EMPLOYMENT AND OUTPUT FUNCTIONS FOR NEW ZEALAND MANUFACTURING INDUSTRIES

NUMBER 33

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WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

UNIVERSITY OF WARWICK
COVENTRY

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University of Warwick June, 1973.

This paper is circulated for discussion purposes only and its contents should be considered preliminary.

The author would like to record his appreciation of the work of his research assistants, Robert Davidson, Graham Walsh, and Ian Selbie, and of the comments of Alan Woodfield, Colin Gillion, Dennis Rose, L. Fraser Jackson, and participants in the Warwick Industrial Economics Workshop.

EMPLOYMENT AND OUTPUT FUNCTIONS FOR NEW ZEALAND MANUFACTURING INDUSTRIES

Tim Hazledine

I. Introduction

The impetus for empirical work on the relationship between employment and output came from the observation that, historically, employment had varied less over the business cycle in Britain and the United States than output, so that productivity (output per worker) was high during output peaks, and low through recessions.[1]

Figures 1 and 2, drawn from quarterly observations on the New Zealand manufacturing sector from 1964 to 1970, reveal a similar phenomenon in that country.

This relationship is surprising to an economist, since it appears to contradict the 'law' of diminishing returns, which predicts that as more of a variable factor, say labour, is added to a fixed factor, capital, in order to increase output, average returns to the variable factor (that is, productivity) decrease, since each worker has less capital to work with.

Section II of this paper is an exposition of the various approaches that have been made to explain cyclical fluctuations in employment. The results of these studies have not been considered to be completely satisfactory, and there has been rather a confusion of explanations of why this is so. I attempt to sort these out in section III, and in so doing to derive some principles for the specification of my own model, in section IV. This model is estimated, and the results discussed, in section V, and the study is concluded in section VI. An appendix contains details of the data.

II. A Description of Short-term Employment Functions

1. The basic explanation for cyclical productivity fluctuations can be summarised thus:

> Employers are aware of an optimal or 'desired' level of employment corresponding to each rate of output, and probably subject to non-increasing returns. Unfortunately, with output varying, they are not generally able to adjust employment fully to its varying optimal levels on each time period because of costs of change-adjustment costs. These adjustment costs are such that at low rates of output more than the desired amounts of labour is held by employers, and at high rates employers have less labour than they would ideally wish, the overall effect being to smooth out fluctuations in employment relative to fluctuations in output.

Adjustment costs are due to the costs involved in hiring, firing, and training labour, reinforced by uncertainty about the future, and it is assumed that they generate an <u>adjustment function</u> of the general form

$$E_t - E_{t-1} = f(E^*_t - E_{t-1}) \qquad \ldots(1)$$

where f is some function, and E^*_t and E_t are the actual and desired levels of employment in period t. f therefore gives the actual change in employment as a function of the desired change, with E_{t-1} the number of workers on hand at the beginning of period t.

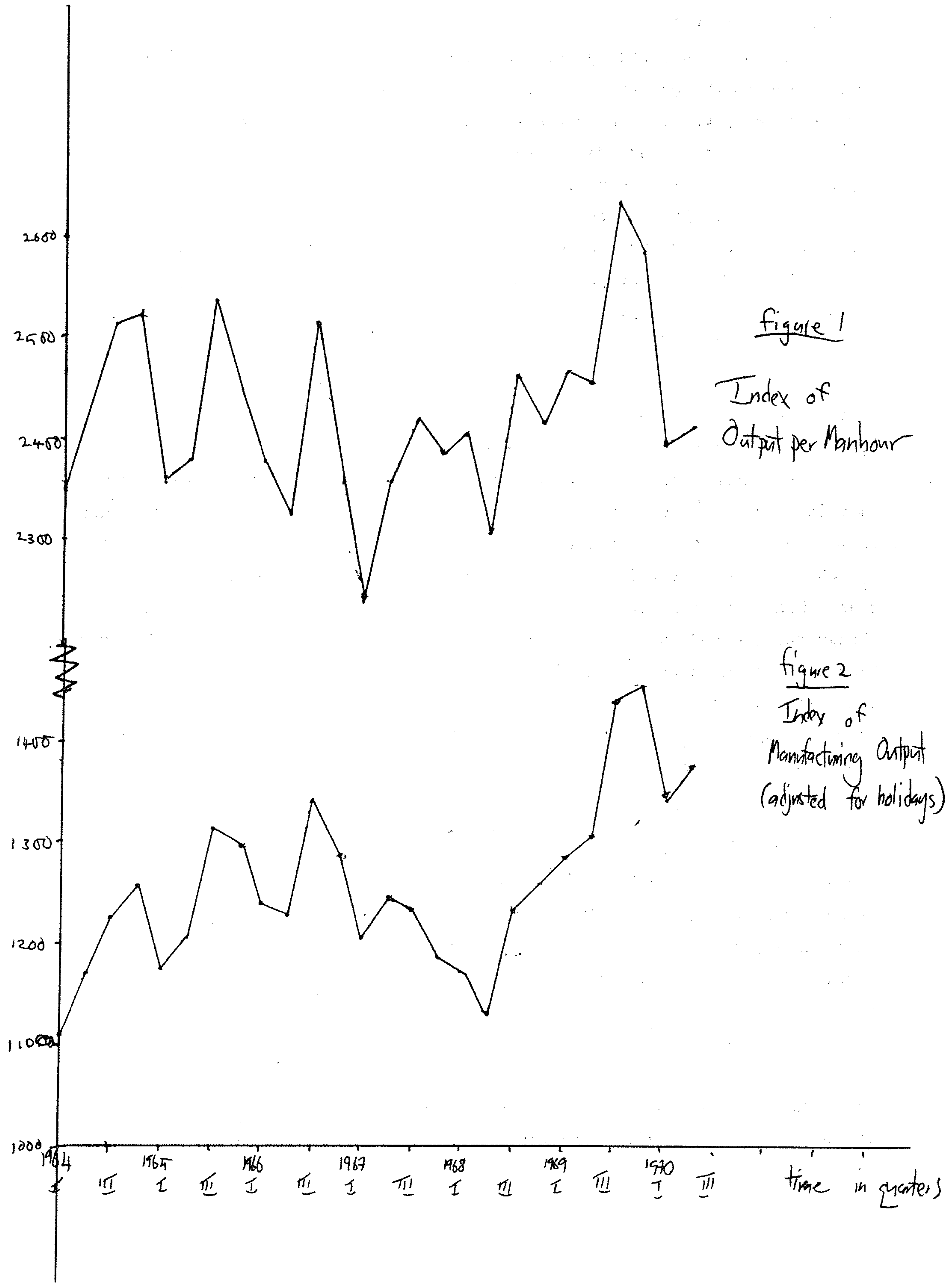
The optimal level of employment for a period is generally supposed to be determined by the planned rate of output, the state of technology, and the stock of capital on hand. For simplicity, the planned rate of output is usually proxied by actual output, and capital and technology are bundled together into a trend term, so that

$$E^*_t = g(Y_t, t) \qquad \ldots(2)$$

Combining (1) and (2)

$$E_t - E_{t-1} = f(g(Y_t, t) - E_{t-1}) \qquad \ldots(3)$$

In the framework of these equations, two different types of models have evolved. The first and most popular approach, which I call type A, contains those models which derive a single estimating equation, of the form of equation (3), in which the parameters of both the functions f and g appear as unknowns to estimated. In models of type B, estimation is a two-stage procedure. First the parameters of g, and thus E* are estimated, then the parameters of f are estimated as a function of the computed variable $(E^*_t - E_{t-1})$.


2600
2500
2400
2300
figure 1
Index of
Output per Manhour
figure 2
Index of
Manufacturing Output
(adjusted for holidays)
1400
1300
1200
1100
1000
1964
1965
1966
1967
1968
1969
1970
I
III
time in quarters

2. Models of type A.

The two seminal attempts to construct a model of cyclical employment functions were the papers of Brechling (1965) and Ball and St Cyr (1966). I shall base my exposition on the approach of Ball and St Cyr, since theirs has become the standard type A model. The difference in Brechling's original approach will be noted.

Making the typical assumption of capital stock and technology that are given in the current quarter, absorbing their influence and movement through time by an exponential trend, and assuming a Cobb-Douglas production function, Ball and St Cyr have the relation

$$Y_t = Ae^{rt}(Eh)_t^{\alpha} \qquad \ldots(4)$$

where A is a constant, and h is the number of hours worked per man, so that Eh is total manhours, which Ball and St Cyr consider to be the appropriate labour input in the production function.

Introducing the hours worked variable means that a desired employment equation (2) cannot be simply obtained by inverting (4), since E_t would then be a function, not just of the independent variables Y_t and t, but also of h_t, which is, however, itself an endogenous variable. However, if the reasonable assumption is made that it is customary for workers to be paid as though they worked, say, a forty hour week, even if they actually work fewer hours, while any hours worked in excess of forty must be paid for at overtime rates, then the implied cost per Manhour function has a minimum which does not depend on E or Y. Ball and St Cyr demonstrate this graphically, and, also, by approximating the Cost per manhour schedule by the analytically docile quadratic

$$W_{ht} = a - bh_t + ch_t^2 \qquad \ldots(5)$$

where W_h is the cost per manhour, equal to total cost, C, divided by the number of manhours worked, Eh. Multiplying both sides of (5) by Eh, substituting for h from (4), differentiating with respect to E, equating to zero, and solving for the total-cost-minimising level of employment, E*, gives

$$E_t^* = \frac{2c}{A'b} e^{-rt/\alpha} \; Y_t^{1/\alpha} \qquad \ldots(6)$$

an expression which does not include the variable hours per man, h. This is because the cost-minimising number of hours worked per man is a constant

(= b/2c) equal to 'normal' hours, where no over- or undertime is worked, This result means that Ball and St Cyr can derive an equation of the form (2); it is, in fact, equation (6) above.

The adjustment function (1) is specified rather differently as

$$E_t/E_{t-1} = (E_t/E_{t-1})^{\lambda}, \quad 0 < \lambda < 1 \qquad \ldots(7)$$

with the restriction on λ incorporating the notion that adjustment costs force the response to any desired change in employment to be less than complete. The multiplicative form is for analytical ease- when (6) is substituted into (7), and logs taken, Ball and St Cyr get

$$\log E_t = a_o - \lambda r/\alpha.t + \lambda/\alpha.\log Y_y + (1-\lambda)\log E_{t-1}, \; a_o = \lambda\log\frac{2c}{bA} \qquad \ldots(8)$$

(adding $\log E_{t-1}$ to both sides), which is the equivalent of our equation (3), with the employment and output variables in logarithmic instead of natural form.

Equation (8) has been estimated (with some variance in the interpretation of the parameters) by Ball and St Cyr (1966), for various sectors of the British economy, by Brechling and O'Brien (1967) for the manufacturing sectors of twelve Western industrialised countries, by Smyth and Ireland (1967) for Australian manufacturing industries, by Hazledine and Woodfield (1971) for the New Zealand manufacturing sector, and by Miller (1971) for some United States manufacturing industries. Brechling's original study (1965) estimated a similar equation in linear and logarithmic form for the British manufacturing sector.

The results of these studies are remarkably consistent with each other in several important respects.

1) In <u>every</u> study, values of the adjustment parameter, λ, are derived, from the coefficient of $\log E_{t-1}$, that are between zero and one, and are thus consistent with the <u>a priori</u> specification noted in equation (7).

2) In nearly every study estimates of α are made, from substituting into the coefficient of $\log Y_t$ in the estimated version of (8), that are in excess of one.[2] In the standard model outlined above, this can only be interpreted as implying increasing returns to labour in the production function.[3]

3) All statistically significant values for the coefficient of the time variable are positive, implying a secular long-run increase in output per man in each case.[4]

Results 1) and 3) are in accordance with *a priori* expectations, and have not attracted a great deal of comment. Result 2), however, is the main cause of dissatisfaction with employment studies; the reactions to it are discussed in section III of this paper.

3. Models of type B.

The first, and most thorough, analysis to take the type B approach is that of Fair (1969). Fair assumes that 'labour hoarding', induced by adjustment costs, prevents the underlying production function constraint from being observed except at periods in the business cycle of peak activity, when all labour is being fully utilised. He supposes that the production function is fixed-coefficients, so that at any peak period p, the relation

$$Y_p/h_p = \gamma_p E_p \qquad \ldots(9)$$

holds[5], and can be solved for the production function coefficient γ_p in terms of the known values of the variables Y, E, and h. Fair chooses the peak periods by eye from a graph of output per man over time to be most of the periods in which output per man was higher than the preceding and succeeding months, and computes a series of γ_p values. The series rises over time, of course, with technical progress and a growing capital stock. Values of γ

for non-peak periods are deduced by linear interpolation- the peak γ_p's are plotted against time on a graph, neighbouring γ's are joined by a straight line, and the implied coefficients for non-peak periods are read off from the lines. Substituting, for each non-peak month, actual output, normal hours, and the deduced γ, in an equation like (9), and solving for E, gives an estimate of desired employment for the period- the number of workers that would have been necessary to produce the output of the period had labour been working to full capacity. The computed E* series is then substituted into a more complicated version of equation (3), and the parameters of the adjustment function estimated directly.

Fair estimates his model for seventeen United States manufacturing industries, with what seem to be good statistical results. Certainly his model fits better than a type A model which he also estimates with the same data, but to an unknown extent his type A model is a strawman, since it does not incorporate the fairly sophisticated expectational hypothesis (discussed below in section III) that are included in his preferred specification.[6]

Fair's work corroborates results 1) and 3) above; built as it is on the assumption of a fixed-coefficients technology, it does not offer any direct evidence on the size of short-term returns to labour.[7]

A different type B approach is that of the Macro-econometric model builders of the Bank of Canada, and the Reserve Bank of Australia, exemplified by Hawkins (1971), who choose a priori values of Cobb-Douglas or Constant-Elasticity-of-Substitution production function parameters, thereby compute a series of E*, and estimate a version of equation (3). The process is repeated with different a priori production function parameters, and the estimated equations are compared for their statistical properties of goodness of fit. The derived coefficients support results 1) and 3), and also 2), since Hawkin's best-fitting equations are those with the highest a priori value of α- 1.6 -, though Hawkins interprets α as returns to scale, not to labour alone (this interpretation is examined in section III).

As an alternative to their type A model, Hazledine and Woodfield (1971) estimated equation (4) directly, and obtained an estimate for α that was not significantly different from 1, supporting their contention that labour-hoarding is not very important in the New Zealand economy, with its historically very low unemployment rates.[8] With an assumption about the size of desired hours, they then calculated an E* series, and estimated an equation like (3) with the difference, however, that their dependent variable was the vacancy rate, which, they felt, was a better proxy for employers' demand for labour, in a fully employed economy, than the actual change in employment, $E_t - E_{t-1}$, which is the result of the interaction of forces of supply and demand.

4) Inter-related Factor Demand Studies.

The main analytical extension of the employment function models described above has been the suggestion that the demand for labour be considered jointly with the demand for the other factor, capital. Two distinct approaches have been made. Dhrymes, (1967), showed that independent estimation of employment and investment functions leads to independent estimates of the underlying production function parameters which do not, in general, coincide, due to the small size of the data sample. Coen and Hickman (1970), faced with widely differing parameter estimates, choose to believe the coefficients implied by their employment function, on grounds of a priori acceptability, and re-estimate the investment function with these coefficients super-imposed on it. Hawkins (1971) in fact applies the search procedure mentioned above simultaneously across investment and employment functions, and compares sets of factor demand functions, each with the same underlying production parameters for investment and employment equation, chosen a priori.

The inter-relatedness of factor demand equation estimation in the above three studies is only statistical. The second, and more fundamental approach to inter-relatedness is made by Nadiri and Rosen (1969) who propose that factor adjustment is jointly determined, in the sense that, in any period, the size of the movement towards the equilibrium or desired value (adjustment) of a factor will depend not only on the extent of disequilibrium in the holding of that factor (that is, the divergence between the amount of it on hand and the amount desired) but also on the disequilibrium in other factor holdings. For example, given $(E^*_t - E_{t-1})$, the actual employment adjustment, $(E_t - E_{t-1})$, might be larger the further was the capital stock below its optimal level. This idea of balancing adjustment rates to reduce the total costs of factor disequilibria seems a plausible generalisation of the single-equation model (1), and if supported by empirical evidence might be thought to make the simpler model obsolete in its narrowness. The implications that the results of Nadiri and Rosen do in fact have for single-equation studies are examined in section III.1 of this paper.

The inter-related factor demand studies briefly described above also include relative factor price variables on the right hand side of their regression equations on the grounds that these should influence the desired levels of the factors. This, too, is discussed below.

III. A Critique of Employment Function Studies

1) Increasing returns to Labour?

A common reaction to the derived output-labour elasticities is expressed by Nerlove (in a review of macro-econometric models)

> 'I would regard the extent to which the elasticities of output with respect to labour lie above one as indicative of the unsatisfactory nature of the results.' (1967, p.225)

A number of explanations have been put forward to explain this apparent violation of the law of diminishing returns to a fixed factor.

Kuh (1965) suggested, tested, and rejected the hypothesis that cyclical movements in aggregate productivity could be explained by shifts in demand between low and high productivity industries.

Ireland and Smyth (1969) propose that labour and capital are varied so that the capital/labour ratio is always at its long-run optimal value, and show for a CES production function that this implies an interpretation of α as returns to scale, that is, to capital and labour moving together.[9]

While under this interpretation, the found values of α are not quite so alarming, they still seem rather too high to be plausible, since, with Fair

> 'One would expect that α(interpreted as returns to scale) should be equal to or slightly less than one, since during high rates of output, less (or at least not more) efficient capital is likely to be utilised and the additional workers hired are likely to be less (or at least not more) efficient'. (1969, p.25)

Other explanations are possible in the same spirit as the interpretation of α as returns to scale- the basic idea being that if additional factors, not included in the regression model, vary when employment varies in response to output rate changes, then the estimated values of α will be an over-estimate of returns to the factor labour alone. Nadiri and Rosen have equations not only for the stock of employment and capital, but also for their utilisation rates. As an experiment, they work out the change in the labour input required to meet a change in output if capital stock and utilisation rates are (hypothetically) held fixed. This suggests returns to scale for employment of .735 - 'in contrast to the usual (employment function) estimates' (1969, p.469). They write:

> "The reason for large returns to labour estimated from short run employment functions is due to omission of the rate of utilisation of capital. These high returns should not be considered as returns to labour alone, as most writers have done, but are more properly interpreted as short run returns to both labour and capital utilisation." (1969, p.469).

However, the persuasiveness of this claim depends on the validity of the capital utilisation variable. It might be thought surprising to find both the variables 'labour utilisation' (measured as hours per worker) and 'capital utilisation' in the same equation system. It seems reasonable to suppose that when the work force is worked longer hours, so too, is the capital stock, and that the two utilisation rates - hours per man, and intensity of machine use move more or less together. This proposition has been regarded as almost self-evident inthe Operations Research literature.[10] Its implication is that the regressions of Nadiri and Rosen should suffer from multi-collinearity. In fact, they don't seem to, the equations for hours per man and for capital utilisation are not at all alike, and in the hours and the employment equations, lagged hours and lagged capital utilisation actually appear with coefficients of opposite sign!

The hours per man variable is quite clearly defined and simply measured, so it should be a good proxy for labour utilisation, and, I believe, therefore for capital utilisation, too, so that Nadiri and Rosen's proxy for the latter variable must be measuring something else. We read that it is the Federal Reserve Board's Index of Capacity Utilisation, described by Nadiri and Rosen as

> "...computed by essentially dividing peak-to-peak output by actual output. We use this measure because no better one exists." (1969, p.470).

By its construction, this capacity utilisation series will tend to take high values when output is high in the business cycle. But so, too, does output per man -productivity. I suggest that, in Nadiri and Rosen's regressions, the FRB index is just acting as a proxy for productivity - a variable whose short-term fluctuations were the initial raison d'etre of the study of short-term employment functions. This is supported by the sign of the lagged FRB index in the employment function of Nadiri and Rosen. A rate of capital utilisation above its equilibrium value, for example, would tend to call forth an increase in employment, other things being equal, to get the system closer to its long-term factor equilibrium. If, however, the index really measures short-term productivity, a high value would mean that, for a given output, <u>less</u> labour would be required. The sign of the FRB index coefficient is negative, and so is consistent with the second interpretation.

If the latter interpretation is accepted, then it is quite uncalled for to, even conceptually, conduct an experiment that involves holding the FRB index constant while output varies. The point is that productivity (proxied, I claim, by the FRB index) does seem to vary with output; in fact, it is this relationship that short-term employment functions are mostly designed to explain.

The point that I have sought to establish in the above discussion is that the size of the derived α's can not be brought down to accord with <u>a priori</u> expectations by allowing for the effects of changes in the <u>actual</u> values of factors not included in the usual single equation employment function analysis. Still, productivity appears to be positively related to output; so too is employment; so that unless we can find some variable moving with output to account for productivity fluctuations, the burden of explanation will remain on employment - that is, we will continue to estimate α's that are above one.

Could the <u>desired</u> (not the actual) value level of factor utilisation - measured, say, by hours per worker - vary with output? Unfortunately, with neo-classical constant elasticity production functions cost-minimising utilisation rates are not dependent on output rates. Nevertheless, Ball and St Cyr have suggested that such factors as union and worker good-will may be relevant, so that, for example, 'firms may be prepared permanently to pay overtime at high rates of output, and in part this may come to be expected by workers at these output rates' (1965, p.188). We can perform a quick <u>a priori</u> test of the plausibility of a desired-hours - varying hypothesis.

Suppose, for example, an estimated α value of 2, so that an x% change in output induces a ½x% change in E* - quite a low response. Then a 5% change in output - a large change for a quarter - would call forth a 2½% change in E*, and an approximately 2½% change in desired hours, under the interpretation proposed by Ball and St Cyr (assuming, as they do, that men and hours have the same exponent in the production function, and also, that there are, in fact, constant returns to manhours). If, before the change, desired hours per week were equal to 40, the 2½% would be equivalent to one hour per week - certainly not an improbably large adjustment.

In section IV of this paper, I propose a non-neoclassical production function such that desired, or static-cost-minimising hours per worker <u>do</u> vary with output.

A quite popular approach to the resolving of the α paradox has been to relax the (often tacit) assumption of a homogeneous labour force. The most common suggestion is to distinguish between direct (production), and indirect (clerical, managerial, technical) workers. The consequences of this for productivity studies is stated by Hughes:

> "Short-run variations in output lead to increased employment of direct workers to a much greater extent than that of indirect workers. Thus, depending on the proportion of direct to indirect workers, increasing returns to <u>total</u> employment may be observed even though such returns are not evident for direct workers or for indirect workers in the long run." (1971a, p.11).

In inter-industry studies, Kuh and Dhrymes have gathered some support for this hypothesis for the United States economy, but Ball and St Cyr could not substantiate it with British data. Although it may well have a significant influence, I do not expect, given the usual ratios of white-collar to production workers, that the hypothesis can completely explain the high α's, certainly not in New Zealand where direct labour is over four fifths of the manufacturing labour force.

'Labour hoarding' - the holding of cyclically fluctuating 'stocks' of idle labour to smooth out the employment series as output varies - as an at least partial explanation of the observed cyclical swings in measured productivity with which these studies began, is believed by Kuh, Neild, Ball and St Cyr, Miller, Fair, Hughes, and no doubt many other people.[11] In addition, it is sometimes suggested (for example, by Ball and St Cyr 1965, p.191-2, and Fair 1969, p.38) that it can account for the unsatisfactorily high values of α. This is much more dubious. The sole analytical purpose of the chief innovation of the employment function literature, the adjustment mechanism, is to cut away the labour hoarding or whatever is responsible for the observed swings in productivity to reveal the 'true', 'normal' or 'longrun' underlying production function. Thus we cannot be happy with a rationalisation of the estimated α's in terms of labour hoarding, since this implies that the model has not done its job, which is largely to allow for explicitly such phenomena as the cyclical variation in utilisation of the employed labour force.

A rather neglected hypothesis is that there are genuine short-term fluctuations in labour productivity - that is, that parameters of the production function are not constant in the short term. As Kuh explains; '... the work force may be capable of short spurts of increased effort for short periods of time' (1965). This may be at the discretion of management, who know they can work their men harder in busy periods in exchange for setting a more relaxed pace when business is slow, or of workers, who may deliberately spin out work during recessions in order to safeguard their jobs. This phenomenon could be termed 'effort hoarding'. I have no direct evidence, apart from casual observation, but it does seem to me that effort hoarding is potentially important enough for it to be surprising that only Kuh and Miller (1971, p.20) from the writers surveyed here have mentioned it. Admittedly, the incorporation of this concept into a formal model probably presents considerable analytical problems, which I do not attempt to surmount in this paper.

To the extent that effort hoarding is empirically important, and is correlated with output, so that, unlike labour hoarding, it is not independently controllable by the firm, then employers may expect, or aim for, levels of labour productivity that are higher in cyclical upswings than in downswings of the business cycle. If this is so, then there is no reason to expect the α's estimated in short-term employment functions to correspond to the exponent of labour in the long-term production function (if such a thing exists).

In summary, the standard specification of a static, constant elasticity production function generating a desired employment function is not satisfactory. It may be that the parameters of the production function fluctuate cyclically. As well, or alternatively, a function such as the Cobb-Douglas cannot imply the variable cost-minising level of hours per worker which might rationalise the high derived values of α. The approach of Fair, though empirically successful, does not provide much insight into the production relations underlying the employment decisions of firms.

2. The Adjustment Function.

Although the regressions of the change in employment on output, time, and lagged employment, in linear of log-linear form, implied by equation (3) have, in general, been statistically successful, this is only a necessary condition for the validation of the model of equations (1) and (2). In principle, any number of underlying models could have generated the regression equation. Above, I criticised the orthodox specification of equation (2), but it is quite possible that the initially dissatisfying result - the value of α - could be solely due to misspecification of the adjustment relation (1). However, in section IV, I develop a formal justification of the simple linear form or log-linear form in which equation (1) is usually specified, and this is supported by the results of the type B studies of Fair, Hawkins, and Hazledine and Woodfield, who estimate equation (1) directly.

Since estimation of (3) does not identify equations (1) and (2) as the underlying model, it might well be wondered why any of the studies surveyed should have bothered using the type A approach, when the (less popular) type B models, with their independent estimates of desired employment, and the adjustment process, are amenable to direct testing of hypotheses about the structural relation under-lying observed fluctuations in employment. Certainly, Fair, Hughes (1971a), and Nadiri and Rosen, in their discussions of the 'consistency problem', make clear their opinion that type A models require that the production function constraint be met at all times. If this is so, why not estimate directly the production function, from a regression of output on employment and other factors of production, then estimate E* and the adjustment relation as in a type B model? The answer seems to be that although those writers who have used Cobb-Douglas or CES production functions in their type A models have, at times, proceeded as though if all the factors of production were accounted for the production function constraint would hold more or less exactly (this is a basis of Nadiri and Rosen's article), they have not really believed this, since short-term fluctuations in productivity have generally been so extreme as to make it most unlikely that any sort of stable neo-classical production function constraint has always, or even often, been met as output varied cyclically. We have noted above the ways in which the three type B studies have dealt with this problem.

Work by Fair (1969, pp. 95-100), and Hawkins has had some success using an index of labour market tightness in period t to help explain changes in employment in that period, and this does suggest that an adjustment function is misspecified if it does not allow a place for labour market conditions as they vary over time.[12]

3. Output as a Dependent Variable.

The almost ubiquitous assumption of exogenous output is equivalent to looking at the adjustment problem from the point of view of a production manager who is required to meet a given rate of production at the lowest possible cost, instead of from the point of view of the firm as a whole, whose managers may wish to treat sales or deliveries as exogenous, but not output, by using buffer stocks of goods, or may go further, and use price and advertising expenditure changes to manipulate sales. To ignore this is to risk simultaneous equation bias in the estimated parameters of the regression model.

Of particular relevance to employment function studies, with their emphasis on adjustment costs, is the remark of Kuh, that; 'An entrepreneur clearly has the choice of stock-piling inventory and/or labor' (1965, p.8). Mortenson (1970) shows an equation for United States manufacturing industry quarterly changes in employment which successfully uses variables for unfilled and new orders in place of an output variable; however, coefficients of the stocks and wage rate variables are completely insignificant.

Miller (1971) found, for twelve United States industries, a significant negative correlation between the output-labour elasticities from both employment functions and directly estimated production functions, and the average Inventory/Sales ratios for the industries, which may support Kuh's remark and so imply that a good model should have an equation explaining output as well as employment.

4. The orthodox model assumes that only two time periods are important to the employment adjustment decision - the current period and the period immediately preceding it. It may be that experimenting with more complicated lag structures would be fruitful. Not much seems to have been done about this.

In the other direction, employers may be affected in their decision-making by their perception of the future values of variables. For example, a firm will probably lay off fewer employees in reaction to a slump in demand if it expects the slump to be temporary, then it will if it believes the downturn to be permanent. The problem, of course, is to find or invent some useful data on expectations. Fair finds that of the two polar assumptions about expectations - one that expectations are perfect, so that firms predict exactly what their output will be in future periods, up to a horizon, and the other that expected output is entirely a function of past output - the first performs rather better in regressions.

Those studies which have used the techniques of the Calculus of Variations to solve multi- or infinite-period problems relating to the employment decision (Solow (1968), Mortenson (1970), Ehrenberg (1971)) have assumed unchanging parameters in their models - an assumption which becomes less and less reliable the longer the decision period is taken to be.

An optimistic position, which I take, is that the complexity of multi-period decision models means that not only are they unmanageable, but also that they are unnecessary, since these difficulties of forecasting and analysis are likely to befuddle not just the econometrician, but the businessman himself, so that the decision period, at least for fairly flexible decisions like the size and nature of the firm's labour input, may be rather short. This hopeful hypothesis is strengthened by the evidence of Fair, who found, in his seventeen industry sample, that the decision horizon appeared to be in no case longer than six months, and of Belsley (1969), who relates that 'interviews conducted by the author with production managers of several large firms revealed that the limit of their production horizon was frequently one or two quarters' (1969, p.85).

5. Inter-related Factor Demand.

An important proposition of Nadiri and Rosen (1969) is that capital may be variable in the short-term along with employment. If this is correct, then both capital and labour stocks are instrumental variables able to be changed by an employer in response to a change in output, and it clearly makes no sense to define 'optimal' employment in terms of a fixed capital stock, as do, implicitly or explicitly, the single-equation employment function writers in the Brechling-Ball and St Cyr tradition. Indeed, two new definitions are required; one for desired employment, and another for desired capital stock, since this factor is now to be considered endogenous in the short term. Nadiri and Rosen choose to define E* and K* (as well as optimal utilisation rates) as those factors levels which for, given relative factor prices would produce the output rate Y at minimum total cost. That is, the factor levels that would be chosen in the absence of adjustment costs. This is the standard neo-classical definition, and is a natural generalisation of the definition of E* when the capital stock is fixed. However, in their capital stock adjustment equation, Nadiri and Rosen show coefficients of lagged capital stock which suggest that 'about 20% of the total (adjustment of capital stock to its equilibrium level) ... takes place in the first four or five quarters' (1969, p.466), so that capital will not be even proximate to its equilibrium value for several years. This implies that the labour force is adjusted to an optimum combination of factor inputs that will not be approached for many quarters. I consider this most unlikely, because

a) of the evidence of Fair and Belsley, mentioned above, that employers look no more than one or two quarters ahead when they make their hiring and firing decisions;

b) output fluctuates over time, so why would employers be so foolish as to plan as though the current rate were to be maintained for several years?

I therefore believe that Nadiri and Rosen's assumption that firms aim to produce current output with the long-run equilibrium combination of factors is false. This criticism also applies to the models of Coen and Hickman (1970) and Dhrymes (1967), and implies that the relative factor price variable be dropped from the employment function,[13] and current capital stock re-introduced as an independent variable, as in the orthodox model. That is, there is no need to link up employment and investment functions.

Other than Nadiri and Rosen, no authors of type A models have included hours worked per man as an independent variable in their employment functions. This omission implies that the speed of adjustment of the labour force employed is not influenced by the extent of disequilibrium in the number of hours worked per man. Given some assumption about rational behaviour, this is really equivalent to the assumption that there are no costs to adjusting hours worked per man, so that there is no trade-off between adjusting hours and adjusting employment.

However, Nadiri and Rosen estimate an equation to explain hours per worker, in which the coefficient of the lagged dependent variable is positive and significant, implying an adjustment coefficient of .6158 - higher than the labour adjustment coefficient of .3496, but still well below one, which it would be near were there no costs involved in changing hours. Thus, there should be some trade-offs between changing employment and changing hours per man, and, indeed, the coefficient of lagged hours in the employment function is significant, and of the correct sign.

This evidence suggests that employment functions may be mis-specified if they do not include lagged hours per man as an independent variable.

IV. The Model

1) Guidelines from the previous section.

The purpose of the critical survey of section III was to establish some principles to be followed in my attempt to set up and estimate a model to explain employment and productivity fluctuations in some industries of the New Zealand economy. These principles are summarised below:

a) Typically, the output-labour elasticities, α, deduced from regression estimates of equation (3) have been above one, so that the original contradiction with the law of diminishing returns (cf. section I) remains. The regression equation generally fits well statistically, so, if the labour exponent is not to be taken at its face value, one or both of the adjustment and desired employment structural equations must be mis-specified.

b) Despite their simplicity, linear or log-linear adjustment relations can be defended as the rational response to quadratic cost function constraints, in a way that I find quite convincing. Such a defence is made, for the linear case, in this section.

c) It appears, then, that the desired employment function is at fault. I have suggested that high implied output-labour elasticities are generated by (i) appropriate variations in the desired utilisation rate of labour, and (ii) genuine fluctuations in productivity that are related to output levels. If this is so, then the orthodox neo-classical production functions, such as the Cobb-Douglas, that are found in most employment function studies, are inadequate, since they imply that the desired level of hours per man is a constant, and do not generate productivity fluctuations like those observed.

In this section I propose an employment demand function, based on a non-neoclassical production function, which is consistent with implied output-labour elasticities that are above one.

d) The evidence of Fair, Belsley, and, to anticipate, of this paper, is that the time horizon over which employment decisions are made is rather short-perhaps six or seven months, at most. This means that the analysis can legitimately be kept to a manageable level without too high a cost in generality lost.

e) Investment and employment decisions are not significantly interdependent in the short-run, so that the employment function should include a variable for the current stock of capital, but not relative factor prices.

f) Firms may trade-off holding stocks of labour with holding stocks of goods, so that sales is a better exogenous variable than output. Thus, an employment function is a part of a larger equation system. I develop a two-equation model, with functions to explain the behaviour of both employment and output.

g) Nadiri and Rosen show that there are adjustment costs involved in changing the number of hours worked per worker, so that adjustment of the number of workers employed will not be independent of the rate at which the present labour force is being utilised. This implies that the variable lagged hours per worker should appear in the employment function.

Unfortunately, only six-monthly data on hours worked are available in New Zealand, so that I have been unable to incorporate a lagged hours variable into my own regression equations.

h) Hughes, and others, have suggested that adjustment speeds are not independent of aggregate labour market conditions. I test the validity of this suggestion for the New Zealand economy, in this paper, with surprising results.

2) The Short-term Production Function.

Consider the short-term Cobb-Douglas production function

$$Y_t = Ae^{rt}E_t^{\alpha} h_t^{\delta} \qquad \ldots(10)$$

which is similar to Ball and St Cyr's (4), but with the exponents of hours and men allowed to differ, for generality. Depending on whether α is less than, equal to, or more than one, returns to labour will be decreasing, or constant, or increasing <u>throughout the range of the function</u>. This is not very plausible in the short-term. For example, suppose that α is less than one. Then output per man (productivity) would be at its highest if only a very

very small group of men were operating the plant. Yet it is likely that most modern manufacturing plants could not operate at all with only a small fraction of their normal workforce. It could be argued that the Cobb-Douglas relation does hold over a limited range. But even if it did, is there any guarantee that this range would encompass all the levels of employment that a firm, with fluctuating output and adjustment costs, might be interested in?

I consider it more likely that most manufacturing processes in operation are either sufficiently complicated or sufficiently mature to be designed for, or have evolved to a technically optimal operating rate - involving a level of employment, and thus of output, at which productivity is at its peak. This optimum may, in fact, exist over a range of output, but I argue that the range will not in most cases be very wide, since, as Stigler has noted, there are costs attached to having processes equally efficient over a wide range - costs of adaptability'.

That is, we have the proposition that with a typical productive process is associated a technically optimum level of employment of labour, at which level labour productivity is maximal, and that any other level of employment represents either under- or over-manning, in the sense that output per man would be below its peak. We would generally expect that, because of fluctuations in demand, it would pay to have processes that were sufficiently adaptable to allow a certain amount of variance from the optimal employment level at a low cost in deviations from maximal productivity, but that eventually this cost would escalate as the size of the labour force became critically divergent from the designed or evolved requirements of the plant.

This notion can be handily expressed by a quadratic form. If we assume constant returns to hours and, for simplicity, symmetry, then output per manhour for the particular process installed at time t is written

$$\frac{Y_t}{h_t E_t} = a'_t - b'_t(E_t - E^+_t)^2 \qquad \ldots(11)$$

where E^+ is the technically optimal level of employment. Note that productivity when $E = E^+$ is equal to the parameter a', which is thus the maximal level of productivity, and that b' measures the adaptability of the process. All of a', b', and E^+ may be expected to alter over time as the size and design of the plant change. It is also true that output per hour plotted as a function of employment is a cubic function, like the total cost functions of microeconomic theory.

Equation (11) could be aggregated, and estimated directly with industry data, if the total number of process in operation were known. A useable proxy for this last variable might be the number of plants in operation for which annual figures are available in New Zealand. However, I have not yet attempted direct estimation.

3) The Desired Employment Function.

Unfortunately, the solution to the problem of minimising a wage-bill function such as (5) subject to the production constraint (11) is possibly extremely complicated (I have certainly not managed it), and so a simple expression for desired employment, like (6) below, is not forthcoming. Nevertheless, some progress can be made with the aid of a two-dimensional graph. Figure 3 follows on page 25. It was suggested above that output per hour is a cubic function of employment. In figure 3, the inverse function is plotted as far as it exists, with employment a function of output for different values of hours worked per man (and per machine, of course). E^+ is the technically optimal level of employment for the plant, which is a constant over the time period, (in particular, it is not, of course, a function of output). h_n is the 'normal' number of hours worked per week - say 40.

figure 3
Employment as a Function of Output

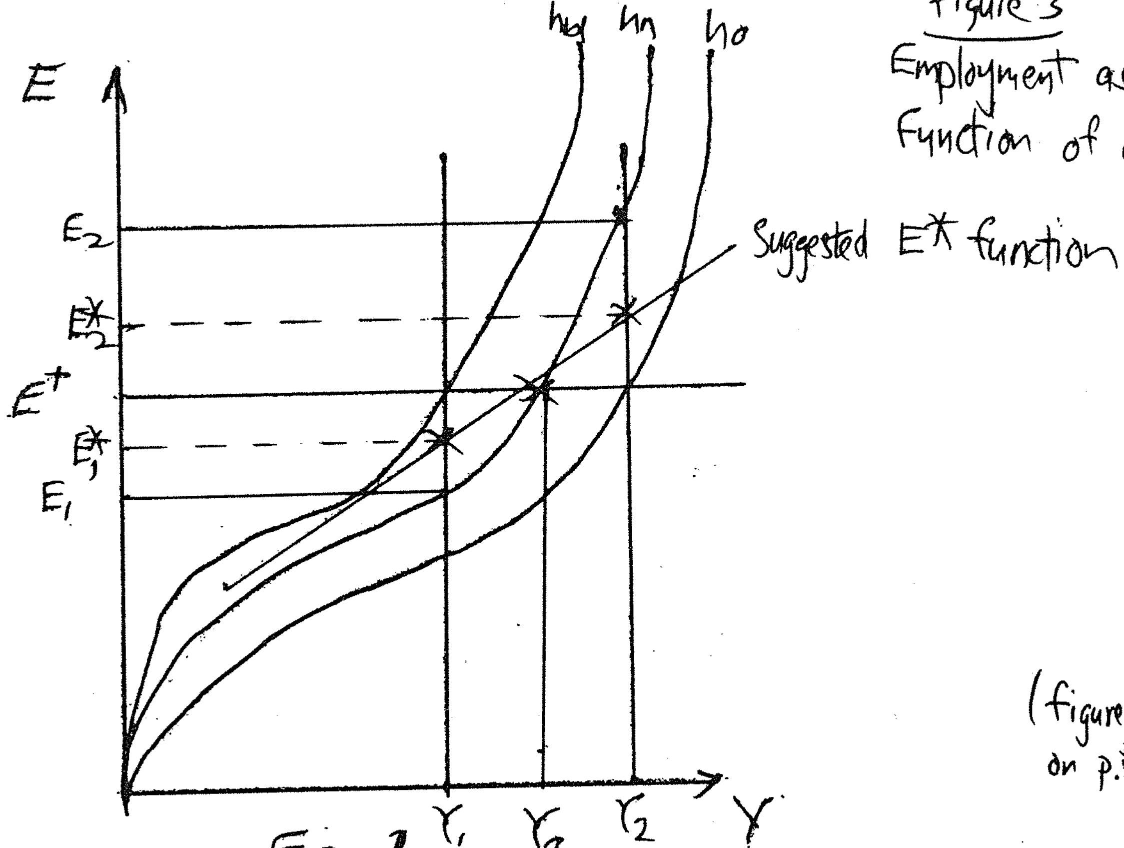
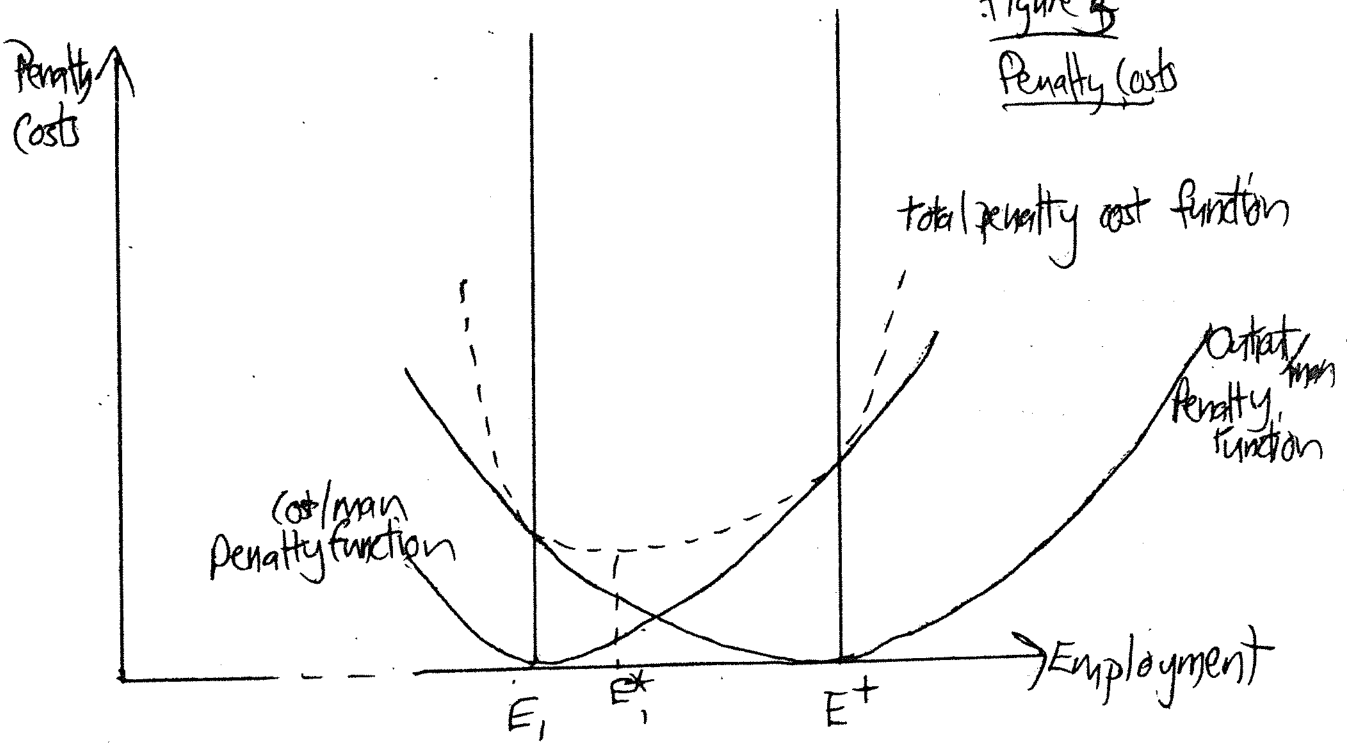


Fig. 3

(figure 4 on p.30.)

figure 5
Penalty Costs



h_u and h_o are less than and greater than 40, respectively. Suppose that the men have to be paid for a 40 hour week, even if they don't work the full 40, while hours in excess of 40 are charged at higher, overtime rates. That is, suppose a cost function something like equation (5). Assume, too, that the labour force can be varied costlessly (this assumption will be relaxed in the next sub-section). Now imagine that the plant is operating initially at production rate Y_o. Employment will be at E^+, and this will be both technically and economically optimal, since output per man will be at a maximum, while cost per man is minimal. Next suppose that this happy situation is shattered by a direction to the plant to reduce the output rate to Y_1. The plant engineer will wish to keep the workforce at level E^+, so that his machines can continue to run at their proper, designed speed and to reduce the hours worked per man to h_u. The plant accountant, not wishing to have men paid to stand around idle, will try to cut employment back to E_1. The total-cost-minimising point will be somewhere between E^+ and E_1, at E_1^*, say, and this is the level of employment that will come into being, by order of the plant manager, an economist. Similarly, if output is to be increased to Y_2, the accountant will wish to stay on the h_n curve, and will plump for E_2, the engineer will stick doggedly to his E^+, and the eventual solution will be something like E_2^* (the curves passing through the cost-minimising points have not been drawn).

E_1^* and E_2^* are examples of what I shall call desired short-term levels of employment. Can we express E* as a function of Y? The points on figure 3 are redrawn on figure 4. As they stand, they fit the linear form as well, but in the absence of an analytic solution to the cost-minimising problem, it cannot be said that they would not in fact be a better match with curve b, or curve c. c passes through the origin, as drawn, and could be a Cobb-Douglas function. Note that if the curvature of c were interpreted as the output-labour elasticity, then the implied value of this parameter would be greater than one. This is, in fact, what I believe to have happened in the employment function studies surveyed in section III of this paper. What is clear from figure 3, is that this 'output-labour elasticity' is not a production function parameter at all, and bears no direct relation to the parameters of what is, I claim, the correct short-term production function specification, equation (11).

For simplicity (and ease of analysis and aggregation) I will assume that the linear form adequately describes the relationship between E* and Y, at least within the observed range of fluctuations of Y. Accordingly, E* is written, as in figure 4;

$$E^* = a + bY \qquad \text{...(12)}$$ [14]

Variables to allow for changes in technology and in the capital stock may be added to taste, along with the time subscript.

Observe that b is not a production function parameter, and that since we have not solved the cost-minimisation problem analytically, we cannot deduce the parameters of the production function from a and b.

4) The Cost Functions.

There are two types of costs in the short-term employment demand problem; costs of using factor inputs at certain levels, and costs of changing the levels, which are known as adjustment costs. An optimal response to any change in the state of the exogenous variables and the shift parameters in the system will require a trade-off between the two sorts of cost. That is, if output is fluctuating over the short term, then the presence of adjustment costs mean that employment will not always be at its desired level, E*, for each output rate. We consider the various costs in turn.

a) Costs of producing at a given rate.

(i) Costs of Divergence from E*.

It is evident, from the discussion in sub-section 3), that failure to produce a given output with the corresponding E* will be punished by a decrease in output per man, or an increase in cost per man, or both. The output per man and cost per man functions are each such that the penalties for divergence from their optimal values will be small at first, but will grow at an increasing rate as the divergences increase. If we note that, for Y_1 on figure 3, say, the penalty costs are always moving in opposite directions between E^+ and E_1 - one is increasing, the other decreasing - and in the same direction outside this range, then it follows that the function measuring the costs of divergence of E from E* will be of the same form as the cost per man and output per man functions, but will increase from its minimum first more slowly and eventually more rapidly than either of the other two functions. Compare figure 5 for a graphical demonstration of this. I will represent the costs of divergence function as a quadratic,

$$C_1(E_t^* - E_t) = c(E_t^* - E_t) + d(E_t^* - E_t)^2 \qquad \ldots(13)$$

There is no point in writing in a constant term in this or the other cost functions since they are all going to be differentiated.

(ii) Costs of holding stocks of output.

In this study, sales are taken to be exogenous. This is a more general restriction than the usual assumption that output is exogenous, since it admits the possibility of stocks being varied, for example, so as to act as a buffer to soften the impact on production of fluctuations in sales. However, there are costs attached to the holding of stocks. In specifying these, I am more or less following the work of Holt et al (1960), and Belsley (1969).

First, there are the costs of storing output over the time period. These may be linear, as drawn in figure 6, though it does not much matter if they are not. Second, there are the costs of being unable to meet orders - 'stock-out' costs, which we take to be roughly as in figure 7 - very high for low levels of stocks, and decreasing sharply, but with diminishing returns. These costs will tend to be larger for a given level of stockholdings the more heterogeneous the output.

The third sort of stock-holding costs are the risks of obsolescence and wastage, which are zero when stocks are zero, and increase with the size of stocks. Again we suppose that the relation is quadratic, as in figure 8.

The three cost functions can be added together, with the likely result drawn in figure 9 - another quadratic. To the extent that the costs of not meeting orders are small relative to the other costs, the cost-minimising point will be further to the left on the diagram. It may even be that there is no positive cost-minimising level of stocks (for example, in an industry with high obsolescence costs, such as newspaper publishing). However, the general formulation of the total stock holding cost function of figure 9 is, ignoring the constant term;

$$C_2(I_t) = - uI_t + vI_t^2 \qquad \ldots(14)$$

b) Costs of changing the rate of production.

(i) Costs of changing the technology and the capital stock.

It is a pervasive assumption in studies of short-term phenomenon that capital and technology are fixed over the period between observations, in the sense that a decision in one quarter to change their value cannot be implemented in that quarter. In fact, this requirement is often used to define the short-term in theoretical work, though its validity when the 'short-term' is a period as long as one quarter has not, to my knowledge, been tested.[16] It is tantamount to the postulate that the costs of change involved are infinite.

(ii) Costs of changing stocks and the rate of hours worked per man.

These costs are here assumed to be zero or insignificant. I have noted above the results of Nadiri and Rosen (1969) suggesting that there are costs attached to changing the rate of hours worked per man, but data limitations force the adoption of the assumption.

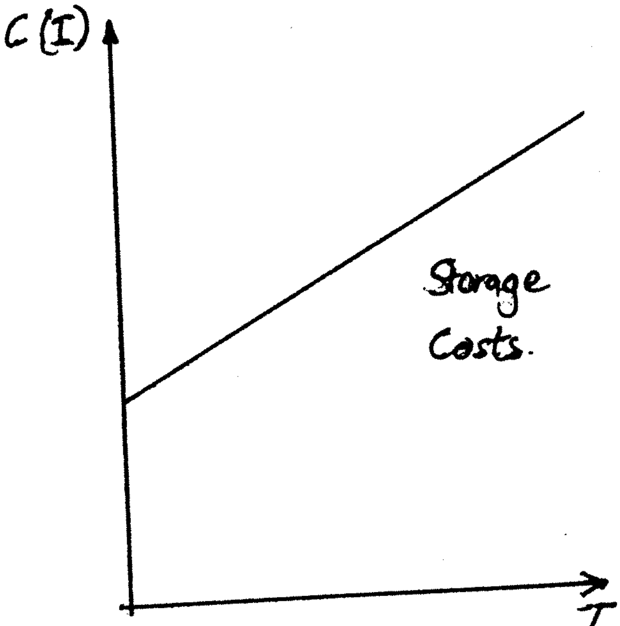


Fig. 6

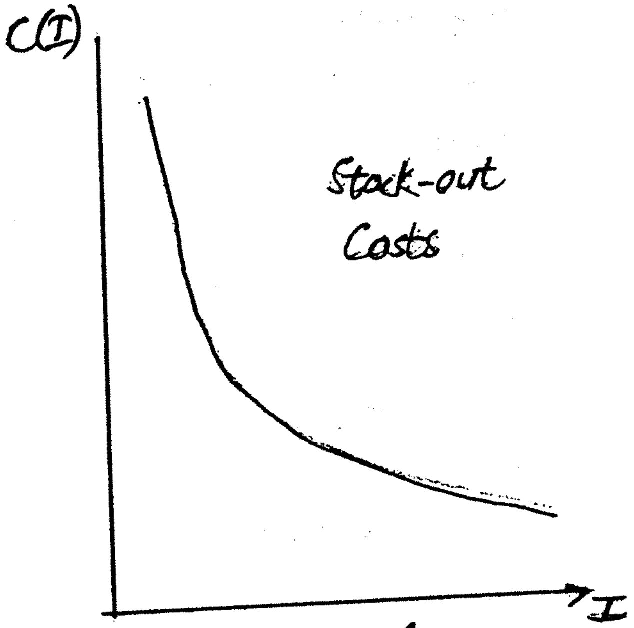


Fig. 7

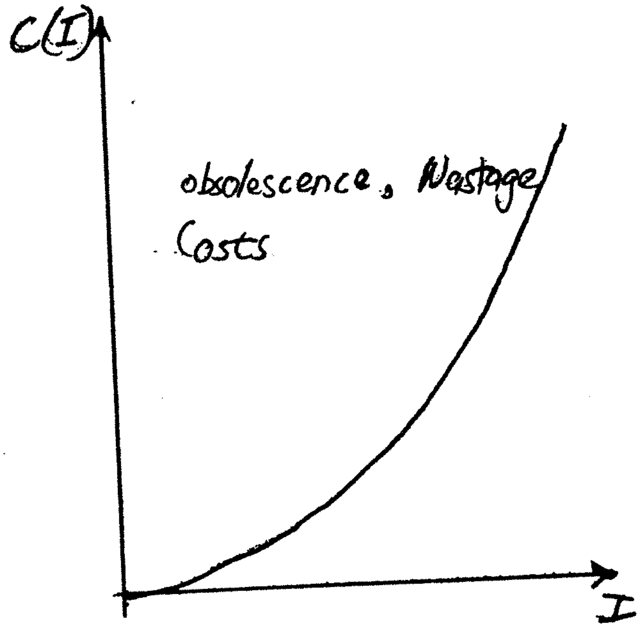


Fig. 8

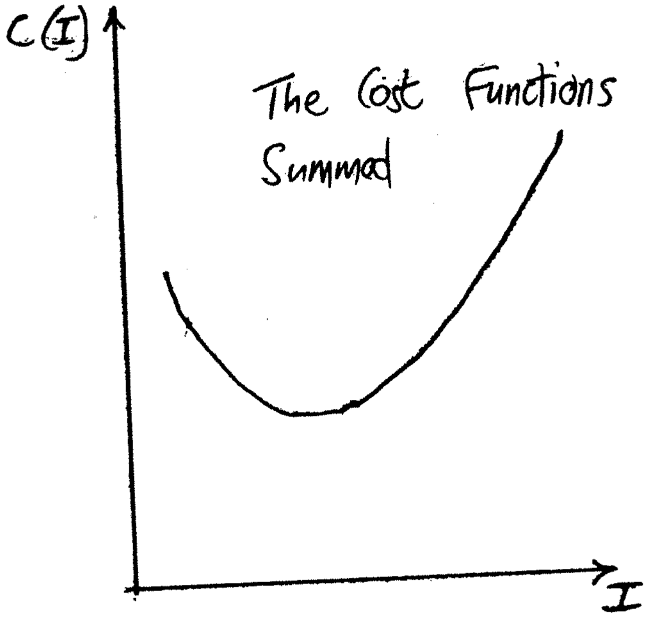
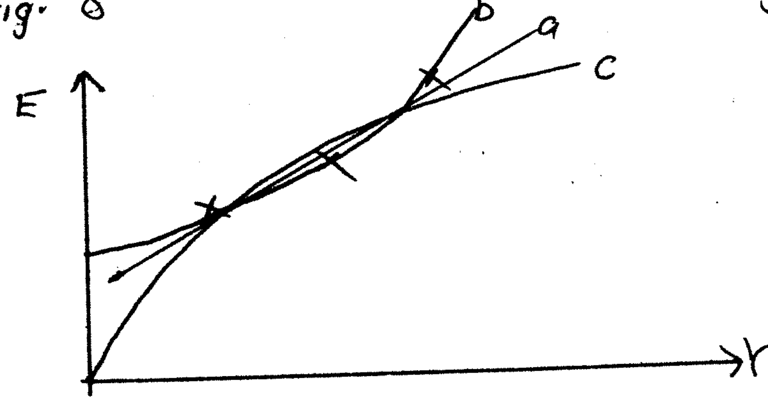


Fig. 9



E* functions.
Figure 4.

(iii) Costs of changing the level of employment.

I divide these costs into two groups; costs related to the organisation of production, and costs related to the individual employees. In the first category are the costs brought about by a change of scale in the plant; that is, as a direct consequence of a non-zero (E_t-E_{t-1}). If we suppose that the organisation can cope quite easily with small ups and downs in the employment level, since these are common, but needs to devote relatively larger amounts of resources to unusually large changes, then we are led again to propose a quadratic cost function (assuming for convenience, symmetry)

$$C_3(E_t - E_{t-1}) = e(E_t - E_{t-1})^2 \qquad ...(15)$$

The second sort of costs are those related to new employees (engagements) - costs of advertising and training - and to departures (terminations) from the firm's workforce - severance pay, clerical costs, morale and industrial relations factors. We look at these now, in more detail.

What are the determinants of the number of suitably qualified people offering themselves for work to a firm? These arepartly within the control of the firm, such as its expenditure on advertising and recruitment and partly without - most importantly, the state of the labour market as a whole. Denoting the firm's own expenditure as C_4, and proxying labour market conditions by, say, the vacancy rate, V, we can write the number of new employees, N, as

$$N_t = h(C_{4t}\ ,\ V_t) \qquad ...(16)$$

For simplicity I assume that (16) is separable into

$$N_t = i(C_{4t}) + j(V_t) \qquad ...(17)$$

It seems reasonable that there should be diminishing returns to recruitment expenditure. Firms trying to increase their labour force by more than a certain amount in a time period will have to broaden their attentions to more distant or less suitable labour markets, which will raise the average cost of a successful recruitment. Again, I suppose that the relationship is quadratic,[15] so that $i(C_4)$ becomes;

$$i(C_{4t}) = 1/\varepsilon(C_{4t})^{1/2} \qquad \ldots(18)$$

What of the function $j(v)$? The results of Fair, Hughes and others suggest that dj/dV should be negative, since, as Fair put it, 'a tight labour market causes a firm to hire less (because workers are difficult and expensive to find)' (cf. 1969, pp.95-100). This negative effect may well exist and be important, but there could be a counter influence at work too. It may be true that a high vacancy rate encourages 'job search' - workers already in employment, but not completely satisfied with it, feel confident enough to look for a new job, and housewives, students and retired people, not in employment, but not, typically, registered as unemployed, enter the labour force and increase the participation rate. The effect of all this is to make dj/dV positive. The net effect of the opposing influences on dj/dV cannot be ascertained *a priori*, so, in the absence of contrary information, I suppose the function $j(V)$ to be linear, without prejudging the sign of the coefficient of V (with $j(V)$ the resultant of two opposing forces, there is no particular justification for proposing a quadratic, or other more complicated functional form). Equation (17) can now be specified

$$N_t = 1/\varepsilon(C_{4t})^{1/2} + \phi + \int V_t \qquad \ldots(19)$$

The relationship between the termination rate, Q, and V, is implied in the above discussion, and can be written

$$Q_t = \psi + \rho V_t \qquad \ldots(20)$$

making the assumption of linearity, for simplicity. We should expect ρ

to be positive. We could include an expression for the morale and labour relations costs of dismissing workers, along the same lines as the expression for advertising costs, C_4, but the results of doing this are easily foreseeable, so that the added analytical complication is not really worthwhile.

The cost model could be completed by a training cost function of N, but again, for the sake of a simpler analysis, I shall not bother to do this.

Noting the identity

$$N_t - Q_t \equiv E_t - E_{t-1} \qquad \ldots(21)$$

and substituting for Q, equation (19) can be re-arranged to

$$C_{4t} = \varepsilon(E_t - E_{t-1} + \psi + \rho V_t - \phi - \int V_t)^2$$

$$= \varepsilon(E_t - E_{t-1} + (\psi - \phi) + (\rho - \int)V_t)^2 \qquad \ldots(22)$$

Adding the change in employment cost functions, C_3 and C_4, and dropping the time subscript

$$C_5 = C_3 + C_4 = e(E - E_{-1})^2 + \varepsilon(E - E_{-1} + (\psi - \phi) + (\rho - \int)V)^2 \qquad \ldots(23)$$

5) The Stocks Identity

The model is closed by an identity constraint relating the level of stocks on hand at the end of a period t, I_t, to output, Y_t, sales S_t, and stocks on hand at the start of the period, I_{t-1}, and by the assumption that sales are an exogenous variable. Formally,

$$I_t \equiv Y_t - S_t + I_{t-1} \qquad \ldots(24)$$

I noted above that the assumption of exogenous sales is one step more advanced than the assumption, more usual in short-term employment studies, of exogenous output. Nevertheless, realism would be better approximated by deriving factor demand functions from exogenous demand curves, with sales then endogenous to the model, as in orthodox economic theory, or by going further still, to a Galbraithian model in which demand can be 'managed', at a cost. There is a conspicuous gap between econometric theories of the pricing process, and econometric investigations of factor demand relationships.

6) The Cost-minimising Equations.

Collecting together the equations of the model;

$$E_t^* = a + bY_t + rt \qquad \ldots(12)'$$

$$C_1 = c(E_t^* - E_t) + d(E_t^* - E_t)^2 \qquad \ldots(13)$$

$$C_2 = -uI_t + vI_t^2 \qquad \ldots(14)$$

$$C_5 = c(E_t - E_{t-1})^2 + \varepsilon(E_t - E_{t-1} + (\psi - \phi) + (\rho - \int)V_t)^2 \qquad \ldots(23)$$

$$I_t \equiv Y_t - S_t + I_{t-1} \qquad \ldots(24)$$

A time variable has been added to (12) in the hope that this will approximate changes in the capital stock and technology for which quarterly data are not available.

We can observe that the optimal solution will not depend on the unit in which cost is measured, so that one of the cost parameters can be assigned a value arbitrarily. I choose to put $d = 1/2$, so that (13) becomes

$$C_1 = c(E_t^* - E_t) + 1/2\ (E_t^* - E_t)^2 \qquad \ldots(13)$$

The problem is to determine those equations which set the endogenous variables E and Y (and thus I) at values such that costs are minimised for given values of the parameters and the exogenous variable, S.

The minimisation of quadratic cost functions subject to linear constraints implies that the optimal values of the variables under the control of the decision-maker - the dependent variables - are given as linear functions of the other variables in the system. These functions are known as <u>linear decision rules</u>, and their use in economics is largely due to the work of Theil (1961, 1964) and, especially, Holt, Modigliani, Muth and Simon (1960). Linear decision rules came to my attention through Belsley (1969), and through the derivation of the linear adjustment function in Griliches (1967).

The use of linear decision rules by Holt et al, was in a normative management science context - they wished to answer the questions, 'Given the parameters of the cost functions and constraints, what is the best (cost-minimising) action for a manager to take?'. In contrast, the approach of Belsley, and of this paper, is in a positive, econometric spirit. For us, the parameters are unknowns to be estimated. Therefore, the problem that we try to solve is; 'Assuming that managers do act as efficient cost-minimisers, what values of the parameters of the system would be consistent with the observed values taken by the variables?'

The model set out above will be optimised only over a one period time horizon. The biases resulting from this 'myopic' procedure will be less the more unpredictable are sales, but they may still be appreciable.

The problem, then, is the simple one of minimising the cost equations (13)', (14), and (23) subject to the constraints (12)', and (24) and this is carried out now.

(12)' into (13)' gives

$$C_1 = ca + cbY_t + crt - cE_t + 1/2a^2 + 1/2\, b^2Y_t^2 + 1/2\, r^2t^2 + 1/2\, E_t^2$$
$$+ abY_t + art - aE_t + brY_t t - bY_tE_t - rtE_t \qquad \ldots(25)$$

substituting (24) into (14)

$$C_2 = -uY_t + uS_t - uI_{t-1} + vY_t^2 + vS_t^2 + vI_{t-1}^2$$
$$-2vY_tS_t + 2vY_tI_{t-1} - 2vS_tI_{t-1} \qquad \ldots(26)$$

Adding C_1, C_2, and C_5 into a total cost function, C, and differentiating with respect to E_t and to Y_t;

$$\frac{dC}{dE_t} = (2\varepsilon(\psi-\phi)-a-c) + (1+2e+2\varepsilon)E_t - bY_t$$
$$-rt - 2(e+\varepsilon)E_{t-1} + (\rho-\int)V_t \qquad \ldots(27)$$

$$\frac{dC}{dY_t} = (b^2 + 2v)Y_t - bE_t - 2v(S_t - I_{t-1}) + br + (cb+ab-u) \quad \ldots(28)$$

The cost-minimising values of E_t and Y_t will be such that (27) and (28) are equal to zero. Imposing this condition and solving for E_t and Y_t,

$$E_t = \frac{a + c - 2(\psi - \phi)}{1 + 2(e + \varepsilon)} + \frac{b}{1 + 2(e+\varepsilon)} Y_t + \frac{r}{1 + 2(e+\varepsilon)} t$$

$$\frac{2(e-\varepsilon)}{1 + 2(e+\varepsilon)} E_{t-1} - \frac{(\rho - \int)}{1 + 2(e+\varepsilon)} V_t \quad \ldots(29)$$

$$Y_t = \frac{u - cb - ab}{b^2+2v} - \frac{br}{b^2+2v} t + \frac{b}{b^2+2v} E_t + \frac{2v}{b^2+2v}(S_t - I_{t-1}) \quad \ldots(30)$$

The model is now in a form such that it can be tested. We note that (29) and (30) are the structural equations of a two-equation simultaneous equation model.

V. <u>The Model Estimated</u>

1) Estimation.

The two equation model (29) and (30) was first estimated, for the data on aggregate manufacturing, by Two Stage Least Squares (2SLS). The results are shown in the first and third rows of Table 1.* Ordinary Least Squares (OLS) estimates for the same equations appear in the second and fourth rows, for comparison.

Although the 't-values' of the coefficients of the 2SLS equations are enormous, in all cases when the corresponding coefficients are significant for both estimating procedures, they are very similar. This is some evidence that the simultaneous estimation bias from the use of OLS is not very large, and so I have used OLS in estimating all my regression equations, since it has a considerable advantage in computational simplicity over other estimating methods.

* Table 1 not shown pending re-estimation.

Ball and St Cyr mention Johnston's warning that OLS estimation of equations such as (29) which include the dependent variable lagged, on the right hand side, is liable to be biased in small samples.

> "If the disturbances are serially independent the estimates will however be consistent and asymptotically efficient. We are not aware of any satisfactory shorthand way of overcoming the problem of bias in the present case. However, the existence and likely direction of any such bias needs to be taken into account in interpreting the results". (1966, p.185).

Ball's experience is that 'the least squares method is likely to reduce the weight given to the lagged term (E_{t-1}) and raise the coefficients of (Y_t) as compared to other methods such as two-stage least squares or limited information maximum likelihood' (1966, p.189).

Despite these caveats, I follow nearly every other worker in this field (Miller and Fair are the exceptions) and use OLS throughout. Even if the absolute values of the coefficient estimates are biased, it can be hoped that the biases are systematic, so that useful comparisons across industries can still be made.

Most equations are estimatdd with seasonal dummy variables for the first and third quarters, following the discussion of the appropriate way to treat seasonal factors in the Appendix of this paper. It would have been better to include a third seasonal dummy in the regressions, but this would have meant in many cases, that our regression program was being asked to handle more than the eight indgpendent variables that are its limit. The first and third quarters were chosen, a priori, as the most unusual; the first because of summer holidays, and the third because of the persistently high productivity of the labour force in that period (cf. the Appendix).

The data series, which are 26 observations in length, are described in the Appendix.

2) The Basic Results.

Equations (29) and (30) are shown estimated for in Tables 2 and 3 for data on Aggregate Manufacturing, and for twelve sub-groups of that sector for which quarterly data could be compiled. The labour market variable does not appear in these regressions. Its influence is discussed later. The regressions with E_t as the dependent variable were run with a) just the time variable (x10), and with b) the time and time squared variables, and the regression equation actually shown in table 3 for each industry is the one with the higher $\bar{R}^2$.

(i) The E_t-dependent regressions (table 3).

Statistically, the results are not particularly impressive. Given that these are time series regressions including a lagged dependent variable, the $\bar{R}^2$'s are not outstanding, although they are mostly quite respectable. The Durbin-Watson statistic takes values which indicate that serial correlation is present in the regressions for the Grain Milling, Knitted Wear, Woollen Mills, Electrical, and Rubber industries, so for these, at least, it seems that there is some extra factor, changing systematically over time, that should have been included in the specification of the model.

Pleasingly, the coefficients of both Y_t and E_{t-1} are, in most cases, highly significant, The trend variable(s) are not always significant, and vary in sign. The seasonal dummies are also not significant in every industry, but the strong tendency for the sign of the first quarter dummy to be positive, and of the third quarter dummy to be negative, is in accordance with a priori expectations.

(ii) The Y_t-dependent regressions (table 2).

The very high $\bar{R}^2$'s of these equations are largely attributable to the very strong influence that the $S-I_{-1}$ variable has on Y - that is, to the influence, which is hardly surprising, of net sales on output. The net sales variable may have swamped the employment variable, which in only one case (vehicles) is significant. More than half of the trend coefficients, and less than half of the seasonal dummy coefficients are significant.

The Durbin-Watson statistics indicate that there is serial correlation in the regression equations for at least five of the industries, although the very high $\bar{R}^2$'s suggest that this may not be quantitatively very important - the residuals are small.

No stocks of finished goods are held by the tobacco industry, so that its net sales variable reduces to the output variable.

(iii) The structural parameters

Estimates of most of the structural parameters of the model can be deduced from the coefficients of the regression equations. From equations (29) and (3) it can be noted that there are eight coefficients and eight structural parameters, a, b, c, e, ε, r, u, and v, so that it should be possible to solve for at least some of the parameters (ignoring, for the moment, the t^2 and vacancy terms, and the parameter i, which is a labour market parameter). In fact, as can be easily checked by inspection, the parameters (e + ε), b, r, and v, are all over-identified, (there is more than one way to derive each parameter, and the values obtained by different means will not, in general, coincide, in a finite sample), while a, ε, c, and u are under-identified - there is no way of deducing their separate values from the regression coefficients. We will henceforth refer to (e + ε) as h.

For the over-identified parameters, some sort of a choice has to be made from the alternative estimates. My own, admittedly ad hoc procedure is as follows : since E_t does not play an important part in the Y_t equation, it is better to estimate b from the E_t equation, where, in most cases, employment and output are significantly linked. To do this, an estimate of h is derived from the coefficient of E_{t-1}, and this is substituted into the coefficient of Y_t in (29) to give an estimate of b, which, in turn, is substituted into the coefficient of $(S_t - I_{t+1})$ in the regression equation for (30) so that v can be derived. As has been noted, the two intercept terms are insufficient to yield estimates of the three parameters a, c, and u.

The results of these computations appear in Table 4. The derivation of the r values is explained below.

In most cases, the b values imply desired employment-output elasticities (using this word rather loosely, since my equations are linear forms) that are less than one, which accords with the results of other employment function studies, althoughI do not, after the analysis of section IV, infer that the b's are the inverse of production function elasticities. The exceptions are Biscuits, for which the elasticity is almost exactly one, and Chemicals, for which the exponent is very large. The latter oddity may be explainable by shifts in the composition of the industry over the sample time period, or by imperfections in the coverage of the data, or it may be quite genuine. The very low elasticity of the paper products industry is derived from an insignificant output coefficient in the employment equation. The insensitivity of employment in this industry to output changes is probably explained by its very high capital-labour ratio - sophisticated machinery running at speeds set by its design and by engineers is not affected in the short-term by fluctuations in the number of employees tending it. Another industry with a low employment elasticity, Beverages, also has a relatively high capital-labour ratio.

Neild found (1963) that in the United Kingdom textile industry, cuts in output were met by large cuts in the labour input, while in the chemicals and paper industries, the cuts were very small. The evidence suggests that similar behaviour is observed in New Zealand in the Woollen and Paper industries, but not in the Chemical sector (which is probably less sophisticated than its United Kingdom counterpart).

The b parameter for aggregate Manufacturing looks nothing like an average of the parameters of constituent industries (it is larger than all but one of them), which suggest that aggregation has had unfortunate consequences. Of course, the separate industries themselves are aggregates, and their regressions, may also give misleading results as a consequence.

The values for h indicate employment adjustment costs which appear to be exceptionally low in the Beverages industry, and, to a less striking degree, in Tobacco. Adjustment costs are low in Fruit and Vegetable Preserving, too, as one would expect, since this is a very seasonal industry, which must have accustomed itself to hiring and firing large numbers of (mostly unskilled) labour throughout the year.

The estimated v's are interesting, as, in all industries bar Beverages, they are derived from coefficients of $S_t - I_{t-1}$ which are fewer than two standard errors from 1, implying that, in these New Zealand industries, stocks of finished goods are not held as buffers, to cushion production from fluctuations in sales. One might infer from this a generalisation about the antiquity of the techniques of New Zealand managers. Alternatively, it may be that, perhaps because they shelter behind an import protection wall, New Zealand firms can manage the demand for their products, either by stockpiling orders - building up backlogs of orders, confident of not losing them to non-existent competitors, or simply by turning down uncomfortably large boosts in sales, in preference for a quiet life.

However, nine out of the twelve coefficients are less than one, which may be taken as a slight indication of the use of buffer stocks. The results might also change were the data better (cf. the Appendix). Nevertheless, my conclusion must be that, for the New Zealand manufacturing industries studied here, with the exception of Beverages, and, perhaps, of Grain Milling, the output equation (30) is redundant.

The trend coefficient, r, should reflect the effects on productivity of both investment and technological advance (as well as, since our output variable is a gross value variable, the effect of any systematic shifts in the value-added/gross value ratio. Such shifts have not been large over the period studied, however). The trend coefficients in the output equations cannot be taken too seriously as potential indicators of secular productivity changes, since they include in the denominator the parameter v, which in most cases is not significantly different from infinity (since most of the coefficients of $S-I_{-1}$ are not significantly different from one.) Nevertheless, eight of the coefficients are significant, which must be explained. I would conjecture that the positive trend coefficients in the output equations merely reflect a tendency to build up stock-holdings over time, as the scale of output of the industries increases. That is, as well as producing for net sales, $S-I_{-1}$, each period, firms put aside a little extra to add to stocks.

Estimates of r have therefore been calculated from the E_t equation. I shall not look very closely at these, since correlation between t and t^2 means that the regressions with these variables are not really comparable with the regressions with just t, and since the linear form of our model makes interpretation in terms of rates of productivity change untidy. We may note, though, that five of the r's are positive, three significantly so, indicating that the effect of investment and technological change in these industries has been to <u>reduce</u> productivity - an interesting result.

3) The Labour Market Variable

The effect of including the vacancy variable V_t in the employment regression equation is shown in the equations given in Table 5. Even though t^2 and the seasonal dummies are not included in the regressions, the $\bar{R}^2$'s are mostly higher than their counterparts in Table 3. The coefficients of V_t are mostly significant and are all, excepting Grain Milling, positive, implying than an individual industry finds it easier to add to its labour force when all other industries are trying to do the same. This apparently paradoxical result is contrary to the experience of other economies (cf. the papers of

Hughes (1971b), Fair, and Hawkins), and is examined in detail in Hazledine (1972). Briefly, it seems that the encouraging effect of a high aggregate vacancy rate on turnover and labour participation is not counterbalanced by the drying up of the pool of unemployed labour from which firms hire in other economies, since, in New Zealand, this pool is never absolutely big enough to be of much use as a source of labour, even in relative recessions, such as that, in the sample period,of 1967-68.

It could be argued that the sign of V_t is positive, not because a tight labour market makes hiring easier, but simply because the aggregate demand for labour is typically correlated with the demand for labour in each industry, and is acting as a proxy for this variable (cf. Table 6). If this were so, however, we should expect to find evidence of multicollinearity, since Y_t is also a natural proxy for the demand for labour in an industry. Comparing the regressions in Table 3 with those in Table 5, we may see that in six of the significant cases, the t-ratio of the output variable actually is higher in the regression including V_t, giving little support to the proxy suggestion.

4) The Time Horizon

The model of equations (29) and (30) was built up on the assumption that output and employment decisions are made over an horizon of just one quarter - the current three month period. I tested this assumption by running regressions including as independent variables S_{t+1} and S_{t+2}, and Y_{t+1} and Y_{t+2}, using these variables as proxies for expectations, as suggested by Fair's results (cf. p.18 of this paper).

The estimated equations (Table 8) suggest that future sales or output have a significant effect on current employment levels in the Grain Milling, Woollen Mills, and Rubber industries, with weaker influences, sometimes negative, oddly enough, in other sectors. The output equations shown in Table 7, show significant negative effects of future sales in the Chemicals, Rubber, and Paper Products industries - certainly a puzzling result.

In all, these regressions seem to raise more questions than they answer, with their recurrent negative coefficients. Certainly, the employment decisions of most industries do not appear to be particularly influenced by events occurring more than a few months ahead, though this conclusion should be qualified by doubts about the excellence of actual future values of variables as proxies for predicted values.

Any inadequacies in the single-period model will probably cause more distortions when the equations are used for prediction than when the aim is for comparative, inter-industry studies.

5) The Log Form

Table 9 shows the results of repeating some of the regressions with data on the natural logarithms of the employment and output variables, instead of their natural values. I performed this experiment because most of the employment functions in the literature are tested in log-linear form.

For each industry we can compare the regression in Table 9 with the corresponding linear regression, five of which are shown in Table 3 (I have looked up the other eight on the computer printout). In seven cases, the linear form has a higher $\bar{R}^2$ than the log-linear, in the other six cases the opposite is so. In no instance, with the possible exception of the electrical industry, does the difference in fit appear significant. Statistically, there seems to be little to choose between the two specifications, but I prefer the linear form because of its analytic tractability.

6) $(E_t - E_{t-1})$ as the dependent variable

Given the purpose of the employment adjustment model, a more appropriate dependent variable than the level of employment, E_t, would be the <u>change</u>

in employment, $E_t - E_{t-1}$. Re-running the regressions with the latter variable dependent does not alter the magnitude or significance of the coefficient of any independent variable apart from lagged employment. Ball and St. Cyr show (1966, p.185n) that if the simple correlation between E_t and E_{t-1} is more than 0.5, then the $\bar{R}^2$ will be higher for the E_t than for the $E_t - E_{t-1}$ regression, and this rule is supported by the figures in Table 10. (The regressions themselves have not been shown here).

Since it is the change in employment, not its absolute level, that the model is supposed to explain, it is the $\bar{R}^2$'s for the $E_t - E_{t-1}$ equations that should be most taken noteof; it can be seen that all but two of these are less impressive, several considerably so, than their E_t equation counterparts.

VI. Uses for the Estimated Model

Employment functions describe the short-term linkage between two very important economic variables - output and employment. In aggregative form, they appear in most econometric models of national economies. Knowledge of the effects on employment of changes in output is useful to government policy-makers contemplating boosting or dampening effective demand. Kuh has noted that results on short-run productivity variations are 'basic to the explanation of cyclical variations in factor shares' (1965, p.1), and Nerlove claims that these relationships are 'an essential element in the explanation of changes in prices over time' (1967, p223).

The model would probably not provide a good description of behaviour during a prolonged slump. As long-term expectations hardened into pessimism, employers would abandon the labour-hoarding that characterises their behaviour in temporary recessions, and would, indeed, try to economise on labour, to reduce operating costs. There is evidence that this has occurred in the United Kingdom, where the economy has been intermittently depressed, without much in the way of compensating booms, since the Labour government's 1966 deflation. An article in The Economist (22/1/72, pp55-6) demonstrates that

British manufacturing and utility industries have persistently run down their labour forces over the last five years, while at the same time increasing (modestly) their output rates, so that productivity has risen quite markedly, despite lagging demand conditions, in contrast to the period up to the early 1960's, studied by Brechling and Ball and St, Cyr, during which labour hoarding occurred in slumps, which were presumably expected by employers to be of short duration. The failure of the British unemployment rate to respond, over the past year, to Keynesian 'pump-priming' policies, suggests that the higher levels of efficiency in British industry have become permanent.

Whatever their merits as predictors, the employment functions estimated here for some New Zealand industries may be of some use in comparative studies of industry conduct, structure, and performance. It would be interesting, and perhaps instructive, to look more closely at the adjustment speeds, employment-labour elasticities, and time trend coefficients of the industries studied, and to try and explain their differences.

A warning note is the judgement of Holt et al, from the results of their applied work, that for the parameters of quadratic cost functions 'an estimating accuracy of, say, ± 50% is probably adequate for practical purposes. This accuracy will yield decision rules whose cost performance is tolerably close to the minimum possible' (1960, p.8). The robustness of the decision rules is a useful property for normative, managerial science applications, but it is a dis-advantage in positive, econometric work, since it implies that even if the estimated decision rules do fit quite closely the employers' optimising behaviour, the derived parameter estimates for the structural cost functions may be extremely unstable.

Data Appendix

1. Output

The volume of production indices were computed from data on prices and output kindly made available by the Reserve Bank of New Zealand Econometric Modelbuilding team. They are Laspeyres indices, with price weights (average 1965-68 prices) computed from gross output value data - information on net output not being comprehensive enough. Limitations in the length and coverage of data series also restricted the study to begin with the first quarter of 1964, and end at the second quarter of 1970, and prevented the 'Aggregate Manufacturing' variable from covering more than about one quarter of total New Zealand Manufacturing output.

These, and the other series used in this paper were computed by Graham Walsh, on a grant from the Golden Kiwi Lottery Research Advisory Council.

The volume of production indices are to a base average 1965-68 output = 1000.

2. Employment

Monthly data from the NZ Department of Labour's Labour and Employment Gazette are averaged into quarterly figures, and transformed to a base 1965 average = 1000.

3. Stocks

Volume indices for holdings of stocks of finished goods were derived from money-value data appearing in Supplements to the NZ Monthly Abstract of Statistics.

The match in coverage between the stocks and output indices is often rather bad, since the stocks data are not prepared in very dis-aggregated form. This may be a factor in the apparent insensitivity of output decisions, in most of my twelve industries, to the level of stocks at the start of each period. Fruit and Vegetables, Grain Milling, and Biscuits actually share the same stocks variable.

4. Sales

These are easily computed as the difference between output and the net change in stocks, for each period.

5. The Labour Market Variable, V_t

This is defined for each quarter as the sum of the figures for total notified vacancies in each month, divided by the sum of the three monthly figures for total male employment in industry. The data are contained in the Monthly Abstract of Statistics.

6. The Seasonal Correction of Data

Many economic time series exhibit regular, pr 'seasonal' fluctuations, as well as their less ordered ups and downs in phase with the business cycle. For example, unemployment in New Zealand tends to reach its annual peak sometime during the winter. Because most of these seasonal influences, such as climate, Christmas, or holidays, are not usually thought of as determined within the economic system, many economists have adjusted their data, to smooth out seasonal effects, before applying them to the testing of economic models, or have introduced 'dummy variables' into the regressions, for the same purpose. Brechling, Ball and St. Cyr, Dhyrmes, Kuh and Hazledine and Woodfield have all done one or the other of these things in their employment function studies. Fair, however, criticises this practice. He writes that

> "... the use of seasonally adjusted data of seasonal dummy variables is incompatible with the production function concept. A production function is a technical relationship between certain physical inputs and a physical output and is not a relationship between seasonally adjusted inputs and seasonally adjusted outputs. Unless one has reason to believe that the technical relationship itself fluctuates seasonally, and at least for manufacturing industries it is difficult to imagine very many instances where this is likely to be true, the use of seasonally adjusted data or seasonal dummy variables is unwarranted." (1969, pp21-2).

I do not find Fair's criticisms persuasive, in the context of employment function models. If employers have a decision-making horizon longer than one time period (and Fair's own results suggest that they do), then a change in output, and thus desired employment, would have a different effect on on employment according to the time of year that it takes place. For example, a drop in demand of a certain magnitude would probably lead to a smaller change in employment if it took place in the third quarter, before the busy December quarter, than if it happended in the first quarter of the year, which is followed by the relatively slack winter months. It may well be true, contrary to Fair's expectations (1969, p.22), that 'the adjustment coefficient λ fluctuates seasonally'.

In addition, there is the odd fact, observed but not explained by Hazledine and Woodfield, that, even after the first and fourth quarters are adjusted for loss of output due to holidays, productivity, measured as output per manhour, in New Zealand manufacturing industry, is higher in the September quarter than in the preceding or succeeding quarters in five of their six sample years, suggesting that the production function does fluctuate seasonally.

For these reasons, I support taking account of seasonal factors when specifying short-term employment functions. I prefer the use of dummy variables, which are both explicit and visible indices for seasonal fluctuations, to the more covert procedure of 'adjusting' the data to smooth out seasonal fluctuations before they are subjected to regression.

Footnotes

1. 'Okun's Law', which was formulated in the early 1960's for the US economy, predicts that an increase in unemployment of one percentage point is normally associated with a loss of output of three percentage points. Cf Brechling and O'Brien (1967, p. 277, fn1) for references.

2. In Ball and St. Cyr's study, three sectors show a value of α that is less than one. (1966, table 1, p.186).

3. Smyth and Ireland (1967) prefer to interpret α as returns to scale. This is discussed in section III of this paper.

4. Hazledine and Woodfield found (1971) a negative, but not significant, coefficient for NZ manufacturing.

5. This is not Fair's notation.

6. Miller's (1971) type A regressions cover some of the same industries as Fair does, and seem to be very similar in data and specification. Miller has E_t as the dependent variable, and shows some very high R^2's, while Fair's regressions have E_t-E_{t-1} on the left hand side, and obtain, mostly, very low R^2's. The differences in fit seem surprising, even given Ball and St. Cyr's footnote (1166, p.185) and Table 10 of this paper.

7. I do not think that the fixed-coefficients assumption itself, as used by Fair, rules out the possibility of some elasticity of substitution.

8. Unemployment averaged less than one half of one percent of the work force in NZ over the last twenty years.

9. Ireland and Smyth's interpretation of α as returns to scale does not depend on their use of a Constant Elasticity of Substitution production function. In fact, the proof of their result is much quicker for a Cobb-Douglas function, and so, since the elasticity of substitution is not identified by the employment function (the elasticity of substitution does not appear in Ireland and Smyth's employment demand equation (8)), there does not appear to be any justification for using the general, but more complicated production function.

10. Cf. Lundgren, (1971). Hours worked per worker and capital utilisation will not move together to the extent that machine speeds vary.

11. Including the present writer. It has not usually been made clear whether labour hoarding is supposed to refer to men hoarding - some members of the workforce doing no work at all, the others working normally - or hours hoarding - all workers doing something, but not working all the time - or both. In a direct production function estimation with the exponents of men and hours not constrained to be equal, Hazledine and Woodfield gained some support for their conjecture that hours hoarding would be more popular than men hoarding, on account of its greater equity, by finding returns to hours of about 2.5, while returns to the <u>number</u> of workers were only .47 (though this exponent was only one and one third times its standard error).

12. The work of Brechling and O'Brien, corrected by Hughes (1971b), is aimed at <u>explaining</u> the λ's, not supplementing them, and so doesn't imply mis-specification.

13. In Nadiri and Rosen's regressions, it has the wrong sign, anyway, suggesting an identification problem caused by supply and demand for labour both being functions of the real wage.

14. The a and b of equation (12), and the c of equation (13) are not supposed to be the same parameters as the a, b, and c of equation (5).

15. The basic rationale behind my heavy use of quadratic cost functions is my conjecture that people and institutions develop enough adaptability to deal comfortably with small fluctuations in their state variables, because such fluctuations are continually occurring, but that it is typically not worthwhile to develop procedures to cope as well with larger fluctuations, since these occur infrequently and unexpectedly; therefore, large fluctuations are handled, less efficiently, by ad hoc methods.

16. This is not quite so, since the results of Nadiri and Rosen discussed on page 19 of this paper imply an adjustment parameter for the capital stock which is small enough to support the assumption that the costs of changing the capital stock within a quarter are prohibitively large.

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Table 2: Dependent Y_t

Dependent Y_t Table 2

	Intercept	t	E_t	$S_t - I_{t-1}$	d_1	d_3	$\bar{R}^2$	D.W.
Aggregate Manufacturing	98.055	0.1221 (4.2340)	-0.0552 (-0.7721)	1.0168 (22.5732)	-2.0495 (-0.4415)	-5.7296 (-1.1534)	0.9874	2.5186
Fruit and Vegetables	103.515	0.3369 (4.0698)	0.0065 (0.1150)	0.9369 (32.2397)	112.7094 (2.2793)	15.0023 (1.2332)	0.9995	1.7234
Grain Milling	172.706	0.1342 (4.7766)	0.0037 (0.0796)	0.8043 (16.7069)	5.3933 (0.8169)	11.1140 (2.4173)	0.9612	1.9477
Biscuits	193.578	0.1810 (4.5351)	-0.0606 (-1.5101)	0.9516 (26.1599)	5.0659 (0.8065)	16.6782 (3.3932)	0.9955	1.8958
Beverages	223.640	0.0370 (0.4781)	-0.0138 (-0.1710)	0.9200 (28.6301)	-10.9947 (-1.7508)	7.2689 (-1.7508)	0.9919	1.3914
Tobacco	-	-	-	-	-	-	-	-
Knitted Wear	89.261	0.1434 (7.1026)	-0.0180 (-0.4855)	0.9764 (43.5177)	-7.3558 (-1.7819)	4.9754 (1.3365)	0.9988	0.7413
Woollen Mills	8.272	0.0370 (1.2805)	0.0458 (1.0310)	0.9876 (30.3620)	-2.7347 (-0.6820)	2.2223 (0.5330)	0.9920	1.0655
Electrical	-31.850	0.0998 (2.5173)	0.0401 (1.2418)	1.0195 (94.0633)	7.7496 (2.4881)	-3.6667 (-1.2138)	0.9996	0.7433
Veakles	-0.692	0.0032 (0.3792)	0.0258 (1.9796)	0.9840 (131.0765)	-0.7904 (-0.4898)	4.4856 (2.8470)	0.9996	2.0443
Chemicals	36.053	0.1445 (4.5753)	0.0380 (0.6135)	1.0289 (25.2604)	-13.5820 (-2.3598)	6.3018 (1.0518)	0.9676	1.5408
Rubber	98.754	0.2568 (5.2983)	0.0011 (0.0191)	0.9794 (41.3032)	-6.1846 (-1.4347)	5.8747 (1.2407)	0.9980	1.8196
Paper	9.151	0.1195 (1.4863)	0.0392 (0.6053)	0.9940 (36.8822)	-3.5753 (-0.8632)	3.9396 (0.9566)	0.9971	0.8240

Dependent E_t; Table 3

	Intercept	t	t^2	Y_t	E_{t-1}	d_1	d_3	$\bar{R}^2$	DW
AGGREGATE MANUFACTURING	36.941	-0.7496 (-1.8144)	-	0.2252 (4.8264)	0.7430 (9.9860)	18.6259 (3.2146)	-4.1933 (-0.6635)	0.9126	1.9437
FRUIT AND VEGETABLES	464.524	10.1608 (1.4202)	-0.3034 (-1.3448)	0.2252 (2.1405)	0.2702 (3.3439)	3.4288 (0.0207)	-8.8951 (-0.2231)	0.9054	1.9559
GRAIN MILLING	19.314	-0.0557 (-0.9741)	-	0.0611 (0.4587)	0.9086 (8.1518)	69.3540 (4.8781)	3.7022 (0.3599)	0.7691	1.3293
BISCUITS	38.693	-0.4398 (-2.4743)	–	0.3692 (2.4513)	0.6354 (3.6259)	-7.7840 (-0.2682)	-32.1964 (-1.4297)	0.5100	1.7859
BEVERAGES	623.515	0.8224 (2.9081)	-	0.3020 (3.8670)	0.0113 (0.0509)	35.0833 (1.9047)	14.2135 (0.6242)	0.8794	2.0339
TOBACCO	326.047	-0.5623 (-1.8774)	0.1012 (1.0175)	0.2611 (3.0111)	0.3906 (2.3443)	7.7636 (0.4799)	-28.6677 (-2.0267)	0.5352	1.7142
KNITTED WEAR	166.198	-0.4268 (-1.7257)	0.1303 (1.5137)	0.1966 (2.3303)	0.6609 (4.7850)	20.3222 (1.1782)	-19.7712 (-1.3023)	0.8120	0.9823
WOOLLEN MILLS	100.979	-0.1662 (-2.1301)	-	0.3061 (4.2562)	0.6144 (6.0810)	0.8585 (0.0726)	-0.3254 (-0.0265)	0.8776	1.2014
ELECTRICAL	158.886	0.5046 (5.1364)	-	0.1574 (6.2540)	0.6610 (9.0613)	8.8459 (0.9488)	-8.1407 (-0.8938)	0.8685	1.2191
VEHICLES	69.526	0.0110 (0.1287)	-	0.2098 (3.5141)	0.7153 (6.4103)	27.5455 (1.8802)	-11.6029 (-0.7576)	0.8723	1.5982
CHEMICALS	-64.163	-0.4186 (-2.0006)	0.1562 (2.0749)	0.1326 (2.3226)	0.9531 (10.4801)	12.2704 (1.5225)	21.5516 (2.6354)	0.8360	2.0040
RUBBER	116.280	-0.2499 (-1.1712)	0.0738 (1.0359)	0.0764 (1.5437)	0.8315 (7.4029)	-0.1668 (-0.0179)	-13.0673 (-2.2996)	0.9056	1.0088
PAPER	352.534	0.4035 (1.9378)	-	0.0092 (0.1277)	0.6233 (3.7161)	3.0904 (0.2792)	-14.8353 (-1.3981)	0.9452	1.9101

Table 4; derived parameters

	$a + c - 2\varepsilon(\psi - \varphi)$	b	$\Sigma + e$	$c/10$	v
AGGREGATE MANUFACTURING	146.3	0.892	1.480	-2.96	-23.794
FRUIT AND VEGETABLES	636.4	0.309	0.185	13.92	0.758
GRAIN MILLING	211.3	0.668	4.97	-0.61	2.110
BISCUITS	106.1	1.012	0.871	-1.21	10.041
BEVERAGES	630.6	0.305	0.006	0.83	0.538
TOBACCO	617.1	0.428	0.320	-0.92	-
KNITTED WEAR	-490.1	0.580	0.974	-1.26	6.979
WOOLLEN MILLS	261.9	0.794	0.797	-0.43	24.880
ELECTRICAL	468.8	0.464	0.975	1.49	-5.615
VEHICLES	244.2	0.737	1.256	0.04	16.688
CHEMICALS	-1368.1	2.827	10.161	-8.93	-141.78
RUBBER	690.1	0.453	2.467	-1.48	4.902
PAPER	935.7	0.024	0.827	1.07	0.083

Table 5: Regressions with V_t (E_t dependent)

	Intercept	t	V_t	Y_t	E_{t-1}	$\bar{R}^2$	D.W				
AGGREGATE MANUFACTURING	187.65	0.1617 (2.60)	0.4093 (3.77)	0.0558 (1.18)	0.6947 (7.36	0.92	2.63				
FRUIT AND VEGETABLES	476.10	0.2163 (1.02)	0.0888 (0.23)	0.2282 (14.43)	0.2795 (3.84	0.91	1.80				
GRAIN MILLING	1269.44	-0.5497 (-2.87)	-0.9961 (-2.38)	-0.1552 (-0.94)	0.0675 (0.21)	0.61	1.18				
BISCUITS	62.69	-0.2145 (-1.58)	0.4862 (2.08)	0.3148 (4.14	0.5823 (3.82)	0.56	2.19				
BEVERAGES	534.98	0.7136 (3.19)	0.0413 (0.17)	0.2907 (4.08)	0.1464 (0.94)	0.86	2.42				
TOBACCO	503.77	-0.1640 (-1.50)	0.1708 (1.04)	0.1463 (7.12)	0.3255 (1.95)	0.50	1.65				
KNITTED WEAR	215.47	0.2229 (2.34)	0.4410 (3.07)	0.0331 (2.51)	0.1102 (5.72)	0.85	1.01				
WOOLLEN MILLS	157.57	0.0017 (0.02)	0.5090 (2.96)	0.2432 (4.16)	0.5420 (6.48)	0.92	1.38				
ELECTRICAL	264.55	0.5262 (5.85)	0.3649 (2.18)	0.1258 (5.92)	0.5296 (5.79)	0.89	1.52				
VEHICLES	182.98	0.2653 (4.09)	0.9363 (6.20)	0.0768 (2.82)	0.4967 (8.44)	0.95	1.93				
CHEMICALS	138.37	0.0606 (0.55)	0.1892 (0.84)	0.1097 (1.80)	0.7295 (4.63)	0.76	2.45				
RUBBER	314.66	0.3198 (2.92)	0.4737 (3.90)	0.0688 (2.42)	0.5365 (4.73)	0.94	1.76				
PAPER PRODUCTS	347.06	0.6276 (3.39)	0.3571 (2.94)	-0.0410 (-0.82)	0.6154 (4.27)	0.96	2.24				

Table 6

Mean number of Vacancies in each industry, and correlation of each industry's series with the Series of total vacancies in the economy

	Mean no. of Vacancies	coefficient of correlation
GRAIN MILLING	14.2	0.719
BISCUITS	60.5	0.619
BEVERAGES	26.3	0.856
TOBACCO	30.5	0.666
KNITTED WEAR	179.9	0.775
WOOLLEN MILLS	103.7	0.859
ELECTRICAL	263.9	0.853
VEHICLES	220.2	0.885
CHEMICALS	103.8	0.910
RUBBER	51.3	0.723
PAPER	79.5	0.873
SAWN TIMBER	161.7	0.892
QLT	1.031	0.605

Table 7 ; Dependent Y_t

Dependent Y_t — Table 7

	Intercept	t	t^2	QLT	E_{t-1}	S_t - I_{t-1}	S_{t+1}	S_{t+2}	$\bar{R}^2$	D.W.
AGGREGATE MANUFACTURING										
FRUIT & VEGETABLES	103.454	-1.645 (-0.535)	0.142 (1.670)	0.0181 (0.1260)	-0.0161 (-0.2590)	1.0059 (68.0806)	-0.0069 (-0.5042)	0.0176 (1.4375)	0.9994	2.6007
GRAIN MILLING	-79.253	-0.2953 (-0.3191)	0.0933 (2.5454)	0.1579 (1.0047)	0.1896 (1.6334)	0.8927 (19.6820)	0.1027 (2.7518)	-0.0403 (-0.9898)	0.9717	2.4355
BISCUITS	151.287	0.7366 (0.5476)	0.0405 (1.0491)	-0.0051 (-0.0901)	-0.0138 (-0.3626)	0.9325 (34.4306)	0.0660 (4.0609)	-0.0440 (-1.8391)	0.9957	2.6508
BEVERAGES	393.411	4.6629 (3.4265)	-0.1106 (-3.1575)	-0.1398 (-2.1712)	-0.1693 (-3.0972)	0.9051 (43.4020)	-0.0119 (-0.5407)	0.0044 (0.2628)	0.9955	2.4962
TOBACCO										
KNITTED WEAR	50.559	2.3626 (4.1926)	-0.0555 (-4.3124)	-0.0970 (-2.0827)	0.0203 (1.0301)	1.0013 (81.5183)	-0.0068 (-1.1205)	-0.0068 (-0.4535)	0.9995	2.3502
WOOLLEN MILLS	-35.406	2.1958 (2.7874)	-0.0939 (-2.8808)	-0.1663 (-2.2652)	0.0392 (1.4222)	1.0429 (47.9264)	0.0108 (0.4854)	0.0032 (0.13172)	0.9960	1.7650
ELECTRICAL	12.197	-3.4583 (-11.7922)	0.1338 (16.8897)	0.0946 (6.7569)	0.0369 (5.0521)	0.9901 (553.5999)	-0.0016 (-0.8309)	-0.0034 (-1.3810)	1.000	-11.4665
VEHICLES	-0.5142	0.1213 (0.2241)	-0.0048 (-0.2018)	-0.0194 (-0.3934)	0.0189 (1.4165)	1.0040 (129.2885)	-0.0108 (-1.7409)	0.0008 (0.0771)	0.9996	2.8465
CHEMICALS	423.216	3.8265 (0.8855)	-0.0127 (-0.3291)	0.4275 (1.5528)	-0.2439 (-1.1492)	0.8293 (15.3902)	-0.1506 (-2.5227)	0.1393 (1.9952)	0.9474	1.6559
RUBBER	161.890	2.7979 (2.2340)	0.0534 (1.6457)	0.0368 (0.5096)	0.0008 (0.0129)	0.9828 (53.8738)	-0.0229 (-1.4315)	-0.0555 (-2.8319)	0.9984	2.3653
PAPER	16.191	-1.5723 [illegible]	0.0951 [illegible]	-0.0853 [illegible]	0.1173 [illegible]	1.0081 [illegible]	-0.0483 [illegible]	-0.0242 [illegible]	0.9990	2.1192

Table 8, Dependent E_t

TABLE 8

Dependent E_t	Intercept	t×10	QLT	E_{t-1}	r_t	Y_{t+1}	Y_{t+2}	d_1	d_3	$\bar{R}^2$	D.W.
AGGREGATE MANUFACTURING	117.9	0.150 (1.284)	0.368 (2.336)	0.738 (8.680)	0.044 (0.604)	-0.010 (-0.189)	0.052 (0.790)	9.800 (1.51)	11.980 (1.54)	0.933	2.427
	-45.3	-0.106 (-2.410)	–	0.814 (9.301)	0.155 (2.527)	-0.012 (-0.203)	0.100 (1.436)	12.483 (1.742)	4.016 (0.507)	0.917	2.109
FRUIT AND VEGETABLES	325.4	-0.110 (-0.240)	0.182 (0.393)	0.293 (1.198)	0.300 (2.449)	0.005 (0.128)	0.110 (0.996)	-82.780 (-0.434)	-158.120 (-0.888)	0.891	1.766
	392.2	-0.114 (-0.256)	–	0.271 (1.481)	0.288 (2.491)	0.003 (0.067)	0.103 (0.968)	-69.543 (-0.379)	-156.021 (-0.898)	0.896	1.706
GRAIN MILLING	286.1	-0.461 (-2.875)	1.102 (-2.761)	0.167 (0.589)	0.220 (1.620)	0.266 (1.924)	0.242 (4.348)	41.282 (2.493)	1.815 (0.146)	0.820	1.024
	10.2	-0.052 (-0.723)	–	0.899 (7.603)	0.042 (0.298)	0.091 (0.635)	-0.051 (-0.300)	62.959 (3.691)	-0.909 (-0.063)	0.754	1.401
BISCUITS	46.0	-0.302 (-1.320)	0.378 (1.561)	0.578 (3.501)	0.348 (2.440)	-0.143 (-1.649)	0.154 (0.963)	-22.583 (-0.766)	0.083 (0.023)	0.575	2.021
	115.3	-0.406 (-1.790)	–	0.601 (3.514)	0.356 (2.403)	-0.163 (-1.826)	0.131 (0.791)	-20.321 (-0.665)	-7.543 (-0.243)	0.541	1.766
BEVERAGES	747.8	0.938 (2.270)	0.006 (0.020)	0.027 (0.106)	0.304 (1.495)	-0.117 (-0.418)	-0.035 (-0.198)	27.492 (0.584)	40.229 (0.423)	0.860	2.065
	748.3	0.936 (2.398)	–	0.026 (0.108)	0.304 (1.556)	-0.116 (-0.431)	-0.034 (-0.208)	27.760 (0.631)	40.080 (0.405)	0.868	2.062
TOBACCO	299.6	-0.056 (-0.380)	0.244 (1.357)	0.553 (3.663)	0.121 (1.594)	0.144 (3.039)	-0.150 (-1.646)	0.961 (0.058)	-35.005 (-2.104)	0.668	1.769
	2537	-0.243 (-2.241)	–	0.541 (3.508)	0.160 (2.052)	0.139 (2.875)	-0.080 (-1.044)	-0.489 (-0.029)	-32.333 (-1.913)	0.652	1.545

Table 8, continued

Dependent Et

TABLE 8, contd

	Intercept	t×10	QLT	E_{t-1}	Y_t	Y_{t+1}	Y_{t+2}	d_1	d_3	$\bar{R}^2$	D.W.
KNITTED WEAR	141.6	0.014 (0.051)	0.264 (0.907)	0.604 (4.419)	0.090 (0.827)	0.050 (1.230)	0.079 (0.716)	-7.445 (-0.365)	10.126 (0.518)	0.841	1.069
	79.9	-0.218 (-2.169)	-	0.585 (4.353)	0.143 (1.542)	0.045 (1.118)	0.160 (2.515)	-8.108 (-0.400)	13.310 (0.695)	0.842	1.256
WOOLLEN MILLS	-24.0	0.007 (0.080)	0.310 (1.524)	0.681 (7.499)	0.125 (1.889)	0.107 (2.102)	0.079 (1.521)	-7.932 (-0.891)	11.578 (1.212)	0.935	1.532
	-110.1	-0.083 (-1.337)	-	0.745 (8.944)	0.140 (2.056)	0.122 (2.380)	0.119 (2.548)	-6.833 (-0.744)	8.558 (0.884)	0.930	1.503
ELECTRICAL	257.8	0.506 (5.112)	0.383 (1.575)	0.545 (4.279)	0.099 (2.489)	0.053 (1.473)	-0.037 (-1.247)	-0.794 (-0.074)	-2.508 (-0.240)	0.879	1.742
	125.8	0.490 (4.786)	-	0.703 (8.584)	0.117 (2.967)	0.064 (1.448)	-0.019 (-0.653)	2.643 (0.241)	-7.252 (-0.697)	0.869	1.377
VEHICLES	164.7	0.261 (3.397)	1.026 (5.702)	0.640 (8.487)	-0.009 (-0.139)	0.017 (0.486)	0.031 (1.155)	-2.197 (-0.181)	28.646 (2.034)	0.951	1.662
	66.8	-0.028 (-0.294)	-	0.754 (6.251)	0.136 (1.321)	-0.004 (-0.073)	0.044 (0.998)	15.581 (0.799)	4.067 (0.183)	0.866	1.538
CHEMICALS	126.8	0.111 (0.898)	0.295 (1.123)	0.704 (3.805)	0.108 (1.591)	-0.015 (-0.232)	0.028 (1.388)	11.143 (1.191)	23.758 (2.664)	0.815	2.104
	-71.9	-0.017 (-0.346)	-	0.885 (9.692)	0.140 (2.249)	0.020 (0.354)	0.031 (1.543)	14.509 (1.626)	21.614 (2.463)	0.813	1.979
RUBBER	216.8	0.116 (0.898)	0.427 (3.499)	0.579 (5.394)	0.057 (1.561)	0.067 (2.556)	0.023 (0.636)	-4.766 (-0.657)	-0.049 (-0.006)	0.952	1.759
	6.580	-0.291 (-4.930)	-	0.833 (8.227)	0.074 (1.588)	0.061 (1.834)	0.059 (1.341)	-5.621 (-0.608)	-6.485 (-0.669)	0.922	1.006
PAPER	313.1	0.536 (1.781)	0.319 (2.266)	0.616 (3.656)	-0.017 (-0.246)	0.009 (0.162)	0.013 (0.178)	0.008 (0.001)	-8.010 (-0.720)	0.952	2.244
	257.0	0.255 (0.839)	-	0.666 (3.592)	0.007 (0.093)	0.010 (0.154)	0.055 (0.695)	0.139 (0.011)	-10.831 (-0.873)	0.941	2.041

Table 9. Logarithmic Regressions

	Dependent	Intercept	t×10	t^2	QLT	$\ln Y_t$	$\ln E_t$	$\ln E_{t-1}$	d_1	d_3	$\bar{R}^2$	D.W.
AGGREGATE MANUFACTURING	$\ln Y_t$	-0.839	-0.0005 (-1.121)	0.00032 (1.988)	-	-	1.420 (4.807)	-	-0.046 (-2.359)	0.046 (2.248)	0.728	1.559
	$\ln E_t$	0.186	-0.00016 (-1.13)	0.00003 (0.6)	-	0.214 (4.05)	-	0.761 (9.09)	0.018 (3.00)	-0.003 (-0.5)	0.910	1.915
	$\ln E_t$	1.602	0.0001 (0.6)	0.00004 (0.9)	0.00042 (2.91)	0.04 (0.6)	-	0.717 (9.89)	0.011 (2.06)	0.011 (1.45)	0.936	2.357
FRUIT AND VEGETABLES	$\ln Y_t$	4.064	0.0025 (1.51)	-0.0004 (-0.7)	-	-	0.350 (0.8)	-	0.977 (7.200)	-0.177 (-3.622)	0.944	1.784
	$\ln E_t$	3.851	0.0010 (1.34)	-0.00025 (-1.1)	-	0.184 (1.85)	-	0.253 (2.919)	0.110 (1.03)	-0.011 (-0.3)	0.878	2.206
	$\ln E_t$	3.665	0.0010 (1.36)	-0.00026 (-1.11)	0.0002 (0.4)	0.195 (1.85)	-	0.266 (2.801)	0.100 (0.9)	-0.005 (-0.1)	0.872	2.341
GRAIN MILLING	$\ln Y_t$	7.042	0.0003 (0.85)	-0.0002 (-1.1)	-	-	-0.02 (-0.1)	-	-0.044 (-4.31)	-0.017 (-0.6)	0.460	2.423
	$\ln E_t$	0.736	0.0001 (0.5)	-0.00007 (0.7)	-	0.017 (0.1)	-	0.874 (7.017)	0.065 (4.394)	0.003 (0.3)	0.768	1.343
	$\ln E_t$	6.736	0.00006 (0.3)	-0.00025 (-2.78)	-0.00121 (-3.49)	0.15 (1.32)	-	-0.1 (-0.3)	0.040 (2.95)	-0.013 (-1.38)	0.854	
BISCUITS	$\ln Y_t$	3.798	0.00155 (3.206)	-0.0002 (-1.17)	-	-	0.438 (2.232)	-	-0.123 (-5.527)	0.079 (3.689)	0.860	1.498
	$\ln E_t$	-0.034	-0.0004 (-0.8)	0.00002 (-0.1)	-	0.413 (2.46)	-	0.599 (3.282)	0.001 (0.04)	-0.032 (-1.43)	0.499	1.764
	$\ln E_t$	0.509	-0.00006 (-0.1)	-0.00008 (-0.5)	0.00044 (1.801)	0.372 (2.321)	-	0.550 (3.149)	-0.002 (-0.07)	-0.023 (-1.065)	0.552	1.982

Table 9, continued

9

	Dependent	Intercept	t x10	t^2	QLT	$\ln Y_t$	$\ln E_t$	$\ln E_{t-1}$	d_1	d_3	$\bar{R}^2$	D.W.
BEVERAGES	$\ln Y_t$	-3.37	-0.0005 (-0.62)	-0.0001 (-0.25)	-	-	1.499 (4.342)	-	-0.0800 (-2.522)	-0.0899 (-2.635)	0.684	1.834
	$\ln E_t$	4.42	0.00087 (1.827)	-0.00005 (-0.4)	-	0.328 (3.787)	-	0.023 (0.1)	0.0331 (1.878)	0.0169 (0.75)	0.872	2.075
	$\ln E_t$	4.48	0.00086 (4.733)	-0.00005 (-0.36)	-0.00003 (-0.13)	0.329 (3.686)	-	0.014 (0.06)	0.0336 (1.814)	0.0163 (0.686)	0.865	2.058
TOBACCO	$\ln Y_t$	0.296	0.0021 (3.748)	-0.00043 (-2.155)	-	-	0.942 (2.660)	-	-0.116 (-4.567)	0.080 (3.204)	0.813	1.473
	$\ln E_t$	2.249	-0.00064 (-1.966)	0.00013 (1.181)	-	0.269 (2.877)	-	0.410 (2.429)	0.009 (0.51)	-0.027 (-1.87)	0.526	1.743
	$\ln E_t$	2.283	-0.00062 (-1.547)	0.00012 (1.042)	0.00002 (0.08)	0.265 (2.421)	-	0.409 (2.349)	0.008 (0.43)	-0.027 (-1.604)	0.500	1.744
KNITTED WEAR	$\ln Y_t$	-0.910	0.0011 (2.152)	-0.0002 (-0.93)	-	-	1.124 (4.936)	-	-0.154 (-6.925)	0.106 (4.536)	0.893	1.728
	$\ln E_t$	0.953	-0.00047 (-1.86)	0.00014 (1.68)	-	0.207 (2.26)	-	0.659 (4.69)	0.013 (1.24)	-0.018 (-1.22)	0.808	1.004
	$\ln E_t$	1.706	-0.0001 (-0.5)	0.0001 (1.30)	0.00037 (2.10)	0.126 (1.35)	-	0.621 (4.75)	0.009 (0.5)	-0.004 (-0.3)	0.837	1.056
WOOLLEN MILLS	$\ln Y_t$	-0.892	-0.0005 (-0.91)	0.00021 (1.923)	-	-	0.153 (7.370)	-	0.025 (-1.289)	0.026 (1.083)	0.717	1.650
	$\ln E_t$	0.595	-0.0003 (-0.85)	0.00003 (0.25)	-	0.324 (3.855)	-	0.594 (5.289)	0.0007 (0.05)	-0.0005 (-0.04)	0.881	1.190
	$\ln E_t$	1.497	-0.00004 (-0.15)	0.00003 (0.28)	0.0006 (2.843)	0.226 (2.836)	-	0.547 (5.633)	-0.004 (-0.4)	0.011 (0.9)	0.913	1.230

Table 9, continued

	Dependent	Intercept	t×10	t^2	QLT	$\ln Y_t$	$\ln E_t$	$\ln E_{t-1}$	d_1	d_3	$\bar{R}^2$	DW
ELECTRICAL	$\ln Y_t$	-15.218	-0.0100 (-7.007)	0.0018 (3.511)	-	-	3.283 (6.512)	-	-0.206 (-3.325)	0.073 (1.138)	0.930	1.145
	$\ln E_t$	2.053	0.0008 (2.959)	-0.00004 (-0.62)	-	0.129 (7.798)	-	0.568 (9.090)	0.018 (2.166)	-0.007 (-0.92)	0.927	1.697
	$\ln E_t$	2.203	0.0008 (2.904)	-0.00005 (-0.63)	0.00006 (0.31)	0.125 (6.15)	-	0.549 (6.083)	0.016 (1.769)	-0.005 (-0.63)	0.923	1.742
VEHICLES	$\ln Y_t$	-2.268	-0.0027 (-4.036)	0.0011 (4.615)	-	-	1.344 (8.225)	-	-0.140 (-5.113)	0.117 (4.063)	0.859	1.909
	$\ln E_t$	0.703	0.0002 (0.4)	-0.00006 (-0.4)	-	0.240 (2.577)	-	0.657 (4.291)	0.033 (1.784)	-0.017 (-0.89)	0.879	1.692
	$\ln E_t$	2.080	-0.0002 (-0.9)	0.00022 (2.100)	0.00121 (6.602)	-0.044 (-0.66)	-	0.720 (8.444)	-0.007 (-0.59)	0.082 (2.481)	0.963	1.948
CHEMICALS	$\ln Y_t$	3.480	-0.0014 (-1.963)	0.00053 (2.042)	-	-	0.500 (1.495)	-	0.027 (0.85)	-0.024 (-0.71)	0.111	1.737
	$\ln E_t$	-0.472	-0.00043 (-2.005)	0.00016 (2.071)	-	0.122 (2.274)		0.950 (10.481)	0.013 (1.537)	0.022 (2.043)	0.835	2.026
	$\ln E_t$	-0.502	-0.0004 (-1.105)	0.00016 (1.503	-0.00001 (-0.02)	0.122 (2.070)	-	0.954 (4.189)	0.013 (1.367)	0.022 (2.477)	0.826	2.026
RUBBER	$\ln Y_t$	2.264	0.0012 (1.395)	0.0001 (0.311)	-	-	0.652 (1.327)	-	-0.087 (-2.385)	0.094 (2.452)	0.804	1.616
	$\ln E_t$	0.691	-0.00025 (-1.134)	0.0001 (1.242)	-	0.0534 (1.087)	-	0.850 (7.500)	-0.002 (-0.193)	-0.010 (-1.052)	0.901	1.001
	$\ln E_t$	2.493	0.00024 (0.956)	.00002 (0.360)	0.00043 (2.928)	0.0554 (1.334)	-	0.574 (4.270)	-0.003 (-0.347)	-0.003 (-0.347)	0.929	1.660
PAPER	$\ln Y_t$	5.159	0.001 (1.012)	0.0001 (6.338)	-	-	0.241 (0.429)	-	-0.070 (-2.399)	0.045 (1.421)	0.787	2.048
	$\ln E_t$	2.837	0.0005 (1.406)	-0.00002 (-0.258)	-	-0.009 (-0.127)	-	0.596 (3.270)	0.003 (0.256)	-0.013 (-1.205)	0.940	1.906
	$\ln E_t$	3.116	0.00074 (2.269)	-0.00005 (-0.18)	0.0081 (2.410)	-0.026 (-0.39)	-	0.564 (3.453)	0.002 (0.162)	-0.008 (-0.80)	0.952	2.205

Table 10; Correlation Parameters

	$\bar{R}^2$ for E_t regression	$\bar{R}^2$ for $E_t - E_{t-1}$ regression	simple correlation, r between E and E_{-1}
Aggregate Manufacturing	0.909	0.478	0.91
Fruit and Vegetables	0.905	0.952	0.04
Grainmilling	0.764	0.671	0.63
Biscuits	0.486	0.505	0.48
Beverages	0.873	0.717	0.77
Tobacco	0.535	0.500	0.57
Knitted Wear	0.812	0.194	0.87
Woollen Mills	0.872	0.391	0.89
Electrical	0.862	0.638	0.81
Vehicles	0.866	0.260	0.91
Chemicals	0.836	0.445	0.85
Rubber	0.906	0.042	0.95
Paper	0.942	0.044	0.97