is the Koyck partial adjustment model, which assumes that a constant proportion of the desired movement between actual and desired levels is accomplished each period. This leads to a one-period lagged dependent variable in the estimation formulation. The implication for employment, for validity of the 'constancy' of adjustment, is that hiring costs are similar in magnitude to firing costs, that these costs remain constant relative to alternative hours costs and inventory costs and that in assessing these costs over time, firms maintain the same time rate of discount. The realism of these conditions is questionable.

The final point to note is the treatment of the capital services input and of output in the determination of employment. The previous section demonstrated that labour, capital and output should be determined jointly to minimize costs. Hence capital and output are not exogenous to the labour input decision and should not be treated as such.[9]

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(9) Whilst the previous section suggested that desired output is also simultaneously determined, the complexity which this would entail makes estimation virtually impossible.

One aspect of the analysis which has been neglected so far is the relationship between desired output and desired inputs i.e. the production function. To be able to explain employment it is clearly necessary to specify a production function which correctly represents the technical relationship between inputs and outputs and takes account of the effects of technical progress. Much work has been done on the specification of production functions with regard to returns to scale and the substitutability of input factors[10] but empirical studies have generally tried to relate <u>actual</u> output and inputs with little regard to their deviation from desired levels, due to a lack of steady-state equilibrium. Employment function studies tend to concentrate on the adjustment process by which actual levels approach desired ones, adopting a particular production function without much justification of its validity.

In this review, the latter approach is followed - the type of function used is noted without much comment on its appropriateness - but it should be recognised that a production relationship and input demand relationships should really be estimated and tested jointly.

(A) <u>The profit-maximising model</u>

This type of model has been put forward by several authors, notably by Dhrymes (1969) and Nadiri (1968). Dhrymes assumes that the 'desired' production relationship can /

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(10) See, for example Heathfield (1971) for a survey of the area.

can be specified as a C.E.S. (constant elasticity of substitution) production function. A profit maximiser will desire to set his labour input so that its marginal product is related in a specific way to the expected real wage i.e. :-

$$\frac{\partial Q^*}{\partial L^*} = s(t) \frac{\hat{w}}{p} \qquad \text{..............(1.1)}$$

where Q* is desired output, L* is desired labour input measured in man-hours, w is the labour cost, p is the product price, ^ denotes the expected value and s(t) is a 'market imperfections' factor. If the product and labour markets are perfectly competitive then s(t) will take a value of unity. If either of the markets are oligopolistic or monopolistic then s(t) will take a non-unitary value such that the marginal product will be proportional to the real wage. To the extent that the structure of the markets changes over time, so s(t) will change. However, Dhrymes does not allow for this in his model, subsuming s(t) as invariant in the constant term.

Taking a C.E.S. production function, with constant returns to scale and no allowance for factor neutral technical progress:-

$$Q_t^* = A\,[\,aK_t^{*\rho} + bL_t^{*\rho}]^{1/\rho} \qquad \text{..............(1.2)}$$

and differentiating it with respect to L^*_t, yields:-

$$\frac{\partial Q^*_t}{\partial L^*_t} = A' \; b Q^{*\,1-\rho}_t L^{*\,\rho-1}_t \quad \ldots\ldots\ldots\ldots(1.3)$$

Equating (1.3) to (1.1) and re-arranging, gives:-

$$L^*_t = A^* b^{1/1-\rho} \; Q^*_t (w/p)^{1/\rho-1} \ldots\ldots\ldots\ldots(1.4)$$

Dhrymes assumes that the labour parameter b is affected by investment in that technical progress will improve the efficiency of new capital. However, as Killingsworth points out, this type of technical progress effect is more appropriate to a putty-clay production function than to the neoclassical one that Dhrymes uses.

The expected real wage is taken to be related to actual real wage by a constant factor and desired output, which ought to be jointly determined in a profit-maximizing context, is taken to be exogenous and to be based on actual output, current and lagged, via a simple 'expectations hypothesis':

$$Q^*_t = Q_t^{\mu_1} \; Q_{t-1}^{\mu_2} \quad \ldots\ldots\ldots\ldots(1.5)$$

We would expect μ_1 and μ_2 to lie between zero and unity and their sum to be close to unity, unless output is growing or declining rapidly.

Whilst /

Whilst the specification of (1.5) seems preferable to the simple assumption that desired output is equal to actual output or that actual output is exogenous to the labour input decision, it is by no means certain that such a naive hypothesis will correctly capture the determination of firms' desired output levels. It should also be noted that, in the method of derivation, the level of input of capital services, K_t^* , has been implicitly assumed constant.

A Koyck lagged adjustment process is added to 'explain' the adjustment of actual labour input towards its desired level i.e.:-

$$\frac{L_t}{L_{t-1}} \equiv \left[\frac{L_t^*}{L_{t-1}}\right]^{\lambda} \text{ with } 0 \leq \lambda \leq 1 \qquad \text{........(1.6)}$$

Whilst Dhrymes recognizes that the lag is due to costs in adjusting labour and capital inputs, in addition to uncertainty, these costs are not explicitly included in the model. (1.6) is a crude proxy for these costs. Nor does Dhrymes' model allow for the fact that the labour input has the two dimensionsof men and hours with potentially different effects on output,different costs and hence different adjustment processes. Thus in terms of our adopted criteria, the Dhrymes model does not fare very well, being unsatisfactory on all four points. However, the model can be modified to take account of the choice between men and hours along the lines of the cost-minimising /

cost-minimising model to be discussed shortly. Also it should be remembered that the criteria are quite stringent for a practical employment function and most of the models to be considered will be found wanting in some respects.

Nadiri's version of the profit maximising model is somewhat different. In addition to relating the marginal product of labour to the real wage,(11) as Dhrymes does in (1.1), he similarly relates the marginal product of capital to the cost of capital, c. Dividing one by the other, an expression is obtained for the desired labour input:

$$L^* = f\ [\ c/w,\ K^u] \qquad \ldots\ldots\ldots\ldots (1.7)$$

where K is the level of capital stock and u is its rate of utilisation. So that, whilst this model does explicitly recognize the effect of capital services on the desired labour input, it treats them as exogenous to the labour decision. Also it excludes explicit allowance of the effect of desired output on the desired labour input.

Again, a lagged adjustment process is added to (1.7) to relate actual labour input to desired, with a second-order Pascal lag(12) in preference to the Koyck process /

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(11) The elasticities of supply of the inputs are included at first but assumed infinite in estimation.

(12) See Griliches (1967) for a description of the Pascal lag structure.

process, as a slightly less restrictive attempt to allow implicitly for the effects of adjustment costs. As with the Dhrymes model no attempt is made to explain how the labour input is determined between men and hours. Consequently, this model is also found to be unsatisfactory on the four criteria.

(B) <u>The cost-minimising model</u>

In this type of model the key feature is that the firm's desired employment decision is made in two stages. First, the desired labour input is determined, generally by inverting a production function rather than differentiating it. Then the desired choice between employment, E, and hours, H, is made such that $L^* = E^*H^*$, with wage costs at a minimum. Thus the two dimensions of the labour input are recognised and a cost-minimising procedure is postulated which enables the split to be explained.

The best known of this type of employment function is that put forward by Ball and St. Cyr (1966). They begin with a Cobb-Douglas production function with the effects of capital stock and technology captured by an exponential time trend:-

$$Q_t = Ae^{\gamma t} L_t^{\alpha} \qquad \ldots\ldots\ldots\ldots\ldots(1.8)$$

This relationship is expressed in actual rather than desired terms implying that firms operate on their production frontiers - a strong assumption. (1.8) is inverted /

inverted to yield:-

$$L_t = A' e^{(\gamma/\alpha)t} Q_t^{1/\alpha} \qquad \text{.............(1.9)}$$

This implies that output is exogenous to the labour decision. However, the production function could have been specified in desired rather than actual terms. In this case we would have the more acceptable proposition that desired output is exogenous to desired labour input. Also the effect of capital services is assumed exogenous and is likely to be mis-measured as a time trend. In addition, men and hours are assumed to have equal elasticities with respect to output and this need not be the case.

The second stage of determining desired employment is achieved by minimising the average wage per hour[(13)], w. This is postulated to be dependent on the number of hours worked per employee, H with a quadratic shape. The rationale for this is that over-time hours have to be paid for at a higher than standard wage rate and that short-time working will raise the effective wage-rate per hour where guaranteed earnings, salaries etc. are in existence. Hence w will rise increasingly as more overtime or short-time working prevails and take a minimum value at 'normal' hours. As normal institutional hours change over time we might expect the quadratic and the cost-minimising level of hours to change accordingly. However /

(13) For a given level of man-hours this is equivalent to minimizing the total wage bill.

However, Ball and St. Cyr specify a quadratic with fixed parameters:-

$$w = a - bH + cH^2 \qquad \text{..............(1.10)}$$

and minimize the cost function, :-

$$C_t = w(EH)_t + F_t \qquad \text{..............(1.11)}$$

with respect to H, where F is fixed costs.
They pursue a long and complex minimization and substitution process, which is equivalent to minimizing (1.10) with respect to H, to yield:-

$$H^* = b/_{2c} \qquad \text{.............(1.12)}$$

and then obtaining desired employment, from (1.9), as :-

$$E_t^* = \frac{L_t}{H_t^*} = \frac{2cA'}{b} e^{-(\gamma/\alpha)\, t} Q_t^{1/\alpha} \qquad \text{.............(1.13)}$$

i.e. effectively removing hours from the active determination of desired employment.

A Koyck lagged adjustment process of actual employment towards its desired level is then specified due to the costs /

costs involved in changing the employment level i.e. :-

$$\frac{E_t}{E_{t-1}} = \left[\frac{E_t^*}{E_{t-1}}\right]^{\lambda} \text{with } 0 < \lambda < 1 \quad \text{..............(1.14)}$$

Actual hours worked per employee must presumably adjust with the 'inverse' adjustment process for L_t to be achieved, but this is not considered.

The model put forward by Brechling (1965) has a similar approach except that his production function is linear (rather than log-linear) and he explicitly includes the level of normal hours and the over-time premia rate in the determination of desired employment rather than assuming them constant over time. The Ball and St. Cyr model can be quite easily modified to allow for changes in normal hours H_o, by specifying desired hours as directly related to normal hours, i.e.:

$$H_t^* = H_{ot}^{\beta} \quad \text{...............(1.15)}$$

We might well expect β to take the value of unity but if the elasticities of output with respect to employment and hours differ or if a certain amount of overtime is expected by labour then the true cost minimizing value of β may differ from unity. (1.13) becomes :-

$$E_t^* = A' e^{-(\gamma/\alpha)t} Q_t^{1/\alpha} H_{ot}^{-\beta} \quad \text{.............(1.16)}$$

The /

The cost-minimizing model is then an improvement on the profit-maximizing model. Whilst it does not explicitly include adjustment costs or justify the treatment of actual output as exogenous,[14] it does recognise the two dimensions of employment and that the number of employees and the number of hours they work involve very different costs. It resolves their desired joint determination by cost-minimization. However, there is no reason why this second stage of the decision process should not be grafted on to the profit-maximizing model to determine desired employment from desired labour input. If this is done then there is little to choose between the two models. Both fail in their treatment of actual output and actual capital services as exogenous to desired labour input decisions. Models which aim to remedy these faults are looked at shortly. But first, the major defect in the cost-minimization and the profit-maximizing models is that the adjustment process, whilst acknowledged as dependent on employment-change costs, is not explicitly specified as such.

(C) Adjustment cost minimizing models

However, several authors, amongst them Solow (1968) and Holt, Modigliani, Muth and Simon (1960) have tried to specify these adjustment costs explicitly and since adjustment can be a lengthy process lasting many periods they have taken the appropriate step of minimizing costs over /

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(14) The assumption that desired output is always actually achieved seems unrealistic.

over time rather than instantaneously.

Solow does not explicitly specify a production function but assumes that desired employment, E_t^* is determined by the expected output schedule with 'capital and other factors essentially constant'. Three elements of cost are identified: 'normal' wage costs, wE; hiring and firing costs, $v\dot{E}^2$ i.e. symmetrical and quadratic; over-time and short-time costs occasioned by actual employment deviating from desired employment and again quadratic in shape i.e. $a(E^*-E)^2 + b(E^*-E)$. The sum of these costs is minimized over the planning horizon of T periods.

By making several strong assumptions, notably that desired employment is constant over the planning period and that the coefficient b is equal to the wage rate, w, Solow derives an expression for the actual change in employment as:-

$$\dot{E} = \sqrt{\frac{a}{v}}\,(E^*-E) \qquad \text{..............(1.17)}$$

This expression is the continuous time version of a linear first-order adjustment process and as such it is very similar to the Koyck adjustment process frequently used. The speed of adjustment is $\sqrt{\frac{a}{v}}$ i.e. the square root of the ratio of the hours cost parameter to the hiring-and firing cost parameter. If these costs remain relatively constant, and hiring costs are of the same magnitude as firing /

firing costs then the Koyck adjustment process would be satisfactory but if the relative costs change then the speed of adjustment changes and a Koyck specification is not valid. Consequently, we need to try to measure the costs involved and specify the adjustment speed accordingly.

Solow does not attempt to measure these costs, nor does he specify the determination of E^*.[15] Nevertheless, his model, in explicitly taking account of the different costs of employment, hours and changes in employment, does provide a basis for improvement in explaining employment if the associated costs can be measured.

Holt et al., in attempting to explain optimal rather than actual firm behaviour, progress further than Solow in explicitly including adjustment costs, both theoretically and empirically. They pay great attention to the elucidation and analysis of the costs involved not only in the labour input but also in output i.e. inventories and order-backlogs. Capital costs are not considered; presumably the input of capital services is assumed exogenous to the labour decision. Desired output is exogenously determined by demand, with price presumably exogenous, but actual output is endogenously determined as part of the cost-minimizing process.

The /

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(15) However, he does point out that if E^* is assumed to be a function of time rather than constant, the resulting optimal expressions is $\ddot{E} = -a/v(E^*-E) + (w-b)/2v$, where $\ddot{E}$ is the second derivative of employment wrt. time. This is not similar to a Koyck process and data quality is unlikely to support the taking of second differences over time, reliably.

The costs associated with the labour input are specified similarly to Solow's with linear 'regular payroll costs' and quadratic 'hiring and layoff costs' and overtime costs.[16] The additional feature is the recognition that, instead of changing the labour input to adjust output, a firm can change its level of inventories or its backlog of orders-on-hand, keeping output steady. The cost function for these changes is also specified as a quadratic. Summing all these costs discretely, rather than continuously, over time and minimising with respect to output and employment yields two linear decision rules for the paths of output and employment respectively. The resulting 'employment function' has employment as a function of last period's employment, desired output and last period's inventory level.[17] This again can be seen to resemble earlier employment functions with the extra inventory term. However, the parameters of this employment function are dependent on the parameters of the various cost functions and need not be constant over time.

The difficulty lies in obtaining the information required to estimate the cost functions so that the paths of the parameters can be traced over time. Holt <u>et.al</u>. make careful and extensive use of accounting information and managerial estimates, often of a subjective nature, made available to them by one or two firms. Even then they /

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(16) Expressed as deviations of actual output from the output achieved by the standard work week of employees.

(17) i.e. $E_t = a + bE_{t-1} + c\,S + dI_{t-1}$ with S being a distributed lag process of forecast sales over the coming year.

they presumably do not have enough information to allow the parameters to change over time as, in their estimation, they assume the functions to be fixed over time. Their resulting employment function is then very little different from earlier ones.

The data required to pursue the model set out above at an aggregate level is simply not available. Data might be available on some cost items but not sufficient to estimate quadratic cost functions with variable parameters over time. Furthermore, many of the 'costs' important to a firm are barely tangible,[18] let alone quantified and available in official statistics.

Without this data, Holt et al's model becomes a flexible accelerator model[19] with desired employment determined by sales targets; adjustment costs in employment and in other factors are allowed for by the presence of one-period lagged values.

The explicit inclusion of adjustment costs, whilst theoretically desirable, is likely to remain impractical in/

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(18) e.g. the morale cost of laying-off employees.

(19) See, for example, Nickell (1978) for a review of such models.

in aggregate employment functions. To specify the costs and then to assume them relatively constant through lack of data is no real improvement on, and may even be equivalent to, a 'naive' lagged adjustment process.[20]

(D) Inter-related adjustment model

As pointed out above, the Holt et al study, whilst paying great attention to the costs of employment and inventory, neglects the costs of the capital services input. This seems an odd omission as a rational decision by a firm must take account of all the associated costs. Thus capital costs will affect employment behaviour and should be considered. As discussed in section 1.2, the costs associated with the capital input are parallel to the labour input costs i.e. the cost of normal usage of the level of capital stock, additional unit costs when the capital is over-used or under-used relative to 'normal' and adjustment costs when the amount of capital stock is increased or decreased.

Nadiri and Rosen (1969) have put forward a model which does attempt to take into account these costs. However, they begin with the strong assumption that actual output is exogenous to input usage decisions. In their own words, 'we recognise that the dynamic input and output paths are jointly determined, contingent on future product price expectations. But their joint estimation requires a full market theory not yet available'. Consequently, firms /

(20) Though it may be possible to relax the restrictiveness of a Koyck process by postulating a cost function which takes limited account of future as well as current desired employment. Deaton (1977) experiments along these lines.

firms are assumed always to produce the output they require and furthermore to always operate on their production functions in doing so. These elements of the model are somewhat restrictive.

Labour input is recognised as having the two dimensions of employment and hours per man and capital input is recognised as also having two dimensions, i.e. capital stock and its rate of utilisation. The desired levels of all these four inputs are determined by minimizing the associated labour and capital costs[(21)] (not including adjustment costs) subject to meeting desired output. A Cobb-Douglas production function is specified with each of the four inputs allowed its own elasticity.

Actual inputs approach these desired levels gradually but they do so in such a way that desired output is still achieved. For this to be the case the adjustment of all four inputs must be related and it is postulated that the inter-relationship is controlled by the firm so as to minimize the overall costs of adjustment. The inputs with the least costly adjustment will initially be 'over-adjusted' to compensate for shortage or excesses of less flexible inputs. A priori, the speed of adjustment ordering is expected to be capital usage, hours per man, employment and, finally, capital stock. A general first-order inter-related adjustment process is specified:

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(21) Capital costs consist of rental, maintenance and depreciation costs, with the last two dependent on the rate of utilization.

$$Y_{it} - Y_{it-1} = \sum_{j=1}^{4} \beta_{ij} (Y^*_{jt} - Y_{jt-1}) \qquad \ldots\ldots\ldots\ldots(1.18)$$

where Y_i, with i = 1, 2, 3 or 4, are the inputs and the β's are assumed constant. Combining expression (1.18) with the desired input demand expressions, Nadiri and Rosen derive an equation system for estimation, where each input is determined by output, relative factor prices, a time trend, and the levels of all four inputs in the previous period.

The Nadiri-Rosen model is thus more satisfying theoretically than earlier models in its treatment of capital and also it recognises the different dimensions and costs, though adjustment costs are not explicitly included. Its main weakness is in the treatment of output as exogenous and in its data requirements.

(E) Other models and features

Whilst the above four categories represent major types of employment function, other studies have been undertaken which either do not easily fit into these categories or have additional features. Often they improve on one aspect of the theoretical requirements but usually at the expense of others. Several studies are considered worthy of mention, firstly in the treatment of desired output and the endogeneity of actual output, then in the treatment of the production relation itself and /

and technical progress, finally in the treatment of the adjustment process and labour hoarding.

a) Both Fair (1969) and Trivedi and Stromback (1976) specify their models with changes in employment dependent on, amongst other variables, expected changes in output. Trivedi and Stromback adopting a type of inter-related adjustment model, then go on to assume that expectations about future output levels are generated by past output levels. In estimation they include the current[22] and previous four quarters' output changes as explanatory variables. The formulation thus includes two hypotheses - their inter-related adjustment explanation of employment and the hypothesis that firms' expectations about future output levels are based on the previous year's actual output with fixed parameters. The validity of either hypothesis cannot be judged in isolation and so it is difficult to assess whether such a specification does 'capture' expected output.

Fair, in addition to postulating a similar expectations hypothesis to Trivedi and Stromback, also includes actual future output changes. The hypothesis here is that firms have perfect foresight and correctly predict future output levels. In addition to the endogeneity incurred by this information, there is strong evidence that firms do not always achieve the output which they expect to and hence actual future output will mis-measure desired output.

/Briscoe

(22) Instrumental variables are used when current output changes are included, recognizing the endogeneity of current output.

Briscoe and Peel (1975) attempt to recognize the joint nature of employment and output decisions by specifying systems of simultaneous equations where inputs and output are endogenously determined. The input demand equations specified are of the profit-maximizing types already discussed. The output equations are of the Cobb-Douglas type of production function. Briscoe and Peel formulate several different specifications of this kind.

However, the joint use of the input demand and output equation involves a logical inconsistency. The input equations recognize the disequilibrium state with actual inputs deviating from their desired levels whereas production functions describe an equilibrium state with inputs and output at their desired levels. The use of actual input and output levels to estimate the production function parameters is clearly incorrect.

Despite this, the attempt to make the determination of output endogenous is valuable, particularly if firms adjust rapidly towards their desired input levels. A production function which allows for adjustment 'inefficiencies' would improve the specification considerably but such a formulation is not known to the author.

b) Most of the above studies are based on neoclassical production functions, such as Cobb-Douglas and C.E.S., where the inputs of capital and labour are divisible and substitutable and returns to scale are fixed, whether increasing /

increasing, decreasing or constant, for all levels of operation. Lack of substitutability and its implications are considered at length in Chapter 5 where a putty-clay or vintage model of production is pursued. Hazeldine (1974) postulates that capital plant is designed for an optimal level of employment, E^+. Any over-manning or under-manning will reduce the productivity of man-hours of labour with returns to hours per man assumed to be unity. The effect is assumed to be quadratic in shape:-

$$Y_t/E_tH_t = a + b(E_t - E_t^+)^2 \ldots\ldots \qquad (1.19)$$

where E^+, a and b may well not be constant over time. Desired hours per man are taken to be normal hours, H_o, where cost per hour is minimized. Where output, Y_t, is not equal to $E_t^+H_o$, the firm has to trade-off overtime or short-time costs (i.e. $H \neq H_o$) against over or under-manning costs in terms of lower productivity (i.e. $E \neq E^+$). The resulting desired level of employment, E^* will be positively dependent on thé level of output but Hazeldine claims that the shape of the relationship is uncertain and should not be interpreted as the production parameter, returns to labour. Thus an estimate greater or less than one is quite possible. He assumes a linear relation between E^* and Y for simplicity and adds a time trend to proxy changes in capital stock and technology.

Hazeldine (1978) develops the idea of varying returns to scale further with different elasticities of output with respect /

respect to labour according to whether production is above or below optimum. The principle remains that the estimated elasticities whilst dependent on the production parameters, will also be affected by cost trade-off considerations. Whilst the rationale for the model is quite plausible, its usefulness would be increased if the underlying production parameters could be identified.

Another aspect of the production relationships used worth considering is that of technical progress. Most of the studies follow the original production functions in proxying the effects of technical progress by a time trend, often with the trend proxying increases in capital stock as well. This is not an ideal means of capturing the effect of technology on employment levels, particularly where firms can influence their rate of technical progress both by their rate of adoption of new techniques and the amount of resources they devote to research and development. The former aspect is considered to some extent in a putty-clay context in Chapter 5, but the latter can be considered in the present context.

Schott (1978) extends the Nadiri-Rosen inter-related factor demand model to allow the stock of technical knowledge, A, to influence, and be influenced by, production and factor demands. A becomes a factor in the Cobb-Douglas production function, as with employment, hours, capital stock and its rate of utilization. The cost function to be minimized includes the additional term Ab where b is defined as the user cost of technical knowledge. Desired levels of the five factor /

factor demands can then be derived with the desired stock of technical knowledge dependent on output and relative factor prices, including b, as are the stocks of labour and capital. An inter-related adjustment process is then added to give a 5 x 5 matrix of adjustment coefficients.

Conceptually, this approach is appealing in its consistency of treatment but problems lie in the measurement of A and its user cost, b. The stock of knowledge is assumed to depreciate at a constant rate, d, and be added to by expenditure on research and development, R, where the effects of basic and applied research expenditure are distinguished and assumed to be distributed over time, W(L):-

$$A_t = A_{t-1} + \gamma W(L) R_t - dA_{t-1} \quad \ldots\ldots\ldots \quad (1.20)$$

where γ is the success rate of the research activity. R is measured at constant prices but the assumption that each unit of expenditure adds equally to the stock of knowledge is unrealistic, though perhaps preferable to a time trend proxy. The user cost, b, is analogous to the cost of capital reflecting the unit purchasing price or cost of research, interest rate, rate of depreciation, tax allowances, investment grants etc. In addition, patents are allowed for in terms of a monopoly rent, declining in value over time as the patent life expires.

The success of this model will depend crucially on the validity of the assumptions about A. In particular, if /

if new techniques are developed by the capital goods industry, they may be adopted by a user industry without any research or development on their part. Therefore, the use of this model at an industry level may cause several difficulties, in the allocation of research costs, to be meaningful. In addition, there are the substantial data requirements and difficulties of the basic Nadiri-Rosen model.

c) The adjustment process of actual employment towards its desired level is meant to be the result of cost minimization over time by firms, tradeing-off over-time and short-time costs against hiring and firing costs. Section (C) of this chapter has shown that the assumption of a Koyck process, whilst popular, is quite restrictive. Amongst other things it implies that hiring and firing costs are of equal importance, such that adjustment is the same speed in both directions, that these costs have remained constant relative to other costs over time, so that the adjustment speed has not changed, and that firms are not influenced by the availability of labour.

Several studies have attempted to relax aspects of these restrictive assumptions whilst remaining within the Koyck process framework. Knight and Wilson (1974) postulate that a major change in the costs occurred with new legislation in 1966, causing firms to shed labour which was being hoarded and paid for during recessions and to rely more on over-time and short-time working to meet fluctuating /

fluctuating demand. They estimate employment functions for both the number of employees and the number of man-hours worked before and after the changes, expecting the adjustment speed of employment to have increased, but not necessarily that of man-hours. Thus, where a once-for-all change in costs can be identified, then it is relatively simple to allow for such changes. Where changes are gradual or less advertised, such a procedure is less viable.

Peel and Walker (1978) postulate that the supply of labour is likely to constrain demand at certain times within an estimation period. They expect employment to adjust more quickly when supply is not restricted than when supply is a constraining factor on demand. Whilst this seems reasonable when firms wish to increase employment, it is less obvious why the shedding of labour should be affected in a similar way. To discover which periods are supply-constrained, Peel and Walker postulate a neoclassical 'wage change' equation where an increase in the expected real wage signifies excess demand for labour i.e. a supply constraint and vv. Observations can then be divided into demand and supply 'regimes' and estimated separately.

The effect of supply on the labour market and its interaction with demand will be considered at great length in Chapters 6 to 10. Also, an attempt to allow different adjustment speeds for increasing or decreasing employment is made in Chapter 3.

Finally /

Finally, other studies, in particular the study by Fair already referred to, treat the hoarding of labour more explicitly. Fair's model postulates that employment changes will be a negative function of 'excess labour' in the previous period. Excess labour is equal to actual employment minus desired employment where the latter is given by actual man-hours worked divided by normal or standard hours of work. The novelty of Fair's approach lies in the measurement of actual man hours worked. Data on numbers of employees and average hours worked refer to the man-hours which are being paid for by firms and not the numbers which are actually being worked. Fair assumes that only when output per man-hour is at a peak will actual and paid for man-hours coincide. At other times labour is hoarded to avoid adjustment costs. By use of the Wharton School method a series for actual man-hours worked can be derived and Fair's excess labour variable can then be calculated.

Whilst it does seem preferable to use a measure of actual hours of work rather than an hours paid-for series, the formulation of Fair's employment function is somewhat ad hoc and does not provide a theoretical improvement over earlier models. The production function used is very restrictive - a fixed coefficient relationship between output and man-hours labour input. No cost function is explicitly included in the firm's decision process and the level of labour hoarding is included as an explanatory variable rather than 'explained' by the model.

1.4 Conclusions

The last section did not attempt to cover fully all the work which has been done on 'employment functions' but it did cover the major developments in the area. The four elements considered to be essential for the theoretical acceptance of an employment function were the separation of labour input into men and hours, a recognition of the different costs involved in the labour input, an adjustment process dependent on the adjustment costs and recognition that output and capital services input are not exogenously determined. In fact, section 1.2 indicated that ideally the requirements would be even more rigorous.

However, a combination of these four elements is a sufficiently demanding 'goal' for a practical employment function and 'the world still awaits a fully-specified theory of the labour input'[(23)] which can be applied empirically. None of the studies looked at have managed to satisfactorily capture all four of the features we desire. Rather, they have concentrated their attention on one or two elements and perhaps specified them adequately to the neglect of the other elements. Furthermore, the treatments are seldom compatible so that the best features of each model cannot simply be added together to obtain the 'best model'.

Finally, we are not yet in a position to say which model does treat which feature best or even to say which of /

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(23) Killingsworth (1970)

of the four elements are important and which are not. We have so far made our assessments on such theoretical grounds as cost-minimizing and profit-maximizing. What is needed is a thorough confrontation of the theory with empirical data to try to discover which studies give the most plausible explanation of actual behaviour. Hopefully from this, we can ascertain which of the four elements are most important, how they are best specified and where there is need of improvement. To this task, we turn our attention in the next two chapters.

2. Other Researchers' Empirical Application of Employment Functions

2.1 Introduction

The purpose of this chapter and the following one is to determine whether the various employment functions are capable of explaining the behaviour of actual employment levels. To do this we can first look at the empirical results of the original papers in which the employment functions were postulated and assess their 'explanatory power', plausibility(1) and stability(2). However, these studies have been carried out in different countries, for different time spans and at varying levels of aggregation. Comparison of these results is thus very difficult and unsatisfactory.

What is needed is to be able to test all the important employment models on consistent sets of data. In this way we should be able to make comparisons more readily. Such a comparison exercise has been carried out in an admirably thorough paper by Briscoe and Peel (1975) for the U.K. Manufacturing Sector, 1955-72.(3) This /

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(1) In particular. the plausibility of the returns-to-labour parameter.

(2) i.e. whether the parameter values remain constant over time, as is normally assumed; an important quality for any model which is to be useful for forecasting or policy purposes.

(3) One important consideration when using quarterly data is how to deal with seasonal variations. Ideally, an employment function should explain how firms cope with seasonal as well as cyclical fluctuations. However, employment statistics do not always represent the number of people actually working. In particular those employees on holiday are included in the number employed and so we cannot expect an accurate relation between output and employment in holiday /

This chapter draws heavily on their results though the interpretation of them may differ. The procedure adopted in this chapter is to take the different models one by one, in the same order as the previous chapter, and to analyse the original results and then those of Briscoe and Peel.

The following chapter proceeds to apply the models (and developments of them) at a somewhat less aggregate level and to more than one set of data, by considering separately the three S.I.C. Orders which make up the engineering industry.

2.2 The Profit-maximizing model

The two main works on this type of employment function are those of Dhrymes (1969) and Nadiri (1968). Both are formulated in terms of man-hours rather than employment. Dhrymes' original formulation is a complex one incorporating investment terms, to allow for technical progress, and current and lagged values of output and real wage, to allow for expectations. The estimation is consequently difficult to interpret meaningfully. The results are not reported here but a high explanatory power of almost 99% is achieved in explaining variations in /

(3) contd:

holiday periods. Two procedures are available - to use seasonal adjusted output data or to use seasonal dummy variables. Briscoe and Peel opt for the former. We desire such procedures to remove seasonal variations in output not relevant to employment but to leave those which will affect employment. Any mismeasurement of such seasonal patterns is likely to bias the returns to labour and adjustment speed estimates.

in the input of man-hours for the U.S. manufacturing sector, 1948-60. However, the influence of investment on the labour input levels does not appear to be significant and the lagged output coefficient has a negative sign contrary to our expectations, expressed in (1.5) in the previous chapter. The implied speed of adjustment of actual man-hours towards the desired level was found to be just over 34% per quarter. In that we would expect the number of hours per man to be more readily adjustable than the number of men it is difficult to assess the plausibility of this figure for man-hours.

Briscoe and Peel adopt a simpler formulation in testing this type of model for U.K. manufacturing[4] and specify it both for the level of man-hours and for the level of employment[5] i.e.:

$$\log\,(EH)_t = \alpha_o + \alpha_1 \log Q_t + \alpha_2 \log\,(w/p)_t + (1-\lambda) \log\,(EH)_{t-1} \quad ..... \quad (2.1)$$

and:-

$$\log E_t = \alpha'_o + \alpha'_1 \log Q_t + \alpha'_2 \log\,(w/p)_t + (1-\lambda')\log\,E_{t-1} \quad ..... \quad (2.2)$$

Their results are reported in Table 2.1. as (A) and (B) respectively. The overall explanatory power of 94% and 93% respectively is lower than that of Dhrymes but still very high. Coefficients are generally of the right sign /and

(4) No allowance is made for the effect of technical progress.

(5) This accords with our discussion in the previous chapter of the consistency of an adjustment process in man-hours with the achievement of desired output.

and strongly significant. An adjustment speed of 39% is found for man-hours - quite similar to Dhrymes' U.S. value. A speed of 17% per quarter is found for employment which, as we would expect, is lower than the adjustment speed for hours worked.

A long-run estimate of the elasticity of output with respect to employment, to be interpreted as returns to scale rather than returns to labour, can be obtained.(6) This is comparable to the 'α' values of the Ball and St. Cyr model in the next section. Formulation (2.1) yields a value of 11.82 whilst (2.2) yields a value of unity. The latter value is consistent with the theoretical specification of (1.4) whilst the former is clearly not and this leads us to prefer the specification in terms of employment rather than man-hours.

Nadiri's formulation is also expressed in man-hours and features capital and the wage-rental ratio, w/c, rather than output and real wage. In addition, Nadiri specifies a Pascal two period lag adjustment process in preference to a Koyck lag of one period. The capital variable is intended to allow for the level of utilization, U, of capital stock, i.e. to measure capital services, though a capacity utilization index is used. For the same data base as Dhrymes, U.S. manufacturing 1948-60, Nadiri also gets explanatory power of over 90%. The explanatory power is not quite as high as Dhrymes', but the model used is more straightforward and signs and significance are generally good.

/ When

(6) Contrary to Briscoe and Peel's assertion (p.132), the production parameters can be derived, as illustrated by Peel and Walker (1978).

When Briscoe and Peel test the Nadiri formulation they adopt a Koyck adjustment process for comparability with the other models and again specify adjustment both in man-hours and employment i.e.:-

$$\log (EH)_t = \alpha_o + \alpha_1 \log (KU)_t + \alpha_2 \log (w/c)_t + (1-\lambda) \log (EH)_{t-1} \quad \ldots\ldots\ldots \quad (2.3)$$

and:-

$$\log E_t = \alpha'_o + \alpha'_1 \log (KU)_t + \alpha'_2 \log (w/c)_t + \alpha'_3 t + (1-\lambda') \log E_{t-1} \quad \ldots\ldots \quad (2.4)$$

Their results are reported in Table 2.1 as (C) and (D) respectively. The overall explanatory power of these two formulations, whilst high, is not as high as the Dhrymes' model results and not all of the estimated coefficients are satisfactory. In particular, the wage-rental term is not significant in either formulation and the capital utilization term is not significant in (2.3). This formulation also has an implausibly low adjustment speed of 1.3% per quarter. Formulation (2.4), which differs not only in the dependent variable but also in the addition of a time trend to reflect disembodied technical progress, is more satisfactory. The time trend takes a strongly significant negative value and the capital utilization coefficient then has the expected positive sign and is significant at the 5% level. Also the adjustment speed of employment of 21.3% per quarter is much more acceptable, though the Durbin (1970) test indicates that the hypothesis of positive autocorrelation is not rejected at the 5% level.

/On

On balance, the Dhrymes model seems superior to the Nadiri one though this probably reflects the inadequacy of measures of capital utilization and capital rental costs rather than inferiority of theoretical specification.

2.3 The cost-minimizing model

The most frequently used model of this type is the one put forward by Ball and St. Cyr (1966). The original formulation for this model is:-

$$\log E_t = A + \frac{\lambda}{\alpha} \log Q_t - \frac{\lambda\gamma}{\alpha} t + (1-\lambda) \log E_{t-1} \quad \ldots \quad (2.5)$$

though this has been much modified in the literature. Ball and St. Cyr estimate (2.5) at the S.I.C. Order level, as well as for all manufacturing in the U.K., for the years 1955-64. In terms of explanatory power, correct signs and significant coefficients, the results are good. However, the α in expression (2.5) is interpretable as the elasticity of output with respect to employment. Thus a value in the region of 0.7 is expected[7] whereas Ball and St. Cyr found α values generally greater than unity and often significantly greater.

Many authors have tried to explain this occurence or to modify the estimation equation until returns-to-labour of less than unity are found. It can reasonably be argued that α should be interpreted as returns to scale rather than returns-to-labour due to the inadequate treatment of capital,[8] but increasing returns to scale

/are

(7) This is equivalent to labour's share of national income.

(8) See Ireland and Smyth (1970). Solow (1973) claims that large fluctuations in capital utilization can mean that apparently high returns to labour are quite consistent with constant returns to scale.

are still hard to accept. However, when Briscoe and Peel estimate this equation for all U.K. manufacturing, 1955-1972, reported as (E) in Table 2.1, in addition to strongly significant coefficients of the right sign and high explanatory power, they get an α value of 0.75. The corresponding value in Ball and St. Cyr's results is 1.14. The more acceptable value of 0.75 seems more due to chance than theoretical consistency. The value seems subject to change and, indeed, Briscoe and Roberts (1977) find considerable evidence of structural breaks in this type of employment function. Similarly, the adjustment speed has fallen from 18% in Ball and St. Cyr's results to 14% in Briscoe and Peel's. Caution is thus needed in assessing the usefulness of this model and it is clear that high explanatory power and strong significance are not sufficient qualities in themselves. Stability is also desirable but is seldom tested for.

An alternative formulation, put forward by Brechling (1965), has a linear, rather than log-linear, production function and adjustment process and also includes the normal hours variable which we argued was theoretically desirable in the previous chapter, plus a quadratic time trend to proxy the effects of overtime premia as well as capital and technical progress. It is difficult to compare the explanatory power of Brechling's results with earlier work as it is not expressed in logs and the dependent variable is the <u>change</u> in employment, which is clearly more difficult to explain than the absolute level. However, Brechling manages to explain 83% of the variation

/in

in employment change for U.K. manufacturing, 1949-63. This seems very high. Coefficients are generally of the right sign and strongly significant with no evidence of autocorrelation. The values of the coefficients are less easily interpretable in a linear formulation and the plausibility of their magnitude is not much considered. However, Brechling does suggest that a ten point rise in the output index would only raise the desired employment index by five points. This implies returns to labour much higher than unity, which is unacceptably high.

Briscoe and Peel estimate a 'Brechling' type of formulation, but including the effects of the normal hours term in the quadratic function of time and with the level of employment as the dependent variable i.e.:-

$$E_t = \alpha_o + \alpha_1 t + \alpha_2 t^2 + \alpha_3 Q_t + (1-\lambda) E_{t-1} \quad \ldots \quad (2.6)$$

The results are reported as (F) in Table 2.1. They too find an implausibily high value of returns-to-labour of 1.5. Consequently the Brechling formulation, whilst yielding high explanatory power, also yields unacceptable estimates.

In summary then, whilst both types of cost-minimizing employment functions seem to explain employment behaviour well both are unsatisfactory empirically. In particular, the Ball and St. Cyr type of function, which is popularly estimated and is used in several macroeconomic forecasting models, has been found to be unstable over time.

/Their

Their use should be undertaken onlywith considerable caution.

2.4 Inter-related adjustment model

In formulating the inter-related adjustment model Nadiri and Rosen (1969) achieve a model which is much more acceptable from a theoretical viewpoint than the earlier studies analysed. The reasons for this are detailed in the previous chapter. However, the greater theoretical plausibility imposes greater demands on its empirical application. Firstly, there are the data problems involved in obtaining conceptually correct measures of the different variables. Secondly, there are the statistical problems of obtaining precise estimates of parameters with a large number of explanatory variables and the likelihood of multicollinearity. Thirdly, the interpretation of these estimates and usefulness in prediction is made much more difficult by the complex nature of the adjustment process.

Nadiri and Rosen estimate their model for U.S. manufacturing, 1947-62. The employment equation óf the model exhibits a high explanatory power of 97% and all explanatory variables are significant at the 5% level except the wage-rental term. However, when the long-run elasticities are calculated, returns to scale of over 1.5 are found. This seems implausibly high.

Briscoe and Peel estimate the Nadiri Rosen model for their U.K. data. The employment equation is of the form:-

/log

$$\log E_t = \alpha_o + \alpha_1 t + \alpha_2 \log Q_t + \alpha_3 \log (w/c)_t + \alpha_4 \log E_{t-1} + \alpha_5 \log H_{t-1} + \alpha_6 \log K_{t-1} + \alpha_7 \log U_{t-1} \quad \ldots\ldots \quad (2.7)$$

The results are reported as (G) in Table 2.1. They also get the expected high explanatory power but only output, lagged employment and the wage-rental are significantly different from zero at the 5% level. A rapid 'own' adjustment speed of 32% per quarter is implied. Two estimates of returns-to-scale can be derived from the estimated parameters of the model and, unlike Nadiri and Rosen, Briscoe and Peel get two very different values from these, i.e. 0.77 and 1.62. As they point out 'clearly we cannot have much confidence in the estimates of production function parameters which are implied by this model'.

2.5 Other models

In progressing through the order of the models set out in the previous chapter, it will be noticed that no empirical works have been reported for the 'Adjustment cost minimizing' models of Solow and Holt *et al.* This is because no empirical analysis of an aggregate nature has been undertaken, to the author's knowledge, using this kind of model. The required 'cost function' data is simply not available in aggregate (or microeconomic) form.

(a) Of the other models discussed in Chapter 1

/Fair's

Fair's (1969) empirical results and their replication by Briscoe and Peel are worth mentioning. Fair uses monthly data in his study and hence the results are not easily compared with those from other studies on a quarterly basis. The use of monthly data enables him to examine the influence of output on employment, via various postulated expectations hypotheses, more precisely. He claims to obtain superior results to the traditional employment functions, with returns to labour of less than unity. However, whether this finding is due to a superior model, use of monthly data or good fortune is not clear. The ad hoc nature of the model makes assessment of its plausibility difficult.

Briscoe and Peel experimented with this type of model and the employment equation which they consider most successful is of the form:-

$$\log E_t = \alpha_o + \alpha_1 \log \tilde{E}_{t-1} + \alpha_2 (\log Q_t - \log Q_{t-1}) + \alpha_3 \log E_{t-1} + \alpha_4 \log UE_t \qquad \ldots (2.8)$$

where $\tilde{E}$ is the measure of excess labour discussed in the previous chapter and UE is the unemployment rate. The latter is meant to indicate the tightness of the labour market. Firms are more likely to hoard excess labour when unemployment is low, because it will be more difficult to hire labour at a later date, when it is needed.[9] The inclusion of log E_{t-1} as an explanatory variable seems to suggest that the difference between actual and desired employment, due to adjustment costs, is allowed for twice.

/The

(9) This applies particularly to skilled labour.

The results are reported as (H) in Table 2.1. Explanatory power is again high and all the coefficients are significantly different from zero, at the 5% level, and of expected sign. The parameter estimates are difficult to interpret given the presence of lagged adjustment and excess labour terms. Briscoe and Peel suggest 'an elimination of undesired labour of about 66% per quarter, ..., whilst the speed of adjustment is separately estimated to be 15% per quarter'.

Empirical work has also been undertaken on models which allow input and output decisions to be made jointly i.e. they recognise the endogeneity of output. Briscoe and Peel formulate several systems of simultaneous equations which incorporate labour demand equations of the type discussed earlier with Cobb-Douglas production functions and hours and capital demand equations. They report four such sets of equations in their study.

Bearing in mind the theoretical limitations, discussed in the previous chapter, in connection with production function estimation, the results are quite reasonable.[10] The production functions themselves are not very successful, with strong evidence of autocorrelation and parameter estimates of implausible magnitudes. However, the employment demand equations are much more acceptable with parameter estimates generally quite sensible. In fact, as Briscoe and Peel point out 'they ...., yield sensible results which

/did

(10) The specifications and results are not reported here as their detailed description can be found in the original article and is not central to the theme of this chapter.

did not vary significantly from those yielded by the single equations'. It would thus appear that the treatment of output as endogenously determined, as theory would demand, makes little difference to the results and so the use of actual output, as if exogenous, may not be a serious error.

In line with the discussion of the previous chapter, it is worth looking briefly at the results of the other studies which had interesting features. Unfortunately, these models or features are not replicated by Briscoe and Peel and so only the original estimates can be reported at this stage. This may well make them appear more favourable than a more consistent comparison would.

(b) Hazeldine (1974) adds a complex adjustment process, based on a cost function similar to that of Holt *et al*, to the expression for desired employment which has been assumed to be linearly dependent on output and a time trend. The resulting equations for employment and output are estimated using quarterly data, 1964-70 for the New Zealand manufacturing sector and for twelve component industries. However, identification of the structural parameters from the estimates is not straightforward as some are not identified and others are overidentified. In particular, the coefficient which measures the effect of an increase in output on desired employment, b, is over-identified. Hazeldine derives a unique estimate for each b by relying on the strongest 'short-run' estimates to obtain it from. He consistently obtains an elasticity of of output with respect to employment of greater than unity

/though

though this is interpreted not as a production parameter but as an indication that New Zealand industry is usually working below full capacity.

In his later study, Hazeldine (1978) adopts a more standard adjustment process, except for inter-relation of employment and hours adjustment, the interest lies in different elasticities for operation of plant below and above 'optimum' capacity. The optimum employment and associated production level is obtained by calculating a time series of output per man hour for an industry, then locating the peaks and interpolating linearly between them.

Estimation is carried out for 14 U.K. manufacturing industries with quarterly seasonally adjusted data for 1964-73. A more familiar employment function, based on a (fixed returns) Cobb-Douglas production function is also estimated for comparison purposes. The explanatory power of the new specification is superior for 11 of the 14 industries but for 6 industries, the imposition of equal elasticities actually raises the $\bar{R}^2$. In seven of the other industries the elasticity of output with respect to employment is higher for under capacity operation than over-capacity, as expected and for 6 of these the over-capacity elasticity is less than one. So, estimates of returns to labour greater than unity in employment function may not be evidence of implausibility but of varying returns and associated cost considerations.

/Before

Before looking at the results obtained by Schott (1978), note can be made of the estimates of technical progress (or increases in capital stock), firstly in Briscoe and Peel's results for the Ball and St. Cyr model which includes a time trend proxy, reported as (E). Unfortunately, Briscoe and Peel do not discuss this aspect of the results and their reported short-run estimates do not enable a very accurate long-run estimate to be obtained. Taking the figures at face value, implies an increase in labour productivity of approximately 0.5% per quarter (2% p.a.). This seems small when this is meant to represent not only technical progress but also increases in capital stock. For the Nadiri-Rosen model, where capital stock appears explicitly, reported as (G), Briscoe and Peel report two estimates of the rate of technical progress. As with the returns to scale parameter, these estimates differ greatly - 1.9% per quarter and 0.1% per quarter. The first estimate would seem very high for pure technical progress whilst the second seems too low.

Schott's inter-related model with the additional technical knowledge equation appears to perform more reliably than Briscoe and Peel's when estimated for the U.K. industrial sector using annual data for the period 1948-70. The model yields <u>three</u> estimates of returns to scale and all three are close to unity and insignificantly different from each other. However, the employment equation itself does not suggest a strong

/relationship

relationship between output and employment with the output term being omitted presumably due to lack of significance. The estimated 'own' adjustment speed for employment is 15% p.a. which seems low. The rate of technical progress is not determined within the model but by imposing values for the success rate, the lags in the effect of research and development expenditure on technical knowledge, and its rate of depreciation. These were obtained from survey data.

(c) Allowing for a postulated change in hoarding behaviour, brought about by government legislation, Knight and Wilson (1974) estimate 'Ball and St Cyr type' employment functions for both employment and man-hours. Their data is for the U.K. Manufacturing Sector 1959 to 1972, with quarterly observations and the overall period split into two sub-periods at 1966. Their results show a considerable increase (in 1966) in the adjustment speed of employment, as expected, from 10% to 35% but no change in the adjustment speed of man hours which is already 34%. In addition, the elasticity of output with respect to employment and man-hours is considered. It is postulated that the former will be biased upwards whether firms hoard labour or use overtime and short-time working, while the latter will be biased upwards by firms hoarding, but not by hours variations. Hence changes or lack of them in the elasticity may indicate changes in firms behaviour. The results seem to support the hypothesis postulated. The elasticity with respect to employment increases slightly /from

from 0.7 to 0.8 and the elasticity with respect to man-hours falls considerably from 1.9 to 0.6. Whether a value of 0.7 for returns to labour can be considered to be biased upwards is debatable.

Finally, Peel and Walker split their quarterly seasonally adjusted observations for the U.K. Manufacturing Sector, 1963 to 1973, into demand and supply constrained regimes according to the sign of the expected change in real wages. They then estimate 'Dhrymes type' employment functions for the two regimes as well as for the overall period, finding a statistically significant difference. As expected, they find a faster adjustment speed when demand is not constrained than when it is, 25% as against 12½% and a more plausible value for returns to scale, 0.8 as against 1.7. The overall period shows even faster adjustment of 28% per quarter and returns to scale of 1.3. The value of estimating a demand equation when supply is the constraining factor is questionable. However, there does seem evidence that a stable employment function is not fully explaining the employment behaviour pattern.

2.6 Conclusions

In this Chapter we have looked at the empirical application of the major types of employment function, both by the original authors and by Briscoe and Peel. The main conclusion is that no model has proved to be consistently superior to the others in terms of explanatory power,

/plausibility

plausibility and stability. All models generally had high explanatory power with major parameters strongly significant and of correct sign. However, plausibility of the estimates in terms of the underlying theoretical production function parameters is less satisfactory. Returns-to-labour or returns to scale substantially greater than unity are frequently obtained and these values can change considerably as the data base is altered.

Of the profit-maximizing models, the Dhrymes function seems to behave better than the Nadiri one. Of the cost-minimising models, the Ball and St. Cyr formulation is easier to use and interpret than the Brechling function, though not necessarily superior. The inter-related adjustment model of Nadiri and Rosen, whilst superior from a theoretical viewpoint is much more difficult to apply and interpret and the results do not seem to be a general improvement. Finally, the extra complication of a simultaneous system does not seem to give the reward of better estimates, but provides some reassurance for the use of single equations with actual output assumed exogenous.

TABLE 2.1 ESTIMATION OF EMPLOYMENT FUNCTIONS FOR THE U.K. MANUFACTURING SECTOR, 1955-72

Dependent Variable	Constant	Log Q_t	Log EH_{t-1}	Log E_{t-1}	Log KU_t	t	t^2	Log $(W/P)_t$	Log $(w/c)_t$	$\bar{R}^2$	DW h	Adjust-ment Speed $\hat{\lambda}$	Returns to Labour $\hat{\alpha}$
(A) LogEH_t	3.219 (4.6)	0.269 (6.1)	0.622 (11.0)					-0.258 (6.6)		0.938	1.89 0.55	0.388	11.82
(B) LogE_t	0.650 (2.1)	0.169 (6.3)		0.831 (20.3)				-0.136 (6.7)		0.930	1.93 0.30	0.169	1.00
(C) LogEH_t	2.837 (3.4)		0.987 (15.7)		-0.014 (1.4)				0.015 (0.7)	0.896	1.83 0.88	0.013	-
(D) LogE_t	1.269 (2.7)			0.787 (13.3)	0.097 (4.6)	-0.001 (5.1)			-0.003 (0.2)	0.915	1.61 1.93	0.213	-
(E) LogE_t	0.418 (1.4)	0.188 (6.2)		0.860 (22.0)		-0.001 (6.6)				0.933	2.03 -0.14	0.140	0.75
(F) E_t †	3353.5 (2.0)	13.953 (6.5)		0.701 (10.6)		-9.780 (3.2)	0.092 (4.1)			0.935	2.08 -0.40	0.299	1.53
	Constant	Log Q_t	Log E_{t-1}	t	Log $(w/c)_t$	Log H_{t-1}	Log K_{t-1}	Log U_{t-1}		$\bar{R}^2$	DW h	$\hat{\lambda}$	
(G) LogE_t	1.249 (1.6)	0.180 (4.1)	0.679 (10.1)	-0.002 (0.8)	-0.031 (2.3)	0.102 (1.1)	0.037 (0.2)	0.062 (1.7)		0.937	1.99 0.07	0.321	-
	Constant	ΔLog Q_t	Log E_{t-1}	Log $\tilde{E}_{t-1}$	Log UE_t					$\bar{R}^2$	DW h	$\hat{\lambda}$	
(H) LogE_t	1.277 (3.2)	0.219 (4.3)	0.851 (20.1)	-0.100 (4.3)	-0.015 (7.7)					0.935	1.89 0.49	0.149	

t - values in brackets. h is the Durbin (1970) value. † All variables arithmetic.

Source: Briscoe and Peel (1975)

3. Empirical Application to the Engineering Industries

3.1 Introduction

The previous chapter illustrated that no single type of employment function is generally superior to the others or completely satisfactory. A function which appears 'best' in explaining employment at a certain level of aggregation for a particular time period in one country may well not be superior in different circumstances. This is to be expected in that all the employment functions are gross simplifications of the actual determination of employment. Each function captures some elements of the process but neglects others through the need to keep the model tractable. If the neglected factors are unimportant or do not change greatly for the data under consideration then the function should work well, but if these factors do change then the function is likely to yield implausible estimates. As different functions include and neglect different factors, then it is clear that relative performance will vary according to the underlying circumstances.

This suggests that, on approaching the explanation of employment in a particular situation, we must be prepared to use several different models and to modify them as required to produce a satisfactory explanation for that situation, in terms of explanatory power, plausibility and stability. The author's work for the Manpower Planning Unit involved explaining the level of employment in sectors of the U.K. engineering industry and /

and this chapter shows how the various models are applied and modified in an attempt to provide a good explanation. In a sense, the task is more demanding than that of Briscoe and Peel (1975) in that three distinct sets of data were used in this study - the S.I.C. Orders VI mechanical and electrical engineering, VIII vehicles and IX metal goods n.e.s. for the years 1959-71 - rather than just one. Any function or modification must satisfy all these sets of data for general acceptability though we must recognise that different employment behaviour in the various sectors of engineering is possible.

The sources, derivations and limitations of the data series are discussed fully in the data appendix.

3.2 The U.K. engineering industry

However, before turning to the empirical investigation of the various employment models, it is worth looking at the industrial pattern in the three SIC's, so that any similarities or differences can be noted and a general impression of what is to be explained can be obtained. For this reason the patterns of employment and output are emphasised, since it is the relationship between these two which is felt to be crucial. A more thorough description of the engineering industry can be found in Wabe (1977).

Figures 3.1, 3.2 and 3.3 show the paths of output and employment for SIC's 6, 8 and 9 respectively, between 1959 and 1971. Both series are in index form with 1958 average being the base for output and 1959 iii) as the base for employment. The output series is a four-quarter moving/

moving average of the original data since the latter shows a strong seasonal pattern, which is better removed for graphical purposes. In the empirical investigation, seasonality is dealt with by the inclusion of seasonal dummies (not reported for convenience of presentation). This is in contrast to the results reported in the previous chapter where Briscoe and Peel use seasonally-adjusted output data. The use of dummies is considered to be preferable since seasonal adjustment procedures can introduce spurious patterns in the data.[1]

For SIC 6, output has risen steeply, by approximately 4.4% per annum on average. Output has not fallen during the period but a cyclical pattern can be detected with slow or zero growth in 1962 and 1967. The level of employment has also grown over the period but less steeply or uniformly than output, with employment of 1,976 thousand at the end of 1959 and an overall average increase of 1.2% p.a. Considerable increases in labour productivity are found, with an average value of 3.2% p.a. Falls in employment appear to correspond roughly to recessions in the output cycle, with a large fall in 1971 indicating that an output recession in 1971/2 has been 'lost' by the moving average procedure.

For SIC 8, output has risen much less quickly, by an average of 2.2% p.a. A cyclical pattern is quite pronounced with the output level falling in recessions which occur around 1961, 1967 and 1970. Employment has /

(1) See Wallis (1974) for discussion of this problem.

has fallen over the period, from a base of 880 thousand employees, by almost 1% p.a. on average. The fall has generally been steep when output is falling and employment has increased when output is rising strongly, but fluctuations have been much less marked than with output. Overall increases in productivity of 3.1% p.a. are indicated.

For SIC 9, output again has a marked cyclical pattern, with recessions around 1962, 1967 and 1971 and a slower average growth rate of 1.2% p.a. Employment has grown slightly on average over the period by 0.5% p.a. from a base of 528 thousand, though periods of recession seem to have been matched by smaller falls in employment. Productivity has increased on average by only 0.8% p.a. over the period.

As can be seen, the industrial patterns of the three SIC's show sufficient differences both in output and employment to set a demanding task for any one employment model to explain employment well in all these SIC's. However, there do seem to be some similarities in the way that employment 'responds' to the cyclical path of output, but does so in a less pronounced manner.

Briefly, the paths of some of the other variables, which appear in the employment models to be tested, can be considered. Normal hours of work have fallen from a level of 43.8 hours to 40 hours over the period, a fall of 8.7% overall, though the fall comes in several discrete steps with periods of stability. Average weekly hours of work /

work seem to have more of a cyclical pattern with an average fall of 0.7% p.a. i.e. of the same magnitude overall as the fall in normal hours. Weekly wages have risen strongly over the period and fairly evenly for the three SIC's, by 5.9%, 6.4% and 6.1% p.a. respectively, on average. Taking into account the fall in average hours, this implies an average rise in hourly earnings, w, of 6.5%, 7.2% and 6.8% p.a. respectively.

Wholesale prices for engineering products as a whole have also risen fairly steadily but not as fast as earnings, by an average of 3.1% p.a., so that the wage-price ratio has risen by an average of 3.5%, 4.1% and 3.7% p.a. respectively for the three SIC's. Similarly, the 'price of capital' variable has risen steadily over the period, by an average of 3.5% p.a. i.e. much less than wages but more than the wholesale price. Thus the wage-rental ratio has risen by an average of 3.0%, 3.6% and 3.2% p.a. respectively.

The capital stock series for the three SIC's all show a very steady upward trend with average increases of 3.3%, 3.1% and 3.1% respectively.

Data on the extent of unemployment and vacancies is relevant to the latter part of this chapter and more so to the later chapters. Both series show considerable variation for all three SIC's but the dominant pattern is for unemployment to be increasing strongly over the period particularly into the 1970's. The number of vacancies is less trended but appears to be falling into the 1970's. Comparing the end of 1971 with the end of 1959 /

1959 indicates a roughly fourfold increase in unemployment and a halving of the number of vacancies.

3.3 Profit-maximising models

(a) The first type of model used was based on that put forward by Dhrymes (1969). However, the formulation was simpler than that actually used by Dhrymes and more akin to the functional forms used by Briscoe and Peel, specified as (2.1) and (2.2) in the previous chapter. In this work we postulate that the desired level of man-hours is determined by output and the real wage but postulate further that the choice between desired employment and desired hours per man is made on a cost minimizing basis. We expect the cost-minimizing level of hours to be closely related to the level of normal hours, as argued in Chapter 1. Thus desired employment is determined by output, real wage and normal hours. Incorporating a Koyck adjustment process of actual to desired employment we obtain the function:-[2]

$$\log E_t = \alpha_0 + \alpha_1 \log Q_t + \alpha_2 \log (w/p)_t + \alpha_3 \log H_{ot} + (1-\lambda) \log E_{t-1} + u_t \quad \ldots (3.1)$$

The results of estimating this function for SIC's 6, 8 and 9 are reported as (A) in Tables 3.1, 3.2 and 3.3 respectively. /

(2) α_2 is interpreted as $-\lambda\sigma$, where σ is the elasticity of substitution, and α_1 as $\lambda\{\sigma(1-1/\nu) + 1/\nu\}$, where ν is the returns to scale parameter.

respectively. Explanatory power is generally high with all explanatory variables of correct sign and significant at the 5% level, except for normal hours in SIC's 8 and 9. However, the values of the DW statistic will be biased towards two, due to the presence of a lagged dependent variable. Durbin (1970) suggests an alternative 'h-test' and these values, to be tested as standard normal deviates are also reported in the Tables. These values indicate the presence of positive autocorrelation for SIC's 6 and 8, which implies that the estimates will be biased and inconsistent. Such evidence of autocorrelation is likely to result from a mis-specification of the model i.e. omitted variables, incorrect functional form or mismeasurement. Re-specification, particularly of the Ball and St.Cyr model, has been attempted and is reported later in this chapter and Chapter 4. Here, it will in general be treated as evidence against a particular model, rather than something to be removed mechanically by using Cochrane-Orcutt or Hildreth-Lu techniques.

Taking the estimates at face-value, adjustment speeds of 13%, 15% and 4% per quarter are implied and these values, especially the latter, seem very low. The returns to scale parameter estimates are derived to be 1.24, 5.11 and -0.40 respectively. Whilst the first value is perhaps plausible, the other two are clearly not. Elasticities of substitution are derived to be 1.79, 0.39 and 1.38 respectively. Values around 0.5 are typically obtained in time series production function studies.

(b) /

(b) The other profit-maximizing model used was the Nadiri (1968) formulation. Again the function is modified to allow for the choice between employment and hours per man so that desired employment is determined by capital utilization, the wage-rental ratio and normal hours. Utilization is measured by a 'Wharton School' capacity utilization index. The conceptual and practical problems involved in measuring capital utilization and rental costs are considerable[3]. These difficulties are likely to weaken the validity of any empirical work on this model.

However, estimation was carried out and is reported as (B) in Tables 3.1, 3.2 and 3.3, using the following specification

$$\log E_t = \alpha_o + \alpha_1 \log (KU)_t + \alpha_2 \log (w/c)_t + a_3 \operatorname{Log} H_{ot} + (1-\lambda) \log E_{t-1} + u_t \quad \ldots \quad (3.2)$$

This formulation provides inferior explanatory power for SIC's 6 and 8 but a marginally better fit for SIC 9. The capital utilization term is barely significant at the 5% level for SIC's 6 and 8. Adjustment speeds are little changed for SIC's 6 and 8 but more than doubled for SIC 9 to a more acceptable, but still low, value of 9% per quarter. Returns to labour parameters are not easily derived, as there is no output terms in the specification.

Evidence /

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(3) See data appendix.

Evidence of positively autocorrelated errors is much stronger for SIC's 6 and 8 and this leads us to judge the Nadiri formulation as inferior to the Dhrymes' one for these two industries. For SIC 9 there is little to choose between the two models.

A time trend can be added to the formulation of either of these two models to proxy the effects of technical progress on employment, not captured by the wage-price or wage-rental terms. However, as these latter terms have had a strong trend over the sixties, there is high multicollinearity between them and a time trend. Consequently, the inclusion of a time trend does not add significantly to explanatory power and often leads to insignificance of the wage terms. On balance, it was felt preferable to allow the wage terms to capture both the 'price-substitution' effect and the technical progress effect.

Overall, the Dhrymes model seemed preferable to the Nadiri one though not completely satisfactory. Its usefulness will depend to some extent on the relative success of the other models to which we now turn.

3.4 <u>Cost-minimizing models</u>

(a) The basic model used to test this type of formulation was the popular Ball and St. Cyr (1966) employment function, which has been described in earlier chapters and is expressed in estimatable form as:

$$\log E_t = A' + \frac{\lambda}{\alpha} \log Q_t - \frac{\lambda\gamma}{\alpha} t + (1-\lambda) \log E_{t-1} + u_t \quad \ldots.(3.3)$$

where /

where λ is the speed of adjustment and a is the elasticity of output with respect to employment. The results of estimating (3.3) for the three SIC's are reported as (C) in Tables 3.1, 3.2 and 3.3. The explanatory power of this formulation is lower than the Dhrymes model for all SIC's but only marginally so for SIC's 8 and 9. Nevertheless, the explanatory power is very high and the coefficient estimates are all significant with the expected signs, though again there is evidence of positive autocorrelation in the estimates for SIC's 6 and 8.

The speed of adjustment is not greatly changed for SIC's 8 and 9 - 18.5% and 5% per quarter - but for SIC 6 it is greatly reduced from a plausible but low value of 13% to an implausibly low value of 1.8% per quarter.

Returns to labour values are derived to be 0.10, 2.23 and 0.52 respectively. These values bear little relation to the a priori expectation of values in the region of 0.70, nor to the returns to scale values obtained using the Dhrymes model, nor indeed to Ball and St.Cyr's estimates for the period 1955 to 1964, where the corresponding returns to labour values are 1.44, 1.27 and 1.49.

The coefficient on the time trend can be used to derive a long-run estimate of the effect of technical progress, and increases in capital stock, where capital does not appear separately, on production. The estimates obtained for the three SIC's imply technical progress of 1.3%, 1.2% and 0.5% per quarter. These values are higher than the figures for average labour productivity, described in /

in Section 3.2.

Consequently, in its present form, the model is clearly unsatisfactory in its explanation of employment behaviour, particularly of SIC 6. Several modifications were tried in an attempt to improve the estimation performance of the Ball and St. Cyr employment function. These were applied to all three SIC's.

(b) Firstly, the normal hours variable is included, in accord with the rationale in the first chapter. The specification then becomes:

$$\log E_t = A' + \frac{\lambda}{\alpha} \log Q_t - \frac{\lambda\gamma}{\alpha} t - \lambda\beta \log H_{ot} + (1-\lambda)\log E_{t-1} + u_t \qquad \text{..... (3.4)}$$

The results of estimating this expression are reported as (D) in Tables 3.1, 3.2 and 3.3. It can be seen that normal hours adds nothing in terms of explanatory power, as the coefficient is not significantly different from zero at the 5% level for any SIC, nor is autocorrelation removed. In SIC's 8 and 9 it takes the opposite sign to our expectations. Its only beneficial feature is to give SIC 6 higher, but still implausibly low, values of adjustment speed and returns-to-labour, i.e. 6.6% and 0.35 respectively.

The lack of significance of the normal hours term is felt to be due more to the lack of variation of normal hours during the sixties [4] than to lack of relevance to employment levels, and so this variable is retained whilst further /

(4) See data appendix.

further modifications are made to the function.

(c) A further restrictive feature of the Ball and St. Cyr model, which we can attempt to relax, is the use of a time trend to proxy the effects of capital on employment. We can can explicitly include capital in the Cobb-Douglas production function, i.e.:

$$Q_t = Ae^{\gamma t} L_t^{\alpha} K_t^{\delta} \qquad \ldots\ldots (3.5)$$

where the exponential time trend now proxies the effect of technical progress only. Then, assuming output and the level of capital stock, K, are exogeneous to the labour input decision, desired labour input, L^*, is determined by inverting (3.5). Incorporating our hypothesis of the firm's desired choice between men and hours on a cost-minimizing basis, we obtain:

$$E_t^* = \frac{L_t^*}{H_t^*} = Be^{(-\gamma/\alpha)t} Q_t^{1/\alpha} H_{ot}^{\beta} K_t^{-\delta/\alpha} \qquad \ldots\ldots (3.6)$$

and, allowing for a Koyck lagged adjustment process of actual employment to its desired level, we get an estimatable expression of the form:

$$\log E_t = A' + \frac{\lambda}{\alpha} \log Q_t - \frac{\lambda\gamma}{\alpha} t - \lambda\beta \log H_{ot} - \frac{\lambda\delta}{\alpha} \log K_t + (1-\lambda) \log E_{t-1} + u_t \quad \ldots (3.7)$$

The /

The results obtained in estimating this function for the three SIC's are reported as (E) in Tables 3.1, 3.2 and 3.3. It can be seen that explanatory power is generally improved by the addition of the capital term, particularly for SIC 8. Also evidence of autocorrelation is reduced in all three SIC's, but is still present for SIC's 6 and 8, on the Durbin test, at the 5% significance level. However, whilst the capital stock term is significant for all three SIC's, it has a positive coefficient for SIC 9. This is contrary to our theoretical expectations. The likely reason for this is the strong multicollinearity between capital stock and the time trend. In this formulation the time trend is intended to represent the effect of technical progress alone and so we would expect it to be negative but of smaller magnitude than in the earlier formulation, reported as results (D). In fact the time trend is positive for SIC's 6 and 8, significantly so as the 5% level for SIC 8, and is negative but of greater magnitude than in (D) for SIC 9, implying disembodied progress of 3.6% per quarter. In all SIC's the standard error of the trend estimate is greatly increased and the overall conclusion is that the multicollinearity between capital stock and the time trend has made it very difficult, if not impossible, to separate the effects of technical progress and capital.

However, if the effects of capital and technical progress are captured jointly, if not distinctly picked up by the time trend and capital stock variables, then it /

it may be that the coefficients of the other variables will be correctly measured, particularly with the reduction in evidence of autocorrelation. In fact, if we look at the adjustment speeds and returns to labour we find that they are not greatly improved - adjustments per quarter of 2.4%, 14.6% and 8.3% respectively and returns to labour of 0.15, 2.21 and 0.78 respectively. Of these, only the results for SIC 9 could be said to be more plausible, and the adjustment speed in this case is still very low.(5)

(d) It can be argued that the capital input relevant to the production function specified as (3.5) is not the level of capital stock but the level of capital services used. This can be defined as the total capital stock multiplied by the rate of utilization, U, of the capital. However, it is much more tenuous to assume that the input of capital services is exogenous to the employment decision than it is to assume capital stock exogenous. A simultaneous determination of labour and capital utilization would seem more appropriate. Nevertheless, attempts were first made to allow for variations in the utilization of capital within the Ball and St. Cyr type of model by redefining the capital term in equation (3.7) as capital services.

Unfortunately, /

(5) It is difficult to assess the plausibility of adjustment speeds, as our theory gives no a priori guidance. However, a speed of less than 10% per quarter would seem to imply a very slow adjustment - less than 57% of initial desired adjustment achieved after 2 years.

Unfortunately, a major empirical difficulty exists in the measurement of (capital) utilization. Direct information on the extent of usage of capital equipment is not readily available and so indirect or proxy measures are required. The most satisfactory measure, in the sense of being calculated independently of labour usage or output capacity considerations, developed by Heathfield (1972), is obtained by relating capital usage to fuel consumption and using data on the latter. However, such data was not available quarterly at the SIC Order level for the earlier years of our estimation period.

Alternative measures can be calculated. The first of these assumes that capital utilization is proportional to capacity utilization, i.e. the ratio of actual output to potential output. Potential output is derived by the "Wharton School" method of interpolation between peaks of actual output. The resulting utilization index is clearly strongly related to output and depends on labour usage as well as capital.

Another possibility, appropriate to an industry where capital plant has definite manning requirements, is to assume capital utilization directly related to labour usage. The latter is measured by industry hours of work. If there is labour hoarding in the industry then some account should probably be taken of the intensity or efficiency with which the hours are actually worked. This can be done by constructing an index of productivity (output per man-hour) relative to peak productivity, again /

again along the "Wharton School" lines. The resulting utilization index is dependent on labour usage and output but may be useful, particularly in the vehicles industry, where the type of production method closely connects labour hours of work per man and capital equipment usage.

In empirical estimation, neither measure of capital utilization provided any improvement in explanatory power or plausibility for SIC's 6 and 9 but the second measure did prove helpful to the explanation of employment in SIC 8, the vehicles industry. The results of this estimation are reported as (E´) in Table 3.2. Explanatory power is increased and both the capital utilization term and the time trend are significantly negative at the 5% level. The adjustment speed is increased to 30% per quarter, the returns to labour parameter takes an eminently more plausible value of 1.07, and the technical progress parameter takes a very low value of 0.14% per quarter. However, the DW statistic is lowered by the new measure so that, on the Durbin test, positive autocorrelation is more in evidence. This is likely to be due to the endogenous method of calculating the utilization measure. Nevertheless there are indications that this type of measure has a part to play in the explanation of employment, particularly in industries with specific capital manning requirements. A more independent measure of capital utilization is desirable before the effects of variations in capital usage on employment can be captured.

(e) /

Finally, within the Ball and St. Cyr employment function context, an attempt can be made to relax the rigid assumption that desired employment is dictated by actual current output. The theory developed in the first chapter suggested that it is desired output rather than actual output which determines desired employment. Desired output is more likely to be related to future output levels than to current output, which is the implicit assumption that Ball and St. Cyr make. However, to use future output levels to explain present employment would be unsatisfactory from simultaneity and forecasting points of view. The alternative, adopted by several authors, including Dhrymes and Coen and Hickman (1970), is to hypothesize that firms form their expectations (or desires) about future output by recent experience of the path of output. A particularly simple form of this hypothesis, frequently used, is that desired output is dependent on current and last period's output levels only, i.e.:

$$Q^*_t = Q_t^{\mu_1} Q_{t-1}^{\mu_2} \qquad \ldots\ldots\ (3.8)$$

If μ_1 and μ_2 are postulated to be constant over time, as is normally the case, then we would expect their values to be positive, so that the higher recent actual output is, the higher desired output is. Also we would expect their sum to be close to unity, since a value for their sum significantly greater (less) than unity would imply either rapid /

rapid growth (decline) of demand or expected output continually overestimated (underestimated) by a wide margin. Combining (3.8) with the Ball and St. Cyr framework of (3.7), we obtain

$$\log E_t = A' + \frac{\lambda\mu}{\alpha}1 \log Q_t + \frac{\lambda\mu}{\alpha}2 \log Q_{t-1} - \frac{\lambda\gamma}{\alpha}t - \lambda\beta \log H_{ot}$$

$$- \frac{\lambda\delta}{\alpha} \log K_t + (1-\lambda) \log E_{t-1} + u_t \quad .... \quad (3.9)$$

This was the formulation adopted and it is reported as results (F) in Tables 3.1, 3.2 and 3.3. The capital variable allows for utilization, measured by the 'productivity' measure. As can be seen by comparison with results (E), the modification offers no improvement in explanatory power and does not affect the parameter estimates greatly. In no SIC is the lagged output term significant at the 5% level and for SIC 6 it takes an unexpected negative sign. The conclusion seems to be that a simple expectational hypothesis like (3.8) is unlikely to be an improvement on the use of current output alone. This does not mean that a more sophisticated specification of expectations might not provide improvement, but initial experimentation with the use of the Almon (1965) lag technique did not yield evidence of any such improvement. An alternative method of measuring desired output is preferred and this is developed in the next chapter.

Thus, despite the appeal of the Ball and St. Cyr type /

type of employment function, no formulation could be found which could satisfactorily explain employment in the three sectors of engineering. Explanatory power was high but the derived estimates of the production relationship parameters were generally implausible.

Furthermore, associated exercises by Briscoe and Roberts (1977) and Evans and Roberts (1975) cast further doubt on the validity of this type of model. Briscoe and Roberts apply the Ball and St. Cyr model to all the SIC Orders which make up the production sector of the U.K. economy, for the years 1954-73. They then proceed to examine the stability of the model by estimating for various sub-periods and using a variety of tests based on covariance analysis[6] to determine the existence and location of structural breaks. The conclusion is that almost all industries had at least one significant change in their employment behaviour, as modelled by the Ball and St. Cyr function. Several industries had two or three such changes. Many of these changes were gradual but some were located at specific dates which were potentially explicable, e.g. construction suffered a structural change early in 1963, presumably associated with the bad winter which caused many firms to be liquidated. Many changes seemed to occur in 1966/7 and in 1971.

When looking at individual coefficients to see what exactly was altering in the model, Briscoe and Roberts found /

(6) See Chow (1960).

found a tendency for the earlier speeds of adjustment and returns to labour to be higher than the later ones, but this pattern was by no means universal. Both earlier and later periods yielded higher figures than the overall estimates. This latter finding is a curious one which is not easily explained.

The existence of such structural changes implies inadequacies in the Ball and St. Cyr model, in coping with actual employment behaviour. If such changes cannot be predicted and allowed for, then the use of the model for forecasting and policy assessment purposes seems limited. However, whether the scale of structural changes is sufficient to cause forecasts to be grossly inaccurate or not,is more an empirical than a theoretical question.

Evans and Roberts attempt to find out how well the Ball and St. Cyr model, and the Dhrymes model, actually do forecast. Their findings, based on estimation for the engineering SIC's, 1959 to 1971, indicate that both models forecast levels of employment,over the period 1972 to 1976, which have a consistent downward bias. This bias is present even over the shorter period of 1972-3 and with 'optimistic' projections of the growth of output and/or lack of growth in the wage-rental ratio. The bias did not seem to be due simply to the iterative nature of the forecasting procedure occasioned by the presence of the lagged dependent variable - simulation over the sample period produced reasonably accurate 'forecasts' for 1971.

These features of instability and forecasting bias belie the frequent use of such functions in macro-economic forecasting /

forecasting models, e.g. the Treasure model.[7]

3.5 Inter-related adjustment model

The next step taken in attempting to satisfactorily explain employment behaviour was to recognise that decisions on employment are necessarily closely related to decisions on hours of work, level of capital stock and its rate of utilization. The Ball and St. Cyr model tends to treat these factors in an inadequate manner. On the other hand, the work of Nadiri and Rosen (1969) goes a long way to incorporating these features and it is to this type of formulation that we now turn.

Nadiri and Rosen's model consists of four equations which determine the levels of inputs of employment, hours, capital and utilization respectively in terms of current output, the wage-rental ratio and lagged values of all inputs. Hence, the employment equation can be written as:

$$\log E_t = \beta_0 + \beta_1 \log Q_t + \beta_2 \log (w/c) + \beta_3 \log E_{t-1} + \beta_4 \log H_{t-1} + \beta_5 \log K_{t-1} + \beta_6 \log U_{t-1} + u_t \quad ..(3.$$

where U is the utilization index, measured as a "Wharton School" capacity index in agreement with the original Nadiri and Rosen formulation.

The estimation of this equation, which was carried out along with corresponding estimation of the other input /

(7) See McLean (1974)

input demand equations, is reported for the three SIC's as (G) in Tables 3.4, 3.5 and 3.6. The explanatory power of these results is generally higher than previous formulations and evidence of autocorrelation is greatly reduced, as indicated by the h values. However, as there is a larger number of explanatory variables, evidence of multicollinearity is much more prevalent and individual coefficients tend to have higher standard errors and hence lower significance(8). Returns to scale estimates can be derived by solving the complex interrelated adjustment process but this depends on all coefficients of the lagged variables, some of which have very low significance. The confidence interval of the resulting parameter values is exceedingly difficult to obtain but the values obtained for returns to scale in the three SIC's, 6.97 and 3.88 and 4.69 respectively, are totally implausible.(9) Furthermore, a negative (but insignificant) adjustment speed of 2.8% is found for employment in SIC 6 - another unacceptable result.

The /

(8) A time trend is not included to proxy technical progress due to the difficulty of isolating this effect. Other variables with a strong trend, particularly capital stock, are likely to pick-up this effect.

(9) In fact, as pointed out in Chapter 2, two values for returns to scale can be derived for each SIC. The derived estimates were not close to each other and the values reported are those obtained mainly from the employment equations.

The conclusion seems to be that, while the Nadiri-Rosen model is theoretically an improvement on earlier models, its use of additional explanatory variables leaves more room for data measurement errors, particularly in the measurement of utilization, and leads to less precision in the estimates due to multicollinearity. The empirical results are by no means an improvement on simpler models.

3.6 Other models and modifications

a) The model put forward by Fair (1969) attempts to allow expected output rather than actual output to influence employment. It also allows a measure of hoarded labour to have a direct effect on employment behaviour rather than the extent of hoarding being implicitly allowed for.

The model is postulated in difference form with the change in employment from one quarter to the next dependent on expected output changes, the extent of 'excess' labour and a time trend to proxy technical progress. Expected output changes are postulated to be captured by the immediate past change, the current change and two future changes in output. Excess labour, $\tilde{E}$, is the difference between actual and desired employment in the previous quarter, where desired employment is measured as the number of employees who, when working normal hours at peak productivity, could have produced the output which was actually achieved, i.e.:-

$$E^*_{t-1} = E_{t-1} \; H^p_{t-1} \; / \; H_{ot-1} \qquad \text{........ (3.11)}$$

A /

A series for H^p is derived by interpolating between peaks of a series of output per man-hour.
Thus, the equation estimated took the following form:-

$$\Delta \log E_t = \gamma_o + \gamma_1 \ \Delta \log Q_{t-1} + \gamma_2 \ \Delta \log Q_t + \gamma_3 \Delta \log Q_{t+1} + \gamma_4 \Delta \log Q_{t+2} + \gamma_5 \Delta \log \tilde{E}_{t-1} + \gamma_6 t + u_t \quad \ldots (3.12)$$

where ΔX_t denotes the difference between X at time t and X at time (t-1).

The results are reported for the three SIC's as (H) in Tables 3.4, 3.5 and 3.6. They are not easily compared with the other results since the dependent variable is in difference form and the equation is not derived from a neoclassical production function. When the final Ball and St. Cyr equation (3.9) was estimated in difference form (not reported), the Fair model was found to be inferior in explanatory power for SIC 6 (56% against 65%), considerably so for SIC 8 (30% against 65%), but marginally superior for SIC 9 (75% against 72%). For all SIC's current output change appears most important of the output terms, but the immediate future change also plays a significant part for SIC 6, the past change for SIC 8 and both future changes for SIC 9. Estimates of γ_5 indicate removal of excess labour of 14.4%, 7.1% and 12.7% per quarter respectively. The relative magnitudes seem to be a reversal of the adjustment speeds derived from the Ball and St. Cyr model and are much lower than the estimate of about 66% found /

found by Briscoe and Peel.

It is difficult to judge the plausibility of the results beyond the above comments since the model is rather ad hoc in construction. The method of calculating excess labour involves some restrictive assumptions e.g. that peak output per man hour indicates a work-intensity that could be achieved over a longer period and that normal hours of work would minimize firms' labour costs. The inferiority of explanatory power indicates that the model is not an improvement on earlier models.

b) Models of the type formulated by Hazeldine (1974) and (1978) were not estimated. As with the Fair model, the estimates do not enable production relationship parameters to be identified and certain key variables, in this case optimum plant output and employment, have to be endogenously determined by the location of peaks in output per man rather than being measured independently.

The model formulated by Schott (1978) does go to considerable length to independently measure key variables such as the stock of technical knowledge and its user-cost, involving extensive survey work. However, in view of the lack of success of the underlying Nadiri-Rosen model, the difficulty of obtaining the relevant data and doubts as to the viability of the model at the SIC level, this type of model has not been pursued here.

c) <u>the Adjustment Process</u>

The final modification made to the traditional type of employment function, before more fundamental changes are considered in the next two chapters, was to try to relax the /

the rigidity of the adjustment process. The rationale and method for this would apply equally to all the employment models considered in this chapter. For simplicity, these modifications are applied to the basic Ball and St. Cyr model only in the empirical work reported here.

The adjustment process generally used assumes that firms will adjust employment so that a proportion of the difference between desired employment and actual employment in the previous period is removed each quarter. This is restrictive in two respects. The adjustment is estimated as a constant proportion, allowing no variation with changed circumstances. In addition the adjustment is forced to take a geometrically declining path which makes another strong assumption about firms' behaviour. However, the adjustment process can be relaxed in respect of these two restrictions.

i) Firstly, the constancy of the proportion of adjustment of actual employment towards its desired level within a period is based on the costs (and difficulties) involved in hiring and firing, overtime and short-time, etc. These relative costs are unlikely to remain constant and, for example, are likely to differ according to whether desired employment is above the present level (requiring expansion) or below (requiring contraction). In other words, hiring costs may differ considerably from firing costs. Data on costs is not available to allow explicitly for this difference but it is possible to postulate a different adjustment /

adjustment speed for hiring than for firing. As the speed of adjustment affects all the coefficients in the estimation equation, this is achieved by splitting observations into expansion or contraction 'regimes' and estimating them separately. Other reasons for changes in the adjustment speed can be considered. The same method is involved but the split into regimes will obviously differ.

The simplest form of change follows the work of Knight and Wilson (1974) in postulating a once-and-for-all change in employment behaviour in 1966. The demand-orientated rationale for this change, put forward by Taylor (1972) and others, is that a 'shake-out' of surplus labour occurred due to the introduction of S.E.T. and redundancy payments and the non-occurrence of an expected boom. The supply-orientated rationale, put forward by Gujarati (1972) and others, is that voluntary redundancies increased because of the higher benefits introduced, reducing the cost of being unemployed. In either case we should expect the speed of adjustment to increase after 1966 as there will be less labour hoarded in a recession and more opportunity for firms to recruit the required labour in a boom.

The Ball and St. Cyr model was estimated for the three SIC's, separating observations into pre-1966 and post-1966. A Chow test can then be applied to see if separate estimation of the two 'regimes' provides a significant improvement in explanatory power over the 'overall' estimation. The F-values of this test for the three SIC's are 1.17, 1.63 and /

and 1.27 compared with the 5% critical value of 2.29 with (7,35) degrees of freedom. In other words, at the 5% significance level there is no evidence of any change in the speed of adjustment (or the other parameters) occurring in 1966. Consideration of the differences between actual estimation results then becomes irrelevant and so the estimates are not reported here.

In contrast, Knight and Wilson do find evidence of a structural break in 1966 for the U.K. Manufacturing Sector. Furthermore, the study by Briscoe and Roberts, estimating the Ball and St. Cyr model for 1955-73 using seasonally adjusted output, finds statistical evidence of such a break in 1966 for mechanical and electrical engineering. It is interesting to note that, in the latter study, the returns to labour estimates are not very different for the two sub-periods, 1.19 and 1.14 respectively, but returns to labour for the overall estimation period takes the implausibly low value of 0.29. Similarly, the speed of adjustment is 21% and 30% in the sub-periods but 4% overall. This is a strange finding and is more likely to have a statistical than an economic answer. The divergence between these findings and the present results, due to modifications in data and the estimation period, leaves room for doubt about the stability of the model in general.

The other two criteria used to separate regimes were based on the differences in costs between expansion and contraction. The most straightforward way of achieving the separation is according to the sign of employment change /.

change. However, because employment is the dependent variable, there are statistical reasons why its use in deciding the regimes will lead to biased estimates and why an independent measure is preferable. Accordingly, a "Wharton School" measure of capacity utilization was first used. Periods of increasing utilization of resources are treated as upswings or expansionary phases whilst periods of decreasing utilization are taken as contraction phases. Hiring and firing will not exactly correspond to the production pattern but may be sufficiently in line to yield a useful means of determining regimes independently of the dependent variable.

The separate regimes were estimated[10] and the Chow test was again applied. No statistical difference in the relationship between upswings and downswings was found for SIC's 8 and 9 and, for SIC 6, the difference was barely significant at the 5% level. The estimated speed of adjustment for SIC 6 is faster in a downswing than in an upswing - 9% and 4% respectively - but neither value is significantly different from zero at the 5% level. The returns to labour estimates of 0.59 and 0.42 are much more plausible than the overall estimate of 0.10 but are still somewhat low and confidence in these values is severely restricted by a lack of strong significance.

One likely reason for a lack of significance in the results is that upswings and downswings do not sufficiently correspond /

(10) Not reported.

correspond to hiring and firing. This will particularly be true when there is substantial labour hoarding in an industry. Thus despite the strong risk of biased estimation it was decided to try the use of direct measures of employment change to determine the regimes. The results should be treated with great caution.

Chow tests on these regimes indicate strong evidence of structural difference, but a considerable reduction in residuals would be expected from estimating positive changes in the dependent variable separately from negative ones. The estimation results are reported as (I) and (J) in Tables 3.4, 3.5 and 3.6. In all three SIC's, a faster speed of adjustment is indicated in expansion than in contraction. This would be the case if hiring costs were low in comparison with redundancy costs. For SIC 6, adjustment of 8.8% per quarter and returns to labour of 0.97 are indicated in hiring periods, whilst no positive adjustment towards the desired level, and hence no returns to labour figure, is found in contraction periods. For SIC 8, the change in adjustment speed is less severe from 16% to 9.5% but output has no significant influence on employment during a contraction period whilst returns to labour of 1.85 are found during expansion. The estimates for SIC 9 are less varied with adjustment falling from 5.6% to 4.6% and returns to labour rising from 0.64 to 0.79, between expansion and contraction. The implied rate of technical progress appears to be slower in expansion than contraction for all three SIC's, 1.0% and 1.3% per quarter for SIC 6, 1% and 5% per quarter for /

for SIC 8 and 0.5% and 0.7% per quarter for SIC 9. It was expected that technical progress would tend to accompany expansion rather than contraction.

An alternative to the above procedure of separation of regimes is to make the adjustment speed explicitly dependent on the factors thought to affect it. As stated earlier, data on the actual costs of hiring and firing labour are not available. However, one factor likely to influence the speed with which employers can increase their labour force when desired and the extent to which they will hoard labour not immediately required, is the availability of labour. The more excess labour is available, the more easily employers can increase their labour force in a boom and the less they need hoard labour for future requirements, in a recession. Thus we would expect the speed of adjustment to be positively related to excess labour.

To incorporate this feature in the employment function framework is one means by which the influence of labour supply factors can be introduced into an essentially demand-orientated framework. The study by Peel and Walker (1978) has a similar aim but they treat the problem using discrete "regimes" rather than the continuous excess labour variable postulated here. A more comprehensive analysis of the supply of labour and its interaction with demand is pursued in later chapters.

For the present, we attempt to incorporate the supply influence by measuring the availability of labour as /

as the level of unemployment, U_e, minus the level of vacancies unfilled, V. Whilst not an ideal measure, due to non-registering of the unemployed and non-reporting of vacancies, (U_e-V) should serve as a useful proxy for the availability of labour to the employer.(11) We formulate the relationship between the speed of adjustment, λ, and (U_e-V) as a simple linear one:

$$\lambda_t = a + b(U_e-V)_t \qquad .... (3.13)$$

with both a and b expected to be positive. However, when this expression is substituted for λ in a Ball and St. Cyr type of formulation, like (3.3), an empirical estimation problem arises. This is because λ appears in all the parameters in equation (3.3) and we end up with variables such as $(U_e-V)_t \log Q_t$, $(U_e-V)_t t$ and $(U_e-V)_t \log E_{t-1}$. (U_e-V) has greater variability than the original explanatory variables so that multicollinearity between these 'compound' explanatory variables is extremely high and the probability of getting sensible and precise estimates by ordinary least squares is very low.

This, indeed, proved to be the case when estimation was attempted for all three SICs. Attempts to overcome this estimation problem were made. If the restriction, that all coefficients should have the same values of a and b, can be imposed then this should reduce multicollinearity considerably. Such a restriction can be imposed, resulting in /

(11) Due to the measurement errors in U_e and V, it may be preferable to use either U_e or V alone, rather than the difference between them, as is done in Chapter 9. This was attempted but did not lead to any obvious improvement in the empirical results.

in a non-linear formulation. This should be amenable to non-linear least squares estimation but proved difficult to apply (the 'hill-climbing' technique in the TSP package seemed reluctant to converge on anything like plausible values).

However, the scope for improvement in explanatory power, from a formulation which does incorporate the availability of labour, can be seen by simply adding the (U_e-V) term, as an extra explanatory variable, to the Ball and St. Cyr model. In fact, the addition was made to formulation (3.7), to ensure that the (U_e-V) term did not capture effects more aptly explained by normal hours or capital utilization. The results, reported as (K) in Tables 3.4, 3.5 and 3.6, show a significant increase in explanatory power for all three SIC's, particularly SIC 6. Also evidence of auto-correlation of the residuals is lessened in all three SIC's. However, as the specification is lacking in theoretical backing, we cannot expect the estimated co-efficients to be reliable.

Further work on this modification would be desirable but, if it is the effect of supply constraints which is being picked up, then we hope we can capture this by the more thorough inclusion of supply influence attempted in later chapters.

(ii) Finally, the geometrically declining nature of the adjustment process is unduly restrictive and can easily be relaxed by allowing earlier periods' employment to influence present adjustment behaviour. Ideally, this aspect should be explored in conjunction with the other modification /

modification discussed in this section. In practice, it is more feasible to consider the 'non-constancy' and multi-period lag'.aspects separately and then to combine them where the first stage empirical evidence merits it. However, work on a lag structure for the adjustment process failed to provide satisfactory results, with insufficient significant estimates of correct sign to encourage further study. Neither ordinary least squares nor use of the Almon lag technique proved successful. In view of this and the inability to adequately allow for non-constancy of the adjustment speed, the methods discussed in this section are not pursued further nor are they applied to the other types of employment function.

3.7 Conclusions

The general conclusion, as with the empirical work surveyed in the last chapter, is that none of the major employment function formulations are capable of explaining employment behaviour in the three SIC Orders of the engineering industry. This conclusion remains even after the original formulations have been considerably modified in an attempt to make them more plausible. Explanatory power is generally high but plausibility of the implied production parameters - in particular, returns to labour or returns to scale - is often lacking and the values tend to change considerably as the function is modified or as the data period is changed. This /

This lack of stability gives little confidence for the basing of forecasts on such models.

The modifications attempted so far have tended to be minor piecemeal changes to the existing models. Certain major criticisms of these models remain to be dealt with. Still within the demand-orientated context, it can be strongly argued that expected or desired output is the relevant determinant of desired employment and that actual output does not measure it adequately. Also, it can be strongly argued that a neoclassical production function, such as the Cobb-Douglas, is totally unsuited to an explanation of employment in modern capitalized industry. A putty-clay formulation is felt to be much more realistic. Attempts to satisfy these two aspects are made in the next two chapters. Finally, the whole body of research analysed so far has concentrated on the determination of employment levels solely by the demands of industry. The availability of a supply of labour suitable and willing to meet those demands is generally ignored. The implied perfect adjustment of supply to demand is a strong assumption which needs substantial justification. The subsequent chapters of this thesis take the view that supply is an important factor, in its own right, in the determination of actual employment.

Figure 3.1 Output and Employment for SIC6, 1959-71

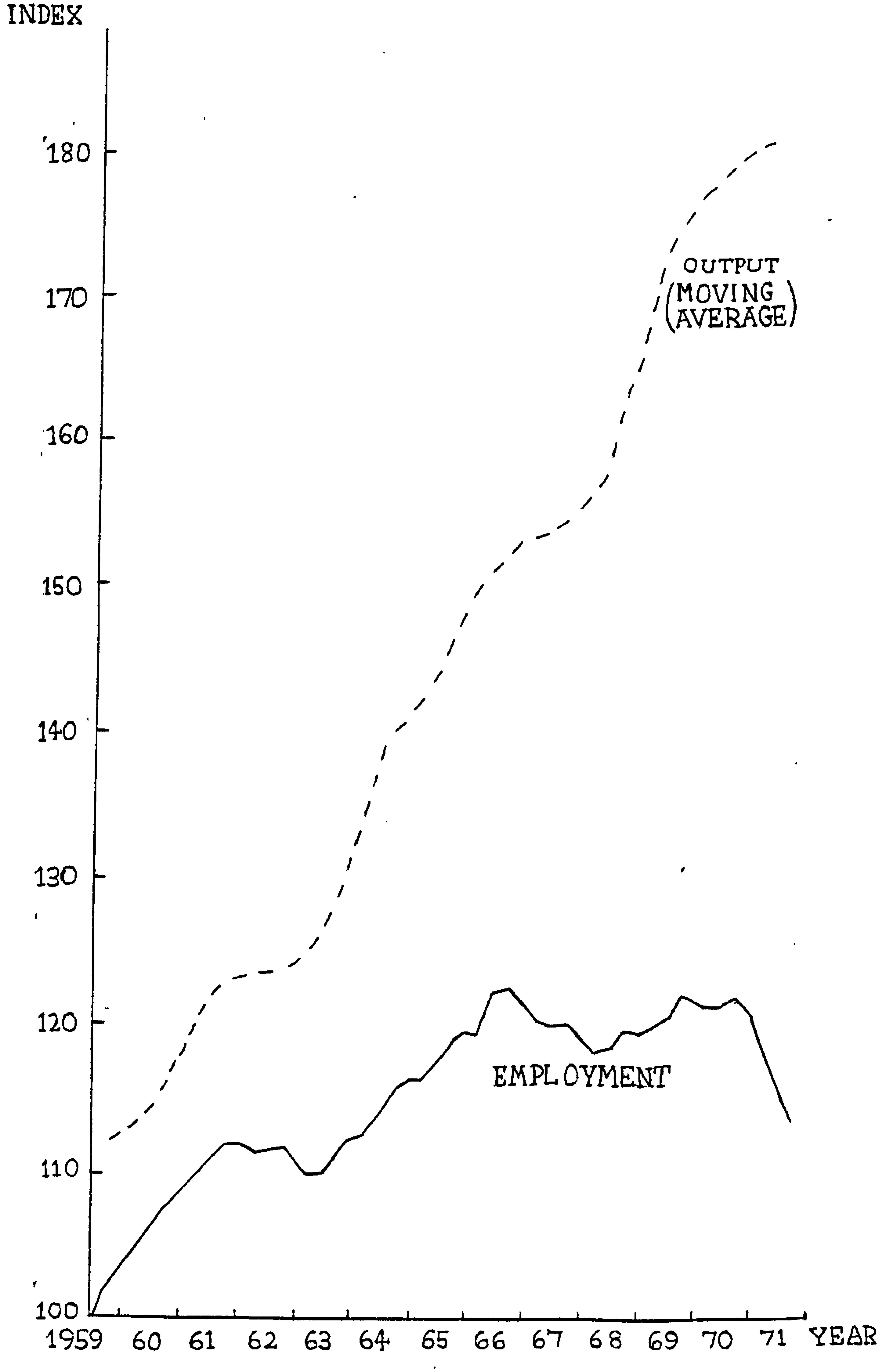

Figure 3.2 Output and Employment for SIC8, 1959-71

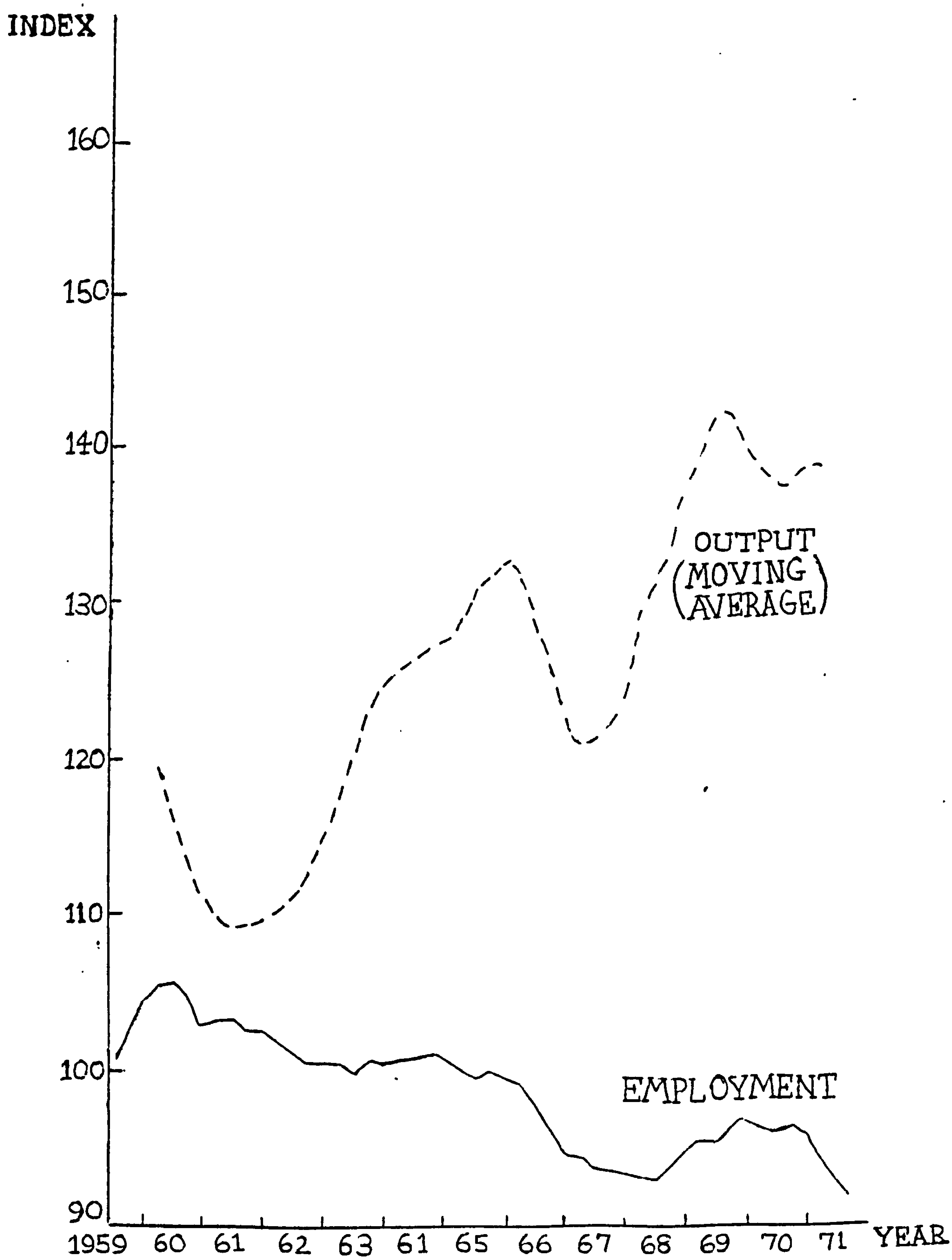

Figure 3.3 Output and Employment for SIC9, 1959-71

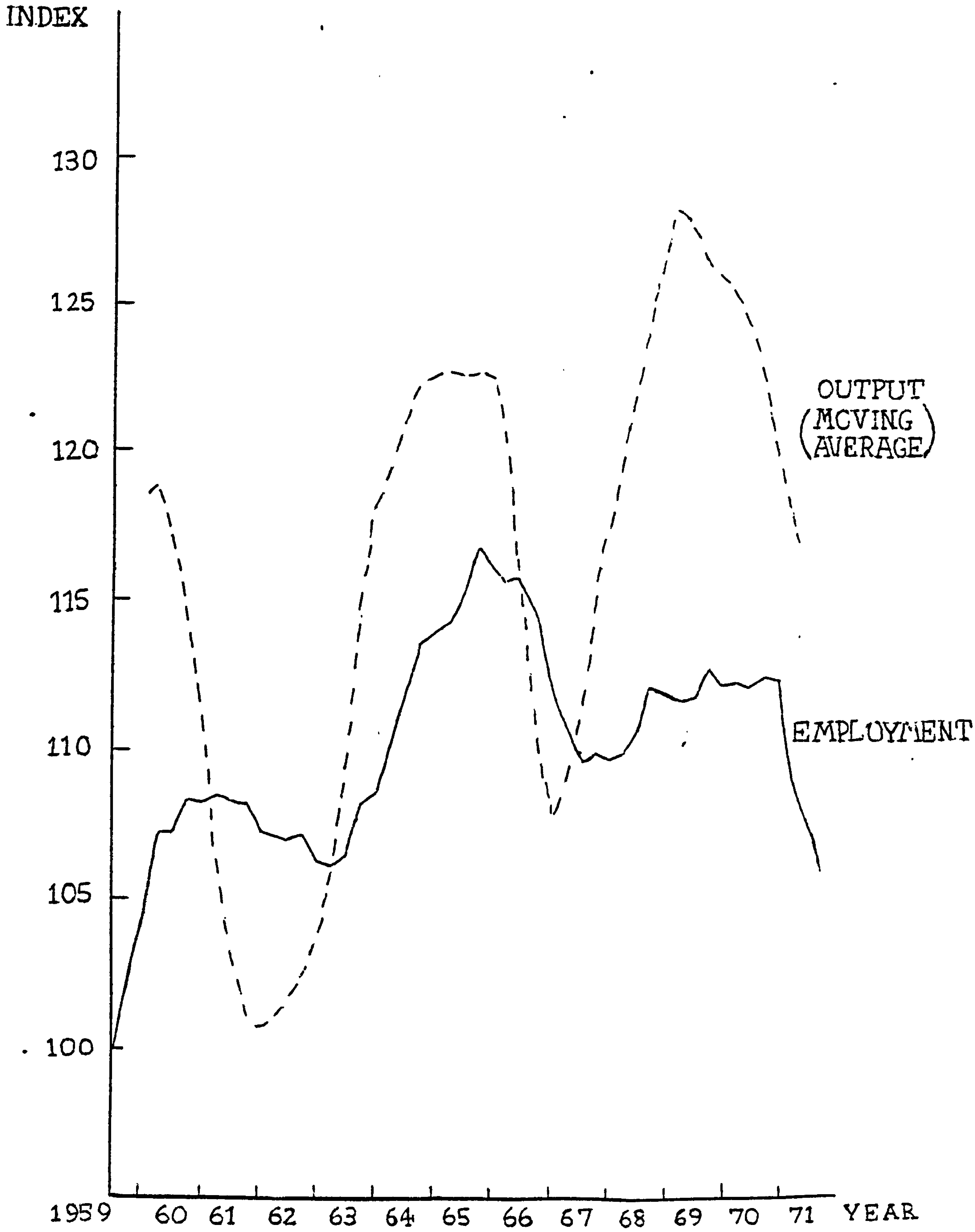

TABLE 3.1 EMPLOYMENT FUNCTION ESTIMATES FOR SIC6, 1959-71

Dependent Variable: $\text{Log}E_t$	Constant	Log Q_t	Log E_{t-1}	t	Log H_{ot}	Log K_t	Log $Q^{\prime}_{t-1}$	Log $(w/p)_t$	Log $(w/c)_t$	$\bar{R}^2$	DW h	Adjustment Speed $\hat{\lambda}$	Returns to Labour $\hat{\alpha}$
(A) Dhrymes Type	0.35 (0.5)	0.151 (5.4)	0.869 (17.9)		-0.262 (2.5)			-0.235 (7.0)		0.987	1.32 2.53	0.131	1.24 $(\hat{\nu})$
(B) Nadiri Type	0.08 (0.1)		0.866 (12.3)		-0.202 (1.5)	0.090 (2.1)			-0.151 (3.4)	0.978	0.66 5.39	0.134	-
(C) Ball & St. Cyr Type	-0.72 (2.4)	0.184 (4.6)	0.982 (27.3)	-0.0023 (5.5)						0.983	1.25 2.71	0.018	0.10
(D) Including Normal Hours	0.31 (0.4)	0.187 (4.7)	0.934 (18.4)	-0.0024 (5.7)	-0.149 (1.3)					0.984	1.29 2.66	0.066	0.35
(E) Including Capital Stock	3.88 (2.3)	0.165 (4.3)	0.976 (16.3)	0.0013 (0.8)	-0.188 (1.7)	-0.446 (2.3)				0.985	1.42 2.24	0.024	0.15
(E)' Including Capital Utilization	1.71 (1.8)	0.286 (5.3)	0.953 (18.2)	-0.0024 (5.8)	-0.111 (1.0)	-0.172 (2.5)				0.986	1.02 3.69	0.047	0.16
(F) Including Lagged Output	1.91 (1.9)	0.313 (4.6)	0.964 (18.7)	-0.0022 (4.2)	-0.104 (1.0)	-0.195 (2.5)	-0.033 (0.6)			0.985	1.08 3.45	0.036	0.13

t - values in brackets. h is the Durbin (1970) value.

TABLE 3.2 EMPLOYMENT FUNCTION ESTIMATES FOR SIC8, 1959-71

Dependent Variable: LogE_t	Constant	Log Q_t	Log E_{t-1}	t	Log H_{ot}	Log K_t	Log Q_{t-1}	Log $(w/p)_t$	Log $(w/c)_t$	$\bar{R}^2$	DW h	Adjustment Speed $\hat{\lambda}$	Returns to Labour $\hat{\alpha}$
(A) Dhrymes Type	-0.35 (0.9)	0.076 (4.5)	0.850 (17.6)		0.160 (1.9)			-0.058 (3.0)		0.971	1.28 2.68	0.150	5.11 ($\hat{\nu}$)
(B) Nadiri Type	-0.87 (1.7)		0.856 (15.5)		0.239 (2.6)	0.044 (1.9)			-0.043 (1.5)	0.961	0.89 4.21	0.144	-
(C) Ball & St. Cyr Type	0.87 (2.4)	0.083 (5.0)	0.815 (15.4)	-0.0010 (5.8)						0.971	1.21 2.98	0.185	2.23
(D) Including Normal Hours	0.27 (0.5)	0.077 (4.6)	0.810 (15.3)	-0.0007 (3.2)	0.143 (1.7)					0.972	1.27 2.75	0.190	2.47
(E) Including Capital Stock	2.68 (2.9)	0.066 (4.2)	0.854 (17.0)	0.0023 (2.2)	0.204 (2.5)	-0.386 (3.0)				0.977	1.49 1.91	0.146	2.21
(E)' Including Capital Utilisation	2.48 (4.3)	0.283 (6.9)	0.698 (15.0)	-0.0004 (2.1)	0.262 (3.7)	-0.243 (5.2)				0.983	1.24 2.81	0.302	1.07
(F) Including Lagged Output	2.31 (3.9)	0.255 (5.3)	0.690 (14.7)	-0.0005 (2.4)	0.261 (3.7)	-0.221 (4.4)	0.018 (1.1)			0.983	1.11 3.30	0.310	1.14

TABLE 3.3 EMPLOYMENT FUNCTION ESTIMATES FOR SIC9, 1959-71

Dependent Variable: $\log E_t$	Constant	Log Q_t	Log E_{t-1}	t	Log H_{ot}	Log K_t	Log Q_{t-1}	Log $(w/p)_t$	Log $(w/c)_t$	$\bar{R}^2$	DW h	Adjust-ment Speed $\hat{\lambda}$	Returns to Labour $\hat{\alpha}$
(A) Dhrymes Type	-0.50 (0.8)	0.098 (8.2)	0.958 (22.8)		0.006 (0.1)			-0.058 (3.2)		0.964	1.69 1.14	0.042	-0.40 $(\hat{v})$
(B) Nadiri Type	-1.59 (2.5)		0.913 (19.9)		-0.001 (0.0)	0.123 (8.5)			-0.150 (5.9)	0.966	1.83 0.63	0.087	-
(C) Ball & St. Cyr Type	-0.14 (0.7)	0.096 (8.1)	0.950 (30.4)	-0.0005 (6.9)						0.963	1.60 1.43	0.050	0.52
(D) Including Normal Hours	-0.50 (0.7)	0.095 (7.9)	0.967 (23.4)	-0.0005 (2.9)	0.057 (0.5)					0.963	1.64 1.32	0.033	0.35
(E) Including Capital Stock	-3.10 (2.4)	0.106 (8.5)	0.917 (19.9)	-0.0038 (2.6)	0.035 (0.3)	0.428 (2.3)				0.966	1.87 0.48	0.083	0.78
(E)' Including Capital Utilisation	1.18 (0.9)	0.210 (2.9)	0.871 (12.2)	0.0003 (0.6)	0.035 (0.3)	-0.132 (1.6)				0.964	1.32 2.75	0.129	0.61
(F) Including Lagged Output	0.62 (0.7)	0.148 (4.3)	0.895 (17.0)		0.035 (0.3)	-0.079 (3.1)	0.021 (1.0)			0.965	1.31 2.60	0.105	0.62

Table 3.4 FURTHER EMPLOYMENT FUNCTION ESTIMATES FOR SIC 6, 1959-71

Dependent Variable: Log E_t	Constant	Log Q_t	Log $(w/c)_t$	Log E_{t-1}	Log H_{t-1}	Log K_{t-1}	Log U_{t-1}	$\bar{R}^2$	DW h	$\hat{\lambda}$	
Nadiri-Rosen (G) Type	-1.54 (1.8)	0.110 (2.8)	-0.025 (0.7)	1.028 (25.7)	0.378 (3.5)	-0.098 (1.5)	-0.060 (1.2)	0.989	1.53 1.71	-	
Log E_t - LogE_{t-1}	Constant	ΔLog Q_{t-1}	ΔLog Q_t	ΔLog Q_{t+1}	ΔLog Q_{t+2}	ΔLog $\tilde{E}_{t-1}$	t	$\bar{R}^2$	DW	$\hat{\gamma}^5$	
(H) Fair Type	0.01 (1.8)	0.009 (0.2)	0.166 (3.7)	0.106 (2.4)	0.010 (0.2)	-0.144 (2.9)	-0.0003 (5.0)	0.559	0.95	0.144	
Log E_t	Constant	Log Q_t	t	Log E_{t-1}	Log H_{ot}	Log KU_t	$(u-v)_t$	$\bar{R}^2$	DW h	$\hat{\lambda}$	$\hat{\alpha}$
(I) Employment Increases	0.25 (0.8)	0.091 (2.3)	-0.0009 (2.0)	0.912 (22.8)				0.975	2.15 -0.44	0.038	0.97
(J) Employment Decreases	-1.20 (1.9)	0.158 (1.9)	-0.0021 (2.4)	1.061 (12.2)				0.968	1.38 0.79	-	-
(K) Ball & St.Cyr including 'Excess Supply'	1.34 (2.3)	0.086 (2.1)	0.0002 (0.6)	0.908 (29.6)	0.094 (1.4)	-0.117 (2.9)	-4.2×10^{-7} (8.5)	0.995	1.63 1.33	0.092	1.07

Table 3.5 FURTHER EMPLOYMENT FUNCTION ESTIMATES FOR SIC 8, 1959-71

Dependent Variable: $LogE_t$	Constant	Log Q_t	Log $(W/C)_t$	Log E_{t-1}	Log H_{t-1}	Log K_{t-1}	Log U_{t-1}	$\bar{R}^2$	DW h	$\hat{\lambda}$	
(G) Nadiri-Rosen Type	1.19 (1.5)	0.044 (2.6)	0.039 (1.3)	0.789 (16.5)	0.232 (4.1)	-0.109 (2.2)	-0.004 (0.2)	0.982	1.79 0.78	0.211	
Log E_t - LogE_{t-1}	Constant	ΔLog Q_{t-1}	ΔLog Q_t	ΔLog Q_{t+1}	ΔLog Q_{t+2}	ΔLog $\tilde{E}_{t-1}$	t	$\bar{R}^2$	DW	$\hat{Y}_5$	
(H) Fair Type	-0.00 (0.5)	0.058 (2.5)	0.087 (3.5)	0.015 (0.6)	0.010 (0.5)	-0.071 (2.4)	-0.0001 (1.1)	0.302	1.00	0.071	
$LogE_t$	Constant	Log Q_t	t	Log E_{t-1}	Log H_{ot}	Log KU_t	$(u-v)_t$	$\bar{R}^2$	DW h	$\hat{\lambda}$	$\hat{a}$
(I) Employment Increases	0.69 (2.4)	0.087 (5.0)	-0.0009 (7.2)	0.839 (20.8)				0.988	2.20 -0.44	0.161	1.85
(J) Employment Decreases	0.61 (1.5)	0.006 (0.3)	-0.0003 (1.4)	0.905 (14.3)				0.951	1.53 1.35	0.095	-
(K) Ball & St.Cyr Including 'Excess Supply'	1.96 (3.2)	0.239 (5.3)	-0.0001 (0.4)	0.683 (15.1)	0.361 (4.3)	-0.213 (4.5)	-4.3 x 10^{-7} (2.1)	0.984	1.30 2.58	0.317	1.33

TABLE 3.6 FURTHER EMPLOYMENT FUNCTION ESTIMATES FOR SIC 9, 1959-71

Dependent Variable: $\text{Log}E_t$	Constant	Log Q_t	Log $(w/C)_t$	Log E_{t-1}	Log H_{t-1}	Log K_{t-1}	Log U_{t-1}	$\bar{R}^2$	DW h	$\hat{\lambda}$	
(G) Nadiri-Rosen Type	-2.59 (4.7)	0.062 (4.0)	-0.060 (1.7)	0.916 (31.6)	0.396 (4.5)	0.091 (2.4)	0.016 (0.7)	0.978	1.75 0.89	0.084	
$\text{Log } E_t - \text{Log}E_{t-1}$	Constant	ΔLog Q_{t-1}	ΔLog Q_t	ΔLog Q_{t+1}	ΔLog Q_{t+2}	ΔLog E_{t-1}	t	$\bar{R}^2$	DW	$\hat{\gamma}_5$	
(H) Fair Type	0.02 (4.0)	-0.007 (0.3)	0.080 (4.1)	0.038 (2.0)	0.051 (2.6)	-0.127 (8.2)	-0.0005 (7.8)	0.750	1.53	0.127	
$\text{Log}E_t$	Constant	Log Q_t	t	Log E_{t-1}	Log H_{ot}	Log KU_t	$(u-v)_t$	$\bar{R}^2$	DW h	$\hat{\lambda}$	$\hat{\alpha}$
(I) Employment Increases	-0.06 (0.2)	0.088 (4.3)	-0.0004 (3.9)	0.946 (25.3)				0.952	2.15 -0.38	0.056	0.64
(J) Employment Decreases	0.02 (0.1)	0.058 (3.9)	-0.0004 (4.4)	0.956 (24.9)				0.937	1.79 0.51	0.046	0.79
(K) Ball & St. Cyr Including 'Excess Supply'	2.67 (2.6)	-0.017 (0.2)	0.0007 (1.7)	0.613 (8.1)	-0.030 (0.4)	-0.001 (0.0)	-0.2×10^{-7} (5.2)	0.978	1.58 1.73	0.387	-

4. The Measurement of Desired Output

4.1 Introduction

In the work done on employment functions surveyed and tested in the previous chapters one feature which is prevalent and which is a theoretical weakness is the treatment of output in the determination of employment. The usual practice is first to relate desired employment to desired output and then to proxy desired output by actual output whilst allowing a lag in the adjustment of employment to its desired level. Hence, actual output is used as the major determinant of employment and it is treated as exogenous to the employment decision.

How desired output is achieved with a less than desired level of employment is often not considered. It may be that average hours of work are increased to achieve a higher labour input, but in some of the work done, e.g. Nadiri (1968) and Dhrymes (1969), the adjustment of labour towards its desired level is specified in man-hours rather than in the number of employees. This implies that at times, labour-input will be less than the amount required to produce desired output and yet it is assumed that desired output is produced. It is a strong assumption, and one that needs to be verified, since it assumes that capital services have increased sufficiently to make up for the labour deficiency, so that desired output is achieved. Even if we accept a neo-classical production function formulation where labour and capital can be directly substituted in this way, we are also implying /

implying that the cost of not producing desired output is so much greater than the cost of increasing utilisation of men or machines that firms always choose to adjust the latter rather than change output.

This point is made even more obvious by the work of Nadiri and Rosen (1969) where great care is taken to specify an adjustment process which allows the amounts of the various inputs, men, hours, capital and capital utilisation to be interrelated so that the costs of adjusting the levels of the inputs, occasioned by a change in the demand for output, are minimized. Yet it is assumed that firms always operate on their production functions, producing the desired amount of output demanded by their customers. At no point is it hypothesized in this model that producers use output as part of their adjustment process towards new desired levels of inputs and output,[1] incurring the costs of lost sales or making customers wait rather than incurring recruitment, overtime, investment or capital usage costs.

Admittedly, Dhrymes and Coen and Hickman (1970) do recognize that it is expected or desired output rather than actual output that is the determinant of employment but, through lack of a measure of expected output, they both specify it as a weighted average of present and previous period's output with the weights to be determined by estimation. Hence, this amounts to virtually the same specification /

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(1) They regret that 'joint estimation requires a full market theory not yet available'.

specification as was used in equations (3.8) and (3,9) of the previous chapter, where output of the previous quarter proved to be unimportant in the determination of employment in the engineering SICs. It is probable that such an expectational hypothesis is invalid and that a better measure of desired output is required.[2]

Desired output may reasonably be treated as determined by demand, exogenous to the firm's employment decision,[3] but actual output will be determined simultaneously with the levels of input, price of output, inventories, etc. To treat actual output as a measure of desired output and hence as exogenous to the employment decision is to ignore this source of simultaneity which is likely to induce bias into the estimation. However, it is felt that the deficiency has been more the mismeasurement of desired output rather than the neglect of simultaneity.[4] Consequently, the aim in this chapter is to specify and measure desired output and then to use the measure instead of actual output in the estimation of an employment function. /

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(2) Fair (1969) does put forward more complicated expectational hypotheses, but the extent to which they capture desired output is questionable.

(3) In fact, desired output may be dependent on present employment levels but this influence is assumed negligible - see Chapter 1.

(4) Briscoe and Peel (1975) use simultaneous systems in which output is endogenously determined but find 'results which did not vary significantly from those yielded by the single equations' - see Chapter 2.

function.

4.2 A specification of desired output

Theoretically, a firm's level of desired output is determined by the expected demand for the firm's product in relation to its present production capacity. Expected demand is clearly dependent on the price which the firm decides to sell its product at and, assuming the product market is not perfectly competitive, it may be possible for the firm to set its price so as to fully utilise its existing production capacity.

In practice, firms do not seem to adjust their prices according to fluctuations in demand.[5] Whether this is due to cost plus pricing, perfect competition or the maintenance of customer goodwill through steady prices is questionable. What is required in this work is the assumption that the price set should not be influenced by the current level of employment in the firm. Consequently, desired output can be treated as exogenous to the firm's employment level and dependent on product demand at present prices.

The form of the relationship between desired output and demand will depend upon the type of product involved. If the good is quick to produce and is perishable, then we could reasonably expect desired output to be equal to demand. When the good takes a long time to produce and can be stored as inventory stock either as an intermediate or finished product, then the relationship becomes more complex. In the engineering industry a large proportion of /

(5) See, for example, Hague (1971).

of output is in the form of capital goods to be used in other industries.[6] This is the type of output which is often made to individual buyers' specification and can take two years or longer to produce. In this case output demand in a period of time consists not only of the actual output delivered in the period but also of the orders-on-hand at the end of the period.[7] The importance of orders-on-hand relative to actual output can be illustrated by the fact that in 1970 the value of orders-on-hand for SIC Order VI was more than twice the value of quarterly sales. It follows that if firms' desired output is related to demand then it is necessary for us to consider more than the current quarter's output or sales. A relationship between desired output and demand, including orders-to-hand is needed.

Several studies, e.g. Trivedi (1970), Bispham (1970) and Lund (1974) have been carried out which try to explain the relationship between orders and deliveries for the U.K. Engineering Industry . However, they do not consider the implications for employment of fluctuations in demand. The work of Holt, Modigliani, Muth and Simon (1960) discussed in the first chapter gives a very thorough treatment of how a cost-minimizing firm should vary production and /

(6) According to Lund (1974) 'for 1968 ... 37 per cent of the total output sales and 48 per cent of the total final output sales ... went directly into gross domestic fixed capital formation'.

(7) This assumes that a buyer who places an order would prefer immediate delivery to waiting i.e. he does not order in advance of requirement.

and employment in the face of changing market demand. A similar approach is followed in this work except that it is desired output and employment which are determined by the cost minimizing process. Actual employment is then obtained by postulating the usual type of adjustment process towards the desired level.

A typical firm in determining its desired level of output has a conflict of interest between its customers demand and its own desires with regard to the employment of inputs. If the firm ignores the level of consumer demand and aims to keep its available resources fully employed then it would minimize the costs of production but incur the costs of the loss of custom and goodwill if orders-on-hand and waiting times become too great or incur high inventory costs if production is greater than demand. If the firm aims to satisfy its customers as quickly as is possible, then it will keep the level of orders-on-hand as low as is consistent with unavoidable production lags. However, demand for engineering products tends to have a pronounced cyclical pattern. Thus a firm which pursued a 'demand' production policy would need to take on extra employees and capital during a boom, incurring recruitment, training and investment costs, only to have idle resources or redundancy costs during a recession.[8]

Holt et al argue convincingly that the costs involved in the two strategies outlined above which we can call 'inventory-backlog order costs' and 'labour change costs' can be each approximated by U-shaped quadratic curves. This /

(8) Overtime and short-time working are available to the firm but their influence will be limited in magnitude.

This implies that there is a minimum value for each, possibly zero, but that deviations from this value in either direction become increasingly costly. This suggests that a cost-minimizing firm will set its production targets according to a mix of the two strategies avoiding the costly use of extremes of a 'pure' strategy. It will desire to keep production as steady over the cycle as is possible so as to fully utilize its capital and labour resources but must also be prepared to adjust its production targets so that the level of orders-on-hand, waiting times and, on the other hand, level of inventories do not get too high. It can do this by allowing orders-on-hand and waiting times to rise to some extent, with inventories being run down, during a boom and then reducing the level of orders and waiting times, whilst building up inventories again, during a recession.

To the extent that long waiting times act as a deterrent and short waiting times act as an attraction, the behaviour of firms postulated may act to smooth out the severity of the cyclical fluctuations in demand as well as in production. The potential for this depends on the situation of competing firms, including foreign ones. If a firm has a longer waiting time than its competitors then it will lose custom and may not regain it during a recession. It is this feature that acts as a constraint on the level of orders-on-hand and it is a relative constraint rather than an absolute one.

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If we could measure the various costs incurred by firms in lengthening order books or varying levels of production we could perhaps determine desired output directly by minimizing these costs. However, data on these costs are not available for an industry aggregate and so we are forced to postulate a hypothesis concerning the behaviour of firms which we would expect to result from this cost-minimizing process. A reasonably general hypothesis is that desired output Q_t^*, is some function of actual output, Q_t, and a measure of orders-on-hand, O_t, i.e.:

$$Q_t^* = f(Q_t, O_t) \quad \ldots\ldots\ldots\ldots \quad (4.1)$$

The functional form is not clearly dictated by the theory. This specification includes as special cases both the extreme situations, where employers ignore the level of orders-on-hand and produce the output they desire and where employers desire to produce output sufficient to satisfy all existing demand, without generally achieving their desired aim. The more general situation, where firms are aware to some extent of /

of the consumer demand, as indicated by orders-on-hand, and desire to produce more output when orders are high and less when they are low is also catered for.

It is important to note that the data on orders-on-hand consist of two elements. The first of these is orders which have been placed and, due to physical constraints, take several months to be manufactured, i.e. 'work-in-progress'. They thus appear as orders-on-hand but are unlikely to affect desired output if their production cannot be quickened. The second element is orders which have been placed and, because the firm is producing to capacity and has an 'order back-log', are either not started right away or else are produced more slowly than they could be. It is this element whose magnitude we expect to affect desired output. Ideally, we would wish to subtract the first element from the total orders-on-hand figure to give us the second element. At the time of commencing this work, data was not available to do this directly and so an indirect method was developed. A data series for the value of work-in-progress (w.i.p.) at constant prices can be constructed from data which has since been kindly supplied by the Department of Industry.

However, such a w.i.p. series is likely to include orders which are being produced more slowly than possible when the firm is working at capacity. Such orders should /

should be included in the orders back-log series. Consequently, the indirect method is described and applied empirically below, so that the results can be compared with those using the direct measure.

The work-in-progress element will be determined by the technical constraints of the production process and the ratio of this element to output is unlikely to fluctuate over time, though it may have a long-run trend due to technical progress or changing type of product output.

It may be a reasonable hypothesis to assume that the ratio of orders-on-hand to output which firms have during a slump is due solely to the constraint of production time rather than any back-log of orders. As firms will have spare capacity during a recession there is no need or justification for keeping customers waiting and such behaviour would be inconsistent with cost-minimizing.(9) Consequently, it may be possible to derive a level of, or a trend in, basic orders-on-hand which represents the work-in-progress element from observations of the minimum level in recession. Subtraction of this element from total orders-on-hand will leave a measure more relevant to the consideration of desired output.

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(9) In fact, firms or their employees may make jobs last longer in a slump to avoid workers being laid-off. In this case, minimum order levels will overstate work-in-progress. Hence OB will understate the back-log.

We can then specify desired output as:

$$Q_t^* = f(Q_t, OB_t) \quad \text{...........} \quad (4.2)$$

where OB is the backlog of orders-on-hand, calculated as total orders-on-hand, OT, minus the basic level of 'work-in-progress' orders on hand. This specification is likely to be superior to (4.1) but, whilst seemingly plausible, its theoretical backing is slender and we must look for empirical support for our hypothesis, using both direct and indirect measures of work-in-progress.

4.3 Empirical use of the measures of desired output

A series of total orders-on-hand, OT, is available, in quarterly seasonally adjusted index form, in the Monthly Digest of Statistics for the engineering industries corresponding to S.I.C. (1958) Order VI. No equivalent data is available for the other SICs and so the empirical analysis and comparison with earlier results is restricted to one rather than three sets of data.

In accordance with the discussion of the last section, two indirect measures were derived which attempt to measure the more relevant back-log of orders-on-hand, OB, by subtracting the basic level of work-in-progress orders from OT. The two measures differ in their derivation of a work-in-progress order series. The first assumes these to be in constant proportion to output over time whilst the second /

second allows a trend in this relationship. The derivation procedure adopted was to obtain a series of the ratio of total orders-on-hand to output, using seasonally adjusted output to correspond with the orders series, and to locate the minimas of this series. The first measure treated the overall minimum, occurring in 1970, as representing work-in-progress orders only and as constant over time. The second measure took this minimum and an earlier one, in 1959, and interpolated linearly between them to obtain a trend in the ratio of work-in-progress orders to output. Multiplying the appropriate ratios by the output of each period yielded two series of the work-in-progress level of orders. These are subtracted from total orders to give two measures of 'backlog' orders, OB. These measures are denoted as OBC (constant) and OBT (trend) respectively. A third measure, denoted as OBD (direct) is obtained by directly subtracting the w.i.p. series from total orders-on-hand.

Before proceeding a brief description of the various measures of orders-on-hand might be useful. The total orders-on-hand series shown in Fig. 4.1, has a general increase over the period 1959-71, rising on average by 2.6% per annum. However, the increase is not a steady one and a cyclical pattern is evident with a noticeable peak in the 1964-6 period and low levels around 1962/3, 1967/8 and 1971. This seems to correspond in general to the patterns of output and employment described in Chapter 3.

The direct measure of work-in-progress, whose derivation is described in the data appendix, shows a faster and steadier increase over the period, by 5.5% per annum on average, and much less of a cyclical pattern. Hence the proportion of total orders which represent work-in-progress is increasing, from a value of 29% in 1959 to roughly 34% in 1971, according to this measure. The indirect measures of work-in-progress, by their method of construction are closely related to the output measure and thus follow a similar pattern to output. They are similar in magnitude to each other but almost twice as large as the direct measure. The three measures of back-log orders, all have a similar cyclical pattern to total orders, though with much weaker trends. They are closely correlated with each other, with correlation coefficients of 0.93, 0.97 and 0.97, but less so with total orders, i.e. 0.88, 0.73 and 0.86 for OBD, OBC and OBT respectively. The main difference is that OBD has a greater magnitude due to the smaller size of the direct work-in-progress measure.

To test hypotheses (4.1) and (4.2) we must first specify their functional forms and then integrate them into an employment function. The functional forms tried were multiplicative and additive. Multiplicative formulation gives:

$$Q_t^* = Q_t \; O_t^{\varepsilon} \qquad \ldots\ldots\ldots \; (4.3)$$

whilst additive formulation gives:

$$Q_t^* = Q_t + \eta O_t \qquad \ldots\ldots\ldots \; (4.4)$$

/and

and the employment function chosen was the 'Ball and St. Cyr type':

$$\log E_t = A + \frac{\lambda}{\alpha} \log Q_t^* - \frac{\lambda\gamma}{\alpha} t - \lambda\beta \log H_{ot} +$$

$$(1-\lambda) \log E_{t-1} + u_t \quad .... \quad (4.5)$$

substituting expression (4.3) for Q_t^* in (4.5) yields:

$$\log E_t = A + \frac{\lambda}{\alpha} \log Q_t + \frac{\lambda\varepsilon}{\alpha} \log O_t - \frac{\lambda\gamma}{\alpha} t - \lambda\beta \log H_{ot} +$$

$$(1-\lambda) \log E_{t-1} + u_t \quad .... \quad (4.6)$$

which can be estimated straightforwardly using each of the four measures of orders-on-hand in turn. However, the additive formulation (4.4) leads to the expression:

$$\log E_t = A + \frac{\lambda}{\alpha} \log (Q_t + \eta O_t) - \frac{\lambda\gamma}{\alpha} t - \lambda\beta \log H_{ot} +$$

$$(1-\lambda) \log E_{t-1} + u_t \quad .... \quad (4.7)$$

which is more difficult to estimate as η is unknown.(10) The iterative procedure used to accomplish the estimation is described later.

One point to be noted in empirical analysis is that the orders series are seasonally adjusted whilst the output series previously used were not. This would not be crucial when estimating (4.6) where output and orders are included separately, with dummy variables for the quarterly seasonal effects, but it is important when using the specification (4.7) where output and a fraction of orders are added together. For consistency in this

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(10) It can be shown that, due to the method of calculating OBC, the resulting estimates should differ from those using OT only in the constant term and the value of η.

operation, seasonally adjusted output is used throughout, though unadjusted series of output and of orders would be preferable if firms' desired output is influenced by the seasonal pattern of orders-on-hand.(11) However, such orders data was not available and so the emphasis is on employers' cyclical behaviour rather than the seasonal pattern.

Empirical results for the years 1959-71 are reported in Table 4.1. First, for comparison purposes, a straightforward Ball and St. Cyr type employment function, including the normal hours term, is reported as (A). This is the same functional form as (3.4) in the previous chapter. The results differ due to the use of seasonally adjusted output. However, the speed of adjustment, λ , is still low at 12.5% per quarter and the elasticity of output with respect to labour, α , is also low at 0.54. Addition of the logs of the four measures of orders-on-hand in turn, reported as (B), (C), (D) and (E), improves matters in that they are all significant at the 5% level and so improve the explanatory power of the equation significantly. They also remove evidence of auto-correlation by increasing the D.W. statistic, so that the Durbin (1970) test is satisfied. In addition, the speed of adjustment is increased to over 20% and the elasticity 'α' increased to a value around unity which, in view of the neglect of capital in the employment function, is a plausible value for returns to scale, rather /

(11) See Wallis (1974) for discussion of the effects of seasonal adjustment.

rather than returns to labour.[12] Estimation does not seem very sensitive to which measure of orders is used, though the measure of orders-on-hand which yields the best results in terms of highest explanatory power, highest D.W. statistic and, incidentally, the highest λ and α is the OBC measure.

However, a weakness of specification (4.3) is that it is not homogenous of degree one. An alternative specification, which does have this property and is perhaps more plausible, can be obtained by taking the ratio of orders on hand to current output as the relevant factor influencing desired output.[13] (4.3) then becomes:-

$$Q_t^* = Q_t (O/Q)_t^{\varepsilon} \qquad \text{.........} \quad (4.3)'$$

incorporating (4.3)' in (4.5) we obtain:

$$\log E_t = A + \frac{\lambda}{\alpha}(1-\varepsilon) \log Q_t + \frac{\lambda\varepsilon}{\alpha} \log O_t - \frac{\lambda\gamma t}{\alpha} - \lambda\beta \log H_{ot} + (1-\lambda) \log E_{t-1} + u_t \qquad \text{...............} \quad (4.6)'$$

This formulation is the same as (4.6) except that the coefficient on $\log Q_t$ now has a different interpretation.

Values /

(12) See Ireland and Smyth (1970)

(13) I am indebted to D. Bosworth for this suggestion.

Values of α, the returns to labour parameter, are obtained by dividing the adjustment speed, λ, by the sum of the coefficients of log Q_t and logO_t. When this is done for (B), (C), (D) and (E), the α' values yielded are 0.847, 1.070, 0.876 and 0.803. These values are lower than the original estimates and more consistent with expected returns to labour values. This fact, in conjunction with the theoretical superiority of (4.3)' over (4.3), leads to a preference for these results over the earlier on

The procedure adopted in estimating (4.7) was to allocate successive values to η at 0.1 intervals in the range from zero to unity, these values corresponding to the two extreme cases. Values of desired output, Q^*, were thus derived for each value of η and used in log form in place of log Q^* in the Ball and St. Cyr type of employment function. The optimal value of η is chosen as the one which yields the minimum sum of squared residuals and its value can be found more accurately by carrying out a 'grid search' as above, with 0.01 intervals around the first stage optimum. The resulting estimates can then be compared with the basic employment function which uses actual output and the improvement in explanatory power observed. One practical point to be noted when adding output and orders together is that they are both series in index form. When logs were taken separately, the scale of the two series did not matter as it affects only the constant and not the coefficients. To add them together before taking logs requires knowledge of their relative magnitudes. The source of this knowledge is

/data

data on the value of average quarterly sales and total orders-on-hand for 1970, £2,224M and £5,466M respectively, kindly supplied by the Department of Industry. The appropriate adjustment to the indices was made - see data appendix.

The optimal results from estimating (4.7) are reported (F), (G) and (H) for OT, OBT and OBD respectively (the results for OBC differed from those for total orders, only in the constant term). The optimal values of η were 0.07, 0.06 and 0.06 respectively. Each formulation yields similar results in terms of explanatory power, speed of adjustment of about 20% per quarter and returns to labour of about 0.8. This latter figure is consistent with the values implied by the multiplicative formulation , (4.3)[1].

The overall impression is that the choice of measure of orders-on-hand is not crucial in the additive formulation. Any measure, whether total or backlog, directly or indirectly obtained, will represent a statistical improvement on the basic Ball and St. Cyr model. In the multiplicative formulation, whilst all measures add significantly the OBC measure appears to add the most in explanatory power. Because of this it is worth pointing out the changes implied between this formulation and the basic model.

The coefficient on log OBC in the specification (4.3), reported as (C), can be interpreted as $\frac{\lambda\varepsilon}{\alpha}$ where λ is the adjustment speed, α is returns to labour and ε is the /power

power to which the orders-ratio is raised in the desired output specification. Dividing this coefficient by the estimate of $\frac{\lambda}{\alpha}$ already obtained, gives an ε estimate of 0.034. This figure implies that a 100% increase in the 'backlog' element of orders-on-hand would increase the level of desired output by 3.4%. At first sight this effect seems small in magnitude relative to the effect of actual output but it should be noted that the orders series is much more subject to variation than output with a coefficient of variation more than three times as large (0.57 compared with 0.17).

What is more important to note is the effect that the inclusion of the orders variable has on the relationship of actual output to employment. Before the addition, unrealistically low returns to labour (or returns to scale depending on the interpretation) of 0.54 were found whereas afterwards the value was much more plausible at 1.07. The implication for employment is that an increase in output would only require approximately half the extra men that the results (A) suggested. Thus the inclusion of this orders-on-hand term has an effect of considerable magnitude.

4.4 Conclusions

The general conclusion from this empirical work is that a series of orders-on-hand, particularly one representing backlog orders rather than work-in-progress, can add significantly to the explanation of employment and can improve the plausibility of such an explanation considerably. The theory postulated suggests that this is due

/to

to the level of orders affecting firms' desired output and that desired output rather than actual output determines desired employment.

For many reasons these conclusions are tentative. Firstly, the specification of the theory is difficult and we cannot be sure that we have found the correct functional form. Secondly, we were only able to test the specification for one set of data. Previously we have used three sets and amendments to the specification have sometimes been found to work well for one set but not for the others. As the models developed are intended to have reasonably general applicability, further testing is desirable.

However, the reason why only SIC6 was considered in this exercise is that it was the only engineering SIC for which the relevant orders data could be obtained. This fact is not merely a quirk of data reporting but reflects the nature of the industry. In SIC6 a large part of the output is as capital goods often tailor-made for the buyers, firms in other industries. Consequently, specific orders will be placed. In most other industries, including other branches of engineering, few specific capital goods are produced and demand can generally be satisfied without the need for lengthy order lists.

It may be possible to study employment determination at a more disaggregate level. Data on orders-on-hand is available for many of the M.L.Hs. which make up SIC6.

/Alternatively,

Alternatively, order series are available for certain other industries, e.g. series for shipbuilding, textiles and clothing, construction and domestic furniture can be found in the Monthly Digest of Statistics. A similar type of analysis may be possible in industries which do not have orders-on-hand but hold inventories of finished goods. Inventories can be considered as the negative of an orders backlog.(14)

Thus, whilst use of the above approach shows some promise in particular situations, its limited applicability, due to the type of output behaviour specified and data requirements, makes it unlikely that a satisfactory general explanation of employment will be achieved by further investigation. Consequently, we now turn to a more general modification of the employment relation which examines the production specification and the substitutability of capital and labour.

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(14) See Holt et al p.49 and 56.
Such a measure of finished goods on hand was included in estimation for SIC6 both instead of and as well as orders-on-hand, but no evidence of significance was perceived.

FIGURE 4.1 ORDERS-ON-HAND FOR SIC6, 1959-71.

TABLE 4.1 ESTIMATES OF THE BALL AND ST. CYR EMPLOYMENT FUNCTION, INCLUDING ORDERS-ON-HAND, for SIC6, 1959-71

Dep. Var. $LogE_t$	Constant	$LogE_{t-1}$	t	$LogH_{ot}$	$LogQ_t$	$LogO_t$	$Log(Q+O)_t$	$\bar{R}^2$ S.E.	DW h	$\hat{\lambda}$ $\hat{\eta}$	$\hat{\alpha}$ $\hat{\alpha}'$	
(A)	0.62 (0.7)	0.875 (15.9)	-0.0028 (5.3)	-0.132 (1.1)	0.232 (4.8)			0.983 0.007	1.41 2.24	0.125 -	0.539 -	(A) BASIC MODEL
(B)	1.25 (1.6)	0.789 (14.5)	-0.0025 (5.3)	-0.148 (1.4)	0.207 (4.7)	0.0423 (3.6)		0.986 0.006	1.64 1.36	0.211 -	1.019 0.847	(B) WITH OT
(C)	1.54 (2.1)	0.755 (14.9)	-0.0020 (4.4)	-0.130 (1.4)	0.221 (5.6)	0.0077 (4.9)		0.989 0.005	1.78 0.82	0.245 -	1.109 1.070	(C) WITH OBC
(D)	1.30 (1.6)	0.774 (13.8)	-0.0026 (5.6)	-0.133 (1.3)	0.253 (5.9)	0.0045 (3.7)		0.986 0.005	1.69 1.18	0.226 -	0.893 0.876	(D) WITH OBT
(E)	1.43 (1.7)	0.796 (14.4)	-0.0026 (5.6)	-0.200 (1.9)	0.227 (5.2)	0.0271 (3.3)		0.986 0.006	1.69 1.18	0.204 -	0.899 0.803	(E) WITH OBD
(F)	1.18 (1.5)	0.795 (15.3)	-0.0025 (7.0)	-0.147 (1.4)			0.249 (6.5)	0.986 0.006	1.64 1.35	0.205 0.07	0.823 -	(F) WITH OT
(G)	1.20 (1.6)	0.798 (15.3)	-0.0027 (7.0)	-0.148 (1.4)			0.251 (6.4)	0.986 0.006	1.64 1.35	0.202 0.06	0.805 -	(G) WITH OBT
(H)	1.32 (1.7)	0.804 (15.3)	-0.0027 (6.8)	-0.193 (1.8)			0.254 (6.3)	0.985 0.006	1.68 1.20	0.196 0.06	0.772 -	(H) WITH OBD

5. A Vintage employment function

5.1 Introduction

In this chapter we attempt to put forward an employment function which, unlike the vast majority of functions reviewed and tested earlier, is not dependent on a neoclassical production framework.

The neoclassical premise, that the inputs of labour and capital used in production are substitutable, i.e. that identical output can be produced by a wide variety of combinations of labour and capital, with capital costlessly malleable as an input, may be unrealistic. In addition, the specification of technical progress as "falling steadily" on all production processes regardless of the age of capital is difficult to accept.

The vintage or 'putty-clay' approach to the production process allows producers to invest in new machinery which has the capital-labour ratio of their choice, subject to technical possibility constraints, but, once installed, machines have fixed capital labour ratios for the rest of their lives. Consequently, capital and labour substitution is not possible on established machines though substitution is possible in a limited way through new investment and through the use of some machines and not others. Technical progress determines the choice available to firms at the time of investment but does not affect machines already installed. This is referred to as 'embodied' technical progress. This last feature is still unrealistic in the sense that modifications to existing capital are not permitted but this feature would make the analysis exceedingly complex.

Vintage /

Vintage production functions, as the neoclassical ones, are formulated at the microeconomic level relating the use of particular types of labour and capital to the production of output. However, the aggregation of the inputs, in particular of capital, is made much more complicated by the vintage assumptions. For valid aggregation, details of the age composition and utilisation of a firm's or industry's capital stock is needed and such information is not readily available. The derivation of a valid macroeconomic putty-clay production function is a difficult task and its empirical application even more so. In this chapter, we do not attempt to formulate and test a rigorous exposition of the putty-clay theory[1]. Rather we attempt to put forward a formulation which could claim to have some links with the putty-clay theory with some necessarily strong assumptions needed for practical purposes. The main purpose is to remedy the neglect of the effects of capital, and in particular of new investment on the level of employment, which is prevalent in the majority of employment studies. In keeping with the rest of this study, the aim is to see if a useful relationship can be found at the industry level of aggregation. The work follows Bosworth (1974), though the various additional assumptions and the level of aggregation chosen are the author's responsibility.

5.2 A putty-clay formulation

Firstly, we assume that a piece of capital, once installed, requires the same input of labour services per unit /

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(1) See Nickell (1978) for an analysis of the theoretical features of the model.

unit of output over the whole of its life. The capital/labour ratio of established machines is thus unaffected by technical progress and is dependent on the 'vintage' only. The present vintage's capital/labour ratio is chosen by firms dependent on the current state of technology and the relative costs of capital and labour. The capital/labour relationship is strictly applicable to individual types of machine of particular vintage related to labour of particular skill levels, producing one type of output. We here assume that we can aggregate within an industry the output, labour and also capital, by machine type but not straightforwardly by vintage, to obtain a relationship:-

$$L_t = \Psi_t K_t U_{t,t} + \Psi_{t-1} K_{t-1} U_{t-1,t} + \Psi_{t-2} K_{t-2} U_{t-2,t} + \cdots$$

$$\cdots + \Psi_{t-\tau+1} K_{t-\tau+1} U_{t-\tau+1,t} \cdots\cdots \qquad (5.1)$$

which states that the amount of labour being used at time t, L_t, is equal to the labour-capital ratio, Ψ, of vintage t (i.e. current) capital multiplied by the amount of capital stock, K, of vintage t multiplied by its rate of utilisation, U, at time t plus the amount of vintage (t-1)'s capital being utilised at time t multiplied by its labour-capital ratio and similarly for each vintage of capital being used in the industry, with τ being the age at which the capital is scrapped.

Of the variables in (5.1), we have data on the amount of /

of capital of each vintage i.e. investment, but we have little information on the rate of utilisation of different vintages and the different vintages' labour-capital ratios are unknown. In fact, little is known about how labour is allocated amongst capital of different ages. Even if data on the rates of utilisation were available it is doubtful whether meaningful labour-capital ratios could be estimated from (5.1) due to the large number of parameters to be estimated - one for each vintage of capital in use.

Rather than attempting estimation of (5.1) directly with a large number of unknowns, we follow Bosworth is specifying expression (5.1) at time (t-1) as well as time t. Taking the difference between the two expressions and denoting $x_t - x_{t-1}$ as Δx_t yields:-

$$\Delta L_t = \Psi_t K_t U_{t,t} + \Psi_{t-1} K_{t-1} \Delta U_{t-1,t} + \ldots\ldots$$

$$\ldots + \Psi_{t-\tau+1} K_{t-\tau+1} \Delta U_{t-\tau+1,t} - \Psi_{t-\tau} K_{t-\tau} U_{t-\tau,t-1} \ldots \quad (5.2)$$

In this form we can make simplifying assumptions about the change in utilisation of all vintages except the newest and the oldest rather than about the absolute levels of utilisation. Several possible assumptions about the pattern of utilisation can be made. The 'pure' putty-clay theory suggests that either machines will be 'profitable' and will be fully utilised or they will be unprofitable and have zero utilisation. The further assumption is generally made that the wage-rental ratio has risen monotonically over /

over time and hence the labour-capital ratio will have fallen monotonically. Consequently profits, defined as revenue minus labour costs i.e. quasi-rent, will decline as the capital gets older until they become zero at which point the capital will cease to be used and will be scrapped unless there is a possibility of profits in the future e.g. a future increase in demand for the industry's product could cause a price rise and so increase revenue.

Therefore the strong implication is that the newer vintages will always be fully utilised but that vintages at a certain age, μ, begin to yield a negative quasi-rent and will be laid up if μ is less than τ, and scrapped if μ equals τ. Expression (5.2) would then become:

$$\Delta L_t = \Psi_t K_t - \Psi_{t-\mu} K_{t-\mu} \qquad \ldots\ldots\ldots\ldots \qquad (5.3)$$

We have available some information on the average age of capital being scrapped in an industry but none on the extent to which capital is laid up. The latter may be particularly important in recessions when demand is low but future profits are expected. Consequently, even with the strong assumptions of putty-clay theory, valid estimation is not possible.

A model has been developed by Peterson (1976) along the above lines. Estimation is made possible by several additional assumptions. The productivity of new investment is assumed to bear a constant ratio to the average /

average productivity of all vintages. Similarly, the productivity of the vintage being scrapped is assumed to bear a constant ratio to average productivity. In addition, the capital-output ratio is assumed to be constant over time. This enables the change in employment between one period and the next to be expressed as a function of the corresponding change in output, the level of investment and the average output per man.

The model is intended for use as a medium-term forecasting model and so the above assumptions may be acceptable for explaining, or at least predicting, in that context. It is not claimed to explain short-run fluctuations, nor to be suitable for ordinary time-series estimation. In particular, no account is taken of vintages being laid-up, rather than scrapped, in recessions to be used when demand increases. The assumption of a fixed capital-output ratio seems restrictive, perhaps more so in a long-run model than in a short-run one.

Furthermore, it is probably unrealistic to expect firms to act in the purely rational way postulated above. Strictly defined, full utilisation would mean that a machine was in use twenty-four hours a day and this is seldom the case. It is perhaps more realistic to expect new machines to be most heavily utilised with utilisation declining as machines get older. We here define full utilisation as the highest practical level of utilisation (dependent on the extent of shift-working etc.) and assume that the rate of utilisation declines to zero at the scrapping /

scrapping age. In this case the extent of scrapping is unimportant to the overall labour requirements as the utilisation of that vintage is so low in the previous period. However, the utilisation of all vintages will change from period to period due both to the 'ageing loss of efficiency' effect and the extent of demand for the industry's product determining the need for machine-time. We assume these 'changes in utilisation' effects are similar for all vintages and so we aggregate all but the latest vintage to give the capital stock at the beginning of time t, $\overline{K}_t$, with an average labour capital ratio of $\overline{\Psi}_t$ (2) and a change in its utilisation of $\Delta\overline{U}_t$. With full utilisation of new capital, (5.2) becomes:-

$$\Delta L_t = \Psi_t K_t + \overline{\Psi}_t \overline{K}_t \Delta\overline{U}_t \qquad \ldots\ldots \qquad (5.4)$$

Measurement of the average rate of utilisation of capital is very difficult and no data is available to achieve this directly. Several indirect or proxy measures for capital utilisation are available.

One method developed by Heathfield (1972) proxies capital utilisation by relating data on the industry's electricity /

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(2) See expression (5.8) for the meaning of $\overline{\Psi}_t$

electricity consumption to the total electrical capacity of the industry's capital stock. This procedure should be quite successful in indicating changes in the rate of utilisation over time but there is a lack of quarterly data on electricity consumption at the industry level, especially prior to 1963. Hence this measure could not be used, though a measure based on 'electricity generated outside the public system' was constructed and used in estimation. However, it proved inferior in performance to another method referred to as the 'Wharton School' measure, as used in Chapter 3. The suggested procedure is to define a capacity output series as a trend through the peaks of actual output and then to express actual output as a percentage of capacity output. This gives a capacity utilisation measure rather than a capital utilisation one and, as such will reflect variations in output and labour usage as well as in capital usage itself. However, the two are likely to be strongly correlated. Consequently, lacking any superior measure, we use changes in capacity utilisation to proxy changes in capital usage.

It is still not yet possible to estimate (5.4) over time, despite having data on $\bar{K}$, $\overline{K}$ and $\Delta\overline{U}$. The reason for this is that, whilst the labour-capital ratio, Ψ, stays constant for a particular vintage once installed, it does not stay constant from vintage to vintage over time. We must specify how the labour-capital ratio changes over time to make (5.4) estimatable. As discussed earlier, /

earlier, the putty-clay theory allows a firm to choose the labour-capital ratio of its new investment, subject to the current state of technology. It is postulated that it chooses the ratio which will minimize its costs of production, given the current wage-rental ratio, w/r. For example, if the ex-ante production function is of Cobb-Douglas form, with constant returns to scale, then the firm will choose its labour-capital ratio inversely proportional to the wage-rental ratio.

For simplicity, we can specify a linear relationship between the labour-capital and wage-rental ratios:-

$$\Psi_t = a' + b' (w/r)_t \qquad \ldots\ldots \qquad (5.5)$$

with b' expected to be negative. We have data on wage rates and on the cost of capital. However, to obtain an expression for $\overline{\Psi}_t$ we would need data on the wage-rental ratio for all vintages of capital in existence. As capital stock is often twenty or thirty years old, this data is not easily available. Instead we follow the Bosworth suggestion that the wage-rental ratio has trended linearly over time:-

$$(w/r)_t = e + ft \qquad \ldots\ldots \qquad (5.6)$$

Combining (5.5) and (5.6) we get:-

$$\Psi_t = a + bt \qquad \ldots\ldots \qquad (5.7)$$

with /

with b negative. We can now define the average labour-capital ratio of existing capital as:-

$$\overline{\Psi}_t = \sum_{t-\tau+1}^{t-1} \Psi_i \, K_i \, / \, \overline{K}_t \qquad \ldots\ldots \qquad (5.8)$$

where $\overline{K}_t = \Sigma K_i$. In other words, $\overline{\Psi}$ is a weighted average of the labour-capital ratios of all existing capital stock in the industry. From (5.7) and (5.8) we get:-

$$\overline{\Psi}_t = \Sigma(a+bi) \, K_i \, / \, \overline{K}_t = a + b \, (\Sigma \, i \, K_i) \, / \, \overline{K}_t \quad \ldots\ldots \quad (5.9)$$

and the multiple of b in (5.9) can be recognized as t minus the average age of capital at time t, which we denote by ν_t.

Thus:-

$$\overline{\Psi}_t = a + b \, (t-\nu_t) \qquad \ldots\ldots \qquad (5.10)$$

Incorporation of expression (5.7) and (5.10) into (5.4) depends upon whether there is data available for the average age of capital or not. Ideally a data series for ν_t would be used to calculate $(t-\nu_t)$ for each time period and so (5.4) could be estimated as:-

$$\Delta L_t = a(K_t + \bar{K}_t \Delta \bar{U}_t) + b(tK_t + (t-\nu_t)\bar{K}_t \Delta \bar{U}_t) \quad \ldots\ldots (5.11)$$

with a and b the only unknowns. Such a data series for ν_t is not available to the knowledge of the author. However, it may be a reasonable approximation to reality to treat the average age of capital either as constant over the estimation period or as having a linear trend over the period. The latter occurring where an industry is gradually expanding or reducing its overall capital stock, or where capital equipment is generally becoming more or less durable. It can also be argued that the average age of capital would vary with the investment and scrapping cycles of an industry but, this pattern is unlikely to be pronounced and is neglected in this study.

The assumption of a constant but unknown average age of capital would result in the estimation of (5.4) as:-

$$\Delta L_t = aK_t + (a-b\bar{\nu})\bar{K}_t \Delta \bar{U}_t + bt(K_t + \bar{K}_t \Delta \bar{U}_t) \quad \ldots\ldots (5.12)$$

with a, b, and $\bar{\nu}$ as the unknowns. Hence, the average age of capital should be estimatable.

The assumption of a trending average age of capital:-

$$\nu_t = \nu_o + \nu_1 t \quad \ldots\ldots (5.13)$$

would result in (5.4) being expressed as:-

$$\Delta L_t = \overset{+}{a}K_t + (\overset{+}{a - bv_o})\bar{K}_t\Delta\bar{U}_t + \overset{-}{b}tK_t + \overset{-}{b(1-v_1)}t\bar{K}_t\ \Delta\bar{U}_t \quad \ldots. \quad (5.14)$$

with a, b, v_o and v_1 as the unknowns, estimates of which should be derivable from estimation of (5.14); expected signs as indicated.

(5.14) then represents the full formulation of our putty-clay hypothesis incorporating the hypotheses of the relationship of labour to new investment and existing capital stock, (5.4), of the movement of the labour-capital ratio over time, (5.7), and of an unknown but linearly trending average age of capital, (5.13). A priori information about v can be incorporated into the estimation by use of formulation (5.11) and constancy of v tested by comparison of formulation (5.12) with (5.14).

Work by Bacon and Eltis (1974) on the age of machine tools would suggest little change in the life of such machinery, for all industrial uses, between 1961 and 1971. If this conclusion can be assumed to hold for all capital stock then constancy of average age would seem to be a reasonable assumption. Furthermore, a value of v in the region of twelve years is indicated. Such a value can be tested by using it in formulation (5.11) and comparing it with (5.12) [and/or (5.14)].

Various other hypotheses are possible which, if valid, would simplify the analysis. One very restrictive hypothesis is that the labour-capital ratio remains constant /

constant over time. This corresponds to a zero b in (5.7) and consequently in (5.11), leaving the formulation:-

$$\Delta L_t = a(K_t + \bar{K}_t \Delta \bar{U}_t) \quad \ldots\ldots \quad (5.15)$$

Another interesting restriction that can be tested is the postulate that only new investment affects changes in employment not changes in the utilisation of the capital stock, (i.e. $\Delta \bar{U} = 0$). This corresponds to the profit maximizing putty-clay theory, discussed earlier and formulated as (5.3), except for the neglect of effects of laying-up or scrapping capital.[3] The combination of this hypothesis and the linear trend in the labour-capital ratio, (5.7), gives:-

$$\Delta L_t = a\ K_t + b\ tK_t \quad \ldots\ldots\ldots\ldots (5.16)$$

We can now proceed to the estimation of the various formulations and testing of the related hypotheses.

5.3 Empirical application and testing of the putty-clay formulation

Details of the derivation of the various data series are given in the appendix. As the investment data are the novel element in the explanation of employment, a brief description /

(3) If firms tend to hoard the labour released by laying-up or scrapping, then such a formulation may be realistic.

description of their pattern over the estimation period might be useful. For SIC6, the investment series shows a weak trend, though the value at the end of 1971 is lower than in 1959. The pattern roughly corresponds to the cyclical pattern of output. Large changes in investment from quarter to quarter are rare; the largest values occur in 1970 but some of the lowest in 1971. The other SIC's have a similar pattern to SIC6.

The various relationships formulated in the previous section were estimated by regression. The explanatory power of these results cannot be directly compared with earlier results for two reasons. Firstly, the variables are expressed in numerical rather than logarithmic form and secondly, the dependent variable is the change in employment rather than the absolute level. It is obviously easier to explain variation in the level of employment than in changes in employment and so a considerably lower $\bar{R}^2$ will be expected, in the following results. One empirical question remains before estimation and that is whether to include a constant term and seasonal dummies. According to the formulations no constant should be included. However, estimation was carried out with and without a constant and it was found to be sometimes significant. For this reason the results reported include a constant as it is possible that there are trends in employment[4] not accounted for by our aggregate putty-clay formulation and the constant will pick /

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(4) Due perhaps to disembodied technical progress or the scrapping or laying-up of capital, neglected here through lack of data.

pick these up. This seems preferable to forcing the regression to pass through the origin which may bias estimation. A similar reasoning applies to seasonal dummies - there may be a seasonal pattern to employment, investment or capital utilisation which is not accounted for by the model e.g. capital utilisation will be low in summer due to holidays but the number of employees will not be reduced (though actual man-hours worked will be). Consequently, seasonal dummies are included in all regressions but omitted from the Tables for convenience of presentation.

First of all, estimation was performed for all three S.I.C. Orders, of the equation (5.14) as the most general formulation of our hypothesis and these are reported in Table 5.1 as (A). The explanatory power of the formulation is quite high for SIC6 (66%), reasonable for SIC9 (36%) but low for SIC8, (13%). In fact, no significant explanation of employment changes can be claimed for SIC8, even at the 5% significance level. The Durbin-Watson test indicates positive autocorrelation for SIC'8 and 9 and is inconclusive for SIC6. Due to its higher explanatory power in this formulation, attention was concentrated on SIC6 in the interpretation of parameter estimates and the testing of further formulations though the same estimation and testing was carried out for the other SIC's and will be discussed though not fully reported.

For SIC6, the coefficients relating to current investment are both strongly significant (from zero) at the /

the 5% level and of correct sign but the coefficients which relate to changes in utilisation of existing capital stock are not significant. The implication of the former coefficients is that, at time zero (1959, second quarter), £1m of investment, at constant prices, causes an increase in employment of 2,309 employees. The trend in the labour-capital ratio will reduce this extra employment by approximately eighteen each quarter so that by the end of 1971, only 1,424 employees are needed for an investment of £1m.

A typical quarterly investment figure of £57m would thus require 142,000 employees in 1959 and only 90,000 in 1971. Set against these changes are the values of the constant and seasonal dummies implying an 'autonomous' loss in the region of 100,000 employees per quarter. This loss is presumably due either to disembodied technical progress or to the scrapping or laying-up of capital equipment which has not been captured directly.

The coefficients on capital utilisation, as well as being insignificant, imply totally implausible values for the average age of capital and its trend.

For SIC9, the 'trend' coefficient on current investment is strongly significant whilst the 'initial' investment term is not - both are of correct sign. The capital utilisation terms are also of expected sign but lacking in significance.

The implied initial labour capital ratio is very low in comparison with SIC6 whilst the trend in it is of comparable /

comparable magnitude i.e. a fall of twelve per quarter. The implications for the average age of capital are again implausible.

For SIC8, the estimated coefficients on current investment are totally insignificant and implausible whilst those on capital utilisation are both significant at the 5% level and of expected sign. However, the implied labour-capital ratios cannot be separated from the unknown average age of capital.(5)

The overall conclusion from these estimates is that (5.14) does not represent an acceptable explanation of 'putty-clay generated' employment changes, particularly in the utilisation of existing capital stock. One reason for this could be lack of information on the age of capital. It may be asking too much of the estimation to yield precise estimates of the labour-capital ratio and its trend <u>and</u> the average age of capital and its trend, particularly as there is some sign of multi-collinearity between the two capital utilisation terms. As already mentioned, work by Bacon and Eltis on the age of machine tools has suggested little change in the average age of such capital over our period of study. If we assume that this is true for all capital then we can estimate (5.12) as a restricted form of (5.14). Explanatory power can not be much improved but more accurate estimates may be obtained if the constancy assumption/

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(5) However, see the interpretation of results (D) below.

assumption is correct. The hypothesis of constancy can be tested by use of an 'F-test' which compares the (unexplained) residual sum of squares of the two estimations. More rigorously, we calculate:-

$$F = \frac{RSS_2 - RSS_1}{RSS_1} \times \frac{n - k}{r}$$

where RSS_2 is the residual sum of squares of the null hypothesis in question, (5.12), and RSS_1 is the residual sum of squares of the more general alternative hypothesis, (5.14). n is the number of observations, k is the number of parameters in (5.14) and r is the number of restrictions imposed to obtain the hypothesis being tested, (5.12). The expression (5.17) has an F distribution with $(r, n-k)$ degrees of freedom. By comparing the calculated value with 'table values' the hypothesis under test can be rejected or tentatively accepted (i.e. not rejected) at a chosen significance level - normally 5% or 1%.

Using this test the assumption of constant average age is strongly rejected at the 1% significance level for SIC's 6 and 9 though it is accepted for SIC8 - F-values of 42.2, 8.5 and 0.1 respectively compared with a critical value of 7.3. However, since estimation of (5.12) does not provide a significant explanation of employment changes in SIC8, this non-rejection of constancy is /

is not very helpful. The results reported as (B) for SIC6 indicate a considerable worsening of explanatory power and autocorrelation with no greater precision of estimates. An implausible average age of capital is still implied. Specification of an average age of capital in the region of twelve years, as found by Bacon and Eltis, is even less acceptable and estimation of (5.11) results in insignificant and implausible labour-capital ratios (not reported).

A further hypothesis, that the labour-capital ratio remains constant and hence the age of capital can be ignored (b=0), was tested by estimating (5.15). This proved equally unsuccessful, being rejected strongly as expected, and is not reported.

However, the hypothesis that it is current investment and not existing capital which determines employment changes so that the age of capital can again be neglected, met with more success. The formulation (5.16) was not rejected at the 1% level in comparison with (5.14) for SIC's 6 and 9 though it was rejected for SIC8 - F values of 4.0, 1.6 and 6.0 respectively.

The results, reported as (C), indicate a slightly lower explanatory power for SIC6 with evidence of autocorrelation present. The parameter estimates of 'a' and 'b' were similar to those in results (A). For SIC9 the 'a' estimate remained insignificant and became negative and the 'b' coefficient was only marginally altered. The results for SIC8 were unsatisfactory in all aspects /

aspects with zero explanatory power - negative $\overline{R}^2$.

The 'reverse' hypothesis that it is changes in the utilisation of existing capital stock rather than new investment which determines employment changes was also tested.(6) This formulation was strongly rejected for SIC's 6 and 9 with F-values of 30.2 and 7.4 respectively. However, the hypothesis is <u>not</u> rejected for SIC8 (F of 0.3) and in fact yields an explanation of employment changes which is significant at the 5% level, though explanatory power is still low at 16% and evidence of autocorrelation is still present. The estimates for SIC8 reported as (D), are difficult to interpret, involving labour-capital ratios and average age of capital. But, if we assume a constant average age of capital of twelve and a half years - a hypothesis not rejected for SIC8 - then (5.18) becomes:-

$$\Delta E_t = (a-b\overline{\nu})\overline{K}_t\Delta\overline{U}_t + bt\overline{K}_t\Delta\overline{U}_t \quad \ldots\ldots\ldots \quad (5.18)$$

where $\overline{\nu}$ = 50 (quarters). The estimates then yield an initial labour-capital ratio of 203 employees per £1m of capital and a reduction in this value of 2.2 per quarter. Both of these values are low when compared with the earlier estimates for SIC6(7).

The /

(6) Formulated as:- $\Delta L_t = (a-b\nu_o)\overline{K}_t\,\overline{U}_t + b(1-\vartheta_1)t\overline{K}_t\Delta\overline{U}_t \quad \ldots.(5.18)$

(7) The initial labour-capital ratio is clearly subject to the assumed average age of capital. However an assumed age of 15 years yields only 225 employees per £1m and an age of 10 years yields 181 employees per £1m.

The general conclusions from the estimation so far is that current investment is most important to employment behaviour in SIC's 6 and 9 whilst changes in utilisation of existing capital stock is most important in SIC8 (vehicles). The degree of explanatory power and the plausibility of the implied labour-capital ratios etc. still leave room for improvement, particularly for SIC's 8 and 9. One possible reason for lack of satisfactory performance may be the treatment of capital effects on employment as occurring instantaneously (within a quarter). It may be much more reasonable to expect a lag in the adjustment of the labour force and this possibility is investigated in the next section.

5.4 Putty-clay formulation with a lag structure

In the last section it was found that a formulation explaining changes in employment purely by investment was statistically acceptable relative to a formulation which also included the effects of changes in the utilisation of existing capital, for SIC's 6 and 9. We now concentrate on this important determinant of employment, investment, and investigate the possibility that new investment may not have a full immediate effect on employment but that it may take several time periods before employment is fully adjusted to the new capital requirements. Hence a lag structure between investment and employment will be expected.

/There

There are several reasons why a lag might be present. Firstly, our data on investment will measure the amount of capital goods purchased in a particular time period. Due to time taken in installing and making operational new machinery it may be several months (more if the capital is in the form of buildings) before the firm needs to adjust its labour force to fully man the new capital. Secondly, it may take time for a firm to recruit new employees of the type required for the new capital, particularly if skills which are in short supply are required.

On the other hand, a firm may anticipate its forthcoming need for extra labour and take on employees at the same time or even before it places an investment order. This would be possible where labour of a certain skill was essential to the new investment and had to be found or trained before investment was worthwhile. In this case, employment changes would lead investment.

However, the magnitude of this latter effect is likely to be small and is unlikely to justify the formulation of a model which explains employment by <u>future</u> changes in explanatory variables. This would yield problems of simultaneity in estimation and make forecasting especially difficult. The more likely postulate, that employment changes will follow investment with a lag, is preferred and an attempt to determine the lag structure is made below.

We have no strong a priori conditions for the

/distribution

distribution of the lag though we would expect positive estimates for the effects of earlier investment on present employment. The procedure adopted was to first regress the (5.16) formulation for all three SIC's using observations of investment and 'trend-investment' with successive lags of zero, one, two, three and four quarters. The aim behind this procedure is to get some idea of the magnitude and strength of each lag term in explaining current employment changes. When many lagged terms are included together their individual effects often become submerged by multicollinearity. Of course, coefficients in the separate regressions may be biased but some idea of their relative importance in explaining employment may be gained.

The regressions for SIC6 (not reported) indicate that current values of investment have the greatest explanatory power, 61% with both coefficients strongly significant. However, a one period lag yields significant coefficients of similar magnitude to the current ones with explanatory power of 47%. The two and three period lags yield lower explanatory power, both about 37% but the four period lag yields explanatory power of 50%. The coefficient on investment is insignificant for the two and three quarter lags but is significantly negative in the four quarter case implying that investment a year ago actually reduces employment now - labour-reducing investment? Also the constant is significantly positive.

/When

When all lag terms are included in estimation together there is high multicollinearity, particularly amongst the 'trend-investment' terms. All terms become insignificant and five of the ten have the wrong sign. The overall explanatory power of 67% is not significantly higher than that obtained with current values only.

For SIC8, all lags from zero to four produce no significant explanation of employment changes whether separately or in conjunction. For SIC9, explanatory power is slightly higher for lagged investment and estimates of the initial labour-capital ratio become significant but sadly remain negative.

It is clear that an appropriate lag structure cannot be obtained by straightforward regression techniques due to multicollinearity. This is often the case in econometrics and techniques have been developed which attempt to overcome this problem. One technique which has been used with some success in the investment context is that developed by Almon (1965). In this we postulate that the lag structure can be closely approximated by a polynomial of a low degree relative to the maximum length of lag e.g. a quadratic or cubic function. The parameters of the polynomial are then determined by minimizing the corresponding residual sum of squares and the lagged investment coefficients are determined by interpolation. This procedure has the advantage of saving degrees of freedom

/over

over the straightforward regression method, often only requiring the estimation of two or three parameters. Provided that the structure can be approximated by a polynomial of low degree this should lead to better estimates with lower standard errors and hence more precision which will counteract the multicollinearity effects.

The Almon method was used in the present context for SIC6 and the degrees of polynomial used were quadratic and cubic. Lags of length four periods, which is comparable with the ordinary least squares regressions, and eight quarters were chosen. The two explanatory variables were allowed separate lag structures whereas they should really be the same. This would represent a further, and more difficult to apply, restriction on estimation and is not pursued here.

A reduction in the sum of squared residuals is not possible, compared with ordinary least squares regression, as the polynomial lag structure represents a restriction on estimation but a significantly greater residual would indicate that the restriction was invalid and hence that a polynomial of that order could not approximate the lag structure well. In fact, both the quadratic and cubic polynomials yield residuals marginally but not significantly larger. The explanatory power, $\bar{R}^2$, is higher at over 69% for both of the polynomials, due to the greater degrees of freedom. However, the improvement we hoped for, in the significance of the coefficients,

/is

is not to be found. None of the lagged terms in either explanatory variable is significantly different from zero at the 5% level in either the quadratic or cubic formulation, for either a four or eight quarter maximum lag and roughly half of them have the 'wrong' sign; the results are not reported.

In view of the failure of a reasonable general lag distribution to perform well in terms of statistical significance, it was felt that a more specific formula tion of how firms' employment levels react to investment was needed.

A possible approach to this is to specify (5.16) in terms of desired employment, L*, rather than actual:-

$$\Delta L^*_t = aK_t + btK_t \qquad \text{........ (5.19)}$$

i.e. investment determines the change in employment which the firm desires rather than its actual change. There are many reasons why desired and actual employment changes should differ, as discussed in earlier chapters on the adjustment processes in themore traditional type of employment function. Rapid changes in employment would involve high recruitment and training costs which could be lower if spread over time. Uncertainty about future demand or the need to build up market demand to fully utilise new investment may also cause firms to only partially adjust employment towards its desired level. In addition, as already mentioned, some or all of the new investment may not be ready for use when the

/expenditure

expenditure is made and so the required labour need not be recruited immediately.

For these reasons we can postulate that firms only adjust their employment by a fraction of their desired change in any one period:-

$$\Delta L_t = \mu(\Delta L_t^*) \qquad \text{.......... (5.20)}$$

where $0 \leq \mu \leq 1$. In the next period a further fraction μ of the remaining desired adjustment is made:-

$$\Delta L_{t+1} = \mu(1-\mu)\Delta L_t^* \qquad \text{............(5.21)}$$

and this process continues until the remaining desired adjustment becomes negligible. At any point in time the overall change in employment will be made up of various fractions of desired changes in the current and previous periods, i.e.:-

$$\Delta L_t = \mu\Delta L_t^* + \mu(1-\mu)\ \Delta L_{t-1}^* + \mu(1-\mu)^2\ \Delta L_{t-2}^* + \text{..........} \quad (5.22)$$

with:-

$$\mu + \mu(1-\mu) + \mu(1-\mu)^2 + \text{.....} = 1 \quad \text{......} \quad (5.23)$$

The assumption of constancy of the adjustment factor μ over time is a strong one involving both the same adjustment treatment for different vintages of investment and a uniform adjustment for each vintage over time. However, such an assumption does remove the /estimation

estimation problem obtained with a more general lag distribution.

Having obtained the formulation (5.22) which is recognisable as a Koyck distributed lag process, an estimatable expression can be obtained by lagging (5.22) by one period, multiplying it by $(1-\mu)$ and subtracting it from (5.22), whereupon most of the lagged terms cancel to leave:-

$$\Delta L_t - (1-\mu)\Delta L_{t-1} = \mu \Delta L^*_t \qquad \text{..........} \quad (5.24)$$

Rearranging and substituting (5.19) for ΔL^*_t we obtain:-

$$\Delta L_t = \mu a K_t + \mu b t K_t + (1-\mu)\Delta L_{t-1} \qquad \text{......} \quad (5.25)$$

which when estimated should yield values of μ, a and b.

(5.25) is in fact equivalent to formulation (5.16) with the addition of the lagged dependent variable. Whilst there may be some justification for the specification of (5.25), it is clear that the addition of the lagged dependent variable is likely to result in a substantial improvement in explanatory power. It would be dangerous to attribute this improvement (solely) to the validity of our adjustment mechanism since other influences can easily be captured in the lagged term. However, the 'natural' correlation between successive values of the dependent variable is likely to be much less in this case where it is measured in changes rather than in absolute values as is often the case.

/The

The results of estimating (5.25) are reported as (E) in Table 5.2. There is a general improvement in explanatory power for all three SIC's over any previous estimations, the lagged dependent variable being strongly significant for all three SIC's and its value lying between zero and unity in all three cases. The Durbin-Watson statistic is much closer to 2 than in previous results but the presence of the lagged dependent variable tends to bias the statistic towards two. The Durbin (1970) h- test indicates that autocorrelation is significant for SIC6 though not for SIC's 8 and 9. The presence of autocorrelation will bias the estimates for SIC6 and so caution must be exercised in their interpretation and use.

The estimated values for SIC6 indicate partial adjustment of 34% per quarter, an initial labour-capital ratio of 2,669 employees per £1m of investment and a reduction in this labour-capital ratio of approximately twenty each quarter. These values are of the same sort of magnitude as those from estimating (5.16), though the significance of the basic estimates is much reduced, by the addition of the lagged dependent variable, to being barely significant at the 5% level.

For both SIC's 8 and 9, the two investment parameter estimates are insignificantly different from zero and the formulation relies mainly on the lagged dependent variable for explanatory power.(8) Thus, whilst specification (5.25) substantially improves the 'fit' of /the

(8) A purely autoregressive formulation i.e. omitting the investment variables yields $\bar{R}^2$ of 0.43, 0.40 and 0.36, implying that current investment is having a significiant effect for SIC's 6 and 9 but not for SIC 8.

the explanation of employment changes it does little to support the 'putty-clay' hypothesis as it is represented here.

Finally, since it was existing capital stock rather than new investment which seemed to influence employment changes in SIC8, a distributed lag function was applied to (5.18) as with (5.16) above. There is less justification for this lag than with new investment but firms may still prefer to change employment gradually over time and so initially meet changed utilisation of capital with partial adjustment of employment and compensating adjustment of the hours for which labour and capital works.

If we specify desired employment changes as:-

$$\Delta L^*_t = (a-b\nu_o)\bar{K}_t\Delta\bar{U}_t + b(1-\nu_1)t\bar{K}_t\Delta\bar{U}_t \quad \ldots\ldots \quad (5.26)$$

and incorporate this in the lag formulation (5.24) we obtain:-

$$\Delta L_t = \mu(a-b\nu_o)\bar{K}_t\Delta\bar{U}_t + \mu b(1-\nu_1)t\bar{K}_t\Delta\bar{U}_t + (1-\mu)\Delta L_{t-1} \quad \ldots\ldots\ldots\ldots \quad (5.27)$$

This was estimated for all three SICs but as before was unsuccessful for SICs 6 and 9. The results for SIC8, reported as (F), show a substantial increase in explanatory power over (5.25), with an $\bar{R}^2$ of 0.56. All three explanatory variables are strongly significant with expected signs. The parameter values on capital utilisation are similar to those obtained in estimating

/(5.18)

(5.18) i.e. without the lagged dependent variable though their interpretation is now different. Allowing for the partial adjustment of 33% per quarter and assuming a constant average age of capital of twelve and a half years as before, we obtain an initial labour-capital ratio of 633 employees per £lm of capital and a reduction in this ratio of approximately seven employees per quarter. These values are still low in comparison with those for SIC6 but more acceptable.(9)

5.5 Conclusions

The general conclusion is that, whilst a putty-clay approach may be theoretically or intuitively appealing, its application at anything above the most micro of levels is very difficult. Many questionable simplifying assumptions have to be made and the remaining restrictions of the theory do not seem to hold up in estimation. The effects of utilisation of existing capital stock could not be satisfactorily captured and emphasis was placed on the effects of recent investment. The lag structure of this was difficult to derive and whilst the final explanatory power of 75% of changes in employment for SIC6 may indicate the potential of this approach, it is debatable whether this figure is due to validity of the putty-clay hypothesis.

/However,

(9) Again it is possible to try other values for the average age of capital. If 15 years is assumed, then an initial labour-capital ratio of 702 employees per £lm is derived and if 10 years is assumed, a ratio of 564 employees per £lm is obtained.

However, use of the type of model discussed here may well be fruitful at a lower level of aggregation by industry and with more information on the composition, age and utilisation of capital.

The previous chapters have reviewed the employment functions literature both theoretically and empirically.. Employment functions have been applied to the engineering industry SIC's and modified considerably,allowing for the effects of capital and desired output, in terms of orders-on-hand,and allowing more flexible adjustment and a more realistic putty-clay type of production relationship. None of the modifications has been wholly satisfactory. Either the theoretical requirements could not be met by available data, and so restrictive assumptions or unsatisfactory proxy variables were required, or the resulting estimates were implausible in relation to the underlying theory and unstable over time.

Whilst further modifications could perhaps be attempted within the existing employment functions framework, one major reason for the implausibility and instability is felt to be the neglect of supply considerations in the explanation of employment levels. The existing literature is essentially demand-orientated. If supply does influence the level of employment then such demand estimates are likely to be unreliable. The remaining chapters of the thesis are devoted to a formulation of a supply function of labour and analysis of the interaction of the demand and supply forces.

TABLE 5.1 ESTIMATION OF 'PUTTY-CLAY' EMPLOYMENT FUNCTIONS, 1959-1971

	EQUATION	INDUSTRY	CONST.	K_t	tK_t	$\bar{K}_t \Delta \bar{U}_t$	$t\bar{K}_t \Delta \bar{U}_t$	$\bar{R}^2$ S.E.	DW	RSS
(A)	(5.14)	SIC6	- 96.4 (4.5)	2.3087 (5.8)	-0.0177 (7.5)	0.0146 (0.3)	0.0031 (1.5)	0.656 11.75	1.22	5932
(A)	(5.14)	SIC8	- 1.30 (0.2)	- 0.0095 (0.0)	-0.0015 (0.5)	0.0921 (3.5)	-0.0022 (3.3)	0.128 5.44	0.76	1785
(A)	(5.14)	SIC9	3.41 (0.5)	0.1652 (0.3)	-0.0120 (3.4)	0.0584 (1.7)	-0.0014 (1.3)	0.357 4.49	0.70	865
							$t(K_t+\bar{K}_t \Delta \bar{U}_t)$			
(B)	(5.12)	SIC6	- 69.06 (2.3)	1.4875 (2.8)		0.2052 (3.6)	-0.0061 (2.8)	0.319 16.35	0.77	12044
(C)	(5.16)	SIC6	-107.22 (4.7)	2.5064 (6.0)	-0.0184 (7.3)			0.609 12.54	0.81	7081
(C)	(5.16)	SIC8	- 0.94 (0.1)	-0.0320 (0.1)	-0.0016 (0.5)			-ve 7.17	0.68	2311
(C)	(5.16)	SIC9	6.20 (1.0)	-0.0590 (0.1)	-0.0113 (3.2)			0.338 4.55	0.58	934
							$t\bar{K}_t \Delta \bar{U}_t$			
(D)	(5.18)	SIC8	- 2.73 (1.4)			0.0929 (3.6)	-0.0022 (3.4)	0.158 6.34	0.75	1808

t - values in brackets. Dependent variable is ΔL_t

TABLE 5.2 ESTIMATION OF 'PUTTY-CLAY' WITH LAGGED ADJUSTMENT, 1959-1971

	EQUATION	INDUSTRY	CONST	K_t	tK_t	$\bar{K}_t \Delta\bar{U}_t$	$t\bar{K}_t \Delta\bar{U}_t$	ΔL_{t-1}	$\bar{R}^2$ S.E.	DW h	RSS
(E)	(5.25)	SIC 6	-32.25 (1.3)	0.9076 (1.9)	-0.0068 (2.3)			0.6605 (5.0)	0.748 10.07	1.64 3.31	4458
(E)	(5.25)	SIC 8	-5.31 (1.0)	0.1223 (0.6)	-0.0005 (0.2)			0.8321 (5.5)	0.348 5.57	1.87 0.77	1366
(E)	(5.25)	SIC 9	6.05 (1.5)	-0.2579 (0.8)	-0.0021 (0.8)			0.7223 (6.9)	0.660 3.26	2.17 -0.87	469
(F)	(5.27)	SIC 8	-1.77 (1.3)			0.0956 (4.5)	-0.0023 (4.4)	0.6681 (7.1)	0.562 4.57	1.79 0.98	918

t - values in brackets. Dependent variable is ΔL_t

6. The Formulation of Labour Supply and Demand Determination

6.1 Introduction

In this chapter we question the basis for the vast amount of empirical work reviewed and tested earlier in the thesis. This work has relied solely on a demand determination of employment which we feel to be a major weakness. We proceed to develop a model of labour supply.

In the first section we consider the meaning of a supply function to an industry and the possible effects on the estimation of a demand function that the neglect of supply may have. In the second section a supply function is developed theoretically and consideration is given to the measurement of the relevant variables.(1) In the third section a demand function is developed which is appropriate to a joint analysis of supply and demand, again looking at the measurement problems involved. An analysis of how demand and supply interact to yield actual levels of employment is the subject of the next and subsequent chapters.

6.2 Omission of supply factors

A common feature in all the 'employment functions' literature which our study has found to be generally lacking in empirical stability and plausibility, is the neglect of labour supply considerations. Either there is

/no

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(1) It should be pointed out that, in formulating a supply function, the emphasis has been placed on a derivation which can be analysed in conjunction with a demand function.

no mention of supply or the explicit assumption is made that employment responds passively to changes in the demand for labour. Hence, actual employment is demand-determined and only a demand function is relevant to the explanation of employment levels.

The convenience of the assumption is readily apparent in that the problems of formulating and estimating a supply function, with employment determined simultaneously by demand and supply, are removed and estimation in terms of well-founded and observable 'demand' aggregates is straightforward. However, the magnitude of this assumption and its plausibility should be noted carefully. To do this let us assume that the correct specification of employment determination in an industry involves both demand and supply functions and then consider the 'demand-determination' approach in the light of this.

If we simply assume, for the present, that the demand for labour is negatively related to the wage rate, the supply of labour is positively related to the wage rate but that both demand and supply are influenced by other factors which will cause the 'wage-labour' relationships to shift then we can represent this situation as:-

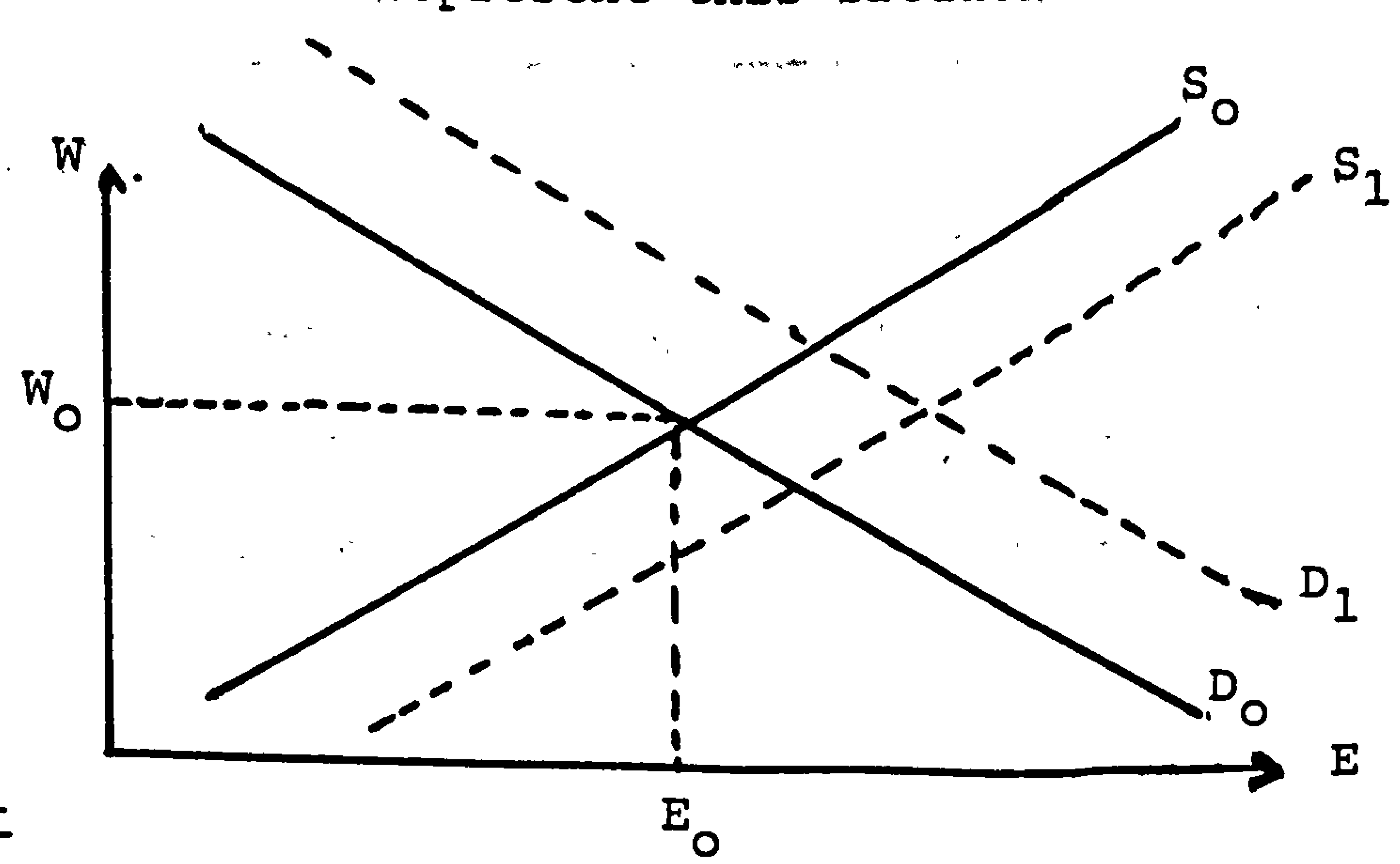


Figure 6.1

If the labour market is in equilibrium, a feature considered in later chapters, then employment would be at a level E_o with wage rate w_o. An increase (shift) in demand will increase employment and the wage rate whereas an increase in supply will increase employment but lower the wage rate. In either case the change in employment would be less than that produced by a shift with no consequent change in wages.

The question then is how employment functions would treat such shifts. This depends mainly on whether the wage rate is explicitly included or not. Employment functions of the Ball and St. Cyr type do not include the wage rate in the determination of employment at all. The demand for labour is implicitly treated as perfectly inelastic with respect to wage rate i.e. vertical demand curves as in Fig. 6.2.

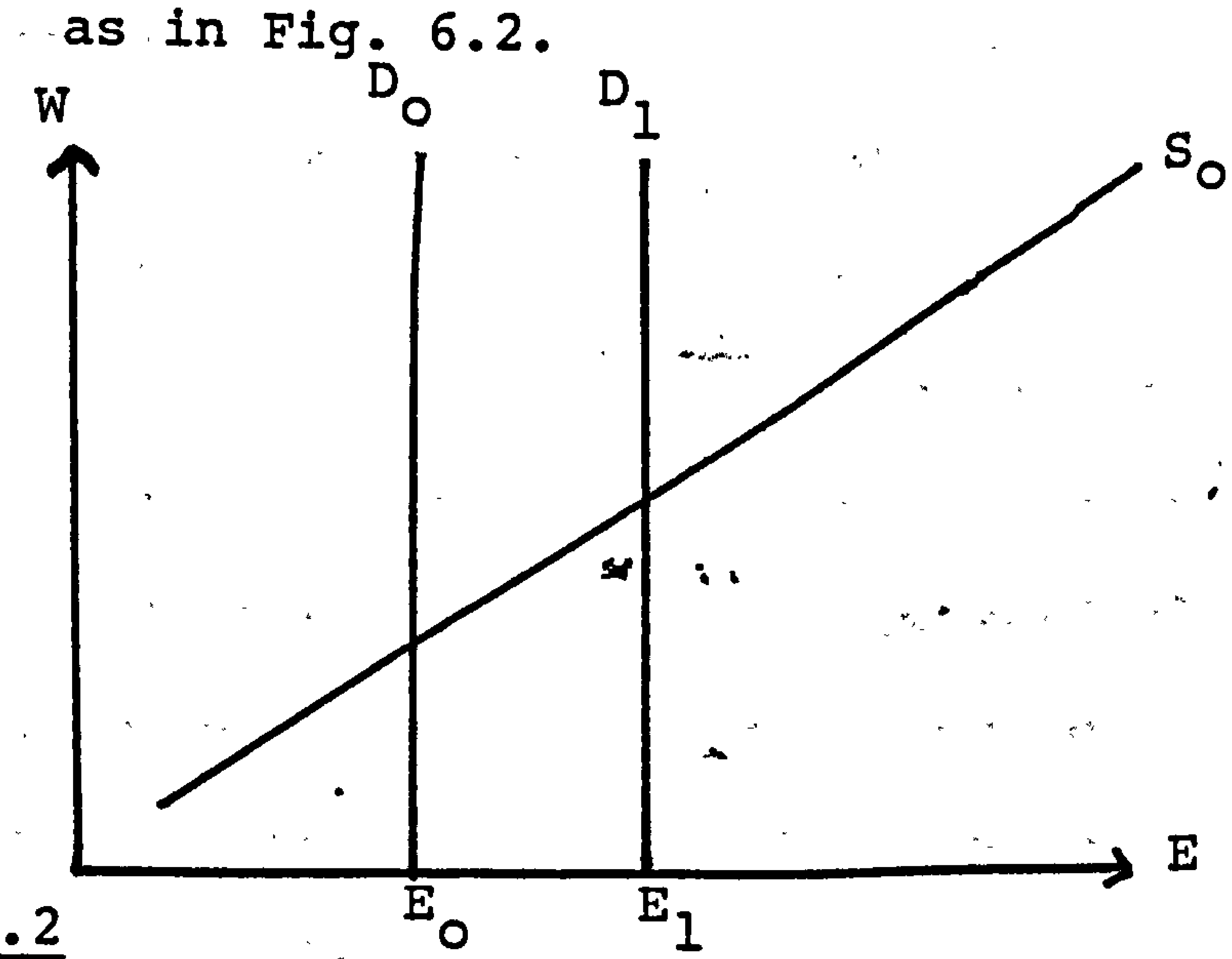


Figure 6.2

If this specification is correct then the slope and position of the supply function will be unimportant to the determination of employment, provided that supply is not also inelastic with respect to the wage rate at a

/lower

lower level of employment. Firms will simply offer the wage rate required to obtain the demand level of employment and shifts in supply will change the wage rate but not employment. Any changes in demand will be fully reflected in employment changes.

However, use of such a model when Fig. 6.1 reflects the true picture will cause problems. An increase in supply which increases employment due to a reduction in the wage rate will be wrongly attributed to a demand factor. The true influence of demand factors will be underestimated since an increase (shift) in demand will cause wages to rise and this will lessen the increase in employment. Both elements are likely sources of instability and implausibility in the estimation of demand. The Ball and St. Cyr model neglects both supply factors and the effect of the wage rate on labour demand. The question then is whether the above problems are mainly due to the latter omission.

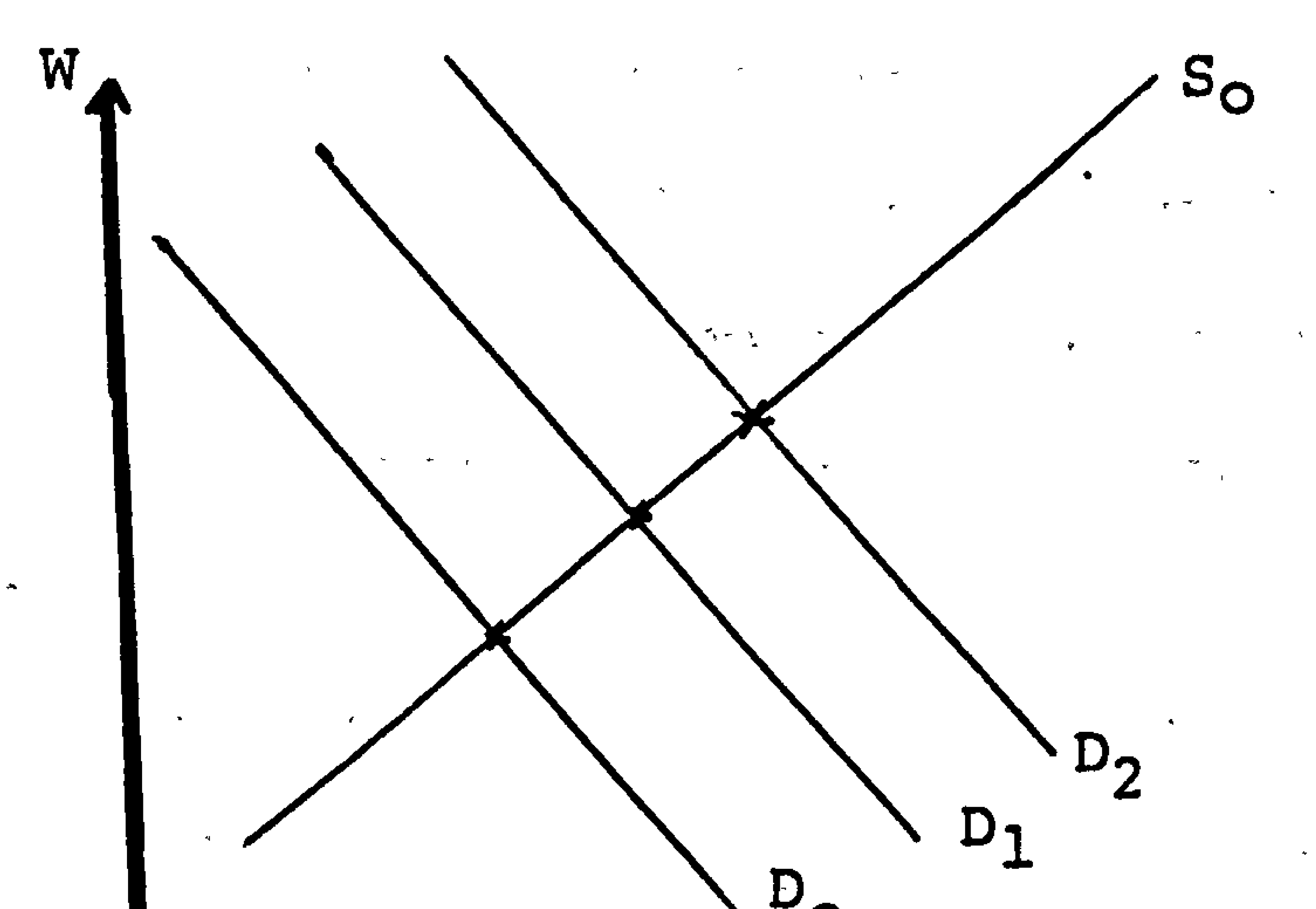
Other employment functions, such as the Dhrymes and Nadiri ones, do include the wage rate in the determination of employment. A downward sloping relationship between the wage rate and demand for labour is allowed for but supply is still ignored.

A shift in the supply function will not now be unnoticed since it will affect the wage level and hence the demand for labour. However, certain problems do remain. Firstly, the wage rate is treated as exogenous to the employment determination, whereas in the situation of

/Fig. 6.1,

Fig. 6.1, employment and the wage rate are clearly <u>jointly</u> determined by supply and demand. Neglect of this feature will lead to biased estimates of the parameters of the demand function.

Secondly, there is the identification problem i.e. whether in estimating a relationship between employment and the wage rate (plus other variables) we are obtaining the demand function, the supply function or a 'mongrel' derivation of both functions with little meaning. This problem can be present even when we have fully specified demand and supply functions to be estimated. We require shifts in the supply function to be able to locate and estimate the demand function and vice versa. In practice, each function must exclude at least one of the explanatory variables present in the other function and those explanatory variables must have enough variation to make the other function identifiable. In the absence of a supply function it is difficult to determine whether such variation is present or not. If the supply function remains stable whilst the demand function shifts over time then observations are likely to yield the supply curve rather than demand, as in Fig. 6.3



<u>Figure 6.3</u>

In general, increases in demand due to exogenous factors will increase both employment and wages and it may be very difficult to separate the true demand effect from the wage-supply effect without the formulation and estimation of both.

As will be seen in the next chapter, the situation becomes further complicated if we drop the assumption that the industry labour market is always in equilibrium and allow for 'non-clearing' of the market. Consideration of supply factors seems even more crucial in this case.

What empirical evidence exists to support the view that supply of labour plays an active and not merely a passive role in the determination of employment? If employers had all the labour they demanded at the current wage then there would be no evidence of excess demand as measured by statistics of the number of vacancies reported and remaining unfilled nor would there be periodic announcements of types of labour being in 'short supply'.

Of course, these situations do exist and in particular the level of vacancies unfilled, which is thought to seriously understate the level of excess demand because many firms do not report vacancies to employment exchanges (especially in times of 'labour shortage' when there is little hope of suitable employees being available), at times, has been over 2% of the labour force in the engineering industry.

How crucial this existence of excess demand is to the estimation of a demand function using actual employment is

/an

an empirical question. Whilst 2% is a small proportion of total employment it is large in relation to the year-to-year changes in employment which are what we are really trying to explain by our models. It is quite possible that neglect of supply and consequent neglect of excess demand has been a major factor in the instability and implausibility found in employment functions and a careful analysis, theoretical and empirical, of supply and its interaction with demand are merited on these grounds.

6.3 The supply function

One possible reason why work explaining aggregate employment has concentrated on the demand side to the exclusion of supply factors is that a body of literature already existed relating aggregate employment to output, capital etc. whereas, on the supply side, no such wealth of background was available.

The literature which deals with the supply of labour largely focuses on the individual's work-leisure decision and attempts to explain the number of hours of work individuals will offer.[2] A development of this analysis takes the household rather than the individual as the decision-making unit. Any consideration of aggregate labour supply has tended to be either at the firm level, where supply is generally assumed to be perfectly elastic, or at the national economy level, where supply is the total labour force and analysis centres on whether people

/work

(2) See e.g. Perlman (1969) and Feldstein (1968)

work or not; in particular, the participation rates of secondary workers.[3]

What is required in this study and what is lacking in the present literature, as far as the author is aware, with the exception of Reuber (1970), is a theory and specification of aggregate supply of labour to an industry, i.e. why people are willing to work in one industry rather than another.[4]

Before going on to formulate such a function it is perhaps worth looking briefly at the available theory and literature to see if it can be useful at the industry level. In this, no attempt to survey the area is claimed.[5] Rather, the features thought most relevent to present purposes are highlighted.

The aspect of labour supply which has traditionally been the concern of 'labour economists' is the relationship between the amount of work an individual is willing to undertake and the wage rate and whether the consequent supply curve would be 'backward-bending' i.e. whether, for certain ranges of wages, an increase in the wage rate would reduce the hours of labour supplied by the individual due to leisure being a strongly 'superior' good and the income effect outweighing the usual substitution effect. Given this possibility the next question was whether an aggregation of individual's supply curves would produce a 'backward-bending' aggregate supply function. Time-

/series

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(3) E.g. Tella (1965) and Black and Kelejian (1970).

(4) See Lindley (1974) for discussion of industry labour supply using a Markov 'flow' model.

(5) See Hunter (1970) for a full discussion of labour supply theory.

series and cross-section empirical evidence appeared to support this contention.[6]

However, it is not at all obvious that workers have the discretion to alter the number of hours they work, at least in the short-run. The vast majority of workers are obliged to work a basic level of hours which is not far below the average level and the amount of extra hours they work in the same employment is at the discretion of the employer. Of course, the employer cannot force employees to work over-time but it is generally accepted in the literature that the over-time premium, in raising the marginal rather than the average wage rate, will have a strong substitution and weak income effect and hence will be sufficient to induce the number of extra hours of work required by the employer.

In the long run the basic number of hours of work can be affected, usually via trade union pressure, by employees' desired hours of work, but this factor acts more as a constraint on employers' behaviour in allocating man-hours labour input between men and hours than as a determinant of total labour supply. Therefore, in this study, the number of hours worked per employee is assumed to be determined by employers, subject to agreed basic hours. When we consider the supply of labour it is the number of people willing to work which is of interest.

This aspect of labour supply has been the concern of much work which has been done on 'participation rates'. This attempts to explain why people undertake employment and/...

(6) See e.g. Finegan (1962), Rosen (1969) for the U.S. and Metcalf et al (1976) for the U.K.

and consequently how many, or what proportion, of the total population are willing to work. This obviously depends upon many demographic and social factors but the usual approach has been to concentrate on those parts of the labour force whose participation rates are subject to considerable change, either trending or fluctuating. The prime subject has been the participation rates of married women. The suggested explanations are complicated by the interaction of the income and substitution effects of both wife's and husband's income opportunities, dependent upon both wage rates and non-labour income. Whilst these considerations may be important to the number of people willing to supply their labour to a particular industry, it is thought preferable by the author to split an analysis of industry labour supply into two stages:- firstly, an explanation of the 'all industry' participation levels i.e. the total labour force and then secondly, an explanation of the proportion of the total labour force who are willing to work in a particular industry. The first of these two has been extensively pursued in the participation rates literature.[7] The approach in this thesis is to concentrate on the second stage.

The area of literature which probably comes closest to considering the choices available to individuals in deciding where to supply their labour is the work done to explain regional migration.[8] In this, the main /incentives

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(7) See e.g. U.K. studies by Corry and Roberts (1970, 1974) and Berg and Dalton (1977)

(8) E.g. Jack (1970).

incentives for a person to migrate to a particular region are seen as the wage rate relative to other regions and the availability of employment in the region, with the distance of the move, in addition to the fixed 'cost' of any move, being the disincentive. Both the incentives could be equally well applied to choice between industries rather than regions and whilst the 'removal' disincentive ceases to be applicable to the extent that many industries will be accessible to an individual without moving, there may be the costs of retraining, in a formal or informal sense, to be met.

Reuber (1970), in attempting to explain wage adjustment in Canada, does formulate a function for the supply of labour to an industry.[9] The function includes as explanatory variables the average wage rate of the industry relative to average wages in manufacturing, the general unemployment level, profits in the industry and the Canadian wage in the industry relative to its U.S. counterpart. The rationale for these various explanatory variables is that high relative wages attract people to offer their services to the industry, that the pool of unemployed workers represents potential supply to the industry and that high recent profits encourages trade unions to push for wage increases by restricting labour supply in the industry. The last variable is peculiar to Canada in being influenced by the U.S. in union actions

/and

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(9) Cross-section studies of wages often make allowances for supply effects but generally in an ad hoc manner, e.g. the inclusion of recent employment change to reflect the pressure on supply availability. See e.g. Sawyer (1973) and Wabe and Leech (1978).

and where workers may move across the border if sufficient wage differentials exist.

Reuber does not attempt to estimate the supply function directly, due to the practical difficulties of obtaining observations of labour supply, to be considered later, but incorporates it with labour demand in a wage adjustment equation. The latter postulates a proportional relationship between wage changes and the excess of labour demand over supply. In empirical estimation for twelve industries, 1953-66, industry wages relative to all manufacturing wages and unemployment appear to have most effect on industry wage changes and hence, if the adjustment process is correctly specified, on the labour supply - having significant effects in eight and seven of the industries respectively. Profits and wages relative to the U.S. appeared to have much less influence - significant in only three industries each. The important factors seem to be the 'market' effects of price (wage) and excess supply (unemployment) rather than the 'power' of the trade unions. These findings support this study in concentrating on the factors felt likely to influence individuals' behaviour and to neglect factors which might shape collective trade union actions.

We now develop a theory of the aggregate supply of labour to an industry. As already mentioned, the approach taken in this study is not to attempt to explain why people undertake employment at all, but, given the total level /of of people working or available for work in the whole of the economy, to explain why people are willing to work in a particular industry at a specific point in time dependent on individuals' utility-maximizing behaviour. It is admitted that the approach may be considered unsophisticated and it is necessarily aimed towards a formulation which can be easily analysed in combination with a demand function. Nevertheless, it is felt that the formulation does include the factors most relevant to the supply of labour available to an industry and that such a concept is meaningful.

The primary determinant of the supply of labour available to a particular industry is considered to be the total 'pool' of labour in the economy i.e. total number of employees plus number registered unemployed and this is taken to be exogenous to the industry. Whilst employment attractions within an industry can affect overall labour supply, the interdependence is thought to be low. This factor could have been allowed for by expressing the dependent variable as the industry's share of total employment but this was not done. Such a formulation would assume that a one percent increase in the total labour supply would cause a one percent increase in the industry's labour supply. This is somewhat restrictive as additions to the labour force need not be similar to the existing labour force in skill, age, sex etc. However, the formulation used allows such 'proportionality' as a special case.

/The

The other determinants of supply consist of variables which attract labour to an industry in preference to others. These, naturally enough, tend to be relative variables and are based on an individual's utility maximising behaviour. The major source of utility to an individual from offering his labour is taken to be the total monetary benefits which a job affords. This is felt to be best captured by the average weekly wage in the industry. Non-monetary benefits or costs may be important but, as they are not easily measured, they are inevitably neglected, except for two other factors felt to influence an individual's utility. These portray two important disutilities from supplying one's labour.

The first of these is the effort required to achieve the weekly wage. Whilst difficult to measure, with a substantial subjective element, effort is taken to be closely related to the average number of hours worked per week. For a given weekly wage there is clearly a disincentive in working more hours. The trade-off between weekly wages and hours worked is an empirical question which is not properly resolved by specification of average hourly wage as the 'combined' determinant.(10)

The second factor is the 'security' of employment in a particular industry. An individual will derive disutility from supplying his labour to an industry where there is a high risk of losing his job in the future. It may be reasonable to assume that the risk of losing
/employment

(10) A multiplicative formulation as in (6.1), will allow such a combination as a special case, ($\lambda = -\beta$). Hours of work are treated as being determined by firms, i.e. exogenous to the individual's supply decision, as is the security factor discussed next. This should be borne in mind when supply is jointly-determined with demand in Chapter 8.

employment in an industry can be expressed by the proportion of employees in an industry expected to be unemployed in the future. How individuals make their expectations on such matters is a difficult question which could perhaps be resolved empirically by the testing of various hypotheses involving different lag structures. This has not been undertaken here as it could not be carried out independently and would thus complicate further the estimation of supply. Instead a simple hypothesis is put forward, namely, that people's expectations are based on unemployment rates over the last twelve months.(11) The hypothesis is implicitly tested by the testing of the overall model framework.

Thus, given these three major factors affecting the individual's utility i.e. wage, hours and security, the choice of which industry to supply one's labour to will be made on the relative values of these factors between industries and the weights which are attached to each factor i.e. the shape of the individual's indifference curves.

In aggregate, four variables - total labour force, relative weekly wages, relative weekly hours and relative unemployment - are taken to determine the number of people who would desire to supply their labour to the industry if free to do so.(12) The expectations of the

/direction

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(11) An arithmetic mean is used.

(12) The problem of consistency of aggregation from individual decision processes to an industry level relationship is discussed in the appendix. In the supply context, other factors affecting individuals are assumed negligible on aggregation e.g. sociological factors.

direction of effect of the four variables enable us to allocate positive signs to the first two and negative signs to the latter two. However, two important considerations remain before we can express the supply of labour in an estimatable form. Firstly, we have not specified a functional form for the relationship. It is felt that the theoretical underpinning is not definite enough to give us a precise form and for this reason, plus the convenience of consistency with a demand formulation and ease of interpretation of coefficients, a multiplicative functional form was chosen:-

$$(ES)^*_t = AL^{\alpha}_t \, W^{\beta}_{rt} H^{\gamma}_{rt} U^{\delta}_{rt} \qquad .... \quad (6.1)$$

where ES* is 'desired' labour supply

L is the total labour force

W_r is relative average weekly wages

H_r is relative average weekly hours worked

U_r is relative unemployment

t is the time period

The final consideration is to link the number of people who would desire to work in a particular industry if able to do so and the number of people who actually are willing, able and available to work i.e. the true supply to the industry. The discrepancy exists because, whilst people may find a particular industry attractive, they do not offer themselves for employment in it for various reasons. These include the costs involved in looking for and changing one's job, moving costs, the need for training etc. in addition to the basic inertia and slowness of adjustment of people's actual behaviour to what they perceive to be

/beneficial.

beneficial. The overall 'costs' in the aggregate are virtually impossible to measure explicitly. As with labour demand in the earlier chapters we can postulate that these adjustment costs cause a partial adjustment process in labour supply relative to desired labour supply.[13] A Koyck one-period formulation is adopted but this differs from that in normal usage in that supply is adjusted relative to actual employment in the previous period rather than supply in the previous period. People supplying their labour this period who were not working in the industry last period will have to incur adjustment costs even if they have offered their labour to the industry previously.

Theoretically, this formulation implies that actual labour supply need never converge upon its desired level and so differs from the usual concept of an adjustment process. In practice, its convergence depends upon the relation of supply to actual employment. The adjustment process put forward is:-

$$\frac{ES_t}{E_{t-1}} = \left(\frac{ES^*_t}{E_{t-1}}\right)^{\lambda} \quad \text{with } 0 \leq \lambda \leq 1 \quad \ldots. \ (6.2)$$

i.e. only an 'exponential' fraction λ of the number of people desiring to work in the industry, relative to the number actually employed in the previous period, E_{t-1}, actually supply their labour to the industry. Equations (6.1) and (6.2) can be combined and, by taking logs, we can express the supply of labour as:-

/log ES

(13) See Lindley for further justification of the lag in adjustment.

$$\log ES_t = \lambda \log A + \lambda\alpha \log L_t + \lambda\beta \log W_{rt} + \lambda\gamma \log H_{rt} + \lambda\delta \log U_{rt} + (1-\lambda) \log E_{t-1} + u_{1t} \quad \text{...... (6.3)}$$

where u_1 is a stochastic error term resulting from a multiplicative error in (6.1), (6.2) or both.

All the explanatory variables on the right-hand side of (6.3) are, in principle, measurable. The question of measurability of the dependent variable, the supply of labour, is more difficult and will be analysed in great detail in the next chapter but consideration is first given to the determination of labour demand and its formulation.

6.4 The demand function

In earlier chapters several formulations of the demand for labour function were discussed from both a theoretical and an empirical viewpoint and generally found lacking when tested empirically, with estimates inconsistent with the theory or unstable. In this work it is argued that the poor results are likely to be due to concentration on demand factors to the exclusion of supply. Consequently, we cannot dismiss the formulations which were put forward on empirical grounds - they may be accurate models of the behaviour of the demand for employment but not of actual employment. Of course, the demand models may, in fact, be deficient in explaining the demand for employees but, in setting up a model, we must be guided by theoretical considerations and not by earlier empirical / misfortunes.

misfortunes. In addition, in the present context it is clearly desirable to formulate a demand model which is consistent with the supply model expounded in the previous section. This is a necessity when their interaction is considered in subsequent chapters.

The approach taken in this section to an explanation of the demand for labour broadly follows that of Dhrymes (1969). A firm is postulated to be a profit-maximiser and to determine its desired labour input by expanding its use of labour until the marginal revenue product of this labour is equated to the marginal cost. Labour input is measured not simply by the number of employees as labour has an important second dimension in the number of hours worked by employees. It is the number of man-hours worked which is of prior importance to a firm rather than the number of employees, though our theory will proceed to consider how a firm chooses between men and hours - clearly essential to the determination of demand for employees.

The marginal condition which each firm desires to achieve can be expressed as:-

$$\frac{\partial Q}{\partial (EHD)^*} = s(t)\frac{w}{p} \qquad \ldots\ldots (6.4)$$

where Q is output

(EHD)* is the desired demand for man-hours

w is the marginal labour cost per man-hour

p is the 'price' of output

s(t) is a trend function (explained below)

/w

w represents the marginal cost to the firm of an extra man-hour of labour input and hence should be an hourly wage cost and should include not only direct wage costs but also all other costs associated with the additional labour. In practice the marginal cost of additional man-hours will differ according to whether it is due to extra men or extra hours working of present employees. The former involves the fixed labour costs of insurance contributions etc. plus recruitment costs as well as normal wage costs whilst the latter probably involves overtime premiums on top of basic wage rates. Furthermore, it has been suggested by several authors, e.g. Feldstein (1967) and Craine (1972), that the marginal product of an extra man-hour will differ.(14) The case for divergence in either direction is not too compelling and here it is assumed that the marginal product of a man-hour is the same whether the number of men or the average number of hours per man is changed. The problem of the diverging marginal cost will be resolved below when firms are postulated to divide their labour input between the number of employees and average hours of work in a cost-minimising manner.

Due to our inability to observe the 'true' marginal cost of labour, w is inevitably measured as the average hourly labour cost and is obtained by dividing the total /wage

(14) Feldstein argues that overtime hours will be more productive than ordinary hours as 'set-up' time and 'break' time are less. However, it can be argued that, due to fatigue, the more hours a person works the less productive he becomes.

wage bill by the total number of man-hours worked. P represents the revenue generated by an extra unit of output and is measured by the value-added concept.

The function s(t) is intended to allow for the fact that either the industry's product market or labour market need not be perfectly competitive. In these circumstances a firm need not equate marginal product and real wage but is likely to aim for a relationship between the two dependent on the degree of competition or oligopoly.(15) The market structure of an industry is unlikely to remain constant over a long period and so s(t) will change. Ideally we would hope for a well-formulated relationship between s(t) and measures of product or labour market structure, such as concentration or unionization, plus a data series of frequent observations of these measures for the industry over time. Unfortunately, such a combination is not readily available and so we assume that changes in market structure and the consequent changes in the relationship between marginal product and real wage have been gradual and stable over time and thus can be proxied by a time-trend. This time-trend will inevitably also pick-up any other trend effects not explicitly allowed for in the demand for labour formulation. In particular, any technical progress effects not accounted for in the production function will be 'picked-up'.

/Following

(15) In fact, the firm should aim to satisfy the condition (6.4) with $s(t) = (1+1/\varepsilon_L)/(1+\varepsilon_Q)$, where ε_L is the elasticity of labour supply and ε_Q is the elasticity of demand for output (see e.g. Nadiri (1968)).

Following Dhrymes, it can be shown that expression (6.4) can be equated to the partial derivative, with respect to labour, of a C.E.S. production function to yield:-[16]

$$\log (EHD)^* = B + \varepsilon t + \eta \log Q_t - \sigma \log \frac{w}{p}t \quad .... \; (6.5)$$

where σ is the elasticity of substitution between labour and capital and the time trend proxies the effects both of the s(t) term and technical progress. The coefficient on $\log Q_t$ should be unity if there are constant returns to scale but will differ from that value in inverse relation to the returns-to-scale.[17]

Thus we now have an expression for the level of man-hours desired by firms and to explain employment we must determine how the choice between men and hours is made. In doing this we diverge from Dhrymes' formulation and so avoid the logical inconsistency discussed in the review of the 'Dhrymes' model' early in the thesis. We prefer to pursue the Ball and St. Cyr formulation where firms choose between men and hours in a cost-minimizing fashion. We postulate that the wage cost per hour is related to the average number of hours worked per employee. Furthermore, because over-time hours have to be paid for at higher rates and because a short-fall of hours below basic levels will raise average hourly wage costs due to fixed labour costs, salaries, guaranteed earnings etc., the relationship is likely to be approximately quadratic in /shape . . . .

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(16) Theoretically output should be jointly determined with labour input to maximize profits but this endogeneity was not allowed for here, largely for reasons of tractability in later chapters. The empirical evidence of Briscoe and Peel (1975) suggests that this omission may not be serious (see Ch.2,p.54/5). The measure of desired output developed in Ch.4 was not used due to data deficiencies and lack of general applicability.

(17) i.e. $\eta = (1/\nu + \sigma(1-1/\nu))$ where ν is the returns to scale parameter.

shape with a minimum at, or closely related to, institutional normal hours. Firms will thus desire to have their employees working normal hours and will aim for a desired employment level in accordance:-

$$ED^*_t = \frac{EHD^*_t}{H_{ot}} \qquad \ldots\ldots (6.6)$$

where ED* is desired employment demand and H_o is normal hours.

Hence, from (6.5) and (6.6):-

$$\log ED^*_t = B + \varepsilon t + \eta \log Q_t - \sigma \log \frac{w}{p}t - \theta \log H_{ot} \qquad \ldots\ldots (6.7)$$

The coefficient on log H_o should be unity but may differ where firms' cost-minimizing hours level differs from basic due to various possible factors such as high fixed costs of labour, non-equality of marginal products of men and hours, expectations of employees for overtime work (the denial of which might involve considerable 'costs') etc.

As with the supply function, all that now remains to obtain an expression for the demand for labour is to relate the desired level of demand to the actual level. The discrepancy exists because of the costs incurred by a firm in changing its labour force.[18] To increase employment incurs costs of recruitment and training and to reduce employment incurs redundancy costs. The nature of these costs is such that rapid changes in either direction are likely to cause the costs to increase steeply. Thus a change in the desired level of employment due to any of /the

(18) Supply restrictions are not now included in the adjustment costs.

the factors in the expression (6.7) is liable to set in motion a gradual process of adjustment of demand for employees towards the new level. The process can be expressed by a Koyck-adjustment model:-

$$\frac{ED_t}{E_{t-1}} = \frac{ED_t^*}{E_{t-1}} \qquad 0 \lessgtr \mu \lessgtr 1 \quad .... \ (6.8)$$

i.e. employers demand a level of employment this period which eradicates a 'proportion' μ of the deficiency/surplus between desired employment and the actual level in the previous period. As with the supply side, this is not the usual sort of adjustment process in that the level of employment demanded may not converge on its desired level.

The combination of (6.7) and (6.8) yields an expression for the demand for labour:-[19]

$$\log ED_t = \mu B + \mu\varepsilon t + \mu\eta \log Q_t - \mu\sigma \log \frac{W}{P}t - \theta \log H_{ot} + (1-\mu) \log E_{t-1} + u_{2t} \quad .... \ (6.9)$$

where u_2 is a stochastic error term resulting from a multiplicative error in (6.7), (6.8) or both.

We now have expressions (6.3) and (6.9) which specify how the supply of and demand for labour are thought to be generated. We can now move on to consider how these two forces of demand and supply interact to determine actual observed employment levels and this is undertaken in the next chapter. But before doing so, some of the differences

/between

(19) The problem of aggregating individual firms' employment decision processes into an industry demand relationship is discussed in the appendix.

between data to be used in the present model and that used in estimation in previous chapters, should be pointed out.

6.5 Measurement of variables

It is clear from the derivations of the supply and demand functions in this chapter that the data used to estimate these functions will not fully represent the desired theoretical concepts. Despite this it was felt important to measure the proxy variables as accurately as possible. In particular, whilst w should be measured as the marginal cost of an extra unit of labour, in the absence of such data, it was thought to be preferable to derive a measure of average labour cost from the total wage bill rather than simply using average hourly wage earnings. This at least ensures the inclusion of the 'overhead' costs of labour - if average rather than marginal. Similarly, it was felt important to measure p as the value-added price of output rather than simply using retail or wholesale prices, even when the degree of competition in the industry is not ideally dealt with.[20]

However, data on the wage bill and value added is only available annually. For this reason estimation of demand and supply functions in the following chapters is carried out on an annual basis rather than quarterly as in earlier chapters. There is nothing about the employment behaviour postulated which dictates whether the model

/should

(20) In practice the different measures of labour cost and prices were not as distinct as expected and so the resultant 'real wage' series is closely correlated with a series which takes the ratio of average hourly earnings to wholesale price.

should be annual or quarterly[21] but use of annual observations does substantially reduce the number of observations, leading to a problem with the number of degrees of freedom. This problem was lessened by lengthening the observation period from 1959 back to 1949, giving twenty-three annual observations. Due to the complexity of estimation methods in the later chapters it was felt that a smaller number of observations (plus a longer time span) might well be an advantage in conjunction with a superior specification of some of the explanatory variables. However, it should be recognized that variation in some of the variables may be lost by using annual rather than quarterly data.

Annual data is more closely correlated with a time trend than quarterly data is. In logarithmic form, the correlation between employment and a time trend rises from 0.861, with quarterly data (1959 to 1971), to 0.970 with annual data (1948-71) and that between output and a time trend rises from 0.955, with seasonally unadjusted quarterly data, to 0.995 with annual data. Hence there is less variation in employment, though not necessarily in demand for labour, to be explained and explanatory variables are more likely to be multicollinear, making the estimation of precise coefficients more difficult.

Because of this, shortened versions of the supply and demand functions, (6.3) and (6.9) respectively, were postulated concentrating on the explanatory variables felt to be the most important in the explanation of demand and

/supply

(21) This is particularly relevant to the adjustment process which we do <u>not</u> assume to be a time-aggregate of a quarterly process.

supply and to be the most likely to indicate potential benefits from the joint consideration of demand and supply. These functions were as follows:-

$$\log ES_t = \lambda \log A + \lambda\alpha \log L_t + \lambda\beta \log W_{rt} + (1-\lambda)\log E_{t-1} + u_{1t} \quad \ldots\ldots (6.10)$$

$$\log ED_t = \mu B + \mu\eta \log Q_t - \mu\sigma \log (\tfrac{W}{P})t + (1-\mu) \log E_{t-1} + u_{2t} \quad \ldots\ldots (6.11)$$

In both 'short' equations, the adjustment process of actual towards desired levels was maintained as an important element of behaviour. On the supply side, the total labour force and relative weekly wage were considered the most important factors with relative hours and unemployment omitted. On the demand side, output and real wage were considered the most important factors with normal hours and the time trend omitted.

Whilst this procedure clearly exposes the estimation of (6.10) and (6.11) to potential mis-specification bias it was felt that this may be an acceptable price to pay for precision if the main factors are accounted for, as believed.

An alternative procedure would be to use quarterly data to estimate the full equations but this would involve use of data series which are further from the desired theoretical concepts than the annual ones.

Also, for reasons of data consistency, due to changes in industrial classification in 1959, and the complexity of estimation methods adopted later, the succeeding empirical work is confined to one set of data viz. that corresponding

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to (1958) S.I.C. VI in previous empirical chapters. The data used is fully described in the data appendix.

Appendix to Chapter 6

Aggregation

It can be demonstrated e.g. Allen (1956), that for a linear macroeconomic or aggregate relationship to be strictly consistent with the underlying linear micro-economic relationships one of two conditions must hold; either the aggregation of each explanatory variable must be performed by giving each micro unit a weight proportional to its marginal propensity or the marginal propensity for each explanatory variable must be equal for all micro units.

The first condition implies aggregation with different weights for different variables and is not the type which is carried out in producing the published aggregate data. The condition could only be satisfied if the investigator had the microeconomic data and parameters available to aggregate and this is generally not the case.

The second situation, entirely uniform reactions to changes in explanatory variables throughout the population, is a very restrictive condition and again is unlikely to hold in practice.

Thus it is clear that in most aggregate studies the relationship estimated will not be strictly consistent with the underlying micro-economic relationships. Even if the micro parameters remain constant but are not equal across units, a change in the relative magnitude of

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an explanatory variable between the units will cause the corresponding aggregate parameter to shift. There is no real answer to this aggregation problem other than to argue (or hope) that either the micro parameters are 'fairly close' to each other in size and/or the weights used in official statistics aggregation are 'fairly close' to the marginal propensities and/or the relative magnitude of the values of explanatory variables across sectors does not change much. The first two assumptions allow a reasonably consistent aggregate relationship to be estimated and the third allows a stable 'average' relationship to be obtained which, whilst not fully representing the underlying economic behaviour may well be useful for forecasting etc.

The above discussion applies to the estimation of both the aggregate demand and the aggregate supply functions in this study. However, aggregation is made more of a problem by two further considerations. The first of these is common to many studies in that the micro-relationships to be aggregated are not simply linear but log-linear. In this case it can be shown that, even with identical parameters or correct weightings, aggregation of data should be carried out geometrically rather than arithmetically. Again, this is seldom how published data has been aggregated and we have little choice but to assume either a small dispersion in the size of the micro units, so that the geometric mean is close to the arithmetical mean, or

/little

little change in relative sizes over-time so that there is a reasonably stable relationship between the geometric and arithmetic means. In this case, a useful 'average' relationship may be obtained despite the errors of aggregation.

The second consideration which is perhaps more unique to this study is that we are not only estimating aggregate demand and supply relationships but we are hoping to analyse them together and to look at points of aggregate equilibrium. The question is whether such equilibrium points can be located given the aggregation problems in the demand and supply functions.

The condition required for both aggregate demand and aggregate supply to be consistent within themselves <u>and</u> with each other is that the aggregation of the wage variable be weighted by the appropriate marginal propensities <u>and</u> that the weights be the same for demand and supply. In other words the relative slopes of the demand curves must be the same as the relative slopes of the supply curves. If this is not the case, then it can be shown that, in summing over local labour markets, the aggregate demand and supply functions will not intersect at the same employment and wage level as we would obtain from the sum of the equilibria employment levels of the local labour markets and the average of the equilibrium wage rates, weighted by employment. In practice, we are not able to

/aggregate

aggregate ideally and must accept the one measure of wage rate obtained from official statistics which, as an industry average wage, will be weighted by employment in aggregating sectors. Consequently, the sum of all sectors' equilibrium employments (unobserved) will lie at the intersection of our aggregate demand and supply curves at the observed aggregate wage rate. As we have already had to assume that the demand and supply curves represent average pictures of the underlying relationships we must now hope that the aggregate equilibrium point gives a good representation of underlying sector equilibria. As before this will be more valid the smaller the dispersion of sector wage levels or relative demand and supply slopes.

We have then merely recognised the existence of the aggregation problem, noted its particular effects in joint demand and supply analysis and then, in keeping with virtually all aggregate studies, we have been forced to assume that the effects are unimportant or at least not too damaging to deny meaning to the forthcoming aggregate empirical investigation.

7. The Labour Market

7.1 Introduction

In this chapter, we look first at the assumptions required about the nature and behaviour of the labour market, to enable valid use of the traditional type of demand and supply approach to explain the behaviour of employment in an industry. These assumptions are found to be restrictive and are gradually relaxed to give a more realistic yet necessarily more complex model of the labour market. Each stage in the relaxation of assumptions yields different formulations and requires different techniques for estimation. These models are developed in the next three chapters where each stage is looked at in turn. In this chapter we outline a theory of the labour market and the effect of relaxing the specific assumptions.

In the first section we consider an industry labour market which is always in equilibrium so that aggregate demand <u>and</u> supply are always observed. In the second section we consider a labour market which is generally not in equilibrium but its constituent parts are sufficiently homogenous for aggregate demand <u>or</u> supply to be observed. In the final section we develop a model of a labour market not generally in equilibrium, with many sub-sections each facing different market conditions, such that neither aggregate demand <u>nor</u> aggregate supply are observed.

7.2 An aggregate labour market in equilibrium

In the previous chapter we formulated demand and supply functions which, although justified at the micro-economic

/individual

individual firm or household level, were assumed to hold at the industry level of aggregation. However, when we come to consider demand and supply together and the equilibrating nature of the labour market, it is useful to consider an intermediate stage of aggregation. Unlike a market for easily movable commodities there are good reasons to believe that an industry labour market is made up of many sub-markets or sectors which obey the same forces of demand and supply but which are distinct because labour is not mobile between them. These sectors may be differentiated by regional location, occupational skill requirements or production methods. In each case, labour will not be perfectly mobile between sectors because of the various costs involved in moving from one sector to another.

This immobility will mean that the normal expectation that aggregate equilibrium will be achieved in the market with uniform price throughout, will not apply to the labour market. The 'perfect market' rationale for uniformity of price is that even a small price rise (fall) in one locality, occasioned by local excess demand (supply) will cause movement of the product into (out of) the sector from (to) other sectors until excess demand (supply) is removed and full equilibrium is achieved with uniform price throughout. However, if labour is not sufficiently mobile to react to small inter-sectional differences in wage rates then the above rationale does not apply.(1)

Excess demand and supply may still be removed by raising or lowering wages in the sector but larger and more permanent /wage

(1) See Mackay et al. (1971) for an extensive study of wage determination in some sectors of the U.K. engineering industry.

wage rate changes will be needed to achieve this and sectoral wage differences will exist.

If the definition of a labour market requires perfect mobility of labour then the industry-level operation is not strictly a labour market. However, for aggregate analysis to be at all possible we have had to assume that the different sectors do have in common the factors which determine the demand and supply of labour and that individuals, and hence sectors, can be aggregated to produce industry demand and supply functions for labour. In a similar way, we should be able to consider how demand and supply interact to produce actual employment and to call this process the industry labour market, provided that we take into account the lack of mobility between sectors and its effect on the aggregate situation.

In this section we put forward the assumption required for the industry labour market to be at, or sufficiently close to, equilibrium at all times so that the aggregate demand and supply functions are always observed. The assumption is that each sector of the industry labour market is always at equilibrium. In this case, sectoral employment will be equal to both demand and supply employment and so industry employment will be equal to both aggregate demand and supply, subject to the aggregation problems discussed in the Appendix to the previous chapter.

In each sector, the forces of demand and supply will be brought into equilibrium by movements in the wage rate sufficiently quickly for equilibrium to be always observed.

In general, wage rates will differ between sectors but the aggregate wage rate will correspond to the intersection of aggregate demand and supply functions. It should be noted that this last feature i.e. the prevalence of the equilibrium aggregate wage rate is not sufficient in itself for overall equilibrium as such an aggregate position is possible with excess demand in some sectors and excess supply in others. These imbalances do not cancel out in aggregation and cause aggregate employment to be lower than its equilibrium level.

However, if the assumption of equilibrium in all sectors and at all times is reasonable then we can expect to observe aggregate demand and supply functions and hence estimate them. In this case, the traditional employment functions may provide good estimates of the demand function though we may still benefit from a joint estimation of demand and supply which treats wages as an endogeneously determined equilibrating factor rather than as exogenous.

The empirical investigation of this situation is pursued in the next chapter.

7.3 A 'Homogenous' aggregate labour market in disequilibrium

However, whilst it may be reasonable, for many easily traded commodities, to assume that equilibrating forces operate quickly enough to ensure that demand and supply are always close to equality at the current price, it does not seem a reasonable assumption for labour. If movements

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in the price of the good are the main mechanism for maintaining equilibrium then there are good reasons to suggest that movements in the price of labour, i.e. the wage rate, do not perform the equilibrating task very efficiently if at all. Various causes of inflexibility of wage rates, relative to each other and to other prices, exist which strongly indicate that labour should not be treated as any other commodity.

On the supply side, the employees in any particular sector, whilst quite happy to see their wage rate increased in times of excess demand, will be unlikely to allow their wage rate to be reduced in times of excess supply. Furthermore, the organisation of employees in trade unions and the ability of these unions to put pressure on employers is likely to generally distort the market forces. A strong or militant trade union can push up the wage rates of its members above the equilibrium level and, by insisting on constant regional or occupational wage differentials, can prevent the use of the wage rate as an equilibrating measure in a particular sector.

On the demand side, it is important to realise that the wage bill constitutes a large part of the costs of a firm. Thus a firm is likely to hesitate before offering the higher wage rate which would be necessary to achieve equilibrium, say during a boom. The firm cannot attract extra workers by only offering higher wages to the new recruits; it must also give its present workers the same increase. Also, it will be difficult to offer workers in a particular region or occupation an increase without giving a similar

/increase

increase to all employees. As wages are inflexible downwards a firm will want to be sure that its high demand will continue and be sufficient to meet the higher wage costs before it makes a wage rate increase. Also, as with trade unions on the supply side, the existence of monopsony, employers' collusion etc. distort the market forces.

It is clear then that wage rates are unlikely to be used as a means of speedily ensuring movement towards equilibrium in each sector of the labour market - the 'instrument' costs are much too high. However, this does not mean that there is no long-run tendency for wage rates in different sectors to move slowly towards levels which would equilibrate the underlying forces of demand and supply. Whilst trade unions can maintain wage differentials in the short-run it is not likely that they can be maintained in disequilibrium for ever. In a region or occupation where there is a labour shortage, trade unions will be in a strong bargaining position and wage increases may even be encouraged by employers. In the opposite position of excess supply, employees will be in a weaker position and increases will be actively opposed by employers. Thus wage rates should move generally towards equilibrium, though the forces affecting demand and supply will obviously be changing over time so that the equilibrium wage rate for each sector will be continually changing.

The hypothesis put forward in this section is that the sectors of an industry labour market are sufficiently homogenous for them <u>all</u> to be demand-determined or <u>all</u> to be

/supply-determined

supply-determined at a particular point in time. Underlying this hypothesis is the assumption that the variables which affect employment demand and supply levels move in a similar way in all sectors. For instance, if demand for the industry's output increases we expect output to rise in all the sectors. Consequently, each sector's demand for labour curve will shift to the right and, due to inflexibility of wage rates, excess demand will occur in all sectors i.e. all supply-determined. Of course, many other factors besides product demand affect demand and supply but, assuming underlying forces towards equilibrium, changes in these factors if reasonably homogenous will cause each sector to be in a similar state of imbalance.

The above hypothesis would probably be untenable if our labour market covered widely varying types of industry but, as we consider a single S.I.C. industry producing similar types of product for the same broad market, then it may be reasonable to put forward the above hypothesis as a viable approximation to reality.

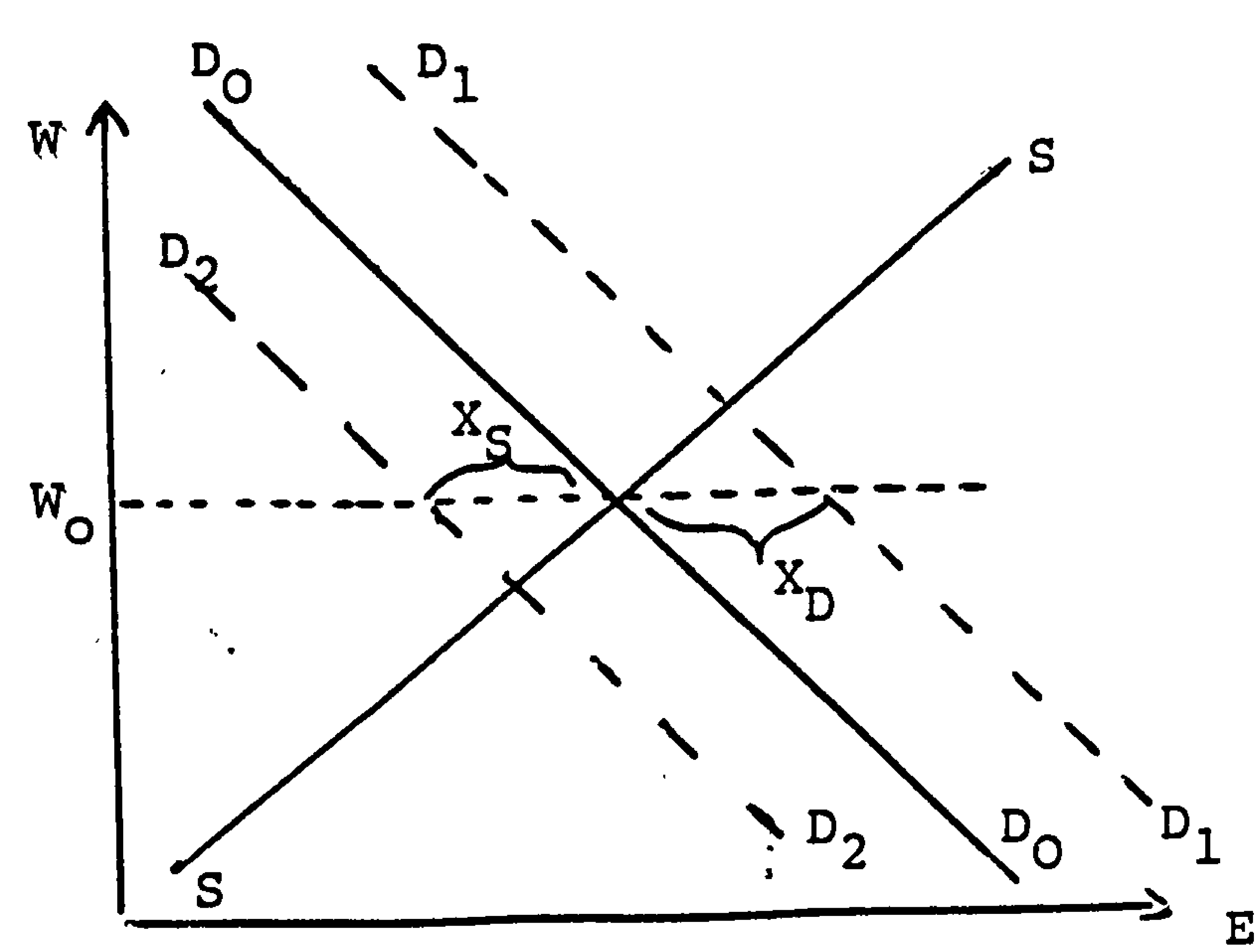

Figure 7.1

If demand for the industry's output could be considered to be the major factor causing the demand for labour to shift and if the supply curve could be considered to have little movement then when product demand is high we expect excess demand for labour, X_D in Fig. 7.1, and hence supply-determination of employment in each sector. Consequently aggregate employment will be supply-determined. Similarly when product demand is low, the aggregate employment should be demand-determined with an excess supply of amount X_S present. We could then use a measure of the cyclical pattern of output to split our observations into demand-determined and supply-determined 'regimes' and estimate the two separately. This process would represent the further hypothesis that, in addition to 'homogeneity' of sectors, output demand change is the dominant cause of shifts in the labour market. However, to test the central hypothesis we would need to look at all other factors as well as output and consider which are causing shifts, how great the shifts are and whether demand-determination or supply-determination is present at any point in time. This would in fact require full knowledge of the magnitude of parameters which will only be known after estimation of demand and supply functions. However, as it is a labour market which we are considering we do have available 'exogenous' measures of excess demand and supply which can give an indication of whether employment is demand-determined or supply-determined without requiring knowledge of which of the underlying /factors

factors are causing it. The measures available are such as the number unemployed and the number of vacancies unfilled. Also information is available about the direction and magnitude of wage changes which may serve as an indicator of excess demand or supply.

The use of such measures in discerning and estimating demand and supply regimes is developed and pursued empirically in Chapter 9 and compared with a purely statistical method of regime separation and estimation.

7.4 A non-homogenous labour market in disequilibrium

In this section we relax the homogeneity assumption of the previous section. We recognise that the product demand may have varying cyclical patterns in different industrial sectors and so may cause wide variations in labour demand in different labour market sectors.

It has been pointed out by several writers[2] that, dependent on the type of product being produced by an industrial sector - whether that product is a consumption, investment or intermediate good, whether for domestic or export use - the relationship of product demand to overall economic cycles will vary widely. The implication of this for the sectors of our labour market is that, at a point in time, some sectors may have excess demand, i.e. their employment is supply-determined, whilst other sectors have excess supply i.e. employment is demand-determined. Aggregate observations will be neither wholly supply nor demand but some mixture of the two with the underlying functions very difficult to distinguish.

/We

(2) e.g. Lund (1974)

We can also relax the assumption that changes in output are the only factors liable to cause substantial shifts in the demand and supply interactions and allow the other determinants of demand and supply to play their part in shifting the functions and causing disequilibrium. Thus there is now a greater likelihood of some sectors being demand-determined whilst others are supply-determined.

The more realistic nature of this situation where, in aggregate, excess demand and supply co-exist (though not in any individual sector, of course) can be readily supported by the fact that we have aggregate data for an industry showing the simultaneous existence of vacancies reported but remaining unfilled (excess demand) and people registered unemployed and looking for work. Some of the vacancies and unemployment are undoubtedly due to frictional imbalances, rather than 'true' demand and supply excesses but there are good reasons to suspect that vacancies and unemployment data do, in fact, understate the extent of excess demand and supply due to non-registering etc. Their existence is certainly not an indication of equilibrium in all sectors or of 'uni-directional' disequilibrium.

If statistics on vacancies and numbers unemployed were reliable measures of excess demand and supply respectively then we could measure aggregate demand by adding the number of vacancies to the level of employment actually observed and similarly for unemployment and supply. We could then use these measures of our dependent variables to estimate the aggregate demand and supply functions in a straightforward manner. This is attempted in Chapter 8, but due to

/serious

serious misgivings about the accuracy of vacancy and unemployment data, the validity of the results from this procedure is questionable.

However, if the aggregate observation of employment is always a mixture of the demand and supply functions then the possibility of separating and estimating aggregate functions will be virtually zero without a large amount of disaggregated data for the individual labour sectors defined not just by regions but by skills, etc. If it is the case that aggregate demand and supply functions cannot be derived from aggregate data then the approach developed in this section and Chapter 10 will be futile in explaining employment,(3) but this comment applies equally well to the vast amount of work that has been carried out in specifying and estimating aggregate employment functions. They will be invalid both because they ignore supply and because they do not, and cannot, observe employment demand. Disaggregation will be the only means of understanding the workings of a labour market but this desirable step will be severely hindered by a dearth of data.

Rather than abandon aggregate employment explanation altogether we prefer here to take the view that, whilst demand and supply functions may often be intertwined, there will be times during a reasonable span of observations when virtually <u>all</u> the sectors of the labour market are demand determined or virtually all are supply determined.

/At

(3) Although, for forecasting aggregate employment, aggregate equations may still be more efficient than the sum of many disaggregate models (see e.g. Grunfeld and Griliches (1960)).

At such times we will be observing the appropriate aggregate functions and so estimation should be possible. This seems, to the author, a reasonable assumption to make, with the most likely causal factor being output demand.[4] When a boom or recession is particularly strong/severe or long-lasting then it seems fair to assume that all sectors will be similarly affected and an aggregate function will be observed. No attempt is made in this model to specify these prior to estimation and to constrain the points in time when aggregate demand or supply should be observed since many other factors may be affecting the labour market, but the consistency of estimation can be checked by reference to prior beliefs or exogenous measures.

From a consideration of aggregation we can state that observed employment will always be less than or equal to aggregate demand and less than or equal to aggregate supply. In the extreme case of all sectors being demand-determined the observed employment will be equal to aggregate demand but much less than aggregate supply (high excess supply) and oppositely in the other extreme case. At all other times observed employment is less than both demand and supply.

This feature enables us to place restrictions on the parameters of the demand and supply functions as they must take values which, given the data series of our explanatory variables over the estimation period, never yield a level of employment demanded or supplied lower than that actually observed.

(4) As we are aggregating over an industry, product demand may be expected to be somewhat homogenous.

Further restrictions on the parameter estimates are desirable for reliable results and the type of information which would seem useful would be not simply that demand and supply were greater than observed but also by how much they are likely to be greater. It is here that our indicators of excess demand and supply, that is vacancies and unemployment, may be useful. Whilst they are thought to be poor cardinal measures of excess demand and supply, it is more reasonable to expect them to be fairly good ordinal indicators,[5] perhaps allowing for some margin of error. Thus comparisons can be made between different points in time.

A more rigorous analysis and formulation of this approach, the restrictions involved and the resulting estimation procedure are left to Chapter 10.

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(5) In this, we extend Dow and Dicks-Mireaux's (1958) treatment of vacancy data to the unemployment data.

8. An Aggregate Labour Market in Equilibrium

8.1 Introduction

In this chapter, we first discuss the assumptions required to enable us to consider the aggregate labour market to be always at, or close to, equilibrium. We then proceed with an empirical investigation of the demand and supply functions in the engineering industry (S.I.C. VI) labour market consequent upon these assumptions.

8.2 Requirements for aggregate equilibrium

The first requirement which is vital not only to this chapter but also to earlier and subsequent work is that industry aggregate labour demand and supply functions do exist and are meaningful descriptions of economic behaviour. This has been discussed at length in the appendix to chapter 6.

The further assumption required for aggregate equilibrium, relaxed in later chapters, is that all sectors of the labour market are in equilibrium. An industry labour market is made up of many sub-markets which through occupational or regional immobility can be considered as separate labour markets whilst subject to the same demand and supply forces. This assumption implies that the market-equilibrating behaviour of wage rates must be sufficiently local and fast-acting for each sub-market to be always at, or close to, equilibrium.

This is a strong assumption. It is not sufficient simply for the aggregate wage to be at its equilibrium level. If some sectors had excess demand whilst others had excess supply we could hardly consider the aggregate market /

market to be in equilibrium. However, there is no necessity for wages to be at the same level in each sector, as the wage in each sector must be such as to equate labour supply and demand. It is wage rates which must be the equilibrating factor, rising when excess demand is present and falling when there is excess supply. This implies not only flexibility of wage rates but also a readiness of response to changes in wages in the levels of employment demanded and supplied.

The situation required is thus a perfect Walrasian market in each sector and, whilst it is hard to think of labour as a perfect commodity, it may be that the above assumption can give a picture of the labour market which is a fair approximation to reality. It certainly enables painless estimation procedures, in that, in this perfect case, aggregate demand and supply functions should be always observable and hence directly estimable. The plausibility of such estimation should give an indication of the usefulness of the 'sector equilibrium' assumption and it is to this empirical investigation that we now turn.

8.3 Empirical investigation of the aggregate labour market in equilibrium

If the previous assumptions are valid then the levels of employment observed for an industry such as engineering are observations both of labour demand and of labour supply. Given data series on the various explanatory variables, we can use the 'full' equations (6.3) and (6.9) or the 'short' equations (6.10) and (6.11) to estimate aggregate demand and supply functions and so to understand the workings /

workings of the industry labour market. The two functions can either be estimated directly by ordinary least squares (OLS) or account can be taken of the endogeneity of the wage variable in equilibrating the market[1] by estimating via two stage least squares (2SLS) or instrumental variables.

Estimation was carried out using annual data for the years 1949-71, with the sources and construction of data series explained in the data appendix. Estimation was repeated for the years 1952-71 for consistency with estimation in later chapters and any fundamental differences in the two sets of estimates is commented on. Such differences would suggest instability in the function in question. The demand results are reported fully in Tables 8.1 and 8.2 and the supply results in Tables 8.3. and 8.4.

i) The <u>full demand function</u> estimated by OLS for 1949-71, is reported as equation (1) in Table 8.1. The signs of the estimated (short-run) parameters are as expected from the theory though only the parameters on output, real wage and lagged employment are significantly different from zero in the expected direction at the 5% significance level. This fact supports consideration of the short demand function later and was expected due to the high multicollinearity present. The corrected R^2 indicates a high degree of explanatory power and the Durbin-Watson statistic /

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(1) Note that the presence of adjustment lags in the demand and supply functions means that the equilibrium will be short-run rather than long-run in general.

statistic would suggest no strong autocorrelation present. However, the inclusion of the lagged dependent variable means that the D.W. statistic is biased towards 2. The Durbin (1970) test was attempted but collapsed as it involved the square root of a negative number. A practical alternative suggested by Kenkel (1974) is to use the upper limit of the D.W. statistic as the critical value. As the d_u value is 1.90 in this case, autocorrelation cannot be discounted and this problem will be pursued shortly. Moreover, due to the small number of observations i.e. 23 there is the possibility of bias due to the presence of the lagged dependent variable even when autocorrelation is not a problem though this bias is unlikely to be severe.

Taking the estimates at 'face value', the coefficient on log E_{t-1} implies that just over 40% of the desired change in employment takes place within a year, though this value is not quite significantly greater than zero at the 5% level. Allowing for the adjustment lag, the coefficient on log Q_t implies that a 1% change in output would cause a 1.4% change in employment.

The estimated coefficient on log Q is, in fact, an estimate of $\lambda(\sigma(1-1/\nu) + 1/\nu)$ and represents the short-run effect of an output change on employment demand. It is fairly simple to derive an estimate of ν, the returns to scale parameter by using estimates of λ and σ from the other coefficients. It is worth noting the difference in interpretation of the output coefficient from the Ball

and /

and St. Cyr model in Chapter 3.

However, it is more difficult to obtain a standard error for the derived estimates, particularly ν, which is required if anything definite is to be concluded about the plausibility of estimation. Whilst this problem is present in any model with composite estimates of parameters, as with models including an adjustment process, the above expression is perhaps particularly complex. It is possible to specify the equation in terms of its parameters and estimate them directly, taking account of the restrictions implied between the coefficients on the variables. This involves non-linear least squares estimation, LSQ, which is available on the TSP, Time Series Processor, econometric package. This procedure was carried out for this equation and for all the other OLS equations reported in Tables 8.1 and 8.3.

The procedure proved successful in quickly converging on parameter estimates consistent with the corresponding OLS estimates. The standard errors reported are derived from the linearised model on convergence and are asymptotically equivalent to non-linear least squares standard errors. With a data set of twenty or so observations, these values will not be fully reliable. An estimate of returns to scale of 0.34 was obtained which is very low relative to neoclassical theory and usual empirical results. However, a standard error of 0.81 suggests a very imprecise estimate. The coefficient on log $(w/p)_t$ implies an elasticity of employment with respect to the real wage of 0.80. Whilst not implausible, this value for the elasticity of substitution of capital for labour is high relative to the value of 0.5 often obtained /

obtained in time series studies.

Estimation for the years 1952-71, reported as (2), yield a similar speed of adjustment of 42% but an even lower and again imprecise estimate of returns to scale of 0.21. However, an F-test value of 0.4 indicates no statistical evidence of instability between the two sets of estimates.

These results can be compared to those in the quarterly study for the period 1959-71, reported in Chapter 3 where adjustment of 13% per quarter is reasonably similar but returns to scale were 1.24 and the elasticity of substitution was much higher at 1.79, possibly due to the absence of a time trend in the quarterly specification.

ii) Estimation of the full demand function by 2SLS to allow for endogeneity of wage determination is complicated by the fact that the wage variables in the two functions are defined differently. Other elements besides the industry wage rate appear in the wage variables and, if they can be treated as exogenously determined, then they should be separated out and used as instrumental variables to improve efficiency of estimation. To do this in the demand function, labour overheads are expressed as a proportion, e, of average hourly wage rates, ω, and assumed exogenous to the firm. Then;-

$$\log (w/p) = \log (\omega(1 + e)/p) = \log \omega + \log (1 + e)/p \quad (8.2)$$

where $(1 + e)/p$ can be treated as exogenous.

In the supply function, weekly wage rates can be expressed as the multiple of average hourly wage rates, ω, and average weekly hours of work, H, so that:-

$$\log W = \log (\omega H/\bar{\bar{\omega H}}) = \log \omega + \log H/\bar{\bar{\omega H}} \qquad (8.3)$$

where the bar indicates an average of all industries and $H/\bar{\bar{\omega H}}$ is treated as exogenous.

If there is doubt about the exogeneity of either $(1 + e)/P$ or $H/\bar{\bar{\omega H}}$ to employment demand and supply then it is possible to omit these variables from the instruments used in the belief that there will be sufficient instruments remaining, but in practice goodness-of-fit and plausibility were lessened by this omission(2).

The resulting full demand function, estimated by 2SLS for 1949-71, is reported as (3) in Table 8.1. As can be seen, the estimates are not drastically changed from OLS. The coefficients on t and log H_{ot} remain insignificant, the speed of adjustment is higher at 47% and the returns to scale is also higher but still implausibly low at 0.56. The standard error of the regression is identical and DW almost identical.

Estimation for 1952-71, reported as (4), yields a similar adjustment speed of 49% but a lower returns to scale of 0.30, with no statistical evidence of instability.

iii) The main problem with the results so far is not a lack of plausibility but a lack of precision in the derived parameters stemming from large standard errors on the estimates of the lagged employment and output variables.

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(2) Ideally, any endogeneity, either from this source or from the variables which appear as exogenous to supply, but are likely to be influenced by demand, in particular hours of work and unemployment, should be jointly explained but this was felt to be beyond the scope of the present model. Even so, their use as exogenous is dubious and strengthens the case for reporting the short model results, where these variables are omitted.

The returns to scale parameter is found to be lower than expected but cannot be shown to be significantly less than unity. In an attempt to get away from this inconclusive situation, the short demand function was estimated, firstly by OLS for 1949-71, and is reported as (5) in Table 8.1.

The expected increase in precision is achieved and all estimates are strongly significant at the 5% level, without any loss of explanatory power and without drastic changes in the implied short-run parameters. The adjustment speed is increased to 50%, the returns to scale becomes 0.89, a more plausible value, though LSQ estimates a standard error of 0.46, and the elasticity of substitution takes a value of 0.72. The Durbin test no longer collapses and its value of 0.93, tested as N(0,1), suggests no problem of autocorrelation, though the Durbin test is intended as a large sample test. The d_u critical value is 1.66 in this case, so autocorrelation is just rejected by the Kenkel test.

Estimation for 1952-71, reported as (6), yields a higher speed of adjustment of 56% p.a. and a lower returns to scale of 0.71.

iv) To allow for endogeneity of wage determination, 2SLS was used as before but with the short version of both demand and supply functions. The short demand function results, estimated by 2SLS for 1949-71, is reported as (7).

Again, little change results from using 2SLS with identical explanatory power, an adjustment speed of 53% and lower returns to scale of 0.78. Simultaneity bias from the wage variable does not seem to be a serious problem.

Results /

Results for 1952-71, reported as (8), follow the usual pattern of a higher adjustment speed of 61% and much lower returns to scale of 0.51.

In summary then, the full demand function yields low but imprecise estimates of the returns to scale parameter whilst the short models yields more precise short run estimates and more plausible but still imprecise values for returns to scale. Simultaneous estimation has little effect but a change in the estimation period suggests that the relationship is not completely stable, though instability cannot be shown statistically.

In view of the inconclusive nature of the attempts to test for the presence of first-order autocorrelation of the error term, it was decided to re-estimate each equation on the assumption that the error term was first-order autocorrelated. In this way it should be possible to estimate the degree of autocorrelation, ρ, its significance and the robustness of the OLS estimates. The Hildreth-Lu (1960) techique, HILU, was used to estimate the equations. This involves a grid search of values of ρ between zero and unity for stable, positive autocorrelation[(3)]. For each value of ρ, the data was transformed and the equation re-estimated, with the optimal value of ρ being chosen as the one which minimizes the standard error of the regression. A stepsize of 0.05 was chosen for ρ, to avoid missing any 'spike' minima without undue extent of estimation.

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(3) Negative and unstable values were also searched where thought appropriate but no such minima were found.

The results are reported for the demand functions in Table 8.2.

HILU estimation of the full demand function for 1949-71, to be compared with (1) of Table 8.1, yields a high $\hat{\rho}$ of 0.90 with a reported t - value of 9.7 implying strong significance, though explanatory power is only slightly increased. Parameter estimates are considerably changed, with an increased adjustment speed of 66%, returns to scale of 1.43, i.e. very high rather than very low, and a very low $\hat{\sigma}$ of 0.12. Interestingly, the short-run estimates of the effect of normal hours and the time trend on employment demand become much larger and significant with correct signs, at the 5% level. A similar pattern emerges for the period 1952-71, to be compared with (2) of Table (8.1), with a $\hat{\rho}$ of 0.85, faster adjustment of 66%, a mugh higher and more plausible returns-to-scale of 1.08 but an even lower $\hat{\sigma}$ of 0.015.

The HILU technique can be applied in conjunction with 2SLS, TSHILU, and the results compared with (3) and (4) of Table 8.1. The effect is similar to that in the HILU results - a high $\hat{\rho}$, faster adjustment, much higher returns to scale, much lower elasticity of substitution and normal hours and time trend significantly negative.

The overall effect of allowing for first-order autocorrelation in the full demand model is considerable but whilst it may be said to improve some aspects of the model with more significant or plausible values, it does so at the expense of the real wage variable and hence the estimate /

estimate of the elasticity of substitution.

In the short demand model the effect of autocorrelation is much less drastic, supporting the Durbin-test results. A value of $\hat{\rho}$ of 0.20 or 0.30 is found which is not significantly positive (t = 1.0 and t = 1.4). Speed of adjustment is increased but only by 7 or 8%, returns to scale and elasticity of substitution are little changed.

Since, first-order autocorrelation is likely to indicate the omission of important explanatory variables, or other mis-specification, it seems curious that the full model has much stronger autocorrelation than the short model and that the two omitted variables are insignificant in the OLS results but significant in the HILU results.

v) A similar treatment was then given to the supply side of the market. Firstly, the full supply function was estimated by OLS, again for the years 1949-71. The results are reported as equation (1) in Table 8.3.

All estimated coefficients have the signs expected but only lagged employment and relative unemployment have short-run estimates which are significantly different from zero at the 5% level. The two parameters expected to be most influential, i.e. those of total labour force and relative wages have very low t- values, which is confirmed by LSQ estimation. Overall explanatory power is high and the Durbin test does not indicate that autocorrelation is present.

Taking the estimates at face value, despite insignificance where present, indicates an adjustment speed of 22% p.a., much slower than demand, a long-run elasticity of supply with respect to total labour force of 1.10 and an elasticity with /

with respect to relative wages of 0.57.

Estimation for the period 1952-71 gives results reported as (2), which are similar in terms of significance but implying a lower adjustment speed of 13% p.a. and a much lower elasticity with respect to labour force of 0.34. The latter is not surprising in view of the lack of significance of the estimate. But the elasticity of supply with respect to relative unemployment which is based on a significant short-run estimate changes from 0.65 to 1.26. An F value of 0.2 again indicates no evidence of overall instability between the two estimation periods.

vi) The results from estimating the <u>full supply function</u> by 2SLS, as described in the demand section, is reported as (3) in Table 8.3, for 1949-71.

Allowing for simultaneity causes the estimate of the total labour force and relative wages parameters to be negative and that on relative hours to be positive, contrary to expectations but still insignificantly different from zero. The adjustment speed is higher at 29% though its standard error is considerably increased from 0.107 to 0.246. Explanatory power is reduced and the DW is lowered to a value which suggests that autocorrelation is present.

For 1952-71, reported as (4), the effect is not so great. Explanatory power and DW are unchanged and estimates maintain the correct sign though lacking in significance. The main effect of 2SLS is to considerably increase the elasticity with respect to labour force to 0.77 and with respect to relative wages to 1.60 with a slight /

slight change in adjustment speed to 15%.

vii) As with the demand model, estimates are generally lacking in precision and this is likely to be due to multicollinearity. Because of this, the short supply function was estimated. In this case the omission of relative hours and unemployment is less defensible since relative unemployment has been seen to have a significant effect whilst labour force and relative wages have not. The choice is made on a priori rather than empirical grounds.

Estimation of the short supply function by OLS for 1949-71 is reported as (5) in Table 8.3.

Explanatory power is significantly reduced but the DW statistic and h-test do not suggest that the omissions are leading to autocorrelation. Adjustment speed is considerably increased to 44% and a strongly significant labour force coefficient estimate yields a long-run elasticity of 2.98, a considerable increase, with an LSQ estimate of 0.31 for the standard error. The relative wage estimate remains insignificant, though with a larger elasticity of 0.95.

Estimation for 1952-71, reported as (6), is not much different from the above with a slightly higher adjustment speed of 47% and lower elasticities.

viii) Estimation of the short supply function by 2SLS for 1949-71 is reported as (7) in Table 8.3.

Explanatory power and Durbin Watson are little changed, but allowing for endogeneity of wage determination appears to /

to remove the effect of relative wages on supply leaving a very weak negative effect. Adjustment speed is slightly increased to 52% and long-run elasticity with respect to labour force reduced to 2.65.

Estimation for 1952-71, reported as (8) gives quite different results with an adjustment speed of 71%, a stronger negative but still insignificant relative wage effect and a long-run elasticity of supply with regard to labour force of 2.04, with inferior explanatory power.

The results of estimating the supply functions by HILU, to allow for possible autocorrelated errors, are reported in Table 8.4. The full supply model yields a high and strongly significant $\hat{\rho}$, both for 1949-71 and 1952-71. The estimate for 1949-71 is unity, suggesting that a 'first difference' formulation is optimal. The speed of adjustment is increased considerably to around 65% and the elasticity of supply with respect to total labour force is lowered to 0.69 for 1949-71 and 0.27 for 1952-71. The elasticity with respect to wages which was quite close in the OLS estimation for the two periods is raised to 0.65 for 1949-71 and lowered to 0.08 for 1952-71.

For TSHILU estimation, the odd results of (3) in Table (8.3) are removed and the results are quite similar to HILU with a $\hat{\rho}$ close to unity.

The extent of autocorrelation in the short supply model is very dependent on the estimation period - 0.15 for 1949-71 and 1.00 for 1952-71. The effect on OLS estimates is similar with little effect for 1949-71 but a considerable increase /

increase in adjustment speed for 1952-71 to a value of 1.14, implying over adjustment within a year, and a corresponding reduction in $\hat{\alpha}$. Again, simultaneity has little effect on the estimates except the wage coefficient for 1949-71.

So, first-order autocorrelation certainly seems to be present in the supply functions but taking it into account appears to emphasise rather than reduce differences between the two estimation periods. This suggests that a reliable representation of economic behaviour has not been found.

In summary, whilst having good explanatory power, the results are generally lacking in precision. A high degree of multicollinearity exists between the many explanatory variables which is reduced but not removed by adopting the 'short' versions of the demand and supply functions. Comparison of the two estimation periods indicates some change in the estimates but this cannot be confirmed statistically. Derivation of key parameters, in particular returns to scale yields implausible values but again such implausibility cannot be confirmed statistically. Autocorrelation of error terms is generally present.

The consequence of this situation for research strategy in the succeeding chapters is deferred until the end of this chapter after a preliminary attempt to relax the assumption of equilibrium.

8.4 Adjusting demand for vacancies and supply for unemployment.

Finally, in this chapter, estimation is reported of a model which perhaps belongs to the later chapters in that /

that the equilibrium assumptions of 8.1 are not assumed to hold. However, the method of estimation is consistent with that used in this chapter and its assumptions represent a preliminary and simple step along the path to a disequilibrium model. Consequently it is worth reporting here since evidence of improvement over the equilibrium model would indicate whether further complexity was desirable or not.

The model follows a suggestion of the previous chapter in treating statistics of vacancies unfilled and numbers unemployed as measures of excess demand and excess supply respectively. Their existence is an obvious indication that individual labour sectors are not in equilibrium i.e. that wages are not adjusted immediately to remove any excess. However, whether the extent of excess demand and supply is enough to completely invalidate the estimation of the previous section is really an empirical question.

Whilst vacancies and unemployment data are known to underestimate excess demand and supply, perhaps seriously, without knowledge of the extent of underestimation, the simplest procedure is to take the data at face-value. The vacancies figures can then be added to actual employment to give a measure of aggregate employment demand which can be used as the dependent variable in estimating (6.9) and (6.11). Similarly, the unemployment figures can be added to employment to give a measure or aggregate employment supply which can be used as the dependent variable in estimating (6.3) /

(6.3) and (6.10). The equations were estimated by OLS only, not by 2SLS since if the wage level is not adjusted immediately, it is not endogenously determined. Vacancies data was not available for the S.I.C. VI classification prior to 1952 and so the demand functions are reported for 1952-71 only, whilst the supply functions are reported for 1949-71 and 1952-71. The full results are reported in Tables 8.5 and 8.6.

Estimation of the full demand function for 1952-71, reported as (1) in Table 8.5, can be compared with (2) in Table 8.1. The explanatory power is very similar as is the DW statistic. Short-run estimates are changed but not drastically so and the long-run parameter estimates, derived from the OLS results and hence without LSQ standard errors, show a slightly higher adjustment speed of 48% but are otherwise almost identical, with an implausibly low returns to scale estimate of 0.20.

Estimation of the short demand function for 1952-71, reported as (2) in Table 8.5 bears a similar relation to (6) of Table 8.1, with changes in the short-run estimates being counteracted by a faster adjustment speed of 66% to give very similar long-run parameter estimates.

On the supply side, the full supply function is estimated first for 1949-71, reported as (3) in Table 8.5 and comparable with (1) of Table 8.3.

Explanatory power and DW statistic are identical. However, differences in short-run estimates, whilst not drastic are carried over to the long-run estimates, with a lower /

lower adjustment speed of 19% and lower elasticities with respect to labour force and relative wages. This pattern is also found for the 1952-71 period comparing (4) in Table 8.5 with (2) in Table 8.3.

Estimation of the short supply function for 1949-71 and 1952-71 reported as (5) and (6) respectively in Table 8.5 can be compared with (5) and (6) of Table 8.3, with similar conclusions though the long-run elasticity with respect to labour force is little changed by the change of dependent variable.

The results obtained allowing for first-order auto-correlation are reported in Table 8.6. As before, the results are not very different from the equivalent regressions in Tables 8.2 and 8.4, without the adjustment of the dependent variable. The exception to this is the short model for the period 1949-71 reported as (5) which is much closer to the estimation for 1952-71, with a $\hat{\rho}$ of 0.95 than it is to the corresponding regression (5) of Table 8.4, with a $\hat{\rho}$ of 0.15.

The overall impression is that the inclusion of vacancies and unemployment data in the dependent variables of employment demand and employment supply does not greatly affect the estimation results. It cannot easily be said that the results are a definite improvement or deterioration. This disappointing empirical finding suggests <u>either</u> that excess demand and supply are unimportant and that the equilibrium model is close enough to reality to be useful <u>or</u> that the data on vacancies and unemployment so seriously underestimates and mis-measures excess /

excess demand and supply that their use is inappropriate and other methods of estimating demand and supply must be found.

In view of the poor quality of the results in terms of lack of precision and implausibility of key parameter estimates, the latter conclusion is preferred. The imprecise nature of the results may be due to incorrect specification of the functions or lack of variability in the data series as well as the assumption of equilibrium. The next two chapters, in addition to improving the realism of the model by removing the equilibrium assumption, also bring to bear additional exogenous information about the state of the labour market. In doing so, it may be possible to compensate for the lack of variability mentioned above. The specification of the functions is not changed and any estimation procedures pursued are necessarily subject to the validity of the model specification.

TABLE 8.1 EMPLOYMENT DEMAND FUNCTIONS, 1949-71 and 1952-71

	DEPENDENT VARIABLE: LOG E_t	CONSTANT	LOG Q_t	LOG $(w/P)_t$	LOG E_{t-1}	t	LOG Ho_t	$\bar{R}^2$ S.E.	DW h	ADJUST SPEED $\hat{\mu}$ (S.E.)	RETURNS TO SCALE $\hat{\nu}$ (S.E.)	ELAST. OF SUBST. $\hat{\sigma}$ (S.E.)
(1)	FULL OLS 1949-71	-1.28 (0.6)	0.559 (3.5)	-0.322 (2.0)	0.598 (2.4)	-0.0059 (0.5)	-0.093 (0.3)	0.983 0.017	1.62 -	0.402 (0.251)	0.337 (0.806)	0.801 (0.271)
(2)	FULL OLS 1952-71	-2.44 (0.8)	0.692 (2.9)	-0.345 (1.9)	0.582 (2.1)	-0.0094 (0.6)	0.065 (0.1)	0.971 0.018	1.49 -	0.418 (0.274)	0.208 (0.570)	0.827 (0.319)
(3)	FULL 2SLS 1949-71	-0.88 (0.4)	0.548 (3.4)	-0.375 (2.2)	0.528 (2.0)	-0.0024 (0.2)	-0.163 (0.4)	- 0.017	1.61 -	0.472	0.561	0.794
(4)	FULL 2SLS 1952-71	-2.16 (0.7)	0.684 (2.8)	-0.401 (2.0)	0.515 (1.8)	-0.0058 (0.4)	0.012 (0.0)	- 0.018	1.48 -	0.485	0.298	0.827
(5)	SHORT OLS 1949-71	-1.10 (1.3)	0.518 (4.6)	-0.363 (4.4)	0.499 (4.1)			0.985 0.017	1.69 0.93	0.501 (0.123)	0.886 (0.462)	0.726 (0.170)
(6)	SHORT OLS 1952-71	-1.57 (1.4)	0.610 (4.1)	-0.433 (3.8)	0.441 (3.0)			0.974 0.017	1.55 1.34	0.559 (0.146)	0.709 (0.595)	0.775 (0.204)
(7)	SHORT 2SLS 1949-71	-1.37 (1.6)	0.567 (4.9)	-0.403 (4.7)	0.469 (3.8)			- 0.017	1.65 1.06	0.531	0.780	0.759
(8)	SHORT 2SLS 1952-71	-2.15 (1.8)	0.700 (4.4)	-0.508 (4.2)	0.394 (2.6)			- 0.018	1.48 1.55	0.606	0.510	0.838

t - values of short-run estimates in brackets. LSQ standard errors of long run parameter estimates in brackets.

TABLE 8.2 FIRST-ORDER AUTOCORRELATION: EMPLOYMENT DEMAND FUNCTIONS

	Dependent Variable LOG E_t	Constant	Log Q_t	Log $(W/P)_t$	Log E_{t-1}	t	Log Ho_t	$\bar{R}^2$ S.E.	DW $\hat{\rho}$	ADJUST. SPEED $\hat{\mu}$	RETURNS TO SCALE $\hat{\nu}$	ELAST. OF SUBST. $\hat{\sigma}$
(1)	FULL HILU 1949-71	7.07 (2.4)	0.487 (3.0)	-0.077 (0.5)	0.338 (1.7)	-0.0218 (2.1)	-1.136 (2.6)	0.984 0.016	2.04 0.90	0.662	1.427	0.116
(2)	FULL HILU 1952-71	6.60 (2.1)	0.615 (3.7)	-0.010 (0.1)	0.337 (1.8)	-0.0292 (2.4)	-0.994 (2.4)	0.978 0.015	1.83 0.85	0.663	1.079	0.015
(3)	FULL TSHILU 1949-71	7.18 (2.4)	0.481 (3.0)	-0.062 (0.4)	0.341 (1.8)	-0.0225 (2.1)	-1.133 (2.6)	- 0.016	2.03 0.90	0.659	1.425	0.094
(4)	FULL TSHILU 1952-71	6.83 (2.2)	0.606 (3.6)	0.019 (0.1)	0.342 (1.8)	-0.0305 (2.4)	-0.990 (2.4)	- 0.015	1.86 0.85	0.658	1.083	-0.029
(5)	SHORT HILU 1949-71	-1.15 (1.1)	0.589 (4.3)	-0.402 (3.8)	0.429 (3.2)			0.982 0.017	1.91 0.20	0.571	0.904	0.704
(6)	SHORT HILU 1952-71	-1.38 (0.9)	0.669 (4.4)	-0.455 (3.6)	0.363 (2.3)			0.970 0.017	1.63 0.30	0.637	0.850	0.714
(7)	SHORT TSHILU 1949-71	-1.74 (1.5)	0.676 (4.7)	-0.476 (4.2)	0.384 (2.8)			- 0.017	1.92 0.20	0.616	0.770	0.773
(8)	SHORT TSHILU 1952-71	-2.33 (1.4)	0.771 (4.7)	-0.550 (3.9)	0.337 (2.1)			- 0.018	1.61 0.30	0.663	0.511	0.830

TABLE 8.3. EMPLOYMENT SUPPLY FUNCTIONS, 1949-71 and 1952-71

	DEPENDENT VARIABLE LOG E_t	CONSTANT	LOG L_t	LOG W_{rt}	LOG E_{t-1}	LOG U_{rt}	LOG Π_{rt}	$\bar{R}^2$ S.E.	DW h	ADJUST SPEED $\hat{\lambda}$ (S.E.)	ELAST. WRT. L $\hat{\alpha}$ (S.E.)	ELAST. WRT. W $\hat{\beta}$ (S.E.)
(1)	FULL OLS 1949-71	-0.83 (0.3)	0.244 (0.7)	0.127 (0.4)	0.779 (7.3)	-0.144 (4.0)	-0.774 (1.2)	0.991 0.013	1.56 1.21	0.221 (0.106)	1.105 (1.183)	0.574 (1.518)
(2)	FULL OLS 1952-71	0.48 (0.1)	0.045 (0.1)	0.074 (0.2)	0.866 (4.8)	-0.169 (2.8)	-0.434 (0.4)	0.983 0.014	1.57 1.60	0.134 (0.179)	0.339 (3.486)	0.550 (3.452)
(3)	FULL 2SLS 1949-71	4.52 (0.6)	-0.221 (0.3)	-2.567 (1.4)	0.713 (2.9)	-0.225 (2.3)	2.099 (0.9)	- 0.029	1.21 -	0.287	-0.770	-8.944
(4)	FULL 2SLS 1952-71	-0.11 (0.0)	0.113 (0.2)	0.233 (0.3)	0.854 (4.6)	-0.158 (2.2)	-0.668 (0.5)	- 0.014	1.59 1.62	0.146	0.774	1.596
(5)	SHORT OLS 1949-71	-9.87 (4.1)	1.317 (4.1)	0.422 (1.4)	0.558 (4.7)			0.984 0.017	1.76 0.68	0.442 (0.118)	2.982 (0.312)	0.957 (0.849)
(6)	SHORT OLS 1952-71	-9.46 (3.8)	1.295 (3.9)	0.324 (0.8)	0.535 (3.8)			0.974 0.017	1.84 0.46	0.466 (0.141)	2.782 (0.445)	0.696 (1.014)
(7)	SHORT 2SLS 1949-71	-9.82 (3.9)	1.375 (4.0)	-0.051 (0.1)	0.481 (3.4)			- 0.018	1.65 1.14	0.519	2.649	-0.098
(8)	SHORT 2SLS 1952-71	-9.05 (2.9)	1.455 (3.4)	-0.872 (1.0)	0.286 (1.2)			- 0.022	1.66 -	0.714	2.038	-1.221

t - values of short-run estimates in brackets - LSQ standard errors of long-run parameter estimates in brackets.

TABLE 8.4. FIRST-ORDER AUTOCORRELATION: EMPLOYMENT SUPPLY FUNCTIONS

	DEPENDENT VARIABLE: LOG E_t	CONSTANT	LOG L_t	LOG W_{rt}	LOG E_{t-1}	LOG U_{rt}	LOG H_{rt}	$\bar{R}^2$ S.E.	DW $\hat{\rho}$	ADJUST. SPEED $\hat{\lambda}$	ELAST. WRT.L. $\hat{\alpha}$	ELAST. WRT.W. $\hat{\beta}$
(1)	FULL HILU 1949-71	- (2.5)	0.454 (1.2)	0.425 (1.6)	0.346 (2.8)	-0.153 (5.7)	-0.216 (0.5)	0.993 0.010	2.48 1.00	0.654	0.694	0.650
(2)	FULL HILU 1952-71	3.36 (0.8)	0.178 (0.4)	0.050 (0.2)	0.339 ((2.6)	-0.186 (5.5)	0.633 (1.0)	0.993 0.010	2.78 0.95	0.661	0.269	0.076
(3)	FULL TSHILU 1949-71	- (2.3)	0.442 (1.1)	0.325 (1.1)	0.352 (2.8)	-0.156 (5.7)	-0.116 (0.2)	- 0.010	2.42 1.00	0.648	0.682	0.502
(4)	FULL TSHILU 1952-71	3.51 (0.9)	0.160 (0.4)	-0.013 (0.0)	0.344 (2.6)	-0.190 (5.4)	0.719 (1.1)	- 0.010	2.81 0.95	0.656	0.244	-0.020
(5)	SHORT HILU 1949-71	-10.26 (3.9)	1.397 (4.1)	0.322 (1.0)	0.504 (4.0)			0.982 0.017	1.96 0.15	0.496	2.817	0.649
(6)	SHORT HILU 1952-71	- (1.9)	2.032 (4.1)	0.793 (2.2)	-0.141 (0.8)			0.972 0.017	2.39 1.00	1.141	1.781	0.695
(7)	SHORT TSHILU 1949-71	-10.49 (3.8)	1.485 (4.1)	-0.047 (0.1)	0.425 (3.0)			- 0.017	1.94 0.20	0.575	2.583	-0.082
(8)	SHORT TSHILU 1952-71	- (1.8)	2.041 (4.1)	0.765 (1.9)	-0.141 (0.8)			- 0.017	2.38 1.00	1.141	1.789	0.670

TABLE 8.5 'VACANCY-ADJUSTED' DEMAND FUNCTIONS, 1952-71, AND 'UNEMPLOYMENT-ADJUSTED' SUPPLY FUNCTIONS, 1949-71 AND 1952-71

	DEPENDENT VARIABLE LOG ED_t = LOG $(E+V)_t$	CONSTANT	LOG Q_t	LOG $(W/P)_t$	LOG E_{t-1}	t	LOG Ho_t	$\bar{R}^2$ S.E.	DW h	ADJUST. SPEED $\hat{\mu}$	RETURNS TO SCALE $\hat{\nu}$	ELAST. OF SUBST. $\hat{\sigma}$
(1)	FULL OLS 1952-71	-2.50 (0.8)	0.809 (3.3)	-0.391 (2.1)	0.524 (1.9)	-0.0120 (0.8)	-0.007 (0.0)	0.969 0.018	1.48 -	0.476	0.203	0.821
(2)	SHORT OLS 1952-71	-1.80 (1.5)	0.720 (4.7)	-0.506 (4.3)	0.340 (2.2)			0.971 0.018	1.58 1.28	0.660	0.720	0.767
	DEPENDENT VARIABLE LOG ES_t = LOG $(E+U)_t$	CONSTANT	LOG L_t	LOG W_{rt}	LOG E_{t-1}	LOG U_{rt}	LOG H_{rt}	$\bar{R}^2$ S.E.	DW h	ADJUST SPEED $\hat{\lambda}$	ELAST. WRT.L. $\hat{\alpha}$	ELAST. WRT.W. $\hat{\beta}$
(3)	FULL OLS 1949-71	-0.29 (0.1)	0.170 (0.5)	0.072 (0.2)	0.808 (7.5)	-0.128 (3.5)	-0.840 (1.3)	0.991 0.012	1.56 1.23	0.192	0.885	0.375
(4)	FULL OLS 1952-71	0.69 (0.2)	0.023 (0.0)	0.043 (0.1)	0.872 (4.8)	-0.146 (2.3)	-0.617 (0.6)	0.983 0.014	1.57 1.70*	0.128	0.180	0.336
(5)	SHORT OLS 1949-71	-8.32 (3.6)	1.123 (3.7)	0.286 (1.0)	0.613 (5.4)			0.985 0.016	1.74 0.76	0.387	2.902	0.739
(6)	SHORT OLS 1952-71	-7.97 (3.2)	1.105 (3.4)	0.196 (0.5)	0.592 (4.3)			0.975 0.017	1.78 0.62	0.408	2.708	0.480

t - values of short-run estimates in brackets.

TABLE 8.6 FIRST-ORDER AUTOCORRELATION: 'ADJUSTED' EMPLOYMENT DEMAND AND SUPPLY FUNCTIONS

	DEPENDENT VARIABLE LOG ED_t = LOG $(E+V)_t$	CONSTANT	LOG Q_t	LOG $(W/P)_t$	LOG E_{t-1}	t	LOG Ho_t	$\bar{R}^2$ S.E.	DW β	ADJUST. SPEED $\hat{\mu}$	RETURNS TO SCALE $\hat{\nu}$	ELAST. OF SUBST. $\hat{\sigma}$
(1)	FULL HILU 1952-71	6.87 (2.2)	0.717 (4.1)	-0.036 (0.2)	0.283 (1.5)	-0.0327 (2.7)	-1.107 (2.6)	0.977 0.015	1.68 0.85	0.717	1.000	0.050
(2)	SHORT HILU 1952-71	-1.78 (1.1)	0.768 (4.8)	-0.528 (4.0)	0.290 (1.8)			0.968 0.018	1.61 0.25	0.710	0.758	0.744
	DEPENDENT VARIABLE LOG ES_t = LOG $(E+U)_t$	**CONSTANT**	**LOG L_t**	**LOG W_{rt}**	**LOG E_{t-1}**	**LOG U_{rt}**	**LOG H_{rt}**	**$\bar{R}^2$ S.E.**	**DW β**	**ADJUST. SPEED $\hat{\lambda}$**	**ELAST. WRT.L. $\hat{\alpha}$**	**ELAST. WRT.W. $\hat{\beta}$**
(3)	FULL HILU 1949-71	- (2.8)	0.414 (1.1)	0.377 (1.5)	0.328 (2.7)	-0.132 (5.1)	-0.230 (0.5)	0.990 0.010	2.52 1.00	0.672	0.616	0.561
(4)	FULL HILU 1952-71	3.99 (1.0)	0.138 (0.3)	0.006 (0.0)	0.315 (2.5)	-0.163 (5.0)	0.578 (1.0)	0.992 0.009	2.81 0.95	0.685	0.201	0.009
(5)	SHORT HILU 1949-71	-7.05 (1.4)	1.492 (3.1)	0.574 (1.9)	-0.014 (0.1)			0.985 0.015	2.50 0.95	1.014	1.471	0.566
(6)	SHORT HILU 1952-71	- (2.2)	1.794 (4.1)	0.667 (2.1)	-0.101 (0.6)			0.979 0.015	2.47 1.00	1.101	1.629	0.606

t - values in brackets

9. A 'Homogenous' Aggregate Labour Market in Disequilibrium

9.1 Introduction

In this chapter, we first discuss the assumptions required to enable aggregate employment to be considered as demand-determined or supply-determined at a point in time, in accordance with section 7.3. This is followed by a brief survey of attempts to specify and test this type of situation. We then develop techniques of empirical investigation which are thought suitable for a model of the labour market and finally pursue the consequent estimation.

9.2. Requirements for 'homogenous' disequilibrium behaviour of the aggregate labour market.

In the last chapter, we assumed that each sector of the labour market was always at, or very close to, equilibrium so that aggregate equilibrium was observable and demand and supply functions could be estimated accordingly. Each sector was assumed to be equilibrated by the sector's wage rate changing readily-rising to remove excess demand for labour and falling to remove excess supply. The different sectors' wage rates were assumed to be insulated from each other due to immobility of labour, by region, occupation etc., and so wage rates need not be equalised throughout the industry.

This assumption of perfect flexibility of wage rates seems somewhat unrealistic. In section 7.3, we discussed several reasons to suggest that sectors'wage rates were not sufficiently flexible to achieve equilibrium in the short run, though there may be a long-run tendency for wage rates to move towards their equilibrium levels. However, /

However, the factors affecting demand and supply will be changing over time, and so the demand and supply functions for each sector will be shifting and changing the equilibrium levels of employment and wage rate.

Therefore, each sector will generally be in dis-equilibrium. If the wage rate is above equilibrium level, then employment will be equal to the demand for labour and excess supply will be present, as shown in Fig. 9.1. If the wage rate is below equilibrium then employment will be equal to the supply of labour and excess demand will be present, as shown in Fig. 9.2.

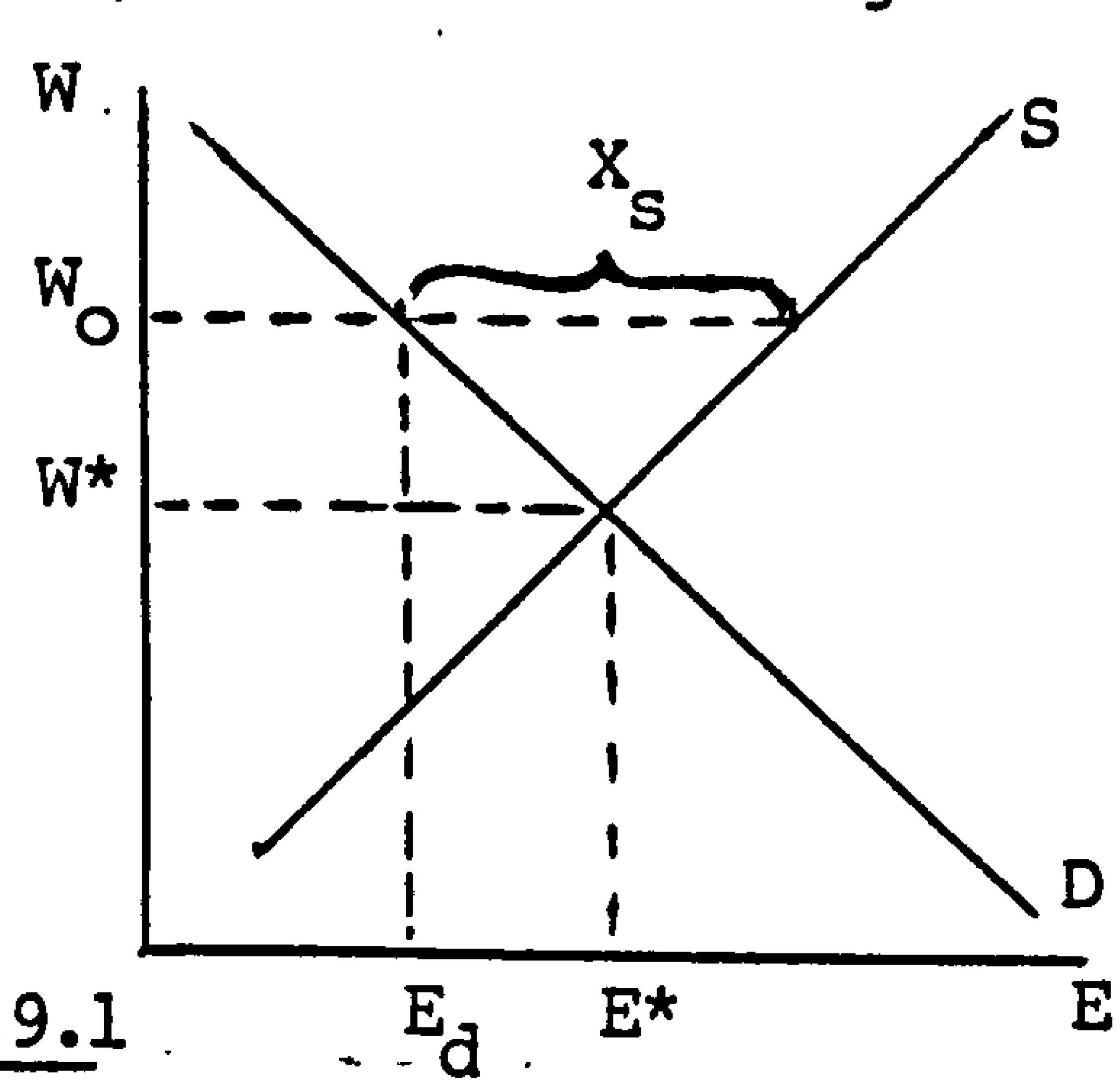

Fig.9.1

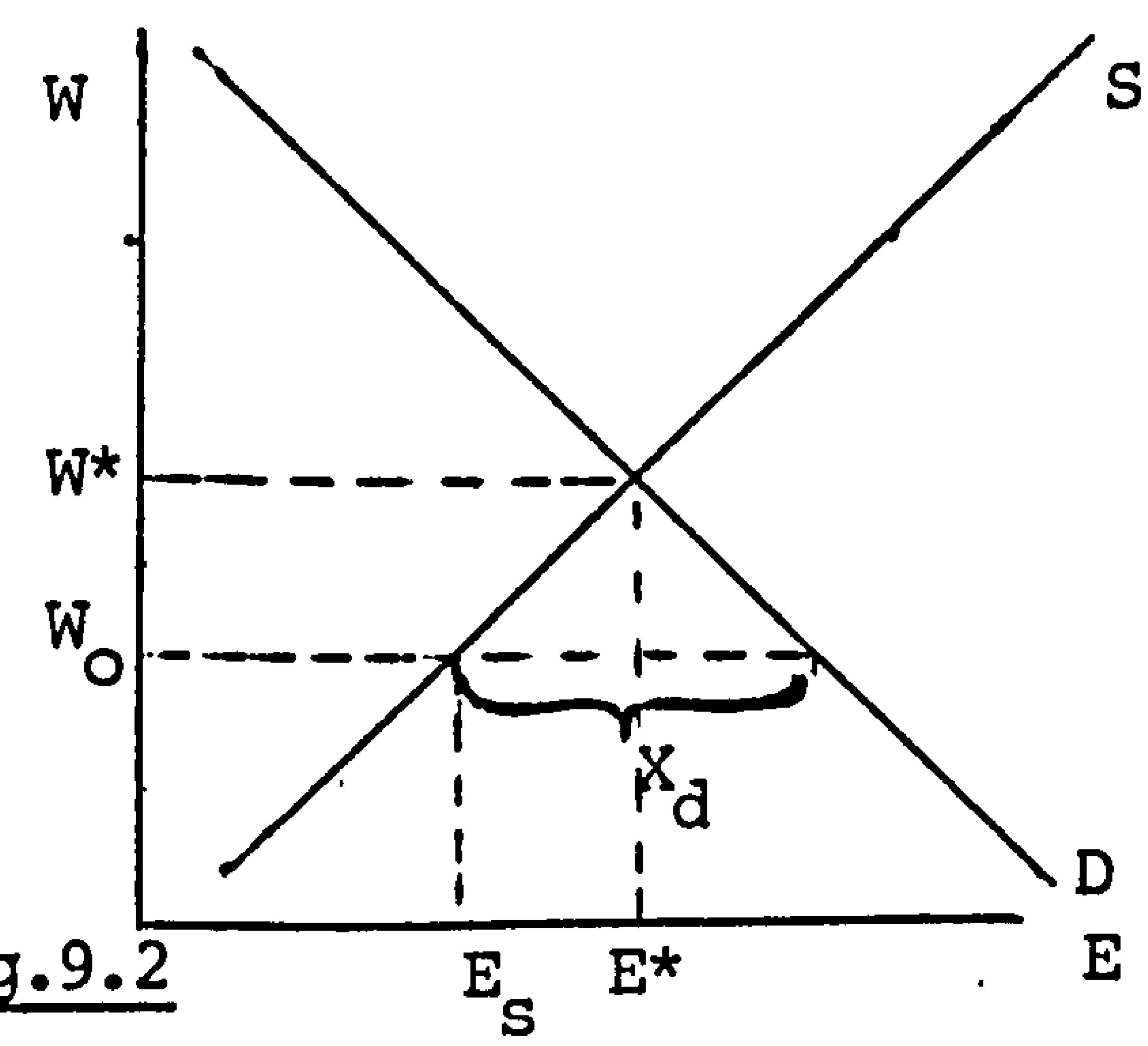

Fig.9.2

Consequently, for us to be able to observe the aggregate demand for labour, at a point in time, it is necessary for all sectors to be demand-determined and hence to have their wage rates at or above equilibrium. Similarly for aggregate labour supply to be observed at a point in time, all sectors must have their wage rates at or below equilibrium. The hypothesis put forward in this chapter is that the sectors of the industry labour market are sufficiently homogenous for them <u>all</u> to be demand-determined or <u>all</u> to be supply-determined/

determined, at a point in time. Underlying this hypothesis is the assumption that the variables, which affect employment demand and supply, move in a similar way in all sectors.

If there is a long-run tendency for employment and the wage rate to move towards equilibrium in each sector, then a change in one of the variables affecting demand or supply, will cause a shift in the corresponding function. This will create an imbalance between demand and supply, given wage inflexibility. Provided that the variable which changes does so for each sector in the same direction, then the resulting imbalances will be in the same direction in each sector, i.e. either all sectors will have excess supply and be demand-determined or they will all have excess demand and be supply-determined. The resulting aggregate position will be that observed aggregate employment will lie either on the aggregate demand function or on the supply function but not generally on both.

A particular hypothesis, which we hope to test, is that it is changes in the demand for the industry's output which are the major cause of shifts in the labour market. When product demand is high, the demand for labour curve shifts to the right and excess demand results, with supply-determination of employment. When product demand is low, the demand for labour curve shifts to the left and excess supply results, with demand-determination of employment, as shown in Fig. 7.1.

9.2 /

9.3 A survey of regime-switching and disequilibrium models

a) Estimation

If it were known prior to estimation, in which periods the aggregate employment level is demand-determined and in which it is supply determined, then it would be a simple matter to separate our observations into the two 'regimes' and estimate the two functions separately. Where this prior knowledge is not available then estimation becomes much more complicated. A substantial body of literature has developed concerned with the theoretical and empirical econometric problems of estimating and testing 'regime-switching' models.

A pioneering article in this area was Quandt (1958). Quandt considered the situation of a single switch from one regime to another at an unknown point in a time series of T observations. He derives a likelihood function which for given T, is dependent solely on t, the location of the switch point. Since t is a discrete rather than a continuous variable, he suggests that the likelihood function be maximized with respect to t by evaluating it for each possible value of t and then choosing the global maximum. Parameters of the two regimes are estimated by ordinary least squares for each value of t.

Whilst this procedure can be generalised to more than one switch of regimes, the type of situation where frequent switching is likely to occur would involve impossibly cumbersome computational work, with order 2^T evaluations of the likelihood function.

This /

This method can only really be practical where observations can be arranged in such a way that a single switch of regimes takes place.

Quandt (1972) suggests an alternative procedure for dealing with the situation of many possible switches. He assumes that there is an unknown probability λ of an observation being generated by regime 1 and probability $(1 - \lambda)$ of being generated by regime 2. A complicated likelihood function is derived which is to be maximized with respect to the parameters of the two regimes, their standard errors and λ, with λ restricted to lie between zero and unity. Thus estimation is difficult and, in sampling experiments, the non-linear maximizing algorithm failed to converge in 22 per cent of all replications. Furthermore, a disadvantage of this procedure is that it does not allow individual observations to be identified with particular regimes, even after estimation.

A feature of both Quandt's estimation methods is that they require no exogenous information about when a switch is likely to occur. Where such information is not available then this feature is clearly an advantage. However, where information is available, as is often the case with economic studies, which can indicate whether a particular regime is likely or unlikely to be observed, a method which incorporates this information should lead to improved estimates of the two regimes.

Fair and Jaffee (1972) put forward several methods which impose varying degrees of restrictiveness in their use of additional information.

A /

A trade-off between the variance and bias of estimates is likely since the more restrictive the assumptions are, the less likely they are to be valid ones.

Fair and Jaffee's basic model consists of demand and supply equations both of which include price, P, as a determinant but P is not assumed to adjust each period to equate demand and supply. The assumption that observed quantity will be equal to the minimum of quality demanded and quantity supplied is also treated as a basic requirement and corresponds to the assumption made about the labour market in the previous section.

Further assumptions concern the strength of relationship between changes in price (observed) and the state of excess demand (unobserved). Their'directional methods' involve the assumption that the sign of the price change will be the same as that of excess demand,based on the rationale that demand greater than supply will cause price to rise and demand less than supply will cause price to fall. Whilst the latter rationale may seem plausible enough, the use of price change as a 'signal' for excess demand is in effect a reversal of the relationship and will only be valid if price is not influenced by other factors than excess demand. For this to be true the demand and supply equations will clearly need to be fully specified.

Fair and Jaffee point out that even if the above assumption is valid, the estimation of the demand and supply functions may still be subject to inconsistency. Large values of the non-stochastic element of demand and /

and supply are likely to be associated with small positive or negative errors since large values plus large positive errors are unlikely to be observed in either regime. This problem is mostly likely where demand and supply quantities are close in magnitude. To minimize this problem of inconsistency, Fair and Jaffee recommend using price information to allocate observations to a regime where the excess demand status is in little doubt and then to evaluate all possible likelihood functions associated with the other 'doubtful' observations to find the maximum. The order of the computational work should be considerably reduced from 2^T.

Fair and Jaffee's 'quantitative method' goes a stage further and assumes a direct proportional relationship between the price change and the extent of excess demand. This assumption allows observed quantity to be adjusted by the price change multiplied by the constant proportional factor, γ, to give (unobserved) demand or supply depending on the sign of the price change. As the proportional factor is unknown, the price change variable is transferred to the right-hand side of the equation, where γ can be estimated along with the other parameters of the demand and supply equations. The price change variable appears in the demand equation only when price change is positive i.e. when excess demand prevails, and is zero otherwise and vv. for the supply equation.

Whilst this procedure appears to make estimatable, relationships which are partly unobserved, it does so at /

at the expense of a strong and perhaps invalid assumption. Furthermore, several estimation problems remain. Firstly, the factor γ appears in both equations and so should be constrained to be the same in both equations. Secondly, not only the price level but price changes will be endogenous variables and methods such as two-stage least squares are complicated by the fact that the price change variable is zero for many observations. Fair and Jaffee are not able to deal with both of these elements together and are left with a trade-off between efficiency, i.e. constraining the γ estimate, and consistency, i.e. allowing for simultaneity.

Fair and Jaffee apply their demand and supply model together with the different directional and quantitative methods to the U.S. housing market, with the price variable being the mortgage rate. They first estimate demand and supply equations using all observations of quantity in each equation, as if in equilibrium, as a benchmark. Then they attempt to use a number of algorithms to obtain the general maximum of the likelihood function of the basic model with no additional assumptions. These attempts proved unsuccessful. Directional method I yields a better fit and lower standard errors than the benchmark equations, though without changing the coefficients drastically. Directional method II, which involves searching for the optimal allocation of those periods whose state of excess demand is doubtful, tends to make the coefficient estimate of the /

the price variable in the demand equation implausibly large. The quantitative method yields results very similar to the (overall) benchmark regressions, though the price change variable is generally significant and of correct sign. This does suggest that disequilibrium is a feature of the housing market, though it is disappointing or comforting (depending on one's viewpoint) to note that little bias seems to be introduced by the assumption of equilibrium.

Whilst the use of price information in regime separation clearly has some appeal to it, it is not necessarily a complete or even the best indicator of excess demand or supply in a particular market. Other authors, e.g. Fair and Kelejian (1974) and Goldfeld and Quandt (1975), have attempted to allow other factors to influence price changes by specifying a stochastic relationship between price change and excess demand and other factors, to be specified in particular situations. However, allocation of an observation to a particular regime becomes probabilistic rather than deterministic and estimation involved the maximization of complicated likelihood functions, with empirical difficulties experienced.

Rosen and Quandt (1978) have attempted to apply such a disequilibrium model to an aggregate labour market. The labour demand function, is obtained from the marginal productivity of labour condition in the context of a neoclassical production function, e.g. CES, so that demand is dependent upon wage, output and a time trend. No lag /

lag is allowed in adjusting labour demand to its desired level. Labour supply, at the economy level, is postulated to depend upon net wage, unearned income and a 'potential labour input' variable,to allow for changes in the population of working age.

Together with the usual assumption ,that observed quantity of labour will be equal to the minimum of demand and supply, Rosen and Quandt also assume adjustment of the real wage stochastically dependent on excess demand and an additional factor to account for non-competitive effects on wages,e.g. union influence. They estimate the model using maximum likelihood without any apparent difficulty. Empirical results are found to be generally plausible. Whether the maximum likelihood estimation technique is always well-behaved is an empirical question not answered from a sample of one, particularly as the demand and supply equations contained no adjustment processes in the form of lagged dependent variables. Also there is the question of whether there is further information available in the case of the labour market, which might help in the separation and estimation of demand and supply, to be pursued in the next section.

b) Testing

If it proves possible to estimate a disequilibrium model of a particular market then it is desirable that we be able to rigorously test the disequilibrium hypothesis against the more usual equilibrium hypothesis. The disequilibrium model clearly involves much more specification /

specification and computational effort so that a clear case for its superiority over the equilibrium model is needed to discourage use of the 'easy option' in appropriate situations. Quandt addresses himself to the testing of 'regime' hypotheses as well as the estimation of them.

In Quandt (1958), a likelihood ratio test is first suggested, where the numerator of the ratio, λ, is the value of the likelihood function when the optimal separation of the two regimes has been carried out (alternative hypothesis) and the denominator is the value of the likelihood function when no switch is allowed so that all observations obey one regime (null hypothesis). Quandt shows that this ratio can be expressed simply in terms of the standard errors of the two separate regime regressions and the overall regression. Under certain conditions, which this model does not really satisfy, $-2 \log \lambda$ can be tested as a Chi-squared distribution.

Alternatively, a classical (variance) Chow test can be carried out, comparing the sum of the residual sum of squares of the two regime regressions, with the overall regression, based on the maximum likelihood split into regimes. However, there will be a problem with the significance of this 'F-test' since the switch point is not exogenously determined. Consequently, the sum of the squared residuals from the two regimes will be lower than it should be, leading to more frequent rejection of the null hypothesis than significance levels would suggest.

To avoid this problem, the split into regimes may be made exogenously but such a split would be arbitrary, e.g. central, /

central, and if incorrectly positioned would lead to 'contamination' of one or other of the regimes. This could weaken the F-test power, leading to less frequent rejection of the null hypothesis. If possible, some central observations could be omitted to lessen the risk of contamination, but this omission of observations lessens the degrees of freedom in estimation and may still leave an inaccurate F-test, if the true switch point is not central. The above considerations appear to favour the likelihood ratio test but Quandt (1960) sets up an (artificial) sampling experiment which indicates that $- 2 \log \lambda$ does not obey a Chi-squared distribution even for samples of size 60.

Another test is put forward in Quandt (1960) based on the use of the estimates of one regime to predict values of the dependent variable for observations from the other regime i.e. predictions of the values of the dependent variable that would have occurred had the regime not switched. Residuals between predicted and actual values can then be calculated and their mean and variances calculated. If the null hypothesis were correct then this mean would have an expected value of zero. Hence a t-test can be performed which tests whether the sample mean is significantly different from zero. As with the F-test suggested above, this test is influenced by the endogeneity of the switch point selection.

More recently, Quandt (1978) explicitly considers a supply and demand disequilibrium model similar to that of Fair /

Fair and Jaffee,with a price adjustment equation relating price changes to excess demand with the possibility of other factors and optionally stochastic. Under certain assumptions, in particular that the price adjustment equation be valid,in the sense that some adjustment be taking place due to excess demand,and that it be a stochastic relation, the equilibrium hypothesis can be seen to be a nested hypothesis of the disequilibrium one. The parameter on excess demand in the price adjustment equation represents the speed of adjustment and,as this approaches infinity, the disequilibrium model approaches the equilibrium one. Thus a test of whether the inverse of this parameter estimate is significantly different from zero is a test of the equilibrium hypothesis.

However, it must be noted that this test is subject not only to correct specification of demand and supply equations,but also to correct specification of the price adjustment equation. Minor changes in specification could lead to loss of the 'nesting property'. In such situations, Quandt recommends use of a likelihood ratio, not as a rigorous theoretical test but as a practical means of discriminating between conflicting hypotheses.

Rosen and Quandt, in estimating their labour market model, also set up an equilibrium version where labour demand and supply are equal to actual labour. This equilibrium version is non-nested by the disequilibrium model but is found to be inferior in terms of likelihood value and plausibility of parameter estimates. Wage levels seem /

seem to take several years to approach equilibrium. Thus the estimation of labour markets in disequilibrium, rather than assuming equilibrium, does appear to be a worthwhile and feasible pursuit. We now consider possible ways of carrying out such a pursuit for the aggregate industry labour market.

9.4. Methods of estimation

Most of the models surveyed in the previous section have concentrated on the use of price information to determine the regime of an observation. In our case, considering a labour market, there are good reasons to modify this approach. Firstly, as will be discussed shortly, changes in the price of labour are unlikely to simply reflect excess demand and secondly, we have available exogenous measures of the extent of excess demand-data unique to a labour market, such as unemployment and vacancies figures. The regime selection process should be considerably improved by judicious use of this information.

If we can obtain enough extraneous information to enable us to rank our observations by the degree of their excess demand or supply then we can assign those with the highest excess demand or lowest excess supply to the supply 'regime' and those with highest excess supply or lowest excess demand to the demand regime. Our problem then becomes essentially one of locating the single switch point from one regime to the other, though there remains the problem of whether middle observations could belong to both regimes or should be omitted from both regimes to lessen the problem of inconsistency mentioned earlier. The location /

location of a single switch point was considered in the basic Quandt (1958) model and the maximum likelihood split is obtained by maximizing the sum of the log-likelihood values from separate O.L.S. estimation of the two regimes, for all possible splits of the data intq the two regimes. Various ways of using extraneous information to perform the ranking of observations presented themselves:-

i) the level of unemployment relative to the level of employment is a straightforward indicator (referred to in the tables as U-BASED) of the extent of excess supply which should be high when employment is demand-determined and low when supply-determined. Its usefulness as a ranking will be limited by the fact that measurement errors in reported unemployment, due to non-registration etc.,may cause its rank to differ from that of 'true' excess supply.

ii) similarly the level of vacancies remaining unfilled relative to the level of employment can be used as an indicator (V-BASED) of the extent of excess demand and the ratio should be high when employment is supply-determined and low when demand-determined. Non-reporting of vacancies is likely to cause larger errors in this ratio than in the excess supply one, weakening its use as a sole indicator of excess demand.

Of course, it is possible to combine the information on unemployment and vacancies to obtain one measure of excess demand/supply. However, any composite measure which involves subtraction of one from the other or division of one by the other, is likely to compound the measurement/

measurement errors of the two separate measures and make the resulting ranking more unreliable, particularly if the measurement errors are negatively correlated. Consequently, this was not done.

iii) the direction of change of the price of labour may be taken as an indicator of whether excess demand or excess supply is present, as suggested by Fair and Jaffee for the housing market. However, if the price of labour is taken to be the hourly money wage rate then its direction of change would appear to be of limited use as an indicator of excess demand. The wage rate has increased monotonically throughout the estimation period but this is unlikely to be due to continuing excess demand. Whilst we do not believe that the money wage rate is rapidly adjusted to remove excess demand due to any shift in demand or supply schedules, there must be some factors affecting demand or supply which are quickly adjusted for, to explain the path of the wage rate, without continual excess demand. In particular, we may expect the price of output on the demand side and the aggregate wage rate on the supply side to have a rapid effect upon the money wage rate, such that wage rate changes occur before excess demand can develop due to these factors.

The strongest rationale for the above phenomena is on the supply side, where workers or their trade union representatives are readily aware of wage increases occurring in other industries and are rapidly able to obtain comparable increases in their own industry wage rate. /

rate. Other factors affecting supply and demand are assumed less easily perceived or acted upon. These other factors do cause excess demand or supply to occur and wage rates will slowly adjust in the right direction to remove the excesses. Hence, if we use the direction of change of the industry wage rate relative to the aggregate wage rate, this may be a viable indicator of the excess demand/ supply present, where the simple money wage rate is not. A similar argument might be made on the demand side,with employers reacting to price changes, but it is felt that the supply reaction will dominate.

The procedure ,then ,is to calculate percentage changes in the ratio of industry wage rate to the aggregate wage rate and to rank observations accordingly. Those observations with the highest percentage increases indicate excess demand and are thus expected to be supply-determined and vice versa.

Clearly, the resultant measure (W-BASED) is subject to the validity of the above hypothesis concerning employees' reaction to aggregate wage changes. Because of this, the measure should be applied cautiously and, as with the other measures, it will be used only as a ranking variable and not as a continuous variable or as a means of a priori separation,i.e. the 'cut-off' point between demand and supply-determination is treated as unknown.

Peel and Walker (1978) adopt a similar method for the aggregate U.K. labour market. However, they specify the direction of change in expected real wage, i.e. the change /

change in money wages over and above the expected change in prices, as the indicator of excess demand or supply. Whilst, this seems a reasonable hypothesis, it does involve the further specification and estimation of expected inflation, a considerable task in itself. Furthermore, Peel and Walker do not specify a supply function but estimate separate demand functions for the two regimes, one of which is meant to be supply-determined. Thus, it is difficult to assess the success of their separation method.

iv) Finally, as suggested in 9.2, changes in demand for the industry's output may be the major cause of imbalance in the labour market. If this is the case then a measure of the pattern of output can be used as a means of splitting our observations into demand and supply regimes. Such a measure was developed for the engineering industry, and for other industries, in Briscoe and Roberts (1975) by de-trending a quarterly, seasonally adjusted, output series and smoothing it by taking moving-averages. The resulting series (O-BASED) shows a definite cyclical pattern which can be used to rank observations - those with highest output values being allocated to the supply regime and those with lowest values to the demand regime. Again the switch-point is unknown.

Thus we have four ways of ranking our observations, all intended to be by degree of (unobserved) excess demand or supply. Each will yield different demand and supply regimes /

regimes and it is worth noting the rank patterns which these measures impose. Table 9.1 indicates the rankings of the four measures, with that of the unemployment ratio reversed so that for all four, a low number represents high excess demand and is thus likely to belong to the supply regime and a high number represents low excess demand and is thus likely to belong to the demand regime. Vacancy data, at the SIC level, was only available from 1952 onwards and so, for consistency, regime separation was performed for the period 1952-71, for all four measures. The earlier years, 1949-51, can then be allocated to demand or supply regimes on the basis of 1952-71, regime estimates. As can be seen, the four measures are by no means perfectly correlated. The Spearman rank correlation coefficient is always positive between pairs of the rank measures, taking a value of just over 0.60 for the three pairings which involve the vacancy-based ranking, about 0.34 for the other two pairings which involve the wage-change ranking but only 0.14 between the output and unemployment based rankings.[1] As we have no strong a priori preference for one measure rather than another and no grounds for combining them into one composite measure,[2] the empirical procedure adopted was to investigate the use of each measure separately; then to attempt to choose between them on the basis of both statistical and economic plausibility criteria.

The statistical criteria for choosing the demand and supply regimes split have already been discussed, i.e. maximizing /

(1) The 5% critical value for 20 observations is approx. 0.45
(2) Factor analysis could be used to combine the various measures, but this was not done.

maximizing likelihood values. This should also serve as a means of comparison, if not a rigorous statistical test, between alternative rank measures. Also, it was felt to be worthwhile to develop, as a benchmark, a regime split based purely on maximizing likelihood. This is now described.

v) Whilst a complete evaluation of the likelihood values for all possible splits was not feasible, a sequential procedure was adopted in which each step taken was on the basis of maximum likelihood. Firstly, a regime was estimated using all twenty observations; then each observation was dropped in turn and the regime estimated for the other nineteen observations. The estimation which resulted in the highest likelihood value indicated the (omitted) observation 'least likely' to belong to the regime. This process can be repeated, dropping each of the remaining nineteen observations in turn and again choosing the maximum likelihood omission and so on until there are enough observations omitted to enable them to be used to estimate the other regime. The above procedure can then be continued estimating both regimes and selecting on the basis of highest sum of the two log-likelihood values. This can continue until the number of observations in the original regime is only just sufficient to estimate it.

In this way, we obtain a series of possible regime splits and can choose the one which yields the highest likelihood value, as with the 'rank measures' method. In /

In fact, since we can start with either the demand or the supply regime, we have two such series for the full model and two for the short model. No claim is made that the above procedure achieves the global maximum likelihood though if the two series yielded the same split of observations then this would strengthen confidence in the method.

Finally, the resulting regime splits can be judged on the basis of economic plausibility. In addition to an assessment of the signs, magnitudes etc. of the coefficients, more demanding criteria can be developed from consideration of the nature of the demand and supply model. If we have estimated the demand equation from observations in the demand regime we can use the estimates to predict the level of employment demanded in those periods when supply rather than demand was observed. If these periods were supply-determined then predicted demand should be greater than actual observed employment i.e. the residual between actual and predicted should be negative as shown in Fig. 9.3.

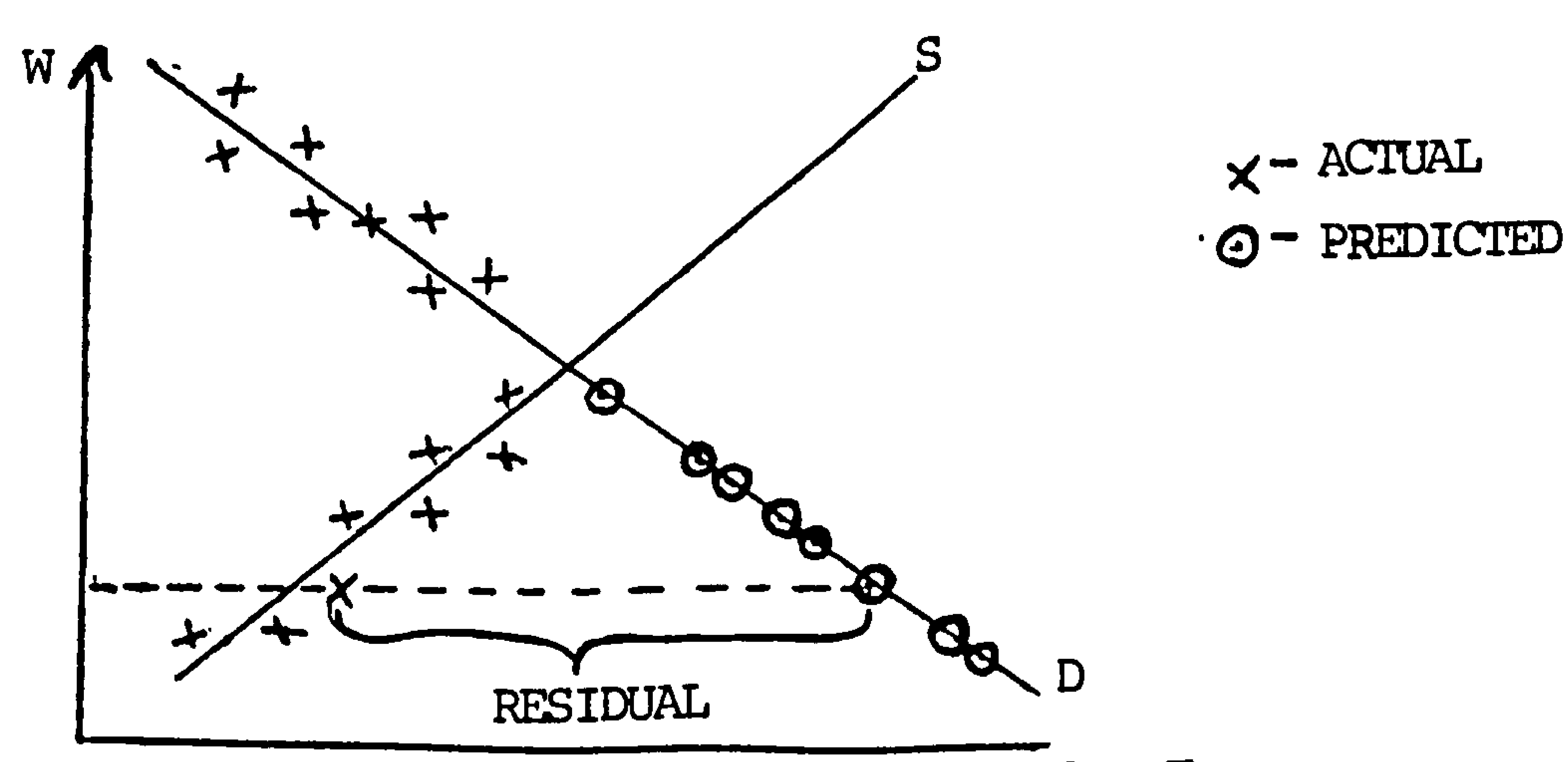

Figure 9.3

The /

The size of the residual would depend upon the difference between the demand and supply equations for the particular levels of the wage rate and other variables. Small residuals, possibly even positive ones, could be expected near the intersection point where stochastic elements may dominate the non-stochastic ones,but several large negative predicted residuals should be obtained if regime separation is likely to be meaningful,and large positive residuals would be an indication of incorrect regime separation.

This process can be repeated for the supply equation, predicting the level of employment supply where demand was the constraining factor. Again large negative predicted residuals are expected and large positive residuals suggest incorrect regime estimation.

As well as being used to check the plausibility of maximum likelihood regime selection, this procedure can be used to augment likelihood in the location of the 'cut-off' value which splits the two regimes. These 'residuals' criteria are felt likely to prove quite strict requirements.

9.5 Empirical investigation of demand and supply regimes

i) Unemployment-based ranking (U-BASED)

As in the previous chapter, both 'full' and 'short' equations were used to estimate the regimes - (6.3) and (6.9) together, (6.10) and (6.11) together, for each possible split of the sample into regimes, in accordance with the ranking of the unemployment-employment ratio. The /

The range of the possible splits was limited by the minimum number of observations required for estimation of a regime to maintain non-zero degrees of freedom; seven observations for the full model and five for the short model. Estimation took place for the years 1952-71, rather than 1949-71, for comparison purposes with regime selection by the vacancy-based ranking (not available before 1952) and later estimation.

Table 9.2 a), i) in the Appendix indicates that for the full model, maximum likelihood is achieved with eight observations in the demand regime and twelve in the supply regime.

The regression results, as reported in Table 9.3 a) and b), i), are considerably weakened by the low number of degrees of freedom particularly for the demand regime. Real wage and normal hours take positive signs, contrary to expectations, though neither is significantly different from zero at the 5% level. Output has a positive sign as expected but interpretation of its magnitude in terms of returns to scale is hampered by the estimated coefficient on lagged employment being greater than unity, though not significantly so. This value implies negative adjustment of employment demand toward its desired level. On the supply side, adjustment of supply towards its desired level of approx 50% per annum is estimated and this is significant at the 5% level. In addition, only relative unemployment has a significant effect, with relative wage taking an unexpected /

unexpected negative sign.

The residuals obtained by subtracting the predicted value of employment demand from actual employment for 'supply' observations and similarly with the predicted value of employment supply for 'demand' observations are reported in Table 9.4. a), i) and compared with actual regression residuals. As already discussed, if correct specification and separation has been achieved then the predicted residuals should be predominantly negative and large relative to the regression residuals. One or two exceptions could indicate the need for slight adjustment of regimes or could be within the bounds of the stochastic error element. However, in this case the residuals would seem to deny any confidence in the regime selection process, as the predicted demand residuals, with one exception, are positive and mostly much larger in magnitude than the regression residuals. The mean absolute error is some nine times larger. Some of the predicted supply residuals are negative but many are again large and positive.

In view of the overwhelming evidence of incorrect signs of predicted residuals, it was not felt to be worthwhile investigating marginal changes in regime separation, about the reported 'optimum'. It was thought very unlikely to yield the massive changes in predictions needed. The unemployment-based ranking was thus found to be unsuccessful in yielding acceptable regimes for the 'full model' specification.

The /

The above exercise was repeated for the 'short model', in the hope that estimation with more degrees of freedom and with more 'precision' could improve the separation process. Maximum likelihood separation occurred at quite a different split with eleven demand observations and nine supply. The signs of coefficients and their significance is generally improved, particularly in the demand function, as can be seen in Table 9.3 c), i). In the supply function, an adjustment speed of greater than unity is indicated, though not significantly so.

However, a predominance of positive and large residuals were predicted for demand and several similar residuals predicted for supply. The general conclusion was reached that the unemployment-based ranking was not acting as a good demand and supply regime separator.

ii) Vacancy-based ranking (V-BASED)

With the regimes split in accordance with the ranking of the vacancy-employment ratio, maximum likelihood is achieved for the full model with only seven observations in the demand regime and thirteen in the supply regime. The successive log-likelihood values are given in Table 9.2 a), ii), and it can be seen that the optimal value is somewhat lower than that obtained with the unemployment-based split i.e. a 'less likely' regime separation. Seven observations represents the minimum number of observations required to estimate a full demand or supply equation and so we have, in effect, a 'corner solution'.

The regression results, reported in Table 9.3 a) and b), ii), are again weak. The demand regime, with one degree /

degree of freedom, has no coefficients significant at the 5% level and totally implausible estimates on output, real wage and lagged employment. The supply regime again has only lagged employment and relative unemployment significant, with expected sign, at the 5% level. Adjustment of supply of almost 14% p.a. is implied. All other estimates have very low significance.

Despite the lack of promise in these estimates, predicted residuals were obtained, as before and are reported in Table 9.4 a), ii). As can be seen, the predicted demand residuals are mostly negative for the earlier years but become large and positive for the later years, contrary to expectations. The supply regime is much more successful in its predicted residuals, with all the 'demand regime' residuals being negative and with a mean absolute error twice as large as that of the regression residuals. The predicted residuals for the years 1949, 1950 and 1951, the pre-estimation observations, are all positive, but no greater in magnitude than the regression residuals. This suggests that those observations should belong to the supply regime.

In view of the plausibility of the predicted supply residuals, some changes in the regime separation were tried, in an attempt to improve estimation of the demand regime. The plausibility and significance of the estimates were increased by increasing its number of observations but predicted demand residuals remained predominantly positive. The 'one-sided' nature of the results /

results could not be improved upon for the full model.

For the short model, with more degrees of freedom, a similar regime split is obtained with eight demand observations and twelve supply. Again the log-likelihood value is below that of the unemployment-based split. The demand regime again yields implausible and insignificant estimates, though the estimates of the supply function are somewhat improved in significance. An adjustment speed of 41% p.a. is implied for supply which is quite different from the full model estimate. All the predicted demand residuals are positive except for 1949 and the mean absolute predicted error is some six times larger than the residual error. This is strong evidence against a correct regime separation, but again the supply regime proves much more successful. All predicted supply residuals are negative and the mean absolute error is twice the mean absolute residual error. Again, some experimentation was made with small changes in the regimes, without great improvement in the predicted demand residuals. Use of the vacancy-based regime split remained one-sided in its success.

iii) Wage-change ranking (W-BASED)

With the regimes split in accordance with the ranking of the size of change in relative wage rates, maximum likelihood is again achieved for the full model with only seven observations in the demand regime and thirteen in the supply regime. The likelihood values, reported in Table 9.2 a), iii) can be seen to be similar to /

to those obtained with the vacancy-based ranking.

The regression results, reported in Table 9.3 a) and b), iii), are more plausible for the demand regime than with the vacancy-based ranking, though negative adjustment is implied and again, with one degree of freedom, individual estimates are insignificantly different from zero. The supply regime estimates have signs as expected but only lagged employment is significant at the 5% level. The adjustment speed implied for supply is 33% p.a.

Predicted residuals are reported in Table 9.4 a), iii). As can be seen, the predicted demand residuals are mainly negative and large relative to the estimation residuals. This includes the predicted residuals for 1949, 50 and 51, suggesting that they should belong to the supply regime. However, five predicted residuals are positive and large, which is contrary to our theoretical expectations. Similarly, the supply regime predicts several large positive residuals as well as several negative ones. Marginal changes in the regime separation showed no sign of removing the positive predicted residuals.

For the short model, with more degrees of freedom, the same regime split is obtained i.e. seven demand observations and thirteen supply. Estimates, particularly of the demand equation, are more plausible and more significant than those of the full model. Adjustment speeds of 62% p.a. for demand and 66% p.a. for supply are implied. However, both sets of predicted residuals again contain several positive and large values.

The /

The wage-change ranking does not seem to yield a plausible regime separation and shows little promise of doing so.

iv) Output-based ranking (O-BASED)

With the regimes split in accordance with the 'cyclical position of output' ranking, maximum likelihood is achieved for the full model at quite a different split, with twelve demand observations and eight supply. The likelihood values, reported in Table 9.2 a), iv), can be seen to be somewhat lower than those obtained with the other rankings.

The regression results, reported in Table 9.3 a) and b), iv), are improved for the demand equation, with more degrees of freedom, estimates mainly of correct sign and the output and real wage terms significantly so. However, the supply estimation is weakened correspondingly, with signs mainly contrary to expectations, negative adjustment implied and no estimates significantly different from zero at the 5% level.

Predicted residuals are reported in Table 9.4 a), iv). The predicted demand residuals are predominantly negative and generally large relative to estimation residuals, with the exception of 1961 from the estimation period and 1949 and 1950 from the pre-estimation period. These pre-estimation years could be taken to be demand-determined, but the residuals are substantially greater than any estimation residuals. The magnitude of the 1961 residual is less than the average estimation residual, suggesting demand /

demand determination. Predicted supply residuals are also predominantly negative and large, with the exception of 1960 and 1965 from the estimation period and 1949 and 1950, which are again large and positive. It seems more likely that 1949 and 1950 belong to neither regime than that they belong to both, with such large residuals. The magnitude of the 1960 and 1965 residuals is much larger than estimation residuals.

In view of the closeness of the predicted residuals to the negativity being looked for, it was felt to be worthwhile to experiment with small changes in the regime separation about the maximum likelihood value. It was found that ten observations in the supply regime yielded an improvement in the predicted residuals, with only one positive, for 1960, and that smaller than the average estimation residual. Furthermore, the corresponding demand regime, with ten observations yielded predicted residuals which were all negative for the estimation period, but the residuals for 1949 and 1950 remained positive and very large in relation to estimation residuals. Looking at Table 9.2 a), iv), it can be seen that the likelihood value associated with this regime separation is very close to the maximum value. In view of the residuals, this separation seems preferable. However, the corresponding demand and supply functions estimates (not reported) do not show a similar improvement in plausibility.

For the short model, maximum likelihood is again achieved with twelve demand and eight supply observations. Estimates /

Estimates of the demand function are improved in significance, though not greatly changed in magnitude. Estimates of the supply function are improved in plausibility, though remaining insignificant except for the lagged dependent variable. Adjustment speeds of 76% p.a. for demand and 31% p.a. for supply are implied.

Predicted demand residuals correspond to those from the full model,with all being negative except 1961, and 1949 and 1950, which are again large. Predicted supply residuals are all negative except for 1960, 1965 and 1971. The 1971 residual is very small but 1960 and 1965 are roughly one and a half times the average estimation residual. Changes in the regime separation did not improve the situation for predicted demand or supply residuals.

Overall, the output-based ranking has proved to be the most successful of the four 'economic criteria' rankings adopted, in terms of predicted residuals. With one or two exceptions the residuals are consistent with theoretical expectations. Its weakness lies in the actual estimates of demand and supply, which are not the most successful.

v) Demand-based statistical ranking (STAT D-BASED)

As described in Section 9.3.v), a purely statistical regime split can be obtained by commencing with all observations in the demand regime and then removing observations to form a supply regime, one by one, on the basis of maximum likelihood. Table 9.2. a), v) shows the /

the likelihood values which are obtained for each regime split, for the full model. As can be seen, the values are generally higher than those achieved by the four 'economic criteria' already discussed. Maximum likelihood is achieved with twelve demand observations and eight supply.

The regression results are reported in Table 9.3 a) and b), v), for completeness. Whilst they are strong in terms of explanatory power and significance of coefficients, they are generally weak in terms of signs and plausibility, particularly the supply function. Predicted residuals are reported in Table 9.4 a), v). Most of the predicted demand residuals are positive and large in relation to the estimated residuals. On the supply side, the earlier predicted residuals are negative but the later ones are strongly positive. Thus, whilst a superior likelihood value has been achieved, the economic support for such a statistical regime separation is lacking.

For the short model, high likelihood values are again achieved and the maximum is with five demand observations and fifteen supply. The regression results for demand suffer from lack of degrees of freedom but do yield estimates of expected sign and apparently strong significance. Supply estimates are also of correct sign though less dramatic in significance. Predicted residuals for demand are predominantly positive and, whilst mostly negative for supply, are positive for 1965 and 1966, though /

though no larger than estimated residuals. No strong economic support for the demand-based statistical regime separation can be claimed.

vi) Supply-based statistical ranking (STAT S-BASED)

In a similar manner to the above, a statistical regime split can be obtained commencing with the supply base. As can be seen in Table 9.2 a), vi), the likelihood values are not quite as high for the full model as achieved with the demand base, though still much higher than for the other regime splits. The maximum value is achieved with seven demand observations and thirteen supply. This is quite different from the demand-based split. The regression results, reported in Table 9.3 a) and b), vi),are again high in explanatory power but the demand function is lacking in degrees of freedom and in plausibility. In particular, strong negative adjustment is implied. The supply function is more satisfactory, apart from the sign of the wage term. The predicted residuals are reported in Table 9.4 a), vi). The predicted demand residuals are predominantly positive and four of the predicted supply residuals are also positive and large relative to the estimation residuals.

For the short model, a higher likelihood value than the demand base gives an opposite split of fifteen demand observations and five supply. Regression results are plausible in sign and strong in significance but weakened by lack of degrees of freedom in the supply estimation. Predicted demand residuals are mostly positive /

positive again and, whilst most predicted supply residuals are negative, the three later ones, for 1969-71, are positive and large.

The conclusion is that the supply-based statistical separation method is no more successful than the demand-based one in obtaining economic support for the regimes derived.

In addition, it was suggested in Section 9.4, that confidence in the method would be improved if the two bases achieved a similar regime separation. This is clearly not the case in terms of numbers of observations in each regime, for either the full or the short model. Furthermore, the rankings of observations derived by the statistical methods can be correlated to see how close they are to each other. For the full model the two rankings show a weak positive relationship with a Spearman correlation coefficient of 0.26. The short model indicates a stronger correlation of 0.52, just significant at the 5% level, but the two rankings are by no means identical. Nor are any of the statistical rankings obviously consistent with any of the 'economic' rankings considered earlier. Little confidence can be held in the purely statistical method of regime selection.

9.6 Conclusions

The estimation and testing of demand and supply regimes was generally unsatisfactory. This was due either to a lack of plausibility and significance in the estimates or to implausible prediction of residuals. The /

The two occurrences were often substitutes rather than complements, as might be expected. Undoubtedly the empirical work is hampered by the low number of degrees of freedom. It is difficult to reject or accept hypotheses rigorously in this situation. However, this problem could occur even with a large number of observations, since the optimal split could easily produce one regime with a small number of observations.

The negativity of predicted residuals was felt to be the most stringent requirement for plausible regime separation and, on this basis, the output-based ranking proved most successful. However, in terms of likelihood value, this ranking proved least successful for the full model and, whilst its demand estimation yields the only plausible adjustment speed, its supply estimation yields the only adjustment speed lying outside the plausible range.

The significance of estimates can be strengthened either by more observations in each regime or by the imposition of more a priori information. The lack of plausibility implies a lack of applicability of the model being tested. In particular, if the sub-sectors of the labour market are not sufficiently homogenous for them to be all demand-determined or all supply-determined at a point in time, then the regime separation process is unlikely to yield plausible or significant results. In the next chapter, the assumption/

assumption of homogeneity is relaxed and a different method of estimation, which allows the imposition of more a priori information, is developed.

TABLE 9.1 RANKINGS OF THE FOUR INDICATORS, 1952-1971

Year	i) U-Based	ii) V-Based	iii) W-Based	iv) O-Based
1952	7	4	1	12
1953	14	13	7	18
1954	10	6	8	9
1955	2	1	16	2
1956	1	5	4	11
1957	6	15	18	13
1958	11	19	11	20
1959	16	16	17	19
1960	9	10	10	14
1961	4	9	2	7
1962	8	17	15	16
1963	15	18	20	17
1964	12	7	5	8
1965	5	2	9	10
1966	3	3	6	3
1967	13	14	12	5
1968	19	11	13	6
1969	18	8	3	1
1970	17	12	14	4
1971	20	20	19	15

TABLE 9.2 LOG OF LIKELIHOOD VALUES FOR REGIME SEPARATIONS

a) Full Model

SPLIT DEM./SUP.	i) U-BASED	ii) V-BASED	iii) W-BASED	iv) O-BASED	v) STAT D-BASED	vi) STAT S-BASED
13/7	69.84	62.46	60.14	62.14	104.31	*95.44
12/8	69.70	60.14	62.46	*64.51	*106.76	94.56
11/9	77.19	60.34	63.99	63.74	91.76	92.11
10/10	71.61	66.82	66.39	64.33	92.09	88.66
9/11	76.70	65.38	68.57	63.94	84.36	87.32
8/12	*79.04	67.46	69.42	63.95	87.20	88.76
7/13	77.23	*73.26	*74.45	63.06	92.59	90.98

* denotes maximum likelihood value.

b) Short Model

SPLIT DEM./SUP.	i) U-BASED	ii) V-BASED	iii) W-BASED	iv) O-BASED	v) STAT D-BASED	vi) STAT S-BASED
15/5	62.19	60.57	57.16	56.33	76.91	85.11
14/6	63.54	56.70	57.98	59.23	75.35	76.80
13/7	62.15	56.92	56.35	59.44	70.17	76.65
12/8	64.64	57.08	57.52	*61.91	64.70	75.87
11/9	*68.61	57.37	58.98	61.11	63.91	74.95
10/10	63.12	59.45	59.70	61.31	67.66	71.33
9/11	65.00	60.26	59.87	60.20	68.25	70.65
8/12	64.73	*60.78	59.86	60.23	71.58	70.61
7/13	64.51	58.93	*62.91	59.67	73.93	71.02
6/14	63.44	58.13	59.30	60.28	76.59	75.30
5/15	66.20	58.25	62.32	61.67	*80.94	*87.73

* denotes maximum likelihood value.

TABLE 9.3 REGIME ESTIMATION RESULTS, 1952-1971

a) Full demand model

DEPENDENT VARIABLE Log E_t	Constant	Log Q_t	Log $(w/p)_t$	Log E_{t-1}	t	Log H_{ot}	$\bar{R}^2$ S.E.	DW	n	ADJUST. SPEED $\hat{\mu}$
i) U-BASED	- 8.71 (3.3)	0.931 (5.2)	0.176 (0.9)	1.259 (4.1)	-0.0449 (3.0)	1.276 (3.2)	0.996 0.007	2.03	8	-
ii) V-BASED	12.03 (2.2)	-0.883 (2.3)	0.722 (2.8)	1.695 (4.4)	-0.0244 (2.1)	-2.086 (2.4)	0.993 0.005	1.00	7	-
iii) W-BASED	- 0.14 (0.0)	0.668 (2.3)	0.138 (0.6)	1.120 (4.2)	-0.0425 (3.1)	-0.512 (0.6)	0.993 0.007	1.26	7	-
iv) O-BASED	- 3.94 (0.9)	1.041 (2.2)	-0.614 (2.8)	0.345 (1.1)	-0.0080 (0.4)	0.012 (0.0)	0.975 0.016	1.00	12	0.655
v) STAT D-BASED	- 7.83 (3.8)	1.007 (7.6)	0.161 (1.0)	1.145 (4.8)	-0.0469 (3.7)	1.169 (3.7)	0.996 0.008	2.16	12	-
vi) STAT S-BASED	-13.07 (16.8)	1.596 (25.7)	0.254 (4.1)	1.949 (17.8)	-0.0937 (14.6)	0.632 (5.5)	1.000 0.002	1.68	7	-

t - values in brackets

TABLE 9.3 (Cont'd)

b) Full supply model

DEPENDENT VARIABLE Log E_t	Constant	Log L_t	Log W_{rt}	Log E_{t-1}	Log H_{rt}	Log U_{rt}	$\bar{R}^2$ S.E.	DW	n	ADJUST. SPEED $\hat{\lambda}$
i) U-BASED	-4.73 (1.1)	0.838 (1.5)	-0.232 (0.6)	0.507 (2.8)	0.207 (0.3)	-0.193 (3.1)	0.994 0.008	1.80	12	0.493
ii) V-BASED	-0.01 (0.0)	0.098 (0.1)	0.130 (0.2)	0.863 (3.9)	-0.628 (0.5)	-0.150 (1.9)	0.987 0.014	2.04	13	0.137
iii) W-BASED	-5.09 (0.8)	0.756 (0.9)	0.231 (0.4)	0.665 (2.5)	-0.471 (0.5)	-0.105 (1.3)	0.990 0.012	1.37	13	0.335
iv) C-BASED	7.95 (0.7)	-1.013 (0.6)	-1.128 (0.5)	1.286 (1.8)	4.902 (0.6)	-0.175 (1.2)	0.961 0.015	2.26	8	-
v) STAT D-BASED	3.13 (11.2)	-0.037 (1.1)	-1.407 (47.0)	0.629 (69.7)	2.016 (43.9)	-0.335 (77.1)	1.000 0.000	2.69	8	0.371
vi) STAT S-BASED	-1.89 (1.1)	0.453 (2.0)	-0.360 (2.0)	0.648 (8.1)	-0.400 (1.1)	-0.136 (5.2)	0.998 0.005	1.62	13	0.352

TABLE 9.3 (Cont'd)

c) Short demand model

DEPENDENT VARIABLE Log E_t	Constant	Log Q_t	Log $(w/p)_t$	Log E_{t-1}	t	Log H_{dt}	$\bar{R}^2$ S.E.	DW	n	ADJUST. SPEED $\hat{\mu}$
i) U-BASED	-0.38 (0.4)	0.498 (3.4)	-0.314 (2.9)	0.465 (2.9)	-	-	0.986 0.014	1.67	11	0.535
ii) V-BASED	-1.70 (1.2)	-0.228 (0.4)	0.031 (0.1)	1.377 (2.4)	-	-	0.981 0.014	1.00	8	-
iii) W-BASED	-3.08 (1.2)	0.806 (2.7)	-0.582 (2.5)	0.384 (2.1)	-	-	0.968 0.016	1.91	7	0.616
iv) O-BASED	-3.35 (2.6)	0.956 (4.7)	-0.680 (4.7)	0.241 (1.3)	-	-	0.981 0.014	1.00	12	0.759
v) STAT D-BASED	-6.02 (90.6)	0.970 (153.5)	-0.812 (127.3)	0.451 (101.4)	-	-	1.000 0.000	1.84	5	0.549
vi) STAT S-BASED	-2.54 (2.8)	0.622 (5.8)	-0.464 (5.6)	0.532 (4.9)	-	-	0.988 0.012	1.87	15	0.468

TABLE 9.3 (Cont'd)

d) Short supply model

DEPENDENT VARIABLE: Log E_t	Constant	Log L_t	Log W_{rt}	Log E_{t-1}	Log H_{rt}	Log U_{rt}	$\bar{R}^2$ S.E.	DW	n	ADJUST. SPEED $\hat{\lambda}$
i) U-BASED	-23.19 (5.9)	3.273 (6.2)	0.437 (1.5)	-0.271 (1.4)	-	-	0.995 0.007	2.12	9	1.271
ii) V-BASED	- 7.61 (2.1)	1.073 (2.4)	0.267 (0.5)	0.586 (3.8)	-	-	0.981 0.016	1.55	12	0.414
iii) W-BASED	-14.10 (4.8)	1.901 (5.1)	0.494 (1.1)	0.343 (2.6)	-	-	0.989 0.013	1.16	13	0.657
iv) O-BASED	- 4.46 (1.0)	0.678 (1.3)	0.711 (1.0)	0.688 (4.0)	-	-	0.964 0.014	1.19	8	0.312
v) STAT D-BASED	- 6.97 (2.0)	0.983 (2.2)	0.494 (1.0)	0.617 (3.5)	-	-	0.959 0.019	1.55	15	0.383
vi) STAT S-BASED	-15.63 (210.1)	2.174 (209.0)	0.464 (41.9)	0.186 (44.7)	-	-	1.000 0.000	1.98	5	0.814

TABLE 9.4 PREDICTED RESIDUALS, 1949–1971

a) Full model.

YEAR	i) U-BASED		ii) V-BASED		iii) W-BASED		iv) O-BASED		v) STAT D-BASED		vi) STAT S-BASED	
	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY
1949	0.0647	0.0220	−0.2380	0.0072	−0.0463	0.0019	0.0585	0.0603	0.0481	0.0552	0.0882	−0.0042
1950	0.0199	−0.0019	−0.1560	0.0088	−0.0618	0.0021	0.0334	0.0142	−0.0014	−0.0018	0.0131	−0.0053
1951	0.0088	−0.0138	−0.0604	0.0043	−0.0545	0.0065	−0.0187	−0.0281	−0.0130	−0.0522	−0.0114	−0.0116
1952	0.0253	-	−0.0667	-	−0.0330	-	[illegible]	−0.0513	[illegible]	−0.0463	0.0116	-
1953	-	−0.0070	−0.1100	-	−0.0509	-	-	−0.0617	-	−0.0186	-	−0.0142
1954	0.0167	-	−0.0115	-	−0.0195	-	-	−0.0348	-	−0.0231	0.0232	-
1955	0.0149	-	0.0720	-	-	0.0227	−0.0199	-	-	−0.0061	-	0.0214
1956	0.0044	-	−0.0082	-	−0.0089	-	-	−0.0431	-	−0.0041	−0.0032	-
1957	−0.0020	-	-	−0.0115	-	−0.0072	-	−0.0163	−0.0053	-	-	−0.0033
1958	0.0318	-	-	−0.0123	0.0242	-	-	−0.0275	0.0310	-	0.0627	-
1959	-	0.0069	-	−0.0135	-	−0.0177	-	−0.0191	-	0.0194	0.0298	-
1960	0.0750	-	0.0668	-	0.0428	-	-	0.0669	0.0666	-	0.0880	-
1961	0.0323	-	0.0382	-	0.0076	-	0.0066	-	0.0276	-	-	0.0143
1962	0.0198	-	-	−0.0208	-	−0.0165	-	−0.0113	0.0213	-	−0.0066	-
1963	-	−0.0163	-	−0.0287	-	−0.0263	-	−0.0350	-	−0.0193	-	−0.0270
1964	0.0183	-	0.1150	-	0.0228	-	−0.0399	-	0.0167	-	0.0140	-
1965	0.0559	-	0.0518	-	0.0213	-	-	0.0247	0.0545	-	0.0350	-
1966	0.0206	-	0.0243	-	−0.0132	-	−0.0137	-	0.0195	-	−0.0333	-
1967	-	0.0230	-	−0.0138	−0.0318	-	−0.0389	-	-	0.0432	−0.0462	-
1968	-	0.0309	0.0280	-	−0.0282	-	−0.0592	-	-	0.0509	−0.0232	-
1969	-	0.0524	0.0782	-	−0.0042	-	−0.0308	-	-	0.0735	-	0.0330
1970	-	0.0472	0.0643	-	-	0.0203	−0.0059	-	-	0.0521	-	0.0242
1971	-	0.0469	-	−0.0128	-	0.0074	-	−0.0065	-	0.0537	0.0484	-
MAE	0.0031	0.0041	0.0019	0.0077	0.0022	0.0065	0.0101	0.0055	0.0043	0.0001	0.0007	0.0027

MAE is the mean absolute estimation residual.

TABLE 9.4 (Cont'd)

b) Short Model

YEAR	i) U-BASED		ii) V-BASED		iii) W-BASED		iv) O-BASED		v) STAT D-BASED		vi) STAT S-BASED	
	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY	DEMAND	SUPPLY
1949	0.0162	-0.0434	-0.0023	-0.0380	0.0527	-0.0198	0.0563	-0.0629	0.0799	-0.0368	0.0364	-0.0418
1950	0.0158	-0.0595	0.0443	-0.0264	0.0420	-0.0192	0.0381	-0.0474	0.0710	-0.0247	0.0352	-0.0444
1951	-0.0023	-0.0275	0.0606	-0.0075	-0.0023	0.0048	-0.0152	-0.0226	0.0075	-0.0028	0.0028	-0.0181
1952	0.0173	-	0.0515	-	0.0211	-	-	-0.0210	0.0311	-	0.0212	-
1953	-	-0.0102	-	-0.0343	-0.0071	-	-	-0.0612	-	-0.0350	-	-0.0268
1954	-	-0.0304	0.0477	-	-0.0056	-	-	-0.0380	-	-0.0160	-	-0.0280
1955	0.0178	-	0.0831	-	-	0.0203	-0.0178	-	-0.0060	-	-	0.0045
1956	0.0135	-	0.0155	-	0.0035	-	-	-0.0376	-	-0.0167	-	-0.0181
1957	0.0162	-	-	-0.0173	-	-0.0078	-	-0.0322	0.0102	-	-	-0.0173
1958	-	0.0163	-	-0.0127	0.0128	-	-	-0.0290	0.0134	-	-	-0.0048
1959	-	-0.0078	-	-0.0328	-	-0.0191	-	-0.0446	-0.0051	-	-	-0.0264
1960	0.0404	-	0.0822	-	0.0241	-	-	0.0124	0.0286	-	0.0313	-
1961	0.0372	-	0.0552	-	0.0173	-	0.0107	-	0.0168	-	0.0223	-
1962	0.0325	-	-	-0.0145	-	-0.0146	-	-0.0203	0.0159	-	-	-0.0185
1963	-	-0.0160	-	-0.0351	-	-0.0278	-	-0.0255	-0.0187	-	-	-0.0315
1964	-	-0.0150	0.0456	-	-0.0292	-	-0.0406	-	-0.0375	-	-	-0.0173
1965	0.0291	-	0.0472	-	0.0016	-	-	0.0131	-	0.0124	-	-0.0084
1966	0.0245	-	0.0370	-	-0.0020	-	-0.0071	-	-	0.0059	-	-0.0077
1967	-	0.0353	-	-0.0180	-0.0302	-	-0.0338	-	-0.0282	-	-0.0248	-
1968	-	0.0359	0.0091	-	-0.0495	-	-0.0568	-	-0.0431	-	-0.0400	-
1969	-	0.0526	0.0587	-	-0.0176	-	-0.0265	-	0.0029	-	-	0.0210
1970	-	0.0935	0.0541	-	-	0.0406	-0.0003	-	0.0349	-	-	0.0472
1971	-	0.1060	-	-0.0053	-	0.0345	-	0.0007	0.0364	-	-	0.0447
MAE	0.0086	0.0049	0.0081	0.0109	0.0087	0.0090	0.0103	0.0082	0.0001	0.0141	0.0091	0.0001

10. A Non-homogenous Labour Market in Disequilibrium

10.1 Introduction

In this chapter we relax the assumption that the sub-sectors of an industry are sufficiently homogenous to be all demand-determined or all supply-determined at a point in time. The requirement, that the forces affecting the demand and supply of labour cause each sector's labour market to be in the same direction of imbalance, is somewhat restrictive. We now allow the more realistic situation where, at a point in time, some sectors are demand-determined and have excess supply whilst other sectors are supply-determined and have excess demand. The implications of this relaxation for aggregate observation are discussed in the second section of this chapter; a method of analysis of the aggregate labour market is developed in the third section; this method is pursued empirically in the fourth and fifth section.

10.2 An aggregate non-homogenous labour market

In the last two chapters we have stated and attempted to test various assumptions, of doubtful validity, required to make the ensuing empirical analysis reasonably simple. In this chapter we relax these assumptions and are left with a more realistic situation with, initially, little to be justified by way of assumptions. The main requirement which we make is that the sub-sectors are defined so that labour is homogenous and mobile within the sector but not between sectors. This does not imply equilibrium in the sub-sectors as wage rigidity is likely to exist /

exist. What it does imply is that in each sector the level of employment will be equal either to the amount demanded or to the amount supplied whichever is the lower, as shown in Figs. 9.1 and 9.2. Ideally we should like to examine these 'local labour markets' individually but it is difficult to define, let alone measure, labour markets which satisfy our assumptions. In this work, the concept of local labour markets can be viewed merely as an aid to the bulding of an aggregate model.

This approach is somewhat different from Hansen (1970) who, whilst accepting the concept of homogenous frictionless submarkets, prefers to consider observable submarkets with some degree of friction. In consequence Hansen's submarkets contain unemployed men and vacant jobs simultaneously. He then implicitly assumes the extent of friction to be related to the degree of excess demand and supply and hence to the wage rate. This enables him to draw a smooth curve relating actual employment in the ith submarket, E_i, to demand and supply, as shown in Fig. 10.1:-

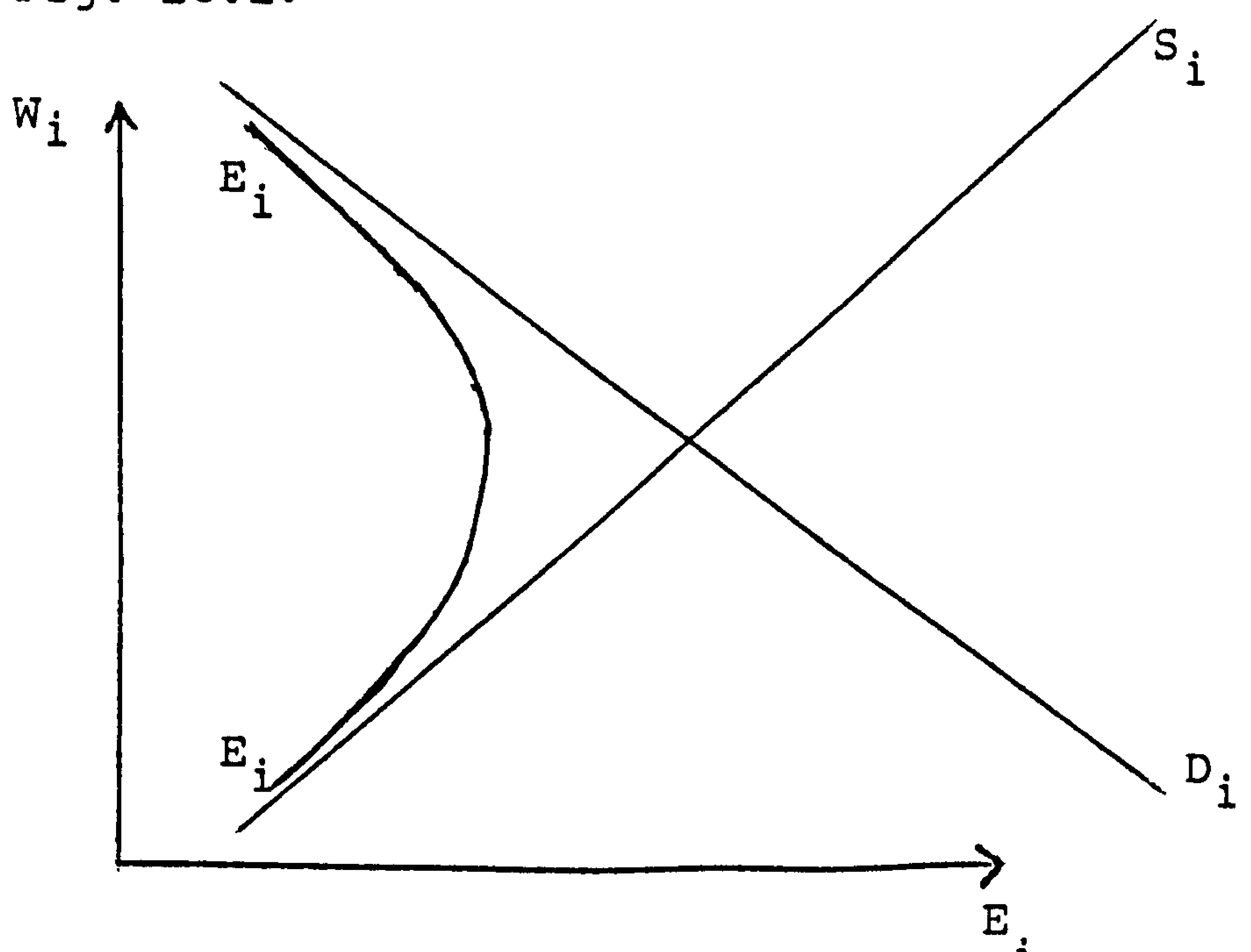

Figure 10.1

Hansen/

Hansen even goes on to suggest that observations may occur outside the 'left-hand quadrant' if overstaffing or over-employment is possible.

In the present study, adjustment in labour demand and supply is allowed for and so the latter phenomena should not occur. Furthermore, the purpose of the study is quite different in seeking to explain aggregate employment rather than to derive a Phillips curve type of relationship.

The approach adopted here is more in line with Muellbauer (1978) where "if a market does not clear then, since neither buyers nor sellers can be forced to sell more than they want, the quantity transacted is the minimum of supply and demand. The very notion of a market means that unsatisfied buyers or sellers cannot co-exist on a single market. In a true micro labour market, true unemployment and true vacancies cannot both be positive"

The implications of non-homogeneity of sectors, for aggregate demand and supply, can most easily be analysed by the consideration of an aggregate labour market made up of two sectors, homogenous within themselves. If both of the sectors are demand-determined then the aggregate observation will be demand-determined, with positive excess supply and zero excess demand. If both sectors are supply determined then the aggregate observation will be supply-determined, with positive excess demand and zero excess supply. These two situations correspond to the 'homogenous' analysis of the last chapter.

However, if one sector is demand-determined and the other /

other is supply-determined then the aggregate observation is neither demand nor supply-determined and there is both excess demand and excess supply present. Extending the analysis to the n-sector labour market, the general situation will be an aggregate observation which lies on neither the aggregate demand function nor the aggregate supply function and with both excess demand and supply present. Only in extreme cases when all sectors are determined by the same force will one of the aggregate functions be observed.

This is a more realistic situation than our earlier assumptions. Measures such as the number of vacancies unfilled and the number of people unemployed indicate that excess demand and excess supply do exist together in an aggregate labour market,(1) suggesting that some sectors are supply-determined whilst others are demand-determined. However, the implications for estimation of aggregate demand and supply are serious. If we never observe either of them then their estimation becomes exceedingly difficult, if not impossible. This problem is not limited to the analysis of this thesis. The multitude of studies which take employment to be solely demand-determined are assuming that observed aggregate employment always lies on the demand function. As we have suggested, this may not generally be the case.

For estimation of aggregate demand and supply functions to be at all viable it is necessary to make a specific assumption /

(1) Search behaviour is a reason for such co-existence within a sector, but it is felt that this will be unimportant relative to structural imbalances, at an aggregate level.

assumption. This is that over a long time-span of observations there will be times when virtually all the sectors of the labour market are demand-determined and times when virtually all the sectors are supply-determined. At these times, one particular aggregate function is observed and estimation may be possible. This assumption would seem reasonable when the aggregate under consideration has been suitably classified, so that sectors of it have features in common. In particular, if fluctuations in product demand are an important determinant of whether sectors are in excess demand or excess supply, then when an industry-wide boom or recession is quite strong or long-lasting, all sectors should have the same direction of labour imbalance, and aggregate demand or supply should be observed.

Such points could be specified a priori, from knowledge of the cyclical pattern of product demand, but in the method of empirical analysis to be developed shortly, only their existence and not their location is required. Rather, it was felt that a comparison, between the estimated levels of excess demand and supply and the cyclical pattern, would be a useful means of assessing the plausibility of estimation.

10.3 Method of analysis and estimation

The basic feature which follows from the above analysis is that at all times, observed aggregate employment will be less than or equal to aggregate demand and less than or equal to aggregate supply; equality only occurring /

occurring on the rare occasions when all sectors are demand-determined or all supply-determined. This information can be used in the form of inequality constraints to impose restrictions on the parameter values of the demand and supply functions. These values must be such as to always yield a 'predicted' level of aggregate demand or supply greater than or equal to actual employment.

The type of restrictions to be imposed suggests a programming approach to the estimation of demand and supply functions. Some consideration is needed of the objective function that should be maximized or minimized in estimating these functions, subject to the inequality constraints. The standard practice in estimating a single function would be to minimize some measure of the residuals, e.g. the sum of squares of residuals, but this is in a situation where observations are hypothesised to deviate from the function due to random errors alone. In our case, in addition to all errors being of the same sign, the size of an error in estimating demand is due to the extent of supply-determination in the market at that time (2) and the size of an error in estimating supply is due to the extent of demand-determination in the market. These errors can hardly be considered random and yet, without disaggregate information, we cannot easily separate out the random and 'systematic' elements of the error term. Whilst it may be reasonable to minimize with respect to the random element, there is no reason /

(2) This can be seen in Fig. 9.3

reason to aim to minimize the systematic element.

A possible means of lessening this problem would be to formulate an objective function, which gave large weight to small errors and less weight to large errors. The rationale for this is that large errors are likely to be mainly due to the systematic element, i.e. estimating the demand function when most of the sectors are supply-determined and vice versa, and so should not be minimized in estimation. However, such a weighting process, achieved for instance by minimizing the sum of the square roots of residuals, as an objective function, would yield a complicated non-linear programming estimation problem, for which the author did not have a computer programme available. A more convenient alternative is to specify a linear programming formulation, where the objective is the sum of residuals, i.e. each residual is given equal weighting. This, at least, avoids giving greater weight to large residuals, as OLS does. The sensitivity of the resulting estimates to the particular specification of the objective function can be ascertained, at a later stage. It is hoped that, once sufficient constraints have been imposed, the demand and supply functions estimated will not be too sensitive to the particular objective function weightings chosen.

If more information about the aggregate labour market can be incorporated into the estimation process, in the form of further restrictions on the parameter values, then this should serve to improve the parameter

/estimates

estimates by making them more precise and less dependent on the objective specification. In addition to the basic constraints,which state that aggregate demand and supply must always be greater than or equal to observed employment, i.e. that excess demand and supply are greater than or equal to zero, it would be useful to be able to say by how much demand and supply are greater than actual i.e. how great excess demand and supply are. It is here that exogenous measures of excess demand and supply can be very useful.

As discussed earlier, if statistics on the number of vacancies, reported and remaining unfilled, accurately measure excess demand and if statistics on the number of people registered unemployed accurately measure excess supply,then there should be little difficulty in measuring the levels of employment demanded and supplied. Unfortunately, as pointed out by Dow and Dicks-Mireaux (1958) and others, there are good reasons why the statistics on vacancies and unemployment will not accurately measure excess demand and supply.

Data on vacancies records the number reported to employment exchanges but remaining unfilled. There has generally been no requirement that firms must report vacancies to the local exchange, but firms may well do so if they cannot recruit elsewhere. However, it is likely that firms' behaviour in reporting vacancies will vary according to the extent of excess demand. When excess demand is high, then firms will be unable

/to

to obtain all the labour they require. This may cause them either not to report vacancies, in the belief that no labour will be forthcoming, or to report more vacancies than they actually require, in the hope that this will encourage labour to apply. When excess demand is low, reported vacancies may represent excess demand more closely, but reasons for their deviation could easily be postulated. Consequently, data on reported vacancies are not expected to measure excess demand accurately, though there should obviously be some relation between the two. The suggestion of Dow and Dicks-Mireaux, that such data may be a good ordinal indicator of excess demand, will be developed shortly.

Data on unemployment for an industry records the number of people registered as unemployed, who previously worked in that industry. This data might be reasonably 'hard' in measuring what it purports to, in that there should be no double-counting and minimal non-reporting of people actively wanting employment. However, it is less definite that it serves as a good proxy for excess supply to an industry. By excess supply we wish to measure the number of people willing to work in the industry, in addition to those already employed in that industry, if the opportunity arises (assuming all other labour market conditions are constant). This will include, not only the unemployed who previously worked in the industry, but also some of the unemployed from other industries, some secondary workers not registered

/unemployed

unemployed <u>and</u> some people currently working in other industries, but wishing to work in the industry in question, if jobs were available. Consequently, it is asking a lot of industry-specific unemployment data to accurately measure excess supply. Yet, as with vacancies and excess demand, there should be some relationship between the two.[3] The possibility of using unemployment data as an ordinal indicator of excess supply is developed shortly.

First, it should be noted that, in addition to data on vacancies and unemployment, there is also available data on over-time and short-time working. These can be thought of as indicators of excess demand or supply. However, it is likely that the extent of both over-time and short-time are determined largely by firms' desires, rather than by the influence of supply. Furthermore, whilst they represent demand for more or less labour input, measured in man-hours, it is not clear that they represent a desire on the part of employers to change their number of employees. It has been argued, e.g. by Knight and Wilson (1974), that their existence is due to the desire of employers to adjust their labour input to meet fluctuations in product demand, <u>without</u> incurring the higher costs of adjusting employment. In the present situation, the latter argument is followed and attention is concentrated on the use of unemployment and vacancies data, in the measurement of excess supply and demand.

/Dow . . . .

(3) The other elements of excess supply might be expected to move in the same direction as unemployment.

Dow and Dicks-Mireaux define excess demand as the difference between employment demanded and employment supplied. They then attempt to derive a measure of excess demand based on the difference between vacancies, adjusted by a 'statement error ratio' if such is available, and unemployment. Thus,they have the problem of taking the difference between two measures whose accuracy is seriously questioned and then treating this as an ordinal measure. This seems a much stronger,and less plausible,hypothesis than using vacancies as an ordinal measure of excess demand, defined as employment demanded minus actual employment, and unemployment as an ordinal measure of excess supply, defined as employment supplied minus actual. Not only is the ordinality hypothesis of the latter less demanding; also the concepts of excess demand and supply seem more meaningful than that of Dow and Dicks-Mireaux. It is not much comfort to firms to have excess demand reduced by an increase in the unemployed pool of labour, if this labour is in another location or is of a type they do not want - the Dow and Dicks-Mireaux 'maladjustment' problem.

In fact, for our purposes, we hypothesize that the <u>ratio</u> of vacancies, V, to actual employment, EA, is an ordinal measure of excess demand, where excess demand, X_D, is defined as the ratio of employment demanded, ED, minus actual employment to actual employment.

/ie.

i.e.: $X_D = \frac{ED - EA}{EA} = f(V/EA)$ with $f' > 0$ ... (10.1)

This proportional form, in keeping with other work on excess demand, allows for changes in the scale of employment and is convenient for use in estimation, where the formulation is in logs. The residuals in the demand function estimation, R_D, are equal to the difference between the log of employment demanded and the log of actual employment, i.e. :-

$$R_D = \log ED - \log EA \quad ..... \quad (10.2)$$

It can easily be shown that R_D is monotonically related to X_D. Thus the residual can be expressed as:-

$$R_D = g(V/EA) \text{ with } g' > 0 \quad .... \quad (10.3)$$

(10.3) states that the higher the ratio of vacancies to employment, the greater the residual in the demand function should be. Given a time series of observations of vacancies and actual employment, all points can be compared by the magnitude of their V/EA ratio. For each comparison, a constraint on the relative size of the corresponding residuals of the linear program can be derived, serving to further restrict the estimation of the parameters of the demand function. In principle, the number of possible constraints is large as each observation can be compared with all others. If n is the number of observations, then there are $n(n-1)/2$

/possible

possible constraints. However, due to the transitivity of inequality constraints, this number is greatly reduced, initially to (n-1).

A similar hypothesis is formulated for excess supply. The ratio of unemployment, U_e, to actual employment is postulated as an ordinal measure of excess supply, where excess supply, X_S, is defined as the ratio of employment supplied, ES, minus actual employment to actual employment ie:-

$$X_S = \frac{ES-EA}{EA} = f(U_e/EA) \text{ with } f' > 0 \qquad \text{....(10.4)}$$

The residuals in the supply function estimation, R_s, are equal to the difference between log ES and log EA. Thus R_s is monotonically related to X_S and can be expressed as:-

$$R_s = h(U_e/EA) \text{ with } h' > 0 \qquad \text{....(10.5)}$$

(10.5) states that the higher the ratio of unemployment to employment, the greater the residual in the supply linear program should be. Again n(n-1)/2 comparisons can be made of the size of the U/EA ratio, at different points in time and each comparison yields a constraint, which can be imposed on the estimation of the supply parameters.

Whilst it is felt that the hypotheses are quite plausible /

plausible theoretically, it may be the case that data on vacancies and/or unemployment is too inaccurate to merit a strictly ordinal relationship, over time. If this is the case then incorrect constraints could be imposed, leading to invalid or infeasible parameter estimates. An attempt can be made to avoid this occurrence by allowing for a margin of error in the data. Constraints are then only imposed when the difference between the V/EA or U/EA ratios for two observations exceeds the margin of error. In this way, if the correct margin of error can be located, incorrect constraints can be removed, hopefully without removing too many valid and useful ones. The required margin of error is not known a priori. In aiming to remove invalid constraints but to keep valid ones, there is likely to be a trade-off between precision and bias. However, the bias'may appear as infeasibility and hence yield no estimates.

Of course, there is an alternative reason why the procedure developed above may be unsuccessful. The constraints produced by the ordinality hypotheses might be quite valid but the specification of the demand and supply functions may be inadequate to deal with them. Incorrect specification is always a possibility in empirical work, but the use of vacancies and unemployment data with <u>known</u> inaccuracies, as indicators of excess demand and supply, should be the prime area for amendment, if /

if unsuccessful.

It should be noted from the development of the technique and constraints that, whilst the procedure is very similar for both demand and supply functions, their estimation is essentially independent. In the empirical work, the basic functions are estimated in section 10.4, for the 'full' and short models and then the 'ordinality' constraints are added in section 10.5.

Before proceeding to the empirical analysis it is worth comparing the proposed usage of linear programming with that of previous studies and with the more usual regression methods. As far as the author is aware, very little applied economic research has made use of such programming techniques. Those that have, have tended to be concerned with planning the allocation of resources. For example, Bowles (1967) is concerned with the allocation of resources to the different levels of schooling in Nigeria. The costs and benefits are calculated for each type of schooling and a function of enrolments, weighted according to net benefits, is maximized over time subject to constraints. The constraints are on the availability of resources, particular grades of teachers etc. via a fixed coefficient production function. Similarly,Olivier and Sabolo (1973) describe a model for the joint planning of employment, production and education, with the objective to be maximized /

maximized dependent upon specific planning priorities, subject to the constraints of labour supply,production capacities etc.

These studies, and indeed the many uses of linear programming which the author has searched in the operations research literature, were concerned with choosing the optimal values of variables subject to constraints, where the parameters of the model are taken as known. In contrast, the present study follows the usual applied economics path of observing the values of the variables and trying to discover the parameters of the model from them. It is the constraints which are of interest,in indicating how the level of employment results from the underlying parameters of the model and the values of other variables. The optimizing element,which is crucial to most linear programming studies, is incidental to this study.

Where the objective function to be optimized and the constraints to be met are clearly and precisely identified, then the application of the programming techniques can, no doubt, be a reasonably straightforward affair. Where, the objective is not clear-cut and where constraints can have a 'margin of error', such application is by no means straightforward, involving the repeated use of the program,with small changes in objective or constraints, as will be detailed in the next two sections.

The main difference between the use of programming techniques and the more usual regression methods is that the latter is designed to incorporate a stochastic element, whilst the former is not, requiring constraints to be satisfied deterministically. Regression analysis will automatically generate confidence intervals for the estimates of the parameter values, which establish the precision of the estimates. In using linear programming to estimate parameter values, one has to undertake sensitivity analysis to get an impression of the stability of the solution. With the programming packages available to the author this proved to be a lengthy and repetitive process.

10.4 Estimation of the basic demand and supply functions - a linear programming approach

a) full demand

As developed in the last section, a linear program was set up, the object of which was to impose the constraint on the (full) demand function parameters that aggregate employment demanded, ED, always be greater than or equal to actual employment, EA. This can be expressed in logs as:-

$$\log ED_t \geqslant \log EA_t, \text{ for all } t. \qquad \ldots. (10.6)$$

The /

The linear program also constrains all the parameters to take non-negative values. For those variables where a negative parameter is expected, a priori ie. on $\log \frac{w}{p}$, t and $\log H_o$, the negative of the original data is used, to allow for these extra constraints. Thus all parameters, except the constant, are constrained to take their a priori expected sign (or be zero). The constant is included as both positive and negative, since its sign is not predictable. The program chooses the sign and value of the constant. In principle, a similar procedure could have been followed for all parameters. This would have allowed parameters to take implausible values and was not pursued.

Substituting the demand function specified, in general form, as (6.9) into (10.6) yields

$$\beta_0 + \beta_1 \log Q_t - \beta_2 \log (w/p)_t - \beta_3 t - \beta_4 \log H_{ot} +$$

$$\beta_5 \log E_{t-1} \geq \log EA_t \qquad \ldots. \ (10.7)$$

for $t = 1, \ldots.., n$; where n is the number of observations, in this case twenty three, for the years 1949-71. These twenty three expressions are the basic constraints on the demand function estimation.

The objective given to the linear program was to minimize the sum of the residuals, measured as the difference between the log of employment demanded and the log /

log of actual employment. The sum of the residuals is equivalent to the sum of the 'left-hand sides' of the basic constraints (10.7) minus the sum of the 'right-hand sides' i.e:-

$$\beta_0 n + \beta_1 \Sigma \log Q_t - \beta_2 \Sigma \log (w/p)_t - \beta_3 \Sigma t - \beta_4 \Sigma \log H_{ot} + \beta_5 \Sigma \log E_{t-1} - \Sigma \log EA_t \quad \ldots.(10.8)$$

The basic results are reported in Table 10.1 a) as (*). The value of the objective function is 0.47 which indicates that the average value of the residuals is 0.02. This can be interpreted as excess demand and, on manipulation, it implies that there is an average excess demand of 40,000 employees out of a labour force of about two million people. This figure is higher than the average number of vacancies reported, of almost 30,000. We would expect a somewhat higher figure if vacancies data does underestimate the extent of excess demand, as is frequently asserted. The individual residuals indicate zero excess demand in the years 1950, 58, 60, 62 and 70, with their 'shadow prices' indicating that the 1960 and 62 observations are most 'binding' on estimation. It is a feature of the linear programming technique that as many constraints will be binding as there are non-zero parameter estimates so that several years will be bound to exhibit zero excess demand. However, the necessity for this perhaps /

perhaps unrealistic feature may be removed by the addition of further constraints.

The behaviour of the residuals can be compared with reported statistics of excess demand. In this ,it is more relevant to consider the ratio of vacancies to employment, rather than absolute levels of vacancies. As this is the ratio to be used as an ordinal indicator of excess demand, in the next section, it is useful to consider how well it correlates with the residuals from this basic estimation. A Spearman rank correlation coefficient was calculated and took a value of 0.27, suggesting quite a weak relationship.

The parameter estimates can be interpreted in the same manner as in Chapter 8. An adjustment speed of 68% per annum is somewhat higher than the value obtained earlier by OLS, but similar to that obtained by HILU. However, an elasticity of substitution of 0.95 and returns to scale of 0.28 are closer to the OLS estimates and the latter is implausibly low. Unfortunately, the linear program does not provide standard errors for these coefficients and so, it is useful to discover how sensitive the estimates are to the objective specification and constraint values, etc., to be able to say how reliable these estimates are.

The 'sensitivity' analysis concentrated on the objective function since, as discussed earlier, this is the aspect with least theoretical support. The constraints were not experimented with, since they are founded on our

/basic

basic theoretical postulates. The procedure adopted was to allow each objective value to vary in turn by plus or minus 5%[4], i.e. giving each variable a 5% higher or lower weight in the objective function to be minimized. The results show considerable changes in the parameter estimates. In fact, of the twelve separate linear program 'runs', six proved to be unbounded.[5] The remaining six are reported in Table 10.1 (a). It can be seen that only one solution is identical to the basic one and that is obtained by changing the objective value of the parameter whose estimate is zero in the basic solution. Implied speeds of adjustment vary from unity (complete) to -0.5 and all parameters have an estimate of zero in at least one solution.

The conclusion must be that our basic estimates are very much dependent on the objective values assigned. Indeed, we did not expect the estimates to be very precise at this stage. We have only imposed the basic constraints and we have extra constraints to impose on estimation. This will be developed in the next section.

b) <u>full supply</u>

The procedure adopted in this section is similar to that of the demand function estimation. The objective function to be minimized is the sum of the residuals between the logs of employment supplied and actual employment. The basic constraints are that employment /supplied

(4) Whilst 5% is an arbitrary value, it seemed a reasonable value to choose in an employment context and in relation to other LP studies.

(5) This may have been due to the precision setting of the program but changes in this did not improve the situation.

supplied always will be greater than or equal to actual employment, i.e. non-negative residuals, with the supply function specified in general form, as (6.3). We minimize:

$$\Sigma(\log ES_t - \log EA_t) = \alpha_o n + \alpha_1 \Sigma \log L_t + \alpha_2 \Sigma \log W_{rt} - \alpha_3 \Sigma \log H_{rt} - \alpha_4 \Sigma \log U_{rt} + \alpha_5 \Sigma \log E_{t-1} - \Sigma \log EA_t \quad \text{....(10.9)}$$

subject to the constraints:

$$\alpha_0 + \alpha_1 \log L_t + \alpha_2 \log W_{rt} - \alpha_3 \log H_{rt} - \alpha_4 \log U_{rt} + \alpha_5 \log E_{t-1} \geqslant \log EA_t \quad \text{...(10.10)}$$

for t = 1, ... n.

Again, the negative of the original data is used for $\log H_r$ and $\log U_r$, where a negative sign is expected, and constants of both sign are included, due to the in-built non-negativity of parameters, imposed by the linear program.

The initial results are reported in Table 10.1 b) as(*). The value of the objective function is 0.43, indicating average excess supply of almost 40,000 which is 50% higher than the average number unemployed of 26,000. Again, we would expect this higher figure since, for the various reasons discussed earlier, unemployment data will under-estimate the extent of excess supply. Consequently, the 40,000 figure may not be unrealistic. Zero excess supply is indicated in 1951, 55, 60, 69 and 71, with 1955 and 69 having large shadow prices. 1971 seems very unlikely to have no excess supply as it was the year with the highest unemployment of the period in engineering. It is worth /noting

noting the extent of correlation between the basic residuals and the excess supply measure,which is to be imposed i.e. the ratio of unemployment to employment. The rank correlation coefficient between the two series was -0.13,suggesting no positive relationship.

The parameter estimates indicate a much slower adjustment of supply than demand,with only 12% adjustment towards desired within a year. The other parameters, allowing for the speed of adjustment, indicate that a 1% change in the total labour supply, relative wages, relative hours and relative unemployment would cause +3.3%, +7.8%, 0 and -0.7% changes in supply respectively.

Again, sensitivity analysis was undertaken, allowing each objective value to vary by plus or minus 5%. The results, reported in Table 10.1 b) are more successful than with demand, in that nine of the twelve runs provided solutions. However, considerable changes in the parameter estimates again occur. Two of the solutions are identical to the basic solution and two are close to it,but the others are quite different, with the speed of adjustment varying from unity to zero. The conclusion must be that the basic estimates of the full supply function are also very much dependent on the objective values assigned and that further restrictions could be useful.

c) <u>short demand</u>

A linear program can be set up to estimate the 'short' version of the demand function in similar fashion

/to

to the full version, using equation (6.11) rather than (6.9). The basic constraints to be imposed become:-

$$\beta_o + \beta_1 \log Q_t - \beta_2 \log(w/p)_t + \beta_5 \log E_{t-1} \gtrless \log EA_t \quad \text{..... (10.11)}$$

and the objective function to be minimized becomes:-

$$\beta_o n + \beta_1 \; \Sigma \log Q_t - \beta_2 \; \Sigma \log(w/p)_t + \beta_5 \; \Sigma \log E_{t-1} - \Sigma \log EA_t \quad \text{..... (10.12)}$$

The basic results are reported in Table 10.1 c) as(*). The value of the objective function is 0.52, slightly higher than for the full model, implying average excess demand of approximately 45,000 employees. Zero excess demand is indicated in the years 1949, 60, 62 and 70, with 1960 and 62 having the strongest shadow prices, i.e. similar to the full demand model,but not quite the same.

The estimates imply a similar speed of adjustment of 66%, an elasticity of substitution of 0.85 and returns to scale of 0.51. Sensitivity analysis, with 5% variation of objective values, produced the results reported in Table 10.1 c). Only four of the eight runs produced solutions. Of these four, none are identical to the basic solution and they differ considerably from each other. Again, the conclusion is that we can have little confidence in the basic estimates,without further constraints.

d) <u>short supply</u>

To estimate the short version of the supply function, (6.10) is used in place of (6.3). The basic constraints to be imposed are:-

$$\alpha_o + \alpha_1 \log L_t + \alpha_2 \log W_{rt} + \alpha_5 \log E_{t-1} \geq \log EA_t \quad ..(10.13)$$

and the objective function to be minimized becomes:-

$$\alpha_o n + \alpha_1 \Sigma \log L_t + \alpha_2 \Sigma \log W_{rt} + \alpha_5 \Sigma \log E_{t-1} - \Sigma \log EA_t \quad ..... \quad (10.14)$$

The basic results are reported in Table 10.1 d) as(*). The value of the objective function is 0.43, identical to the full supply solution, and so with the same implications for average excess supply. Zero excess supply is found for the years 1951, 55, 60 and 1970. Again, similar to the full model, but slightly preferable in <u>not</u> having 1971 as a year of no excess supply.

The parameter estimates indicate a faster adjustment speed of 32%, a similar elasticity of industry supply with respect to total labour supply of 3.7 and a lower elasticity w.r.t. wages of 3.3. The results from successively varying the objective values by 5% are reported in Table 10.1 d). Five of the eight runs produced solutions, one of which was close to the basic solution, but the others were quite different. Again, the estimates are imprecise, without further restrictions. It is to these further restrictions that we now turn our attention.

10.5 <u>Estimation of the demand and supply functions with additional constraints</u>

a) <u>full demand</u>

As our data on the number of vacancies unfilled in the engineering industry is available for the years 1952-71 and

/not

not for the earlier years 1949-51, we have twenty observations of our excess demand ratio. In accordance with the discussion of Section 10.3 and equation (10.3), this gives a possible 190 inter-year excess demand comparisons and each of these can yield a constraint i.e. if the excess demand ratio is greater at time i than at time j then the constraint imposed is:-

$$\log ED_i - \log EA_i \geq \log ED_j - \log EA_j$$

$$\text{i.e. } \log ED_i - \log ED_j \geq \log EA_i - \log EA_j$$

which in parametric form is:-

$$\beta_1(\log Q_i - \log Q_j) - \beta_2(\log(w/p)_i - \log(w/p)_j) - \beta_3(i-j) - \beta_4(\log H_{oi} - \log H_{oj}) + \beta_5(\log E_{i-1} - \log E_{j-1}) \geq \log EA_i - \log EA_j \quad \ldots\ldots\ldots\ldots \quad (10.15)$$

Initially, because of the transitivity of these inequality constraints, only the 19 adjacent pairs of the 190 extra constraints need be included in the linear program, in addition to the basic constraints. The program was found to be infeasible, indicating that the extra constraints were so restrictive that there is no combination of non-negative parameters which will satisfy them all. This implies, at the two extremes, <u>either</u> that the vacancies/employment ratio does capture excess demand accurately, but that our employment function is not specified well enough to reflect this information, <u>or</u> that the constraints misrepresent excess demand to some extent, and hence cannot be all satisfied by our correctly-specified /function.

function. Due to serious misgivings,concerning the quality of vacancies data,we prefer to accept the latter explanation.

We can now proceed to eliminate those constraints which we are least sure of, in the hope that the removal of invalid constraints will leave a feasible solution , which is sufficiently precise,due to the remaining constraints.

The method adopted,in the absence of a priori information, is to allow a margin of error for the vacancies/employment ratio and to remove those constraints whose ratios differed by less than this margin. In this way we retain the constraints we have most confidence in. The magnitude of the margin of error required is unknown beforehand and so increasing values were tried. First a margin of plus or minus 10% was tried. This removed all of the original 19 constraints, to be replaced by 55 'weaker' ones[6], but the solution remained infeasible. A margin of 20% imposed 66 weaker constraints in the program, but the solution was still infeasible. However, when the margin was raised to 25%, with all the remaining 54 of the original 190 constraints being imposed, a feasible solution was achieved. The value of the objective function is 0.83, i.e. almost twice as large as the basic estimation, implying /

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(6) Removing adjacent inequalities loses some of the transitivity and so more constraints have to be explicitly imposed rather than being implicit.

implying an average excess demand of about 80,000 people - almost three times the average number of vacancies. Zero excess demand is found in 1949, 58, 62 and 71, with 1962 particularly strong.

The results are reported in Table 8.2 a) as (*). The estimated parameters indicate an adjustment speed of 95% per annum, i.e. almost complete, and returns to scale of 0.44. This value is much in line with the earlier results but the speed of adjustment is faster. It suggests that firms would adjust their labour force almost completely within a year to their desired level, with adjustment costs being unimportant. The fact that earlier results indicate much slower adjustment, perhaps suggests that it is supply that hinders adjustment, rather than the hiring and firing costs. This could be an important difference in the determination of employment demand, from that provided by traditional employment functions. However, since we do not have standard errors for the linear program estimates, it would be dangerous to place much confidence in this finding.

Sensitivity analysis was attempted but proved unsuccessful. Whereas the original estimation, minimizing the sum of residuals subject to (10.15), was undertaken some time ago, the sensitivity analysis has only been attempted recently, using a different linear programming estimation package. Most of the original results were replicated quite closely, but this particular estimation proved impossible to replicate. The solution remained unbounded. As before, this may have been /

been due to the precision setting of the program, but could not be corrected for. Hence, sensitivity analysis has not been undertaken for this section.

Furthermore, the extent to which we have had to relax the excess demand constraints to obtain feasibility is disappointing. Obviously, many of the constraints which have been removed did not cause the infeasibility, but unless we have other criteria for selection than the margin of error, we have no choice but to remove them - it is difficult to postulate that vacancies are relevant to the extent of excess demand in some years but not in others and not advisable to remove them on an ex post basis. The 25% margin of error, for example, means that we do not impose the constraint that 1955, the year with highest vacancies/ employment ratio, has more excess demand than 1957, which ranks fifteenth, even though there are almost 14,000 less vacancies in 1957 - 23,000 as against 37,000.

b) <u>full supply</u>

For comparability with the demand estimation we use observations of the unemployment/employment ratio for the years 1952-71, which, via equation (10.5), gives a possible 190 inter-year excess supply comparisons. The corresponding constraints are that, if the excess supply ratio is greater at time i than at time j, then:-

$$\log ES_i - \log EA_i \geq \log ES_j - \log EA_j$$

which /

which, for use in the linear program, is written as:-

$$\alpha_1(\log L_i - \log L_j) + \alpha_2 (\log W_{ri} - \log W_{rj})$$
$$-\alpha_3(\log H_{ri} - \log H_{rj}) - \alpha_4 (\log U_{ri} - \log U_{rj})$$
$$+\alpha_5(\log E_{i-1} - \log E_{j-1}) \geq \log EA_i - \log EA_j \qquad \ldots\ldots (10.16)$$

The inclusion of the 19 'adjacent pair' constraints caused infeasibility and so the margin of error is again applied. The program remained infeasible until a margin of 25% was allowed. At this point, 64 of the extra 190 constraints are imposed.

The value of the objective function was 1.09, two and a half times the value of the basic supply estimation, and implying average excess supply in the region of 100,000 compared with average unemployment figures of 26,000. 1955 is now the only year whose excess supply is zero and the constraint has a strong shadow price. The extra constraints are clearly having the effect of making estimation more 'difficult' for the program. The estimates are reported in Table 10.2 b) as (*). The adjustment speed of supply, which already seemed low at 12% p.a., is further reduced to 6% p.a. and the elasticities wrt. to relative wages and unemployment both take a value of zero. Elasticities wrt. total labour supply and relative hours of work are estimated at 3.2 and -5.5 respectively.

Sensitivity analysis was attempted to see how dependent the above estimates were on the objective function /

function values. This exercise was certainly more successful than with the previous demand estimation and indeed, than the basic supply estimation. All twelve runs provided solutions reported in Table 10.2 b) and six of them were identical to the above results, though four of these correspond to the variables with zero parameter estimates. The other solutions show less variation than in the basic case, with the fastest adjustment speed being 12% and only one being implausibly negative, at -13%.

Consequently, it would seem that the precision of the estimates is improved with the extra constraints. Whether the actual estimates are improved is debatable. Taken at face value, they imply very slow adjustment of labour supply towards its desired level and do suggest that labour supply constraints are not a factor to be ignored in the determination of employment.

Again, a disappointingly large margin of error has had to be allowed. For instance, 1968, which has the second highest excess supply ratio (unemployment of 35,000) can only just be constrained to have a larger supply residual than 1958 which ranks tenth (unemployment of 18,000).

c) <u>short demand</u>

Extra constraints can be imposed upon the short version of the demand function using equation (10.11), taking the form of (10.15) with the β_3 and β_4 coefficients equal to zero, and hence omitted. When the extra constraints were imposed the program was again found to be infeasible and /

and the infeasibility persisted even when margins of 10%, 20% and 25% were allowed. Whilst it is possible to further increase the margin of error, to 30% or more, as was pointed out above, this is already a considerable margin. To extend it further would allow us to say very little about excess demand in relation to vacancy figures. Consequently, this was not done and no solution or sensitivity analysis is reported for the short demand model.

d) short supply

Extra constraints are imposed upon the short version of the supply function using equation (10.10) and they take the form of (10.16) with the α_3 and α_4 terms omitted. Again a margin of error of 25% is needed before the LP solution becomes feasible, with the 'weakest' 64 of the extra 190 constraints imposed. The value of the objective function is 1.09, identical to the full supply value and implying average excess supply of about 100,000. 1955 is again the only year whose excess supply is zero and this constraint has a high shadow price .

The estimation results are reported in Table 10.2 c) as (*). The adjustment speed is estimated to be even lower, at 4% p.a. The elasticities of the labour supply wrt. total labour supply and relative wages are 5.9 and 0 respectively. Sensitivity analysis was attempted as before and, as with full supply, all of the runs (eight) produced solutions, reported in Table 10.2 c). Only two of /.

of these were identical to the above solution, but most were not too far removed. In particular, the adjustment speed varied between 5% and -13%, so that again very slow (or zero) adjustment of labour supply towards its desired level is found.

10.6 Conclusions

In this chapter, the unrealistic assumptions about the behaviour of labour markets, adopted in earlier chapters, were dropped. It was not assumed that wages were sufficiently flexible to equate demand and supply in all parts of the industry, nor even that, given wage rigidity, all parts have the same type of imbalance.

The basic assumption remained that we can define conceptually, if not measure, local labour markets within which labour is perfectly mobile. Consequently, given inflexibility of wages, these sub-sectors are either demand-determined or supply-determined. The implication for aggregate observations of employment was that they are rarely completely demand-determined or completely supply-determined. In general, actual aggregate employment is less than the levels demanded and supplied and so positive excess demand and excess supply co-exist. Furthermore, the difference between actual and demand, can be related to data indicating the extent of excess demand; in particular the number of vacancies unfilled. Similarly, the difference between actual and supply can be related to data on the numbers unemployed, as /

as a proxy for excess supply.

The above requirements do not seem too stringent, or unreasonable, a priori. However, when they were formulated as constraints in a linear programming context, neither the full models nor the short versions of the demand and supply functions were capable of dealing with them adequately. The basic constraints proved to be not restrictive enough to obtain precise parameter estimates. The additional constraints proved to be too restrictive to allow LP estimation at all. The most obvious source of deficiency appeared to be the inaccuracy of vacancies and unemployment data as indicators of excess demand and supply. The use of these indicators to impose the extra constraints was relaxed, but had to be relaxed considerably before most of the functions became feasible. At this point, the estimates were found to have improved stability, to the objective function minimized, but to be disappointing in terms of plausibility. Several variables, which were felt to be important in the determination of labour demand or supply, were found to have zero coefficients.

The only empirical finding that could be reported with anything approaching confidence, was the difference in the value of the lagged dependent variable between the demand functions and the supply functions. If this can be interpreted as the speed of adjustment towards desired levels of demand and supply, then it does suggest that /

that demanders of labour adjust their demands much faster than the suppliers of labour adjust their supply. The implication for the adjustment of actual employment appears to be that it is supply that is the constraining factor, which should not be ignored. It would be difficult to be more definite than this without stronger evidence in support.

There are several reasons why the results might have been unsatisfactory. The first may still lie with the accuracy of the vacancies and unemployment data - perhaps it is too unrealiable to use as any type of excess demand or supply indicator. The second reason may be the data used in general. As discussed in Section 6.5, annual data was used because of the improvement in conceptual quality of several variables over the data available on a quarterly basis. However, the extent of variation in the annual data was limited and hence the problem of lack of precision of estimates was ever present in the later chapters. Where quarterly data shows more variation, other than purely seasonal patterns, the improvement in precision may outweigh the conceptual quality of the data, though errors of measurement in the variables, resulting in biased estimates, may become more of a problem.

The specification of the demand and supply functions themselves are obviously a possible reason for unsatisfactory results, though this is difficult to assess unless a superior specification is postulated and tested. Finally, the /

the technique chosen for estimation, i.e. linear programming is a possible reason. The imposition of constraints seemed a natural consequence of the minimal theory postulated, but whether the constraints should be imposed deterministically,in a programming context,or be imposed stochastically, remaining within a statistical framework, is not clear. Whilst the latter would seem to be desirable in terms of the interpretation of the results, i.e. confidence intervals and comparability with earlier results, the difficulty lies in the combination of sampling information from the data with the 'theoretical' information from the constraints. It is not at all obvious how to weight these two separate and, to some extent, conflicting pieces of information, to obtain the 'mixed' estimates.

TABLE 10.1 BASIC LINEAR PROGRAM ESTIMATES, 1949-71

(a) Full demand model

	OBJECTIVE FUNCTION	CONST.	Log Q_t	− Log $(w/p)_t$	Log E_{t-1}	− t	− Log H_{ot}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQUATION (10.8))	0.00	0.755	0.645	0.324	0	0.764	0.47	0.676
(3)	+ 5% ΣLogQ	6.81	0	0.164	0.688	0	1.502	-	0.312
(5)	+ 5% ΣLog(w/p)	3.47	0.449	0	0.310	0.003	0	-	0.690
(7)	+ 5% $\Sigma LogE_{-1}$	0.37	1.051	0.847	0	0	0.942	-	1.000
(9)	+ 5% Σt	-10.34	1.792	0	1.543	0.089	0	-	-0.543
(10)	- 5% Σt	0.00	0.755	0.645	0.324	0	0.764	-	0.676
(12)	- 5% $\Sigma LogH_o$	- 2.35	0.757	0.561	0.339	0	0	-	0.661

TABLE 10.1 (Continued)

(b) Full supply model

	OBJECTIVE FUNCTION	CONST.	Log L_t	Log W_{rt}	Log E_{t-1}	− Log H_{rt}	− Log U_{rt}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQUATION (10.9))	− 3.19	0.399	0.938	0.880	0	0.085	0.43	0.120
(2)	− 5% ΣCONST	7.79	0	0	0	12.058	0.120	−	1.000
(3)	− 5% ΣLogL	− 0.10	0	0.826	0.999	0	0.117	−	0.001
(5)	+ 5% $\Sigma LogW_r$	− 7.00	0.996	0	0.602	0	0.129	−	0.398
(6)	− 5% $\Sigma LogW_r$	− 3.29	0.415	1.030	0.873	0.159	0.074	−	0.127
(7)	+ 5% $\Sigma LogE_{-1}$	−15.86	2.340	0	0	3.250	0.181	−	1.000
(9)	+ 5% $\Sigma LogH_r$	− 3.19	0.399	0.938	0.880	0	0.085	−	0.120
(10)	− 5% $\Sigma LogH_r$	− 3.19	0.399	0.938	0.880	0	0.085	−	0.120
(11)	+ 5% $\Sigma LogU_r$	− 3.36	0.424	1.028	0.869	0.165	0.073	−	0.131
(12)	− 5% $\Sigma LogU_r$	− 0.07	0	0.731	0.995	0	0.133	−	0.005

Table 10.1 (continued)

c) Short demand model

	OBJECTIVE FUNCTION	CONST.	Log Q_t	$-$Log $(w/p)_t$	Log E_{t-1}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQN. (10.12)	-2.34	0.754	0.559	0.342	0.52	0.658
(2)	- 5% Σconst	6.35	0.320	0	0	-	1.000
(3)	+ 5% ΣLogQ	1.65	0	0	0.791	-	0.209
(5)	+ 5% ΣLog(w/p)	3.50	0.352	0	0.353	-	0.647
(7)	+ 5% $\Sigma LogE_{-1}$	-2.68	1.079	0.770	0	-	1.000

Table 10.1 (continued)

d) Short supply model

	OBJECTIVE FUNCTION	CONST.	Log L_t	Log W_{rt}	Log E_{t-1}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN Eqn. (10.14))	-9.55	1.192	1.051	0.677	0.43	0.323
(2)	- 5% Σconst	7.774	0	0	0	-	1.000
(3)	+ 5% ΣLogL	1.65	0	0	0.791	-	0.209
(5)	+ 5% Σ$LogW_r$	-6.49	0.970	0	0.580	-	0.420
(6)	- 5% Σ$LogW_r$	-9.25	1.146	1.155	0.696	-	0.304
(7)	+ 5% Σ$LogE_{-1}$	-23.59	3.117	0	0	-	1.000

TABLE 10.2 ESTIMATES WITH ADDITIONAL CONSTRAINTS, 1949-71

a) Full demand model

	OBJECTIVE FUNCTION	CONST.	Log Q_t	− Log $(w/p)_t$	Log E_{t-1}	− t	− Log H_{ot}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQUATION (10. 8))	-1.26	1.244	0.720	0.048	0.012	0.515	0.83	0.952

b) Full supply model

	OBJECTIVE FUNCTION	CONST.	Log L_t	Log W_{rt}	Log E_{t-1}	− Log H_{rt}	− Log U_{rt}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQUATION (10.9))	-1.48	0.202	0	0.937	0.344	0	1.09	0.063
(1)	+ 5% ΣCONST	-2.96	0.312	0.091	0.986	0	0	-	0.014
(2)	− 5% ΣCONST	0.99	0	0	0.884	2.844	0	-	0.116
(3)	+ 5% ΣLogL	0.14	0	0	0.990	0.680	0.014	-	0.010
(4)	− 5% ΣLogL	-2.96	0.312	0.091	0.986	0	0	-	0.014

Table 10.2 (continued)

b) Full supply model (continued)

	OBJECTIVE FUNCTION	CONST.	Log L_t	Log W_{rt}	Log E_{t-1}	- Log H_{rt}	- Log U_{rt}	OBJECT. VALUE	ADJUST SPEED
(5)	+ 5% ΣLog W_r	-1.48	0.202	0	0.937	0.344	0	-	0.063
(6)	- 5% ΣLog W_r	-1.48	0.202	0	0.937	0.344	0	-	0.063
(7)	+ 5% ΣLog E_{-1}	-1.70	0.244	0	0.912	0.600	0	-	0.088
(8)	- 5% ΣLog E_{-1}	-0.95	0	0.184	1.131	0	0	-	-0.131
(9)	+ 5% ΣLog H_r	-1.48	0.202	0	0.937	0.344	0	-	0.063
(10)	- 5% ΣLog H_r	-1.48	0.202	0	0.937	0.344	0	-	0.063
(11)	+ 5% ΣLog U_r	-1.48	0.202	0	0.937	0.344	0	-	0.063
(12)	- 5% ΣLog U_r	-1.48	0.202	0	0.937	0.344	0	-	0.063

TABLE 10.2 (Continued)

c) Short supply model

	OBJECTIVE FUNCTION	CONST.	Log L_t	Log W_{rt}	Log E_{t-1}	OBJECT. VALUE	ADJUST. SPEED
(*)	BASIC (AS IN EQUATION (10.14))	-1.94	0.230	0	0.961	1.09	0.039
(1)	+ 5% ΣCONST.	-2.96	0.312	0.091	0.986	-	0.014
(2)	- 5% ΣCONST.	-0.46	0	0	1.070	-	-0.070
(3)	+ 5% ΣLogL	-0.46	0	0	1.070	-	-0.070
(4)	- 5% ΣLogL	-2.96	0.312	0.091	0.986	-	0.014
(5)	+ 5% $\Sigma LogW_r$	-1.94	0.230	0	0.961	-	0.039
(6)	- 5% $\Sigma LogW_r$	-1.94	0.230	0	0.961	-	0.039
(7)	+ 5% $\Sigma LogE_{-1}$	-2.58	0.301	0	0.952	-	0.048
(8)	- 5% $\Sigma LogE_{-1}$	-0.95	0	0.184	1.131	-	-0.131

General Conclusions

In the first half of the thesis, the demand-orientated employment function models were thoroughly considered. Chapter 1 presented an 'ideal' employment function and then analysed the various types of model which have been put forward,in relation to this theory. Chapter 2 examined the same models used empirically, both in their original studies and on a consistent data base (U.K. manufacturing sector). Whilst the models generally performed well in the original studies, they were less satisfactory for the U.K. manufacturing sector.

Chapter 3 applied most of these models to quarterly data for the S.I.C. Orders of the U.K. engineering industry 1959-71, and their performance was even less satisfactory. Models frequently seemed to explain well for one SIC but not for others or to have different parameter values from earlier studies. Since the models were designed to have reasonably general applicability, this finding casts doubt on the models usefulness. The models were developed in various ways, attempting to move towards the ideal model without major revisions, but the implausibility or instability tended to persist. An attempt to allow the speed of adjustment to depend upon labour market tightness showed some evidence of significant effect, suggesting importance of supply considerations, but proved difficult to model satisfactorily.

Chapter 4 attempted to improve the employment function specification /

specification in terms of desired output, again based on the ideal model. The aim was to distinguish between actual and desired output by allowing excess demand for the product to influence a firm's desired output. Various measures of the 'backlog' of orders-on-hand were suggested and tried as measures of this excess demand with some success but again general applicability cannot be claimed, due to lack of appropriate data.

Chapter 5 took a different approach in trying to relate employment to investment, in a putty-clay framework. Despite the theoretical appeal, such an approach was severely constrained by data availability. The resulting estimates did not plausibly support the putty-clay hypothesis, but hardly constituted a rigorous test, given the simplifying assumptions which had to be made.

The general conclusion from the first half of the thesis was that a demand-orientated model, which yielded plausible and stable estimates for all three SICs, could not be found. This led to the consideration of supply factors and the development of a supply function for an industry, in Chapter 6, to analyse in conjunction with a demand function. This analysis and consequent estimation, constituted the second half of the thesis.

Chapter 7 set out the various levels of assumptions about the operation of the industry labour market which were pursued in the following chapters. The analysis was based /

based on consideration of the sectors or local labour markets which made up the industry labour market. Labour was assumed perfectly mobile within sectors but immobile between them, due to geographical and occupational barriers. The degree of wage flexibility was also considered to be important. No attempt was made to observe these local labour markets, but the implications of their existence for aggregate observations was analysed.

Chapter 8 assumed flexibility of wages within a sector, so that each sector was in, or close to, equilibrium. The aggregate employment was then taken as equal to both aggregate demand and supply and the two functions were estimated separately and simultaneously, using annual data for SIC6, 1948-71. The resulting estimates were lacking in plausibility and stability but also lacking in precision, so that the validity of the underlying assumptions could not be confidently rejected.

Chapter 9, assumed a degree of inflexibility of wages which meant that sectors were not generally in equilibrium. The further assumption of homogeneity implied that aggregate employment was either demand-determined or supply-determined but not generally both. The problem was to determine which observations belonged to which regime, in order to estimate them separately. Several ways of ranking the observations were suggested so that a single cut-off point could be searched for between demand and supply regimes. The average number of /

of observations of a function was effectively halved from the estimation of Chapter 8 and so degrees of freedom were low. None of the rankings yielded demand and supply functions which were plausible and able to predict values of employment, in excess of actual employment, for those observations which did not belong to the particular regime.

Chapter 10 dropped the assumption of homogeneity, so that aggregate employment could not be taken as an observation of demand or supply. Estimation of the functions, subject to the constraints of non-negative excess demand and supply, took a linear programming approach, but was hampered by a lack of definite objective to optimise. Quite imprecise estimates resulted. Further constraints, which ranked demand and supply residuals according to vacancies and unemployment data,proved too restrictive to be fully accommodated. Relaxing these constraints considerably enabled estimates to be obtained, which were reasonably robust but, with several coefficients estimated to be zero, generally unsatisfactory. Employment demand appeared to adjust quickly to its desired level, while supply seemed to adjust very slowly.

The results of the last three chapters were disappointing. The benefit of allowing for supply factors could not be demonstrated in terms of more plausible and stable estimates. Furthermore, it could not be claimed that the relaxation of unrealistic assumptions led to superior /

superior estimation.

However, it is still felt that supply factors have an important part to play in the determination of employment,which should not be neglected. It is hoped that further development and testing of the final model could produce stronger evidence to support this claim.

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DATA APPENDIX

a) Quarterly, 1959-1971 (Ch. 3-5)

(separate series are obtained for each of the 1958 SIC Orders VI, VIII and IX, unless otherwise stated).

1. Employment

The number of employees in employment series are quarterly averages of monthly figures supplied by the Department of Employment on a consistent basis (despite changes in SIC definitions, etc.)

2. Output

The production series are quarterly averages of monthly figures, in index form, from the Monthly Digest of Statistics. The series are not seasonally adjusted, except in Ch.4 for SIC6.

3. Wage and average hours worked

The wage series are of average hourly earnings and are in index form. They are derived by dividing an average weekly earnings series by an average weekly hours worked series. Average earnings series are available for all employees monthly in the Department of Employment Gazette (post 1963) but only bi-annually prior to 1963. The quarterly series interpolate the earlier observations and average the later monthly ones. Series of average weekly hours worked by operatives is available monthly (post 1963) and about six times a year prior to 1963, for SIC8 and for 'engineering, electrical goods, metal goods' - the latter was used for both SIC's 6 and 9. Quarterly series /

series were derived.

4. Price

The price series is of wholesale prices for 'engineering and allied industries' (one series for all three SIC's). Quarterly averages are derived from data in monthly index form in the Monthly Digest of Statistics (post 1965) and the Board of Trade Journal (pre 1965).

5. Normal hours

Normal hours series are quarterly averages of monthly indices from the British Labour Statistics - Historical Abstract and Yearbooks.

6. Capital stock

The capital stock series are derived from annual capital formation figures in the National Income and Expenditure Book. Depreciation is allowed for by the 'perpetual inventory method'. The annual figures are interpolated linearly[(1)] to give quarterly series.

7. Capital (capacity) utilization

Series for capital utilization are derived by the Wharton School capacity method. This involves the selection of peaks in output during the estimation period, taken to be periods of full capacity utilization. Interpolation between these peaks gives potential capacity output at each point in time and actual output can be expressed as a percentage of this amount to give a figure for /

(1) Theoretically, interpolation by investment expenditure is preferable, but in practice this made little difference to the stock series.

for capacity utilization. Variations in this series clearly depend on labour usage variations as well as capital usage changes. In using this series as a proxy for capital utilization, this deficiency should be noted.

8. <u>Price of capital and rental cost</u>

Series for the price of capital goods can be derived from data on fixed capital expenditure in the Monthly Digest of Statistics. This data is given at current prices and at constant prices so that a price index is obtained by division. Unfortunately, for the SIC's, the constant price series is seasonally adjusted whilst the current price series is not. The division process would then yield a false seasonal pattern to prices,which proved difficult to remove. To avoid such errors a price series for total manufacturing was used for all three SIC's,since both constant and current price data were available unadjusted for total manufacturing.

However, the price of capital goods is only one element of the rental cost of capital. The rate of depreciation, rate of interest, corporate tax rate, income tax rate, investment grants and initial allowances for tax should all be taken into account. Initial experimentation with such calculations did not suggest any empirical improvement over the straightforward use of the price of capital, since its variations tended to dominate; and so the simple price series was used in the reported empirics.

9. Unemployment

Unemployment series are quarterly averages from monthly data on the number of people registered as unemployed having previously worked in the particular industry (within the last year). This data is available in the Department of Employment Gazette.

10. Vacancies

These series, derived similarly to unemployment, measure the number of job vacancies reported to the Department of Employment and remaining unfilled.

11. Total orders-on-hand

A series of total orders-on-hand is available in seasonally adjusted volume index form in the Monthly Digest of Statistics for SIC6. When output is added to an (unknown) proportion of orders on hand, in Chapter 4, it is necessary for output to be seasonally adjusted and for the relative magnitudes of orders and output to be known. The information to do this was supplied by the Department of Industry: in 1970, the value of average quarterly sales was £2,224M and the value of total orders-on-hand was £5,466M. Their respective index numbers were 100 and 155.5. For consistency in addition the orders-on-hand series is multiplied by 1.58 (i.e. 5,466 x 100 ÷ 2,224 x 155.5).

12. Work-in-progress

A series of quarterly changes in the constant (1970) price /

prices value of 'work-in-progress' stocks was supplied by the Department of Industry together with an end of year (1972) figure for the <u>stock</u> of work-in-progress. From these a full series of work-in-progress can be constructed.

13. <u>Investment</u>

Data on 'fixed capital expenditure' is available quarterly, seasonally adjusted, at constant prices in the Board of Trade journal. However, whilst there is a separate series for SIC8, SIC's 6 and 9 are combined with SIC7 in an 'engineering, shipbuilding and metal goods' series. To obtain separate series for each SIC, data on annual net investment (current prices) by SIC was used. The quarterly investment expenditure was allocated according to the proportions of annual investment undertaken by these three SIC's.

b) Annual, 1948-71 (Ch. 6-10)

(for the 1958 SIC Order VI, unless otherwise stated)

1. Employment

The number of employees in employment series is available for the U.K. in the British Labour Statistics Historical Abstract (Table 132) and later Yearbooks. The figures are mid-year estimates.

Various links in the series had to be made due to changes in classification and method of calculation. The most important of these are the SIC classification changes in 1959 and 1969 - figures for these years are given in both the earlier and the later classifications. Some of the changes involved the 'clearcut' movement of complete M.L.H.'s from one SIC to another, or the sub-division of one SIC into several. Before 1959, shipbuilding (and repairing) and marine engineering were included in the equivalent of SIC6, whilst instruments and watches and clocks (manufacture and repair) were not. Post 1969, SIC6 has been split into the three new SIC's of mechanical, instrument and electrical engineering. Also, "engineers' small tools and gauges" has been moved from SIC6 to SIC9 (1958 Order).

Where these definite changes took place, adjustments of the series to the 1958 order classification were made by use of MLH data on employment (Tables 138 and 139). Any remaining differences, due to reclassification of parts of MLH's or to changes in the method of calculation, were /

were small in magnitude and were removed by a correction factor, in the absence of further information. This method is unlikely to cause much error in the figures, unless the particular sector neglected behaves very differently from the rest of the SIC and is large enough to influence the 'true' aggregate appreciably. This is unlikely.

2. Total labour force

Figures of the number of employees (employed and unemployed) for all industries and services are available in the B.L.S. Historical Abstract (Table 125) and Yearbooks in similar form to the employment figures.

Some linking is necessary for changes in the method of calculation of the figures.

3. Normal Hours

A series of normal weekly hours of manual workers is derived for 'all metals combined' by averaging the monthly figures available in the B.L.S. Historical Abstract (Tables 25 and 26) and Yearbooks. The figures are not available for SIC6 alone but variation between industries within 'all metals combined' is likely to be small.

4. Output

An annual index of industrial production is available in the Annual Abstract of Statistics. The index changed base several times over the period but could be linked to give a series with the common base of 1970=100. Post 1969 /

1969 figures are derived via a weighted average of the three component SIC's - mechanical, instrument and electrical engineering - with the given weights.

5. Average weekly earnings

Data on the average weekly earnings of manual workers (men and women separately) are available in the B.L.S. Historical Abstract (Tables 41 and 42) and Yearbooks, biannually for SIC6 and for all industries. Annual series are derived by averaging the biannual figures and the (small) base changes in 1959 and 1969 are corrected for by a multiple factor as before. The series for men and women are aggregated using male and female employment series (Tables 133 and 134) as weights. Post - 1969, SIC6 is again reconstituted, aggregating using employment weights. Non-manual earnings are assumed to move in proportion to manual earnings.

6. Average weekly hours

Data on the average weekly hours of manual workers (men and women separately) are available in the B.L.S. Historical Abstract (Tables 44 and 45) and Yearbooks, biannually for SIC6 and for all industries. Annual series are derived as with average weekly earnings.

7. Labour cost

A series of average labour costs can be obtained which includes both the over-time premia element and the direct overheads associated with the employment of labour. The /

The Department of Applied Economics at Cambridge, "Programme for Growth: 12" includes an 'income from employment' series for the years 1948-68 (Table 23). This series comprises wages and salaries and employers' contributions. The annual data on wages and salaries is directly obtainable from National Income and Expenditure 'Blue Books'. However, employers' contributions are only available as an annual series for all manufacturing. The D.A.E. used more detailed information on employers' contributions by industry, from the 1963 Census of Production, to allocate the contributions between industries for all other years. A similar procedure is followed in extending the series to 1971 and in revising recent D.A.E. figures for data revisions which occur in later copies of the Blue Book.

A series for the total wage bill is thus derived. To obtain a series of average labour cost per man-hour, this is divided by the number in employment and the average hours worked series, already obtained.

8. Value-added Price

This series is again based on data published by the D.A.E. For the years 1948-58, 'net output' figures are presented in the D.A.E. series 'A Programme for Growth: 4', obtained for the various SIC's from annual censuses of production. Since 1958, these net output statistics are no longer available. However, 'A Programme for Growth: 12' includes data series on 'income /

'income from employment' (Table 23) and 'gross income from property and self-employment, 1954-1968, excluding stock appreciation' (Table 25). Adding these two series together gives a net output series (excluding stock appreciation) for the years 1954-68 - stock appreciation data was not available before 1954, and so the original series is used for these years.

This series then required extending to 1971 to be used for estimation purposes and, in doing this, both data revisions in more recent Blue Books and the change in SIC classification were allowed for. The derivation and extension of the 'income from employment' series has already been dealt with. The other series is made up of gross profits of companies, gross trading surpluses of public corporations, other trading income and income from self-employment. Company profits are available in the Blue Book for engineering but the industry definition corresponds to the Inland Revenue classification, rather than the usual one. Correction to the normal basis is made by the D.A.E. with reference to Census of Production information. Data on income from self-employment and other trading income is only available in the Blue Book for all manufacturing. The D.A.E. allocate this to the various industries by reference to Inland Revenue Reports. Data on stock appreciation is available in the Blue Book for an aggregate of all engineering and changes in the book value of stocks are known for Census of Production years, and for sample censuses in other years. These enable stock appreciation to be allocated to SIC6 on the basis /

basis of its value of stocks (assuming stock prices will be the same in all sectors of engineering).

These data series were extended to 1971, using more recent information from the 1973 Blue Book, revising the later D.A.E. figures and applying allocation factors etc. consistent with those of the D.A.E.

The resulting series gives the net output or total value added for SIC6. To obtain a value added price series, the figures in the above series are divided by the volume of output figures already discussed.

9. Unemployment (as a security factor)

The unemployment measure felt to best represent this factor is the number of people registered as wholly unemployed, having previously worked in SIC6. However, this data is available for Great Britain but not for the U.K. - the U.K. data includes those temporarily unemployed, (both sets of data are available monthly in the Department of Employment Gazette). A series for U.K. wholly unemployed - is obtained by 'inflating' the G.B. wholly unemployed series by the ratio of U.K. to G.B. 'unemployed: wholly and temporarily'. The implicit assumption is that lay-offs form the same proportion of unemployment in N. Ireland as in G.B. This is unlikely to be too erroneous.

The monthly figures are then averaged over the year from July to June so that an average information lag of six /

six months is produced. A similar series is derived for 'all industries'.

10. Unemployment (as an excess supply indicator)

A monthly series for the number of people registered as unemployed, both wholly and temporarily, having previously worked in SIC6, can be obtained from the Department of Employment Gazette. The figures were averaged over calendar years.

11. Vacancies

Similarly, a monthly series of the number of vacancies remaining unfilled in SIC6, can be obtained from the Department of Employment Gazette, from 1952 onwards. Annual averages were calculated.

List of Abbreviations

S.I.C. (SIC)	-	Standard Industrial Classification Orders
M.L.H.	-	Minimum List Heading
w.i.p.	-	work-in-progress
C.E.S.	-	constant elasticity of substitution
OLS	-	ordinary least squares estimation
HILU	-	Hildreth-Lu estimation procedure
2SLS	-	two-stage least squares estimation
LSQ	-	non-linear least squares estimation
TSP	-	Time Series Processor
LP	-	linear program estimation

U-BASED, based on a ranking of the unemployment/employment ratio

V-BASED, based on a ranking of the vacancies/employment ratio

W-BASED, based on a ranking of changes in industry/aggregate wage ratio

Q-BASED, based on a ranking of actual/trend output ratio

STAT D-BASED, statistically-determined ranking based on demand regime

STAT S-BASED, statistically-determined ranking based on supply regime

List of Symbols

L	the labour input
E	the number of employees
H	the average number of hours worked per employee
Q	the level of output
K	the capital stock
U	the rate of utilisation of capital
W	the marginal labour cost
p	the product price
c	the cost of capital
H_o	normal hours
$\tilde{E}$	a measure of excess labour
s(t)	a trend proxying the extent of market imperfections
U_e	the level of unemployment
V	the level of vacancies
*	denotes 'desired'
^	denotes the expected value or an estimate
σ	the elasticity of substitution
ν	the returns to scale
O	the level of orders-on-hand
OT	total orders-on-hand
OB	the backlog of orders-on-hand with:-
OBD	a direct measure
OBC	a measure based on a constant ratio
OBT	a measure based on a trending ratio
w/r /	

w/r	the wage-rental ratio
ψ	the labour-capital ratio
τ	the age at which capital is scrapped
μ	the age at which capital is laid-up
ν	the average age of capital
$-$	denotes aggregate or average
ED	the demand for employees
ES	the supply of employees
EA	actual employment
L	the total labour force
W_r	relative average weekly wages
H_r	relative average weekly hours worked
U_r	relative unemployment
X_D	the excess demand for labour
X_s	the excess supply of labour
R_D	a demand function residual
R_s	a supply function residual