THE CYCLICAL RELATIONSHIP BETWEEN REAL WAGES AND EMPLOYMENT

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REAL WAGES AND EMPLOYMENT

By

ANTHONY EDWIN MYATT, B.A., M.A.

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Doctor of Philosophy

McMaster University

June 1981

DOCTOR OF PHILOSOPHY (1981) McMASTER UNIVERSITY
(Economics) Hamilton, Ontario

TITLE: The Cyclical Relationship Between Real Wages and Employment

AUTHOR: Anthony Edwin Myatt, B.A. (Lancaster University)

M.A. (McMaster University)

SUPERVISOR: Professor W.M.Scarth

NUMBER OF PAGES: xiv, 472

ABSTRACT

The standard textbook Keynesian macro model predicts counter-cyclical movements of real wages when cycles are assumed to be caused by aggregate demand shocks. However, most of the empirical work seemed to suggest that real wages actually moved procyclically. Rather than abandon any crucial assumptions in the "micro base" of the model (i.e. perfect competition, diminishing returns, and variable coefficients of production) , neoclassical theorists either modified the standard model in other ways, or "refined and clarified" the nature of the data required to test this model. While the "statistical clarifications" are for the most part well grounded theoretically, the theoretical modifications were generally found to contain undesirable features. In response to this, two models were developed which could explain procyclical real wage movements and which did not contain any undesirable features.

The empirical part of the thesis involved testing four different hypotheses about the determination of employment, taking into account the "statistical refinements" suggested in the literature. We found that the data rejected both of the models developed in the theoretical part of the thesis. In addition, we found that the best specification

of the labour market was "employment equals the minimum of demand and supply", and since most of the observations were to be found on the demand curve, a simple fitting of a labour demand curve would do as an approximation. Frictional unemployment and vacancies were found to be important in the determination of employment , but were not easily modelled. None of these modifications, neither the "theoretical" nor the "statistical", had any significant effect on the coefficient relating real wages and employment. Though this was consistently significantly negative, it was too small in absolute size, causing us to reject the Cobb-Douglas specification of the production function. Finally, using time series methods , a causal relation was found running from real wages to employment when wages were deflated by the wholesale price index. However, this relationship disappeared when wages were deflated by industry selling prices.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisory committee, Professors Ahmad, Butterfield and Scarth, for their enormous assistance with this thesis and their unceasing willingness to be of help in every way. Without their perceptive direction and support this thesis would not have been possible. I would also like to thank Professor Burbidge who lent a significant hand with a version of the thesis that got lost somewhere.Thanks also go to Ken, Erin, John, and Joanne for helping out in the seemingly never ending work of actually putting the thesis together, **to** Aloma for struggling with my handwriting, and to Sue for smiling through thick and thin. Finally, I would like to dedicate this thesis to my parents to whom I owe more than words can express.

TABLE OF CONTENTS

PAGE

PAGE

LIST OF DIAGRAMS

CHAPTER 1

INTRODUCTION

1.1 Description of Contents

This section serves as a brief guide to the thesis, and section 1.2 explains the motivation for the study. It argues that the longevity of interest in the real wage employment relationship is to be explained by the desire to test two intimately connected theories, neoclassical employment and distribution theory. The final section of this introductory chapter deals with some methodological considerations, and discusses the limitations of falsifiability as a guide to model selection.

Chapters 2 and 3 deal with the various ways in which the standard textbook Keynesian macro model can be modified in order to remove the countercyclical real wage prediction. The standard textbook Keynesian macro model is comparative static. That is to say that equilibrium solutions to the endogenous variables are calculated given initial values of the exogenous variables. Then, given a new set of exogenous variables, new equilibrium solutions are derived. The movement through time of an actual economy can be approximated by substituting into the model the actual values of the exogenous variables. None of the modifications to the standard textbook Keynesian model considered in chapter 2 change the model's comparative static nature. Chapter 2 is labelled "comparative static amendments" because none of the modifications considered in this chapter alter the fact that the only way to produce movement in the endogenous variables from one period to another, in the standard textbook model, is by changing an exogenous variable. Those modifications which introduce other linkages between periods, for example by incorporating expectations or exogenous variables which are lagged endogenous variables, and those models which explicitly deal with the process by which equilibrium is reached, are all dealt with in chapter 3 under the heading "dynamic models".

Chapter 4 contains a brief summary of chapters 2 and 3 highlighting the drawbacks with the existing models and presenting an alternative model which removes the countercyclical real wage prediction without encountering those drawbacks. The final section of this chapter shows how those contributions which remove the negative real wage prediction from the textbook model (rather than clarifying and refining the nature of that prediction) relate back to the textbook model in terms of assumptions made.

Chapter 5 surveys the empirical work done to date on the real wage employment relationship, in the light of the theory covered in chapters 2,3 and 4. The eight papers covered are organized chronologically and can be divided into two groups; the "early work", comprising the first five papers, which has been construed as evidence for pro-cyclical real wage movements; and the "later work", which attempts to resolve the apparent paradox by taking into account the refinements and clarifications suggested in the literature for testing the textbook model.

Chapter 6 lays out the programme of empirical work to be undertaken, this programme being oriented around testing four different hypotheses about the determination of employment. These hypotheses are: first, a simple employment equals labour demand specification; second, a frictional specification which states that unemployment and vacancies always lie on a rectangular hyperbola; third, an equilibrium specification which assumes that labour demand always equals labour supply; and finally a disequilibrium specification which assumes that employment equals the minimum of demand and supply of labour. Within each specification additional complications are added. Within each specification we test for the existence of costs of adjustment, production lags, and the overtime aggregation feature. The objective is to evaluate the real wage-employment relationship and in the process evaluate the competing hypotheses concerning the determination of employment. This lays out the course of the rest of the thesis.

Before embarking on this plan of action it is necessary to consider the question of which variable, real wages or employment, should be treated as exogenous when fitting a labour demand schedule. Chapter 7 applies time series methodology to the real wage-employment data, partly in order to answer this question. This chapter also surveys the empirical work done on the real wage-employment relationship using time series methodology.

The rest of the thesis follows the plan laid out in chapter 6. Chapter 8 builds various models of costly adjustment of labour under the hypothesis that employment equals labour demand, and under various assumptions about the determination of expectations. Chapter 9 estimates these models. Chapter 10 builds two models which incorporate frictions, and estimates them. The frictional models require an estimate for the natural rate of unemployment and this is contained in chapter 11. Chapter 12 estimates both the equilibrium and the disequilibrium models. Chapter 13 concludes.

1.2 Motivation for the Study

Economists have been discussing the significance of the cyclical relationship between real wages and employment for nearly a hundred years. Marshall and Foxton disagreed about the relationship in the 1890's, and interest was revived with the publication of the findings of Dunlop and Tarshis who used British and American data respectively to show a procyclical relationship between real wages and output[1]. In accounting for the longevity of interest between two highly aggregated statistical series, it must be borne in mind that economists continue to regard the core of their subject as a science, in the sense that it produces interesting and falsifiable predictions. The interest in the cyclical movements of real wages results in an effort to test two intimately linked theories, neo-classical short run distribution and employment theory.

1.2.1 Neo-Classical Distribution Theory

In the neo-classical model distribution is determined by technology, tastes and factor supplies. In the short run, given perfect competition and profit maximising firms in equilibrium, workers earn their marginal productivities. Though propenents of this theory are prepared to admit that a dynamic economy is rarely in equilibrium, and that few markets are perfectly competitive, they hypothesize that the economy adjusts towards equilibrium fast enough, and that competitive forces are prevalent enough, to justify the theory as an approximation.

This marginal product model was severely criticized in the capital controversy[2], the intricacies of which remain veiled from most practising economists and opinions concerning the significance of which continue to differ, sometimes dramatically, amongst leading theorists. Yet, this much seems clear. Neo-classical theory was critised for confusing capital as a factor of production and capital as a recipient of income. The aggregate models were criticised for appearing to tell causal stories, that marginal products determine distribution; whereas causal stories are not possible since capital goods must be first aggregated in value terms in order to derive a quantity to substitute into a production function, which, along with a quantity of labour would then determine the rate of interest and hence the value of capital. According to the neo-classical theorists, the fact that the value of capital must be known before the value of capital can be determined, is not a vicious circle, but rather is no more than the usual simultaneous mutual dependence which we are accustomed to handling in economics. For example, the fact that consumption depends on income and income depends on consumption poses no special difficulties. However,the possibility of reswitching does seriously damage this frmework, because with reswitching the equilibrium solution of the system of simultaneous equations may not be unique. Reswitching means that a technique which was chosen as most profitable at a high rate of interest may again be chosen as most profitable at a low rate of interest, while being inferior to alternative techniques at intermediary rates of interst. This would either imply that the relationship between capital per man and the rate of interst is not inverse, or that one technique can be both more and less capital intensive than another. If reswitching occurs, there may not be a determinate solution. According to the protagonists in the debate, this left the neo-classical theory in ruins, since if it is not possible to derive well behaved demand functions for labour and capital from a production function, then distribution and total employment cannot be determined by equality of demand and supply for factors of production.

The neoclassical reply to these changes was essentially to shrug them away. Since there are always problems involved in aggregation, the possiblity of reswitching, which was at first strenuously denied, was merely one more problem. The neoclassical retort was that the aggregate model was only a "crude simplification made for the purpose of applying the theory to real numbers, and so it has to be judged pragmatically and not by the standards of rigorous analysis"[3]. Furthermore, the capital controversy did not affect the validity of general equilibrium theory, "which is the only intellectually respectable and viable form of neoclassical theory," which, "cannot be criticised on logical grounds where it is particularly robust"[4,5].

The aggregate model, therefore, derives its usefulness on the grounds of empirical applicability rather than the watertightness of its logical underpinnings. However, the possible existence of procyclical real wage movements has posed a threat to the aggregate model at this empirical level, since in the short run with diminishing returns, profit maximization and perfect competition, the neoclassical model was thought to clearly predict counter-cyclical movements of real wages[6].

1.2.2 Neo-Classical Employment Theory

In discussing the evolution of neoclassical employment theory a natural place to begin is with

Keynes and the controversies which arose as the General Theory became absorbed into mainstream theory. Keynes claimed to be revolutionising economics in his endeavour to show that equilibrium could exist characterised by large scale unemployment, that there would be no natural tendency to recovery, and that cutting money wages would not aid recovery but might deepen the depression, all of which was in contrast to the accepted ideas of his day. Though Keynesian concepts, such as the liquidity preference function and the consumption function, did have a lasting impact upon macroeconomics, in other respects the Keynesian revolution quickly petered out. Whereas Keynes stressed the theory of effective demand and argued that unemployment was not due to rigid money wages, by 1944 Modigliani was able to sum up the Keynes-Classics debate in the following way[7]:

"It is usually considered one of the most important achievements of the Keynesian theory that it explains the consistency of economic equilibrium with the presence of involuntary unemployment. It is, however, not sufficiently recognized that, except in a limiting case, this result is entirely due to the assumption of rigid wages."

The limiting case, price inelasticity of aggregate demand was thought to have been disposed of by the workings of the Pigou effect, though whether the Pigou effect is itself sufficiently powerful to cause a return to full employment equilibrium in the absence of wage rigidity, is an empirical question. Nevertheless, the theory of effective demand was dethroned, and wage rigidity as a policy prescription, was overturned.

This backfiring of the Keynesian revolution was a direct result of his acceptance of a traditional competitive micro base to his theory and its presentation in a static framework[8]. Keynes accepted the classical demand function for labour and the traditional distribution theory. He states: "... with given organization, equipment, and technique, real wages and the volume of output (and hence employment) are uniquely correlated, so that, in general an increase in employment can only occur to the accompaniment of a decline in the rate of real wages"[9].

The combination of the competitive micro base and the static framework on the one hand caused his theory to be in accord with traditional distribution theory and thus more easily accepted, but on the other hand led to the prediction that real wages and employment should be negatively related. This prediction arises since the shocks to the system are presumed to be predominantly from the aggregate demand side and thus employment would fluctuate along a stable labour demand curve. This aspect of Keynes' system led to the backfiring of the Keynesian revolution since it was hard to differentiate his system, where real wages are always above their equilibrium level whenever there is unemployment, from a system where there is unemployment _because_ real wages are above their equilibrium level. Furthermore, the prediction of a negative relation between real wages and employment was clearly a testable prediction and the work of Dunlop and Tarshis[10] appeared to show a positive relation. Writing[11] in reply to the Dunlop-Tarshis results Keynes observed that procyclical real wage movements did not jeopardize his theory of effective demand, but rather would allow that theory to be clearly differentiated from others which attributed unemployment to simply too high a level of real wages. He writes:

"I was already arguing at that time (1929) that the good effect of expansionist investment policy on employment was due to the stimulant it gave to effective demand. (Others) explained the observed result by the reduction in real wages covertly effected by the rise in prices which ensued on the increase in effective demand and that the same favourable effect on employment would have resulted from a more direct attack on real wages,... e.g., by reducing money wages. ... (But if) the falling tendency of real wages in periods of rising demand is denied, this alternative explanation must of course, fall to the ground"[12].

Though Keynes was unwilling to allow himself to be convinced by the Dunlop-Tarshis evidence, he suggested that it could be explained by a mixture of imperfect competition and non-diminishing returns.

For about 30 years the core of macroeconomic theory remained virtually unchanged. It consisted of Keynes' system within the static fremework built upon the competitive micro structure and containing the real wage prediction which did not appear to be confirmed by the facts. Involuntary unemployment was due in this model to rigidity of the money wage. Recent developments in macroeconomic theory can be divided into three groups which can be interpreted as dealing with the real wage anomaly in different ways. These three groups are the disequilibrium theorists, the "neo-Austrian" theorists, and the "post-Keynesians".

1.2.3 Modern Developments

The work of the disequilibrium theorists, especially Barro and Grossman, was specifically aimed at redeveloping Keynes' system so as to remove the countercyclical real wage prediction and the dependence on rigidity of money wages to generate involuntary unemployment. These theorists point to the static market clearing framework as being incompatible with the essence of Keynes' system which emphasizes processes and information flows. They specifically work out the spillover effects of the failure of one market to clear onto other markets. They stress that involuntary unemployment is a dynamic disequilibrium phenomenon, the dynamic disequilibria being inevitable as long as adjustments of wages and prices to aggregate demand shocks are anything other than instantaneous. The countercyclical real wage prediction is removed since the effective demand for labour schedule is determined by the effective demand for goods and is simply the inverse of the production function evaluated at the effective demand for goods, and is invariant to changes in the real wage except to the extent to which the effective demand for goods is influenced by the real wage[13].

The neo-Austrian approach in contrast emphasizes equilibrium and market clearing. Output and employment changes represent the voluntary choices of individuals in response to price level changes and their expectations regarding future price levels. These expectations will not be perfectly accurate, but if they are formed rationally the errors will be purely random. A business cycle would be generated, however, if for example, there were costs of adjusting employment or output, or if some goods were durable, the over-production of which would have effects which persist. In the Lucas[14] version of this model firms know current wages and their own product price but workers do not know the general price level which they need to calculate their real wage. In this model as the ratio of their own product price to the expected general price level alters, the supply of labour shifts along the demand for labour function. Consequently, this model continues to predict a negative relationship between the own product real wage and employment[15]. However, the recent development of contracting models, which fit nicely into the general framework of the rational expectations equilibrium models, removes this prediction since firms and households find it mutually beneficial to enter into wage contracts where wages do not fluctuate in tune with the value of the marginal product. In a sense those models are pre-Keynesian since they do not explain the existence of involuntary unemployment, but rather assume it away.

The third strand of theory to emerge, the **"post-Keynesian"** theory arose not primarily as a result of the real wage anomaly, but more directly out of the desire to correct the perceived misinterpretation of Keynes' system as depending upon rigidity of wages, and to some extent out of the capital controversy in that the double role of capital as a factor of production and a recipient of profit was removed. This group deserves mention because it represents a complete alternative to the neoclassical tradition. It is best described as an attempt to develop an alternative paradigm[16]. Though this group is by no means **unified** by far the most numerous group within the neo-Keynesians adhere to a Kaleckian theory of income distribution which assumes oligopolictic markets, fixed coefficients of production in the short run, and mark ups over prime costs fixed in the short run[17]. The latter assumption translates directly into the prediction of no relationship between real wages and employment. With a given wage and a given mark up determined by longer run considerations such as the need for investment funds, the price in oligopolistic markets is fixed, leaving demand for goods to determine output. In these models investment expenditure in any period is determined by decisions taken in previous periods, and therefore any effort to cut real wages would, if successful, only succeed in reducing effective demand and worsening unemployment.

These developments of macroeconomics all remove the countercyclical real wage prediction. Coincident with these developments other theorists have suggested other factors which could impinge on our ability to observe countercyclical real wage movements. For example, Lucas suggested there may be an overtime aggregation problem; Phelps suggested a production and payment lag; Miller pointed out that the distinction between the gross output and domestic value added could, in an open economy, account for the failure to observe a negative relation between employment and the marginal value added to the product; and Neftci and Sargent pointed out that costs of adjusting labour make the relationship between the whole time series of employment and the real wage relevant, rather than just the co~~u~~ntemporaneous relation[18]. Moreover, as econometrics has developed it has become possible to estimate more sophisticated models of the labour market which allow for non-market clearing and short side dominating. These developments have undermined the statistical basis of the need for multi-market disequilibrium models, the contract models or a rigid mark up model. That is, these developments throw previous empirical results into doubt. It is by no means certain that, taking account of the appropriate shift factors, that real wages do not move counter cyclically, and that therefore even the simple Keynesian rigid money wage model may not be refuted by the real wage data. It is the purpose of this thesis to test the various explanations for the movement of real wages, and as far as is possible, to test at least some of the proposed theories, and to put some coherence into the relevant literature, ordering the contributions into those parts that are consistent with each other and those parts which are not, and also taking note of the implications for distribution theory of the suggested modifications.

1.3 Some Methodological Considerations

Before embarking on the above program it would seem wise at this stage to consider the limitations of falsifiability as a guide to model selection. I shall discuss the following four points:

(1) Falsifiability or predictive power is of no help in distinguishing between theories which are equally accurate in prediction.

(2) Accuracy of prediction is itself a relative concept.

(3) Reliance on prediction leaves the method

open to the charge that the theory is tautologous and incapable of refutation.

(4) Prediction is of little help in the choice between different paradigms.

Finally, in Section 1.3.2, I discuss some additional criteria for model selection: realism, consistency and usefulness.

1.3.1: The Limitations of Falsifiability

(1) When two or more theories yield the same predictions concerning the observable variables which they seek to explain, then plainly falsifiability is of no help in the choice of theory[19]. It could be objected that if economics is interested in prediction then the choice between two theories with the same predictions is of no consequence. However, economics is also called upon to give policy prescriptions, and the different explanations offered by different theories may well give rise to different policy advice. It is possible, but by no means necessary, that following the policy advice of one theory would generate the data which would enable a choice between the theories to be made. Yet, this may not be the case, not only because the ceteris paribus restrictions never hold,

but also because the policy advice may be aimed at variables which are very difficult to observe, such as efficiency.

An example of this problem is the choice between the human capital model and the signalling model as explanations for the role of schooling. The human capital model views education as adding to the productive capacity of individuals, and **assumes that firms are** aware of each individual's marginal value product. The signalling approach assumes that firms cannot directly evaluate the productivity of an individual worker and that schooling does not necessarily add to the individual's productive capacity. However, productive capacities vary across individuals and the cost of education varies negatively with productive capacity[20]. Information is transferred because firms are aware of the negative relation between productive capacity and schooling costs and consequently construct a relationship whereby individuals with more schooling receive a higher wage. Individuals therefore chose the amount of schooling to undertake by maximizing the discounted excess of wages over signalling costs[21]. Both theories predict a positive relationship between the amount of schooling and income and are therefore impossible to distinguish using the earnings function approach.

Different policy prescriptions may arise, though, regarding the efficiency of subsidizing or taxing education. In the human capital model the possible existence of external benefits from a general increase in the productive capacity of the work force would justify educational subsidies. If there were no external benefits the correct policy would be to leave education alone. However, in the signalling model education does not have any social benefits since it does not add to the productive capacity of individuals,[22] whereas it is socially costly, and therefore the optimal policy would be to tax education to dissuade people from engaging in this socially wasteful activity. Both models would predict that the amount of education undertaken is a negative function of the cost of education, but whereas the human capital model plus external benefits would recommend subsidies as the efficient policy, the signalling model recommends taxes. Thus, the choice between the theories is not immaterial, but predictive power is of no help since as far as observables are concerned, the two models have the same predictions.

(2) A second problem with the falsifiability ~~criteria~~ criterion is that predictive power is a relative

concept. To statistically test a model we must give it stochastic properties which involves choosing an appropriate degree of significance or probability of rejecting the model even if it is true. Often the appropriate statistical series will not be self evident, there being a choice amongst series any of which could be justified. It is quite possible that this preliminary choice of series to use could affect the results of the test. For example in Chapter 5 we find that causality unambiguously runs from real wages to employment when prices are measured using the wholesale price index, but when the own product price is measured using industry selling prices no relationship exists between real wages and employment. Furthermore, we find that results are affected by the choice of monthly, quarterly or annual observations.

A related problem concerns the plentitude of possible functional forms to represent the theory. Any statistical test only gives us information concerning the predictive power of both the model and the particular functional form chosen to represent it. It is always possible to claim that the poor showing of a particular model was due to an incorrect choice of functional forms.

(3) If the model is nothing more than an identity then it is not strictly speaking a model and certainly it will not be possible to refute it. However, placing too much faith in predictive power does have the concomitant danger that a "model" which is in reality little more than a cleverly disguised identity will not be discovered and exposed. The most startling example of this problem is provided by the remarkable success of the empirical estimates of the Cobb-Douglas production function.

Estimates of the Cobb-Douglas production function are by no means passé. Griliches and Ringstad [23] as recently as 1971 concluded that it is very hard to improve upon the simple Cobb-Douglas form. It is found that whenever the share of wages in total product is roughly constant the Cobb-Douglas performs well in the following senses:

(i) the fit between aggregate output and input data is good.

(ii) the coefficients of labour and capital reflect income shares.

(iii) when constant returns to scale are not imposed empirical results indicate that returns to scale are close to unity.

The good performance of the Cobb-Douglas aggregate production function is an important part of the empirical strength of the aggregate model. However, it is not widely recognized that this function is theoretically misconceived and is not measuring what it claims to be measuring. Rather, as long as wages are a constant proportion of total product the Cobb-Douglas function cannot fail to perform well in the three senses given above, because in fact, the function can be derived from the distributive relation. The empirical strength reflects the model's tautological structure. This has been shown in a superbly insightful paper by Shaikh[24], and for completeness of exposition, I will include an outline of the proof.

At any moment of time, if all factor inputs are classified as either capital or labour, then the sum of wages and profits will always add up to the total product:

$$Q_t = W_t + \Pi_t \qquad (1)$$

Given any index numbers K_t and L_t it is always possible to write:

$$\frac{Q_t}{L_t} = \frac{W_t}{L_t} + \frac{\Pi_t}{K_t} \cdot \frac{K_t}{L_t}$$

or

$$q_t = w_t + r_t k_t \qquad (2)$$

where $q_t = Q_t/L_t$ = the output labour ratio; k_t is the capital labour ratio; and w_t and r_t equal W_t/L_t and Π_t/K_t or the wage and profit rates respectively.

If we now differentiate equation (2) with respect to time and define the share of profits in output as β we can arrive at identity (3), (where time derivatives are denoted by dots);

$$\dot{q} = \dot{w} + \dot{r}k + \dot{k}r = w(\frac{\dot{w}}{w}) + rk(\frac{\dot{r}}{r}) + rk(\frac{\dot{k}}{k})$$

$$\therefore \quad \dot{q}/q = \frac{w}{q}(\frac{\dot{w}}{w}) + (\frac{rk}{q})(\frac{\dot{r}}{r}) + \frac{rk}{q}(\frac{\dot{k}}{k})$$

or, since $\beta = rk/q$

$$\dot{q}/q = \frac{\dot{A}}{A} + \beta\frac{\dot{k}}{k} \qquad (3)$$

where

$$\frac{\dot{A}}{A} = (1 - \beta)\frac{\dot{w}}{w} + \beta\frac{\dot{r}}{r}$$

Integrating identity (3);

$$\ell n\ q = \int \frac{\dot{A}}{A}\, dt + \beta \ell n\ k + c_0$$

or $$q = \left\lfloor e^{\int \dot{A}/A\ dt} \right\rfloor \left\lfloor c_0\ k^{\beta} \right\rfloor$$

or $\quad q = Z\, c_0\, k^{\beta}$

or $\quad Q = Z\, c_0\, K^{\beta}\, L^{1-\beta} \qquad (4)$

where $\quad Z \triangleq e^{\int \dot{A}/A dt}$

and c_0 = a constant of integration.

Equation (4) is an algebraic relationship which always holds for any input output data as long as factor shares are constant, and yet it is mathematically identical to the constant returns to scale Cobb-Douglas production function. Such a function is merely a disguised distributive relationship shedding no light on production relationships. As long as factor shares are constant the Cobb-Douglas function must work in the three senses given above, and therefore the null hypothesis that the data was generated by a neo-classical production function can not be refuted. Fundamentally, if income shares are constant then the good fit of the Cobb-Douglas necessarily follows which is in contrast to the view that the good fit of the Cobb-Douglas "explains" the constancy of income shares.

(4) Prediction is of little help in the choice between different paradigms. Before considering the reasons for this, we must be careful to understand

what is meant by a paradigm. The term "paradigm" was coined by Kuhn who employed it to cover a "constellation of philosophic and methodological values and techniques shared by members of a scientific community." It can also be employed to denote the "concrete puzzle-solutions which employed as models serve as the basis for the solution of the remaining puzzles"[25]. That is to say that a paradigm defines the relationships to be investigated and the methods and abstractions to be regarded as legitimate.

To make the term "paradigm" fully concrete it is worthwhile to illustrate it in an economic context. As stated in Section 1.2 above the post-Keynesians are not differing from the mainstream theorists purely over the size of various elasticities or assumptions about market structure[26], but rather have set themselves the task of developing an alternative paradigm. I will use this post Keynesian attempt as an example to illustrate what is entailed in the term paradigm.

The essential properties of the neoclassical paragidm can be organized into the following four main points;

(i) Commitment to the idea that the economy is always tending towards full equilibrium.[27] The short run oscillations of the economy take place around its long run equilibrium growth path. Long run equilibrium can be defined independently of the economy's short run movements.

(ii) Commitment to the methodology of maximization and choice subject to constraints. Present situations can be regarded as freely chosen optima.[28]

(iii) Focus on exchange with the resulting implication of harmony of interest; since both parties gain from the trade both have an interest in the continuation of the exchange.

(iv) Distribution is determined by tastes, technology and factor supplies working through the medium of marginal productivities. Distribution is only one aspect of value theory which rests fundamentally on the notions of scarcity and opportunity cost.

Point (i) is used to justify point (iv) in that notions developed for a world of scarcity are used in models where there are unemployed resources and this is justified since the unemployment is viewed as temporary. The post Keynesians refer to this aspect of the neoclassical tradition as its "schizophrenic" approach, treating problems of value as microeconomic where there are no macroeconomic problems of unemployment, and treating problems of unemployment as macroeconomic. Because the post Keynesians reject point (i) there are also led to reject a theory of distribution built on scarcity. Specifically, they deny that the rate of profit is determined by the relative degree of scarcity of capital, but rather **argue that the rate of profit is linked to** the rate of expansion of capital. Markets and prices are not seen as the place where, and the means by which, scarce resources are allocated amongst competing ends; but rather as the place where and the means by which funds required for investment and expansion are realized. This is not only because prices are tied to the size of the gross profit margin which is the major source of a firm's investment funds, but also because investment, by being the pump behind aggregate demand which allows profits to be realized, finances itself[29]. The post Keynesian paradigm emphasizes the fact that production is carried on using produced commodities. In this system diminishing returns are neither necessary for the stability of the system, nor an appealing assumption based on empirical inference, and therefore accumulation is viewed as a self sustaining process which is not primarily dependent upon either nature given scarce resources or upon the preferences and needs of individuals. Thus, the philosophic values of the post Keynesians differ from the neoclassicists.

Methodologically too, the post Keynesians part company from the neo-classicists in that there is a greater emphasis on realism of assumptions; though of course, the degree of realism of assumptions is hard to measure and in the end, probably is more meaningfully interpreted as a preference for assumptions which fit one's own philosophic value system.

As far as the concrete puzzle solutions are concerned the post Keynesians clearly reject both the long run and the short run neoclassical macro models[30]. The long run neoclassical growth model is a balanced full employment model where planned investment and saving are equal ex ante, the growth rate being determined by the exogenous rate of growth of population and technical change. The post Keynesian approach in contrast has been to take the rate of accumulation in any era as exogenously given and then investigate the conditions necessary for this rate to be reproduced over time. Assuming that the propensities to save differ amongst classes or institutions, the distribution of income must adjust so that the rate of investment is adequately financed. Accumulation determines the rate of profit with no reference to marginal productivities, factor prices having a distributive role, rather than an allocative role. The post-Keynesians point to capital reversing and reswitching to argue that if investment demand is not a monotonic inverse function of the rate of interest, then supply and demand and relative factor movements cannot be relied upon to ensure balanced full employment growth.

The short run macro model is rejected because they argue that investment and the liquidity preference functions are inherently unstable and therefore the neoclassical comparative static analysis is illegitimate[31].

Thus, we find in the post-Keynesian neoclassical debate all of the features of a paradigmatic split; differing philosophic and methodological values and a lack of shared concrete puzzle solutions which serve as a basis for a solution of the remaining puzzles.

Let us now consider why we should not be optimistic that falsifiability could resolve this dispute. There are four essential reasons:

(i) A fertile paradigm where there is ongoing research must always contain unsolved puzzles. This is true of both the post Keynesian and the neoclassical pardigms.

(ii) There is no easy dividing line between a puzzle and an anomaly. A necessary condition for a puzzle is the assured existence of a solution. An anomaly is a counter instance, or failure of predictive power, which contains no solution within the paradigm. Such an anomaly may call into question explicit and fundamental generalizations of the paradigm, and may have been wrestled with for a long period of time. The cyclical movement of real wages fits this case precisely in terms of its long history, and in terms of its status.

(iii) Different paradigms may be more efficient in solving different problems. Choice between paradigms often involves a choice as to which are the most important problems to be solved. Thus the post Keynesians put much more emphasis on distributional questions and on the mutual interaction of pricing and investment decisions for example, whereas the neoclassicals certainly downplay the former question.

(iv) There is an extent to which different paradigms use different concepts and hence generate different data, which causes problems of comparison and communication. Theories are not merely man made interpretations of given data. First of all, we must focus on that data which is relevant out of the infinity of facts which present themselves. After the relevant facts have been selected they must be collected, usually with difficulty, and then manipulated. The appropriate measurements and manipulations are all paradigm determined. A good example of this is the difference between the Marxist paradigm and the neoclassical where the latter does not even collect information on say the rate of exploitation or the rate of surplus value.

1.3.2 Some Additional Criteria for Choice of Theory

(1) Realism

Since theories are essentially simplifications of a more complex reality, they must necessarily be unrealistic. The skill of a theoretician is to ignore the unimportant and so capture the essence of a problem. On the other hand the realistic bearing of theoretical deductions from sets of assumptions depends on how accurately the assumptions have been selected (abstracting from errors of reasoning). These two factors define the tight rope along which theoretical development proceeds. Needless to say the precise location of this tight rope is open to different interpretations. For example, whereas leading neoclassical theorists are agreed that general equilibrium theory is "the only intellectually respectable and viable form of neoclassical theory"[32], they have been attacked on the grounds that this theory is irrelevant because it is unrealistic. This charge is made because of the information economic agents are required to possess in order that a full equilibrium should be achieved. Full equilibrium is coincident with the absence of any disappointed expectations. Economic agents should act in such a way that the prices on which they base their actions should actually be realised, and this requires assuming away uncertainty.

In defence of general equilibrium analysis, however, Hahn claims that its value lies in the negative, in pointing out what cannot be said[33]. Thus, for example, in relation to the proposition that a floating exchange rate tends to its equilibrium level, general equilibrium points out that:

"... quite apart from all the dynamic problems, there may be no equilibrium level, or there may be many, or it may be advantageous to support an otherwise unstable equilibrium."

Or, in relation to the proposition that only investments profitable to private investors can be beneficial, therefore foreign aid is redundant;

... there is no difficulty in pointing to those features of the actual situation which are at variance with what would have to be true if such a claim were to be true."

If Hahn's statement, that the value of general equilibrium theory lies in revealing what cannot be said, is accepted, then it would appear to be exploring the realm of necessary assumptions, where the question of realism is directly relevant. Most theories, however, are built from sufficient assumptions, the violation of which does not automatically make the theorem false. The difficulty of finding all the possible sets of necessary assumptions partly accounts for this. Even if the necessary assumptions are easily obtained there is still the question of testing the realism of these necessary assumptions, a prospect which raises again many of the issues already discussed in relation to the problems of falsification. Finally, even if a necessary assumption is deemed to fail a "realism test" there still remains the question of how this biases an analysis or the direction of bias imparted. These considerations would seem to imply that considering the realism or optimum degree of realism of assumptions does not give any advantages over the principle of falsifiability, but rather moves the domain of falsifiability from the conclusions to the assumptions. In this case, if general equilibrium theory can properly be viewed as an explanation of necessary assumptions then it too would seem to be misplaced effort.

(2) Usefulness

This criterion immediately raises more questions: useful to whom, and to do what? At a broad level of interpretation these questions suggest the political approach of analysing the interests that a theory could have, or has in fact, served. At a narrower level of interpretation the criterion appeals to the economist's own set of values, or, in the absence of the mythical social welfare function, the politicians' values, as to whether the theory is addressing "important" problems and extends our ability to deal with these problems. Clearly, this criterion cannot be objective, yet appeals to it are not uncommon especially when practitioners cannot agree on a set of philosophic or methodological values, or when there is a paradigmatic split. Thus, for example, the post Keynesians complain that general equilibrium theory is useless because it cannot answer questions to do with the determination and movement of the rate of profits (one would need to aggregate the value of capital to do so), the determination of relative shares of income as capital accumulates, or the choice of technique. Clearly, this does not prove that general equilibrium theory is useless, but may simply reflect differing views as to the important questions to address, or may even reflect the fact that no one theory can address all the relevant questions at once. Here again, an extreme post Keynesian stance would be that general equilibrium theory does not address any of the relevant questions, since not only is it too cumbersome to admit of any conclusions except under the most rigid assumptions, but even that it is inherently flawed by its method[34].

A second role of the usefulness criterion is in pointing out that though a theory may not be testable either because of a current lack of econometric techniques, or because it is so flexible it can explain anything,it may still be useful as a classificatory device, or a tool through which we may organize our thoughts.

(3) Consistency

It is often stated that from inconsistent assumptions only nonsense can be derived. In relation to this, two comments are relevant. First, the nonsense that is derived may not be so imcomprehensible that it is patently obvious that inconsistent assumptions have been made. For example, before Sraffa's 1926 article[35], economists were quite innocently drawing conclusions from partial equilibrium perfectly competitive models, unaware of the fact that perfect competition and partial equilibrium were inconsistent with one another. Second, inconsistent assumptions can sometimes be so useful that economists are reluctant to abandon them. For example, the fact that the capital controversy showed some logical inconsistencies with the neoclassical production function did not stop that function being considered an extremely useful simplifying device.

Whatever the relative importance of consistency on a logical level, on a practical level one can say that economists have not been convinced by arguments which revolve around consistency. Thus, in his 1926 article, Sraffa was not concerned with the realism of the assumption of perfect competition, nor with accuracy of predictive power, but solely with the difficulty that the formal requirements of a partial equilibrium analysis do not permit the conditions necessary for the existence of perfect competition. Though these arguments led to the development of the theory of imperfect competition, economists continue to use the perfectly competitive model in a partial eqiulibrium framework. Similarly, in relation to the capital controversy, Mirlees[36] draws a distinction between economists in the scholastic tradition for whom consistency is important, and economists in the scientific tradition for whom empirical success is more important.

We can conclude that from the point of view of the neoclassical paradigm, at least, consistency must often be sacrificed and that it is less important than prediction. The problem with this methodological position is that an inconsistent theory may receive empirical support because of a tautological method. Consistency may be of prior importance before predictive power, and therefore the neoclassical methodological position may itself be inconsistent. But then consistency must often be sacrificed!

1.3.3 The State of the Art.

The usefulness and realism criteria are the weakest considered, being dependent on subjective factors. The falsifiability criterion is the strongest, being most easily framed in objective statistical terms, but we must be fully aware of its limitations if it is to be used properly. In particular the falsifiability criterion is susceptible to the weakness of tautology. This would suggest a stronger emphasis on the consistency criterion than we have hitherto placed. It is ironic that differences of opinion within the profession over the relative importance of consistency and falsifiability, were in part responsible for the split of the profession into opposing camps and the emphasis on one or other of the criteria characterises the opposing paradigms. Such a one-sided emphasis in each is likely to be a weakness for both.

In subsequent chapters I will not only be concerned with a theory's implications for the cyclical movements of real wages, but also with its consistency; both internal consistency and consistency with other theoretical developments either by the same theorists or within the same school of thought.

FOOTNOTES

Chapter I

1. Assuming a positive relationship between employment and output their findings were taken to imply a positive relationship between real wages and employment.

2. See Harcourt, "Some Cambridge Controversies in the Theory of Capital", Cambridge University Press, 1972.

3. Solow, "Cambridge and the Real World", Times Literary Supplement, 1975, page 277.

4. F. Hahn, "The share of wages in National Income: An Inquiry Into the Theory of Distribution".

5. I return to this question again in Section 3 below.

6. As theoretical research has progressed the precise assumptions when this is true have multiplied, as will become apparent in Chapters 2 and 3.

7. Modigliani, "Liquidity Preference, Interest and Money", Econometrica 1944, page 65.

8. The latter was done in Chapter 19 of the General Theory, developed by Hicks, and endorsed by Keynes.

9. "The General Theory of Employment, Interest, and Money", page 17.

10. See Chapter 4 for a detailed discussion of their work.

11. "Relative Movements of Real Wages and Output", Economic Journal, 1979, page 40.

12. Ibid, page 40.

13. In this model the real wage determines the distribution of income between wages and profits. If all individuals are situationally identical in the sense that the proportion of wage income to profit income is the same

for all individuals, or if all individuals have identical homeothetic tastes, or if the marginal propensity to save out of wage income equals the marginal propensity to save out of profit income, then distribution is irrelevant to the level of effective demand for goods.

14. Lucas, "Some International Evidence on Output Inflation Trade-Offs", A.E.R., 1973, page 326 to 334.

15. Variants on this model are explored in Chapter 3.

16. I return to this point in Section 2 below.

17. Major contributors to this group include Asimakopulos, Burbidge, A. Eichner, Harcourt, Kenyan, Kregel, Nell and Joan Robinson.

18. These contributions are discussed in Chapters 2 and 3.

19. The relevant predictions need not be restricted to magnitudes and signs of parameters, but may also include the nature of the error term.

20. The more productive workers being on average faster learners.

21. See for example, John Riley, "Information, Screening and Human Capital", AER, P & P, 1976 pages 154-66.

    M.A. Spence, "Job Market Signalling", Q.J.E., 1973, pages 355-74.

22. If jobs and individuals have characteristics that require matching, then there could be some social benefit in the information transfer, since firms would find out which labour should have the most central jobs. The models discussed in the text assume identical jobs, but varying abilities across individuals.

23. Griliches & Ringstad, "Economics of Scale and the Form of the Production Function", Amsterdam North Holland, 1971.

24. Anwar Shaikh, "Laws of Production and Laws of Algebra: The Humbug Production Function", Review of Economics and Statistics, 1973.

25. Kuhn, "The Structure of Scientific Revolutions" 2nd Edition, Chicago 1970, page 175.

26. See Yellen "On Keynesian Economics and The Economics of Post Keynesians", AER, P & P May 1980, for a good discussion on these lines.

27. This is an oversimplification in so far as numerous models are found to be unstable.

28. Though not necessarily Pareto optimal due to moral hazard questions.

29. Since price is separated from demand in oligopolistic markets, price is free to be determined by the need for investment funds, and demand is free to determine output and become effective demand.

30. For a good discussion see James R. Crotty, "Post Keynesian Economic Theory: An Overview and Evaluation", AER, P & P , May, 1980.

31. This one sided list of complaints is not meant to imply that the post Keynesian paradigm is more fruitful or promising. In fact, the paradigm is in difficulty because of its unwillingness to model expectations (because of uncertainty) and its resort to "animal spirits" to explain investment which hinders its own attempt to model economic processes.

32. Frank Hahn, "The Share of Wages in National Income: An Inquiry Into the Theory of Distribution", 1972.

33. Hahn, "The Winter of our Discontent", Economica 1973.

34. See for example, Kaldor "The Irrelevance of Equilibrium Economics" EJ 1972, page 1237

35. Sraffa, "The Laws of Returns Under Competitive Conditions", Economic Journal 1926.

36. Mirlees and Stern, "Models of Economic Growth" page (XXI).

CHAPTER 2

THE COMPARATIVE STATIC AMENDMENTS

The purpose of this chapter is to discuss various modifications to the conventional textbook Keynesian macro model which could explain apparently observed procyclical real wage movements. None of these modifications change the comparative static nature of the textbook macro model, which is such that the only way to produce movement in the endogenous variables over time is by inserting a different set of exogenous variables into the model.

Section 2.1 discusses general problems of testing for a counter-cyclical relationship of real wages using aggregate data. Sections 2.2,2.3 and 2.4 discuss three "refinements and clarifications" of the counter-cyclical real wage prediction. Ignoring these suggestions could produce the erroneous impression of pro-cyclical real wage movements. However, they do not remove the negative contemporaneous correlation of real wages and employment as a prediction from the textbook model. Rather, they simply force the researcher to collect more data to test this prediction in order to allow for various shift factors.

Sections 2.5, 2.6 and 2.7 consider the possibility of removing the counter-cyclical real wage prediction from the textbook model by removing the assumptions of perfect competition, variable co-efficients of production, and decreasing returns. The costs of changing the model's "micro base" and retaining a "neo-classical" model which contains predictions concerning the relationship between real wages and employment, are emphasized.

Section 2.8 considers a simple change to the textbook model which does remove the counter-cyclical real wage prediction and retains the model's neo-classical flavour.

Section 2.9 contains some concluding remarks.

2.1 Statistical Problems and Aggregation

2.1.1 There always exists a problem of deciding on the appropriate degree of aggregation. If one aggregates too much, shifts in the underlying structural relations may give rise to absurd relationships between the aggregate series. In the context of the real wage employment relationship, there could be a perfectly normal downward sloping relationship between labour demanded and the own product real wage for each firm in an industry. However, this relationship may be lost when using industry data. It is possible, for example, that a fall in the own product real wage coincides with the bankruptcy of a major firm and as a result total employment in the industry falls, even though each remaining firm has increased its employment. There is no simple answer to this problem. It is possible to use data on an individual firm but even here we may be aggregating over many plants. Clearly we do not want to continue to disaggregate to the point where all knowledge of the aggregate is lost. It is pointless to study an individual's demand for peanuts. The assumption we must make in aggregating is that shocks to the aggregate relationship caused by factors such as bankruptcies are random and balance out on net.

2.1.2 A second "statistical" problem is the tendency of some researchers to identify the real wage with wages deflated by the consumer price index. The conventional macro model contains no predictions concerning the cyclical movement of this measure of the real wage. It may well be that in a boom the output of investment goods increases to such an extent that the absolute quantity of consumption goods produced declines as labour moves into the investment goods sector. If this occurred, the own product real wage in the consumption sector would increase and there would be a positive relationship between total employment and the wage deflated by the consumer price index. Another factor which could cause this positive relation is a change in the terms of trade. Improving terms of trade would tend to increase the real wage for any given level of employment.

2.1.3 **A more difficult problem concerns the interpretation** to be put on an aggregate production function. If we assume that capital is putty, fixed in supply in the short run but mobile between sectors, and postulate two sectors, say consumption and investment goods, with different technologies, then we can derive different levels of the own product real wage correlated with a fixed level of employment, in the usual international trade manner. That is, if investment goods are relatively capital intensive, an increase in demand for investment goods would cause both capital and labour to move from the consumption goods industry, though not as much capital as is demanded by the investment goods industry. Thus, the capital intensities of both industries decline and the real wage falls.

2.2 Intermediate Imports

In a closed economy there is no difference between marginal value added and marginal productivity for an integrated macro analysis. However, when we open the economy and allow for imported intermediate goods, then we must recognize that factors earn their marginal value added to the product. The following example assumes a two stage production process such that labour and capital are substitutable, but that there is a fixed relation between the quantity of imported intermediate goods and gross output.

We will use the following notation:

X = gross output (real terms)

G = domestic value added (real terms)

M = imported intermediates (real terms)

P_x = price index of gross output

P_G = implicit deflator for domestic value added

P_m = price index of imported intermediate goods.

Now, $$X = G + M \tag{1}$$

and, $$P_xX = P_GG + P_mM \tag{2}$$

Assume, $M = \alpha X$

Therefore, from (1)

$$G = (1 - \alpha)X$$

and assume, $G = f(L,\overline{K})$

Firms attempt to maximize profits (Π),

$$\Pi = P_x X - r\overline{K} - wL - P_m M$$

$$= P_x \frac{G}{1-\alpha} - r\overline{K} - wL - P_m \frac{\alpha}{1-\alpha} G$$

$$\frac{\partial \Pi}{\partial L} = \left(\frac{P_x}{1-\alpha} - \frac{P_m \alpha}{1-\alpha}\right) \frac{\partial f}{\partial L} - w = 0$$

$$\text{or } w = F_L \cdot \frac{P_x}{1-\alpha} \left(1 - \frac{\alpha P_m}{P_x}\right)$$

To allow for this factor we must multiply the wholesale price index (P_x) by the intermediate import adjustor (IMA), where

$$(2.1) \quad \text{IMA} = \frac{1}{1-\alpha} \left(1 - \alpha \frac{P_m}{P_x}\right)$$

The above treatment assumed that domestic value added was a smooth twice differentiable function of domestic labour and capital. It is possible, however, to postulate that intermediate imports are used according to the requirements of gross output (as before) but that it is gross output that is the smooth twice differentiable function of domestic labour and capital. Since there really are no strong theoretical underpinnings for a neoclassical aggregate production function, there would seem to be no strong prior beliefs as to whether it is gross output or domestic value added that is better assumed to be a smooth function of domestic labour and capital.

Branson and Miller[1] both assume that $X = f(L, \overline{K})$. In this case profit maximization leads to the following IMA term:

$$\Pi = P_x f(L,K) - wL - r\overline{K} - P_m M = 0$$

$$= P_x f_L - w - Pm\ \alpha\ f_L = 0$$

$$\therefore w = f_L P_x (1 - \alpha \frac{P_m}{P_x})$$

2.2 $\quad$ or $IMA' = (1 - \alpha \frac{P_m}{P_x})$

Both equation (2.1) and equation (2.2) show that when P_m/P_x increases, the value added function shifts down making a procyclical relation between own product real wages and employment possible. As is shown in Figure 2.1., if the terms of trade deterioriate ($\frac{P_m}{P_x}$ increases) then both employment and the own product real wage decrease. Though the diagram is drawn using equation 2.2, exactly the same conclusions following using equation 2.1.

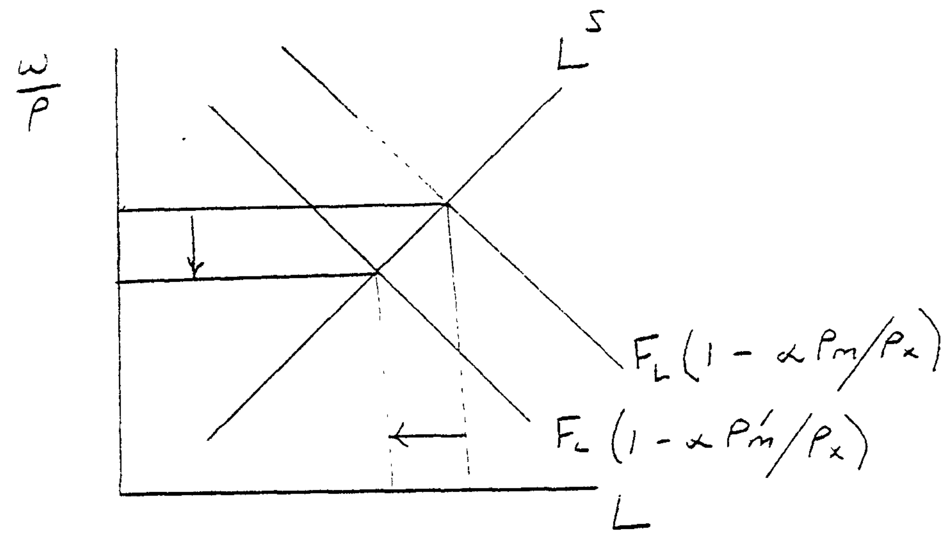

FIGURE 2.1

This termsof trade factor may account for procyclical movements of real wages without any major changes to the conventional comparative static model, providing the terms of trade deteriorate in the slump and improve in the boom, or in other words, if the terms of trade lead the trade cycle rather than follow it. The tendency has been however, prior to the formation of the OPEC cartel in 1973, for the terms of trade to deteriorate in a boom and improve in a slump. This is because the supply of raw materials is relatively inelastic and their prices are determined, for the most part, by competitive markets. Thus a boom in the developed capitalist world sends the prices of raw materials up and a slump sends them down. The trade cycle tends to cause movements in the terms of trade, rather than the other way around. Post 1973, however, it may well be that a decision by the oil cartel to increase oil prices would cause a slump in the oil importing countries, with the implication of a fall in both real wages and employment.

2.3 The Utilization of Capital

The short run demand for labour schedule is derived by varying the real wage, holding the quantity of capital constant. It is assumed that there are variable coefficients of production so that as the real wage falls it pays to operate the fixed quantity of capital with more labour, and thus we generate a predicted negative relationship between short run real wage and employment fluctuations. This assumes a fixed flow of capital services over the trade cycle, a flow which is determined by both the quantity of capital available and its rate of utilization. Since the quantity of capital is fixed in the short run (as a defining criterion of the short run), a fixed flow of capital services over the trade cycle translates into a fixed rate of utilization of capital over the trade cycle. Typically it is simply assumed that capital is fully employed.

On the surface it would appear that in the short run, an individual firm facing constant factor prices would only leave capital idle in the extreme case of its marginal productivity falling below zero. Apart from this case, it would always be more profitable to produce a given output level by minimizing variable costs and by using as much equipment and as little labour as possible. Since equipment is a fixed cost it may as well be used as long as it is productive. However, there are various factors which can account for both intended and unintended idle capital, some of which come from the product demand side, others from the **input supply side**,as categorized by Gordon Winston[2]. Unintended idle capital may result if deficient demand causes price to fall below average variable costs, or the marginal product of capital to become negative; or if quantities of inputs and spare parts are inadequate. Intended idle capital may be due to such causes as a combination of economies of scale and secular demand growth; stochastic demand patterns for services or perishable products; regular rhythms in demand patterns for services or perishable products; or from rhythmic changes in input prices in general.

The relevance of the utilization of capital to the real wage employment relationship is immediately apparent. If it should turn out that in a recession the flow of capital services was reduced by more than the flow of labour services, then we have a decrease in the capital to labour ratio and we would expect real wages to fall as employment falls. Thus, for example, John Tatom[3] has suggested that if we substitute capital in use data for capital in place data when estimating labour demand functions that real wages become negatively related to the corrected measure of the labour capital ratio[4].

The problem with this explanation for procyclical real wages is first, that it leaves open the question of why the capital to labour ratio for the individual firm moves procyclically, and second, it fails to provide a coherent story in moving from the micro analysis to the macro analysis. Taking these points in turn, consider first the individual firm. With constant input prices, a fall in the selling price would cause reductions in the quantity of the variable factor until either the price fell below average variable cost, at which point the plant would close, or until the marginal product of capital fell to zero, at which point labour and capital would be laid off in equal proportions. In the first case, the capital to labour ratio rises until the plant closes down at which point it becomes undefined; in the second case the capital to labour ratio rises up to the point where capital and labour is laid off in equal proportions. In both cases the capital to labour ratio rises as output and employment fall. Thus deficient demand may be a cause for idle capital, but it cannot explain procyclical movements of the capital to labour ratio. On the other hand if the ratio of labour costs to capital use costs fell in the slump then the firm may have an incentive to lay off more capital than labour and thus to decrease the capital to labour ratio. This, however, leads to the second problem of finding consistent micro and macro stories. This arises since in aggregate it is the capital to labour ratio which determines factor prices, whereas in the micro analysis the reverse is true. It would be circular to use procyclical real wage movements to justify procyclical capital to labour ratio movements in the firm, which when aggregated cause the original procyclical real wage movements.

In summary, in an aggregate production function context it is the employment of capital and labour which determine factor prices and not the total quantities in existence. It is an empirical matter whether this distinction removes the procyclical real wage problem. At the present moment, however, it seems as if we are lacking an explanation for procyclical movements of the capital to labour ratio.

2.4 Overtime Working and Shift Working

As Georgescu-Roegen has pointed out[5] a production function may be written either as a relation between quantities

$$Q = F(X, Y, Z \text{ --}) \qquad (1)$$

where all symbols stand for quantities; or as a relation between inputs per unit time and output per unit time,

$$q = f(x, y, z \text{ --}) \qquad (2)$$

where all symbols stand for rates of flow. Now since it is true that

$$Q = tq, \quad X = tx, \quad Z = tz$$

for any time interval t, we can substitute for the input quantities in equation (1) to derive equation

(1)' and we can substitute for the rate of output in equation (2) to derive equation (2)'

$$(1)' \quad Q = F(tx,\ ty,\ tz)$$

$$(2)' \quad Q = tf(x,\ y,\ z)$$

$$\therefore F(tx,\ ty,\ tz) = tf(x,\ y,\ z)$$

and since this holds for any interval t it follows that F and f are the same function, and that the functions are homogenous of the first degree in relation to time. In other works if we double the time which a factory works then the quantity of every flow element and the service from every stock (or fund) element will double also, and output will be doubled. This process of doubling the time which stock inputs are used is not to be confused with doubling the quantity of the stocks. The issue of returns to scale is concerned with the latter question, with the efficiency of various sized stocks in using the flow elements.

In the short run there are two ways which the capital to labour ratio may be reduced. At each point in time it is possible to work a fixed stock of equipment with more labour, and over a period of time it is possible to increase the fraction of that period during which capital is in use. Along both margins increasing marginal cost is met. Along the first there are diminishing returns in a productive sense, and along the second there are diminishing returns in a financial sense as operations are extended into hours which workers regard as unattractive and a rising schedule of premium wages is encountered.

For simplicity let us divide the day into two periods: the day and the night, of twelve hours each. Let us assume that labourers prefer to work during the day so that at equal wage rates for day and night work, more labour will be forthcoming during the day. Let us also assume that labour is equally efficient at night and at day, so that the marginal product of labour schedules are identical in each. These assumptions ensure that there will be established a higher equilibrium real wage for night work than for day work.

It has been suggested by some authors[6] that if the proportion of total employment supplied by night work increases in the boom, that the average real wage, average marginal product (and even average measure of average product) will increase in the boom, even though the marginal product from each shift declines as output expands.

Sargent and Wallace pointed out[7] that this aggregation effect cannot happen if the production function is Cobb-Douglas. They investigated the effect of a falling wage structure with constant wage differentials, with a Cobb-Douglas function.

$$\frac{\partial Q}{\partial L} = (1 - \alpha)AK^{\alpha}L^{-\alpha} = (1 - \alpha)A(\frac{L}{K})^{-\alpha}$$

$$\log MP_L = B - \alpha \log L/K$$

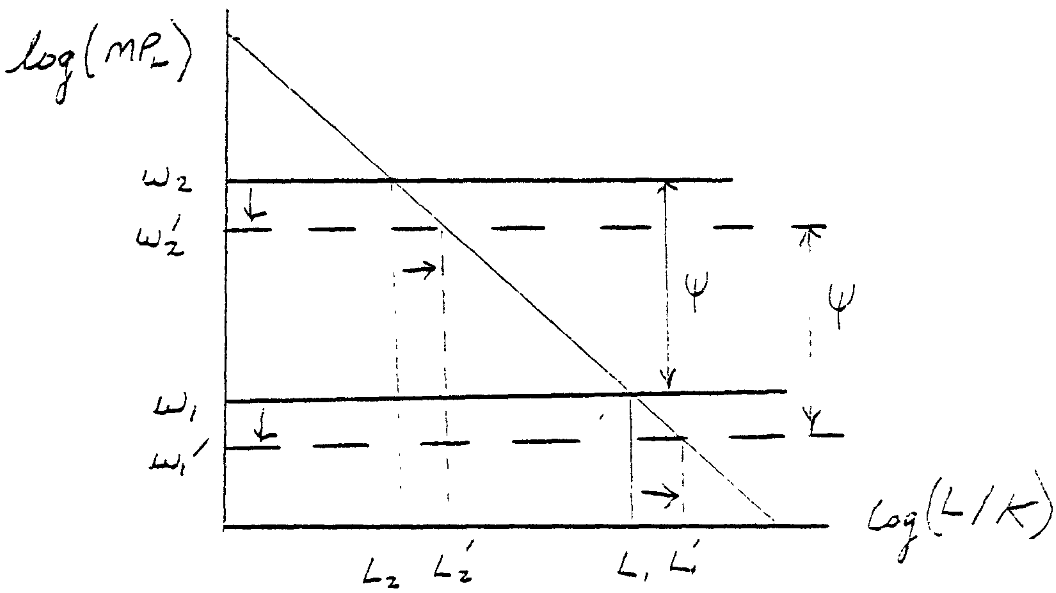

FIGURE 2.2

where ψ = wage premium for night work

L_2= log of night shift L/K

L_1= log of day shift L/K

W_2= log of night shift real wage

W_1= log of day shift real wage

Primes indicate bomm values of the wage structure.

It can be seen in the above diagram that as the wage structure falls the proportion of night and day work remains unchanged, and therefore there will be no aggregation effect counteracting the falling marginal product in both shifts.

It may be of some interest here to consider the assumption of the constant wage premium throughout the trade cycle. It is not necessary to make this assumption. We need only assume a rigid base or day wage in order to be able to generate unemployment and hence a trade cycle in these comparative static models. We could then assume the wage premium to be fixed by demand and supply for night workers. We have just seen that with a Cobb-Douglas function and a constant wage premium the demand for night workers would increase in proportion with the demand for day workers as the base real wage fell. If preferences were such that as base real wages fell in the boom more workers were willing to work the night shift, there would be an excess supply of workers on the night shift and downward pressure would be put on the wage premium. Thus incorporating an endogenous wage premium could account for an increasing proportion of night to day shift workers as employment expands, even in the Cobb-Douglas case.

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For a C.E.S. production function with $\sigma < 1$, as real wages fall with a constant wage premium, relatively more night shift workers would be demanded and the direction of movement of the wage premium is indeterminate a priori. Let us assume it is constant. This case is shown , using the same notation as before, in Figure 2.4

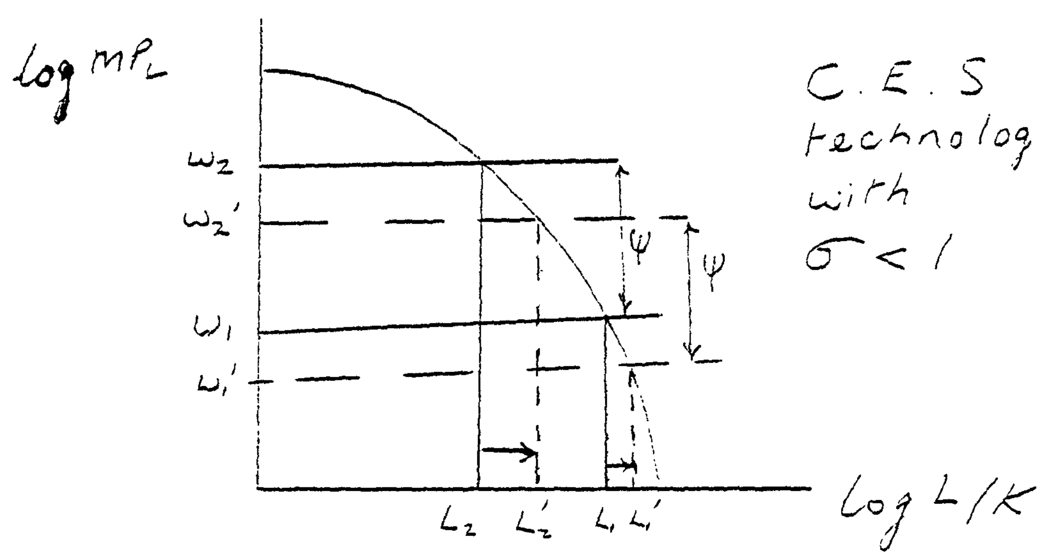


FIGURE 2.4

The curvature of the diagram increases the smaller the value of σ (the elasticity of substitution).[8]

In the above diagram it can be seen that as the wage structure falls in the boom the proportion of night to day workers increases, and though the real wage for both shifts falls, since more weight is to be attributed to the higher night shift real wage, it may be that the average real wage increases. The likelihood of this being the case increases:-

i) the greater the curvature of the diagram; that is the smaller the elasticity of substitution.

ii) the greater the wage differential between day and night shifts.

The above factors ensure that straight time employment is subject to quite rapidly diminishing returns, while the second shift is subject to much less rapidly diminishing returns. If this is the case then as the real wage structure falls, there will be a substantial shift in the proportion of night workers to day workers. The greater is the wage differential between the two shifts the greater is the likelihood that real wages averaged over both shifts will increase.

In summary then, the overtime factor provides a possible explanation for procyclical aggregate real wage movements which is consistent with the marginal product theory of distribution and which fits nicely within the comparative static framework. Though in theory this overtime factor is capable of causing aggregate real wages (and average productivity) to move in any direction, this does not justify the view taken by Lucas that;

"the theory is consistent with the cyclical observations cited in the nearly vacuus sense that it is consistent with any pattern whatsoever"[9].

Rather, the overtime issue is essentially another aggregation problem which implies that in order to threaten marginal productivity and diminishing returns in a static equilibrium framework, average real hourly wages must be split into base real hourly wages and overtime time, the former subsequently being correlated to straight time employment. A positive relation between base real wages and straight time employment leaves the problem as acute as before.

Finally, it is curious that so many successful estimates of production functions have been made using capital stock data with no allowance for the variable length of capital's working day. Presumably, such factors as overtime work, speed ups and slow downs, are erroneously tucked into the technical change parameters[10].

2.5 Imperfect Competition

In a monopoly model the equation for the real wage is $w/p=(1 - 1/n)D_L$, where n is the elasticity of demand for the monopolist's output.Whether or not the real wage falls as output increases depends on how the elasticity of demand moves.Various authors have speculated on how this might move over the trade cycle. Kalecki defined the degree of monopoly as equal to the inverse of the elasticity of demand. Both he and Joan Robinson speculated[11] that this degree of monopoly would fall in the boom due to a lack of a need to cooperate. Harrod thought the opposite more likely since in a slump there is more effort to find cheap sources of supply.[12] It is difficult to make sense of these speculations. Why should increased effort to find cheap sources of supply decrease the elasticity of demand?

The elasticity of demand is usually used in a partial context. In a macro model the relevant elasticity is that of the aggregate demand curve, affected as it is by the slopes of the IS and LM curves. It can easily be shown that in the monetarist case where the interest elasticity of the demand for money equals zero, that the elasticity of the aggregate demand curve is unity throughout, and hence counter-cyclical movements of real wages would be expected.

However, it is not correct to add a monopolist in a one good model without at the same time realizing that this must also involve adding monopsony in the labour market. Labour would not receive its marginal revenue product. Rather the monopolist-monopsonist would equate the marginal expense of the input to the marginal revenue product, and again predictions as to real wage movements are not derivable.

We could instead postulate oligopoly and draw on the kinked demand curve of Hall and Hitch[13]. Firms expect that rivals will follow price cuts uniformly, but will only partially follow price increases. This expectation creates a kink in the demand curve and a discontinuity in the marginal revenue curve. This has been used to provide an explanation for stable prices in the face of shifting costs.

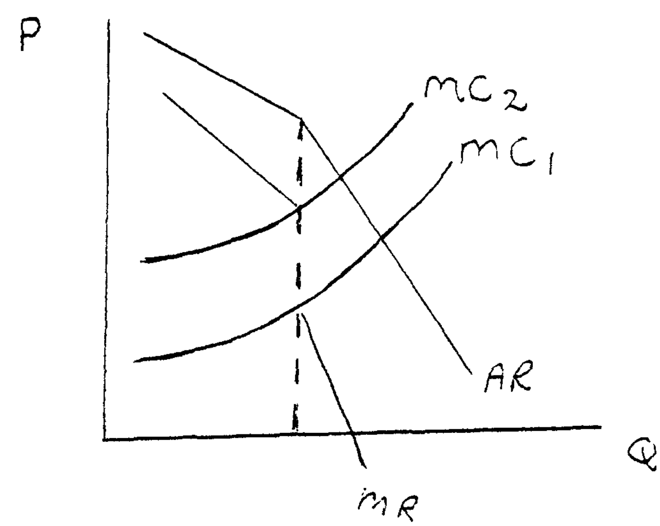


FIGURE 2.5

If marginal costs shift from MC_1 to MC_2 because of wage increases, there is no change in price or quantity, and hence the own product real wage would rise with unchanged employment.

To summarize, on the positive side, introducing either monopoly or oligopoly removes the possibility of a counter factual prediction about real wage movements while retaining diminishing returns and variable production co-efficients and the comparative static framework. However, on the negative side the model loses its predictions about real wage movements and moves towards being irrefutable. If we allow the aggregate model to be interpreted as if there were many industries lying behind the aggregation then we face ignorance about how the various interrelated elasticities of demand move over the trade cycle. If we interpret the aggregate model as being a one sector model then we introduce monopsony and face ignorance about the elasticity of the supply of labour curve. In the case of oligopoly matters are no better. Oligopoly is strong on why prices are stable but weak on the determinants of where they are stable. Furthermore, both models involve giving up the marginal product theory of distribution. Also, without perfect competition laissez-faire cannot be pareto optimal. The factoral distribution would no longer be determined by contribution to output.

Finally, if perfect competition were abandoned, linear homogenous production functions would also have to be given up, as would the simple treatment of time which perfect competition allows. The linear homogenous production function depends on perfect competition because with such a technology, when factors are paid their marginal products, factor payments just exhaust total product. If factors were paid less than their marginal products there would be an unexplained residual. Making the production function linear in values would not be very helpful since it is crucial in determining values. The simple treatment of time arises since, in perfect competition, all firms are price takers and therefore maximizing profits at a point in time is equivalent to maximizing a sum of discounted profits, and to this extent the problem of modelling how entrepreneurs form expectations is avoided since they do not need to form any. This, however, is only true for an entrepreneur with a fixed size plant, since they must anticipate future prices in order to plan changes in plant size.

2.6 Increasing Returns

In one sense imperfect competition and increasing returns are best considered together since when there is one the other is necessary to fulfill the adding up requirement based on marginal revenue productivity. I have chosen to treat them separately though, because imperfect competition can exist without increasing returns and because increasing returns may exist temporarily in a perfectly competitive market.

Monopolies need not arise solely because of increasing returns, but may also arise because of government legislation as in the utilities, or because of patency laws, or because of imperfections of the capital market leading to economies of scale in borrowing funds. Since monopolies can earn above normal profit in the short and long runs, satisfaction of the adding up requirement is not of overriding importance. Furthermore, though increasing returns in a competitive market imply factor payments which are greater than total revenue, this is quite acceptable in the short run when firms may be making losses.

However, when assuming increasing returns it is customary to also assume imperfect competition, and since this makes no difference for my purposes I will follow custom. That is, the demand for labour is $L^D = (1 - 1/\varepsilon)F_L$ and $F_{LL} > 0$. I will ignore the problem of the elasticity of demand; to be precise the problem that:

(i) the elasticity is a partial concept. We cannot obtain the aggregate demand curve for labour by horizontally summing industry demand curves since that would imply that product demand curves were independent of one another. Whereas product demand curves are drawn up on the basis of given incomes and given price configurations throughout the economy and changes in the level of wages affects incomes and those price configurations.

(ii) In a one sector model the elasticity of aggregate demand is in general unpredictable; and monopoly in a one sector model also involves monopsony with the added uncertainty of the elasticity of labour supply.

There are three possibilities, **which are shown in figure 2.6 below;**

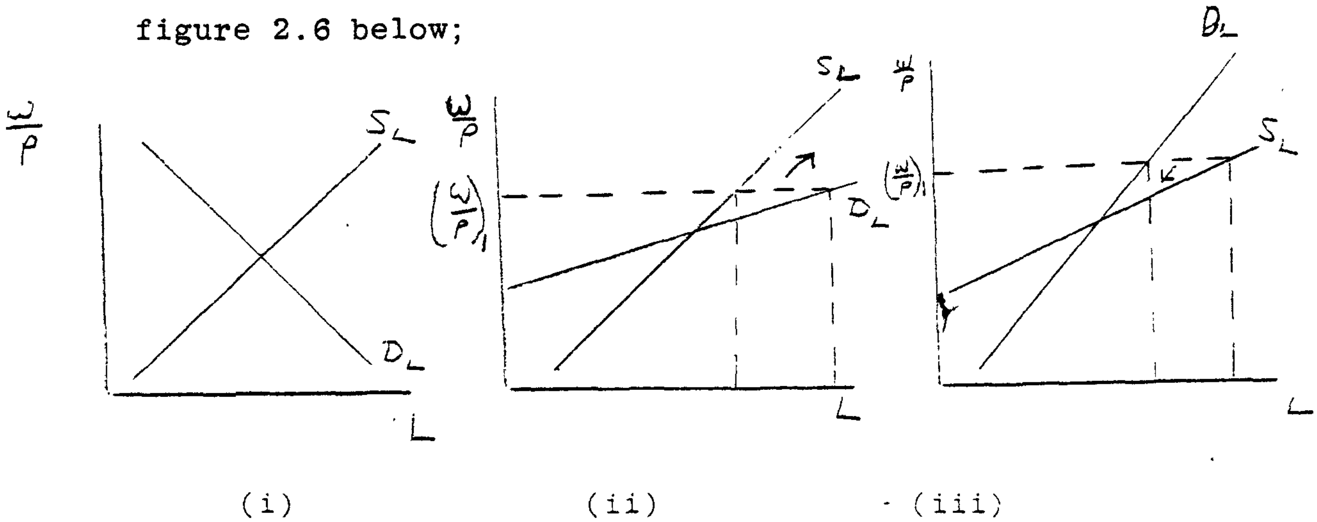


FIGURE 2.6

where $D_L = (1 - 1/\varepsilon)F_L$

and $F_{LL} > 0$.

In Figure 2.6(i) the elasticity of demand decreases at such a rate that it offsets the increasing returns. In this case countercyclical movements of the real wage would be expected. In Figures 2.6 (ii) and (iii) the demand curve for labour is upward sloping and procyclical movements of real wages would be expected. However, Figure 2.6 (ii) must be ruled out since it is unstable. At a real wage (w/P_1) which is greater than the equilibrium real wage, there is excess demand causing the real wage to move even further away from equilibrium. Figure 2.6 (iii) is stable but contains some disconcerting properties. For example, starting from a position of equilibrium, let us assume an exogenous decrease in investment expenditure which causes excess supply in the commodity market and commodity prices to fall. This causes real wages to rise and employment to increase! Again in Figure 2.6 (iii) starting from an equilibrium position, let us postulate an exogenous decrease in labour supply[14] Not only does this cause real wages to rise as would be expected, but most unexpectedly it causes employment to increase.

In summary, increasing returns may lead to instability. If it does not, it does lead to unusual and undesirable predictions. Coupled with competitive markets the combination is unsustainable for anything other than the short period since it implies that firms are making losses. Coupled with imperfect markets the previous problems of lack of predictive power and loss of the marginal product theory of distribution remain.

2.7 Fixed Coefficients

There are four cases to be considered here depending on whether capital is all of one vintage or of different vintages each with a different fixed capital to labour ratio, and depending on whether the market is competitive or noncompetitive. It turns out, because of the assumptions made about firms' behaviour in noncompetitive conditions, that it is immaterial whether there is one vintage or many vintages in the noncompetitive case.

2.7.1 One Vintage: Competitive Model

In this framework there is no marginal product theory of distribution. There is simply one aggregated fixed proportion production function of the form

$$X = \min\left(\frac{K}{a}, \frac{L}{b}\right)$$

This production function is sometimes used as an "ex post" construction by neoclassical theorists, who postulate a smooth twice differentiable production function ex ante. If this ex ante function is used to determine distribution then we are back to counter-cyclical real wages. If the ex ante function is not used to determine distribution then what is? In a one sector model with one vintage and fixed coefficients, marginal productivity is excluded.

2.7.2 Many Vintages; Competitive Markets

Let us postulate a single competitive market with many firms who own capital of different vintages:

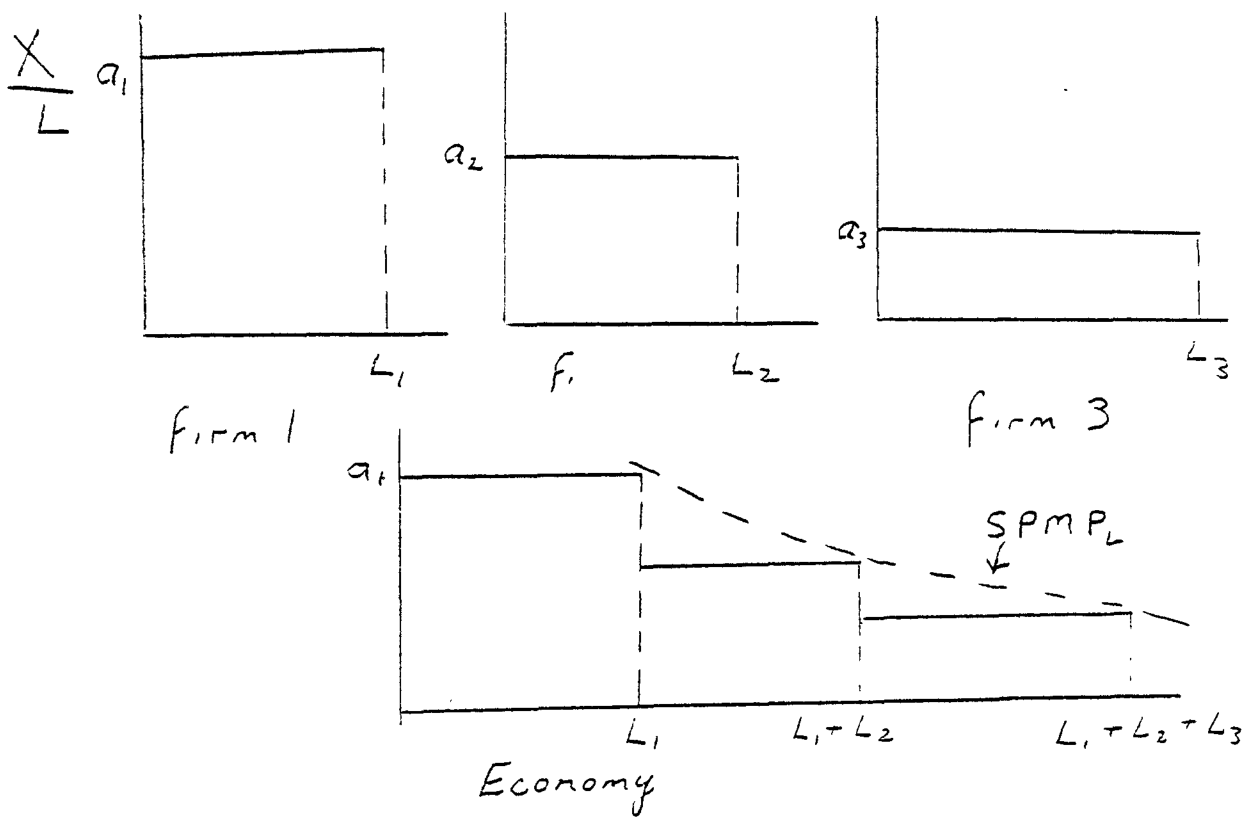


FIGURE 2.7

Average productivity is highest in firm one which owns the most efficient vintage. The vertical axis measures output. The "a's" symbolize output per man. If the real wage is above a_2 but below a_1 then only L_1 men will be employed. Aggregating the 'a' curves for all the firms yields the short period marginal product of labour curve in the sense that it tells us the amount of labour that would be employed given the real wage. If there are enough vintages the steps may approximate a smoothly falling line. This, however, is not the usual classical demand function for labour. Given the real wage it tells us the quantity of employment,(firms operate on an all or nothing basis). Labour does not earn its marginal product except in the marginal firm. In firms of greater efficiency the average and marginal products are greater than the real wage.

In this framework there will be a unique negative relation between employment and real wages up to full capacity. This framework does not help remove the counter cyclical real wage prediction.

2.7.3 The Conventional Treatment of Noncompetitive Markets

This is where problems with the elasticity of demand arise. In the many vintage case where each vintage is operated by a different monopolist there is the problem of aggregating the industry demand for labour schedules, as explained above. If there is only one monopolist, with or without many vintages, there is also the element of monopsonistic exploitation. The marginal product theory of distribution is not operative. The weight of explaining why labour does not receive its average product is placed on the elasticity of demand for the product, or upon the elasticity of supply of labour.

2.7.4 The Kaleckian Treatment of Noncompetitive Markets

Let us begin with the case of many vintages. The case of only one vintage is merely a simplified special case. A particular oligopolistic structure is assumed where there is a recognized price leader whom all other firms follow; the output share of each plant is fixed in the short period; and the price leader charges the same price for all levels of output. The output share of each plant being fixed implies that all firms operate at the same relative level of capacity. Thus forming a ratio of maximum employment in firm i to the maximum employment in the industry gives us the market share for firm i. All vintages are always in use, though rarely fully used which implies a fairly non-aggressive pricing policy by the price leader. As stated, all firms operate at the same relative level of capacity which could be shown symbolically as

$$\frac{\bar{L}_{1i} - L_{1i}}{\bar{L}_{1i}} = \frac{\bar{L}_{1j} - L_{1j}}{\bar{L}_{1j}}$$

where L_{1i} is employment of direct labour in firm i and $\bar{L}_{1i}$ is maximum employment of direct labour in firm i. Since both the most efficient and the least efficient firms operate at the same relative level of capacity, all firms reach capacity utilization at the same time and therefore the ratio $(\bar{L}_{1i}/\bar{L}_1)$, which is the ratio of maximum employment in firm i to maximum employment in the economy, gives the correct measure of market shares.

The price leader sets its price by marking up its constant prime costs, and these markups are assumed to be relatively stable in the face of short term fluctuations in demand and output. Costs are divided into prime costs and overheads. Prime costs consist of the wages of direct labour and the cost of raw materials. Direct labour actually works on the machines. Overhead costs consist of ground rent, interest payments and salaries of personnel.

The price setting equation for the price leader is

$$P_L = (1 + u) \frac{w}{a_L}$$

where w = wage, P_L is the price leader's price, a_L is average productivity of direct labour and u is the price leader's markup.

The economy's average productivity will be a weighted average of the productivities of all the plants.

$$a = \sum \frac{\bar{L}_{1i}}{\bar{L}} a_i$$

The markup for the economy as a whole is determined by the price leader's markup, the technical characteristics of all the plants and the market shares,

$$u = \sum \frac{L_{1i}}{\bar{L}_1} u_i$$

This is then not a marginal theory. It predicts constant real wages over the trade cycle in the above form with the markup exogenously fixed by the price leader throughout the cycle. The theory does not require aggregating capital which exempts it from the problems of the capital controversy. Since prices do not adjust to clear the markets for goods, demand generated by investment multiplied through a consumption function is free to be effective demand. In a full Kaleckian short run model investment is treated as exogenously determined by investors' plans in previous periods, and differential savings behaviour is also postulated. That is, it is postulated that savings are made out of profits, not out of wages. In this model unemployment is due to deficient aggregate demand. A policy of decreasing wages would fail not only for the reason that prices would fall along with wages, but more importantly because if prices did not fall with wages, consumption and employment would fall even further.

In a neoclassical framework fixed coefficients are hard to incorporate in the short run, that run of time when they are most realistic. The marginal product theory of distribution has to be given up. Instead the theory becomes an "elasticity of demand theory of distribution" or a "spread between the most efficient and least efficient vintage" theory of distribution, if the product market is noncompetitive or competitive, respectively. In a neo-Keynesian framework distribution is determined by the markup which depends on market power considerations such as barriers to entry and upon the need for investment finances, and is also determined by the level of aggregate demand through its effect on reducing average overhead costs as output expands. The markup theory of pricing is still a fertile ground for theorizing, and already many different hypotheses abound[15], which are concerned with how the price leader determines its markup. Given constant market shares, we may rearrange the aggregate price setting equation for the oligopolistic sector of the economy to express the real wage as a function of the markup

$$w/p = \frac{a}{1+u}$$

Since it is assumed that in the short run additions to the capital stock are small relative to the total capital stock we may take 'a' as being constant over the trade cycle. The movement of real wages would then depend on the movement of the desired markup over the trade cycle and upon any divergencies which may arise between the actual and the desired markup due to inaccurate expectations. However, as yet we remain in a static framework which excludes divergencies between actual and desired markups. As far as the movement of desired markups is concerned, all the theories are unanimous in assuming that it is insensitive to short term fluctuations of demand. These theories therefore predict constant real wages over the trade cycle.

In conclusion let me repeat that fixed coefficients exclude marginal productivity in the short run producing a vacuum where a theory of distribution should be.

2.8 Upward Rigidity of Wages and Employment Equalling the Minimum of Labour Demand and Labour Supply

Buiter and Lorie have argued[16] that a simple change in the disequilibrium specification of the labour market in the conventional mcro model, is sufficient to remove the unfortunate counter cyclical real wage prediction. They propose specifying some rigidity of the money wage in both an upward and a downward direction. This change,coupled with the assumption that the short side dominates out of equilibrium, allows the possibility of a positive association between real wages and employment.

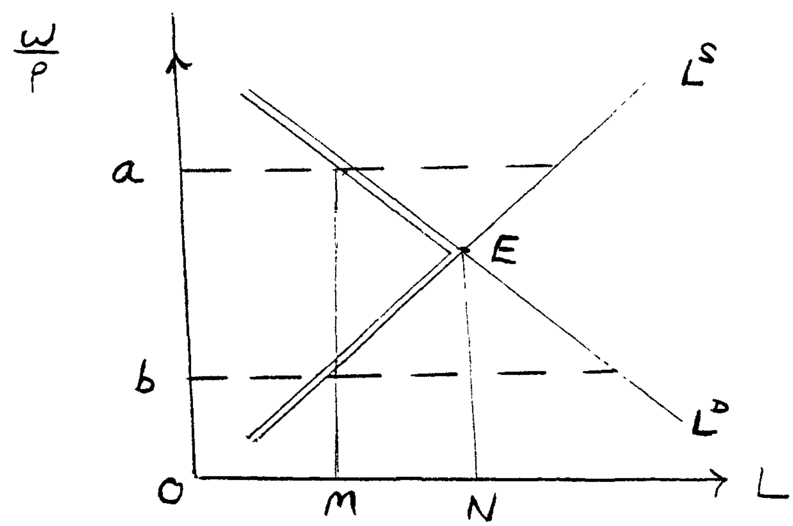


FIGURE 2.8

Figure 2.8 illustrates the aguement. An increase in aggregate demand bids up the price level and (given a fixed wage in the immediate run) results in a lower real wage. If real wages fall to point b employment falls to OM on the labour supply curve. As wages start to increase in response to the excess demand for labour, both real wages and employment increase along the labour supply curve. If some of the observed points lie along the labour supply curve which is assumed to be positively sloped, then we will observe a positive correlation between employment and real wages.

There are various problems with this explanation. First, it entails the unfortunate prediction that employment must fall from its full equilibrium value following an increase in the demand for goods. Second, the model implies that the time duration of the full cycle in employment and output be roughly half that for autonomous expenditure, the price level and the real wage. To illustrate this assume for convenience a fixed wage rate so that the cycle in autonomous expenditure produces a parallel cycle in prices which produces a mirror image cycle of the real wage.

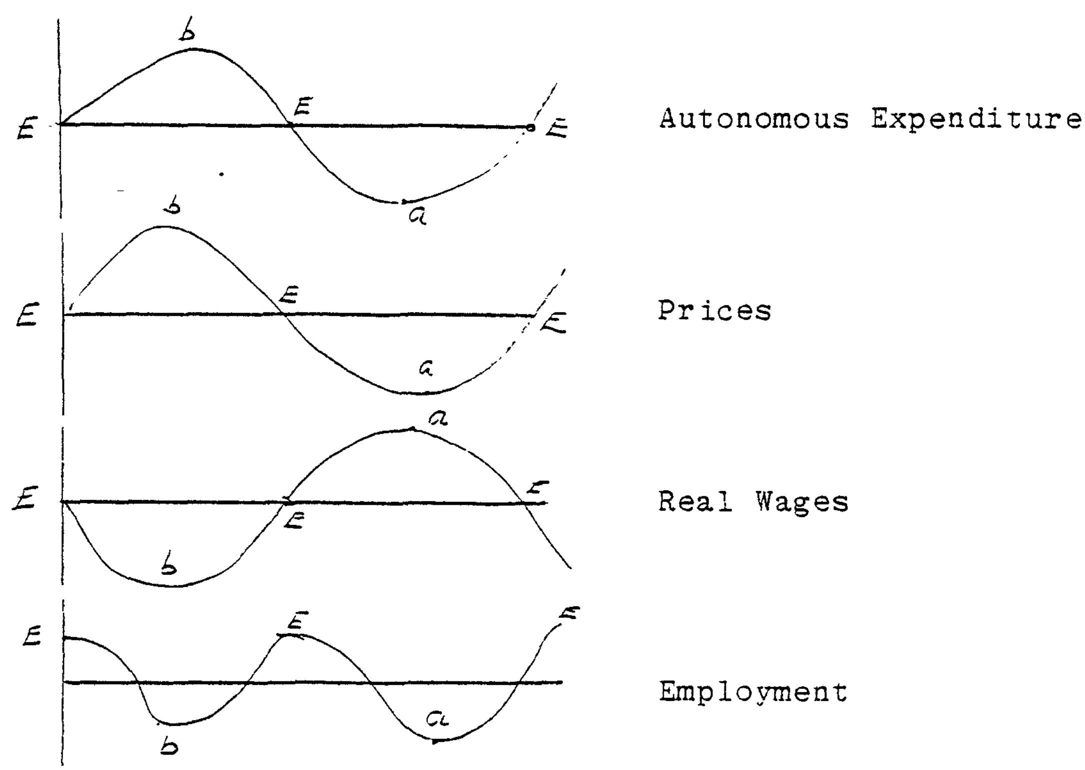


FIGURE 2.9

As illustrated in figure 2.9, the employment cycle peaks each time the autonomous expenditure series, the price series and the real wage series are at their mean values, causing the cycle in employment and output to be twice as rapid as the cycles in the other series. Given that the cycles in government expenditure and exports (measures of autonomous expenditure), and GNP, are of the same time duration for most countries, it must be concluded that Buiter and Lorie's approach must be rejected. Finally, we should note that in this framework unemployment must be zero for employment and real wages to correlate positively.

This final weakness was avoided by Lipsey in a similar construction to Buiter and Lorie's.[17] He assumes that frictions prevent employment from ever being on the demand or supply of labour schedules. Rather the observed point is always somewhere to the left of these schedules;

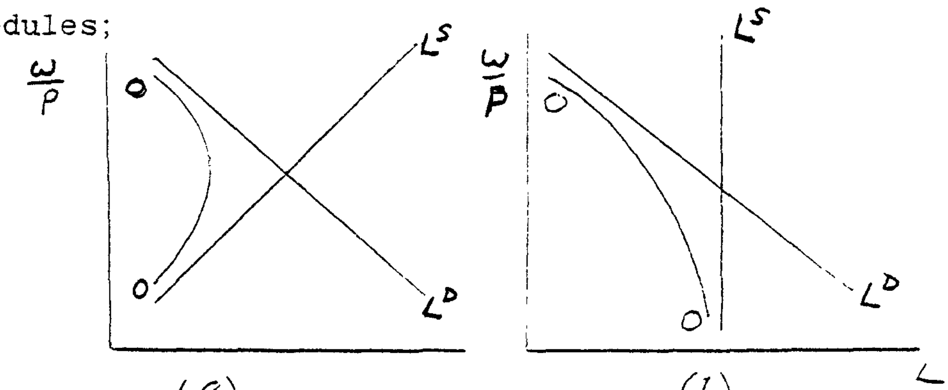


FIGURE 2.10

Clearly this amendment removes the necessity for zero unemployment when real wages and employment are positively correlated, but it does not remove the relevance of the other two criticisms, unless the supply curve were drawn vertically as in figure 2.10(b). However, in this case we do not observe the period of positive association between real wages and employment. Finally, it is interesting to observe that in the Lipsey construction firms are not on their demand curve for labour even in long run equilibrium, which suggests that perhaps firms are not maximising their profits. Frictions and therefore costs exist which prevent firms reaching their demand schedule in the long run, but it is not stated who bears these costs, and the demand and supply of labour schedules seem to be the same ones which we derived in the absence of these costs.

The effect on distribution theory of either Buiter and Lorie's model or Lipsey's model is to remove marginal productivity as the determinant of real wages when excess demand prevails. Since real wages are never above the marginal product but either equal to it or less than it, marginal productivity can not even be regarded as a "centre of gravity" for real wages. [18]

2.9 Concluding Remarks

This chapter has surveyed the modifications to the standard textbook Keynesian model which fit into the comparative static framework. It has argued that the intermediate import correction, the utilisation of capital correction, and the overtime correction do not remove the contemporaneous counter-cyclical prediction, but rather change the nature of the data required to test this prediction, by introducing shift factors. The intermediate import and overtime corrections are well grounded theoretically, whereas the correction for the utilisation of capital services is not, as yet, well grounded in theory. However, the significance of these corrections is an empirical issue.

Pro-cyclical real wage movements could easily be derived by introducing imperfect competition, fixed coefficients, or increasing returns into the standard model. However, there are drawbacks to introducing any of these changes. In the first case the model retains a theory of distribution, but it becomes a theory based on elasticities of demand for goods, and loses its predictions concerning distribution. In addition the use of linearly homogenous production functions becomes illegitimate because of the need to satisfy the adding up constraint. Increasing returns either introduces instability in the labour market, or introduces unfortunate predictions such that a decrease in the supply of labour would increase employment. Finally, introducing fixed coefficients causes the short run neo-classical theory of distribution to collapse. For these reasons, modifying the "micro base" has not been attractive to neo-classical theorists.

The last modification considered was to amend the specification of the labour market in the standard textbook Keynesian model. Assuming upward and downward rigidity of wages,and assuming that actual employment always equals the lesser of demand and supply,can produce pro-cyclical contemporaneous correlations of real wages and employment when excess demand prevails in the labour market. However, this suggestion involves the unfortunate prediction that an increase in aggregate demand at an initial position of full equilibrium causes employment to fall, and involves cycles in employment which are twice as rapid as those in autonomous expenditure.

FOOTNOTES

Chapter 2

1. Branson "Macroeconomics" page 122
Miller, "Can A Rise in Import Prices be Inflationary and Deflationary", AER, September 1976.

2. G.C. Winston, "The Theory of Capital Utilization and Idleness", Journal of Economic Literature, p. 1301-1320, 1976

3. J.A. Tatom, "The 'Problem' of Procyclical Real Wages and Productivity", Journal of Political Economy, p. 385-394, April 1980.

4. See Chapter 5 for Tatom's results.

5. Georgescu Roegen, "The Economics of Production", AER, 1970, 1-14.

6. For example, there are the following three papers, listed in chronological order;
Lucas, "Capacity, Overtime, and Empirical Production Functions", AER, 1970, 23-27,
and,
Sargent and Wallace, "The Elasticity of Substitution and the Cyclical Behaviour of Productivity, Real Wages and Labour's Share", AER, 1974, 469-504,
and,
Canzeroni, "Returns to Labour and the Cyclical Behaviour of Real Wages", R.E.Stats., 1978, 1-16.

7. Refered to in footnote 6 above.

8. The curvature in figure 2.7 can be shown by first deriving the expression for $\partial Y/\partial L$;

$$Y = v(\delta K^{-r} + (1-\delta)L^{-r})^{-1/r}$$

$$\partial Y/\partial L = F_L = (1-\delta)v(\delta(L/K)^r + (1-\delta))^{-(1+r)/r}$$

Differentiating this with respect to L/K, and then multiplying the result by $(L/K)/F_L$ yields;

$$\frac{\partial F_L . L/K}{\partial (L/K) . F_L} = \frac{\partial \log F_L}{\partial \log (L/K)} = \frac{(1+r)\delta}{(\delta + (1-\delta)(L/K)^{-r})}$$

By differentiating this again with respect to log(L/K) it can be shown that;

$$\text{the sign of } \frac{\partial^2 \log F_L}{(\partial \log(L/K))^2}$$

$$= -\text{the sign of } (1+r)\delta r(1-\delta)(L/K)^{-r} = -\text{ve when } r > 0$$

since $0 < \delta < 1$. Finally, since $\sigma = 1/(1+r)$, the curvature of figure 2.7 increases the smaller the value of σ.

9. Lucas op. cit. page

10. Feldstein, "The Theory of Temporary Lay-Offs" Journal of Political Economy, 1976, postulates a production function of the form $X = G(L,K,h)$ where 'h' is average hours per employee. However, though increasing 'h' is sufficient to increase the plant's working day, it is not necessary because of the possibility of shift work. 'h' measures the length of labour's working day, not capital's.

11. Kalecki made this suggestion in his book, "The Theory of Economic Fluctuations", 1935,

and Robinson made her suggestion in, "Review of Harrod - The Trade Cycle", Economic Journal, 1936, 691-693.

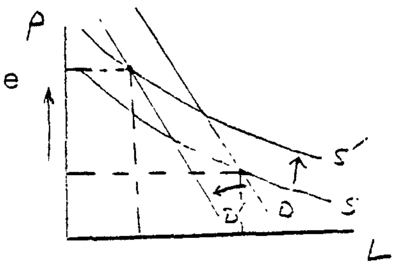
12. Harrod, "A Theory of the Trade Cycle", Oxford University Press, 1936.

13. Hall and Hitch, "Price Theory and Business Behaviour", OEP, 1939, 12-45.

14. This shift left could be due, for example, to an increase in income taxes when workers are concerned with post tax income. With increasing returns not only is the effect of tax increases on output positive, but also the effect of income tax increases on price is negative! These results are incidentally counter to those of John Hotson, "Stagflation and the Bastard Keynesians", page 45, who used the following

14. (continued)

diagram to show that where there are increasing returns, tax increases have big negative effects on output and positive effects on prices. The equilibria shown in Hotson's diagram are unstable, incidentally.



15. For example, Wood "A Theory of Profits", ('73), Eichner (EJ '73), Harcourt-Kenyon (Kyklos '76).

16. Buiter and Lorrie, "Some Unfamiliar Properties of a Familiar Macroeconomic Model", Economic Journal, 1977, 743-754.

17. R.G.Lipsey, "The Relation Between Unemployment and Wage Rates", Economica,1960, 1-31.

18. The effect of unions in this framework could be incorporated by shifting the reaction function of wages, causing faster increases in response to excess demand and slower decreases in response to excess supply. By affecting the reaction function unions can affect the actual distribution of income, though since the demand and supply of labour schedules are unchanged, the equilibrium distribution would be unaffected.

CHAPTER 3

DYNAMIC AMENDMENTS

The amendments to the standard Keynesian textbook model covered in this chapter either introduce explicit linkages between short period equilibrium positions, or contain an explicit analysis of how the economy moves towards a short period equilibrium position. The linkages introduced between short period equilibrium positions include the following: limited information about current prices and hence the necessity to form expectations about current prices from past prices; production lags and hence the necessity to form expectations about future prices; and costs of adjustment and hence a gradual movement to a full equilibrium position. The explicit analysis of how the economy moves towards a short run equilibrium position is contained in the disequilibrium analyses of Patinkin, Barro and Grossman, and Solow and Stiglitz.

Section 3.1 contains a discussion about technical change and argues that without an explicit model of technical change, there may be found a positive relation between real wages and the capital to labour ratio. The placing of this section in a chapter labelled "dynamic amendments" is somewhat arbitrary since the links between the short period equilibrium positions are not explicitly described. However, the aim of this section is merely to point out the need for an explicit model of technical change, and not to supply one. Since technical change is by its nature a long run phenomenon it is placed amongst the dynamic models.

3.1 Technical Change

Most of neo-classical economics has an analytical treatment of time, split up into "runs" or horizons. In the short run unemployed resources are recognised as existing, the total quantity of resources being fixed. In the long run, however, the growth of resources is focused upon and the problem of unemployment of resources is abstracted from. This treatment makes the testing of both short run and long run models problematic. In the real world the total capital stock is never constant, but is continually depreciating and being renewed, continually changing in both quality and quantity, thus making the data inappropriate for testing short run models. Similarly the historical data will always contain some unemployed resources, thus making it inappropriate for testing long run models.

In testing short run propositions most investigators chose to detrend their data in an attempt to remove the "long run" influences[1]. Initially with this method the analyst should be careful to choose comparable years to start and finish the data series, so that the trend is properly separated out. Obviously the trend would not be properly separated if the initial observation was a boom year and the final observation was a slump one.[2] This may become very troublesome if the appropriate choice of starting and finishing years is not the same for each time series.

An alternative would be to estimate a long run model. The purpose of this section is to show that technological progress may cause a negative correlation between the capital-labour ratio, (K/L), and the real wage, contrary to the predictions of a long run model. To clarify this point assume a C.E.S. production function with an elasticity of substitution less than one, and a capital to labour ratio increasing over time, (because the rate of accumulation of capital is greater than the exogenously given rate of growth of the labour force). If technology were constant, as the observation point moved rightwards along f_1 in figure 3.1 labour's share $\frac{WL}{PQ}$ would increase as K/L increased. Since L/Q is decreasing this implies that W/P increases as K/L increases.

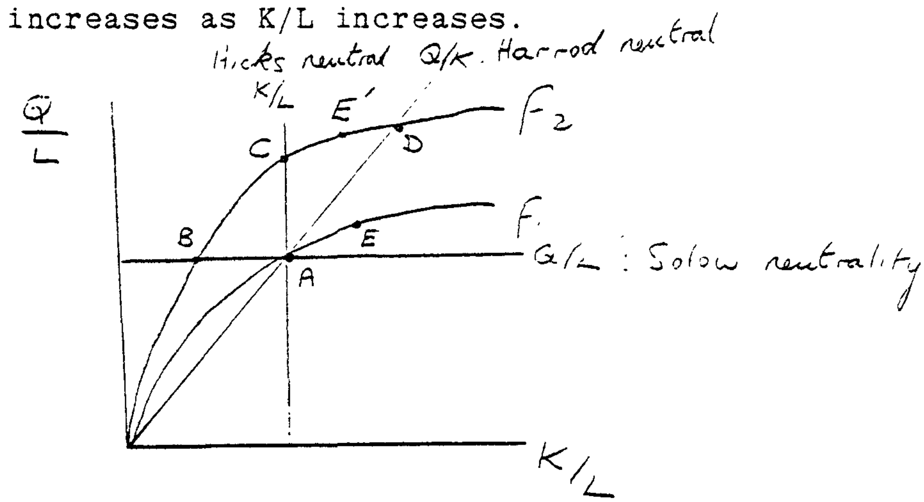


FIGURE 3.1

If, however, there was Harrod labour saving technological change then the economy would move from A to E' and labour's share would fall. (The basic definitions of technological change are contained in footnote 3). This is so by definition of Harrod labour saving technical change. As the economy moved from A to D, and with an elasticity of substitution of less than one labour's share would also fall in moving from D to E'. Thus in moving from A to E', L/Q falls, but WL/PQ could fall by much more, implying a fall in W/P. In this event W/P would fall as K/L increased which is contrary to the predictions of a long run model which has failed to pick up the Harrod labour saving technical change. Of course, if technical change were to occur at a steady rate then a time trend might be able to pick up its effects. But if the nature of technical change were to alter, or if it proceeded erratically, then a time trend would not be able to pick up these effects. In this event not only would the long run model fail to perform well, but also the short run model estimated with detrended data would perform badly. The only way to stop the influence of such technical change from impinging on our ability to test the assumptions of diminishing returns - profit maximisation - perfect competition, would be to isolate those factors causing technical change i.e. to build a model explaining technical change itself.

3.2 The Micro Model of Phelps and Winter[4]

This model represents an attempt to introduce greater realism into the theory of atomistic competition. It does this by introducing a single element of economic friction which makes instantaneous adjustment either impossible or prohibitively costly. This is achieved by dropping the assumption that customers respond instantaneously to price change. Dropping this assumption results in the possibility that a firm chooses to pay a higher real wage in terms of its product, while increasing its output.

The problem considered is quite abstract. The assumptions of homogeneity of the product and large numbers such that no individual firm can influence the average market price are retained. Only the assumption of perfect information is dropped, while the real world consequence of imperfect information, the existence of advertising policies and costs, is not considered. The immediate consequence is that the "law of one price" ceases to hold, and there is a range of prices for the product in the industry. An industry demand curve is postulated

$$q = n (p ; y)$$

where y is a shift factor. Total industry sales are given by **inserting** the average industry price into the industry demand curve. Firm's prices are weighted by their market shares to form the average industry price. At each moment in time each firm, say firm j, will be serving a proportion of the total industry customers, x_j. Customers buying from a particular firm are assumed to choose their purchase quantities according to the price quoted by that firm; thus when firm j posts price p_j it sells quantity $x_j . n(p_j)$.

Since customers only shift gradually from those firms charging higher prices to those charging lower prices each firm finds itself with transient monopoly power. Information gets transmitted through random encounters among customers. The products of any two firms' market shares determines the probability that a particular price comparison is made. It is expected that the rate of customer flow between any two firms will be proportional to that product. However, for simplicity it is assumed that a firm chooses its price policy on the basis of a subjectively perceived customer flow relationship which is a function of the difference between the firm's own product price and the average industry price. Since this latter variable is also assumed unknown the firm forms expectations of the average industry price.

The objective of the firm is assumed to be to maximise the expected stream of profit, or the firm's present value.

Let x_o = the firm's initial market share

r = the discount rate

$n(p;y)$ = The industry demand curve where y is a shift parameter and is suppressed when unnecessary

$x.n(p;y)$ = The firm's demand curve

$\emptyset(x.n(p);w)$ = total variable costs

w = input prices; suppressed when not necessary

$\bar{p}$ = expected average industry price

The firm maximises

$$V = e^{-rt} \left[p.x.n(p) - \emptyset\,(x.n(p)) \right] dt$$

subject to the subjectively perceived customer flow relationship;

$$\dot{x} = S(p;\bar{p})\, x_o$$

Using optimal control theory the optimal planned path can be derived, holding $\bar{p}$ constant as a parameter in the analysis. Given the industry demand curve the discount rate and $\bar{p}$, an equilibrium market share $\bar{x}$ can be derived. The approach path will then be determined by the firm's initial market share and the other parameters.

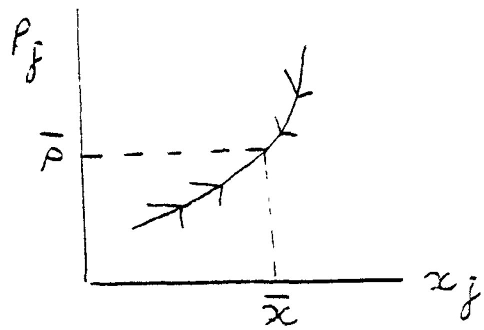
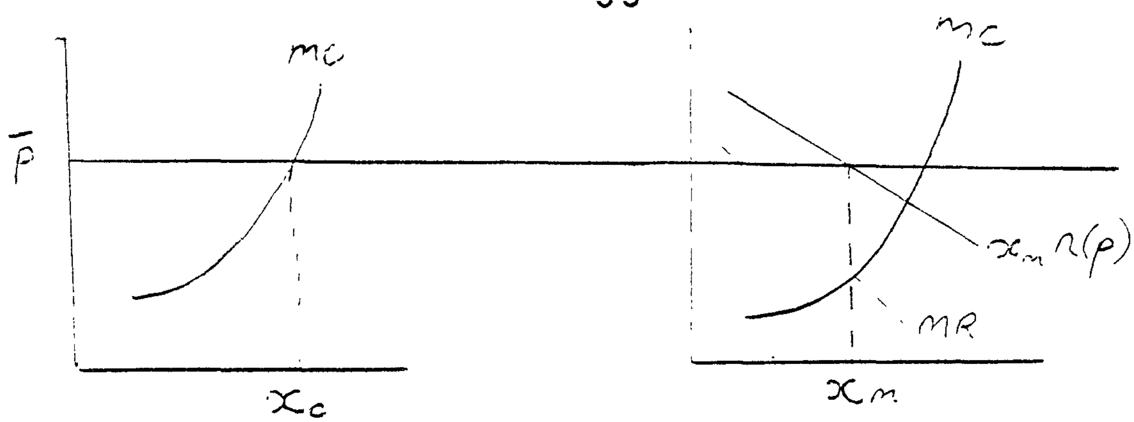


FIGURE 3.2

In equilibrium, of course, the firm will set a price equal to the industry average price since a higher price would result in the loss of its market while a lower price would attract a huge number of customers. In the sense that in equilibrium all firms set the same prices we may say that firms are "asymptotically competitive". The equilibrium market share, $\bar{x}$, may be such that the firm's demand curve cuts the firm's marginal cost curve at the equilibrium price $\bar{p}$. This would be equivalent to a perfectly competitive solution. Alternatively the market share may be such that the marginal revenue associated with the firm's demand curve cuts the marginal cost curve at the quantity demanded when the price is $\bar{p}$.



"Competitive Case" "Monopoly Case"

FIGURE 3.3

However as long as the rate of discount is between zero and infinity the equilibrium market share will be between the two extremes.[5] To move from the equilibrium share $\bar{x}$, to xm would entail gaining a larger cash flow in the short term at the expense of a smaller cash flow later. To move from $\bar{x}$ to xc would entail temporarily reducing its price to attract additional customers and represents sacrificing immediate cash flow for a greater cash flow later. The exact position of the equilibrium market share between xc and xm will be determined by the elasticity of demand, the rate of customer flow, and the real rate of interest.

Procyclical real wage movements are derived as follows. The firm's optimal price is homogenous of degree one in the customers' demand price, the wage rate, and the expected average industry price. Its optimal output is homogenous of degree zero in those variables. If an increase in aggregate demand causes a neutral upward shift in the firm's demand curve, and if money wages rise in the same proportion, but the firm's expected average industry price rises by a smaller proportion then the firm will raise its quoted price by less than the instantaneous increase in the demand price, meeting the increased quantity demanded with increased output and employment.

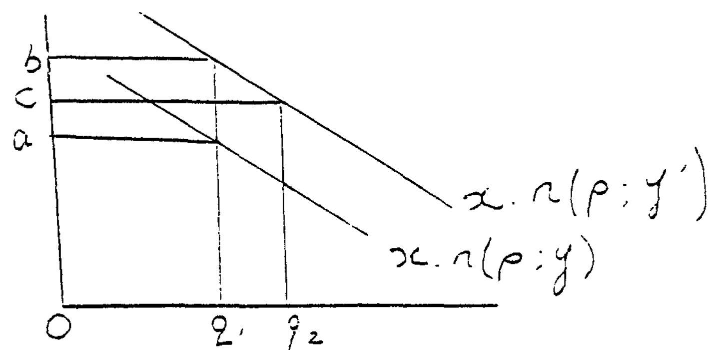


FIGURE 3.4

$\frac{ab}{oa}$ = the proportional increase in the firm's demand

$\frac{ac}{oa}$ = the proportional increase in the firm's quoted price

q_1q_2 = the increase in output

Countercyclical movements of the real wage are also possible in this model. If wages did not increase as the demand price increased, the effect would be an even larger increase in output and a fall in the real wage. An exogenous increase in wages ceteris paribus would cause a less than proportionate increase in price, an increase in real wages and a fall in output.

Comparing this model to the simple perfectly competitive model, it is apparent that the added realism introduced has not been purchased without its costs. For whereas the theory of perfect competition allows for consumers with different tastes, for substitutes from other industries and for the possibility of entry into the industry, Phelps and Winter have assumed these possibilities away in order that the firm may know its instantaneous demand curve. That is, these assumptions are necessary in order to move from an industry demand curve specified as $Q = n(p)$, to the firms demand curve specified as $q = x_j . n(p_j)$. If each firm were to set a price equal to $\bar{p}$, each firm would sell $x_j . n(p_j)$ the industry demand curve, obtained by each firm setting a price and selling to exactly the same customers as previously. Hence, a constant number of customers exist in this industry, with no new buyers entering or old buyers leaving. The assumption of identical customers is necessary to avoid the dependence of the firms demand curve on the composition of its customers. The assumption of no new entry is necessary to specify the firm's market share, n_j, to be solely a function of the difference between its price and the average industry price. This is assumed despite the fact that firms maximise expected discounted profits over an infinite time horizon.

In this theory the subjective factors are the expected rate of flow of customers and the expected average industry price. Costs and the instantaneous demand curve are known objectively. Pro-cyclical real wage movements rely on systematic errors in estimating the average industry price. When aggregate demand increases each firm considers the increase in demand peculiarly specific to itself.

Finally, the simple marginal product theory of distribution does not hold in this model even in equilibrium. Distribution depends in this framework, not only on productivity, but also on the elasticity of demand, the rate of discount and the rate of information flow (or the rate at which customers shift from high price to low price firms).

3.3 Inventories

The purpose of this section is to show that in a competitive market the existence of inventories does not break the equality of price and marginal cost (and hence the equality of the real wage with the marginal product of labour) except in the extreme case when the firm does not produce anything for current sale.

Many reasons exist for holding inventories, the most important of which are;

(i) the prospect of a financial gain because of an expected future price or cost increase,

(ii) to create a buffer against unforseen demand increase or unforseen dislocations in productions,

(iii) the desire to save on transportation charges by making block purchases,

(iv) unplanned accumulations due to a rate of sales below that which is expected.

However, for a perfectly competitive firm able to sell all it wants at the ruling market price, supplied by a perfectly competitive industry, reasons (ii), (iii) and (iv) are not relevant. Figure 3.5 below facilitates the analysis of the degree of production for inventory by competitive firms when their forecast for the price which will prevail next period, p_2, differs from the price prevailing this period, p_1. MC is the current marginal cost of production. Assuming increasing marginal storage costs of holding inventories, P_2BP_2' represents the net price expectation on each unit of current output.

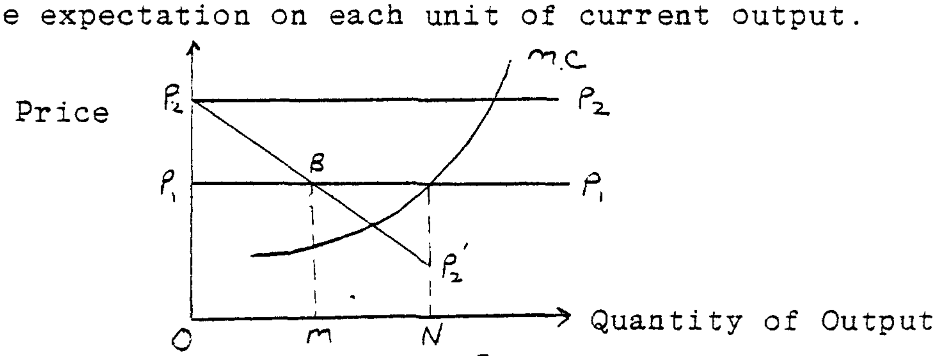


FIGURE 3.5

Until an output of OM has been reached it will be profitable to assign this period's output to inventory rather than sell it currently, for this will enlarge aggregate income by P_2BP_1. But beyond OM, current sales will be more lucrative than withholding for future disposal. Providing point B is to the left of the MC curve, the existence of inventories will not disturb the equality of current price and current marginal cost. If, however, point B is to the right of the MC curve, then all of current output will be held as inventory for sale next period and price will no longer equal marginal cost. In such a situation if the expected next period price increased, leading to an increase in output and employment, while this period's price diminished, leading to an increase in the real wage, then a positive relationship between real wages and employment would result. This, however, is quite an extreme case.

3.4 A Production Lag

3.4.1 Phelps[6] assumes a production and payment lag of one period, so that firms maximise the expected value of next period's profits and hire labour in the current period on the basis of the expected real wage. Also, the payment lag means that labour makes its work-leisure decision by evaluating the current wage at prices expected for next period. A less than perfectly flexible money wage is assumed so that a trade cycle can exist when both firms and labour hold the same expectations. Consider a recession involving a drop in the actual price from an initial position of fulfilled expectations.

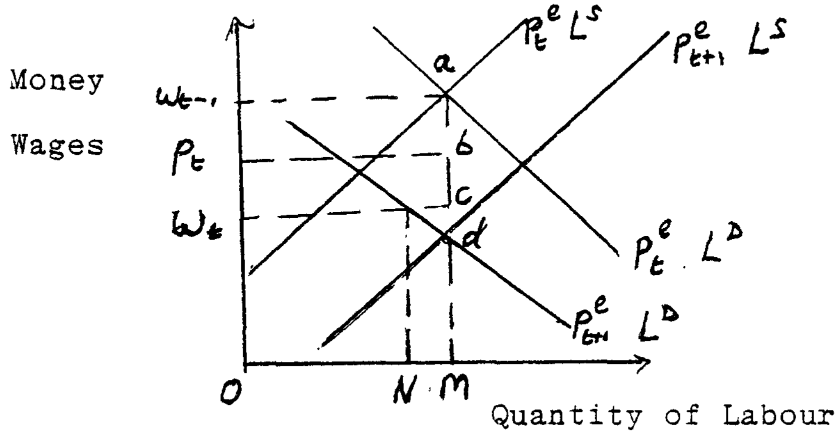


FIGURE 3.6

In figure 3.6 the intial equilibrium in period t-1 is at point "a" and $P^e_{t-1} = P_{t-1} = P^e_t$. However, prices in period t fall, and assuming extrapolative expectations this causes the expectation of prices which will prevail in t+1 to fall by a greater proportion. Thus actual prices between t-1 and t fall by ab/am. Since wages are less than perfectly flexible, it is possible for wages to fall by more than actual prices but by less than expected prices, in proportionate terms. Thus the expected real wage increases, so employment is lower than the natural rate (employment falls to ON from OM when expectations were fulfilled), while the actual real wage falls.

The drawback with this analysis by Phelps, is that it is inconsistent with the accelerationist position (which Phelps himself supports). In the above scenario employment is below its natural rate, $(L-\bar{L}) < 0$, but the expected real wage rises, $\dot{w}/w - \dot{p}/p^e < 0$, since both rates of change are negative. This outcome is inconsistent with the condition $(\dot{w}/w) - (\dot{p}/p)^e = \lambda\,(L-\bar{L})/\bar{L}$, when $\lambda > 0$ as the accelerationists assume.

Had the model been specified without the payment lag, but the demand for labour had continued to be a function of the expected real wage then necessarily the same problem would persist. Such a demand curve specifies a negative relationship between expected real wages and employment, so that starting from an initial position of fulfilled expectations if $(\dot{w}/w) - (\dot{p}/p)^e$ is positive then $(L-\bar{L})/\bar{L}$ must be negative, in contradiction to the accelerationist position. However, this analysis is incomplete since if there is a production lag without a payment lag, next period's expected selling price must be discounted.

3.4.2 Let us assume a production lag of one period and no payment lag. The objective of the firm is to maximise profits at time t,

$$(3.1) \quad \text{Max } \Pi_t = \frac{1}{(1+i)} P^e_{t+1} L^g - W_t L_t$$

$$\therefore \frac{d\Pi_t}{dLt} = \frac{1}{(1+i)} g P^e_{t+1} L^{g-1} - W_t = 0$$

$$(3.1a) \quad \therefore \log \frac{1}{(1+i)} + \log g + (g-1) \log L_t = \log W_t - \log P^e_{t+1}$$

$$(3.2) \quad \text{And } \log \frac{1}{1+i} = -\log (1+i) \simeq -i$$

$$(3.3) \quad \text{And also } i = r + \log P^e_{t+1} - \log Pt$$

Substituting in (3.1a),

$$\log L_t = \frac{1}{(g-1)} \log g + \frac{1}{(g-1)} (\log W_t - \log P^e_{t+1})$$

$$+ \frac{1}{(g-1)} (r + \log P^e_{t+1} - \log P_t)$$

$$(3.4) \quad \therefore \log L_t = \alpha + B(\log W_t - \log P_t) + Br$$

From equation (3.1) it can be seen that the discount factor cancels out when there is both a payment and a production lag. With only a production lag, though, the expectation of next period's price must be discounted by the nominal rate of interest i. After making the approximation (3.2), and substituting in Fisher's equation (3.3), we emerge with a demand-for-labour equation which is the usual function of real wages but with an extra term included-the real rate of interest. From IS/LM analysis we know that the real rate of interest itself will be expected to move over the trade cycle. The appropriate interest rate in the IS curve is the real rate of interest, whereas the appropriate interest rate in the LM curve is the money rate of interest. Therefore, if we draw the IS/LM curves in real interest/output space the LM curve will shift as changes in the rate of inflation cause the nominal rate of interest to diverge from the real rate of interest, as in figure 3.7 below.

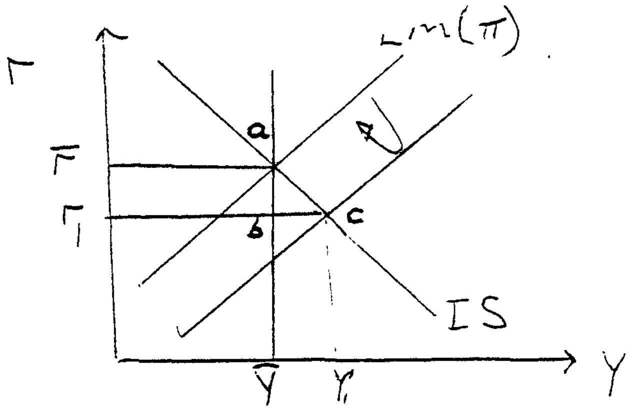


FIGURE 3.7

Using the triangle abc we can relate divergencies in the real rate of interest from its natural rate to divergencies in the level of output from its natural rate,

$$(r-\bar{r}) = (\text{slope of IS})\ (Y-Y)$$

$$\text{or } (r-\bar{r}) = K.\ (Y-\bar{Y}) \quad , \ K < 0$$

Since Y will be uniquely related to log L we can write,

$$(r-\bar{r}) = \Psi(\log L - \log \bar{L}) \quad , \quad \Psi < 0$$

and substitute this into equation (3.4),

$$(3.5) \quad \log L - \frac{(A + B\bar{r})}{(1-B\Psi)} + \frac{B}{(1-B\Psi)} (\log W - \log P)$$

where $B<0$, $\Psi<0$, and $\therefore B\Psi>0$. The question now is whether $B\Psi$ could be greater than one. If so, this relationship could explain the observed positive relationship between real wages and employment. We can get an idea of the magnitude of $B\Psi$ in the following way. First, to simplify let us group all interest sensitive expenditures into the group labelled "investment" and all income sensitive expenditures into the group labelled "consumption", and let us define $Y - C \equiv S$. Now equilibrium in the goods market will occur when,

$$S(Y) = I(r)$$

$$\text{and } \therefore \quad dr = \frac{S_y}{I_r} \, dY \qquad (3.6)$$

Now since $d \log Y = \frac{1}{Y} dY$ we may write (3.6) as,

$$dr = \frac{S_y}{I_r} \cdot Y \cdot d \log Y. \qquad (3.7)$$

Now the elasticity of aggregate demand with respect to the real interest rate, ε is,

$$\varepsilon = - I_r \cdot \frac{\bar{r}}{\bar{Y}} = - \frac{\partial I / I}{\partial r / \bar{r}} \cdot \frac{I}{Y} \qquad (3.8)$$

Estimates of the elasticity of investment expenditure with respect to interest rates,

$$-\frac{\partial I / I}{\partial r / \bar{r}}$$, vary from between .05 to .1,

while investment as a proportion of GNP is between .2 and .3. Combining the two lowest figures and the two highest puts $\mathcal{E}$ in the range from .01 to .03.

Now re-arranging (3.8)

$$Ir = -\mathcal{E}\frac{Y}{\bar{r}} \qquad (3.8')$$

Substituting (3.8$'$) into (3.7) we get,

$$dr = \frac{Sy \quad Y}{\frac{-\mathcal{E} \quad Y}{\bar{r}}} \; d \log Y = \left(\frac{\bar{r}\, Sy}{-\mathcal{E}}\right) d \log Y \qquad (3.9)$$

$$\therefore (r-\bar{r}) = -\left(\frac{\bar{r}\; S_y}{\mathcal{E}}\right) (\log Y - \log \bar{Y})$$

Since log Y = g log L we get,

$$(r-\bar{r}) = -\left(\frac{\bar{r}.\; Sy.\; g\;.}{\mathcal{E}}\right) (\log L - \log \bar{L})$$

$$\therefore \Psi = -\frac{\bar{r}\;.Sy\;.\;g}{\mathcal{E}} \qquad (3.10)$$

And also note that

$$\beta = \frac{1}{g-1}$$

Now $\bar{\Gamma} \triangleq .04$; Sy ranges from .2 to .4; while g ranges from .6 to .8; and ε ranges from .01 to .03. To find the smallest possible boundary for $B\Psi$ take the smaller values for Sy, and g; and the larger value for ε. Doing so results in a value of $B\Psi$ of 0.4 which is too small to cause the co-efficient in front of the real wage to become positive. To find the largest possible boundary for $B\Psi$ take the larger values for Sy and g; and the smaller value for ε. When we do this we get a value of $B\Psi$ of 6.4. Therefore, $B\Psi$ can be greater than unity and thus the existence of a properly discounted production lag could account for apparent procyclical movements of real wages, without the direct contradiction of the accelerationist position.[7]

3.5 Costs of Adjustments[8]

Another theory which admits positive correlation of real wages and employment, while still assuming profit maximisation and goods market clearing is Sargent's (1978)[9] partial adjustment model for labour demand. The specification of lagged adjustment was motivated by Neftci's (1978)[10] re-examination of the real wage - employment relationship for US data. After first filtering each series to obtain a white noise process, Neftci tested for a relationship between the resulting innovations in each series. He found a significant negative relationship between lagged values of the real wage and current employment; only the contemporaneous correlation had the "wrong" sign. Neftci criticised the earlier empirical studies for paying insufficient attention to lags and the specification of the error term.[11] The real wage-employment dynamics that stem from the partial adjustment approach are explained by reference to the following two models. We begin with the assumption that employment is equal to labour demand and then consider an alternative assumption that employment is the minimum of supply and demand.

3.5.1 Employment Equal to Labour Demand

We begin by considering the following model:[12]

$$Y = E(Y,r) + A, \tag{1}$$

$$\Psi(Y,r) = M/P, \tag{2}$$

$$Y = f(L,K), \qquad (3)$$

$$\dot{L} = \beta[L^{*}-L], \qquad (4)$$

$$L^{*} = F(W/P,K), \qquad (5)$$

$$S = S(W/P), \qquad (6)$$

$$\dot{W}/W = a(L-S)/S, \qquad (7)$$

where the notation is: A, autonomous real expenditure; E, induced consumption and investment expenditure; K, capital stock; M, nominal money stock; L, actual employment (which is equal to short-run or momentary labour demand); L^{*}, long-run demand for labour; P, product price; r, interest rate; S, long-run supply of labour; W, nominal wage rate; and Y, real output. The parameters (A and B) are positive, the dots stand for time derivatives and the signs of the derivatives of the behavioural functions (indicated by subscripts) are:

$\Psi_2, E_2, f_{11}, f_{22}, F_1 < 0, \Psi_1, f_1, f_2, f_{12} = f_{21}, F_2,$
$S_1 > 0$, and $0 < E_1 < 1$.

Equations (1), (2), and (3) are the standard IS, LM, and production function relationships. Equations (4) and (5) specify labour demand. Firms partially adjust their momentary demand for labour in the direction of the gap between their long-run desires and the existing level of employment.[13] The long-run desired level of employment, L^*, is defined by equation (5), which is a compact way of writing the marginal product real wage condition, $f_1(L^*, K) = W/P$. $F_1 < 0$ since $F_1 = f_1^{-1}$.

It is difficult to provide a fully satisfactory theory of the firm to justify equations (4) and (5). The standard approach is to posit profit-maximising firms with non-linear factor adjustment costs formally involved as a constraint. Adjustment costs are assumed for capital so that the usual finite ex ante investment function (an integral part of the IS relationship, see Sargent-Wallace[14]), can be derived. In some analyses adjustment costs for labour are considered, and as Brechling[15] (p.72-9) among others has derived, this results in the following set of first order conditions: $\left[K, L\right]' = Z\left[(K^* - K), (L^* - L)\right]'$, where Z is a (2 x 2) matrix of adjustment co-efficients. Equation (4) and our expenditure function E can be viewed as ad hoc simplifications in which the off-diagonal elements of Z are presumed to be zero. While this is clearly an arbitrary simplification, we make it to follow Sargent (1978). It is noteworthy that the existing theory of non-linear adjustment costs is even less applicable if we assume that firms encounter a quantity constraint in acquiring labour. This occurs if actual employment is specified to equal the lesser of demand and

and supply, so that employment equals supply some of the time. We consider this modification below. Until then, however, the easiest interpretation is that labour contracts are such that labour supply is completely elastic at a point in time when the money wage is rigid. If employment is different from desired labour supply (S) the wage is adjusted according to equation (7).[16]

Full equilibrium in the model exists when wages are constant (implying that L=S) and when the long-run demand is met ($L^*=L$). We examine the dynamics about this equilibrium by reducing the system to a set of two differential equations in employment and the real wage ($w = W/P$), and drawing a phase diagram.

By substituting (5) into (4) we have

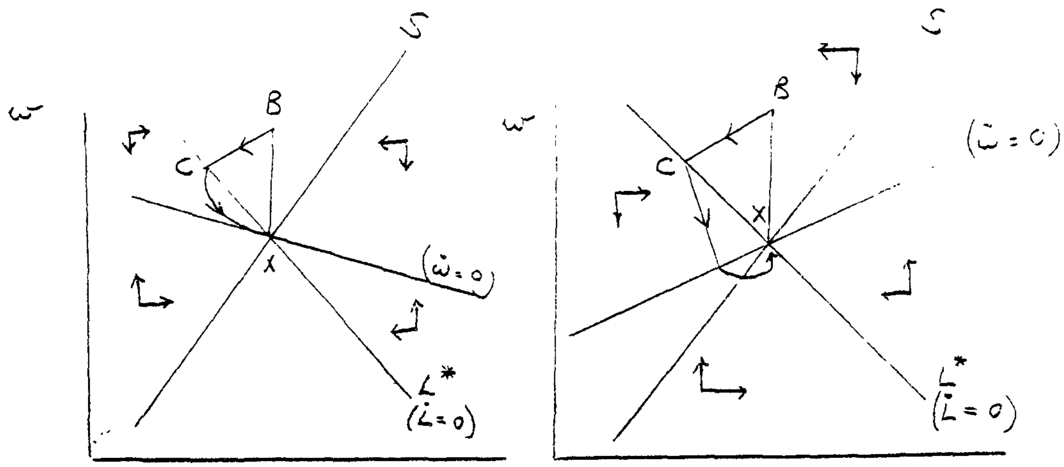
$$\dot{L} = \beta \left[F(w) - L\right], \qquad (8)$$

and by eliminating Y and r from (1), (2) and (3) we have

$$P = G\,(L,\ A,\ M), \qquad (9)$$

where $G_1 < 0$ and G_2, $G_3 > 0$. By taking the time derivative of (9) and substituting it, (6), (7), and (8) into $\dot{w}/w = \dot{W}/W - \dot{P}/P$ we have

$$\frac{\dot{w}}{w} = a\left[\frac{L-S(w)}{S(w)}\right] - \frac{G_1 \beta}{P}\left[F(w) - L\right] - \frac{G_2}{P}\,(\dot{A}), \qquad (10)$$



(a) FIGURE 3.8 (b)

assuming $\dot{M} = 0$. We construct the phase diagram from equations (8) and (10). The slopes of the $\dot{L} = 0$ and $\dot{w} = 0$ loci are derived by taking the total differential, while holding $\dot{L} = \dot{w} = \dot{A} = \dot{M} = 0$. We have

$$\text{slope } (\dot{L} = 0) = \frac{dw}{dL} = \frac{1}{F_1} < 0, \tag{11}$$

$$\text{slope } (\dot{w} = 0) = \frac{dw}{dL} = \frac{a/S + G_1 \;\_\; /P}{aS_1/S + G_1 \;\; F_1/p} \gtrless 0 \tag{12}$$

If expression (12) is subtracted from (11) we have

$$\frac{a(S_1 - F_1)}{SF_1((aS_1/S) + (G_1\beta F_1/P))} < 0,$$

so expression (12) is algebraically larger and the only possible drawings of the phase diagram are given in the two panels of Fig. 3.8 . It should be noted that the $\dot{L} = 0$ locus is the long-run demand curve, L^*. The arrows of motion are derived as follows. Taking equation (10) first, an increase in w reduces $\alpha\left[\frac{L}{S(w)} - 1\right]$, and reduces

F(w). Since $G_1 < 0$ the total effect is negative. Therefore real wages decrease when we are above the $\dot{w} = 0$ locus. From equation (8) an increase in w reduces F(w) and therefore causes $\dot{L} < 0$.

As a sample of the dynamics which are possible, consider a once-for-all decrease in real autonomous expenditure (A). At a point in time, employment is given and the price level is bid down; hence, the initial disturbance is to some point like B. As time proceeds, the adjustment follows path BCX back to equilibrium. A positive correlation between employment and the real wage is observed for the BC portion of this adjustment (and in later stages as well in Fig.3.8 (b). Thus, the partial adjustment theory of demand can rationalise the observed employment - real wage correlations.

The difficulty with this model is that with short-run labour demand always being satisfied, job vacancies as normally defined (i.e. D-L) cannot exist. Another way of stating this difficulty is that no adequate explanation as to why employment often exceeds desired supply has been given. It is for this reason that many analysts prefer the specification that actual employment equal the lesser of labour demand and supply (the short side of the market dominates). We now consider this variant of the adjustment cost model.

3.5.2 Employment Equal to Minimum of Demand and Supply

The model now examined consists of equations (1), (2), (3), (5), (6), and the following new relationships:

$$\dot{D} = \beta(L^* - D), \qquad (4a)$$

$$\dot{W}/W = a(D - S)/S , \qquad (7a)$$

$$L = \min(D,S), \qquad (13)$$

where all variables are defined as before except that D now represents short-run or momentary labour demand, and L is actual employment.[17] We now show that this model suffers from the same unappealing feature as that of Buiter-Lorie, so that adjustment costs in the context of L = min (D,S) are not sufficient to 'explain' the 'stylised facts'.

We derive the phase diagram for this variant of the adjustment cost model in a similar manner, but this time draw it for the W and D variables. For points to the left of the supply curve L = D, and the derivation is precisely the same as before. For points to the right of the supply curve L = S, so the equations used for this part of the phase diagram are:

$$\dot{D} = \beta \left[F(w) - D\right] \qquad (14)$$

from 4(a) and 5(a), and

$$\frac{\dot{w}}{w} = a\left[\frac{D-S(w)}{S(w)}\right] - \frac{G_1 S_1 W}{P}\frac{\dot{w}}{w} - \frac{G_2}{P}\dot{A} \qquad (15)$$

from (6), (7a) and the time derivatives of (9) and the real wage identity $w = W/P$. The slope of the $\dot{D} = 0$ locus (derived from (14) and evaluated in the neighborhood of full equilibrium) is $1/F_1 < 0$. By re-arranging (15) we obtain

$$\dot{w}/w = \theta\, a(D/S(w)-1) \quad \text{where } \theta = \frac{1}{1+G_1 w S_{1/P}}$$

Therefore the slope of $\dot{w} = 0$ locus is,

$$0 = \theta \left(\frac{dD}{S} - \frac{D}{S^2} S_1 dw\right) \qquad (15')$$

$$\text{or} \quad \frac{dw}{dD} = \frac{1}{S_1} > 0$$

again evaluating in the neighborhood of full equilibrium ($D = S$). Thus the two possible drawings of the phase diagram are given in the two panels of figure 3.9 . There are some slight variations in the slopes of the loci drawn in figure 3.9 which are possible, but they do not affect the argument.[18]

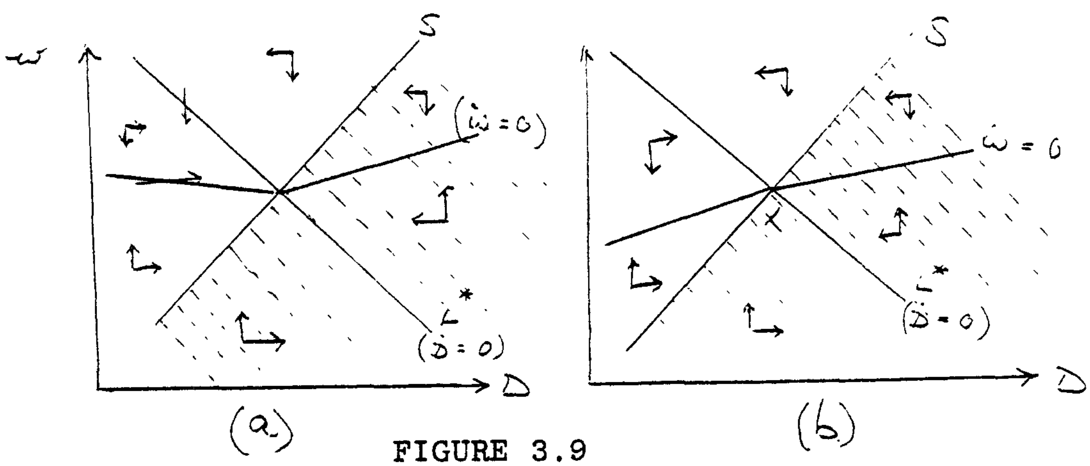


FIGURE 3.9

The arrows of motion to the right of the supply curve are derived by using equations (14) and (15'). From equation (14) if we are initially on the D = 0 locus, but we now increase w, F(w) falls causing $\dot{D}$ to be negative. From equation (15') if we assume that θ is positive, increasing w increases S(w) causing $\dot{w}$ to decrease. The arrows of motion shown in the diagrams assumed $\theta > 0$. If $\theta < 0$ then the model is unstable. The presumption of stability can be defended by the following argument.

$$\frac{G_1 S_1 w}{P} \quad \text{can be written as} \quad \left(\frac{dP}{P.dL}\right)\left(\frac{ds}{dw}\, w\right)$$

which in turn can be written as $\left(\frac{dP}{dY}\ \frac{Y}{P}\right)\left(\frac{dY}{dN}\ \frac{L}{Y}\right)\left(\frac{ds}{dw}\ \frac{w}{s}\right)$

or as $\frac{1}{n}$ (Υ) $(\mathcal{E})$, where n is the price elasticity of aggregate demand, Υ is labour's exponent in a Cobb-Douglas production function, and $\mathcal{E}$ is the real wage elasticity of labour supply. Equations (1) and (2) can be used to derive an expression for n. Totally differentiating (1) and (2) we get,

$$\begin{bmatrix} (1 - Ey) & -Er \\ \Psi_Y & \Psi_r \end{bmatrix} \begin{bmatrix} dY \\ dr \end{bmatrix} = dA \begin{bmatrix} 1 \\ 0 \end{bmatrix} + dm \begin{bmatrix} 0 \\ 1/p \end{bmatrix} + dp \begin{bmatrix} 0 \\ \frac{-m}{p^2} \end{bmatrix}$$

Using Cramer's rule,

$$\frac{dy}{dp} = \frac{-m/p^2\ Er}{(1-Ey)\Psi r + \Psi y\ Er}$$

$$\frac{P}{Y}\ \frac{dY}{dP} = \frac{-\ m/py}{(1-Ey)\ \frac{\Psi r}{Er} = \Psi y}$$

This expression can be evaluated by using the following information,

(i) The income elasticity of money demand,

$$\frac{d\,M/p}{dY}\ \frac{Y}{M/p} = 1$$

(ii) The marginal propensity to spend, $Ey = 0.6$

(iii) The autonomous expenditive multiplier on aggregate demand $= 1.5$. Using Cramer's Rule on the totally differentiated versions of equations (1) and (2), we get,

$$\frac{dY}{dA} = \frac{1}{(1-Ey) + \Psi y \left(\frac{Er}{Lr}\right)} = 3/2$$

(iv) The velocity of circulation, $PY/M = 2\ 1/2$. From (i), $\Psi y \frac{Y}{M/p} = 1$, and from (iv), $PY/M = 5/2$, which implies that $\Psi y = M/yp = 2/5$. Plugging this information into (iii) we can deduce that $Er/\Psi r = 8/12$.

$$\text{Therefore, } n = \frac{p}{Y} \cdot \frac{dY}{dP} = \frac{-2/5}{(1-0.6)(12/8) + (2/5)} = -.5$$

Since τ is in the region of 0.7 and ε is thought to be quite low (less than 0.5), $\left(\frac{1}{n}\right)(\tau)(\varepsilon)$ would seem to be greater than -0.7, thus assuring stability.

Returning to figure 3.9 since $L = \min(D,S)$ the actual employment observations are given by the arrows of motion subject to the constraint that L values in the shaded region cannot exist. The main problem with the predictions of this model, which involves inflationary shocks in A, can now be explained. An increase in A pushes the employment point down the supply curve and employment must decrease, since the lags in the demand process now play no role in determining actual employment. If business cycles involve a series of shocks in A which push the real wage above and below X, then this model generates the same unfortunate feature as that of Buiter-Lorie: that the cycle in employment and output is twice as frequent as that in A. In addition this model cannot explain the co-existence of unemployment and vacancies.

3.6 Multi-Market Disequilibrium Models

Walras' Law states that the sum of the excess demands across all markets must equal zero. In the previous analysis any excess demand for labour was implicitly reflected in an excess supply of bonds, while the goods market was continuously cleared. In the following models the goods market is not assumed to clear continuously.

3.6.1. Patinkin's Contribution

In Chapter 13 of "Money Interest and Prices"[19] Patinkin argued that under conditions of general excess supply the effective demand for labour will diverge from the marginal product of labour curve. When excess supply prevails the demand for labour will be the minimum amount necessary to produce the quantity of output demanded. Thus if the production function is $Y = F(L)$ and excess supply prevails when the quantity of output demanded equals Y_1, then the demand for labour will be $L = F^{-1}(Y_1)$, a quantity which is insensitive to the real wage. Patinkin further argued that a condition of excess supply of goods was not an equilibrium position since prices and wages will be changing out of equilibrium and these will have wealth effects which tend to bring the system back to equilibrium. For Patinkin involuntary unemployment is a dynamic disequilibrium phenomenon and the essence of dynamic analysis is involuntariness.

To illustrate this model consider the labour and commodity markets initially at full employment, but subsequently disturbed by a downward shift in the total expenditure function.

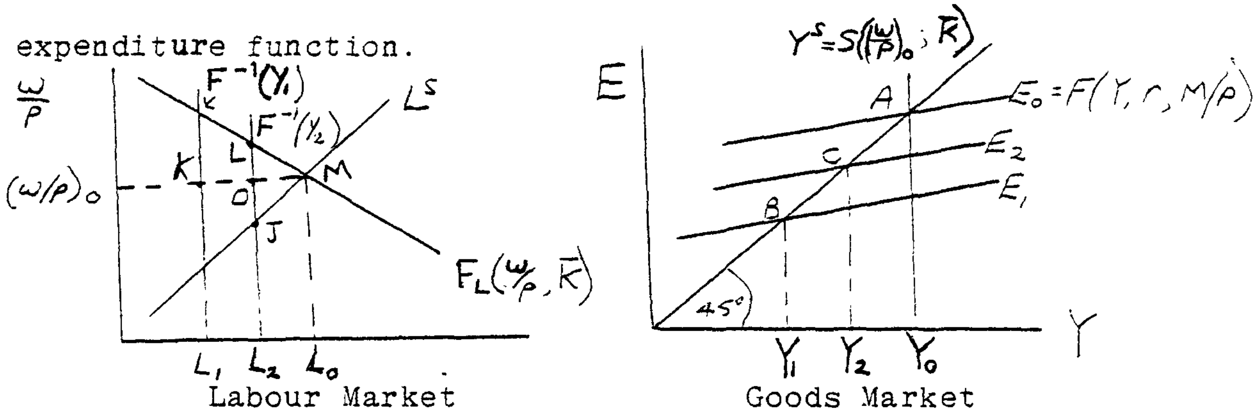


FIGURE 3.10

Total expenditure, E, is a function of the level of output, Y, interest rates, r, the level of real balances $\frac{M}{P}$, and the animal spirits of entrepreneurs. The fall in the demand for goods from E_0 to E_1 may be accompanied by an increase in the demand for bonds causing interest rates to fall and ameliorating the decrease in total expenditure. If, however, total expenditure is insensitive to interest rate changes then it will remain at E_1, and the quantity of output demanded will be Y_1. Producers will react to accumulating inventories by selecting the minimum quantity of labour necessary to produce Y_1 and this is determined by $F^{-1}(Y_1)$. With no change in wages or prices discussed so far, the economy moves from point M to K in the labour market and from points A to B in the goods market, in figure 3.10

In Patinkin's model wages and prices adjust according to the following specification;

$$\dot{w} = B\,(D - L^S)$$
$$\dot{p} = \alpha\,(Y^A - Y^S)$$

D is the labour actually demanded and is the minimum of F_L and $F^{-1}(Y)$. Y^A equals actual output (equal to output demanded), and Y^S equals desired output as determined by the quantity of labour the firm would like to hire with unconstrained profit maximisation at the ruling real wage.

That is,

$$Y = F(L, \bar{K})$$

$$\text{and} \quad \frac{w}{p} = F_L(L, \bar{K})$$

$$\therefore \; L^D = F_L^{-1}(W/P, \bar{K}) = G(W/P, \bar{K})$$

$$\therefore \; Y^s = F(G(W/P, \bar{K}), \bar{K}) = S(W/P, \bar{K})$$

With Patinkin's specification of wage and price adjustment it is apparent that points K and B do not represent an equilibrium situation. With real wages still $(W/P)_o$ firms would still like to supply Y_o. Therefore, even though at point B actual output produced is equal to output demanded, prices fall. At K labour demanded is less than labour supplied and therefore wages fall. If wages and prices fall in the same proportion the real wage remains at $(W/P)_o$ and the desired supply of output remains at Y_o. But as prices fall the quantity of real balances increases causing aggregate demand to increase, pulling up actual output and employment until the economy is once more back in equilibrium at M and A. In this scenario the real wage (which remains fixed at $(W/P)_o$) would be unrelated to employment (which fluctuates between L_o and L_1). If the wage rate falls relatively slowly, the real wage rises and the economy may arrive at a position such as L in the labour market. The rise in W/P has now reduced the desired supply of output to Y_2 equal to output demanded and prices stop falling. Only the excess supply of labour remains causing prices to fall and real balances to increase, until the economy again reaches full equilibrium. In this case, the movement in the labour market was from K to L to M, and real wages are first positively correlated with employment and then negatively correlated. Finally, if wages fall faster than prices, the desired supply of output moves to the right of Y_o and the labour market may arrive at a point such as J. At this point wages stop falling, though since prices continue to fall, the real wage increases and employment moves up the supply of labour curve. In this case there is an initial negative correlation between W/P and employment, from K to J, followed by a positive correlation, from J to M. No matter what the relative speeds of adjustment are, though, the economy will arrive back at full equilibrium providing aggregate expenditure is sensitive to the level of real balances.

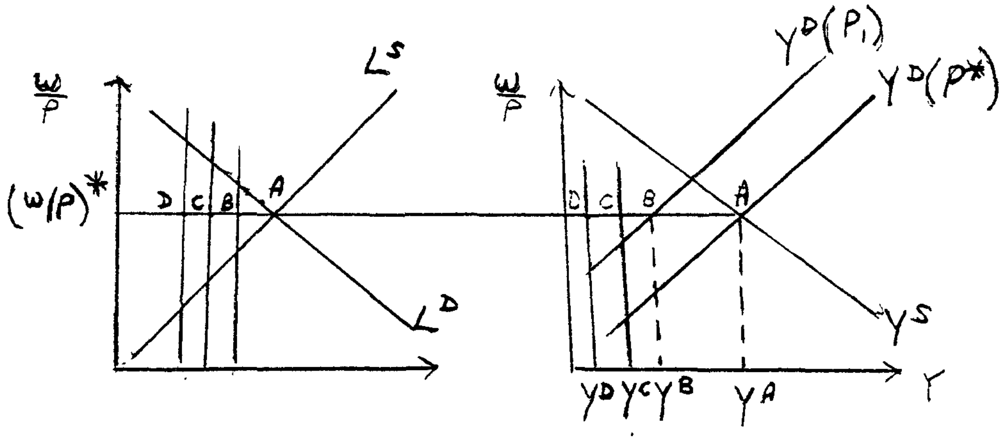
In Patinkin's analysis the output produced is always equal to the output demanded. He does not consider the case of an excess demand for goods, where this assumption would no longer hold. It is the contribution of Barro and Grossman to extend Patinkin's analysis to the case of an excess demand for goods and to work through the

the spillover effects between the goods market and the labour market.

3.6.2 Barro and Grossman's Analysis[20]

Besides extending Patinkin's analysis to the case where excess demand prevails, Barro and Grossman also show how a Keynesian multiplier process can be derived as a result of the quantity rationing of sellers when they are constrained to trade at non market clearing prices.

The diagrams below, figure 3.11, differ from Patinkin's only for the goods market where instead of showing the Keynesian cross, the analysis is in terms of the notional demand and supply of goods, in order that the multiplier process may be derived step by step. The notional supply of commodities is a downward sloping function of the real wage because of diminishing marginal productivity. The notional demand for commodities is an upward sloping function of the real wage because leisure and consumption are substitutes (and the real wage measures the opportunity cost of leisure) and because at a higher income more will be consumed. Consumption is also a positive function of the level of real balances.

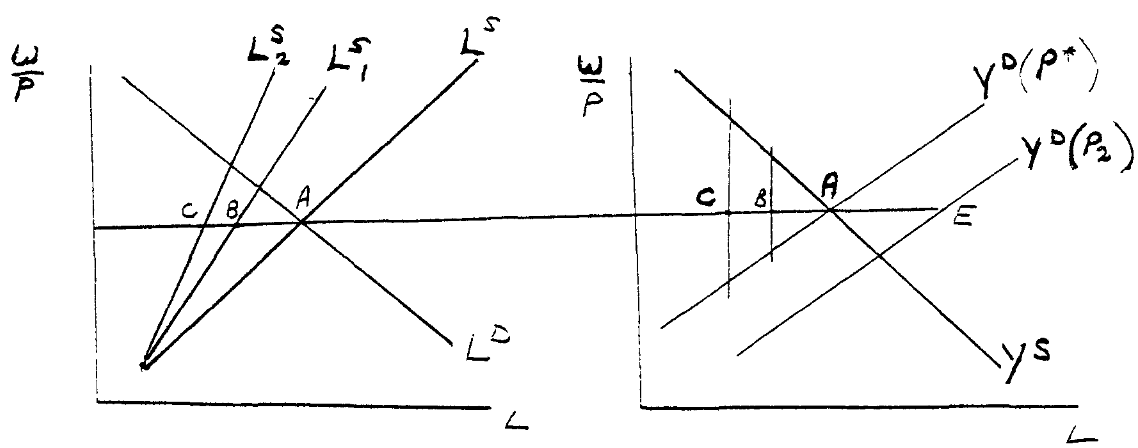


Labour Market Goods Market

FIGURE 3.11

Initially both the goods and labour market are in equilibrium at points A in both diagrams. Then it is assumed that the auctionneer calls out a price $P_1 > P^*$. This reduces the level of real balances and causes notional demand to be reduced for any given real wage rate. At $(W/P)^*$ there is now an excess supply of goods equal to BA. Just as in Patinkin, since only Y^B output is being sold, the demand for labour falls to $F^{-1}(y^B)$. This further reduces the demand for goods, since the new notional demand for goods is now constrained by the excess supply in the labour market. The demand for goods now falls to Y^C which reduces the demand for labour to $F^{-1}(Y^C)$ which further reduces the demand for goods. Eventually the multiplier process reaches a limit since each reduction in employment and income reduces consumption by a lesser amount, because the marginal propensity to consume is less than one. The economy is now at position D in both markets, which is stable given a real wage of $(W/P)^*$ and a price level of P_1. If wages and prices are allowed to move in the direction of excess demands (which are negative in this case), then the economy will gradually creep back to equilibrium, because of the real balance effect in the effective demand for goods, just as in Patinkin.

Let us next consider the case neglected by Patinkin, of excess demand for goods. We begin, as before, at equilibrium in both markets. The auctionneer calls out a price which is too low, increasing the level of real balances, and increasing the notional demand curve for goods at any given real wage rate. This causes an excess demand for goods equal to AE in figure 3.12 below;



Labour Market Goods Market

FIGURE 3.12

Though output initially remains at A, households now find that they cannot buy all that they want, and they react by substituting leisure for consumption causing the effective supply of labour to fall. This reduction in labour supply reduces the amount of output produced causing it to fall below the notional supply. This further increases the excess demand for goods which causes another reduction in labour supply. The process comes to a halt since on the supply of labour side, leisure is an imperfect substitute for consumption so that any given increase in excess demand causes a smaller reduction in labour supply; and on the supply of output side, diminishing returns to labour cause any given reduction in labour supply to have a proportionately smaller impact on the supply of goods as employment falls. These multiplier effects are assumed to be instantaneous, the complete quantity multiplier working itself out before prices and wages begin to adjust. Just as in the excess supply case, price and wage adjustment would bring about a gradual return to full equilibrium through the real balance effect.

The analysis of Barro and Grossman compliments that of Patinkin. Clearly in both analyses the equality of the real wage and the marginal product of labour is broken, and procyclical movements of real wages are possible. The main weakness of both analyses is that they fail to offer an explanation as to how prices are formed beyond the crude hypothesis that they move in the direction of excess demands. This is an important weakness since the assumption that prices fail to respond quickly enough to clear markets lies at the heart of the approach. Nor does it explain why agents should be constrained to trade at these prices nor why they fail to perceive the opportunity for mutually beneficial trading at prices different from the ruling market price. Yet strangely they do not, but rather they leave the market and rework their utility maximisation problem at these given prices. The weakness of this approach suggests that if we must resort to the hypothesis of disequilibrium and sticky prices, we should do so as little as possible (i.e. it is better to confine it to one market). Another weakness of the approach is the prediction that employment and output must fall when aggregate demand increases from an initial position of full equilibrium or even of generalised excess demand. This is an unfortunate prediction given the observed positive correlation of aggregate demand and output. The ability to explain deviation amplifying forces as a result of quantity rationing is not really such a great achievement. Such a multiplier process can be derived even when markets do clear providing that the reduction in output and employment be associated with a reduction in the typical household's expected lifetime wealth, causing a secondary reduction in aggregate demand that is not fully anticipated by all price setters[21]. Finally the model does not address the co-existence of unemployment and vacancies.

3.6.3 The Solow and Stiglitz Model[22]

Solow and Stiglitz construct a dynamic model incorporating disequilibrium in the goods and labour market and costs of adjustment on labour demand. Since any one of these features is sufficient to remove the counter cyclical real wage prediction their model is open to the criticism of being unnecessarily complicated.

The outline of their model is as follows. They assume a short run production function,

(1) $Y = F(L) \qquad F' > 0 \qquad F'' < 0$

and also perfect competition and profit maximisation. Aggregate supply is that output which results from the employment level which equates the marginal product to the real wage;

(2) $Y^S = F(F_L^{-1}(W/P)) = G(V), \quad G'(V) < 0$

They define the momentary supply of output as completely inelastic at the ruling employment level.

(3) $Y^* = F(L)$

Employment adjusts towards the minimum of desired supply of output Y^S, and aggregate demand;

(4) $\dot{L} = \theta \ (F^{-1}(\min(Y^S, Y^D) - L)$

On the aggregate demand side investment is treated as enogenous and different marginal propensities to save wage and profit incomes are incorporated,

(5) $Y^D = I + (1-S_w) V_L + (1-S_p)(Y^D - V_L)$

The definition of profit income in equation (5) above as $Y^D - V_L$ is unobjectionable when actual output is constrained by Y^D. When actual output is less than Y^D equation (5) is strictly speaking mispecified, but since Y^D would still be an increasing function of the real wage there would be no qualitative difference to the results.

Actual output is defined as the minimum of Y^* and Y^D.

(7) $Y^A = \min(Y^*, Y^D)$

Prices are assumed to adjust in the direction of excess demand or supply. Since we have now defined actual output, Y^A, momentary supply, Y^*, desired supply, Y^S, and output demanded, Y^D, there will inevitably be some arbitrariness about the way this excess demand is specified. It is assumed that prices adjust to short run excess demand and are partially cost determined;

(8) $$\frac{\dot{p}}{p} = g\left(\frac{Y^D}{Y^S}\right) + j\,\frac{\dot{w}}{w}$$

A vertical labour supply curve is assumed. The main influence on the level of wages is taken to be the ratio of current employment to the supply of labour (again an arbitrary choice), and changes in the price level are allowed to react back on the rate of change of wages;

(9) $\frac{\dot{w}}{w} = h \frac{L}{L^S} + k \frac{\dot{p}}{p}$

The model is analysed by deriving two loci in real wage employment space, the $\dot{V} = 0$ locus and the $\dot{L} = 0$ locus.

In evaluating this model we should note that in the specification of equation (4) the possibility that employment is constrained by the supply of labour is not recognized. In this specification there is the implicit assumption that unless quantity constraints from the goods market are encountered, labour demand will always be satisfied. Therefore, it suffers from the same defect as the model in section 3.5.1 of this chapter, in that no explanation is given as to why employment may exceed desired supply, and that job vacancies do not exist in this model. Furthermore the price level is left indeterminate in this model as a result of ignoring the monetary sector. Neither the rate of interest nor the level of real balances affects the demand for goods and moreover none of the functions in the model are influenced by the price level independently of the real wage. Consequently the level of money wages and prices is left indeterminate. This also means that unlike the other models considered in section 3.5, and unlike Patinkin's model, there is no tendancy for the model to return to a full classical equilibrium position. As far as distribution is concerned, the real wage may never exceed the marginal product of labour in a short run equilibrium position and it will be smaller than that marginal product in a demand constrained equilibrium. Between equilibrium positions it is determined by a combination of relative speeds of adjustment, costs of adjustment, and the difference in the propensities to spend out of wage income and profit income.

3.7 Concluding Remarks

This chapter has surveyed those amendments which introduce dynamic elements into the standard Keynesian textbook model.Section 3.1 argued that technical change could disrupt a negative relation between real wages and employment, creating the erroneous impression of a positive relationship, unless we have an explicit model explaining technical change. The development of such a model would be an interesting area for future research. Section 3.2 dealt with the micro model of Phelps and Winter. This model is not sufficiently well motivated as far as the cyclical relationship of real wages is concerned, and would be difficult to apply in a macro context. The third section argued that the existence of inventories does not disrupt the equality between price and marginal cost (and therefore between real wages and labour's marginal productivity), unless nothing is produced for current sale. The first section , therefore, pointed out the need for a model, the second section pointed out the inapplicability of a model, and the third section pointed out the irrelevance of an issue to the problem at hand.

Section 3.4 argued that Phelps' production and payment lag model is inconsistent with the accelerationist position which he himself supports. We then proceeded to build an alternative production lag model which avoids this feature. A simple costly adjustment model is presented in section 3.5 under two different assumptions about the determination of employment, beginning with employment equals labour demand. The modification to this model, to allow for the domination of the short side of the market, necessarily entails the unfortunate prediction that employment must fall given an increase in aggregate demand at an initial position of full equilibrium. Section 3.6 discusses the multi-market disequilibrium models. In addition to complexity , one unfortunate feature of these models is, once again, the prediction that employment must fall from its full equilibrium level given an increase in aggregate demand.

FOOTNOTES

Chapter 3

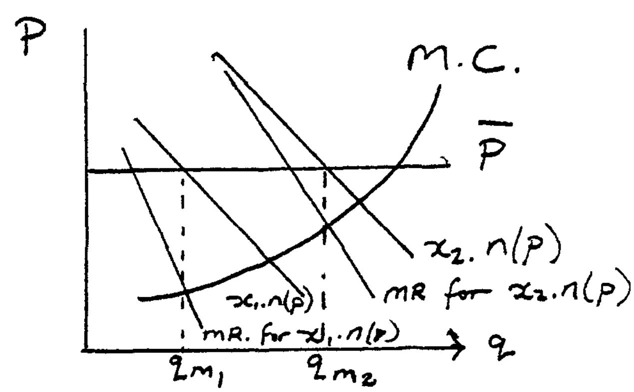
1. See chapter 5.

2. The importance of the choice of initial and terminal years has been illustrated by the different conclusions reached by Feldstein and Nordhaus about the long run trend of the U.S. profit share. See Brookings Papers 1977 and 1974 respectively, and the May 8, 1977, edition of the "New York Times" for the article called "Debate on Profits" by R.Magneson.

3. If relative shares are constant along a given O/L ratio technical change is "Solow neutral". If relative shares are constant along a given O/K ratio, technical change is "Harrod neutral", and if constant along a given K/L ratio it is called "Hicks neutral". If an invention is labour saving, then the relative share of labour becomes lower after the invention. The labour saing nature of the invention must be defined in relation to Hick's fixed K/L, Solow's fixed O/L, or Harrod's fixed K/L.

4. Phelps and Winter, "Optimal Price Policy under Atomistic Competition", in Phelps et. al., "Micro Economic Foundations of Employment and Inflation Theory, New York, 1970.

5. It may be asked whether the monopolistic solution is unique. However the following diagram is not possible:



Marginal revenue is a function of the price and the elasticity of demand at that price. From the

5. (continued)
industry demand curve, at price $\bar{p}$, there will be an elasticity of demand and an associated marginal revenue. The uniqueness of the monopolistic solution is guarenteed since the elasticity of the firm's demand curve is equal to the elasticity of the industry demand curve at any price. This is easily shown, where Q=n(P) is the industry demand curve, and q=x.n(P) is the firm's demand curve.

$$\text{Elasticity of industry demand} = \frac{P}{Q}\cdot\frac{dQ}{dP} = \frac{\bar{P}}{n(\bar{P})} : n'(\bar{P})$$

$$\text{Elasticity of firm's demand} = \frac{P}{q}\,\frac{dq}{dP} = \frac{P}{x.n(\bar{P})}.\ x.n'(P) = \frac{\bar{P}.n'(\bar{P})}{n(\bar{P})}$$

Given $\bar{P}$ and the elasticity, the height of the marginal revenue is determined, which ensures a unique intersection with the marginal cost schedule.

6. Phelps, E.S., "A Note on Short Run Employment and Real Wage Rate Under Competitive Commodity Markets", <u>International Economic Review</u>, 1969, 220- 232.

7. It is interesting that two explanations for the Lucas supply story have been focused upon to the neglect of a third explanation, a production lag. This neglect is an important omission because the other two explanations are problematic. These are:

1) intertemporal substitution ,

2) uncertainty about the current general price level.

The first explanation was rigorously worked out by Lucas and Rapping in the context of adaptive expectations (in the Phelps 1970 volume) and Minford and Peel found(Oxford Economic Papers 1980) that they were unable to find underpinnings for this version of the Lucas equation when rational expectations were assumed.
The second explanation is problematic for reasons analysed in Phelps and Winter (see section 3.2). The general price level is an average of industry prices. If the general price level is unknown then the industry prices are unknown. But if consumers do not know the ruling industry price, then it does not pay the firms in the industry to act as perfect competitors. Rather they should exploit their instantaneous monopoly power.

7. (continued)
On the other hand the existence of a production lag is not only a priori extremely reasonable, but also allows one to derive a Lucas supply curve without much fuss. Whether this Lucas-type supply curve contains the neutrality proposition of Sargent and Wallace, and whether it implies the same conclusions about the relative effectiveness of fiscal and monetary policy as the other versions of the Lucas supply curve is being investigated by the author.

8. Parts of this chapter and of chapter 5 have already been published in a joint paper with Professor Scarth entitled "The Real Wage Employment Relationship", Economic Journal, 1980, 85-94.

9. Sargent, T.J., "Estimation of Dynamic Labour Demand Schedules Under Rational Expectations", J.P.E., 1978, 1009-44.

10. Neftci, S.N., "A Time Series Analysis of the Real Wages-Employment Relationship", J.P.E., 1978, 281-91.

11. See chapter 7 for a full discussion of Neftci's contribution.

12. This specification simplifies Sargent's model of labour demand in two respects: Sargent adds rational expectations, and the Lucas-Sargent-Wallace aggregation feature. Neither of these effects are essential for deriving the effects of partial adjustment which we stress. In Sargent's model labour demand and supply are equal at every point in time, and it is shocks to the supply curve which are implicitly assumed to indentify the labour demand curve he estimates. We assume that the money wage adjusts at a finite rate so that a gap between labour demand and supply exists in the short run. It is unfortunate that the standard theoretic underpinnings for the partial adjustment equation which we use involves static expectations when wages and prices are changing in the model. Nevertheless, Sargent makes the implausible asumption of no adjustment costs for capital (as we do).

13. Solow and Stiglitz have constructed a model involving a partial adjustment of employment function, but our model has two relatively appealing features: (i) our model is simpler in that disequilibrium

13. (continued)
in the goods market is avoided; and (ii) return to a full classical equilibrium is possible in our model (but not in that of Solow and Stiglitz;see their page 550).

14. Sargent and Wallace, N. (1971), "Market Transaction Costs, Assets demand Functions, and the Relative Potency of Monetary and Fiscal Policy". Journal of Money, Credit and Banking,pp. 469-505.

15. Brechling, F.P.R.(1975), "Investment and Employment Decisions", Manchester University Press.

16. Given that many authors (e.g., Laidler, 1976) explain their price change equations solely by reference to firms, these labour supply assumptions are quite common.

17. Readers may be concerned that equation (4a) appears to stem from adjustment costs on labour demand as opposed to actual employment levels, and would therefore prefer D=B (L*-L). We argue below that none of our arguments are affected by this change. In any event, both specifications are arbitrary in that quantity constraints have not been introduced in any of the existing micro derivations involving adjustment costs.

18. For example, the section of the w=0 locus to the right of the supply curve can be steeper than the section to the left of it. Also, as previously noted, some readers may prefer that equation (4a) be replaced with D=B(L*-L). If this is done the D=0 locus is horizontal to the right of the supply curve, but again our arguments are unaffected.

19. Don Patinkin, "Money Interest and Prices", Harper International, 2nd Edition, 1965.

20. Barro and Grossman, "A General Disequilibrium Model of Income and Employments", AER 1971, and Money, Employment and Inflation", Cambridge University Press, 1976.

21. This point was made by Peter Howitt, "Evaluating the Non-Market clearing Approach", AER May 1979.

22. Solow and Stiglitz, "Output Employment and Wages in the Short Run," QJE November 1968.

CHAPTER 4

A BRIEF SURVEY OF THE EXISTING THEORIES AND AN ALTERNATIVE MODEL

The purpose of this chapter is twofold. First to critically review the theory described in chapters 2 and 3, and to point out a need for a further theoretical contribution, which is then presented. Second, to show how the various models discussed relate to the standard textbook model by showing how those models can be derived from the textbook model by an appropriate removal of assumptions. The chapter is split into three sections. Section 4.1 reviews the theory of chapters 2 and 3, section 4.2 presents a theoretical contribution which is not subject to the weaknesses of the other contributions, and section 4.3 shows the relationship between those theoretical models seeking to explain procyclical movements of real wages and the standard model.

4.1 A Brief Survey of The Theory

The theory of chapter 2 falls into three types. First, general difficulties of aggregation are considered which make any movement from a coherent micro structure to a predictable macro structure problematic. Unfortunately these difficulties are part of any macro analysis. Second, the possibility of giving up the static assumptions which give rise to the countercyclical prediction, (perfect competition and diminishing returns), was considered. We concluded that there were serious costs involved in giving up these assumptions. In particular a loss of simplicity, a loss of predictive power and even the loss of a theory of distribution. Typically analysts have been unwilling to abandon these assumptions and it is suggested that the cause may be found in the costly nature of removing them. Third, comes those contributions which do not remove the countercyclical real wage prediction from the standard model, but rather refine and clarify the precise nature of that prediction. Here we learn that the appropriate wage and employment concepts refer to straight time work only, or to overtime work only, but not an average of the two; that the appropriate price concept is the own product price net of the cost of imported intermediate inputs; and that any measure of the labour capital ratio should take into account the utilisation of capital.

In contrast, chapter 3 deals with those models which do remove the countercyclical real wage prediction, all of them being dynamic models. The first model we considered was by Phelps and Winter, who removed the assumption of perfect information in a competitive micro setting. This model entails giving up the simplicity involved in assuming competition, firms being endowed with instantaneous monopoly power. The problem here would seem to be that the search for a model to explain procyclical real wage movements only makes sense if we are unwilling to abandon the perfectly competitive micro base, because if we do abandon it, procyclical real wages can be derived immediately. Therefore, it would seem that the Phelps and Winter model is not adequately motivated as far as the real wage issue is concerned. Apart from this, it is not clear how the model would be operationalised in a macro context. The other factor (besides lack of perfect information) about which little can be said, apart from acknowledging its existence and its intractability, is technical change. We pointed out that a combination of Harrod labour saving technical change and a C.E.S. production function with an elasticity of substitution less than one, could produce a positive correlation between real wages and the labour-capital ratio. Ideally one should have a model of technical change to isolate its determinants and remove its influence. However, without such a model technical change is assumed outside the scope of economic analysis and is to be removed with time trends, a method which would fail if the technical change proceeded erratically.

The remainder of the theories may be divided into two groups, those where the goods market clears and those where it does not. In the group where the goods market does not clear, we have the contributions of Patinkin, Solow and Stiglitz, and Barro and Grossman. Patinkin's analysis did not consider the case of an inflationary shock or the possibility of excess demand. His analysis was extended in this respect by Barro and Grossman who show that the logic of spillover effects of markets operating under quantity constraints implies a "supply multiplier" such that output falls when aggregate demand increases from a full equilibrium position. Solow and Stiglitz produced a sophisticated dynamic Patinkin-type model incorporating costly adjustment. This model had no advantages over simpler models where the goods market clears and which have costly adjustment of employment. Indeed it is inferior in two respects. First it is more complicated; and second the model did not allow a return to a full classical equilibrium since it excluded real balances and the interest rate from the expenditure functions.[1]

Two types of costly adjustment, goods market clearing models were considered. In one, labour demand was always satisfied, in the other actual employment was the minimum of supply and demand. The main drawback with these models was that with the first assumption it is difficult to explain why employment should exceed labour supply, and with the second assumption an inflationary shock at full equilibrium must decrease output and employment. This second drawback could be avoided by postulating a vertical labour supply curve (as Solow and Stiglitz did) but in the first place this only replaces the prediction of negative correlation with a prediction of no correlation; and in the second place it is contrary to the empirical evidence we have, which shows a positive real wage elasticity of the labour supply curve. A very simple explanation for procyclical real wage movements was proposed by Buiter and Lorie who proposed using the positive slope of the labour supply curve to explain procyclical real wage movements. No goods market disequilibrium or costly adjustment of labour was needed. They simply assumed sluggish adjustment of wages. Unfortunately, the upward sloping supply curve, besides producing positive correlations of real wages and employment when there is excess demand for labour also produces the unfortunate feature of a negative correlation between aggregate demand and output. An alternative route was taken by Phelps who assumed a production and payment lag of one period. With this model he could show the possibility of procyclical movements of real wages but unfortunately the model implied that $\lambda < 0$ in the equation $(\dot{w}/w) - (\dot{p}/p)^e = \lambda\,(L-\bar{L})/\bar{L}$, whereas the accelerationists assume that $\lambda > 0$.[2] This problem can be avoided if one simply assumes a production lag (and no payment lag) and recognises the necessity of discounting expected prices in the profit equation. This is probably the simplest way of generating the procyclical real wage result while avoiding other unfortunate features. Nevertheless, this model, like all the other models considered cannot generate the coexistence of unemployment and vacancies. Furthermore, there appears to be good evidence in favour of costly adjustment of labour[3] and as yet we do not have a model incorporating costly adjustment which avoids either a negative correlation between aggregate demand and output when excess demand prevails, or employment being greater than labour supply. Consequently a simple model is presented in the next section which incorporates both costly adjustment and the co-existence of unemployment and vacancies while avoiding the negative features mentioned above.

4.2 A Model With Partial Adjustment of Labour and Frictional Unemployment and Vacancies:- The Scarth and Myatt Model[4]

The simplest model of frictional unemployment and vacancies[5] is vu=h,a rectangular hyperbola relating the vacancy rate v (defined as the vacancy/employment ratio,V/L) and the unemployment rate u (defined as (S-L)/S).This model implies

$$V = hLS/(S-L).$$

The common short side of the market hypothesis, can be viewed as a limiting case of this relationship, when the friction parameter,h, approaches zero.Equations (7) and (7a) differ in the specification of the excess demand terms in the wage adjustment equation.We now consider a third specification

$$\frac{\dot{W}}{W} = \frac{\alpha(J-S)}{S},$$

where jobs available, J=V+L, which is re-expressed as

$$\frac{\dot{W}}{W} = \frac{\alpha}{S}\left(L-S+\frac{hLS}{(S-L)}\right).$$

The complete model consists of the following equations,

(1) $Y = E(Y,r) + A,$

(2) $\Psi(Y,r) = M/P,$

(3) $Y = \mathcal{F}(L,K),$

(4) $\dot{L} = B\,(L^{*}-L),$

$$(5) \quad L^{*} = F_{L}(W/P, K),$$

$$(6) \quad S = S(W/P),$$

$$(7) \quad \dot{W}/W = (\alpha/S)\left[L-S+hLS/(S-L)\right]$$

We assume that the friction in the labour market stems from imperfect information, and that firms are aware of this information problem. Thus firms advertise jobs available, J, in excess of actual employment wanted, as long as $S-L > 0$. At the level of the individual firm, $J=((h/u)+1)L$ is taken as a constraint in the optimisation process. The individual firm assumes it has no effect on the aggregate unemployment rate (u), but that this rate inversely affects the degree by which its J signals must exceed L, for a given L to be obtained.

Equations (4) and (5) can be derived by assuming firms maximise:

$$\Pi = \sum_{t=0}^{t=\infty} \left(\frac{1}{1+r}\right)^{t} \left[Pf(L_t, K) - WL_t - b(L_{t+1}-L_t)^2 - CV_t\right]$$

subject to the expectation that all variables without a time subscript stay constant and the constraints: $V_t=J_t-L_t$; $J_t = (L/u+1)L_t$. The final two terms represent the adjustment costs for labour (costs resulting from actually changing employment) and the costs associated with job vacancies/advertising, interviewing, etc.) By differentiating with respect to the L_t we derive the discrete time analogues to equations (4) and (5).[6] Equation (5) is simply a compact way of writing the full adjustment condition for the firm - that $f_L - w - Ch/Pu = 0$. This condition states that labour demand depends negatively on the real wage (due to the diminishing marginal product assumption) but even in full equilibrium firms find it optimal to employ labour so that its marginal product exceeds the real wage, since the imperfect information requires that demand signals in excess of employment be placed, and there are costs in making these signals.

The phase diagram in real wage-employment space for this amended model follows routinely. Substituting equation (5) into (4) we get the $\dot{L}$ equation;

$$\dot{L} = B\,(F(w) - L) \qquad (8)$$

Eliminating Y and r from (1), (2) and (3) we have

$$P = G\,(L, A, M) \qquad (9)$$

where $G_1 < 0$ and G_2, $G_3 > 0$

By taking the time derivative of (9) and substituting it, (6), (7) and (8) into $\dot{w}/w = \dot{W}/W - \dot{P}/P$, we have

$$\frac{\dot{w}}{w} = \alpha\left(\frac{L}{S} - 1 + \frac{hL}{(S-L)}\right) - \frac{G_1 B}{P} \quad (F(w) - L) \qquad (10)$$

assuming $\dot{A} = \dot{M} = 0$. The phase diagram is constructed from equations (8) and (10).

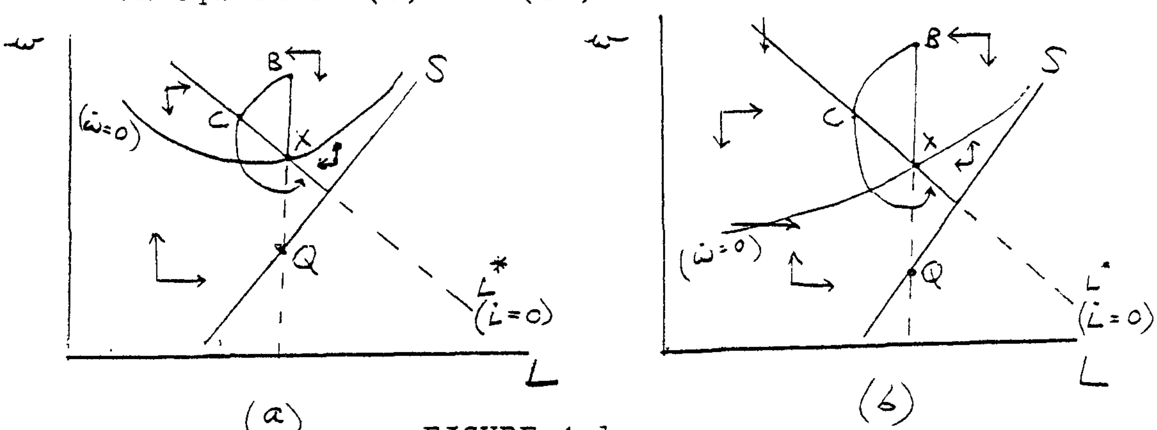


FIGURE 4.1

The slopes of the $\dot{L} = 0$ and $\dot{W} = 0$ loci are derived taking the total differential, while holding $\dot{L} = \dot{W} = \dot{M} = 0$.

We have slope $(\dot{L} = 0) = \frac{dw}{dL} = \frac{1}{\overline{F}_1} = 0$ (11)

totally differentiating (10) we have,

$$\alpha \frac{dL}{S} - \frac{LS_1}{S^2}\, dw + \frac{h}{(S-L)}\, dL - \frac{hL}{(S-L)^2} S_1 dw + \frac{hL}{(S-L)^2}\, dL$$

$$- \frac{G_1 B}{P} \left(F_1\, dw - dL\right) = 0$$

$$\therefore \text{slope}(\dot{W}=0) = \frac{dw}{dL} = \frac{\frac{\alpha}{S} + \frac{h}{(S-L)} + \frac{hL}{(S-L)} + \frac{G_1 B}{P}}{\frac{LS_1}{S^2} + \frac{LLS_1}{(S-L)^2} + \frac{G_1 BF_1}{P}} \gtrless 0 \qquad (12)$$

If expression (12) is subtracted from (11) we have,

$$\frac{\dfrac{LS_1}{S^2} + \dfrac{hLS_1}{(S-L)^2} - \alpha\dfrac{F_1}{S} - \dfrac{hF_1\ (1+L)}{(S-L)}}{F_1\left[\dfrac{LS_1}{S^2} + \dfrac{hLS_1}{(S-L)^2} + \dfrac{G_1BF_1}{P}\right]} < 0$$

so expression (12) is algebraically larger, showing that when the $\dot{W}=0$ locus is negatively sloped it must be less steeply sloped than the $\dot{L}=0$ locus. ($S-L>0$ since there is always frictional unemployment).

The important constraint in this model is that negative vacancies and unemployment must be ruled out. From the $vu=h$ equation we have an expression for vacancies, $V=hLS/(S-L)$. As long as $S>L$ negative vacancies are precluded. This, of course, is also the condition which rules out negative unemployment rates. Thus, the important question is: is there anything in the revised model to automatically preclude the observed time path, and the $\dot{W}=0$ and the $\dot{L}=0$ loci from crossing to the right of the supply curve? The answer is "yes", since as L approaches S, V and J approach infinitely large quantities and since $\dot{W}/W = \alpha((J-S)/S)$, $\dot{W}/W$ and hence $\dot{w}$ also approach infinitely large quantities. Therefore the $\dot{w}=0$ locus cannot cross the supply curve, but must asymptotically approach it as w rises.

The arrows of motion in figures 4.1(a) and (b) are derived as follows. Choosing a point where $\dot{L}=0$, if we raise w so the point is now above the $\dot{L}=0$ locus, F(w) is reduced and $\dot{L}<0$. Therefore to the left of the $\dot{L}=0$ locus, L moves rightwards, and to the right of the

$\dot{L}=0$ locus, L moves leftwards. With the $\dot{W}=0$ locus, increasing w increases S(w) which decreases the first term in equation (10). Similarly an increase in w reduces F(w) and since $(-G_1B)/P>0$ the second term in equation (10) is also reduced. Therefore above the $\dot{W}=0$ locus, $\dot{W}<0$, and below the $\dot{W}=0$ locus, $\dot{W}>0$.

Clearly this model allows periodic positive correlations between real wages and employment that were previously derived in the simple adjustment cost framework of section 3.5.1 of chapter 3. However, this model has derived these movements in a context where vacancies and unemployment exist simultaneously. In addition this model does not necessarily involve the objectionable prediction of the earlier work involving inflationary shocks. When aggregate demand increases so that the initial shock in Fig. 4.1 is to some point below X, now we need not move to a lower level of N. As long as the shock moves the observation point no lower than point Q, the response to the increase in demand will be a gradual increase of employment beyond its 'natural' level (OL), followed by a gradual decrease in employment back to the natural level. Thus, the cycle in employment and output can easily be of the same frequency as that in autonomous expenditure, and it is the frictional unemployment which allows this appealing prediction.

4.3 The Relationship of the Amended Models to the Standard Textbook Model

The standard textbook model assumes that output results instantaneously from the input of labour, this output being immediately sold on a product market which is continously in equilibrium. Only the labour market is allowed to be in disequilibrium, and this only in an excess supply sense. This is achieved by postulating an assymetry in the wage adjustment process, such that wages are perfectly flexible in an upward direction but rigid in a downward direction. Labour is assumed to be a perfectly variable factor, there being no costs of adjusting employment.

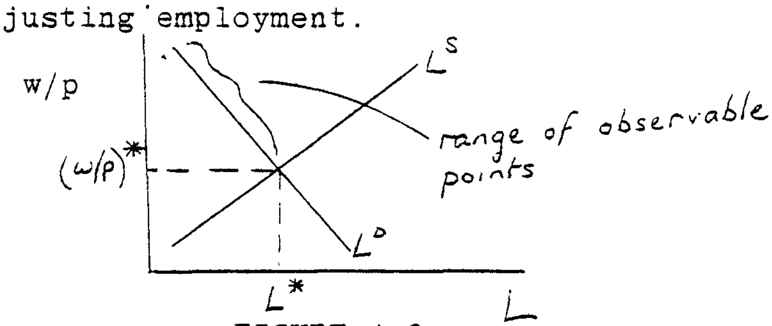


FIGURE 4.2

The downward rigidity of money wages makes possible unemployment equilibria, at which employment is determined by the short side of the labour market - the demand side. The upward flexibility of wages prevents the possibility that employment could exceed L*. At the peak of the trade cycle full employment may be reached, though it need not necessarily be reached. Consequently the observed real wage employment observations over the trade cycle should all lie on the demand for labour schedule to the left of L* and above W*.

All the models considered in Chapter 3 remove the textbook assumption about wage adjustment, though in only one case, that of Buiter and Lorie, is this change the crucial factor in allowing the model to be consistent with procyclical real wage movements. To better see the relationships amongst the models and the textbook model, table IV.1 below lays out the assumptions that each model makes. Clearly there is a range of assumptions concerning the labour market. Only in the model of Phelps and Winter is the labour market assumed to be in continous equilibrium. In the others out of equilibrium behaviour must be specified. Wages are unanimously assumed to adjust in the direction of excess demands, but in the model of Solow and Stiglitz the definition of excess demand is modified by the possibility of product market disequilibrium to be effective excess demand, while the textbook model differs from the rest in assuming different (and extreme) downward and upward adjustment speeds for wages. These specifications, is should be noted, though plausible, are essentially ad hoc and arbitrary. As yet there does not exist any firm micro-economic underpinnings for these wage adjustment equations in terms of optimal wage and price adjustment.

Table IV.1 <u>The Relationship Between Alternative Models in Terms of Assumptions</u>

	Text-book-	Buiter & Lorie	Phelps and Winter	Myatt and Scarth	Simple Costly Adjust-ment Model	Phelps	Solow and Stiglitz
Labour Market	$L = \min(L^D, L^S)$ $\dot{\omega} = \alpha(L^D - L^S)$ $\alpha = 0;\ L^D < L^S$ $\alpha = \infty,\ L^D > L^S$	$L = \min(L^D, L^S)$ $\dot{\omega} = \alpha(L^D - L^S)$ $0 < \alpha < \infty$	$L^D = L^S$ $\dot{\omega} = \alpha(L^D - L^S)$ $\alpha = \infty$	$L = J - V$ $\omega = \alpha(J - L^S)$ $\alpha > 0$	$L = L^D$ $\dot{\omega} = \alpha(L^D - L^S)$ $\alpha > 0$	$L = \min(L^D L^S)$ $\dot{\omega} = \alpha(L^D - L^S)$ $\alpha > 0$	$L = \min(D, S)$ $\omega = \alpha(D - S)$ $\alpha > 0$
Product Markets Clear	✓	✓	✓	✓	✓	✓	✗
Zero Costs of Adjusting Labour	✓	✓	✓	✗	✗	✓	✗
No Frictional Unemploy-ment	✓	✓	✓	✗	✓	✓	✓
No Production Lag	✓	✓	✓	✓	✓	✗	✓
Perfect Information About Current Prices	✓	✓	✗	✓	✓	✓	✓

✓ the assumption is made

✗ the assumption is not made

Only one model drops the assumption of perfect knowledge of current prices, that of Phelps and Winter, and because of this firms find that they do not face a perfectly elastic demand curve for their product. In this respect the model is similar to the analysis of Barro and Grossman who also retain the assumption of atomistic competition but deny that firms can sell all they want to at the ruling market price because of the existence of quantity constraints.

Finally, we should note that the properly discounted production lag model does not depend upon a particular specification of wage adjustment in the labour market. It can explain an observed positive real wage co-efficient in the labour demand curve whether the labour market is assumed to be in continuous equilibrium or whether employment is always assumed to be on the labour demand curve, since it suggests that the estimation of this co-efficient could suffer from omitted variable bias. In this respect this model is similar to those of Chapter 2 which have been characterized as not removing the counter cyclical real wage prediction, but rather refining and clarifying the exact nature of that prediction.

FOOTNOTES

Chapter 4

1. This is not a necessary feature of a model with costly adjustment of labour and goods market disequilibrium.

2. Phelps later adds inventories to his model. But, inventories do not destroy the equality between price and marginal cost, in a perfectly competitive market operating without quantity constraints and without lags, unless the firm does not produce at all for current sales. If this latter case is deemed unrealistic, then inventories add nothing except where there are lags or Barro-Grossman type quantity constraints, and under such conditions the equality between price and marginal cost is already broken.

3. For example Oi "Labour as a Quasi Fixed Factor" J.P.E., 1966, and Neftci "A Time Series Analysis of the Real Wages - Employment Relationship", J.P.E. 1978, p. 281-291.

4. Myatt and Scarth, "The Real Wage Employment Relationship", Economic Journal, March 1980.

5. See Hansen, B. (1970). "Excess demand, unemployment, vacancies, and wages.', Quarterly Journal of Economics.

6. See chapter 10, where two different ways of generating equations (4) and (5) are shown.

CHAPTER 5

THE EMPIRICAL EVIDENCE - THE TRADITIONAL APPROACH

This chapter surveys that empirical work which uses the "traditional" approach to hypothesis testing. The "modern" approach or the "time series approach", distinguishes itself from the "traditional" approach by its emphasis on the pitfalls of hypothesis testing using serially correlated data. As a result the "modern approach" removes all traces of serial correlation from the time series by pre-filtering them until only the white noise processes are left. Typically, this approach then invokes the principle "post hoc ergo propter hoc" and tests for the influence of each series upon the other, concluding that there exists either bi-directional causality, uni-directional causality or independence between the series. The drawback with this modern approach is indeed precisely that the range of null hypotheses that it is capable of testing is extremely limited. We may have, for example, good grounds for believing that the expected rate of inflation enters the wage change equation with a coefficient of unity, but it would be impossible to deduce from this the size of the coefficient relating the white noise process of expected inflation and the white noise process of the rate of wage change. The traditional approach, on the other hand, proceeds by building a model which explicitly lays out formal relations between series involving signs and/or sizes of coefficients within this model. Serial correlation would be dealt with by first differencing, or at most, second differencing such a structure. Because of its greater flexibility in being able to test a much greater range of null hypotheses than the time series approach, the traditional model building and model estimation approach still flourishes. The empirical work which utilizes the time series methodology to study the real wage employment relationship is surveyed in Chapter 7.

Notwithstanding the above remarks about the traditional approach involving a formal model building process, the first attempts at studying the real wage employment relationship did not explicitly set out the model they were testing beyond making reference to Keynes' "General Theory" and its proposition that at less than full employment, employment would be determined by labour demand, and real wages and employment would be negatively correlated.

The rest of this chapter surveys the empirical work to date, organized chronologically.

5.1 THE DUNLOP AND TARSHIS PAPERS[1]: 1938 and 1939

These papers were the precursors of the literature on the cyclical movement of real wages. For years it was accepted that these papers showed that real wages moved pro-cyclically and constituted evidence against diminishing returns and/or perfect competition. This is remarkable since both papers address themselves to the relationship between real wages and money wages, which only has implications for the real wage employment relationship if one takes as given a particular relationship between employment and money wages. Both papers simply assumed a positive relationship between employment changes and money wages changes and did not put this assumption to any empirical test. However, Dunlop and Tarshis did show that real wage changes and money wage changes were related positively using British and U.S. data respectively, and this was construed as evidence against diminishing returns. The failure of these studies to test the assumption of a positive relationship between money wage changes and employment changes is even more remarkable since Tarshis states in a footnote that when he investigated the relationship between real wage changes and employment changes directly, he found a significantly negative relation.

Both authors choose wages in manufacturing for their wage series. This was deflated by an aggregate price index to obtain a real wage series. Both authors adjusted this aggregate price index for changes in the terms of trade between agriculture and manufacturing in an attempt to approximate the aggregate price series to one measuring only prices in manufacturing, and both authors agreed that this adjustment did not affect their results. Neither author detrended their data, but claimed to approximate short run conditions by first differencing.

5.2 KEYNES' PAPER: 1939[2]

Keynes' reply to the Dunlop and Tarshis papers consisted in part of presenting more statistical evidence on real wages and employment, which is very badly presented in so far as there is almost a complete lack of description of the data and the methods used to analyse it. He presents some data for the British economy but does not say whether these figures relate to the whole economy or only the manufacturing sector. He states that he removed the influence of trend from the data, but he does not state how he does this. He does, however, directly study the relationship between real wages and employment, rather than follow the approach of Dunlop and Tarshis. He finds a counter cyclical relation between these series in the one cycle between 1880 and 1886, and a procyclical relation between the series in the 3½ cycles between 1886 and 1914.

Keynes also quotes Meade's study for the League of Nations[3] to the effect that during the great depression after 1929 real hourly **wages** rose as employment fell, and during the recovery real hourly wages fell in every country except France and the United States.

Finally Keynes brought up a factor not yet discussed. He worried about the possibility that measurement error would give rise to spurious correlation. The absolute range of most of the observations on Tarshis' scatter diagram was small especially for changes in real wages. The great majority of both Dunlop's and Tarshis' observations relate to changes of less than 1.5%. He quoted Bowley[4] to the effect that this is probably less than the margin of error for statistics of this kind.

5.3 KUH'S PAPER: 1966[5]

Kuh performed a visual examination of the real wage employment relationship for U.S. manufacturing for the years 1913-57. He deflates average weekly earnings by the wholesale price to obtain his real wage series, however, he makes no overtime aggregation adjustment, nor any adjustment for imported intermediate inputs. Kuh detrends the real wage series (he does not state how) and compares the resulting residuals with the change in the unemployment rate[6].

He concludes that the traditional view receives support during some periods (e.g., 1924, 1930-31) but not at others (1932-33, 1954, 1955). The only thing which is unambiguously evident is that real wages are considerably more stable than money wages.

5.4 BODKIN'S PAPER:[7] 1969

Bodkin's paper represents the first major empirical study of the real wage employment relationship. It is a bulky study since it investigates both the U.S. and the Canadian economies, it covers a large span of time, and he experiments with different series and different cycle indicators. The paper is flawed, however, in two respects. First, Bodkin presents results from ordinary least squares regressions where serial correlation is present[8] and therefore we would expect biased estimates. Second, Bodkin does not explicitly study the real wage employment relationship, but chooses instead to use the unemployment rate and the participation rate as proxies for the detrended level of employment.

The unemployment rate was chosen as a proxy on the grounds that it automatically corrected for the scale of the economy. The rationale here is hard to fathom since there are so many problems with such a proxy compared to a more direct approach of using the detrended level of employment. The first problem is that the modern notion of the natural unemployment rate, which is a full employment level of unemployment which is influenced by economic variables, casts doubt on Bodkin's notion that the unemployment rate is not influenced by the scale of the economy. On the contrary the theory of the natural unemployment rate suggests that the unemployment rate does contain trend elements. Second, a change in the participation rate (which may leave the natural unemployment rate unaffected[9]), could change the unemployment rate while leaving the level of employment unaffected. If the unemployment rate were always negatively related to the deviation of the employment level from its trend, then diminishing returns would imply a positive relationship between the unemployment rate and the deviation of the level of real wages from its trend. However, an increase in the participation rate, caused for example, by a large number of school leavers, may result in an increase in employment, a reduction in real wages and an increase in the unemployment rate, giving the spurious impression of a procyclical movement in real wages. Furthermore, there are factors which may cause the participation rate to move cyclically. In a slump, for example, when the detrended employment level is low, some workers may get discouraged in their search for a job and may drop out of the labour force causing the unemployment rate to be lower than it otherwise would be. Thus, changes in the participation rate and the natural unemployment rate reduce the usefulness of the unemployment rate as a proxy for detrended employment. On the other hand the usefulness of the participation rate as a cycle proxy depends on the discouraged worker effect dominating all other possible causes of changes in the participation rate.

Bodkin used quarterly data which he split up into two periods, a historical **or pre world war II period,** and a post world war II period. His wage series were generally average hourly earnings unadjusted for overtime, though one data set, the historical Canadian data, did exclude overtime earnings. Bodkin worked at two levels of aggregation, the whole manufacturing sector and the whole economy, and at both of these levels of aggregation he constructs two real wage series, one of which measures the own product real wage and the other measuring the welfare of the typical worker. Bodkin detrends his real wage data by regressing it on a trend and using the residuals from this regression. To ensure that the fitted trend passed through the peaks and troughs of his data, he broke it into subperiods. In some regressions seasonal dummies were used but we are not told whether this had any effect on the results nor which regressions used seasonal dummies and which did not. Finally, we should note that the unemployment rate and participation rate used by Bodkin refer to the whole economy which is one more reason why they may be bad proxies for the short run cycle in the manufacturing sector.

Before turning to the results one final point should be made. The ordinary least squares approach assumes that causality runs from the independent variable, the unemployment rate or the participation rate, to the dependent variable, real wages. If actually causality runs both ways there would be single equation bias. To check for this possibility Bodkin did some regressions using two stage least squares, but he reports that the results were substantially unchanged.

The main characteristics of Bodkin's results are summarized in Table 5.1 below. Bodkin's own summary of his results emphasized the recurring procyclical result and stated that the results cast doubt on the assumption of diminishing returns and/or perfect competition. This is curious since when he used a measure of the own product real wage he got counter-cyclical results for the post war Canadian and U.S. manufacturing sectors, and only one procyclical result,

TABLE 5.1

BODKIN'S RESULTS

Wage Series	Price Index	Cyclical Variable	Results
Historical Cdn. Data:			
Manufacturing Sector	P^S	U	Not signift. Counter cyclical.
Economy Wide	P^S	U	Not signift. Counter cyclical
Historical U.S. Data:			
Manufacturing Sector	P^S	U	Not signift. Procyclical
Post War Cdn. Data:			
Manufacturing Sector	P^S	U	Not signift. Procyclical
Manufacturing Sector	P^D	U	Not signift. Counter cyclical
Post War U.S. Data:			
Manufacturing Sector:	P^D	U	Significant. Counter cyclical.
Manufacturing Sector	P^S	U	Significant Procyclical.
Manufacturing Sector	P^S	P	Significant. Procyclical.
Economy Wide	P^S	U	Significant. Procyclical.
Economy Wide	P^S	P	Significant Procyclical.
Economy Wide	P^{D1}	U	Significant Procyclical.

P^S : Implicit deflator of consumption component of GNP.

P^D : Wholesale Price Index.

P^{D1}: Implicit defaltor for whole GNP.

U : The unemployment rate.

P : The participation rate.

that for the U.S. economy wide data. The other results have no bearing at all on the question of diminishing returns. What his results seem most strongly to indicate is a cyclical divergence between the consumer price index and the own product price index potentially caused by cyclical changes in the terms of trade between agriculture and manufacturing.

5.5 MODIGLIANI'S 1977 PAPER[10]

Modigliani used annual U.S. data for both the manufacturing sector and the private non farm sector. His real wage series was average hourly earnings deflated by the own product price, or more specifically, the wholesale price index for the manufacturing sector, and the private non farm deflator on output per man for the private non farm sector. He makes no overtime aggregation correction, nor does he make any correction for imported intermediate inputs. However, he specifically ends his series in 1973 on the grounds that the oil price increase post '73 shifted the terms of trade. He used data covering the years, 1953-73, and ran the following regression,

$$\log(W/P) = \alpha \log t \ - \ \beta \log L$$

He corrected for first order serial correlation, but does not report the Durbin Watson statistic after making this correction.

Modigliani obtains significant procyclical real wage movements for both the manufacturing sector and the private non farm sector.

5.6 CANZERONI'S PAPER: 1978[11]

Canzeroni assumes a Cobb-Douglas production function of the form:

(1) $$Y_t = Ae^{\lambda t} L^{\alpha} K^{1-\alpha}$$

or,

(2) $$Y_t/K_t = A\ e^{\lambda t}\ L^{\alpha}\ K^{-\alpha}$$

Assuming marginal product pricing we can derive equation (3) below;

(3) $$(W/P)_t = (1 - \alpha)Ae^{\lambda t}\ (K/L)^{\alpha-1}$$

These equations can be rewritten in log linear form as follows:

(1') $$\log Y_t = \log A + \lambda t + \alpha \log L_t - (1-\alpha) \log K_t$$

(2') $$\log Y_t - \log K_t = \log A + \lambda t + \alpha(\log L_t - \log K_t)$$

(3') $$\log W_t - \log P_t = \log[A(1-\alpha)\lambda] + \lambda t - (1-\alpha)(\log L_t - \log K_t)$$

He then estimated equations (4), (5) and (6) below,

(4) $$\log Y_t = \beta_0 + \beta_1 t + \beta_2 \log K_t = \beta_3 \log L_t$$

(5) $$\log Y_t - \log K_t = \beta_4 - \beta_5 t + \beta_6(\log L_t - \log K_t)$$

(6) $\log W_t - \log P_t = \beta_7 + \beta_8 t + \beta_9(\log L_t - \log K_t)$

Canzeroni estimates those equations for quarterly Canadian data from 1954-1970 using an instrumental variable procedure in an attempt to avoid simultaneous equation bias. He augments equations (4), (5) and (6) with 3 quarterly dummies to remove seasonal influences. He estimates equations (4), (5) and (6) using economy wide data. The results are given below, omitting intercept trend and quarterly dummy variables.

(4') $\log Y_t = \underset{(1.1)}{.0542} \log K_t + \underset{(5.0)}{.592} \log L_t$ $R^2 = .991$
DW = 1.73

(5') $\log Y_t - \log K_t = \underset{(16.1)}{.946} (\log L_t - \log K_t)$ $R^2 = .895$
D.W. = 1.78

(6') $\log W_t - \log P_t = \underset{(4.0)}{-.156} (\log L_t - \log K_t)$ $R^2 = .977$
D.W. = 1.99

From equation (4') constant returns to scale is rejected since $\beta_2 + \beta_3 \neq 1$. Equation (5') and (6') impose constant raturns to scale, and these appear to fit well apart from the fact that α appears unreasonably large (.95 in equation (5') and .84 in equation (6').) On the other hand there is a negative relation between real wages and employment which is consistent with diminishing returns.

Canzeroni hypothesised that the reason for the overly high value of α and the rejection of constant returns to scale was the omission of the overtime factor.

To test this he estimated equations (7), (8) and (9);

$$(7)\qquad \log Y_t = \beta_{11} + \beta_{12}t + \beta_{13}\log K_t + \beta_{14}\log L_t^S + \beta_{15}(\log L_t^O - \log L_t^S)$$

$$(8)\qquad \log Y_t - \log K_t = \beta_{21} + \beta_{22}t + \beta_{23}(\log L_t^S - \log K_t) + \beta_{24}(\log L_t^O - \log L_t^S)$$

$$(9a)\qquad \log W_t - \log P_t = \beta_{30} + \beta_{31}t + \beta_{32}(\log L_t^S - \log K_t)$$

$$(9b)\qquad \log W_t - \log P_t = \beta_{40} + \beta_{41}t + \beta_{42}(\log L_t^O - \log K_t)$$

(where L_t^O = overtime hours; L_t^S = straight time labour hours)

Canzeroni gives no theoretical basis for these equations. Equation (7) implies a production function of the form

$$Y = Ae^{\,t}\, K_t^{\beta_{13}}\, L_t^{S(\beta_{14}-\beta_{15})}\, L_t^{O\,\beta_{15}}$$

but equations (9a) and (9b) cannot be derived from this implied production function. The equations are essentially ad hoc and as such, it is difficult to interpret their results. Canzeroni hypothesises however, that if the overtime aggregation hypothesis of Lucas is important then the ($\log L_t^O - \log L_t^S$) term should be significant, though he has no priors on the sign of its coefficient. Furthermore, β_{14} and $\dot{\beta}_{23}$ should be lower than they were in equations (5) and (6) which are 'averages' over both shifts. In addition, if the true labour demand curve is concave so that overtime employment is proportionally more responsive to real wage changes than is straight time employment[12] then $|\beta_{32}|$ should be greater than $|\beta_{42}|$. His results are presented below:

$$(7') \quad \log Y_t = \underset{(0.9)}{.0866} \log K_t + \underset{(4.03)}{.557} \log L_t + \underset{(1.4)}{.0273} (\log L_t^0 - \log L_t^S)$$

$$R^2 = .991 \quad D.W. = 1.7$$

$$(8') \quad \log Y_t - \log K_t = \underset{(8.0)}{.951}(\log L_t^S - \log K_t) + \underset{(1.4)}{.031})\log L_t^0 - \log L_t^S)$$

$$R^2 = .905 \quad D.W. = 1.77$$

$$(9a') \quad \log W_t - \log P_t = \underset{(3.9)}{-.181} (\log L_t^S - \log K_t)$$

$$R^2 = .975 \quad D.W. = 1.98$$

$$(9b') \quad \log W_t - \log P_t = \underset{(3.5)}{-.025}(\log L_t^0 - \log K_t)$$

$$R^2 = .979 \quad D.W. = 2.03$$

Equations (7') and (8') offer little support for the Lucas hypothesis. The coefficients β_{15} and β_{24} are not significantly different from zero at an 8% level of significance. Also the capital coefficient implied by equation (5') is still insignificantly different from unity.

On the other hand, equations (9a') and (9b') appear to give some support to the Lucas hypothesis in so far as (β_{32}) is significantly larger than $|\beta_{42}|$, implying that overtime employment is proportionately more responsive to real wage fluctuations than is straight time employment. It should be noted, however, that these equations are misspecified in so far as both have an aggregated real wage series as the dependent variable, rather than straight time real wages in (9a) and overtime real wages in (9b).

In summary, Canzeroni's attempt to test the Lucas hypothesis is inconclusive not only because the results are not unanimous, but also because the functions themselves have no rigorous grounding in theory. Furthermore, two equations suffer from a misspecified dependent variable. However, Canzeroni did show that there is a negative relationship between real wages and employment, the only trouble being that capital's coefficient is insignificantly different from zero.

5.7 ROSEN AND QUANDT: 1978[13]

Rosen and Quandt have an explicit model of the labour market which they estimate using annual U.S. economy wide data for the years 1930 through 1973. They make no correction for overtime work, or imported intermediate imports. The labour demand equation which they estimate is derived from the assumption of cost minimization, and it is:

$$\text{(1)} \qquad \log L_t^D = \alpha_0 + \alpha_1 \log W_t + \alpha_2 \log Q_t - \alpha_3 t + \varepsilon_1 t$$

where W_t is a measure of average hourly wages, Q_t is gross national product in constant dollars, and L_t^D is the demand for labour[14]. The supply of labour function is

$$\text{(2)} \qquad \log L_t^S = \beta_0 + \beta_1 \log W_{nt} + \beta_2 \log A_{nt} + \beta_3 \log P_t + \varepsilon_{2t}$$

where W_{nt} is the after tax real wage, A_{nt} is real after tax unearned income per head and P_t is the size of the population between 16 and 60 years. Rosen and Quandt assume first that disequilibrium prevails in the labour market, and then they compare this model with the performance of the equilibrium model. The disequilibrium model is:

$$\text{(3)} \qquad \log L_t = \min (\log L_t^S, \log L_t^D)$$

$$\text{(4)} \qquad \log W_t - \log W_{t-1} = \gamma_1 (\log L_t^D - \log L_t^S) + \gamma_2 V_t + \varepsilon_{3t}$$

Equation (3) is a short side dominates specification. Equation (4) specifies that real wages respond to excess demand plus a term, $\gamma_2 V_t$ which allows for non competitive elements. V_t is defined as the percentage of the labour force that is unionised.

The equilibrium version of the model consists of equations (1), (2) and (5) below,

$$(5) \qquad L_t = L_t^S = L_t^D$$

His results are contained in Table 5.2.

TABLE 5.2

ROSEN AND QUANDT'S RESULTS

α_0	α_1	α_2	α_3	β_0	β_1	β_2	β_3	r_1	r_2	log L
-1.33	-0.984	1.095	-.003	0.209	.008	0.49	0.871	0.182	.002	202.6
(6.5)	(9.4)	(28.8)	(1.0)	(0.4)	(0.2)	(10.6)	(9.6)	(3.1)	(3.0)	
-2.44	-1.48	1.24	.012	3.62	.015	0.526	0.216			178.3
(2.6)	(3.2)	(6.1)	(.9)	(4.0)	(0.2)	(7.0)	(1.3)			

A = Disequilibrium model

B = Equilibrium model.

The labour demand curve estimates are quite satisfactory in both models. There is significant evidence of diminishing returns(α_1 is negative)and α_2 is not significantly different from unity as is implied by both the Cobb Douglas and C.E.S. function. In addition, α_1 is not significantly different from unity in the disequilibrium model, suggesting that the elasticity of substitution is unity, or that the Cobb-Douglas function is appropriate.

It is incidental to the present context but of the two models the disequilibrium model seems to perform better on the following three criteria: (i) the parameter estimates are quantitatively more satisfactory, (ii) - 2log(likelihood ratio) is 48.7 rejecting equilibrium strongly, (iii) $1/\gamma_1$ is significantly different from zero, suggesting that real wages do not move infinitely fast in response to excess demand in the labour market[15].

5.8 TATOM'S PAPER: 1980[16]

Tatom proceeds by estimating a Cobb-Douglas production function and a labour demand curve derived from this function for annual U.S. private business sector data for 1948-73. These estimates reveal increasing returns to labour and procyclical movements of real wages. He then replaces capital in place data with capital in use data and re-estimates his two functions. The new estimates reveal diminishing returns to labour and countercyclical movements of real wages. Finally, he tests the Cobb-Douglas specification and finds that he cannot reject it. The functions he estimates are:

(1) $\log X_t = a_0 + a_1 t + \beta \log K_t - \alpha \log L_t$

(2) $\log X_t - \log K_t = a_0 + a_1 t + \alpha(\log L_t - \log K_t)$

(3) $\log W_t = b_0 + b_1 t - (1 - \alpha)(\log L_t - \log K_t)$

where W_t represents real average hourly compensation, X_t is real annual output in the private business sector, L_t is man hours employed in that sector, K_t is the net stock of real non residential capital existing at the end of the prior year, and t is a time trend representing neutral technological change. The results were:

(1)' $$\underset{(2.65)}{\log X_t = 3.11} - \underset{(2.5)}{0.48} \log K_t + \underset{(10.0)}{1.18} \log L_t + \underset{(6.00)}{0.04t}$$

$$R^2 = .998 \qquad D.W. = 1.76$$

(2)' $$\log X_t - \log K_t = \underset{(13.3)}{1.48} + \underset{(12.05)}{1.25} (\log L_t - \log K_t) + \underset{(10.7)}{.035t}$$

$$R^2 = .94 \qquad D.W. = 1.86$$

(3)' $$\log W_t = \underset{(47.4)}{4.26} + \underset{(11.2)}{.03t} + \underset{(0.56)}{0.047} (\log L_t - \log K_t)$$

$$R^2 = .998 \qquad D.W. = 2.10$$

He estimates the above functions using the Cochrane-Orcutt iterative technique. Note that the capital stock coefficient is negative and the man hours coefficient is greater than one in equation (1)'. Equation (2)' imposes constant returns to scale (using an F test the restriction cannot be rejected) to avoid possible problems of co-linearity between labour and capital. However, in equation (2)' α is significantly greater than unity. Finally equation (3)' shows insignificant procyclical movements of real wages.

Tatom's results when he replaced K_t with a measure of capital in use, were:

$$(2)'' \quad \log X_t - \log K_t = \underset{(19.9)}{0.95} + \underset{(13.3)}{0.676} (\log L_t - \log KU_t) + \underset{(9.2)}{.02t}$$

$$R^2 = .9746 \qquad D.W. = 1.74$$

$$(3)'' \quad \log W_t = \underset{(83.2)}{4.08} + \underset{(12.2)}{.024t} - \underset{(2.5)}{0.145} (\log L_t - \log KU_t)$$

$$R^2 = .999 \qquad D.W. = 1.89$$

The estimate of α in equation (2)'' is now significant, less than one, and not significantly different from the mean share of labour in total cost during the period (which was 66.2%). In equation (3)'' real wages are significantly negatively related to employment per unit of utilized capital though the coefficient $(1 - \alpha)$ is significantly different from capitals share in total output.

5.9 SUMMARY

The early work of Dunlop and Tarshis that was thought to have constituted evidence against counter-cyclical real wage movements did not in fact study the employment-real wage relationship directly. Rather money wages were used as a proxy for employment, and no justification for this was provided. Proxies for employment were also used in Bodkin's paper, apparently in an attempt to correct for the scale of the economy. The use of these proxies is problematic compared to studying the real wage-employment relationship directly.

Only one of the papers surveyed directly confronts the identification issue, that being the paper by Rosen and Quandt. The other papers are open to the charge that if they find a procyclical movement of real wages, that they have estimated a labour supply curve rather than a labour demand curve.

The papers by Kuh and Modigliani both report procyclical movements of real wages for U.S. manufacturing and economy wide data, whereas Bodkin's results clearly show counter cyclical movements of real wages for both post W.W.II United States and Canadian data.(The reason that Bodkin more often reports a procyclical relationship than a countercyclical one, is because he more often deflates wages by the implicit deflator for the consumption component for GNP, than by the wholesale price index.Both Kuh and Modigliani deflate by the wholesale price index when using manufacturing data).

The final three papers surveyed attempted to resolve the apparent paradox of procyclical real wage movements in various ways. Canzeroni initially had the problem of increasing returns to scale when he fitted a Cobb-Douglas production function to economy wide Canadian data. The attempt to remedy this by correcting for the aggregation of straight time and overtime employment was not completely successful, not only because the results themselves were not unanimous, but also because the functions he used were ad hoc and had no rigorous grounding. Tatom used annual U.S. private business sector data and fitted a Cobb-Douglas production function. The problems he encountered included a positive co-efficient relating the labour-capital ratio and the real wage. These problems were dramatically removed when he substituted the use of capital services for capital stock data. Rosen and Quandt's paper is the only one to provide a consistent and fully specified model. When they estimated an equilibrium model for U.S. economy wide data they encountered no problems in fitting their labour demand equation, which is derived on the assumption of cost minimisation. Nor did they encounter problems in fitting their disequilibrium model, which was accepted instead of the equilibrium model. Their estimations would seem to indicate that the previous estimations had a misspecified model when they assumed that actual employment always equals labour demand.

FOOTNOTES

Chapter 5

1. J.T. Dunlop, "The Movement of Real and Money Wage Rates", Economic Journal, 1938.

   Lorrie Tarshis, "Changes in Real and Money Wage Rates", Economic Journal, 1939.

2. J.M. Keynes, "Relative Movements of Real Wages and Output", Economic Journal, 1939.

3. "World Economic Survey, 1937-1938", League of Nations.

4. Bowley, "Wages and Income in the U.K. since 1860".

5. Edwin Kuh, "Unemployment, Production Functions and Effective Demand", J.P.E., 1966.

6. The problems with using the unemployment rate as a cycle indicator are dealt with in the next section in relation to Bodkin's paper.

7. Ronald G. Bodkin, "Real Wages and Cyclical Variations in Employment", C.J.E., 1969.

8. As indicated by low values of the Durbin-Watson statistic.

9. In the context of Gordon's theory, discussed in Part II of Chapter 10, this would be the case if it was the participation rate of prime aged adult males which changed.

10. Modigliani, "The Monetarist Controversy", AER, March 1977.

11. Canzeroni, "Returns to Labour and the Cyclical Behaviour of Real Wages", Review of Economics and Statistics, 1978.

12. This is a necessary condition for the aggregation issue to work in the direction of concealing diminishing returns - see Chapter 2.

13. H.S. Rosen and R.E. Quandt, "Estimation of a Disequilibrium Aggregate Labour Market" Review of Economics & Statistics, 1978.

14. If we assumed a C.E.S. production function equation (1) would be:

$$\log L_t^D = \alpha_0 + \alpha_1 t + \log Q_t - \frac{1}{(1+\rho)} (\log W_t)$$

where ρ is the elasticity of substitution parameter. Assuming a Cobb-Douglas production function:

$$\log L_t^D = \alpha_0 + \alpha_1 t + \log Q_t - \log W_t.$$

a special case of the C.E.S. when $\rho = 0$.

15. See Chapter 11 for a further discussion.

16. J.A. Tatom: "The 'Problem' of Procyclical Real Wages and Productivity", J.P.E., April 1980.

CHAPTER 6

PROGRAMME OF EMPIRICAL WORK

Much of the existing empirical evidence is marred by the lack of an explicit model. Frequent reference is made to Keynes' "General Theory..." the traditional or textbook interpretation of which is a labour market where wages adjust infinitely fast in an upward direction and not at all in a downward direction.

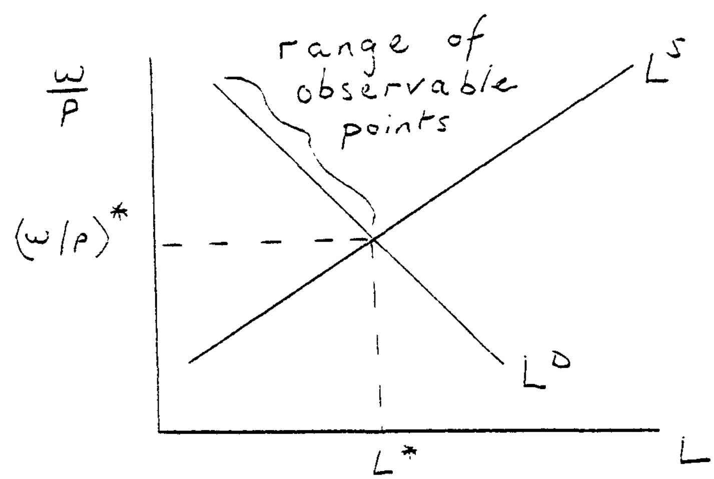


FIGURE 6.1

Consequently, the range of observable points all lie on the demand curve for labour above (W/P)* and to the left of L*. At the peak of the trade cycle full employment may, but need not be reached. This model has been interpreted by most of writers cited in Chapter 5 as being equivalent to simply assuming that employment is determined by labour demand given the real wage[1]. However, if Keynes' model is true and the investigator simply fits a labour demand function, biased estimates would be obtained of the real wage elasticity of employment. This can be demonstrated with the aid of Figures 6.2 and 6.3. Figure 6.2 (a) represents the observations we would observe if the true model generating the observations were:

$$L_t^D = \alpha + \beta(W/P)t + e_i$$

where $\sum e_i = 0$

and $\sum e_i^2 = \sigma^2$

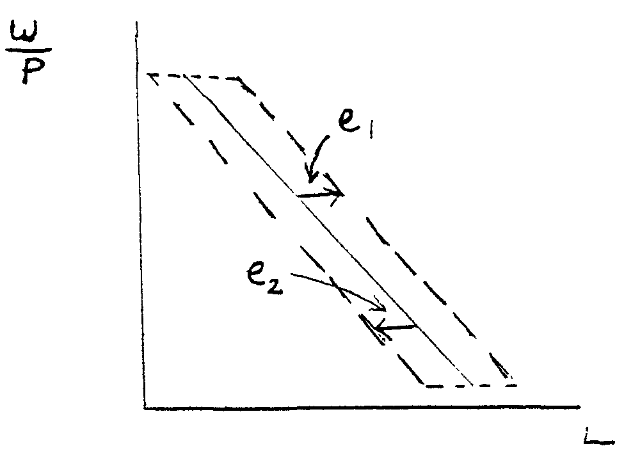


FIGURE 6.2(a)

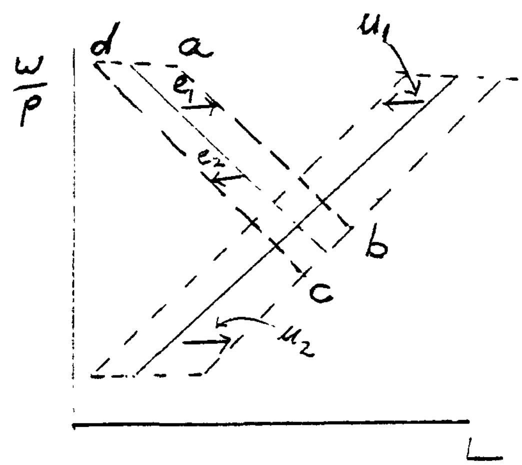


FIGURE 6.2(b)

Figure 6.2(a) ignores the full employment point $(W/p)^*$, L^*, in Figure 6.1. Once we recognize that this full employment point will generate observations which will be influenced by the random errors entering into the supply function (u_{it}) as well as those entering into the demand function, then it is clear that the observations must lie in an area such as abcd in Figure 6.2(b). Figure 6.3 demonstrates that if we were to fit a demand function to the scatter abcd we would obtain biased estimates.

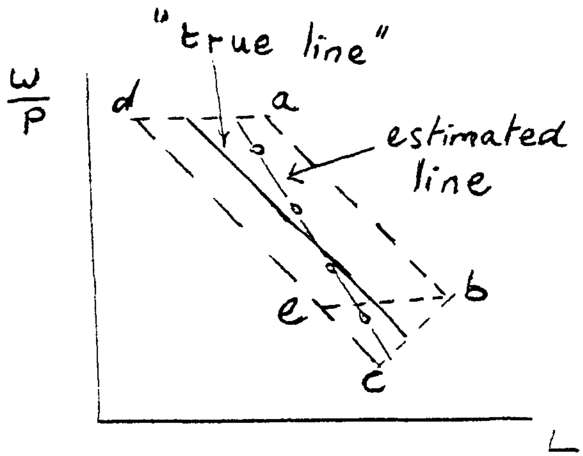


FIGURE 6.3

If the scatter were abed then least squares regression of a labour demand curve would yield unbiased coefficients. However, the actual scatter of points is abcd. The additional observations ebc are not distributed evenly about the true demand curve, but rather there is a preponderance of points below the demand curve. Therefore, in minimizing the sum of squared errors the estimated demand curve will have a steeper slope than the true curve.

The fact that interest in the real wage employment relationship arose out of an attempt to test the Keynesian macro model, and yet most of the empirical work done to date does not test this model, serves to underline the importance of having a fully specified model before embarking on the empirical work[2].

In the theoretical work covered in Chapters 2 and 3 we have encountered four different hypotheses concerning the determination of employment and its relation with labour demand. These are:

(i) $L = L^D$

(ii) $L = L^D = L^s$

(iii) $L = \min (L^D, L^s)$

(iv) $(L^D - L)/L = \mathbf{h/u}$

The first hypothesis is easiest to operationalize, and as already noted, was the typical assumption of researchers in this area, even though it is not the same as Keynes' hypothesis. The second hypothesis is that equilibrium prevails in the labour market. The third hypothesis is the one most favoured by analysts wishing to specify disequilibrium in the labour market since it avoids postulating that the level of employment can be greater than labour supplied. Keynes' model can best be viewed as a specific case of (iii) rather than of (i), as most researchers have done. This is so since model (iii) can be consistently estimated with allowance for different downward and upward adjustment speeds of wages. If it turned out that the inverse of the upward adjustment speed was insignificantly different from zero (implying infinitely fast upward adjustment), while the inverse of the downward adjustment speed was significantly different from zero (implying sluggish downward adjustment of wages), then the Keynesian model would have been estimated, though not necessarily vindicated as will be explained in the next paragraph. Hypothesis 4 is the simple Hansen friction model, and has been relatively ignored in the literature despite the fact that empirical economists have frequently fitted a rectangular hyperbola to the uv scatter[3].

If these hypotheses were nested it would be possible to estimate a general model and by classical hypothesis testing techniques decide which one is best. Unfortunately, none of these hypotheses are nested. Hypotheses (i) and (iv) have the appearance of being nested since they can be rewritten as:

$$\text{(i)}' \quad \log L = \log L^D ,$$

$$\text{(iv)}' \quad \log L = \log L^D + \log \left[\frac{u}{H + u}\right]$$

from which one might conclude that the more general version of both would be:

$$\log L = \log L^D + h \log \left[\frac{u}{H + u}\right]$$

where h = 1 supports hypothesis (iv) and h = 0 supports hypothesis (i). However, as is more fully discussed in Chapter 10, this nesting is somewhat artificial since unemployment is not an exogenous variable in hypothesis (iv), and therefore (iv) should be estimated substituting $(L^S - L)/L^S$ for u, where L^S is replaced by its exogenous determinants (i.e., the equation for the supply curve). This explains the above comment that finding the Keynesian-textbook wage adjustment speeds when estimating model (iii), would not necessarily vindicate the Keynesian textbook model, since it is difficult to compare the performance of non-nested hypotheses[4].

As yet no mention has been made about the behaviour of wages in these models. Presumably models (i), (iii) and (iv) would have wages adjusting in the direction of the excess demand or supply of labour, while wages are endogenous in model (ii) to be determined by a reduced form equation. The precise nature of the wage adjustment equation would determine whether current wages could be treated as exogenous or not. For example, we could have:

$$\text{(a)} \quad W_t - W_{t-1} = \alpha(L_t^D - L_t^s)$$

or

$$\text{(b)} \quad W_{t+1} - W_t = \alpha(L_t^D - L_t^s)$$

In equation (a) W_t is endogenous, whereas in (b) it is exogenous[5]. Nevertheless, even if W_t is exogenous in period t, W_t/P_t could still be endogenous through the influence of P_t. Since both real wages and employment are endogenous variables in a Keynesian macro-economic model, the question arises as to which should be the dependent variable in a least squares regression of the labour demand curve[6]. Two subsidiary questions are pertinent to this issue. First, which way does the causality run? and second, which variable is subject to the most random influences? The second consideration does sometimes override the first. For example, in investigating the demand for houses, income is regressed on house demand, not because it is thought that the demand for houses causes the level of income, but because income is subject to more random influences. In our case, however, we have no reason to expect more random influences on the level of real wages than on the level of employment. As far as the direction of causality is concerned, it is possible to justify causality running in either direction. In a macro context with rigid money wages aggregate demand may determine the level of output, which determines employment through the production function, which then determines prices through a mark-up equation ($P = W/MP_L$). In this case one could say that employment determines the level of real wages. In a micro context with firms being price takers it is certainly the case that real wages determine employment. Thus it is an open question which way causality would run when one uses data from a single sector of the economy (i.e., data on the manufacturing sector; this is most commonly used). Rather than trying to answer this question using a priori reasoning, an alternative approach would be to perform a causality test using real wage and employment data. Such a causality test is performed in Chapter 7, but it is only useful from a negative point of view. This is because a causality test cannot give us any information on contemporaneous causality[7]. Therefore, if the test revealed uni-directional causality running fron real wages to employment we still do not know whether we would be justified in treating real wages as exogenous in an employment equation. We do know, though, that putting real wages on the left hand side would definitely give biased results since a random shock, e_t, which affects $(W/P)_t$ would affect L_{t+1}, causing L and e to be correlated, which violates the orthogonality requirements for an unbiased regression.

Beyond the question of endogeneity versus exogeneity of wages and/or prices, hypotheses (i), (iii) and (iv) do not need to go. However, to facilitate a comparison of these hypotheses with hypothesis (ii), a search for the best wage adjustment equation will be carried out in Chapter 12.

Within each hypothesis additional complications are added. In particular, costs of adjusting employment, and production lags are included. Both of these amendments require postulating some mechanism of expectation fromation. It will be noted (and proved in Chapter 8) that the common form of the partial adjustment equation:

$$L_t - L_{t-1} = \beta(L^*_t - L_{t-1})$$

implicitly assumes static expectations of future wages and prices. Chapter 8 develops the partial adjustment equation for the hypothesis that $L = L^D$, under the assumptions of static, adaptive, and rational expectations. In a similar manner, partial adjustment and production lags are introduced into hypothesis (iv), assuming both static and rational expectations. When we come to hypotheses (ii) and (iii), building a rational expectations partial adjustment model becomes problematic. To see this clearly, assume $L = \min(L^D, L^s)$, and consider the problem of a firm, facing costs of adjusting its employment, maximizing its expected profits over time. For simplicity, assume a quadratic production function of the form: $X = AL_t - \beta L_t^2$. Its real profit function is

$$\Pi = E \sum_{t=1}^{\infty} R^t \left[AL_t - \; L_t^2 - W_t L_t - d(L_t - L_{t-1})^2\right]$$

where R^t is a discount factor and $d(L_t - L_{t-1})^2$ represents adjustment costs. Substituting in for L_t we get:

$$\Pi = E \sum_{i=1}^{\infty} R^t \{A \min(L_t^D, L_t^s) - \beta[\min(L_t^D, L_t^s)]^2$$

$$- w_t \min(L^D, L^s) - d[\min(L_t^D, L_t^s) - \min(L_{t-1}^D, L_{t-1}^s)]^2\}$$

The problem here is that we need to know L_t^D in order to solve the profit function and hence derive L_t^D. This is actually nothing more than a problem of finding a consistent rational expectations solution, but in the context of this model the problem is intractable and awaits solution.[8]

The problem with the rational expectations partial adjustment model when we assume equilibrium to prevail is that the model differs in no essential respect from the model under the hypothesis that $L = L^D$. Simply because in the equilibrium model L^D also happens to equal L^S does not change in any essential way the nature of the firms maximization problem.[9] This involves forecasting future real wages in order to plan the long run demand for labour. Whether these future real wages are actually formed by an equilibrating process of demand and supply, or whether they are formed by an adjustment to the prevailing excess demand or supply is irrelevant, so long as the firm can form expectations of the real wage that differ from the actual real wage only by a random disturbance term. Thus, for example, Sargent[10] is able to estimate the partial adjustment rational epxectations model under the assumed hypothesis that equilibrium prevails, without ever needing to specify a labour supply curve.[11]

For hypotheses (ii) and (iii), then, the partial adjustment model is not estimated under the assumption of rational expectations, but only under the assumption of static expectations using the ad hoc adjustment equation

$$L_t - L_{t+1} = \gamma(L_t^* - L_{t-1})$$

Finally, a straight time wage series will be generated and the results tested for sensitivity to this series.[12] In addition, whenever a capital series is used we will test whether better results can be obtained using utilized capital rather than the measured capital stock. For the most part, quarterly data is used and since value added data in manufacturing is only available on an annual basis, it was not possible to correct for outside intermediate inputs. However, some tests were performed using annual data which allowed this correction to be made. The objective is to try to explain the real wage-employment relationship and in the process evaluate the competing hypotheses concerning the determination of employment.

FOOTNOTES

Chapter 6

1. This comment applies to Dunlop and Tarshis, Bodkin Modigliani, Canzeroni, and Tatom.

2. In fact since the bias makes the estimated line steeper than the true line, this makes a negative relationship between real wages and employment easier to obtain. Therefore we should place more confidence in those studies reporting a positive relationship ,and less confidence in those reporting a negative one.

3. See for example, Cousineau and Green,"Unemployment in Canada:The Impact of Unemployment Insurance", Chapter 4, Economic Council of Canada, Ottawa, 1976.

4. Non-nested hypothesis testing is discussed in some detail in chapter 12.

5. See chapter 12 for a fuller discussion of these equations.

6. While the choice of dependent variable would not affect the sign of the coefficient relating employment and real wages ,it would affect its size, variance, t-scores, and tests of significance. Consider the following regressions:

   $Y = a + bX + e$, and $X = c + dY + u$

   then $\hat{b} = \dfrac{\sum y_i x_i}{\sum x_i^2}$, and $\hat{d} = \dfrac{\sum y_i x_i}{y_i^2}$ (where small case letters indicate deviations from means).

   Clearly $\hat{b} \neq 1/\hat{d}$.

7. This is further discussed in chapter 7.

8. In maximum likelihood estimation of the disequilibrium model, a joint density function of the observed variable L_t is derived. This could be the basis for computing the rational expectations solution.

9. It may seem as if the firm would need to know the labour supply function in order to generate unbiased estimates of the real wage since it is

determined by equality between demand and supply. However, this is not the case. The firm has the past history of the real wage, and if this can be modelled as a stationary ARIMA process the firm can form expectations of the real wage, that differ from the actual real wage only by a random disturbance term, without any knowledge of the labour supply function.

10. T.J. Sargent, "Estimation of Dynamic Labour Demand Schedules under Rational Expectations," J.P.E., 1978.

11. In terms of the discussion at the beginning of this chapter, we can see that there is no bias involved in estimating the demand curve when all the points are equilibrium points rather than just some of them, as in Figures 6.2 and 6.3.

12. Since L_t is measured as employment, straight time man hours is simply $40 \times L_t$.

CHAPTER 7

THE TIME SERIES APPROACH

The purposes of this chapter are to discuss the time series methodology, review the work done by Neftci, Sargent, and Kennan and Geary on the real wage employment relationship using this methodology, and to discuss my own results with this methodology. The chapter is divided into four sections. The first introduces time series analysis, the second discusses Neftci's tests using Canadian data, the third section deals with Sargent, and the fourth section deals with Kennan and Geary.

7.1 WHAT IS THE TIME SERIES APPROACH?

There are two aspects of the time series approach that I will discuss here. The first aspect is its emphasis on the requirement that proper hypothesis testing requires a serially uncorrelated error term with mean zero and constant variance. The second aspect is the use of time series methods to try to establish causality between two or more time series, perhaps because an attempt is being made to test the null hypothesis of independence between the series or perhaps in order to determine which variable may be considered exogenous in the usual econometric sense. I will discuss these points in turn. While most practitioners of applied econometrics are aware of the necessity of serially uncorrelated errors in order to properly test hypotheses, most are content to check the assumption of independent errors with the Durbin-Watson statistic which only measures the degree of first order serial correlation. It is the contribution of the time series analysts to point out that such a naive treatment of residuals can seriously lead analysts astray. Granger and Newbold[1] have presented the results of a simulation study whereby two independent series are artificially generated and a simple linear least squares regression equation was estimated to test for a contemporaneous relationship between the two series. Integrated moving average processes were used to generate the two series:

$$X_t = X_{t-1} + \varepsilon_t + b\varepsilon_{t-1} \qquad X_0 = 100 \quad t = 1..50$$

$$Y_t = Y_{t-1} + N_t + \beta N_{t-1} \qquad Y_0 = 100 \quad t = 1,..50$$

Granger and Newbold found that for large values of β and small values of b that a significant regression of the form

$$Y_t = \alpha_0 + \alpha_1 X_t + e_t,$$

coupled with an absence of warning signals from the

Durbin-Watson statistic, would be found on about 20% of the experiments. Furthermore, re-estimating those equations which revealed first order serial correlation, using the Cochrane-Orcult technique revealed significant estimates of α_1 sometimes as high as 31.3% of the time, depending on the values of b and β. The point of this simulation exercise is that the analyst could avoid finding these spurious relationships if he constructed a correlogram of the errors, discovered the nature of serial correlation and corrected for it properly. Of course, this point is well taken and could even yield easy dividends if a simple error structure were found. The drawback is in terms of computational cost especially when the error structure is a complicated ARIMA process. Indeed, the techniques for correcting for such error processes, while maintaining the equation in a form in which the desired hypotheses can be tested, are often simply not available.

The causality test comes in different shapes and sizes, there being in existence the Pierce and Haugh[2] technique, the Sims[3] test and the Granger[4] test, but all of them revolve around removing the deterministic components from both time series to discover the innovations in each time series (or white noise) and then applying the principle "post hoc ergo propter hoc". For example, Granger's version of causality is that variable X causes variable Y, if the innovations in Y can be better predicted from the past innovations of X and Y together than from the past innovations of Y alone.

The obvious question that arises with regard to the post hoc ergo propter hoc principle is that the existence of expectations could lead the principle astray. A consumer expecting a wage increase next month may increase his spending today, whereas post hoc ergo propter hoc may be led to conclude that causality ran from spending to income. Sims has argued[5] that the existence of expectations is more likely to make a structure where there is one way causality appear as if there were mutual causation, than it is to give the appearance of causality running the wrong way only, or to make a bi-directional structure appear uni-directional. This is because past values of a variable will be useful in predicting future values of that variable so that the causal influence of the expectations will be picked up from the past values of that variable. Thus, providing past values of a variable are useful in predicting future values and hence in picking up expectations, it would be difficult to overlook the true causal influence, though it would be fairly easy to also mistakenly conclude that some causal influence were travelling from the present values of the caused series to the future values of the causal series. Of course, the more economic actors base their expectations of a future variable on information not contained in the past series of that variable, the less assuaging are Sims' comments.

A more subtle problem has been mentioned by Scarth[6], that being that prewhitening series may cause the identification problem to interfere with the causality test. For example, we may wish to test whether real wages cause employment and assume that employment equals labour demand. The **counter cyclical real wage prediction** is based on the presumption that aggregate demand shocks which cause movements along the demand schedule are much larger than either shocks in technology or in the relative price of raw materials imported into that sector, both of which cause shifts of the labour demand schedule. It is not obvious, however, that the size of the innovations of the real wage series would be large compared to the innovations of the supply side shocks, and therefore the failure to **find a negative** relationship may simply be a reflection of this identification problem[7]. This point highlights the weakness of the claim often made by time series analysts[8] that time series methods are structure or model free. Plainly they are not since it is economic models which suggest the interesting relationships to test. For example, economic theory suggests that if one is interested in testing whether employment lies along a labour demand curve in the manufacturing sector then one ought to defate wages by the wholesale price index . rather than with the consumer price index[9]. Or, if one believed the Hansen friction model then one ought to first multiply observed employment data by the ratio of $((u^*)^2 + u)/u$ to obtain data on labour demand[10]. As the theoretical underpinnings change, so the appropriate causal test changes and hence the appeal of testing the various models directly.

Finally the ability of causality tests to show exogeneity in the usual econometric sense, has recently been clarified by Jacobs, Leamer and Ward[11]. They consider the following structural model:

(1) $$Y_t = \theta x_t + \beta_{11} Y_{t-1} + \beta_{12} x_{t-1} + \varepsilon_{1t}$$

(2) $$x_t = \gamma y_t + \beta_{21} y_{t-1} + \beta_{22} x_{t-1} + \varepsilon_{2t}$$

which gives rise to the following reduced form:

(3) $$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

where $$\begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} = (1 - \theta\gamma)^{-1} \begin{bmatrix} (\beta_{11} + \theta\beta_{21})(\beta_{12} + \theta\beta_{22}) \\ (\gamma\beta_{11} + \beta_{21})\ \gamma\beta_{12} + \beta_{22}) \end{bmatrix}$$

Jacobs, Leamer and Ward consider three different cases:

(i) The first is the case where x_t is exogenous in relation to y_t and therefore an ordinary least squares regression of equation (1) would yield consistent estimates of θ, β_{11}, and β_{12}. This requires that $\gamma = 0$.

(ii) The second is the case where y has no impact on x at all, or y does not cause x. This requires that $\gamma = \beta_{21} = 0$.

(iii) The final possibility is that an optimal prediction of x_t does not depend on y_{t-1}, or y is not informative about future x. This is often referred to as the hypothesis "that y does not cause x in Granger's sense". It requires $\Pi_{21} = 0$ or $\gamma\beta_{11} + \beta_{21} = 0$.

It is clear from the above model that Granger's test of causality which states that y causes x if the innovations in x can be better predicted from the past innovations in x and y together than from the past innovations in x alone, is only testing whether or not $\Pi_{21} = 0$. If we find that y does not cause x, in Granger's sense, then $\Pi_{21} = 0$, but this does not imply that $\gamma = 0$ and therefore we have no support for an OLS regression on equation (1).

Secondly, the lack of informativeness (or $\Pi_{21} = 0$) is a necessary but not a sufficient condition for y not to cause x as in (ii) above.

The paper by Jacobs, Leamer and Ward has shown that if we have two variables x and y and we want to know which variable should be treated as dependent and which as independent in an OLS regression then we should not do a Granger[12] type causality test since this yields no information about this question.

7.2 NEFTCI'S CAUSALITY TEST[13]

7.2.1 Neftci's paper **has two parts. He first uses** a Sims' test using monthly observations of manufacturing employment and average hourly earnings excluding overtime deflated by the consumer price index for the United States between 1948 and 1971. He estimates the following two sided distributed lag relationships

$$(1) \qquad W(t) = \sum_{s=-\infty}^{\infty} b_1(s)\, L_{(t-s)} + \sum_{s=0}^{\infty} b_2(s)\, \varepsilon_1(t-s)$$

$$(2) \qquad L(t) = \sum_{s=-\infty}^{\infty} a_1(s)\, W_{(t-s)} + \sum_{s=0}^{\infty} a_2(s)\, \varepsilon_{2(t-s)}$$

where W(t) and L(t) are the "whitened" series. He finds that the future coefficients of real wages in equation (2) are insignificant. He argues that this indicates that a one sided distributed lag relation of employment on real wages can be estimated consistently and without loss of any explanatory power. However, Neftci not only wants to consistently estimate the coefficients in a one sided distributed lag regression of employment on real wages, but also he wants to test for the significance of this relationship. This requires adjusting for the presence of serial correlation. He then estimated equation (3) below for different values of k.

$$(3) \qquad L_{(t)} = \sum_{s=0}^{k} c(s)\, W_{(t-s)} + \sum_{u=0}^{\tau} d(u)\, \varepsilon(t-u)$$

Five different values of k were tried, k = 24, 18, 12, 6, 0 the latter being equivalent to a simple contemporaneous equation. He then shows that the sum of the coefficients are not only negative but significantly so for all values of k except k = 0. The only significant coefficient with a positive sign is the contemporaneous one. Neftci therefore concludes that the apparent paradox of a positive relationship between real wages and employment is a result of ignoring the dynamics of the problem.

7.2.2 Neftci's Test Replicated for Canada

Monthly data was used, from the Canadian manufacturing industry on employment and average hourly earnings deflated by the wholesale price index between the years 1961 to 1978. In addition, by using data on average weekly hours a real wage series corrected for overtime was generated by assuming an overtime premium of time and a half and an average straight time work week of 36.8 hours[14].

A Granger type causality test was implemented between average wages deflated by the wholesale price index (W) and employment (N) and between overtime corrected wages deflated by the wholesale price index (R) and employment. All three series were whitened by taking logarithms, first differencing and regressing the outcome on time, a constant and eleven monthly dummies. The residuals from these equations were then used as data in equation (1) below

$$(1) \qquad Y_t = \sum_{i=1}^{m} \phi_1(i)\, Y_{t-i} + \sum_{j=1}^{n} \phi_2(j) X_{t-j} + a_t$$

where first W (or R) was set equal to Y and L as X; and then L as Y and W(or R) as X. The choice of lag length is inevitably somewhat arbitrary, but the most important consideration is to include all significant lagged dependent variables. It is better to include too many rather than not enough since if some lagged values are insignificant by definition they will not be contributing significantly to the explanation of Y_t. On the other hand, including too few lagged dependent variables may bias the test in favour of rejecting the null hypothesis that the coefficients of the lagged independent variable are zero[15]. All the regressions were therefore, run using 24 lagged values of the dependent variable as explanatory variables. Three different lag lengths were tried for the independent variable, n = 24, 18 and 12. Table 7.1 below reports the F statistic for the null hypothesis that $\sum_{j=1}^{n} \phi_2(j) = 0$ for the three different lag lengths of X, and also reports the 5% and 1% critical values of F.

TABLE 7.1 RESULTS OF THE DIRECT GRANGER TEST

Dependent Variable	Independent Variable	# of lags of the Indep't Variable	F	5%F*	1%F*
L	W	12	2.56	1.82	2.3
		18	2.09	1.68	2.05
		24	1.64	1.59	1.91
L	R	12	3.12	1.82	2.3
		18	2.29	1.68	2.05
		24	1.72	1.59	1.91
W	L	12	1.34	1.82	2.3
		18	1.62	1.68	2.05
		24	1.68	1.59	1.91
R	L	12	1.15	1.82	2.3
		18	1.29	1.68	2.05
		24	1.43	1.59	1.91

The results are little affected by the overtime correction. The null hypothesis that the sum of the coefficients of the values of W or R are insignificantly different from zero must be rejected for all three lag lengths at the 5% level of confidence and must also be rejected for lag length 12 and 18 at the 1% level of confidence.

When L is the independent variable the null hypothesis that the sum of its coefficients is insignificantly different from zero is accepted for all lag lengths at the 1% level of confidence, is accepted for all lag lengths at the 5% level of significance when R is the dependent variable, and is only barely rejected at the 5% level of significance when there are 24 lagged values of L and W is the dependent variable. This is overwhelming evidence of one way Granger type causality running from real wages to employment and is therefore consistent with the results of Neftci.

Part II of Neftci's paper was also replicated using the same data (only dropping the R variable on the grounds that it performed very much as W did), even though we were fully aware that Granger type one way causality (or Sims' causality) did not prove that W was exogenous in relation to L in the econometric sense and that there was therefore a danger of simultaneous equation bias entering through the contemporaneous W_t term (as Jacobs, Leamer and Ward pointed out). The exercise could be justified if one had strong a priori beliefs about the exogeneity of current W (which I did not), or simply in order to test whether Canadian data performed in a similar fashion to United States data as reported by Neftci. This will be seen to be especially useful when we come to the results of Kennan and Geary in the fourth section. We therefore estimated the following equation

$$(2) \qquad L_{(t)} = \varepsilon_0 + \sum_{s=0}^{k} c(s)\, W_{(t-s)} + \varepsilon_t$$

for values of k = 18, 12, 6 and 0. The results are reported in Table 7.2 below[16].

These Canadian results differ from Neftci's U.S. results in that the negative value for the sum of the coefficients is insignificant when the lag length equals 18 months. For the other three lag lengths 12, 6 and 0 however, these results are again consistent with Neftci's[17].

TABLE 7.2

CURRENT EMPLOYMENT ON CURRENT AND LAGGED REAL WAGES

Coefficients	k = 18	k = 12	k = 6	k = 0
t	.111	.083	.075	.020
t-1	-.078	-.094	-.078	
t-2	-.110	-.111	-.102	
t-3	-.062	-.068	-.053	
t-4	-.026	-.033	-.021	
t-5	-.050	-.038	-.028	
t-6	-.062	-.054	-.038	
t-7	-.095	-.082		
t-8	-.076	0.054		
t-9	.082	.115		
t-10	.044	.059		
t-11	-.019	-.007		
t-12	.074	.082		
t-13	.037			
t-14	.018			
t-15	-.034			
t-16	.032			
t-17	.125			
t-18	.053			
Sum of Coefficients	-.042	-0.202	-0.245	.020
t-Score for sum of coefficients	-0.36	-2.03	-2.78	0.45
R^2	0.2086	0.1504	0.0735	0.0009
DW	2.2	2.13	2.06	1.97
F for the equation	2.45	2.57	2.27	0.19
F* 5%	1.57	1.75	2.01	3.84

7.3 Sargent[18]

Sargent uses time series analysis to directly test the partial adjustment rational expectations model. He assumes that capital is always on its trend growth path and that the off diagonal elements of the matrix Z in the equation $[K,L]' = Z[(K^* - K), (L^* - L)]'$ are equal to zero, so that detrending the data completely removes the influence of the capital stock . He also assumes employment equals labour demand. The firms objective is to minimize its expected discounted cost which is the sum of the cost of disequilibrium and adjustment[19],

7.3.1 $$\text{Minimize } E \sum_{t=1}^{\infty} R^t[g(L_t - L_t^*)^2 + (L_t - L_{t-1})^2]$$

where

7.3.2 $$L_t^* = \alpha + \beta W_t$$

The firms optimal choice of L_t satisfies

7.3.3 $$(1 - \lambda B)L_t = (1 - \lambda)d_t$$

where d_t is the long run employment target defined by

7.3.4 $$d_t = \beta(1 - \lambda R) \sum_{s=0}^{\infty} \lambda^s R^s E_t W_t + s$$

and λ is an adjustment parameter defined by[20]

7.3.5 $$1 - (1 + R + g)\lambda + R\lambda^2 = 0$$

If W_t has an autoregressive representation

7.3.6 $a(B)W_t = \beta_t$

where B is the lag operator, $(a(B) = 1 - a_1B - a_2B^2 \ldots)$

and ε_t is white noise,

then equation 7.3.3. can be re-expressed as a function of past and present W_t,

7.3.7 $(a - \lambda B)L_t = \alpha(B)W_t$

and Kennan[21] has shown that,

7.3.8
$$\alpha_0 = \beta g\lambda / a(\lambda R)$$
$$\alpha_1 = \alpha_0[a_2\lambda R + a_3\lambda^2R^2 + \ldots$$
$$\alpha_2 = \alpha_0[\qquad a_3\lambda R + a_4\lambda^2R^2 + \ldots$$
$$\alpha_i = \alpha_0 \sum_{k=i+1}^{\infty} a_k \lambda^{k-i} R^{k-i}$$

Sargent's procedure is to estimate 7.3.6 and 7.3.7 and then test whether the restrictions implied by 7.3.5 and 7.3.8 are satisfied. Sargent was unable to reject the restrictions at the 9% confidence level.

7.4 KENNAN AND GEARY[22]

This international study applies the Pierce-Haugh causality test, to test the null hypothesis of no relationship between real wages and employment, using quarterly data for the manufacturing sectors of twelve OECD countries. They conclude that the null hypothesis cannot be rejected for all twelve countries. They then go on to consider the possible reasons for their results to conflict with those of Neftci and Sargent.

7.4.1 Reasons for the Conflict with Neftci

Kennan and Geary used the sample period 1947-77 and deflated wages by the wholesale price index, whereas Neftci used monthly data for the period 1948-71 and deflated wages by the consumer price index. Kennan and Geary state that in order to make a comparison with Neftci, they also used monthly data, replicated Neftci's result using his deflator and his sample period, and then changing his deflator and sample period to their deflator and sample period they discover that the long run relationship disappears. They conclude that the "wholesale price index deflator gives a theoretically superior measure of the demand price of labour, and in any case, the Neftci findings do not survive extension of the sample period to 1977"[23].

With regard to the question of the superior deflator the conclusion that the wholesale price index is best is not necessarily always true. For example, consider the following model which when solved yields a reduced form equation explaining employment as a negative function of the wage deflated by the consumer price index. Assume a fixed capital stock, employment equal to labour demand, and recognize that firms hire on the basis of a given wage which is constant for this period, but that the price level is endogenously determined by demand and supply for the good.

The equations of the model are

(1) $Q^S = AL^{\alpha} \qquad 1 > \alpha > 0$

where Q^S is output in manufacturing and L is employment,

(2) $L^D = B(W/WPI)^{1/\alpha-1}$

where L^D is labour demand (equals actual employment) and WPI is the wholesale price index. Substituting (2) into (1) we get

(3) $Q^S = \Psi(W/WPI)^{\alpha/\alpha-1}$

and finally the demand for manufacturing output (Q^D), assuming a fixed level of income, is a function of the relative price of manufacturing goods compared to all goods, or,

(4) $Q^D = \phi(WPI/CPI)^{\beta} \qquad \beta < 0$

where CPI is the consumer price index. Equating (3) and (4) we derive an expression for WPI,

(5) $WPI = (\Psi/\phi)^{\alpha-1/\alpha+\alpha\beta-\beta}(W)^{\alpha/\alpha+\alpha\beta-\beta}(CPI)^{\beta(\alpha-1)/(\alpha+\alpha\beta-\beta)}$

substituting (5) into (4) we can derive an expression explaining manufacturing output in terms of the nominal wage and the CPI, and substituting this expression into the inverted form of equation (1) yields

$$(6) \qquad L = \tau(W/CPI)^{\beta/(\alpha+\beta(\alpha-1))}$$

where $\alpha + \beta(\alpha - 1) > 0$

and therefore $\beta/(\alpha+\beta(\alpha-1)) < 0$

I therefore suggest that it is not necessarily wrong to use the CPI deflator and that Kennan and Geary's results are not necessarily superior for this reason. It is unfortunate that Kennan and Geary did not isolate the reason for their different results compared to Neftci. We are left in the dark as to whether the crucial difference is the sample period or the deflator used.

7.4.2 Reasons for the Conflict with Myatt

Things are more comparable when we come to Kennan and Geary's results for Canada. Their Canadian sample period 1961-1977 is almost identical to mine which is 1961-1978, both studies used the WPI as deflator, the differences between the studies being the choice of technique and the frequency of observations (quarterly as compared to monthly observations). The use of quarterly observations rather than monthly observations does represent a serious loss of information with no compensating benefit since time series analysis is specifically designed with serial correlation in mind. Yet without further work it is impossible to say whether their result of independence differs from mine, of uni-directional causality running from real wages to employment, because of the series used (quarterly rather than monthly) or because of the technique used (Pierce-Haugh as opposed to direct-Granger). To explore this question we applied both the direct Granger test and the Pierce Haugh test to Canadian quarterly data obtained by averaging the monthly series.

Both tests begin by first taking logarithms of each series, then differencing and regressing on time and seasonal dummy variables. Trend and seasonal components accounted for 78% of the variation of the rate of change of quarterly employment, 32 % of the variation in the rate of change of quarterly real wages and 22% of the variation in the rate of change of quarterly real wages adjusted for overtime work.

The direct Granger test was run using 12 lagged values of the dependent variable each time as explanatory variables. Three different lag lengths were tried for the independent variable, n = 4, 8, and 12. The results are contained in Table 7.3.

Table 7.3 differs very little compared to the results for monthly data. Using four lagged values of the independent variable there is evidence of one way causality flowing from either W or R to L at the 1% level of confidence. Increasing the number of lags of the independent variable reduces the strength of this relationship, but with eight lags it still exists at the 5% level of confidence, and with twelve lags it

TABLE 7.3

THE DIRECT GRANGER TEST USING QUARTERLY DATA

Dependent Variable	Independent Variable	# of lags of Independent Variable	F	F*		
				10%	5%	1%
		4	4.06	2.09	2.59	3.8
L	W	8	2.77	1.83	2.19	3.02
		12	2.01	1.8	2.05	2.76
		4	4.44	2.02	2.59	3.8
L	R	8	2.69	1.83	2.19	3.02
		12	1.91	1.8	2.05	2.76
		4	1.33	2.09	2.59	3.8
W	L	8	0.51	1.83	2.19	3.02
		12	0.63	1.8	2.05	2.76
		4	1.23	2.09	2.59	3.8
R	L	8	0.88	1.83	2.19	3.02
		12	0.78	1.8	2.05	2.76

still exists using the 10% level of confidence. Employment does not cause either W or R at even the 10% level of confidence.

This result would tend to imply that the difference between my results and Kennan and Geary's must lie in the type of test used. To check this we performed the Pierce-Haugh test on the quarterly W and L series. This involves two steps after the removal of trend and seasonal components. First the innovations in each series are estimated by either fitting parsimonious ARMA models of the Box Jenkins kind, or by approximating the AR(∞) representation of each series. Kennan and Geary used an AR (10) model. In my replication I used an AR (12) model. Table 7.4 shows the resulting regression coefficients alongside those reported by Kennan and Geary.

The results are quite comparable at this stage. The final stage in the Pierce-Haugh test is to take the residuals from the invariate models and calculate the cross correlation coefficients:

$$\rho(k) = \mathrm{CORR}\ (V_t, u_{t-k})$$

for all integers k. However, since the time innovations are unknown, the $\rho(k)$ are consistently estimated by $\hat{r}(k)$,

$$\hat{r}(k) = \mathrm{CORR}\ (\hat{v}_t, u_{t-k})$$

When v and u are independent the $\hat{r}(k)$ are asymptotically normal and independent across k, each

TABLE 7.4

REGRESSION COEFFICIENTS IN THE UNIVARIATE MODELS OF

	Real Wages		and Employment	
	Myatt	Kennan	Myatt	Kennan
Lags 1	.37(2.5)	.37(2.58	.39(2.6)	.36(2.5)
2	.13(.75)	.05(.35)	.22(1.4)	.21(1.4)
3	.23(1.4	.25(1.63)	-.07(.45)	-.08(.51)
4	-.26(-1.5)	-.16(1.05)	-.13(.85)	-.07(.47)
5	.002(.01)	.18(1.18)	-.09(.6)	-.19(1.28)
6	.007(.04)	-.06(.37)	.06(.41)	.10(.7)
7	-.01(-.07)	-.16(1.01)	-.25(1.6)	-.24(1.7)
8	-.2(-.9)	-.14(.91)	.17(1.2)	.19(1.3)
9	-.05(-.29)	-.06(.41)	.01(.08)	-.03(.18)
10	-.04(.23)	-.08(.52)	-.07(.5)	-.13(.92)
11	.08(.5)		-.16(1.1)	
12	-.23(-1.5)		.09(.63)	
R^2	.4659	.42	.3459	.31

$\hat{r}(k)$ having a mean zero and a variance = $\sqrt{n}$, where n is the number of observations. Thus $2\sigma = 2/\sqrt{n}$ is often used as a convenient significance criterion for individual cross-correlation coefficients. In addition, Kennan and Geary use the property that any sum of squared correlation coefficients has a X^2 distribution when they are scaled by sample size. That is

$$S = n \sum_{k=0}^{m} (\hat{\tau}(k))^2$$

is distributed as $X^2(M + 1)$ if the two series are independent. Table 7.5 shows the cross correlations for various lags and leads, alongside the results reported by Kennan and Geary.

The results of the Pierce-Haugh test support the direct Granger test in that there is evidence of one way causality flowing from W to L, as can be seen from the significant correlation between the current innovation in employment and the innovation in real wages at lags 1 and 2. Applying the X^2 test for the first six real wage lags yields:

$$X^2(7) = .309 \times n = .309 \times 54 = 16.71$$

and the 5% significant level for $X^2(7)$ is 14.07. The equivalent result using Kennan's reported cross correlations is 9.83, thus showing no significant correlation.

TABLE 7.5

CROSS CORRELATIONS OF INNOVATIONS IN REAL WAGES AND EMPLOYMENT

	Employment on Post W		$2/\sqrt{n}$	Real Wages on Post L	
Lags	Myatt	Kennan		Myatt	Kennan
0	-.1172	-.06	0.26	-.1172	-.06
1	-.3086	-.27	"	-.2022	-.27
2	-.3010	-.17	"	.0287	-.11
3	-.0414	-.02	"	-.0273	.02
4	.2109	.20	"	-.0888	-.17
5	-.1108	-.06	"	-.0164	-.07
6	.2268	.19	"	.0310	.02
7	-.0824	-.04	"	-.0072	.06
8	.0740	-.17	"	.1917	.06
9	.0079	.09	"	.0864	.06
10	-.0707	-.05	0.29	-.0318	-.16

TABLE 7.6

RESULTS OF X^2 TESTS

	L on Past W		W on Past L		
	Myatt	Kennan	Myatt	Kennan	5% Critical Level
$X^2(3)$	10.78	5.58	3.0	4.69	7.8
$X^2(7)$	16.71	9.83	3.53	6.53	14.07
$X^2(11)$	17.62	12.0	5.97	8.46	19.69

Table 7.6 shows the results of the X^2 test for different values of k. As with the direct Granger test the influence of past real wages on employment weakens the greater the number of lags considered. Clearly the difference between my results and Kennan and Geary's must lie in the data used. The following table lists the data used in the two studies.

TABLE 7.7: DATA SOURCES

Kennan and Geary	1961-1977
Employment:	Index of total employment in manufacturing, Cansim #D1318
Wages:	Average hourly earnings in manufacturing, Cansim #D1518
Prices:	Industry Selling Prices, all manufacturing, Cansin #500000

Table 7.7 (continued)

Myatt	1961-1978
Employment:	Index of total employment in manufacturing, Cansin #D700115
Wages:	Average hourly earnings in manufacturing, Cansim #D1518
Prices:	General Wholesale Price Index for fully and chiefly manufactured goods, Cansim #D601013

Upon comparing the employment series D1318 and D700115 it was found that they were exactly identical, there evidently being more than one Cansim number for the same series. Since the wage series were the same, the difference comes down to the choice of price index.

Though Kennan and Geary state in the main body of their paper that they use the wholesale price index, in their appendix they state they use industry selling prices for Canada. Of course, all data has its drawbacks, and the ability of both the wholesale price index and industry selling prices to approximate the own product price is no exception. The wholesale price index will include the prices of goods not manufactured in Canada. The same is true for industry selling prices because the price indexes for imported goods sold by Canadian manufacturing establishments (automobiles for example) would also be included[24]. Similarly, both indexes include transportation costs. However, the wholesale price index has an advantage over the industry selling price index in that it does not include retail mark ups as the latter does. This is not to imply that Kennan and Geary's choice of price index was wrong. Rather, one ought simply to state that the use of different price indexes accounts for the different results obtained.

7.4.3 Reasons for the Conflict with Sargent

The superficial reasons are similar to the ones discussed in the preceeding section. Sargent's sample period 1949-72, his use of the CPI deflator as compared to Kennan and Geary's use of 1947-1977 and the WPI deflator. Some other differences also helping to obscure matters are the facts that Sargent used the total civilian labour force and a linear formulation, whereas Kennan and Geary used manufacturing employment and a log-linear formulation. To repeat, Kennan and Geary explored the possible reasons for the conflict, by applying their Pierce-Haugh technique to the United States, utilizing the CPI deflator and the sample period 1947-71, and found a strong relationship between employment and past W. They conclude that the important differences were the deflator and sample period but again do not narrow the difference down any further. It does seem however, from the diversity of results, that if they are all to be believed, that the time series relationship between employment and real wages is not stable over time.

Before closing this rather open ended chapter it is worth first reporting a very interesting part of the anlaysis by Kennan and Geary. They point out that Sargent's test has no power against the alternative hypothesis that the W and L series are independent and L follows an AR(1) process. The reasoning is that the model collapses if g, the disequilibrium cost relative to the adjustment cost, is zero. A value of zero for g implies a value of unity for λ and by referring to 7.3.3 we see that $\alpha(B)$ is then identically zero[25]. (Also since g is zero, α_0 is zero and therefore α_i is zero for any i). If however, employment is an AR(1) process then equation 7.3.7, which now reduces to

$$(1 - \lambda B)L_t = \varepsilon_t, \qquad \varepsilon_t = \text{white noise}$$

must fit well. Indeed since Sargent introduces an ad hoc AR(1) disturbance into 7.3.7 then it will fit well even if L_t is approximately an AR(2) process with one root close to unity. Since this description fits the actual employment series for every country studied by Kennan and Geary, they conclude that Sargent's test would have failed to reject the neoclassical model for each of those countries.

Sargent's test therefore has no power against an alternative hypothesis of independence when employment is an AR(2) process.

7.5 CONCLUDING REMARKS

This chapter had two aims. First, we wanted to use the causality test to establish which variable is better suited to be the dependent variable in a labour demand equation. Since we found evidence of one way causality flowing from real wages to employment it would not be legitimate for real wages to be the dependent variable in the labour demand curve. Second, we wished to use the time series approach to investigate the relationship between real wages and employment, as a supplement to the investigation undertaken using traditional model building techniques. In replicating Neftci's study using Canadian data, and comparing these results with those obtained by Kennan and Geary, we discovered that the existence of a causal relationship between real wages and employment depends on the choice of price index used to deflate wages. Two equally plausible measures of the own product price give quite different results. Using industry selling prices to deflate wages, Kennan and Geary find no relationship between real wages and employment; whereas when the wholesale price index was used to deflate wages, we discovered a strong causal relationship from real wages to employment. Finally, an overtime aggregation correction was tried, but made no difference to the results.

FOOTNOTES

Chapter 7

1. Granger Newbold,"The Time Series Approach to Econometric Model Building" in "New Methods in Business Cycle Research: Proceedings from a Conference",Federal Reserve Bank of Minneapolis, 1973.

2. References proliferate ,but see for example,Haugh, "Checking the Indepence of Two Covariance-Stationary Time Series;a Univariate Residual Cross Correlation Approach",American Statistical Association,June 1976.

3. Sims,"Money,Income,and Causality",A.E.R.,1972.

4. Granger,"Investigating Causal Relations by Econometric Models and Cross Spectral Methods",Econometrica,1969.

5. See Sims supra.

6. Scarth and Myatt,"The Real Wage Employment Relationship", Economic Journal,March1980.

7. A similar problem arises with measurement error, which may have accounted for only 5% of the variation in in original.

8. Compare ,for example C.A.Sims, "Macro Economics and Reality", Fisher-Shultz Lecture,Vienna 1977; University of Minnesota,Centre for Economic Research Discussion Paper #77-91,1977.

9. But the CPI could be justified by an appropriate model. See below,page .

10. See chapter 10.

11. Jacobs,Leamer and Ward,"Difficulties with Testing for Causation",Economic Inquiry,July 1979.

12. The same is true for the Sims ,or Pierce and Haugh tests.

13. Salih Neftci,"A Time Series Analysis of Real Wage Employment Relationship",J.P.E., April 1978.

14. See chapter 8,section 8.3.1. for a full discussion.

15. This follows the treatment of Burbidge and Harrison, "The Impact of Changes in Import Prices :A Time Series Analysis",McMaster Working Paper,#80-02.

16. The standard error of the some of co-efficients was calculated as:

$$S^2_{\sum c(s)} = S^2_{c_1} + \dots + S^2_{c_{18}} + 2\sum_{i,j} \mathrm{cov}(c_i, c_j) \quad (i \neq j)$$

The data for the regression were the residuals from the whitening process,i.e.,the data are logged differenced, detrended, and deseasonalised.

17. It is worth pointing out that Neftci adjusted for serial correlation in part II of his paper using Fourier transformations, and amongst other things a 37 element moving average filter. On the other hand we made no adjustment for serial correlation because we did not find any significant evidence of it.We checked for serial correlation by taking the errors resulting from equation 2 (reported in Table 7.2).and formed a correlogram. These correlograms are reported below along with the theoretical standard error assuming that the errors are white noise.That is to say,if the errors are white noise, the true unobserved autocorrelations would be zero,but each sample autocorrelation has a standard error equal to $1/\sqrt{T}$,where T is the number of observations.

CORRELOGRAM OF ERRORS RESULTING FROM THE EMPLOYMENT EQUATION REPORTED IN TABLE 7.2

Equation \ Lags	1	2	3	4	5	6	7	8	9	Standard Errors
k = 18	-.10	.12	-.11	.14	.03	.08	-.09	.05	.07	.07
k = 12	-.08	.11	-.10	.14	.04	.07	-.06	.09	.06	.07
k = 6	.03	.12	-.07	.15	.04	.06	-.03	.07	.04	.07
k = 0	.01	.11	-.02	.17	.07	.09	-.06	.10	.02	.07

Using the rough criterion of significance that the autocorrelation $(r_j) > 2\text{x}$ Standard Error

17.(continued)
we find that the errors are quite satisfactory except for some marginally significant correlation for the fourth lag, which does not seem worth attempting to correct for.

18. T.Sargent,"Estimation of Dynamic Labour Demand Schedules Under Rational Expectations", J.P.E. ,pp.1008-1044,1978.

19. This is described in detail in chapter 8.

20. From chapter 8 we know $\lambda' = 1/R\lambda$ and $\lambda + \lambda' = \frac{1+R+g}{R}$

$$\therefore \lambda + 1/\lambda R = \frac{1 + R + g}{R}$$

$$\therefore \lambda^2 R + 1 = (1 + R + g)\lambda$$

$$\text{or } 1 - (1 + R + g)\lambda + \lambda^2 R = 0.$$

21. See following footnote.

22. J.Kennan and P.T. Geary, "The Employment Real Wage Relationship: An International Study",McMaster Working Paper,#79-13.

23. Ibid, page 23.

24. See, "Industry Selling Price Indexes : Manufacturing," Government of Canada,catalog #C 528 .

25. $g = \frac{(1-\lambda)^2}{\lambda}$, again see chapter 8 section 8.1.2.

CHAPTER 8

EMPLOYMENT EQUALS LABOUR DEMAND

The purpose of this chapter is to develop a model of labour demand assuming costly adjustment, under various assumptions about the formation of expectations, and to incorporate production lags into this model. The final section considers introducing the overtime aggregation feature and the imported (into the sector not the country) intermediate input adjustment.

8.1 The Cost of Adjustment Model

8.1.1 Some Preliminary Considerations

Brechling[1] has shown how a model which incorporates costs of adjusting both labour and capital leads to a set of first order conditions of the kind $[\dot{K}, \dot{L}]' = Z[(K^* - K), (L^* - L)]$ where K^* and L^* indicate the comparative static equilibrium levels of capital and labour respectively, and Z is a (2 x 2) matrix of adjustment coefficients. This type of model is appropriately labelled a long run model since adjustments of capital are explicitly taken into account. An initial problem therefore, concerns the method in which a short run model is operationalized. A common assumption, which is made either to operationalize a short run model or merely to achieve simplicity, is that the off diagonal elements of matrix Z are zero. This implies that the adjustment of labour on its growth path will not be directly influenced by the adjustments of capital on its growth path, though there will clearly be an indirect link in so far as the adjustments of capital affect the level of the capital stock which will affect L^*. Furthermore, if we assume that capital is always on its trend growth path then the influence of the capital stock on L^* can be ignored by simply detrending the data, if we have linear homogenous technology. Thus, assuming a Cobb-Douglas production function of the form:

$$X_t = Ae^{\gamma t} L_t^{\alpha} K_t^{1-\alpha}$$

then L_t^* can be written as:

$$\ell nL^* = -\frac{1}{\alpha-1} \ell n\ W/P - \frac{1}{\alpha-1} \ell n(\alpha A) - \frac{\gamma}{\alpha-1} t - \ell nK$$

Denoting the trend growth in L^* by L^{**}, and the trend growth in W/P and K by W/P^* and K^* respectively, we may write:

$$\ell n\ L^{**} = \Psi_0 - \Psi_1 t - \Psi_2 \ell n(W/P)^* - \ell nK^*$$

If we assume that K never departs from its trend growth path then the deviations of L^* from its trend growth path will be a function of the deviations of W/P from its trend growth path:

$$\ln L^* - \ln L^{**} = -\Psi_2[\ln(W/P) - \ln(W/P)^*]$$

Assuming then that the offdiagonal elements of matrix Z are zero, that capital is always on its trend growth path, that we have linear homogenous technology and that all variables from now on are considered as deviations from trend we may simply ignore the capital stock and write $L^* = -\beta W/P$. This will prove useful for the treatment of monthly and quarterly data since capital stock data only exists on an annual basis[2].

The costly adjustment model begins either with the assumption that the firm minimizes its total cost, or that it attempts to maximize its profits. We will begin with the cost minimization approach and then show that it is equivalent to a special case of the profit maximization approach.

Assume that actual employment differs from its planned value by a disturbance ε_{2t} which is realized after L_t is selected and is white noise

$$L_t = L_t^P + \varepsilon_{2t}$$

Now suppose the decision maker wishes to minimize the expected present value of the following quadratic loss function[3]:

$$\text{Min } \lambda = E \sum_{t-1}^{\infty} R^t [a_1(L_t - L_t^*)^2 + a_2(L_t - L_{t-1})^2]$$

where R is a constant discount factor, the first cost component is a disequilibrium cost and the second component is an adjustment cost. Differentiating λ with respect to L_t yields,

$$\frac{d\lambda}{dL_t} = E\ R^t[2a_1(L_t - L_t^*) + 2a_2(L_t - L_{t-1})]$$

$$+ ER^{t+1}\ [-2a_2(L_{t+1} - L_t)] = 0$$

which upon simplification becomes:

$$R\ E\ (L_{t+1}) - (1 + g + R)L_t^P - L_{t-1} = -g\ L_t^*$$

where $g = a_1/a_2$. This equation has a central role to play and will be referred to as the optimality condition. The same equation can be derived from profit maximization if we assume a quadratic production function of the form:

$$X = AL_t - \beta L_t^2$$

The firm's real revenue function is

$$REV = X - W_t L_t - a_2(L_t - L_{t-1})^2$$

and its objective is to maximize the expected present value of its profit function two terms of which contain the variable L_t,

$$V_t = ER^t[AL_t - \beta L_t^2 - W_t L_t - a_2(L_t - L_{t-1})^2]$$
$$+ R^{t+1}[AL_{t+1} - \beta L_{t+1}^2 - W_{t+1} L_{t+1}$$
$$- a_2(L_{t+1} - L_t)^2]$$

differentiating with respect to L_t yields

$$\frac{dV_t}{dL_t} = ER^t[A - 2\beta L_t - W_t - 2a_2(L_t - L_{t-1})]$$
$$+ R^{t+1}[2a_2(L_{t+1} - L_t)] = 0$$

From the first order condition of the production function we know that L^* satisfies the equation

$$A - 2\beta L_t^* = W_t,$$

and therefore,

$$A - 2\beta L_t - W_t = A - 2\beta L_t - A - 2\beta L_t^*$$
$$= 2\beta(L_t^* - L_t)$$

Substituting this result into the optimality condition yields:

$$E[\beta(L_t^* - L_t) - a_2(L_t - L_{t-1}) + Ra_2(L_{t+1} - L_t)] = 0$$

or

$$RE(L_{t+1}) - (1 - R + g)L_t^P + L_{t-1} = - gL_t^*$$

where $g = \beta/a_2$

Thus, the cost minimization model is identical to a profit maximization model which assumes a quadratic production function. Since a quadratic production function is a special case the resulting optimality condition is not general. In addition, generality is precluded because adjustment costs, which in their general[5] form are specified as

$$\Phi(L_t - L_{t-1}), \quad \Phi' \gtrless 0 \text{ as } (L_t - L_{t-1}) \gtrless 0 \text{ and}$$

$\Phi'' > 0$, are approximated again by the quadratic expression $a_2(L_t - L_{t-1})^2$. A perceptive reader might be concerned about the proliferation of quadratic forms. The reason is clear from considering the resulting optimality condition. The quadratic specifications are made to ensure linearity. Now a fundamental point appears here, and that is that the test of any theory requires a choice of functional form, and the rejection of the resulting model by the data may either reflect rejection of the theory or rejection of the choice of functional form. However, this is always true, and indeed there are always more functional forms to be tried. In the face of such a prospect, all we can do is realize the limitations of our knowledge and sensibly choose the simplest functional forms to start with.

8.1.2 Manipulating the Optimality Condition

The optimality condition is amenable to algebraic manipulation through which it is possible to derive the partial adjustment equation

$$L_t = (1 - \lambda)L_t^* + \lambda L_{t-1}$$

and show that it depends on the assumption of static expectations. We will also derive alternative specifications by assuming in turn adaptive and rational expectations[6].

In the deterministic case with the future known with certainty **the optimality condition can be rewritten** as:

$$L_{t+1}[1-B(\frac{1 + R + g}{R}) + B^2 1/R] = -g/R\ L_t^*$$

where B is the backward operator such that $BX_t = X_{t-1}$ and $B^2X_t = X_{t-2}$ and so on. The above equation is a quadratic equation in B of the form

$$L_{t+1}[1 - (\lambda + \lambda')B + \lambda\lambda' B^2] = - g/R\ L_t^*$$

or

$$(8.1.1) \qquad L_{t+1}[(1 - \lambda B)(1 - \lambda' B)] = -g/RL_t^*$$

where λ and λ' are the roots of the quadratic, and where $\lambda\lambda' = 1/R$ and $(\lambda + \lambda') = (\frac{1 + R + g}{R})$,

and therefore both roots are real. Also, since $(\lambda-1)(\lambda'-1) = \lambda\lambda' - (\lambda + \lambda') + 1 = -g/R < 0$, it is apparent that one root is greater than unity while the other is less than unity. Therefore, let us define $\lambda' > 1 > \lambda = 1/R\lambda'$.

Equation (8.1.1) may now be rewritten[7] utilizing the forward operator F, ($F X_t = X_{t+1}$ and $F^2 X_t = X_{t+2}$ and so on),

$$(F - \lambda')(1 - \lambda B)L_t = (1 - \lambda)(1 - \lambda')L_t^*$$

which may be rewritten as

$$(8.1.2) \quad (1 - \lambda B)L_t = \frac{(1-\lambda)(1-\lambda')}{(F - \lambda')}L_t^* = (1-\lambda)\frac{(1-1/\lambda')}{(1-F/\lambda')} L_t^*$$

$$= (1-\lambda)\frac{(1-\lambda R)}{(1-\lambda RF)} L_t^*$$

Now,

$$\frac{L_t^*}{1-\lambda RF} = [1 + \lambda RF + (\lambda RF)^2 \ldots + (\lambda RF)^\infty]L_t^*$$

$$= \sum_{s=0}^{\infty} \lambda^s R^s L_{t+s}^*$$

Define the long run target demand for labour as d_t where

$$(8.1.3) \quad d_t = (1 - \lambda R) \sum_{s=0}^{\infty} \lambda^s R^s L_{t+s}^*$$

Substituting (8.1.3) back into (8.1.2) yields

$$(1 - \lambda B)L_t = (1 - \lambda)d_t, \text{ or}$$

$$(L_t - L_{t-1}) = (1 - \lambda)(d_t - L_{t-1})$$

Since $E_t(L^*_{t+s}) = \alpha - BE_t(\frac{W_{t+s}}{P_{t+s}})$, if there are static expectations formed on the levels of wages and prices then $E_t\,(\frac{W_{t+s}}{P_{t+s}}) = \frac{W_t}{P_t}$ and $E_t(L^*_{t+s}) = L^*_t$. Making this substitution into (8.1.3) yields:

$$\begin{aligned} d_t &= (1 - \lambda R)(L^*_t + \lambda R L^*_t + (\lambda R)^2 L^*_t \ldots) \\ &= \frac{(1 - \lambda R)}{(1 - \lambda R)}\, L^*_t \\ &= L^*_t \end{aligned}$$

Therefore in the special case of static expectations concerning the levels of wages and prices, equation (8.1.4) becomes the familiar partial adjustment equation,

$$(L_t - L_{t-1}) = (1 - \lambda)(L^*_t - L_{t-1})$$

However, more generally when we do not assume static expectations, d_t will be an unobserved function of expected future real wages.

8.1.3 Costly Adjustment With Adaptive Expectations

This section attempts to build a consistent costly adjustment model assuming adaptive expectations[8]. Let us begin by making the intuitively reasonable assumption that d_t is adjusted towards L_t^* in an adaptive way

8.1.5 $$L_t = (1 - \lambda)d_t + \lambda L_{t-1}$$

8.1.6 $$d_t = (1 - \theta)L_t^* + \theta d_{t-1}$$

which can be solved to yield:

8.1.7 $$L_t = (1 - \lambda)(1 - \theta)L_t^* + (\theta + \lambda)L_{t-1} - \theta\lambda L_{t-2}$$

Equation 8.1.6 is of course completely ad hoc. It is merely produced out of thin air. Interestingly though it is possible to generate an equation which looks very similar, as follows. Expand equation (8.1.3)

$$d_t = (1-\lambda R)[L_t^* + \lambda R L_{t+1}^* + (\lambda R)^2 L_{t+2}^* \ldots (\lambda R)^T L_{t+T}^*]$$

If we now lag this equation, divide it through by λR and subtract the result from itself we get:

8.1.8 $$d_t = \frac{(\lambda R - 1)}{\lambda R} L_{t-1}^* + \frac{1}{\lambda R} d_{t-1} + (1 - \lambda R)(\lambda R)^T L_{t+T}^*$$

Since $\lambda < 1$ the last term in equation 8.1.8 can be ignored, and equation (8.1.8) can be written

8.1.9 $\quad d_t = (1 - \theta)L^*_{t-1} + \theta d_{t-1}$

where $\theta = 1/\lambda R$ and $(1 - \theta) = \frac{\lambda R - 1}{\lambda R}$

Using (8.1.5) and (8.1.9) we can solve for L_t.

8.1.10 $\quad L_t = (1 - \lambda)(1 - \theta)L^*_{t-1} + (\theta + \lambda)L_{t-1} - \theta\lambda L_{t-2}$

We can gain insight into this equation if we first do some manipulations on it so as to put it into a comparable form to the optimality condition. Lag equation (8.1.10) one period forward, substitute $1/\lambda R$ for θ and continue to put L_t on the left hand side:

$$L_t = \frac{-(1-\lambda R)(1-1/\lambda)}{R\lambda + 1/\lambda} L^*_t + [\frac{1}{R\lambda+1/\lambda}] L_{t-1}$$

$$+ \frac{R}{R\lambda+1/\lambda} L_{t+1}$$

Since $\lambda + 1/\lambda R = \frac{1+R+g}{R}$, the above equation may be expressed in terms of g and R rather than λ,

8.1.11 $\quad L_t = [\frac{R}{1+g+R}] L^*_t + \frac{R}{1+g+R} L_{t-1} + \frac{R}{1+g+R} L_{t+1}$

If we now rewrite the optimality condition for ease of comparison

$$RE_t(L_{t+1}) - (1 + R + g)L^P_t + L_{t-1} = - gL^*_t$$

It is now apparent that equation 8.1.10 is merely the optimality condition with $E_t(L_{t+1})$ replaced by

L_{t+1} and L_t^P replaced by L_t. It is also apparent that though (8.1.10) was derived by using (8.1.9) which looks like an adaptive expectations equation, there is very little "adaptive" about this formulation. In fact since $E_t(L_{t+1})$ is replaced by its actually realized value L_{t+1}, it is probably better described as a perfect foresight or a rational expectations version. This problem arises since d_t is derived for the deterministic case with the future known with certainty.

Let us therefore turn to the optimality condition and consider estimations based on it.

8.1.4 One Step Estimations Based on the Optimality Condition

In this section we will be primarily concerned with the error structure of the structural and reduced form equations and the consistency of the estimation technique.

We have already specified that there may be a white noise error arising from differences between the planned value of employment and the realized value.

$$L_t = L_t^P + \varepsilon_{2t}$$

Another source of white noise error arises from the specification of L_t^*

$$L_t^* = \alpha + \beta Wt/P_t + \varepsilon_{1t}$$

where ε_1 would reflect the influence of omitted variables in the L_t^* function.

Finally, if we specify rational expectations we have a third source of error arising from the $E_t(L_{t+1})$ term:

$$E_t(L_{t+1}) = L_{t+1} + n_{t+1}$$

Making these substitutions in to the optimality condition we may write:

8.1.12 $$RL_{t+1} + L_{t-1} = -g(\alpha + \beta W_t/P_t) + (1+R+g)L_t + \varepsilon_{2t} - g\varepsilon_{1t} - n_{t+1}$$

Since n_{t+1} is a rational prediction error made at time t, it will not be correlated with W_t/P_t, and it looks as though 8.1.12 can be estimated using ordinary least squares. However, this is not the case since n_{t+1} is serially correlated as a result of ε_2. Lagging equation 8.1.4 forward one period and subtracting its expectation from itself,

$$L_{t+1} = (1 - \lambda)d_{t+1} + \lambda L_t + \varepsilon_{2t+1}$$

$$\underline{E_t(L_{t+1} = (1 - \lambda)E_t(d_{t+1}) + \lambda L_t^P}$$

$$-n_{t+1} = (1 - \lambda)[d_{t+1} - E_t(d_{t+1})] + \lambda\varepsilon_{2t} + \varepsilon_{2t+1}$$

and we now see that 8.1.12 would lead to biased estimates since it has both a serially correlated error term and a lagged dependent variable on the right hand side. Because of this problem Kennan advocated a two stage procedure which will be discussed in the next sub-section.

It is to be noted that the theoretical adequacy of estimating equation 8.1.12 has been discussed in terms of an assumed error structure. Clearly if we made different assumptions our conclusions would change. Equation 8.1.12 would theoretically yield unbiased results if we assumed $\varepsilon_{2t} = 0$, implying that plans are successfully carried through or the lack of any constraints to prevent them from being carried through. Indeed, it seems to be a more prevalent procedure for econometricians not to worry unduly about whether or not transformations of equations (such as the Koyck transformation) or substitutions theoretically produce a serially correlated error in the reduced form. This is because there is no prior knowledge that the errors in the structural equations are white noise to begin with, and therefore we do not know a priori whether the transformations we perform are introducing serial correlation or removing it. Rather it is more prevalent to simply check for serial correlation when the equation is estimated. On these grounds (or, if it is preferred, assuming $\dot{\varepsilon}_2 = 0$) application of O.L.S. to equation 8.1.12 would be justified.

Equation of 8.1.12 may also be rewritten so that L_t is the dependent variable:

$$8.1.13 \qquad L_t = \frac{R}{1+R+g} L_{t+1} + \frac{1}{1+R+g} L_{t-1} + \frac{g}{1+g+R} L_t^* + e_t$$

In this case an instrumental variable must be used for L_{t+1}, since e_t affects L_t which affects L_{t+1} and therefore e_t will not be orthogonal to L_{t+1}. However, providing e_t is not serially correlated, applying indirect least squares to equation 8.1.13 should yield unbiased estimates of the parameter.

Let us now turn to the problem of finding a consistent costly adjustment model assuming adaptive expectations. In this case, we must somehow get rid of the term $E_t(L_{t+1})$. One possibility would be to assume that:

$$L^e_{t+1} = \gamma L_t + (1 - \gamma) L^e_t$$

and apply a Koyck transformation to 8.1.13. This results in the following equation:

$$8.1.14 \qquad L_t = \frac{g}{1+R+g-\ \gamma R} L_t^* - \frac{g(1-\gamma)}{1+R+g-R\gamma} L^*_{t-1}$$

$$+ \frac{[1+(1-\ )(1+R+g)]}{1 + R + G + R\gamma} L_{t-1}$$

$$- \frac{(1\ -\gamma)}{1+R+g-R\gamma} + e'_t$$

Unfortunately this equation is underidentified and therefore cannot be used. Another possibility would be to avoid the Koyck transformation by using Klein variates[9].

Suppose we have an equation of the form:

$$Y_t = \alpha + \beta X^e_{t+1} + v_t$$

where X^e_{t+1} is the expected value of X_{t+1} made in period t, and X^e_{t+1} is formed according to

$$X^e_{t+1} = \gamma X_t + (1 - \gamma) X^e_t$$

or $$X^e_{t+1} = \gamma X_t + \gamma(1-\gamma)X_{t-1} + \gamma(1-\gamma)^2 X_{t-1} \ldots \gamma(1-\gamma)^\infty X_{t-\infty}$$

$$= \gamma \sum_{i=0}^{\infty} (1 - \gamma)^i X_{t-i}$$

and therefore,

$$Y_t = \alpha + \beta\gamma \sum_{i=0}^{\infty} (1-\gamma)^i X_{t-i} + v_t$$

The above equation can be rewritten as

$$Y_t = \alpha + \beta\gamma \sum_{i=0}^{t-1} (1-\gamma)^i X_{t-i} + \beta\gamma \sum_{i=t}^{\infty} (1-\gamma)^i X_{t-i} + v_t$$

or

8.1.15 $$Y_t = \alpha + \beta\gamma \sum_{i=0}^{t-1} (1-\gamma)^i X_{t-i} + \beta\gamma(1-\gamma)^t \sum_{i=0}^{\infty} (1-\gamma)^i X_{-i} + v_t$$

The second term in 8.1.15 can be computed from the actual observations for any given value of γ. The third term cannot be computed because X_0, X_{-1}, X_{-2}, etc., are not observed. But we may define:

$$Z_{1t} = \gamma \sum_{i=1}^{t-1} (1-\gamma)^i X_{t-i}$$

$$Z_{2t} = \gamma(1 - \gamma)^t$$

$$n_0 = \beta \sum_{i=0}^{\infty} (1 - \gamma)^i X_{-i}$$

and write 8.1.15 as

$$8.1.16 \qquad Y_t = \alpha + \beta Z_{1t} + n_0 Z_2 t + v_t$$

where n_0 is a parameter which corresponds to a truncation remainder. For each value of γ we construct the variables Z_{1t} and Z_{2t}, estimate 8.1.16, and choose that value of γ for which the residual sum of squares is a minimum. This is the maximum likelihood estimate of γ and β and n_0. It can be shown that the estimates for γ and β are consistent.

Therefore a consistent way to implement the costly adjustment model while assuming adaptive expectations would be to use Klein variates and estimate:

$$8.1.17 \qquad L_t = \frac{g}{1+R+g} L_t^* + \frac{1}{1+R+g} L_{t-1} + \frac{R}{1+R+g} Z_{1t} + n_0 Z_{2t} + v_t$$

8.1.5 Implementing the Model Using Two Stage Procedures and Assuming Rational Expectations

The following two stage procedure to estimate the costly adjustment rational expectations model was proposed by Kennan to obtain consistent estimates when serial correlation is present in equation (8.1.12).

Step 1 involves using equation 8.1.4

$$L_t = \lambda L_{t-1} + (1 - \lambda)d_t$$

to obtain consistent estimates of λ. Though d_t is unobserved it depends only on expected future values of the real wage. If real wages follow an autoregressive process of order (p) then the expectation in period t of the real wage in period t+s will be a linear combination of present and past values of the real wage and therefore d_t will also be a linear combination of present and past values of the real wage. Substituting present and (p - 1) past values of the real wage into equation (8.1.4) yields:

$$8.1.18 \qquad L_t = \lambda L_{t-1} + \alpha_0 \frac{W_t}{P_t} + \alpha_1 \frac{W_{t-1}}{P_{t-1}} \cdots \alpha_{p-1} \frac{W_{t-p}}{P_{t-p}}$$

Providing we are prepared to set the value of R in advance, a consistent estimate of λ translates into a consistent estimate of g^{10}. (It is an advantage of the one step methods that R does not have to be arbitrarily set at some level but may be estimated as a parameter in the model.)

Stage 2 involves estimating the optimality condition with no lagged values of the dependent variable on the right hand side by making use of the estimate of g obtained from stage one:

$$R\,L_{t+1} - (1+R+\hat{g})L_t + L_{t-1} = -\,\hat{g}\,L_t^* + e_t$$
$$= -\,\hat{g}(\alpha + \beta\,\frac{W_t}{P_t}) + e_t$$

An alternative two stage procedure has been suggested by Nerlove[11] which involves combining estimates of equation (8.1.18) with direct estimates of the process generating W_t/P_t. In the following equation, let w_t refer to logged real wages. (All the variables have implicitly been logged to the natural base.) For example, suppose that logged real wages can be modelled as an AR1(1,1) process, then

$$(w_t - w_{t-1}) = \phi(w_{t-1} - w_{t-2}) + v_t$$

where v_t is a sequence of identically and independently distributed random disturbances with zero mean and variance σ_v^2, often referred to as "white noise".

The model to be estimated consists of the following three equations:

1. $L_t^* = \alpha + \beta w_t$
2. $L_t = (1 - \lambda)d_t + \lambda L_{t-1}$
3. $d_t = (1 - \lambda R)(\sum_{s=0}^{\infty} {}^{s}R^{s}\, L_{t+s}^*)$

Substituting equation (1) into equation (3) we obtain

$$d_t = (1-\lambda R)[\alpha + \lambda R\alpha + (\lambda R)^2\alpha \; \ldots .$$

$$+ \; w_t + \lambda R\beta w_{t+1} + (\lambda R)^2\beta \; w_{t+2} \; \ldots . \;]$$

$$\therefore \; d_t = \alpha + \beta(1- R)[w_t + \lambda R \, w_{t+1} + (\lambda R)^2 \, w_{t+2} \; \ldots .]$$

or

$$d_t - d_{t-1} = \beta(1-\lambda R)[(w_t - w_{t-1}) + \lambda R(w_{t+1} - w_t)$$

$$+ (\lambda R)^2(w_{t+2} - w_{t+1}) \; \ldots ..]$$

Now, from the ARI (1,1) process we know that

$$E_t(w_{t+1} - w_t) = \phi(w_t - w_{t-1})$$

$$E_t(w_{t+n} - w_{t+n-1}) = \phi^n(w_t - w_{t-1})$$

Substituting the expectation in period t of $(w_{t+s} - w_{t+s-1})$ into the equation for $d_t - d_{t-1}$,

$$d_t - d_{t-1} = \beta(1 - \lambda R)[(w_t - w_{t-1}) + \phi\lambda R(w_t - w_{t-1})$$

$$+ (\phi\lambda R)^2(w_t - w_{t-1}) \ldots ..]$$

and if $\phi \lambda R < 1$ ($\phi, \lambda < 1$, $R > 1$) then the infinite sum converges and we may write:

$$d_t - d_{t-1} = \beta(1 - \lambda R)\frac{(w_t - w_{t-1})}{(1 - \lambda R\phi)}$$

Finally, first differencing equation (2) and substituting in for the expression $d_t - d_{t-1}$, we get:

$$8.1.19 \qquad (L_t - L_{t-1}) = \frac{(1-\lambda)(1-\lambda R)}{(1 - \lambda R\phi)} (w_t - w_{t-1}) + \lambda(L_{t-1} - L_{t-2})$$

Estimating equation 8.1.19 gives us estimates of λ and $\frac{\beta(1-\lambda)(1-\lambda R)}{(1 - \lambda R\phi)}$. If we set a value arbitrarily for R, then the independent estimate of ϕ from a Box Jenkins analysis of the process generating the real wage, allows us to obtain an estimate of β.

8.2 Introducing Production Lags into the Costly Adjustment Model

Let us first summarise the one step costly adjustment equations that we have generated under various assumptions about the formation of expectations.

Assuming Static Expectations:

$$8.2.1 \qquad L_t = (1 - \lambda)L_t^* + \quad L_{t-1}$$

Assuming Adaptive Expectations:

First the ad hoc version:

$$L_t = (1 - \lambda)d_t + \lambda L_{t-1}$$

$$d_t = (1 - \theta)L_t^* + \theta d_{t-1}$$

which results in:

$$8.2.2 \qquad L_t = (1-\lambda)(1-\theta)L_t^* + (\theta + \lambda)L_{t-1} - \theta\lambda L_{t-2}$$

Second, using Klein variates in the optimality condition, we have a consistent adaptive model:

8.2.3 $$L_t = [\frac{g}{1+R+g}] L_t^* + [\frac{1}{q+R+g}]L_{t-1} + \frac{R}{1+R+g} Z_{1t} + n_0 Z_{2t}$$

Assuming Rational Expectations:

8.2.4 $$RL_{t+1} + L_{t-1} = -gL_t^* + (1 + R + g)L_t$$

8.2.5 $$L_t = \frac{R\ L_{t+1}}{(1+R+g)} + \frac{1}{(1+R+g)} L_{t-1} + \frac{g}{(1+R+g)} L_t^*$$

(where an instrumental variable for L_{t+1} must be used).

The introduction of production lags is achieved in the specification of L_t^*. Letting $W_t - P_t$ denote the logarithm to natural base of the real wage, L_t^* is specified as

$$L_t^* = \alpha + \beta W_t - \beta P_{t+1}^e$$

Now we can assume that expectations about next periods price are formed statically, adaptively or rationally, and we can either assume that expectations are formed about the level of prices or about the rate of price change. The corresponding equations are:

Expectations formed on the level of prices:

Static:

8.2.7 $$P_{t+1}^e = P_t;$$

Adaptive:

8.2.8 $$P^e_{t+1} = \gamma P_t + (1 - \gamma)P^e_t$$

Rational:

8.2.9 $$P^e_{t+1} = P_{t+1} + n_{t+1}$$

Expectations formed on the rate of price change:

Static:

$$(P^e_{t+1} - P_t) - (P^e_t - P_{t-1}) = [(P_t - P_{t-1})-(P^e_t - P_{t-1})] ,$$

or

8.2.10 $$P^e_{t+1} = (P_t - P_{t-1}) + P_t$$

Adaptive:

$$(P^e_{t+1} - P_t)-(P^e_t - P_{t-1}) = \gamma[(P_t-P_{t-1})-(P^e_t - P_{t-1})], \text{ or}$$

8.2.11 $$P^e_{t+1} - (1 - \gamma)P^e_t = (P_t - P_{t-1}) + \gamma P_t$$

Rational:

$$(P^e_{t+1} - P_t) = (P_{t+1} - P_t) + n_{t+1}, \text{ or}$$

8.2.12 $$P^e_{t+1} = P_{t+1} + n_{t+1}$$

We should note that the assumption that expectations are formed statically about the level of prices is not distinguishable from the assumption that there is no production lag. Secondly, the difference between expectations being formed about price levels and expectations being formed on rates of price change disappears when expectations are formed rationally.

The final reduced form equations are obtained by piecing together an adjustment equation, the definition of L_t^*, and an equation describing expectation formation. Conceptually we could try each of the five adjustment equations with each of the five different equations describing expectation formation, but the resulting hybrid models would not all be interesting. However, I propose to test the combinations given in Table 8.1 below.

TABLE 8.1

The Reduced Form Combinations

Version of the Adjustment Equation	Formation of Price Expectations
Static (Eqn 8.2.1)	Static on levels Eqn. 8.2.7
	Static on rates Eqn. 8.2.10
	Adaptive on levels Eqn. 8.2.8
	Adaptive on rates Eqn. 8.2.11
Adaptive ad hoc (8.2.2)	Adaptive on levels
	Adaptive on rates
Adaptive - Klein (8.2.3)	Adaptive on levels
	Adaptive on rates
Rational 8.2.4	Rational
Rational 8.2.5	Rational

It will be noted that five out of the ten reduced form equations will be the result of consistently applying a given assumption about the formation of expectations throughout the whole model. The reason why there are only five and not eight as might first appear, is of course, because both the static adjustment equation and the adaptive adjustment equations all assume that expectations are formed about the level of prices and wages (and thus employment) and not about the rates of change of these magnitudes. The five hybrid models are included for interests sake, and were chosen with an effort to avoid too jarring a clash of assumptions made at different stages of the same models.

Let us now turn to the derivation of the equations themselves. We begin with the static adjustment equation and the adaptive expectations formed on levels of price, plus equation 8.2.6:

8.2.1 $L_t = (1 - \lambda)L_t^* + \lambda L_{t-1}$

8.2.6 $L_t^* = \alpha + \beta W_t - \beta P_{t-1}^e$

8.2.8 $P_{t+1}^e = \gamma P_t + (1 - \gamma)P_t^e$

Substituting 8.2.6 into 8.2.1 yields

8.2.13 $L_t = (1-\lambda)\gamma + (1-\lambda)\beta W_t - (1-\lambda)\beta P_{t-1}^t + \lambda L_{t+1}$

multiplying the lagged version of 8.2.13 by $(1 - \gamma)$ and subtracting from itself yields:

Static 1 (S1) $\quad L_t = \gamma(1-\lambda)\alpha + (1-\lambda)\beta W_t - (1-\gamma)(1-\lambda)\beta W_{t-1}$

$$-(1-\lambda)\beta\gamma P_t + (1+\lambda-\gamma)L_{t-1} - \lambda(1-\gamma)L_{t-2}$$

If $\gamma = 1$ this indicates either that there is no production lag, or that expectations are formed statically. If $\lambda = 0$ then there are no costs of adjustment on labour hired.

If we now assume that expectations are formed adaptively on rates of price change we generate:

Static 2 (S2) $\quad L_t = \text{Static 1} - (1 - \lambda)\beta\ (P_t - P_{t-1})$

Since equation "Static 2" (S2) is identical to equation "Static 1" (S1) except for the additional term $(P_t - P_{t-1})$ it may appear as if S1 is nested in S2 and that only S2 need be estimated. However, this is not the case, since the coefficient of $(P_t - P_{t-1})$ involves only λ and β, terms which were already in the equation, and the significance of which will not be determined by $(P_t - P_{t-1})$ alone. Since the dependent variable is the same one could perform a non-nested hypothesis test[12], but at this stage going to such lengths would seem to be premature. The equations may be more simply compared on the basis of R^2 values and on the basis of correct signs of parameters. Of course, the usual presumption that the R^2 will be higher in the equation with the added explanatory variable is not true in this case, because we will be using non-linear least squares and imposing the constraints on the reduced form parameters implied by the structural coefficients (otherwise the equation is overidentified).

For the adaptive adjustment equation we take first the simple model, equation 8.2.2, 8.2.6, and 8.2.7

8.2.2 $L_t = (1-\lambda)(1-\theta)L_t^* + (\theta + \lambda)L_{t-1} - \theta\lambda L_{t-2}$

8.2.6 $L_t^* = \alpha + \beta W_t - \beta\ P_{t+1}^e$

8.2.7 $P_{t+1}^e = P_t$

which results in:

Adaptive 1 $L_t = (1-\lambda)(1-\theta)(\alpha + \beta W_t - P_t)+(\lambda+\theta)L_{t-1}-\lambda\theta L_{t-2}$
(A1)

Next we exchange 8.2.7 for 8.2.8 which results in

Adaptive 2 $L_t = (1-\lambda)(1-\theta)[\alpha\gamma+\beta W_t-\beta(1-\gamma)W_{t-1}-\gamma\beta P_t]$
(A2)

$+ (1-\theta+\lambda-\gamma)L_{t-1}+[(1-\gamma)(\theta+\lambda)+\theta\lambda]L_{t-2}$

$+ (1-\gamma)1_{t-3}$

And finally if we exchange (8.2.8) for (8.2.11) we get:

Adaptive 3 $L_t =$ Adaptive 2 $- (1 - \lambda)(1 - \theta)\beta\ (P_t-P_{t-1})$
(A3)

Now to avoid undue repetition, let us turn to the rational expectations versions. For example, let us take equation 8.2.4, and 8.2.6 to yield:

Rational 1 $\quad RL_{t+1} + L_{t-1} = -g(\alpha + \beta W_t - \beta P^0)+(1+R+g)L_t$

(R1)

Instead of writing P^e_{t+1} I have substituted P^0 to indicate that various production lags will be tried here. Expected price series will be generated by fitting the appropriate parsimonious ARIMA model to the price series and then using it to generate optimal forecasts for future prices. Production lags of 0,3,6 and 12 months will be assumed.

Finally, let us turn to the introduction of production lags into the two step version of the costly adjustment model. Stage 1 which is build around equation 8.1.4

8.1.4 $\quad L_t = \lambda L_t + (1 - \lambda)d_t$

could be written as:

$$L_t = \lambda L_t + \alpha_0(W_t-P_t) + \alpha_1(W^*_{t+1} - P^*_{t+1})\ldots.$$

Now, assuming that the process generating $(W_t - P_t)$ is strictly stationary then the joint probability distribution which is conceived to generate $(W_t - P_t)$ will be invariant to a displacement in time, i.e.,

$$p[(W_t-P_t), (W_{t+1} - P_{t+1}), \ldots(W_{t+p}- - P_{t+p})]$$

$$= p[(W_t - P_t), (W_{t-1} - P_{t-1})\ldots(W_{t-p} - P_{t-p})]$$

where p[ ] stands for the probability density function, and hence we generate equation 8.1.18,

$$8.1.18 \qquad L_t = \lambda L_{t-1} + \alpha_0(W_t - P_t) + \alpha_1(W_{t-1} - P_{t-1})$$

$$\cdots \alpha_{p-1}(W_{t-p} - P_{t-p})$$

If we now wish to introduce a production lag "L" periods in length then we have:

$$L_t = \lambda L_t + \alpha_0(W_t - P^*_{t-L}) + \alpha_1(W^*_{t+1} - P^*_{t+L+1}) \cdots \alpha_{p-1}(W^*_{t+p} - P_{t+L+p})$$

If the process generating $(W_t - P_{t+L})$ is strictly stationary then the joint probability distribution generating $(W_t - P_{t+L})$ will be invariant to a displacement in time[13], i.e.,

$$p[(W_t - P_{t+L}) \cdots (W_{t+p} - P_{t+L+p})] = p[(W_t - P_{t+L})$$

$$\cdots (W_{t-p} - P_{t+L-p})] = p[(W_{t-L} - P_t) \cdots (W_{t-L-p} - P_{t-p})]$$

and therefore stage one becomes,

$$L_t = \lambda L_{t-1} + \alpha_0(W_{t-L} - P_t) + \alpha_,(W_{t-L-1} - P_{t-1}) \cdots \alpha_{p-1}$$

$$(W_{t-L-p} - P_{t-p})$$

Next utilising $\hat{g} = R\hat{\lambda} + 1/\hat{\lambda} - (1 + R)$, stage two is accomplished by plugging in the generated expected price series for P^0_t below

Rational 2 (R2):

$$R\ L_{t+1} + L_{t-1} = -g(\alpha + \beta W_t - \beta P_t^O) + (1 + R + G)L_t$$

8.3 SOME FINAL CONSIDERATIONS

8.3.1 The Overtime Correction

The wage data available is average hourly wages and represents the average of straight time average hourly wages and overtime average hourly wages. However, by using data on average weekly hours worked, and by making some assumptions about the length of the straight time work week and the size of the overtime premium, a corrected wage series representing the straight time average weekly wage can be constructed as follows:

Define

L = the number of employed persons

W = average hourly wage

R = (average) straight time wage

H = total hours worked per week

Assuming a straight time work week of 40 hours, the number of man hours during which R is earned is 40 x L, and the proportion of total man hours during which R is earned is 40L/H. Assuming that the overtime premium is time-and-a-half and that it is earned for the remainder of the total man hours worked, we may write:

$$W = \left(\frac{40L}{H}\right)R + \left(1 - \frac{40L}{H}\right)R \times \frac{3}{2}$$

which may be rearranged to express R in terms of W and H/L

$$R = W \frac{1}{1.5-0.5\left(\frac{40}{H/L}\right)}$$

Now plainly the choice of 40 hours to represent the length of the straight time work week was arbitrary and is a bad choice. This is because employment data includes part-time employees as does data on W. A prior check on the average weekly hours series revealed that between 1961 and 78 the minimum H/L was 36.8 (in December 1974). Therefore, to avoid the possibility of a negative weighting of the overtime hours, R was constructed as follows[14]:

8.3.1 $$R = W \frac{1}{1.5-0.5\left(\frac{36.8}{H/L}\right)}$$

We can then test the effect of the overtime aggregation factor by re-estimating the reduced form equations using R instead of W.

8.3.2 The Intermediate Goods Correction

In Chapter 2, Section 2, two corrections were given for the intermediate import phenomenon. Both could be justified on theoretical grounds, but on practical grounds equation 2.2 is to be preferred, since to obtain an estimate of an index of intermediate goods prices imported into the manufacturing sector is required, and this is not available. On the other hand $\alpha\frac{Pm}{Px} = \frac{MPm}{XPx}$, and therefore IMA' requires data on only the total value of output and the total value of domestic value added in manufacturing. To be exact IMA' was calculated as follows:

$$IMA' = 1 - \left[\text{The Total Value of Output} - \text{Net Indirect Taxes} - \text{Labour Income} - \text{Net Income from Unincorporated Business} - \text{Other Operating Surplus}\right] \div \text{Total Value of Output.}$$

8.3.3. Utilising Capital Stock Data

The data on value added in manufacturing is only available on an annual basis. To make the IMA' correction annual data will have to be used. While using annual data we might just as well drop the assumption that capital is always on its trend growth path and use the available annual data on the capital stock in manufacturing. In addition, a capital in use series will be tried to see if Tatom's point makes any difference[15]. This series will be constructed by multiplying the capital stock series by the capacity utilization rate. We shall not however, remove the assumption that the rate of adjustment of the capital stock series does not affect the rate of adjustment of labour (or that the off diagonal elements of matrix Z, page 1 of this chapter, are zero).

These changes affect the equation defining L_t^*. It now becomes:

8.3.4 $$L_t^* = \alpha + \beta W_t - \beta P_t - \beta(IMA') + c\ K_t$$

where c = 1 if constant returns to scale prevail.

FOOTNOTES

Chapter 8

1. Brechling, F.P.R., "Investment and Employment Decisions", Manchester University Press, 1975, 72-79.

2. Section 8.3 below discusses the need to use annual data to introduce the imported intermediate input adjustment. When we come to use annual data it is no longer necessary to assume that capital is on its trend growth path. However for simplicity I retain the assumption that the off diagonal elements of z are zero, and specify that $L_t^* = f(t, w/p, K_t)$.

3. This cost of adjustment model is to be found in Kennan, "The Estimation of Partial Adjustment Models with Rational Expectations", Econometrica, 1979, 1441-1445.

4. Since we require a linear homogenous production function to justify ignoring capital, the profit maximisation model may not be consistent in this respect.

5. Clearly this is not the most general formulation, but it is the most general formulation of adjustment costs which gives rise to lagged adjustment behaviour. See Brechling, pages 36-38.

6. The next two pages of manipulations can be found in Kennan, op. cit.. I include them here for the sake of continuity of exposition, and I also include more detail.

7. This can be proved by solving $(F - \lambda)(1 - \lambda' B)L_t$. It equals $(F - FB\lambda' - \lambda + \lambda\lambda' B)L_t$ which equals $L_{t+1} - (\lambda + \lambda')L_t + \lambda\lambda' L_{t-1}$.

8. Except in the special case where the correct theoretical model which generates the series is an IMA(1,1) model, it must be admitted that adaptive expectations are essentially ad hoc. (See Nelson, C.A., "Applied Time Series Analysis for Managerial Forcasting", Holden-Day, 1973, 60-63)

9. See Maddala, "Econometrics" pages 360-363.

10. Since $\lambda + 1/\lambda R = \frac{1+R+g}{R}$, $\hat{g} = R\hat{\lambda} + 1/\hat{\lambda} - (1 + R)$.
    Kennan sets R=1 resulting in $\hat{g} = \frac{(1 - \hat{\lambda})^2}{\hat{\lambda}}$

11. Nerlove, A., "Distributed Lags and Unobserved Components in Economic Time Series", in Fellner et.al., "Ten Economic Studies in the Tradition of Irving Fisher", New York, 1967.

12. See chapter 12.

13. Strict stationarity requires that the marginal probability functions for any two observations are the same, and that the covariance between any two observations depends only on the number of periods separating them, and not on their position in the series as a whole. See Nelson, pages 19-22.

14. I aknowledge that this correction ignores the problem of shift work, shift work premiums, and the responsiveness of the amount of shift work to the stage of the trade cycle. However a lack of data precludes a consideration of this factor.

15. Tatom , op. cit.. See chapter 2.

CHAPTER 9

THE EMPIRICAL RESULTS FOR THE MODEL EMPLOYMENT EQUALS LABOUR DEMAND

As already discussed in the previous chapter, this model assumes that the supply of labour is infinitely elastic at the prevailing wage rate, actual employment always being equal to labour demand. Supply side considerations implicitly enter in that the difference between actual employment and the desired supply of labour as given by the supply curve determines the adjustment of wages.[1] An initial question arises as to whether the wage in this model should be treated as exogenous or endogenous. In discrete time one could argue that the wage is exogenous during the period, but changes between periods, as a result of differences between the actual supply of labour and the desired supply at last period's observed real wage rate. This explanation clearly fails in a continuous time context, but the existence of wage contracts in the real world may imply that the real world is approximated better by the discrete time model. A similar problem of exogeneity or endogeneity arises with respect to the own product price. Since labour demand equals actual employment which (in combination with other factors of production) determines the quantity of output supplied, we could argue that the own product price should be treated as endogenous[2]. Though assumptions could be made that would justify treating the price as exogenous (for example, an infinitely elastic demand schedule), they would seem to be unnecessary, especially since taking account of endogeneity need not entail building a complete general equilibrium model but could simply be achieved by using an indirect least squares estimation technique. Nevertheless, it is of some interest to see whether the treatment of wages and prices as either exogenous or endogenous makes any difference to the results. Consequently, the estimation process will begin by assuming both wages and prices to be exogenous, after which the assumption of exogeneity will be relaxed in order to appraise the significance of this factor.

This chapter is divided into four sections. The first deals with the question of deseasonalization and looks at the question from both the theoretical and empirical standpoints. Section 2 contains all the empirical work undertaken with monthly and quarterly data. Sub-Section 2.1 contains the static and adaptive equations; 2.2 contains the rational expectations equations; and 2.3 considers the impact upon these estimations of making first wages, then prices, and finally both wages and prices endogenous. Section 3 contains the annual results, the first sub-section dealing with the static and adaptive equations and the second subsection with the rational expectations equations. Section 4 contains a brief summary of the implications of the empirical work reported in this chapter. Finally an appendix to this chapter contains the Box-Jenkins analyses of monthly and quarterly prices undertaken to provide a rationally expected future price series and the Box Jenkins analyses of monthly and quarterly real wages undertaken to operationalize Nerlove's variant of the two stage rational expectations, costly adjustment model.

SECTION 9.1: THE QUESTION OF DESEASONALIZATION

9.1.1 Some Theoretical Considerations

There are two quite distinct reasons for deseasonalising the data. One of them is simply to remove serial correlation so that reliable hypothesis testing can be carried out. The other is that the weather itself exerts a systematic influence over the behaviour of some series and to omit this influence and to try to explain those series in purely economic terms would lead to omitted variable bias.

Employment in manufacturing is not as obviously affected by the seasons as, for example, employment in the construction industry.Nevertheless, many manufacturing industries do clearly display "seasonal" cycles.The automobile industry, for example, lays off thousands of workers every summer as the factories retool for the new models. For this reason the employment series should be deseasonalised.

Hourly wages are less obviously affected by the seasons. It is not obvious that contracts are negotiated at a particular time every year. However, since the hourly wage series represents average hourly wages throughout manufacturing, then if employment is seasonal, the average hourly wage throughout manufacturing will be seasonal too[3].

If input prices and the outputs of different sectors of manufacturing are seasonal, then the price index of total manufacturing output should be seasonal too. However, here we have a problem. The price index of manufacturing output (the wholesale price index for manufactured goods) is calculated with a constant weight attached to each particular commodity throughout the year. Therefore variations in relative output levels due to seasonal factors, though it would translate into variations in the average hourly wage in manufacturing would not translate into variations in the average price index. Therefore, should the average price index be deseasonalized? Though there does not seem to be any persuasive a priori reasons as to why the seasons should affect this index, a safe approach would be to deseasonalize it anyway, since if our a priori reasoning is correct the deseasonalizing would not greatly affect the series. Furthermore, the deseasonalizing can always be justified by the first reason given, namely, to assist in the removal of serial correlation.

9.1.2 Does Deseasonalization Make Any Difference?

In a preliminary study on whether or not deseasonalizing made any difference, the following equations were estimated using monthly data, 1961 to 1978:

(1) $Lt = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \beta(W_t - P_t)$

(2) $Lt = \alpha_1 t + \alpha_2 t^2 + \alpha_3$ WINTER $+ \alpha_4$ SPRING

$+ \alpha_5$SUMMER $+ \beta(W_t - P_t)$

(3) $L_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3$MD1 $+ \alpha_4$ MD2,... α_{14}MD11

$+ \beta(W_t - P_t)$

Equation 1 has no deseasonalising. Equation 2 has three seasonal dummies, where Winter is defined as 1 for January, February and March and zero otherwise, Spring is defined as 1 for April, May and June and zero otherwise, and Summer is defined as 1 for July, August and September and zero otherwise.

Equation 3 has eleven monthly dummies. The results were (statistics are given in brackets)

Equation	α_1	α_2	β	R^2	SSR	D.W.
1	.4E-02(8.4)	-.1E-04(6.5)	-.23(3.3)	.9703	.041577	1.9
2	.4E-02(9.5)	-.1E-04(7.5)	-.23(3.5)	.9734	.037226	1.85
3	.2E-03(1.5)	-.5E-05(1.1)	.01(0.3)	.9935	.009108	1.95

The equations were estimated using the Cochrane-Orcutt iterative technique. Clearly, there is a big difference in the results, β being significantly negative in the first two equations and insignificantly positive in the third. An F test on the 8 restrictions,

$$H_0 : \quad MD1 = MD2 = MD3;\ MD4 = MD5 = MD6\ ;$$
$$MD7 = MD8 = MD9;\ MD10 = MD11 = MD12$$

which are implied by equation 2 resulted in $F = 79$ which is overwhelming evidence against equation 2 and in favour of equation 3. Clearly deseasonalising and the method of deseasonalising does make a difference.

In the estimations which follow when using monthly data, the data were all previously logged, first differenced, detrended and deseasonalized, using eleven monthly dummies. When using quarterly data the deseasonalising is accomplished by using three quarterly dummies[4]. This process removed 14% of the variation in the logged, differenced monthly price series, 43% of the variation in the logged, differenced monthly wage series, 53% of the variation in the overtime adjusted logged, differenced monthly wage series, and 79% of the logged differenced monthly employment series. To generate quarterly series the raw monthly series were averaged. The detrending and deseasonalising process removed 23% of the variation in logged differenced quarterly prices, 61% of the variation in logged differenced wages, 22% of the variation in overtime adjusted, logged, differenced wages, and 78% of the variation in logged differenced employment.

SECTION 9.2 THE EMPIRICAL RESULTS FOR MONTHLY AND QUARTERLY DATA

9.2.1 The Static and Adaptive Equations

To facilitate presentation of the results I will first describe in summary form the static and adaptive equations to be estimated. The results for each equation can then be read off the larger tables 9.1 to 9.4. After discussing these results we will then consider the rational expectations equations.

All the equations are estimated four times, using monthly data with unadjusted wages, W, using monthly data using overtime adjusted wages, R, and using quarterly data for both W and R. Rather than proceed equation by equation, reporting four estimations at a time, it seems more convenient to report all the equations at once using a given data set. All of the equations contain a lagged dependent variable term on the right hand side, making the Durbin-Watson statistic inappropriate. The appropriate check for first order serial correlation in these circumstances is Durbin's "h"[5]. However, rather than just check for first order serial correlation I report the simple correlation coefficients back to the 13th order along with a rough guide to significance. These tables are presented after the results, Tables 9.5 to 9.8. It will be noted that all the variables used are logged to natural base, detrended and deseasonalized.

List of "Static" Equations

Equation - "Static 1" (**Assuming static expectations of prices in the costly adjustment of labour equation, and adaptive expectations of prices in the production lag).**[6]

$$L_t = \gamma(1-\lambda)\alpha + (1-\gamma)\beta[W_t - (1-\gamma)W_{t-1}] - (1-\gamma)\beta\gamma P_t$$

$$+ (1 + \lambda - \gamma)L_{t-1} - \lambda(1-\gamma)L_{t-2}$$

Static 2 assumes expectations are formed adaptively on the rate of price change.

$$L_t = \text{Static 1 } (1 - \lambda)\beta[P_t - P_{t-1}]$$

Static 3. In some of the equations estimated γ, the adjustment coefficient for price expectations, was significantly greater than unity. This is a nonsense result since

$$P^e_{t+1} = \gamma P_t + \gamma(1-\gamma)P_{t-1} + \gamma(1-\gamma)^2 P_{t-z} + \gamma(1-\gamma)^3 P_{t-z} \ldots$$

and it therefore implies that every other price term is given a negative weight in the formation of expected prices. Because of this we estimated an equation with $\gamma = 1$ imposed. That is

$$P^e_{t+}1 = P_t$$

$$L_t = (1 - \lambda)\alpha + (1 - \lambda)\beta \quad (W_t - P_t) + \lambda L_{t-1}$$

Static 4.

This equation imposes $\gamma = 1$ when expectations are formed on rates of change of prices;

$$L_t = \text{Static 3} - (1 - \lambda)\beta[P_t - P_{t-1}]$$

Static 5.

In some of the equations the adjustment coefficient of labour, λ , was significantly negative. Therefore $\lambda = 0$ was imposed, and assuming adaptive price expectations on levels of price, we get

$$L_t = \alpha\gamma + \beta W_t - (1-\gamma)\beta W_{t-1} - \beta\gamma P_t + (1-\gamma)L_{t-1}$$

Static 6.

This equation also imposes $\lambda = 0$ but assumes adaptive expectations of the rate of price change

$$L_t = \text{Static } 5 - \beta(P_t - P_{t-1})$$

The Adaptive Equations

Adaptive 1.

This is composed of the equations:

$$L_t = (1 - \lambda)dt + \lambda L_{t-1}$$

$$d_t = (1 - \theta)L_t^* + \theta d_{t-1}$$

$$L_t^* = \alpha + \beta W_t - \beta P_t$$

which yields:

$$L_t = (1-\lambda)(1-\theta)(\alpha+\beta W_t-\beta P_t)+(\lambda+\theta)L_{t-1}-\lambda\theta L_{t-2}$$

Adaptive 2.

This adds a production lag and generates the expected price term through adaptive expectations on the level of prices

$$L_t = (1 - \lambda)(1 - \theta)[\alpha\gamma + \beta W_t - \beta(1 - \gamma)W_{t-1}-\gamma\beta P_t]$$
$$+ (1 + \theta + \lambda - \gamma)L_{t-1}-[(1-\gamma)(\theta+\lambda) + \theta\lambda]L_{t-2}$$
$$+ (1 - \gamma)\theta\lambda\ L_{t-3}$$

Adaptive 3.

This equation assumes adaptive expectations on rates of price change

$$L_t = \text{Adaptive 2} - (1-\lambda)(1-\theta)\beta \quad (P_t - P_{t-1})$$

Adaptive 4.

This changes the ad hoc assumption to

$$d_t = (1-\theta)\, L^*_{t-1} + \theta d_{t-1}$$

Consequently "Adaptive 4" equals "Adaptive 1" except with all the W and P terms lagged an extra period.

Adaptive 5.

This is equivalent to "Adaptive 2" except with all the W and P terms lagged an extra period.

Adaptive 6.

This is equivalent to "Adaptive 3" except with all the W and P terms lagged an extra period.

Adaptive Klein

Here we use the optimality condition and estimate $E(L_{t+1})$ by the use of Klein variates. The equation is

Klein 1.

$$L_t = \frac{g}{1+R+g}(\alpha + \beta W_t - \beta P_t) + \frac{1}{1+R+g}\; L_{t-1} + \frac{R}{1+R+g} Z_{1t}$$
$$+\, n_0 Z_{2t}$$

Klein 2.

Assuming adaptive expectations on levels of prices
prices

$$L_t = \frac{g}{1+R+g}(\alpha\gamma + \beta W_t - (1-\gamma)\beta W_{t-1} - \gamma\beta P_t)$$

$$+ [(1-\gamma) + \frac{1}{1+R+g}] L_{t-1} + \frac{R}{1+R+g} [Z_{1t}-(1-\gamma)Z_{1t-1}]$$

$$- \frac{(1-\gamma)}{1+R+g} L_{t-2} + n_0[Z_{2t} - (1 - \gamma)Z_{2t-1}]$$

Klein 3.

Assuming adaptive expectations on rates of price change:

$$L_t = \text{Klein } 2 - \frac{g}{1+R+g} \beta(P_t - P_{t-1})$$

Because of the expense involved in estimating the 3 versions of the Klein equation (a search over values of λ from 1/10 to 9/10 must be carried out: See Chapter 7 for detailed explanations), Klein 2, and Klein 3 were not estimated using monthly data.

The Results.

The last column of Tables 9.1 to 9.4 is labelled "Comments", and this contains a summary of the performance of the equation. Comparing Tables 9.1 to 9.4 we notice some general similarities in the performance of the equations regardless of data set used. Equations Static 1 and 2, Adaptive 1 through 6, and Klein 2 and 3 result

TABLE 9.1

Monthly Data - W

Equation Static	β	λ	γ	R^2	SSR	Comment
1	.071	-.35	.61	.0207	.009041	λ < 1
	(1.58)	(-3.7)	(6.2)			
2	.026	.32	1.31*	.0130	.009112	O.K.
	(.73)	(2.85)	(11.7)			
3	.021	.006		.0010	.009271	O.K.
	(.45	(.08)				
4	.023	.009		.0036	.009198	O.K.
	(.86)	(.14)				
5	.023			.0011	.009221	O.K.
	(.5)					
6	.02			.0037	.009197	O.K.
	(.89					

Adaptive	β	λ	θ	γ	R^2	SSR	Comment
1	.04	.34	-.33		.0133	.009109	θ < 0
	(.77)	(3.05)	(-3.06)				
2	.071	-.06	-.32	.59	.0208	.009037	λ,θ < 0
	(1.56)	(-.11	(.88)	(3.15)			
3	.03	-.35	.034	.66	.0193	.009051	λ < 0
	(1.27)	(-1.34)	(.06)	(2.07)			
4	-.10	.27	-.26		.0292	.008959	θ > 1
	(-2.02)	(1.9)	(-1.9)				
5	-.13	.25	.25	1.49	.0275	.008975	τ > 1
	(-2.1)	.26E-04	.26E-04	(10.27)			
6	-.04	.21	.21	1.4	.0179	.009063	ι > 1
	(-1.1)	.25E-03	.25E--3	(7.1)			

	β	L	g	n_0	R^2	SSR	Comment
K	.035	.5	25.0	.26	.0205	.009039	O.K.
	(.71)		(1.32)	(1.43)			

* significantly different from unity

** not significantly different from unity

t-scores are in brackets

TABLE 9.2

MONTHLY DATA R

	β	λ	γ	R^2	SSR	Comments
Static 1	.012	-.33	.65	.0117	.009124	λ < 0
	(.57)	(-3.1)	(6.03			
2	.011	-.33	.65	.0133	.009110	λ < 0
	(.8)	(-3.1)	(6.09)			
3	-.009	-.006		.0007	.009272	λ < 0
	(-.38)	(-.08)				
4	.003	-.7E-04		.0001	.009231	λ < 0
	(.15)	(-.001)				
5	-.009		1.01**	.0007	.009226	O,K.
	(.38)		(14.3)			
6	.02		.998**	.0001	.009231	O.K.
	(.16)		(14.2)			

	β	λ	θ	γ	R^2	SSR	Comments
Adaptive 1	-.0026	.31	-.32		.0104	.009173	θ < 0
	(.09)	(2.69)	(-2.78)				
2	.011	-.36	.06	.69	.0117	.009120	λ < 0
	(.5)	(-1.4)	(.09)	(1.73)			
3	.1	-.36	.6	.69	.0133	.009106	λ < 0
	(.72)	(-1.4)	(1.09)	(1.7)			
4	-.06	.26	-2.6		.0341	.008914	θ < 0
	(-2.28)	(1.95)	(-2.0)				
5	-.08	.2	.2	1.4*	.0403	.008857	ι > 1
	(-2.4)	(.5E-04)	(.5E-04)	(7.0)			
6	-.04	.22	.22	1.4*	.0245	.009003	ι > 1
	(-1.7)	.2SE-03	.25E-03	(8.5)			

	β	g	L	n_0	R^2	SSR	Comments
K	.035	.25	.5	.26	.0205	.009139	O.K.
	(.71)	(1.32)		(1.43)			

** not significantly different from unity

*significantly different from unity

t-scores are in brackets

TABLE 9.3

QUARTERLY DATA - W

		β	λ	γ	R^2	SSR	Comments
Static	1	-.27	.46	1.31*	.2377	.005482	$\gamma > 1$
		(-2.9)	(3.14)	(7.7)			
	2	-.19	.54	1.35*	.2267	.005561	$\gamma > 1$
		(-2.4)	(4.4)	(9.07)			
	3	2.24	.21		.2136	.005655	O.K.
		(2.95)	(1.75)				
	4	-.13	.27		.1865	.005850	O.K.
		(-2.2)	(2.35)				
	5	-.23		.818**	.2015	.005742	O.K.
		(-2.89)		(6.5)			
	6	-.097		.732	.1731	.005946	O.K.
		(-1.98)		(6.01)			

		β	λ	θ	γ	R^2	SSR	Comments
Adaptive	1	-.26	.46	-.28		.2283	.005549	$\theta < 0$
		(-2.7)	(2.9)	(-1.61)				
	2	-.14	-.37	.43	.85**	.2475	.005367	$\lambda < 0$
		(-2.4)	(-1.5)	(1.4)	(1.77)			
	3	-.14	-.41	.53	.88**	.2240	.005535	$\lambda < 0$
		(-1.7)	(-1.5)	(2.08)	(1.8)			
	4	-.22	.44	(-.18)		.2107	.005630	$\theta < 0$
		(-2.1)	(2.2)	(-.86)				
	5	-.22	.35	.35	1.4*	.2226	.005545	$\gamma > 1$
		(-2.0)	(.002)	(.002)	(6.3)			
	6	-.14	.37	.37	1.5*	.2112	.005626	$\gamma > 1$
		(-1.6)	.14E-03	.14E-03	(6.7)			

		β	g	γ	L	n_0	R^2	SSR	
Klein	1	-.33	2.6		.1	.002	.2296	.005495	
		(2.4)	(1.1)			(.03)			
Klein	2	122.0	-0.2	.17	.7	.62	.3884	.004394	$g < 0$
		(.37)	(.5)	(2.3)		(.76)			
Klein	3	-.09	-.27	.17	.7	.72	.3807	.004453	$g < 0$
		(.16)	(.72)	(2.2)		(.89)			

** not significantly different from unity   * significantly different from unity

TABLE 9.4

QUARTERLY DATA - R

		β	λ	γ	R^2	SSR	Comments
Static	1	-.15	.43	1.27**	.2391	.005472	$\gamma > 1$
		(3.0)	(2.8)	(7.2)			
	2	-.13	.5	1.3*	.2370	.005486	$\gamma > 1$
		(2.7)	(3.75)	(8.53)			
	3	-.14	.2		.2313	.005656	O.K.
		(-3.4)	(1.6)				
	4	-.10	.25		.2056	.005712	O.K.
		(-2.7)	(2.07)				
	5	-.12		.805**	.2160	.005637	O.K.
		(-3.03)		(6.3)			
	6	-.08		.76*	.1922	.005808	O.K.
		(-2.4)		(6.11)			

		β	λ	γ	θ	R^2	SSR	Comments
Adaptive	1	-.14	.45	-.27		.2300	.005489	$\gamma < 0$
		(-2.9)	(2.8)	(-1.5)				
	2	-.27	.35	.35	1.5**	.2555	.005310	$\gamma = \lambda = 0$
		(-2.5)	.2E-03	.2E-03	7.4			
	3	-.10	-.4	.5	.86	.2378	.005436	$\lambda < 0$
		(-1.9)	(-1.6)	(2.0)	(1.9)			
	4	-.10	.47	-.20		.1979	.005721	$\gamma < 0$
		(-1.8)	(2.5)	(-1.0)				
	5	-.09	-.35	.43	.80*	.1995	.009520	$\lambda < 0$
		(-1.4)	(-1.3)	(1.0)	(1.3)			
	6	-.07	-.33	.47	.86	.1972	.005726	$\lambda < 0$
		(-1.2)	(-1.08)	(1.51)	(1.5)			

		β	g	γ	L	n_0	R^2	SSR	
Klein	1	-.12	22.3		.6	.41	.1182	.061540	O.K
		(2.2)	(1.1)			(1.3)			
Klein	2	82.0	-.26	.16	.7	.74	.3882	.004399	$g < 0$
		(.5)	(.70)	(2.2)		(.93)			
Klein	3	-.09	-.28	.16	.7	.72	.3807	.004453	$g < 0$
		(.16)	(.72)	(2.2)		.89			

* significantly different from unity

** not significantly different from unity in unacceptable estimates either because γ is significantly greater than one, or because λ or θ or g is significantly negative. Equations Static 3 to 6 generally perform well except for monthly data when R is used, and Adaptive Klein 1 performs well. The introduction of a production lag and an expected price term into the Adaptive Klein equation is not successful. The expected price term is removed by using a Koyck transformation and as can be seen from Tables 9.7 and 9.8, this introduces considerable serial correlation into a previously fairly well behaved error term. On the other hand, if we compare the errors resulting from equations Static 3 and 4 with those resulting from equations Static 1 and 2, we see that the use of the Koyck transformation in equations Static 1 and 2 did not worsen the resulting error structure at all. Klein originally introduced his Klein variate technique expressly to cope with the serial correlation problem introduced from the Koyck. However, it is only where we are already using Klein variates for the expected employment term in the optimality condition that the introduction of the Koyck causes serious problems of serial correlation. Clearly one possibility would be to use Klein variates for the expected price term also, but the problem with this is that an already expensive estimation procedure would become ten times as expensive[7].

TABLE 9.5

CORRELOGRAM OF ERRORS FOR W-MONTHLY

Equation		1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
Static	1	.01	.02	.04	.17	.11	.07	.08	.10	.03	.01	.05	.08	.11	.137
	2	.01	.00	.03	.18	.10	.08	.08	.09	.03	.01	.34	.08	.11	.137
	3	.01	.12	.02	.19	.09	.11	.06	.10	.01	.02	.05	.08	.12	.136
	4	.01	.12	.03	.20	.09	.11	.06	.11	.02	.02	.05	.08	.12	.137
	5	.02	.12	.03	.19	.09	.11	.06	.11	.01	03	.06	.09	.12	.137
	6	.01	.12	.03	.20	.08	.11	.06	.11	.02	.03	.05	.09	.12	.137
Adaptive	1	.00	.00	.03	.18	.11	.08	.07	.09	.03	.01	.04	.08	.11	.137
	2	.01	.02	.04	.18	.12	.08	.07	.11	.02	.01	.03	.09	.10	.137
	3	.01	.01	.03	.18	.10	.08	.08	.10	.04	.01	.03	.08	.11	.137
	4	.03	.02	.07	.15	.06	.06	.10	.10	.04	.00	.05	.07	.13	.137
	5	.03	.14	.05	.13	.08	.03	.11	.09	.06	.03	.04	.07	.13	.137
	6	.02	.06	.03	.15	.09	.07	.09	.09	.05	.02	.05	.08	.12	.137
Adaptive	K	.03	.14	.02	.20	.09	.12	.06	.12	.02	.04	.05	.10	.12	.137

TABLE 9.6

CORRELOGRAM OF ERRORS FOR R MONTHLY

Static	1	.01	.02	.04	.18	.13	.08	.07	.11	.02	.00	.03	.89	.10	.137
	2	.01	.02	.04	.18	.10	.08	.08	.09	.04	.01	.04	.08	.11	.137
	3	.02	.09	.08	.03	.18	.09	.10	.07	.10	.02	.02	.07	.09	.136
	4	.01	.11	.03	.19	.09	.10	.07	.11	.02	.03	.06	.09	.12	.137
	5	.02	.10	.03	.18	.08	.10	.07	.10	.01	.02	.07	.09	.12	.137
	6	.02	.11	.03	.19	.09	.11	.07	.11	.02	.03	.06	.09	.12	.137
Adap-tive	1	.01	.01	.04	.17	.10	.08	.08	.09	.03	.01	.05	.08	.11	.137
	2	.01	.02	.03	.17	.11	.07	.07	.09	.03	.00	.04	.08	.11	.137
	3	.01	.02	.03	.18	.10	.08	.08	.10	.04	.01	.04	.08	.11	.137
	4	.03	.02	.07	.15	.06	.06	.10	.11	.04	.00	.06	.07	.14	.137
	5	.02	.08	.06	.14	.07	.04	.10	.10	.06	.10	.04	.07	.14	.137
	6	.02	.10	.04	.15	.08	.05	.10	.09	.06	.02	.04	.08	.13	.137
Adap-tive	K	.05	.11	.03	.19	.09	.11	.07	.11	.02	.03	.06	.09	.12	.137

TABLE 9.7

CORRELOGRAM OF ERRORS FOR W QUARTERLY

Equation \ Lags		1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
Static	1	.06	.01	.01	.17	.21	.02	.29	.12	.05	.02	.07	.14	.07	.24
	2	.04	.00	.03	.16	.21	.03	.29	.14	.07	.01	.08	.14	.09	.24
	3	.01	.08	.01	.14	.23	.06	.30	.14	.00	.01	.07	.12	.13	.24
	4	.04	.13	.02	.11	.23	.09	.34	.16	.02	.02	.10	.13	.18	.24
	5	.03	.07	.00	.15	.22	.04	.29	.12	.01	.01	.07	.11	.11	.24
	6	.00	.14	.01	.11	.23	.07	.33	.14	.02	.01	.10	.12	.18	.24
Adaptive	1	.05	.01	.01	.16	.21	.02	.29	.11	.05	.01	.07	.13	.07	.24
	2	.02	.00	.01	.15	.19	.02	.29	.13	.06	.04	.08	.13	.09	.24
	3	.01	.01	.01	.15	.20	.05	.30	.13	.07	.02	.08	.14	.09	.24
	4	.02	.12	.01	.12	.21	.05	.31	.06	.03	.03	.08	.16	.10	.24
	5	.04	.03	.06	.15	.18	.06	.30	.04	.02	.02	.07	.15	.05	.24
	6	.00	.01	.09	.17	.16	.03	.27	.07	.05	.04	.06	.14	.05	.24
Klein	1	.01	.01	.00	.13	.23	.05	.32	.13	.01	.00	.09	.12	.03	.24
	2	.06	.52	.03	.12	.24	.14	.37	.11	.23	.04	.25	.12	.31	.24
	3	.06	.52	.07	.12	.21	.12	.34	.08	.21	.04	.25	.13	.30	.24

TABLE 9.8

CORRELOGRAM OF ERRORS FOR R QUARTERLY

Lags Equation		1	2	3	4	5	6	7	8	9	10	11	12	13	$1/\sqrt{n}$
Static	1	.07	.05	.01	.15	.21	.00	.29	.13	.04	.02	.09	.12	.10	.24
	2	.06	.03	.01	.16	.22	.02	.30	.14	.06	.02	.09	.13	.11	.24
	3	.00	.11	.00	.13	.22	.04	.30	.16	.01	.00	.09	.11	.14	.24
	4	.04	.13	.01	.12	.23	.07	.33	.17	.00	.01	.01	.12	.18	.24
	5	.01	.10	.00	.14	.22	.03	.29	.15	.02	.01	.09	.11	.14	.24
	6	.01	.13	.01	.13	.23	.06	.32	.16	.00	.00	.09	.11	.18	.24
Adaptive	1	.06	.07	.00	.15	.21	.00	.29	.13	.05	.03	.08	.12	.09	.24
	2	.02	.06	.05	.17	.18	.02	.30	.11	.08	.05	.07	.15	.05	.24
	3	.01	.01	.00	.15	.20	.04	.30	.15	.07	.03	.09	.14	.11	.24
	4	.05	.12	.01	.12	.21	.04	.29	.05	.02	.02	.09	.15	.11	.24
	5	.03	.07	.04	.13	.19	.03	.29	.06	.00	.01	.09	.15	.11	.24
	6	.02	.06	.05	.15	.18	.03	.27	.07	.01	.01	.01	.14	.10	.24
Klein	1	.23	.09	.11	.13	.05	.06	.15	.01	.14	.04	.23	.12	.06	.24
	2	.06	.52	.05	.13	.21	.15	.33	.12	.22	.07	.25	.13	.30	.24
	3	.06	.53	.07	.12	.21	.12	.34	.08	.21	.04	.25	.12	.31	.24

Turning now to an evaluation of the monthly results, let us consider the evidence relating to costly adjustment and production lags. With the static version of the cost of adjustment equation and the unadjusted wage series, there is no evidence of costly adjustment and only slight evidence in favour of a production lag. When we impose $\gamma = 1$, λ is insignificantly different from zero, and when we impose $\lambda = 0$, γ is significantly different from one, which consistently indicates lack of costly adjustment, and static formation of expectations. Since the equation which assumes that expectations are formed on the rate of price change has a higher R^2 than the equation which assumes that expectations are formed on price levels, there is some evidence for a production lag. This is because we cannot distinguish the case of expectations being formed statically on the level of prices from the case of no production lag (they are equivalent), but we can distinguish the absence of a production lag from the static formation of expectations on rates of price change. With the adaptive Klein version of the costly adjustment equation we may say that there is some slight evidence of costly adjustment. The parameter, g, is of the correct sign, but is not significant, and the equation has the highest R^2 of all the acceptable equations in Table 9.1. In all these equations β is insignificantly positive. None of the acceptable equations in Table 9.1 suffer from acute problems of serial correlation, the simple correlation coefficients typically being below two times the appropriate standard deviation if there were no serial correlation ($2/\sqrt{n}$). The only exception occurs on the 4th lag. Finally, applying an F test [8] on the significance of these equations we find that none of them are significant at the 5% level.

The results using monthly wages adjusted for overtime are very similar to those just discussed. The differences are that in two of the "acceptable" equations β becomes insignificantly negative, and that the slight evidence in favour of a production lag now disappears since the equation which assumes that expectations are formed on levels performs better than the equation which assumes that expectations are formed on rates, and results in an adjustment coefficient equal to unity. As before, none of these equations pass an F test on significance.

Turning next to the quarterly data we find both the unadjusted and the adjusted wage series behaving very much the same as each other. In both β is significantly negative throughout. In the static adjustment equation when $\gamma = 1$ is imposed, λ is significantly different from zero. The fit of the equations which assume that expectations are formed on levels of price is unanimously better than the fit of those equations which assume that expectations are formed on rates of change . Moreover, the coefficient of price expectation when expectations are formed on levels, is insignificantly different from unity, which gives no evidence of a production lag. The best acceptable fit of those equations which assume a static adjustment of labour equation is "Static 3" which yields significant costs of adjustment and no evidence of a production lag.

The Klein equation 1 performs significantly better when using unadjusted wages, W, than adjusted wages, R. When using W it is the best fit of the acceptable equations, but when using R its explanatory power is low. All the quarterly equations are significant at both the 5% and 1% levels except for the Adaptive Klein equations with overtime adjusted wages, which is only significant at the 5% level. None of the quarterly equations suffer from serious serial correlation, there being significant correlation only at the 7th lag.

To summarize the above discussion, the monthly data fails to reveal significant costs of adjustment or production lags, the equations themselves being insignificant. The quarterly data yields significant equations which gives us evidence of costly adjustment but no production lag. The value of β is consistently significantly negative but its absolute value is higher when unadjusted wages are used than when overtime adjusted wages are used. In this sense the adjusted wage series performs worse than the unadjusted wage series. This is because if the underlying production function in manufacturing is of the form $X = Ae^{\lambda t} L^{\alpha} K^{1-\alpha}$ then $\beta = -1/(1-\alpha)$, and this provides the basis for our a priori belief that β should be negative. However, since α may lie anywhere in the range 0.5 to 0.8 say, then β should not only be negative but should also lie in the implied range of -2.0 to -5.0. Since the use of the adjusted wage series results in lower absolute estimates of β, it is making the results worse. Therefore, the use of this series will be abandoned in the next section on rational expectations.

To conclude this discussion of the adaptive and static expectations equations, we note that the ad hoc adaptive equations all fared badly, and that though a significantly negative relationship between real wages and employment was found for quarterly data, the size of the coefficient still implies rejection of these neoclassical models.

9.3.2 The Rational Expectations Equations

The first rational expectations equation estimated is the optimality condition rewritten with $E_t(L_{t+1})$ replaced by next period's realized value.

Equation R1.

$$L_t = \frac{1}{1+R+g} L_{t-1} + \frac{1}{1+R+g} L_{t+1} + g(\alpha+\beta Wt-\beta P_t) + e_t$$

Because e_t is not orthogonal to L_{t+1} an instrument was used for L_{t+1}. The instrumental variable was the mechanical one $(L_{t+1} - \overline{L_{t+1}})/|L_{t+1} - \overline{L_{t+1}}|$ where $\overline{L_{t+1}}$ signifies the average value of L_{t+1}. This instrument takes on three values, +1, 0, -1, depending on whether L_{t+1} is above, equal to, or below its average level.[9]

To check for the presence of a production lag the equation was re-estimated replacing P_t with a three month ahead forecast, a six month ahead forecast and a 12 month ahead forecast derived from the Box-Jenkins analysis. This procedure was repeated using monthly and quarterly data for the W series. The procedure was not carried out using the overtime adjusted series, R, since the results of the previous sub-section showed that the correction hardly affected the results and if anything, it made them marginally worse. Tables 9.9 and 9.10 contain the results of equation R1 using both

TABLE 9.9

EQUATION R1, USING MONTHLY SERIES, UNADJUSTED WAGES

	α	β	g	R^2	n
Current P	.12E-06 (.008)	.27E-05 (.007)	2208 (.008)	.0006	213
P^e_{t+3}	.51E-05 (.05)	.5E-04 (.05)	388 (.047)	.0038	209
P^e_{t+6}	.7E-05 (.11)	.4E-03 (.10)	171 (.12)	.0288	209
P^e_{t+12}	.5E-05 (.04)	.2E-04 (.04)	446 (.04)	.0035	209

Correlograms of Errors

	1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
Current P_t	.02	.11	.03	.19	.08	.11	.07	.10	.01	.12	.06	.09	.12	.137
P^e_{t+3}	.01	.12	.02	.20	.08	.12	.07	.10	.01	.03	.06	.08	.12	.137
P^e_{t+6}	.02	.12	.04	.20	.07	.11	.07	.10	.00	.04	.04	.07	.12	.137
P^e_{t+12}	.02	.12	.03	.20	.08	.11	.07	.10	.01	.03	.06	.08	.12	.137

TABLE 9.10

EQUATION R1 USING QUARTERLY SERIES, UNADJUSTED WAGES

	α	β	g	R^2	SSR	n
Current P	.13E-02 (.56)	-.05 (1.2)	3.5 (1.8)	.2483	.005426	69
P^e_{t+1}	.14E-02 (.82)	-.03 (-2.0)	4.2 (1.6)	.2476	.005302	69
P^e_{t+2}	.13E-02 (.7)	-.03 (-1.96)	3.9 (1.7)	.2445	.005324	68
P^e_{t+4}	.13E-02 (.68)	-.03 (-1.9)	3.7 (1.8)	.2429	.005336	68

CORRELOGRAM OF ERRORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
Current P	.18	.08	.03	.09	.21	.14	.31	.19	.00	.03	.15	.17	.14	.24
P^e_{t+1}	.25	.06	.03	.12	.22	.13	.32	.19	.01	.02	.17	.20	.13	.24
P^e_{t+2}	.26	.08	.04	.10	.22	.15	.33	.21	.10	.03	.17	.21	.15	.24
P^e_{t+4}	.27	.09	.04	.10	.22	.15	.33	.21	.01	.03	.17	.21	.16	.24

monthly and quarterly series.

The monthly estimates are not exciting. All the coefficients are insignificant, β is positive and g seems too large. There are no apparent problems of serial correlation. A six month production lag is indicated by the increase of the value of R^2 when P^e_{t-6} is used.

The quarterly estimates represent an improvement in terms of significance of coefficients, the sign of β is now negative, and g is taking on more reasonable values. Using the movement of R^2 as an indicator there would not seem to be a production lag since R^2 is highest when current prices are used. However, when a one step ahead forecast is used both β and g move from being insignificant to being significant at the 5% level. The second equation estimated a **rearranged** equation R1 so as to avoid the use of instrumental variables.

Equation R2

$$RL_{t+1} + L_{t-1} = (1 + g + R)L_t - g(\alpha+\beta W_t-\beta P_t)+e_t'$$

As before, three expected price series were used in both monthly and quarterly estimates. The results are contained in Tables 9.11 and 9.12.

The estimates of equation R2 are flawed by the negative value of g which is unacceptable. Apart from

TABLE 9.11

EQUATION R2 - MONTHLY DATA

	α	β	γ	R^2	SSR	n
Current P	-.3E-04	-.12	-2.04	.0622	.019541	208
	(-.09)	(-3.6)	(-19.8)			
FP3	.46E-04	-.07	-2.0	.0464	.019870	208
	(-.14)	(-3.1)	(-19.6)			
FP6	-.5E-04	-.02	-2.1	.0028	.02078	208
	(-.15)	(-.71)	(-19.0)			
FP12	-.5E-04	-.04	-2.0	.0336	.02014	208
	(-.15)	(-2.6)	(-19.5)			

CORRELOGRAM OF ERRORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
P	.12	.02	.07	.09	.02	.05	.13	.08	.04	.01	.12	.08	.13	.139
P^*_{t+3}	.11	.02	.06	.12	.04	.06	.12	.08	.02	.01	.12	.11	.11	.139
P^*_{t+6}	.02	.09	.03	.18	.08	.11	.07	.10	.02	.02	.08	.09	.12	.139
P^*_{t+12}	.09	.01	.06	.13	.05	.07	.09	.09	.02	.01	.11	.11	.12	.139

TABLE 9.12

EQUATION R2 - QUARTERLY DATA

	α	β	g	R^2	SSR	n
Current P	.12E-03	-.25	-1.5	.3434	.012505	68
	(.11)	(-3.9)	(-8.6			
P^*_{t+1}	.36E-04	-.23	-1.5	.3507	.012367	68
	(.03)	(-4.06)	(-8.6)			
P^*_{t+2}	.47E-04	-.20	-1.5	.3368	.012632	68
	(.04)	(-3.8)	(-8.5)			
P^*_{t+4}	.43E-04	-.18	-1.5	.3315	.012733	.68
	.38E-01	(-3.7)	(-8.4)			

CORRELOGRAM OF ERRORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	$1/\sqrt{n}$
P	.15	.09	.16	.08	.05	.13	.22	.02	.13	.23	.16	.21	.21	.24
P^*_{t+1}	.13	.04	.20	.12	.07	.14	.16	.03	.09	.20	.14	.23	.21	.24
P^*_{t+2}	.02	.07	.14	.14	.07	.19	.17	.08	.06	.15	.07	.21	.25	.24
P^*_{t+4}	.00	.11	.14	.15	.07	.20	.16	.10	.04	.12	.04	.21	.25	.24

this R2 would seem to perform better than R1 in terms of higher R^2, higher levels of significance, and lower values of serial correlation. Nevertheless, negative values of g are unacceptable. These negative values are not ameliorated by the addition of a production lag.

Next we turn to the two stage estimations as proposed by Kennan. The first stage involves approximating an AR(p) process in $(W_t - P_t)$, which is done by adding past values of the real wage until extra values are insignificantly different from zero.

Table 9.13 contains the attempt to estimate stage 1 using monthly data, assuming no production lag. The table shows four equations with various numbers of real wage terms, ranging from 4 to 12. In all of the equations λ was negative and since $g = \frac{(1 - \lambda)^2}{\lambda}$, this implies a negative value of g. Stage one was repeated assuming the three sizes of production lag but λ was consistently negative. Since a negative value of g is inadmissible, stage two was aborted for monthly data.

Table 9.14 contains stages one and two for quarterly data on the assumption of no production lag. Equation 2 is the preferred equation in stage one since W5 was found to be insignificant. Stage two was then calculated using the implied value of $\hat{g}$ assuming that $R \simeq 1$.

TABLE 9.13

STAGE ONE OF KENNAN'S TWO STAGE PROCEDURE-W-MONTHLY DATA-NO PRODUCTION LAG

	Equation 1	Equation 2	Equation 3	Equation 4
λ	-.03	-.03	-.06	-.06
α_0	.07 (1.5)	.08 (1.6)	.07 (1.6)	.07 (1.6)
α_1		"	"	-.08 (1.8)
α_2		"	"	-.12 (2.5)
α_3	-.07 (1.6)	"	"	-.08 (1.6)
α_4		"	"	-.04 (.8)
α_5		"	"	-.04 (.9)
α_6		-.04 (0.8)	"	-.06 (1.2)
α_7			"	-.08 (1.8)
α_8			"	-.06 (1.3)
α_9			"	.11 (2.3)
α_{10}			.07 (1.6)	.07 (1.5)
α_{11}				.006 (.12)
α_{12}				.10 (1.9)
R^2	.0643	.0837	.1416	.1586

Stage one was also tried with monthly data assuming a 3 month, a 6 month and a 12 month production lag but λ always took on a negative value.

TABLE 9.14

STAGE ONE OF KENNAN'S TWO STAGE PROCEDURE USING W, NO PRODUCTION LAG - QUARTERLY DATA

$$L_t = C + \lambda L_{t-1} + \alpha_0(W_t - P_t) + \alpha_1(W_{t-1} - P_{t-1}) \ldots \alpha_p(W_{t-p} - P_{t-p})$$

	λ	W	W_1	W_2	W_3	W_4	W_5	R^2	n
Equation 1	.19	-.14	-.10	-.15	.19			.2927	68
	(1.54)	(-1.68)	(-1.2)	(-1.6)	(2.3)				
Equation 2	.17	-.12	-.12	-.17	.11	.14		.3454	68
	(1.3)	(-1.5)	(-1.4)	(-2.0)	(1.3)	(1.7)			
Equation 3	.16	-.12	-.12	-.18	.10	.13	.03	.3475	68
	(1.17)	(-1.5)	(-1.3)	(-2.0)	(1.1)	(1.4)	(.44)		

t^* (5%) (62 DF) = 1.67

Equation 2 is preferred $\hat{\lambda} = .17$ $\hat{g} = \dfrac{(1 - \hat{\lambda})^2}{\hat{\lambda}} = 4.05$

STAGE TWO. $RL_{t+1} - (1 + \hat{g} + R)L_t + L_{t-1} = -\hat{g}(\alpha + \beta W_t - \beta P_t)$

α	β	R^2	n
-.24E-03	-.24	.0843	68
(.15)	(2.5)		

CORRELOGRAM

1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
.66	.50	.31	.09	.02	.19	.29	.34	.34	.31	.31	.31	.29	.24

TABLE 9.15

STAGE ONE OF KENNAN'S TWO STAGE PROCEEDURE-QUARTERLY DATA

W-Q. 1 Quarter Production Lag

$L_t = C + \lambda L_{t-1} + \alpha_0 (W_{t-1} - P_t) + \alpha_1 (W_{t-2} - P_{t-1}) \ldots$

	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
λ	.17(1.32)	.15 (1.2)	.094 (.77)	.08 (.6)	.07 (.6)
α_0	-.15(1.9)	-.15 (1.9)	-.16 (2.1)	-.16 (2.1)	-.15 (1.9)
α_1	-.17 (2.0)	-.19 (2.1)	-.18 (2.1)	-.18 (2.1)	-.17 (2.0)
α_2	.09 (1.1)	.04 (.38)	-.005 (.05)	-.005 (.05)	-.02 (.10)
α_3		.10 (1.2)	-.01 (.15)	-.02 (.2)	-.01 (.10)
α_4			.21 (2.7)	.20 (2.2)	.17 (1.9)
α_5				.03 (.3)	-.05 (.5)
α_6					.14 (1.8)
SSR	.005147	.005033	.004514	.004506	.004268

if $\hat{\lambda} = .07$

$$g = \frac{(1-\hat{\lambda})^2}{\hat{\lambda}} = 12.36$$

STAGE 2

$RL_{t+1} - (1 + R \pm \hat{g})L_t + L_{t-1} = -\hat{g}(\alpha + \beta W_t + \beta P^e_{t+1})$

α	β	R^2	n
-.25E-03	-.22	.1310	68
(.19)	(3.2)		

Correlogram of Errors.

1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
.63	.39	.33	.11	.01	.10	.26	.36	.36	.30	.29	.36	.32	.24

TABLE 9.16

STAGE ONE OF KENNAN'S TWO STAGE PROCEDURE W-Q - TWO QUARTER PRODUCTION LAG

$L_t = C + \lambda L_{t-1} + \alpha_0(W_{t-2} - P_t) + \alpha_1(W_{t-3} - P_t)$

	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
λ	.14 (1.1)	.12 (.9)	.05 (3.8)	.04 (.3)	.04 (.3)
α_0	-.24 (3.3)	-.27 (3.8)	-.26 (3.7)	-.26 (3.6)	-.24 (-3.5)
α_1	.09 (.10)	-.01 (.15)	-.06 (.8)	-.06 (.8)	-.07 (.8)
α_2	.01 (.12)	-.08 (1.0)	-.08 (1.0)	-.08 (1.0)	-.08 (.9)
α_3		.17 (2.5)	.09 (1.2)	.09 (1.2)	-.07 (.9)
α_4			.15 (2.1)	.15 (1.8)	.15 (1.9)
α_5				.02 (.2)	-.02 (.2)
α_6					.07 (.9)
SSR	.00518	.004712	.004388	.004384	.004321

if $\hat{\lambda} = .048$

$\hat{g} = 18.88$

STAGE 2

$RL_{t+1} - (1 + R + \hat{g})L_t + L_{t-1} = -\hat{g}(\alpha + \beta W_t - \beta P^e_{t+2})$

α	β	R^2	n
-.23E-03	-.19	.1310	68
(.20)	(3.2)		

CORRELOGRAM OF ERRORS

1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
.51	.30	.30	.08	.03	.07	.25	.33	.32	.26	.23	.35	.31	.24

TABLE 9.17

STAGE ONE OF KENNAN'S TWO STAGE PROCEDURE W-Q; 4 QUARTER PRODUCTION LAG

$$L_t = C_0 + \lambda L_{t-1} + \alpha_0(W_{t-4} - P_t) + \alpha_1(W_{t-5} - P_t) \ldots$$

	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
λ	.17 (1.3)	.12 (1.0)	.099	.10	.11 (.8)
α_0	-.27 (2.9)	-.28 (-3.0)	-.26 (2.8)	-.26 (2.8)	-.24 (2.5)
α_1	-.02 (.18)	-.07 (.67)	.08 (.8)	-.87 (.8)	-.08 (.8)
α_2	.14 (1.5)	.05 (.4)	.02 (.14)	.02 (.2)	.03 (.2)
α_3		.18 (1.9)	.13 (1.2)	.13 (1.2)	.12 (1.1)
α_4			.10 (1.0)	.12 (1.06)	.09 (0.8)
α_5				-.03 (.3)	-.07 (.06)
α_6					.07 (0.7)
SSR	.00538	.005091	.00507	.004998	

Equation 2 is the preferred one.

$$\hat{\lambda} - .123$$

$$\therefore \quad \hat{g} = 6.25$$

STAGE TWO

$$RL_{t+1} - (1 + R + \hat{g})L_t + L_{t-1} = -\hat{g}(\alpha + \beta W_t - \beta P^e_{t+4})$$

α	β	R^2	n
-.28E-03	-.17	.0938	68
(.19)	(2.6)		

CORRELOGRAM OF ERRORS

1	2	3	4	5	6	7	8	9	10	11	12	13	$2/\sqrt{n}$
.56	.34	.27	.07	.03	.16	.28	.37	.34	.25	.21	.28	.28	.24

The two stage proceedure was repeated using quarterly data, assuming the presence of a 3 month, a 6 month, and a 12 month production lag. The production lag did not significantly affect the size of β in stage 2, although the estimates of $\hat{g}$ diverged substantially. A production lag would appear to be present in the data since the R^2 in step 2 was highest when a one quarter production lag is assumed. It is interesting to note that though equation R2 yielded negative estimates of g, its estimates of β were within 0.1 of the estimates resulting from the two stage procedure for each assumed production lag.

Comparing the estimates resulting from the static cost of adjustment equation and the rational expectations cost of adjustment when there is no production lag, we find that they are very similar. In equation "static 3" $\lambda = .21$ compared to $\lambda = .19$ in the two stage, and β is exactly identical being equal to -.24 in each case. We find ourselves unable to reject the static cost of adjustment equation on this evidence, although, as previously mentioned, all the estimates so far must be deemed unacceptable since the low absolute value of β implies increasing returns to labour.

As a final check on the estimation procedure, Nerlove's method was used for the case of no production lag. The first stage in this procedure involves fitting an AR model to the real wage process. This was described in Section 8.2.4 of chapter 8. Since it was found that an ARI(1,1) process fits the data nicely, the second stage involved fitting the equation[10]

$$L_t = \frac{(1 - \lambda)(1 - \lambda R)}{(1 - \lambda R \quad \phi)} \beta \ (W_t - P_t) + \lambda L_{t-1}$$

where all variables are logged, differenced, detrended and deseasonalized. The result was:

$$L_t = -.7E\text{-}04 - \underset{(2.6)}{.19}(W_t - P_t) + \underset{(1.75)}{.21}\, L_{t-1} \qquad R^2 = .2136$$

The estimate of ϕ, the autoregression coefficient from stage one, was .5327. Therefore, plugging these values into $\frac{(1 - \lambda)(1 - \lambda R)}{(1 - \lambda R \phi)}$ and assuming $R = 1.04$, we can calculate an estimate of β. The resulting estimate is:

$$\hat{\beta} = -0.27$$

which is again extremely close to the estimates of β obtained from R2 and Kennan's method when no production lag is assumed ($\hat{\beta}$ from R2 = -0.25, $\hat{\beta}$ from Kennan's method = -0.24).

The picture that emerges from the estimations so far is that the rational expectations procedures yield comparable estimates to the static and adaptive Klein costly adjustment equations; and that there does appear to be evidence of a one period production lag but that it hardly makes any difference in practice to the estimate of β. A rather puzzling result is the failure of equations R1 and R2, especially R2 since there was no evidence of serial correlation, and therefore this equation should have yielded consistent estimates. (In fact, it did yield consistent estimates of β, but not of g.) This could be explained as a failure of the test for serial correlation. That is, one could argue that the equation should have given consistent estimates if there was no serial correlation, and since the equation did not give consistent estimates, this implies the presence of serial correlation. Another puzzling feature is the difficulty of modelling the monthly data, its apparent rejection of costly adjustment of labour and the complete failure of the two stage method using monthly data. These results are in constrast to the systematic behaviour displayed by monthly data in the time series analysis of Chapter 7. However, the stock answer to explain problems with monthly data is that the series contains too much noise, which is alleviated by working with quarterly or annual series.

9.2.3 The Effect of Allowing Wages and/or Prices to Be Endogenous

To test whether or not the assumption of exogeneity of wages and prices made any difference, I performed three more estimates of equation Static 1, first with W endogenous, next with prices endogenous, and finally both wages and prices endogenous The results are reported in Table 9.18 along with the results when both wages and prices are assumed exogenous.

The high degree of similarity between these results suggests that whether or not wages and prices are treated as exogenous or not makes very little

TABLE 9.18

Equation "Static 1" - Quarterly

	β	λ	γ	R^2
W,P exogenous	-.27 (2.9)	.46 (3.1)	1.31* (7.7)	.2377
W endogenous P exogenous	-.25 (2.8)	.36 (1.7)	1.22** (5.1)	.2321
W exogenous P endogenous	-.36 (1.6)	.43 (2.4)	1.34* (7.3)	.2220
W endogenous P endogenous	-.27 (1.4)	.46 (2.7)	1.3* (7.4)	.2371

(* significantly different from unity;** insignificantly different from unity)

difference. Therefore, we note that treating the price as endogenous results in the highest absolute value of β and move on to the annual estimates[11].

9.3 THE ANNUAL RESULTS

Using annual data the correction for intermediate inputs can be tested, and we are also able to relax the assumption that capital is always on its trend growth path since annual capital stock data are available. In order to test Tatom's[12] suggestion that the cyclical pattern of factor employment should be taken into consideration, a capital series was constructed which adjusted the raw figures by multiplying them by their average annual utilization.

We begin by testing the static cost of adjustment model without any production lags or overtime correction. The model is:

9.4.1 $$L_t = (1 - \lambda)L_t^* + \lambda L_{t-1}$$

9.4.2 $$L_t^* = \alpha + \beta W - \beta P_t - \beta IGA + cK_t$$

where IGA is the intermediate good adjustment factor, and K_t is the capital stock. These two equations yield the following reduced form:

Equation 1.

$$L_t = (1-\lambda)(\alpha + \beta W_t - \beta P_t - \beta IGA_t + cK_t) + \lambda L_{t-1}$$

In addition the equation was re-estimated using capital stock figures adjusted for capital utilization, and also without a capital stock term and without an IGA term. The equations estimated were:

Equation 2. Used capital data adjusted for utilization (KU)

Equation 3. Omitted the IGA term; used K.

Equation 4. Omitted the IGA term; used KU

Equation 5. Omitted IGA and K (or KU)

Equation 6. Includes IGA, omits K (or KU).

All variables are first differenced and detrended, 1961-1975. The results are given in Table 9.19.

Constant returns to scale requires that the co-efficient "c" be insignificantly different from unity. Equations 2 and 4,both of which include a capital utilisation term, succeed in finding a value of "c" insignificantly different from unity, but β was insignificantly different from zero in both of these equations. The performance of the KU term was hardly affected by the presence or absence of the IGA term, though equation 4 (without the IGA term) does have a marginally higher R^2 than equation 2 (which includes the IGA term).When the capital stock (K) was

TABLE 9.19

STATIC COSTS OF ADJUSTMENT - ANNUAL DATA

	α	β	c	λ	R^2	D.F.	t*(5%)	Terms Included
Equation 1	-.2E-02	-.51	.38	.15	.6477	9	1.8	(IGA;K)
	(.35)	(3.0)	(.86)	(.6)				
2	-.9E-4	-.10	1.41**	.47	.8957	9	1.8	(IGA;KU)
	(.02)	(.6)	(2.7)	(3.7)				
3	-.2E-02	-.36	-.5	-.31	.655	9	1.8	(K)
	(.5)	(4.7)	(1.8)	(1.00)				
4	-.3E-03	-.13	1.2**	.41	.9022	9	1.8	(KU)
	(.7)	(1.1)	(2.7)	(2.9)				
5	-.69E-03	-.37		-.4E-03	.5735	10	1.8	
	(.14)	(3.44)		(.02				
6	-.14E-02	-.53		.26	.6243	10	1.8	(IGA)
	(.22)	(2.8)		(1.3)				

** insignificantly different from unity.

included (in equations 1 and 3), β was significantly negative, though the performance of the K term was significantly affected by the IGA term. When the IGA term was absent (in equation 3), both the returns to scale parameter,"c", and the cost of adjustment parameter, λ , were negative, "c" significantly so. Both of these defects were absent from equation 1, which included the IGA term. When no capital term was included (equations 5 and 6) the inclusion of the IGA term did improve the performance of the equation, by changing the sign of λ from negative to positive, by increasing the absolute value of β (which was significantly negative in both cases) and by increasing the value of R^2. It would seem from these results that if one simply forgot to include the IGA term, that the capital utilised term would perform better than the capital stock term. However, when the IGA term is included,the choice between K and KU involves a trade off. When K is used β is significantly different from zero, but both "c" and λ are insignificantly different from zero; whereas when KU is used β is insignificantly different from zero, λ is significantly positive, and "c" is insignificantly different from unity. In addition higher R^2 values occur in the KU equations. On balance it would seem that the utilisation of capital performs better than capital in place, and that in general the intermediate input correction does improve the fit of these equations.

In addition to the above equations, I also estimated a version which assumed no costs of adjustment but a one period production lag which necessitated application of the Koyck transformation to remove the expected price term. This gave rise to the following reduced form:

Equation 1.

$$L_t = \alpha\gamma + \beta W_t - (1-\gamma)\beta W_{t-1} - \beta(IGA)_t + \beta(1-\gamma)(IGA)_{t-1}$$
$$+ c(KU)_t - c(1-\gamma)(KU)_{t-1} - \gamma\beta P_t$$

In addition equation "2" was estimated which omitted the IGA variable. The results are contained in Table 9.20.

TABLE 9.20

Annual Data - No Costs of Adjustment

One Period Production Lag

	α	β	c	γ	R^2
Equation 1	.73-03	.2E-02	.68	1.34*	.8556
	(.33)	(.02)	(5.0)	(8.1)	
Equation 2	.8E-03	-.07	.6	1.2**	.8642
	(.36)	(.7)	(5.0)	(6.01)	

* significantly different from unity
** insignificantly different from unity

These production lag equations perform worse than the costly adjustment equations of the preceeding table, since not only is β insignificantly different from zero, but also "c" is significantly different from unity, γ is either greater than or equal to unity, and the values of R^2 are lower. In this case the equations perform marginally better when the IGA term is excluded (β becomes insignificantly negative when IGA is excluded).

Finally, I will mention, but not show the results when both costs of adjustment and a production lag were included.These results consistently suffered from wrong signs and insignificant t-scores, and suggests rejecting such a composite model. Since equations 2 and 4 in Table 9.19 perform better than the equations in Table 9.20, the production lag is rejected , while the static cost of adjustment model is supported.

9.4.2 Rational Expectations Using Annual Data

In an attempt to operationalize the two stage model, the following equations were used:

$$L_t = (1 - \lambda)\, d_t + \lambda L_{t-1}$$

$$d_t = (1 - \lambda R) \sum_{s=0}^{\infty} (\lambda RF)^s L_t^* \quad \text{where F is the forward operator}$$

TABLE 9.21

STAGE ONE - INCLUDING BOTH IGA AND KU

	λ	α_0	α_1	α_2	α_3	Ψ_0	Ψ_1	Ψ_2	"h"	R^2
Equation 1	-.4E-02	.64	-.48	.59		.65	.5	.06		.9703
	(.002)	(.64)	(.23)	(.34)		(1.2)	(.6)	(.13)		
2	-.34	.24	-1.01			.5	.7			.9682
	(1.1)	(.89)	(1.2)			(2.6)	(3.1)			
3	-.07	.22				.7	.5		.03	.9574
	(.3)	(.9)				(7.7)	(2.8)			
4	.49	.04				.8			.06	.8897
	(3.2)	(.12)				(6.2)				
5	.30					.76	.04			.8768
	(1.05)					(7.2)	(.18)			
6	.35					.77			.06	
	(3.05)					(8.8)				.8764

$$L_t^* = \alpha + \beta(W_t - P_t . IGA) + (KU)_t$$

Assuming that $(W_t - P_t . IGA_t)$ can be approximated by an AR(p) process and that $(KU)_t$ can be approximated by an AR(m) process, the stage one estimating equation is

$$L_t = \lambda L_{t-1} + \alpha_0(W_t - P_t . IGA_t) \ldots \alpha_p(W_{t-p}P_{t-p} - P_{t-p}IGA_{t-p})$$

$$+ \Psi_0(KU_t) \ \ldots \ \Psi_{pm}(KU_{t-m})$$

Various lengths of lags were tried in an effort to approximate the AR(p) and AR(m) process. Table 9.21 contains the results.

From equations 1 to 4 it appears as if the change in the real value of manufacturing's value added $(W_t - P_t \ IGA_t)$ is a random walk, since none of the terms are significant. When this term is removed only one capital in use term is significant. Therefore, the chosen equation is equation 6, and $\hat{\lambda} = .35$. Assuming that the real rate of interest is about 4%, then $R = 1.04$, and $\hat{g} = 1.18$. The stage 2 equation then is:

$$RL_{t+1} - (1+R+\hat{g})L_t + L_{t-1} = -\hat{g}(\alpha + \beta W_t - \beta P_t IGA_t + KU)$$

which resulted in the following estimated ceofficients

TABLE 9.22

STAGE TWO - INCLUDING BOTH IGA AND KU

α	β	R^2
.19	-.45	.567
(.15)	(1.5)	

Next I repeated the two stage process without the IGA term. The results from the stage one estimations are given in Table 9.23.

TABLE 9.23

Stage One - Annual Data

Including KU; Excluding IGA

λ	α_0	ψ_0	ψ_1	R^2
.01	-.03	.7	.4	.9515
(.05)	(.4)	(5.1)	(2.2)	
.4	-.09	.68		.9043
(2.2)	(1.0)	(4.07)		

It appears from Table 9.23 that the rate of change of the real wage process, unadjusted for intermediate inputs, is also a random walk. Consequently the presence or absence of the IGA term is irrelevant and the appropriate estimate of $\hat{g}$ is again 1.2, as obtained from the previous estimates.

Stage 2 is implemented as follows:

$$RL_{t+1} + (1 + R + g)L_t + L_{t-1} = -g(\alpha + \beta W_t - \beta P_t + KU_t)$$

and this resulted in the following estimated coefficients.

Stage 2 - Including KU, Excluding IGA

α	β	R^2
.16	-.55	.6569
(.14)	(2.4)	

As before, when KU is used β **is more negative than** without the IGA term, and the fit of the equation is better.

Next, the two stage process was implemented excluding the capital in use term, but including the IGA term. The stage one results appear in Table 9.24.

In this case, the change in the real value added in manufacturing appears to be an AR(2) process with the first root insignificantly different from zero. However, λ takes on a negative value in equation 2, and therefore, the rational expectations costly adjustment model, fails in this case.

Finally, the two stage process was implemented excluding both the capital in use term and the IGA term The stage one results appear in table 9.25

TABLE 9.24

Stage One; Excluding KU; Including IGA

Equation	λ	α_0	α_1	α_2	α_3	R^2
1	.47	-.44				.1730
	(1.2)	(.53)				
2	-.01	-.25	-.32			
	(.05)	(.5)	(3.09)			
3	-.34	-.45	-3.1	-1.8		.7477
	(.82)	(.79)	(3.1)	(1.2)		

TABLE 9.25

Stage One - Annual Data

Excluding both (KU) and (IGA)

λ	α_0	α_1	α_2	R^2	"h"
-.36	-.44			.6072	
(1.8)	(4.1)				
-.24	-.45	.10		.6245	
(.9)	(4.07)	(.68)			
-.10	-.62	.30	-.24	.6937	
(.37)	(3.9)	(1.5)	(1.4)		

In this case λ consistently takes on a negative value, again implying rejection of the rational expectations, costly adjustment model.

SECTION 9.4 IMPLICATIONS OF THE RESULTS

9.4.1 The Overtime Correction

The effect of the overtime correction depended on whether monthly or quarterly series were used. Using monthly series the effect was to change a consistently positive and insignificant value of β into a consistently insignificant but sometimes positive and sometimes negative value for β. Using quarterly data β was consistently negative and significant using unadjusted wages, and the overtime correction, in the majority of cases, caused the absolute value of β to fall. Apart from this the overtime correction did not significantly affect the results, and so on the basis of the estimates in Section 9.3.1 the overtime correction was dropped.

9.4.2 The Choice of Monthly or Quarterly Data

In contrast to the systematic behaviour of the monthly time series presented in Chapter 7, we have been unable in this chapter to adequately model the monthly series even though severe serial correlation problems have not been apparent. The monthly data has rejected the costs of adjustment model both in its static expectations and its rational expectations forms, and in the adaptive Klein version the equation performs adequately but is barely significant at the 5% level. On the whole we can say that monthly data gives little indication of there being costs of adjustment. This is a difficult finding to explain given that the quarterly data does display significant costs of adjustment[13]. It is primarily because of this reason that the monthly data was abandoned. A second important reason for abandoning it was to give every opportunity for the neoclassical models to prove themselves, so that if these models fail to perform adequately we will have the strongest possible conclusion. Since the performance of the neoclassical models are better but still inadequate with the quarterly data, the monthly data will be abandoned.

9.4.3 The Effect of Production Lags

There is no evidence of any production lags using the static cost of adjustment equation with **either** monthly **or** quarterly data. Stage two of the two stage rational expectations approach has a higher R^2 when a one or two quarter production lag is assumed, but the value of β moves in the wrong direction as lags are introduced; that is β equals -0.24 when no lag is assumed, and it equals -0.22, -0.19, and -0.17 with

1, 2 and 4 quarter production lag, respectively. Therefore, the evidence for production lags is weak, and their effect seems to be to worsen the estimate of β.

9.4.4 The Type of Expectation Generating Mechanism

Contained in the following table are the estimates of β and λ derived from quarterly data from the static, adaptive and rational expectations costs of adjustment models when no production lag is assumed.

Type of Equation		β	λ	g[14]
"Static 3"		-.24	.21	3.0
Adaptive Klein		-.33		2.6
Rational Expecta- tions	Kennan's Two Stage:	-.24	.17	4.05
	Nerlove's Two Stage:	-.24	.21	3.0

From these results it is not possible to reject the static adjustment model or the adaptive adjustment model against the rational expectations version. The assumption made about expectations would not seem to be of critical importance.

9.4.5 The Intermediate Input Correction

This correction improved the fit of a static cost of adjustment labour demand equation except when a capital in use term was included. Without any capital measure the effect of including the IGA term is to cause the cost of adjustment parameter, λ, to become positive (rather than negative), the absolute value of β to increase and the overall fit of the equation to improve. When a measure of capital in place is included in the equation the effect of including the IGA term is to change the capital coefficient from a negative number to a positive one, to increase the absolute value of β, and to change λ from a negative number to a positive one. However, when a capital in use measure in included, the absolute value of β is higher and the overall fit of the equation is better without the IGA term. Since including capital in use produces much improved explanatory power compared to the absence of a capital stock term or the presence of a capital in place term, the role of the intermediate input correction is obscure[15].

9.4.6 The Capital Stock Term

The capital in place term is comparatively unsuccessful. Without the IGA term, the capital coefficient is negative, as is the cost of adjustment parameter; with the IGA term included the capital coefficient, though positive, is significantly different to unity indicating the absence of constant returns to scale which are necessary to ensure that factor payments just equal the value of output (assuming marginal productivity). The capital in use term performed much better. The capital coefficient was 1.2 without IGA, and 1.41 with IGA, but in both cases was insignificantly different to unity. Moreover, the explanatory power of the equations which included capital in use was higher than any other. On this basis, the capital in use term was successful. However, the absolute value of β took on its lowest values when the capital in use term was included.

9.4.7 Closing Remarks

The use of annual and quarterly data has produced a significantly negative relationship between real wages and employment. However, the absolute value of the coefficient relating real wages and employment signifies increasing returns to labour if we assume that a Cobb-Douglas production function lies behind the log-linear demand functions estimated.

APPENDIX I

THE BOX JENKINS ANALYSES

A Box-Jenkins analysis of the log of the raw monthly price series was performed in order to generate three forecasted price series, a 3-month, a 6-month and a 12-month ahead series; and similarly, an analysis was performed on the log of the raw quarterly price series in order to generate a 1-quarter, a 2-quarter and a 4-quarter ahead forecasted series. These forecasted series were then differenced, detrended and deseasonalized before being used as data to test the rational expectations models of Chapter 7 which included production lags.

On the other hand a Box-Jenkins analysis was performed on the logged, differenced, detrended and deseasonalized monthly and quarterly real wage series in order to perform a Nerlove type two stage estimation of the costly adjustment rational expectations model.

The reason for the difference in procedure was that the main reason for deseasonalizing the price series is to remove serial correlation and to have the data in a comparable form to the other series. After all, firms are not interested in forecasting detrended and deseasonalized prices. On the other hand, composition effects are present in the real wage series and an attempt should be made to remove them before moving on to the Box-Jenkins analysis.

The Box-Jenkins analysis is an iterative procedure. In the first stage autocorrelations and partial autocorrelations are calculated in an effort to identify a model. Next, this model is estimated and checked for adequacy. If it is not satisfactory another model must be tried. If it is satisfactory, the model can be used for forecasting. Table 8.1 contains some useful summary information as to the behaviour of the autocorrelation and partial autocorrelations for different kinds of processes.

TABLE A.1

Behaviour of Autocorrelations and Partial Autocorrelations for 3 Classes of Processes[16]

Class of Process	Autocorrelations	Partial Auto-correlation
Moving Average of order q	Significant correlations at lags 1 through q, then cut off	Tail off
Autoregressive of order p	Tail off	Significant Correlation at lags 1 through p then cut off
Mixed ARMA (p,q) process	Irregular pattern at lags 1 through q, then tail off	Tail off

The sample autocorrelations are estimates of the true autocorrelations and as such, are subject to sampling error. If the generating process is a moving average process of order q, the formula (Bartlett's formula) for the variance of r_j (the j^{th} autocorrelation) is:

$$V(r_j) = \frac{1}{T} [1 + 2 \sum_{i=1}^{q} r_i^2] \qquad j > q$$

and the rough criterion for significance may be employed:

$$(r_j) > \frac{2}{\sqrt{T}} [1 + 2 \sum_{i=1}^{q} r_i^2]^{1/2}$$

to test whether an r_j at lag greater than q may reasonably be considered to be zero (where T equals sample size).

The standard error for the partial autocorrelations is given by $1/\sqrt{T}$ [17]

A.2 Now let us turn to the identification of the process generating monthly prices. The following table shows the autocorrelations and the partial autocorrelations for the integrated (or differenced) logarithm of the price series.

TABLE A.2

Autocorrelations for Lagged Integrated Monthly Prices

Lags													S.E.
1-12	.34	.31	.28	.13	.20	.30	.26	.25	.29	.19	.23	.21	.07
13-24	.16	.09	.22	.00	.16	.17	.18	.17	.10	.00	.00	.03	.11
						Partial Autocorrelations							
1-12	.34	.22	.14	.05	.11	.22	.10	.03	.12	.01	.07	.01	.07

Since the autocorrelations seem to tail off, and apart from the partial autocorrelation at the 6^{th} lag, only the first two partial autocorrelations are significant the ARIMA model (2, 1, 0) was fitted. One test of the adequacy of a model is provided by a Chi Square on the autocorrelations of the residuals from the fitted model. These residuals should be white noise. The results were

TABLE A.3

Chi-Square Test of Auto correlations	Degrees of Freedom	Critical Level 5%	Critical Level 10%
Q(12 lags) = 25.5	9	16.9	14.67
Q(24 lags) = 46.8	21	32.7	29.6
Q(36 lags) = 51.5	33	48.1	44.2

Since the residuals from the fitted model exhibit serial correlation the model must be rejected.

Next, I tried the ARIMA model (1, 1, 6) which performed adequately. The results of the Chi-Square test were:

TABLE A.4

Chi Square Test of Autocorrelations	Critical Level	
	5%	10%
Q(12 lags) = 2 (4 D.F.)	9.48	7.76
Q(24 lags) = 22.5 (16 D.F.)	26.3	23,5
Q(36 lags) = 31.3 (28 D.F.)	40.8	37.5

The estimated coefficients along with their t scores were:

AR	MA parameters						Constant Term
parameter	1	2	3	4	5	6	
.928	.776	-.02	.014	.20	-.16	-.10	.00035
(21.7)	(9.7)	(.19)	(.15)	(2.27)	(1.85)	(1.46)	(1.42)

This model was then used to generate the forecasted price series.

Turning now to quarterly prices, the autocorrelations for the lagged integrated price series were:

TABLE A.5

Autocorrelations for Integrated Logged Quarterly Prices

Lags													S.E.
1-12	.59	.52	.50	.40	.29	.29	.19	.02	.02	.09	.07	.06	.12
13-24	.09	.14	.11	.23	.23	.19	.22	.15	.17	.07	.04	.03	.22

Partial Autocorrelations

1-12	.59	.25	.20	-.01	-.09	.06	-.07	-.24	-.00	.20	.13	.01	.12

The tailing off of the autocorrelations, suggests an ARI process. Since there are two significant partial autocorrelations an ARI (2,1) process was tried. The AR parameters were (t scores in brackets)

.529 (4.5) .343 (3.0)

The Chi-Square Statistics were:

TABLE A.6

	Degrees of Freedom	Critical Level 5%	10%
Q(12 lags) = 7.9	10	18.3	16.0
Q(24 lags) = 11.5	22	33.9	30.8
Q(36 lags) = 13.9	34	49.6	45.6

The ARI (2.1) model passes the Chi-Square tests on autocorrelations of the residuals and its coefficients are significant. Therefore, this model was used to generate 1, 2 and 4 quarter ahead forecasts of quarterly lagged prices. These forecasts were then differenced, detrended and deseasonalized before being used . This process removed 21% of the variation from the one step ahead forecast, 19% of the variation from the two step ahead forecast, and 17% of the variation from the 4 step ahead forecast[18].

A.4 An attempt was made to model the behaviour of monthly and quarterly real wages in order to perform a Nerlove type estimation as described in the previous chapter. This type of estimation requires that the series in question be capable of being modelled in some fairly simple manner. Unfortunately, detrended and deseasonalized monthly real wages did not follow a simple AR structure, thus precluding the use of Nerlove's technique on the monthly series. Quarterly detrended and deseasonalized real wages, on the other hand, were successfully modelled as an ARI (1,1) process. The following two tables give the results:

TABLE A.7

Autocorrelations for Detrended, Deseasonalized, Logged Quarterly Real Wages

Lags													S.E.
1-12	.50	.42	.36	.14	.02	-.06	-.20	-.26	-.35	-.37	-.30	.32	.12
13-24	-.25	.12	.07	.10	.09	.06	.16	.10	.13	.07	.05	.01	

Partial Autocorrelations

Lags											S.E.
(1-10)	.50	.22	.12	-.17	-.14	-.07	-.14	-.11	-.17	-.08	.12

The single significant partial autocorrelation suggests an ARI (1,1) model. The model was fitted and the autocorrelation coefficient (and its t score) was

AR.Coefficient; t score

.533 (5.06)

The Chi Square statistics from the residuals of the fitted model are given in Table A.8.

TABLE A.8

Chi Square Test of Autocorrelations of the Residuals From an ARI (1,1) Model on Quarterly Real Wages

	Degrees of Freedom	Critical Levels 5%	10%
Q(12 lags) = 12.8	11	20.1	17.0
Q(24 lags) = 19.2	23	35.2	32.0
Q(36 lags) = 21.8	35	49.7	46.2

Since the ARI (1,1) model performs quite adequately the estimate of the autocorrelation coefficient can be used in a "Nerlove-type" 2 stage estimation process of the partial adjustment rational expectations model.

FOOTNOTES

Chapter 9

1. The easiest explanation for the difference between the actual supply of labour and the desired supply, is that labour contracts are such that the actual labour supplied is completely elastic at a point in time when the money wage is rigid. If employment is different from desired labour supply (as defined by the labour supply curve)the wage adjusts in proportion to the excess demand or supply.

2. Compare chapter 7, section 7.4.1 for further discussion of this point.

3. Assuming different hourly wages in the different sectors of manufacturing.

4. The use of a 12 month moving average was considered, but it has less flexibility than the use of dummy variables.

5. J. Durbin, "Testing for Serial Correlation in Least-Squares Regression when some of the Regressors are Lagged Dependent Variables", Econometrica, 1970, pages 410-421.

6. The production lag specified in the text does not include a discount rate on next periods expected price. To check the effect of including such a discount term, the production lag equations were re-estimated both with and without costs of adjustment for quarterly data. The equations estimated were:

$$(1)\quad L_t = \alpha + \beta(W_t - P^e_{t+1}) + \beta R_t + cK_t$$

$$(2)\quad L_t = \lambda(\alpha + \beta(W_t - P^e_{t+1}) + \beta R_t + cK_t)+(1-\lambda)L_{t-1}$$

where R_t is the yield on three month treasury bills, and K_t is the quarterly capital stock series generated by interpolating the annual data. Another change from the test was the avoidance of Koyck transformation to eliminate the P^e_{t+1} term. Instead, I

6. (continued) assume that expectations are formed rationally and use an instrumental variable $\hat{P}_{t+1}$ for P^e_{t+1}, where $\hat{P}_{t+1}$ is the fitted value of P_{t+1} resulting from a regression of P_{t+1} on the lagged exogenous variables. In addition, equations (1) and (2) were re-estimated with quarterly data on capital services utilized rather than the capital stock. These equations are labelled (1a) and (2a). The following results were obtained:

	α	β	c	λ	D.W.	R^2
(1)	.001 (.7)	.005 (2.5)	.92 (2.8)		1.5	.2055
(1a)	.003 (.3)	.003 (1.7)	.43 (7.7)		2.3	.5372
(2)	.0003	.003	.88	.73	1.2	.2628
(2a)	.001 (.5)	.005 (2.05)	.45 2.07	.88	0.9	.5483

It is apparent that if we discount next period's expected price, there is clear evidence against the existence of a production lag , since the value of β becomes significantly positive. These results also show that capital stock data is preferable to capital utilization data in so far as we believe a priori in constant returns to scale ($c = 1$), but capital utilization data is preferable in terms of explanatory power (higher R^2 values).

7. Essentially we have two variables, L^e_{t+1} and P^e_{t+1} which are functions of a weighted average of past values of L_t and P_t;

$$L^e_{t+1} = \lambda L_t + (1 - \lambda)\lambda L_{t-1} + (1 - \lambda)^2 \lambda L_{t-2} \ldots$$

$$P^e_{t+1} = \gamma P_t + \gamma(1 - \gamma)P_{t-1} + \gamma(1 - \gamma)^2 P_{t-2} \ldots$$

Previously we search over the realm $\lambda = 1/10$ to $9/10$. Now in addition for each value of λ we must search for γ over the realm $1/10$ to $9/10$.

8. $F = \dfrac{R^2/k}{(1-R^2)/n-k}$ where k is the number of parameters and n is the number of observations . See Thiel page 189.

9. A. Wald proves that this mechanical instrument is consistent in the one variable case in "The Fitting of Straight Lines if Both Variables Are Subject To Error", Annals of Mathematical Statistics, volume II, pp.284-300, 1940.
See also,
J.W.Hooper and H.Theil, "The Extension of Wald's Method of Fitting Straight Lines to Multiple Regression", Review of the International Statistical Institute, vol. 26, pp37-47, 1958.

10. See Chapter 8 for further explanation of Nerlove's method and derivation of this equation.

11. Mechanical instruments were again used for W_t and P_t, i.e. $\dfrac{W_t-\overline{W}_t}{|W_t-\overline{W}_t|}$ and $\dfrac{P_t-\overline{P}_t}{|P_t-\overline{P}_t|}$

12. See Chapter 2.

13. It would make sense if monthly data displayed costly adjustment and quarterly data did not, but it does not make sense the other way around.

14. The values of g in brackets are calculated from the formula:

$$g = \frac{(1 - \lambda)^2}{\lambda}$$

15. Of course, the failure of this correction may simply reflect the way we chose to measure it; See Chapter 8, Section 8.3.2.

16. This table is taken from Nelson op cit page 89. See Chapter 5 of Nelson for a full discussion.

17. See Nelson Chapter 5.

18. See Nelson Chapter 6 for a description of the forecasting procedure. The empirical work was performed using Nelson's (PDQ), ESTIM, and FORC programs.

CHAPTER 10

THE HANSEN FRICTION MODEL

This chapter is divided into eight sections. Section 10.1 introduces the simple Hansen friction model. Section 10.2 discusses a more sophisticated and internally consistent version which incorporates costs associated with the existence of vacancies. Section 10.3 considers the problem of operationalizing these models within the context of the Canadian manufacturing sector. Section 10.4 contains the empirical results of the simple friction model, and Section 10.5, the results of the "sophisticated" friction model. Section 10.6 summarises the results up to this point. Section 10.7 contains some diagnostic checks on the previous estimations, and Section 10.8 concludes.

10.1 The Simple Hansen Friction Model

Hansen[1] (1970) postulated that employment was never on the demand or supply curves of labour because of frictions. Rather it was always to the left of both curves. Furthermore, he assumed that the relationship between vacancies and unemployment was a rectangular hyperbola, $v \times u = K$ where v = the vacancy rate, u = the unemployment rate and K is a constant. Since this relationship is always assumed to hold, it is also true in equilibrium when the vacancy rate equals the unemployment rate which is itself equal to the natural unemployment rate. Defining the vacancy rate as the vacancy-employment ratio, we can derive a relationship between actual employment (L) and labour demand (L^D):

$$uv = H$$

In equilibrium $u = v = \bar{u}$

$$\therefore \quad uv = (\bar{u})^2 = H$$

$$\therefore \quad \frac{L^D - L}{L} = \frac{(\bar{u})^2}{u}$$

$$\therefore \quad \frac{L^D}{L} = \frac{(\bar{u})^2 + u}{u}.$$

or

$$L_t = \left(\frac{u_t}{(\bar{u}_t)^2 + u_t}\right) L_t^D$$

10.1 or $L_t' = \theta_t + L_t'^D$

where $\theta_t = \log\left(\frac{u_t}{(\bar{u}_t)^2 + u_t}\right)$ and L_t' and $L_t'^D$ are the logarithms to natural base of employment and labour demand respectively.

Equation 10.1 could be regarded as a structural equation in models which incorporate production lags and costly adjustment. For example, assuming the static expectations version of adjustment costs we would have the following model:

$$L^D = (1 - \lambda)L_t^* + \lambda L_{t-1} \qquad (1)$$

$$L_t^* = \alpha + \beta W_t - \beta P_t \qquad (2)$$

$$L_t = \theta_t + L_t^D \qquad (3)$$

which yields the following reduced form:

$$L_t = (1 - \lambda)(\alpha + \beta W_t - \beta P_t) + \lambda L_{t-1} + \theta_t$$

Although I shall estimate models of the above type, they are not, strictly speaking, internally consistent. The problem is centered around the fact that the existence of frictions embodied in the rectangular hyperbola, prevents firms from being on their labour demand curves even in full equilibirum. That is to say, frictions cause real wages to be less than labour's marginal product even in full equilibrium. Yet we have assumed that real wages are equal to labour's marginal product in the derivation of equation (2). In general, this equation simply says that firms desire to employ labour up to the point where real wages are equal to labour's marginal product, and equation (3) tells us that frictions prevent them from doing so. The model then does not allow firms to be in full equilibrium, or alternatively, in full equilibrium the model is inconsistent.

This problem can be removed by introducing such costs as advertising costs and interviewing costs which are associated with the existence of job vacancies.

10.2 Introducing Costs Associated with Job Vacancies

We shall assume that the friction in the labour market stems from imperfect information and that firms are aware of this information problem. For this reason firms advertise jobs available, J, in excess of actual employment wanted in the attempt to actually acquire the desired amount of employment. Vacancies are defined as jobs available, J, minus employment, L, and the frictional hyperbola can be stated as:

$$\frac{J_t - L_t}{L_t} \cdot u_t = (\bar{u}_t)^2$$

or

$$J = \frac{(\bar{u}_t)^2 + u_t}{u_t} \quad L$$

The individual firm assumes that it has no effect on the aggregate unemployment rate, but that this rate inversely affects the degree by which its J signals must exceed L, for a given L to be obtained. Thus this model differs from the previous one in that in the simple model firms were prevented from ever achieving their desired quantity of employment, whereas in this model firms give whatever job signals are necessary in order to employ the desired number of workers. This differs from the simple employment equals labour demand model in that in making these decisions about job signals, firms not only consider the costs of being out of full equilibrium (and the costs of adjusting employment, if any), but also the costs of making these job signals. These costs determine the firms short run demand curve, and employment is always on this schedule.

Firms are assumed to maximize the expected future discounted stream of real profits, Π;

10.2.1 $$\Pi = E \sum_{t=0}^{\infty} R^t (F(L) - WL_t - a_2(L_t - L_{t-1})^2 - cV_t)$$

and

$$V_t = J_t - L_t \text{ and } J_t = \frac{(\bar{u}_t)^2 + u_t}{u_t} L_t .$$

Substituting in and differentiating with respect to L_t yields:

10.2.2 $$\frac{d\Pi}{dL_t} = R^t \left[F_L(L_t) - W_t - 2a_2(L_t - L_{t-1}) - c(\bar{u}_t)^2/u_t \right] + R^{t+1} 2a_2(L_{t+1} - L_t) = 0$$

In full equilibrium $L_t = L_{t-1} = L_{t+1} = L^*$ and therefore:

$$F_L(L^*) - W_t - c(\bar{u})^2/u = 0 \tag{10.2.3}$$

The above equation shows that the introduction of "information" costs into the firms profit function removes the contradiction between the full equilibrium condition and the existence of frictions.

There are a number of ways in which the above model can now be solved. We could assume a quadratic production function, $X = AL_t - \beta L_t^2$, which would yield the optimality condition directly from 10.2.2. In full equilibrium

$$W_t = A - 2\beta L_t^* - c(\bar{u}_t)^2/u_t$$

$$\therefore\ A - 2\beta L_t - c(\bar{u}_t)^2/u_t - W_t = 2\beta(L_t^* - L_t)$$

Therefore, 10.2.2 can be rewritten as

$$2\beta(L_t^* - L_t) - 2a_2(L_t - L_{t-1}) + R2a_2(L_{t+1} - L_t) = 0$$

or

$$RL_{t+1} - (1 + R + g)L_t + L_{t-1} = -gL_t^*$$

where $g = \beta/a_2$ which is exactly the optimality equation

of Chapter 8, the only difference being in the definition of L_t^*, which in this case is equal to,

$$L_t^* = (A/2)\beta - (1/2)\beta\ W_t - (c/2)\beta\ (\bar{u}_t)^2/u_t$$

Alternatively, we could totally differentiate

10.2.2 with respect to L_t and approximate the dynamic properties of the time paths by straight lines in the neighbourhood of L^*, by letting $dL_{t+i} = L_{t+i} - L^*$ (for i = 1, 0, -1). This results in

$$(F_{LL} - 2a_2 - R2a_2)(L_t - L^*) + 2a_2(L_{t-1} - L^*)$$

$$+ R2a_2 (L_{t+1} - L^*) = 0$$

or

$$RL_{t+1} - (1 + R + g)L_t + L_{t-1} = -gL^* ,$$

where $g = -F_{LL}/2a_2$. Clearly in the general case g will only be a constant if there are strictly quadratic production and adjustment cost functions. For other production and cost functions, g will only be constant in the neighbourhood of L^* providing L^* itself is constant[2].

As a final way of deriving the optimality condition we could assume cost minimizing behaviour as in Chapter 8, adding the extra term in the definition of L_t^*. If we follow this route and assume Cobb-Douglas technology equation 10.2.3 becomes:

$$e^{Zt} A\alpha(L_t^*)^{\alpha-1} = W_t + c(\bar{u}_t)^2/u_t$$

Let us write $\psi_t = c(\bar{u}_t)^2/u_t$ and take logarithms and differentiate the full equilibrium condition with respect to time:

$$\log(W_t + \Psi_t) = \log A\alpha + Zt + (\alpha - 1)\log L_t^*$$

$$\left(\frac{1}{W_t + \Psi_t}\right)\frac{d(W_t + \Psi_t)}{dt} = Z + (\alpha - 1)\frac{dL_t^*}{L_t^* \, dt}$$

or

$$\frac{1}{W}\frac{dW}{dt}\left(\frac{W}{W+\Psi_t}\right) + \frac{1}{\Psi_t}\frac{d\Psi_t}{dt}\left(\frac{\Psi_t}{w+\Psi_t}\right) = Z + (\alpha - 1)\frac{dL_t^*}{dtL_t^*}$$

Assuming that $W_t/(W_t+\Psi_t)$ is a constant equal to P, and writing dashed letters for variables which have been logged and differenced, we may write

$$L_t'^* = \frac{-P'}{1-\alpha}W_t - \frac{(1-P)}{1-\alpha}Q_t' + \frac{Z'}{1-\alpha}$$

where $Q_t' = \log \Psi_t - \log \Psi_{t-1}$

$$= \log \frac{c(\bar{u}_t)^2}{u_t} - \log c\frac{(\bar{u}_{t-1})^2}{u_{t-1}}$$

$$= \log c + \log \frac{(\bar{u}_t)^2}{u_t} - \log c - \log \frac{(\bar{u}_{t-1})^2}{u_{t-1}}$$

$$Q_t' = \log \frac{(\bar{u}_t)^2}{u_t} - \log \frac{(\bar{u}_{t-1})^2}{u_{t-1}}$$

In this case $-\frac{1}{1-\alpha}$ can be found by adding the coefficients of W_t and Ψ_t.

Returning to the optimality condition, which is identical to the condition of Chapter 5, we would make the same algebraic manipulations as Section 8.1.2

and derive

$$L_t - L_{t-1} = (1 - \lambda)(d_t - L_{t-1})$$

where

$$d_t = (1 - \lambda R) \sum_{s=0}^{\infty} \lambda^s R^s L^*_{t+s}$$

The rational expectations version can now be implemented using two stage procedures. Since d_t depends on present and future values of W_t and Q_t, then if W_t follows an AR(P) process and Q_t and AR(m) process, step one would be

$$L_t = \lambda L_{t-1} + (\alpha_0 W_t \ldots \alpha_p W_{t-p}) + (\gamma_0 Q_t \ldots \gamma_m Q_{t-m})$$

From $\hat{\lambda}$ we may find $\hat{g}$ and estimate step two as follows:[3]

$$RL_{t+1} - (1 + R + \hat{g})L_t + L_{t-1} = -\hat{g}(a+\beta W_t + \gamma Q_t) + e_t$$

and a test of the model could be based on the value of α resulting from

$$\beta + \gamma = -1/1-\alpha$$

10.3 Operationalizing the Friction Models Within The Context of the Canadian Manufacturing Sector

The essential question to be discussed in this section is whether the rectangular hyperbola relating vacancies and unemployment to the natural unemployment rate should be postulated to exist at the aggregate level or the sectoral level, when estimating the model using sectoral data.

Considering the simple friction model first, we need a relationship which links actual employment in manufacturing with labour demand in manufacturing, and plainly this requires that we postulate that the rectangular hyperbola exist at the level of the manufacturing industry. This would require estimating the natural unemployment rate for manufacturing. Unfortunately the data on participation rates, labour force shares, etc., which are necessary to calculate $\bar{u}$ are not available at the sectoral level. One way around this problem would be to assume that the proportional deviation of the unemployment rate from its natural rate is the same in the manufacturing sector as it is in the aggregate:

$$\frac{u_m}{\bar{u}_m} = \frac{u}{\bar{u}}$$

10.3.1 or $$\bar{u}_m = \frac{\bar{u}}{u} \times u_m$$

where m subscripts indicate manufacturing data. Unfortunately, unemployment data by sector are only available beginning March 1976, which necessitates the calculation of a proxy variable for actual unemployment in manufacturing prior to that date.

For example, there might exist a simple relationship between manufacturing unemployment and aggregate unemployment which could be discovered using the available post 1976 data, and projected back to generate "predicted" unemployment in manufacturing prior to 1976. To check for this possibility the following equation was estimated using monthly data from June 1976 to May 1980:

10.3.2 $$u_{mt} = a + b\, u_t + e_t$$

Using ordinary least squares the result was:

$$\underset{(0.31)}{u_{mt} = -0.22} \quad + \quad \underset{(11.5)}{1.003\, u_t} \qquad R^2 = .7350 \quad \text{D.W.} = 0.73$$

Since this equation suffers from serial correlation the equation was re-estimated using the Cochrane-Orcutt iterative technique and the result was:

$$u_m = \underset{(.09)}{0.8} \quad + \quad \underset{(8.4)}{.966\, u_t} \qquad R^2 = .8380 \quad \text{D.W.} = 2.06$$

Since .966 is insignificantly different from unity and the constant term is insignificantly different from zero, it would appear that $u_m = u$ is a good proxy for u_m. Substituting this into 10.3.1 we find $\overline{u}_m = \overline{u}$ and we may approximate manufacturing data with aggregate data on $\overline{u}_t$ and u_t.

Turning next to the "sophisticated" friction model we find that there is no need to postulate the existence of the rectangular hyperbolic relationship at the sectoral level. This is because it would seem perfectly reasonable that the successfulness of the individual firm's job advertising campaign to attract workers would be inversely affected by the aggregate unemployment rate. Furthermore, even if there were significant labour immobilities between sectors which suggest that the rectangular hyperbola should be postulated at the sectoral level, provided that the proportional relationship 10.3.1 holds, the use of aggregate data in equation 10.2.2 would only affect the size of coefficient 'c' in this equation, a coefficient which drops out when we take logarithms and difference the data.

To conclude, we may postulate the hyperbolic relationship at the aggregate level and use aggregate data on $\bar{u}_t$ and u_t to test the sophisticated friction model using manufacturing data for employment and wages and prices. On the other hand, the simple friction model requires that we postulate the existence of the hyperbolic relationship at the sectoral level, but the use of the ad hoc proportional relationship 10.3.1 and the finding of a one to one relationship between manufacturing and aggregate unemployment using monthly data from June 1976 to March 1980, permits the use of aggregate data to test this model too. However, before these models can be tested we must estimate $\bar{u}_t$ at the aggregate level. The estimate of $\bar{u}_t$ is discussed in Chapter 11. We now turn our attention to the results of the estimates of the frictional models.

10.4 The Results of the Simple Friction Model

10.4.1 The Equations:

We will estimate four models of this type. The first one ignores costs of adjustment and production lags, the second incorporates a static cost of adjustment function, the third embodies a production lag and adaptive price expectations, and the fourth has both production lags and the static cost of adjustment function.

An initial question concerns the nature of the static cost of adjustment function. It cannot be consistently derived since the nature of the simple model is such that frictions exist which either are not perceived by the firm, or if perceived, do not affect the firms behaviour since there are no costs to the firm associated with these frictions. Therefore, the model is ad hoc, and there would seem to be at least three possibilities for the adjustment equation.

10.A $\quad L_t^D - L_{t-1} = (1 - \lambda)\ [L_t^* - L_{t-1}]$

10.B $\quad L_t^D - L_{t-1}^D = (1 - \lambda)\ [L_t^* - L_{t-1}]$

10.C $\quad L_t^D - L_{t-1}^D = (1 - \lambda)\ [L_t^* - L_{t-1}^D]$

Equation A says that this period's demand for labour will be somewhere between this period's equilibrium quantity and last period's actual employment. Equation B says that the change in labour demand will be a fraction of the difference between this period's equilibrium quantity and last period's actual employment. Both equations A and B appear to stem from adjustment costs on actual employment levels. Equation C, however, appears to stem from adjustment costs on labour demand since it says that the change in labour demand will be a fraction of the difference between this period's equilibrium level and last period's labour demand. Since we cannot choose between these formulations on an a priori basis all three formulations will be tried for models two and four:

Model 1.

$$L_t^D = a + \beta W_t - \beta P_t$$

$$L_t = \theta_t + L_t^D \ .$$

$$\therefore L_t = a + \beta W_t - \beta P_t + \theta_t$$

Model 2:

A: $$L_t^D = (1 - \lambda)L_t^* + \lambda L_{t-1}$$

$$L_t^* = a + \beta W_t - \beta P_t$$

$$L_t = \theta_t + L_t^D$$

$$\therefore \quad L_t = (1 - \lambda)(a + \beta W_t - \beta P_t) + \lambda L_{t-1} + \theta_t$$

B: $$L_t^D = (1 - \lambda)L_t^* + \lambda L_{t-1} - \theta_{t-1}$$

$$L_t = a + \beta W_t - \beta P_t$$

$$L_t = \theta_t + L_t^D$$

$$\therefore \quad L_t = (1 - \lambda)[a + \beta W_t - \beta P_t] + \lambda L_{t-1} - \theta_{t-1} + \theta_t$$

C: $$L_t^D = (1 - \lambda)L_t^* + \lambda L_{t-1}^D$$

$$L^* = a + \beta W_t - \beta P_t$$

$$L_t = \theta_t + L_t^D$$

$$L_t = (1-\lambda)[a + \beta W_t - \beta P_t] + \lambda L_{t-1} - \lambda\theta_{t-1} + \theta_t$$

Model 3:

$$L^D = a + \beta W_t - \beta P_t^e$$

$$P_t^e = \gamma P_t + (1 - \gamma)P_{t-1}^e$$

$$L_t = \theta_t + L_t^D$$

$$L_t = a\gamma + \beta[W_t - (1-\gamma)W_{t-1}] - \gamma\beta P_t + (1-\gamma)L_{t-1}$$
$$-(1 - \gamma)\theta_t - 1 + \theta_t$$

Model 4:

A:

$$L^* = a + \beta W_t - \beta P_t^e$$

$$L^D = (1 - \lambda)L_t^* + \lambda L_{t-1}$$

$$P_t^e = \gamma P_t + (1 - \lambda)P_{t-1}^e$$

$$L_t = \theta_t + L_t^D$$

$$\therefore \quad L_t = (1-\lambda)a\gamma + (1-\lambda)\beta\left[W_t - (1-\gamma)W_{t-1}\right]$$

$$- \gamma(1-\lambda)\beta P_t + \theta_t - (1-\gamma)\theta_{t-1} + (1+\lambda-\gamma)L_{t-1}$$

$$- (1 - \gamma)\lambda L_{t-2}$$

B:

$$L^* = a + \beta W_t - \beta P_t^e$$

$$L^D = (1 - \lambda)L_t^* + \lambda L_{t-1} - \theta_{t-1}$$

$$P_t^e = \gamma P_t + (1 - \gamma)\, P_{t-1}^e$$

$$L_t = \theta_t + L_t^D$$

$$\therefore \quad L_t = (1-\lambda)a\gamma + (1-\lambda)\beta[W_t - (1-\gamma)W_{t-1} - \gamma P_t]$$

$$+ (1+\lambda-\gamma)L_{t-1} - (1-\gamma)\lambda L_{t-2} + \theta_t - (2-\gamma)\theta_{t-1}$$

$$+ (1 - \gamma)\theta_{t-2}$$

C:

$$L^* = a + \beta W_t - \beta P_t^e$$

$$L_t^D = (1 - \lambda)L_t^* + \lambda L_{t-1}^D$$

$$P_t^e = \gamma P_t + (1 - \gamma)\, P_{t-1}^e$$

$$L_t = \theta_t + L_t^D$$

$$\therefore \quad L_t = a(1-\lambda)\gamma+\beta(1-\lambda)\ [W_t-(1-\gamma)W_{t-1}-\gamma P_t]$$
$$+ (1-\gamma+\lambda)L_{t-1}-\lambda(1-\gamma)L_{t-2}-(1-\gamma+\lambda)\theta_{t-1}$$
$$+ \lambda(1-\gamma)\theta_{t-2} + \theta_t$$

10.4.2 The Results:

Table 10.1 contains the estimates of the above eight equations using quarterly data on Canadian manufacturing from 1962 (2) to 1975 (3). The estimates of the coefficients and the correlograms of errors are obatined from non-linear estimates of the eight equations as they are given above, with L_t as the dependent variable. The R^2 statistic does not result from this equation, however. This is because I want to test the joint hypothesis that $a = \beta = \lambda = (1 - \gamma) = 0$, but since θ_t is constrained to have a coefficient of unity, the R^2 resulting from this equation would be inappropriate. Therefore, the stated R^2 is calculated by generating the fitted values of $L_t - \theta_t$, using the estimated coefficients, and correlating this with the actual values of $L_t - \theta_t$. The R^2 is then the square of this correlation coefficient.

Let us now consider Table 10.1. An initial question would seem to be which version of the costly adjustment equation performs best. The evidence seems

TABLE 10.1

THE SIMPLE HANSEN FRICTION MODEL

Equation	a	β	λ	τ	R^2	n
1	.12E-02 (.15)	-1.7 (3.5)			.4109	50
2A	-.0018 (.10)	-3.14 (.44)	.58 (.55)		.4169	50
2B	-.0007 (.25)	-0.34 (2.17)	-2.6 (2.1)		.2903	50
2C	.16E-02 (.15)	-1.7 (3.0)	.17 (1.2)		.4455	50
3	.0016 (.17)	-1.6 (3.0)		.88* (5.9)	.4271	50
4A	-1.14 (2.6)	-0.6 (2.2)	-1.68 (1.6)	.65** 4.8	.4491	50
4B	-0.6 (2.4)	-0.36 (2.3)	-1.8 (1.5)	1.2* (9.5)	.3148	50
4C	.16E-02 (.15)	-1.7 (2.9)	.21 (0.5)	1.05* (2.2)	.4464	50

* not significantly different from unity; ** significantly different from unity.

CORRELOGRAM OF ERRORS:

Lags Eqn.	1	2	3	4	5	6	7	8	9	10	11	12	$2/\sqrt{n}$
1	.02	.22	.14	.11	.04	.16	.30	.04	.13	.04	.05	.12	.33
2A	.01	.23	.14	.14	.04	.16	.28	.05	.15	.04	.08	.13	.33
2B	.33	.02	.24	.23	.00	.04	.13	.00	.00	.07	.03	.20	.33
2C	.08	.20	.14	.14	.04	.12	.25	.04	.14	.04	.06	.14	.33
3	.04	.21	.14	.13	.04	.13	.27	.05	.14	.05	.06	.13	.33
4A	.09	.08	.18	.16	.01	.05	.22	.06	.03	.09	.02	.16	.33
4B	.14	.22	.23	.21	.08	.02	.16	.04	.07	.08	.00	.17	.33
4C	.07	.19	.14	.13	.04	.13	.26	.05	.14	.03	.05	.13	.33

unanimous in pointing towards equation C, which appears to stem from costs of adjustment on labour demand. Equation B yields illegitimate negative values for λ in both models 2 and 4, and equation A yields a negative value for λ in model 4, while in model 2 none of the coefficients taken individually are significant (though the joint hypothesis that $a = \beta = \lambda = 0$ must be rejected). On the other hand adjustment equation C yields values of $\beta = -1.7$ which coincides with the estimates resulting from models 1 and 3, and furthermore the size of the adjustment coefficient is in line with previous estimates (see Chapter 8).

If we therefore consider C the appropriate adjustment equation, we can summarize the results of the simple Hansen friction model up to this point as being very encouraging. All the equations are significant, signs are correct, the sizes of coefficients are reasonable, and there are no problems of serial correlation.

In particular, the value of β of -1.7 which implies a value of $\alpha = 0.4$ (where α is the exponent of labour in the production function $X = L^{\alpha}K^{1-\alpha}$), which though still a little small is a great improvement over the estimates recorded in Chapter 8. We should also note that in conformity with previous estimates, the value of γ is not significantly different from unity, thus giving us no evidence in favour of the existence of a production lag. Indeed, the evidence in favour of costly adjustment is also fairly weak since though λ is of the correct size and sign it is not significantly different from zero at the 5% level.

In order to check for the effect of endogeneity of wages and prices equation 2.C was re-estimated using an instrumental variable for real wages[4]. The following result was obtained:

$$(L_t - \theta_t) = \underset{(.19)}{\underset{(.16E-02)}{a}} + \underset{(2.3)}{\underset{(-1.9)}{b(W_t - P_t)}} + \underset{(.68)}{\underset{(.11)}{\lambda (L_{t-1} - \theta_{t-1})}} \qquad R^2 = .2159$$

and since $b = (1 - \lambda)\beta \therefore \beta = \frac{-1.9}{.89} = -2.13$

β is significantly different from zero if b is significantly different from zero and $\lambda \neq 1$. Since the probability of $\lambda = 1$ is approximately zero (since λ is continuous and therefore has an infinite range of possibilities) the significance of β can be found from the significance of b. Therefore β is significantly different from zero. The equation does not suffer from serial correlation as can be seen from the correlogram of errors, therefore the coefficients are unbiased. Taking account of the possible endogeneity of wages and prices results in an even larger value of β, the implied

Correlogram of Errors:

Lags	1	2	3	4	5	6	7	8	9	10	11	12	2/ n
	.07	.22	.13	.11	.05	.13	.28	.02	.16	.03	.06	.13	.33

value of α now being 0.53

The simple friction model was not implemented assuming rational expectations since it is, after all, essentially ad hoc.

10.4.3 Testing the Simple Friction Model Against Employment Equals Labour Demand

The only difference between the simple friction model and $L = L^D$ is the equation $L_t = \theta_t + L^D_t$. The resulting reduced form equations are identical apart from the presence of the term θ_t. We can therefore, test the simple friction model by adding a coefficient, K, to the θ_t term:

$$L_t = L^D + \mathbf{h}\,\theta_t$$

It is now readily apparent that the simple friction model and $L = L^D$ are nested hypotheses. If **h** is insignificantly different from unity, the simple friction model is true; if **h** is insignificantly different from zero the $L = L^D$ model is true. Therefore, the eight equations were re-estimated including the **h** coefficient. The results are contained

TABLE 10.2

THE SIMPLE FRICTION MODEL VERSUS $L = L^D$

Equation	A	β	λ	τ	h	R^2
1	-.9E-03 (0.8)	-0.23 (3.4)			-.08 (3.7)	.4428
2A	-.001 (0.8)	-0.22 (2.7)	.11 (0.7)		-.07 (3.6)	.4496
2B	-.002 (0.7)	-0.32 (3.6)	.17 (1.03)		-.01 (0.5)	.3065
2C	-.8E-03 (0.9)	-0.23 (3.7)	-.12 (0.7)		-0.08 (4.1)	.4565
3	-.8E-03 (0.9)	-0.24 (3.8)		1.16* (7.4)	-.08 (4.06)	.4539
4A						
4B						
4C						

* not significantly different from unity.

Correlogram of Errors

Lags	1	2	3	4	5	6	7	8	9	10	11	12	$2/\sqrt{n}$
1	.20	.26	.04	.17	.20	.12	.31	.19	.15	.11	.02	.13	.32
2A	.30	.28	.07	.19	.21	.19	.32	.18	.16	.11	.06	.16	.32
2B	.23	.19	.05	.06	.23	.06	.40	.09	.08	.03	.10	.19	.32
2C	.21	.25	.04	.17	.22	.15	.33	.16	.13	.09	.06	.11	.32
3	.05	.24	.03	.14	.16	.08	.26	.20	.11	.12	.02	.07	.32
4A													.32
4B													.32
4C													.32

in Table 10.2.

Equations 4A, 4B and 4C are not reported since convergence was problematic, the results were unstable, and they were characterized by high serial correlation. From the remaining equations it would seem that all lead to rejection of the simple Hansen friction model. (Indeed the $L = L^D$ model is also rejected by all the equations apart from equation 2.B where **h** is not significantly different from zero.)

Section 10.5 Frictions Plus Costs Associated With Job Vacancies

Section 10.2 developed a model incorporating both frictions plus costs associated with job vacancies and costly adjustment of labour, in a rational expectations framework. It is possible, however, that the assumption concerning rational expectations is unnecessary. To check for this possibility we will follow the pattern of the previous section and estimate the static expectations costly adjustment equation with and without production lags, as a basis fo comparison. In addition, we will impose the constraint of no costly adjustment, both with and without production lags.

The equations to be estimated are the following:

10.5.1 The Equations:

Equation 1.

$$L_t = a + bW_t + c\Psi_t$$

Equation 2.

$$L_t = (1 - \lambda)\ L_t^* + \lambda L_{t-1}$$

$$L_t^* = a + bW_t + c\Psi_t$$

$$\therefore \quad L_t = (1 - \lambda)(a + bW_t + c\Psi_t)$$

Equation 3.

$$L_t = a + bW_t - bP_t^e + c\Psi_t$$

$$P_t^e = \gamma P_t + (1 - \gamma)P_{t-1}^e$$

$$\therefore \quad L_t = a\gamma + bW_t - b(1-\gamma)W_{t-1} + c\Psi_t - c(1-\gamma)\Psi_{t-1}$$

$$- b\gamma P_t + (1 - \gamma)L_{t-1}$$

Equation 4.

$$L_t = (1 - \lambda)L_t^* + \lambda L_{t-1}$$

$$L_t^* = a + bW_t - bP_t^e + c\Psi_t$$

$$P_t^e = \gamma P_t + (1 - \gamma)P_{t-1}^e$$

$$\therefore \quad L_t = (1-\gamma)[a\gamma+bW_t-(1-\gamma)bW_{t-1}-b\gamma P_t + c\Psi_t$$

$$-c(1-\gamma)\Psi_{t-1}] +(1-\gamma+\lambda)L_{t-1}-\lambda(1-\gamma)L_{t-2}$$

10.5.2 The Results.

The results of these equations are contained

TABLE 10.3

THE "CONSISTENT" FRICTION MODEL

Equation	A	β	c	λ	γ	R^2
1	-.66E-03	-0.32	.002			.2907
	(.5)	(4.3)	(.18)			
2	-.74E-03	-0.31	-.002	.19		.3092
	(.46)	(3.4)	(.11)	(1.1)		
3	-.69E-03	-0.31	.0002		.91*	.2938
	(0.47)	(3.7)	(.02)		(5.2)	
4	-.64E-03	-.44	-.024	.62	1.6**	.4206
	(.32)	(3.4)	(0.8)	(4.9)	(10.1)	

* not significantly different from unity

** significantly different from unity.

Correlogram of Errors.

Lags	1	2	3	4	5	6	7	8	9	10	11	12	$2/\sqrt{n}$
Equation 1	.07	.17	.08	.01	.21	.02	.39	.07	.06	.00	.07	.17	.33
2	.22	.17	.07	.03	.22	.07	.39	.06	.06	.01	.12	.20	.33
3	.13	.17	.08	.01	.21	.01	.39	.06	.06	.00	.09	.18	.33
4	.03	.03	.10	.01	.20	.00	.34	.08	.03	.01	.03	.21	.33

in Table 10.3.

The most significant feature of these equations is that the value of β is not altered from the simple $L = L^D$ model discussed in Chapters 8 and 9, and furthermore that the coefficient 'c' is not significantly different from zero, thus indicating that the sophisticated friction model should be rejected in favour of the $L = L^D$ model.

The evidence on costs of adjustment and production lags follows the pattern discovered for the $L = L^D$ model. Neither production lags nor costs of adjustment significantly affect the estimate of β; there is little evidence in favour of production lags. In equation 3 the adjustment coefficient is not significantly different from unity indicating that $P^e_{t+1} = P_t$, which is indistinguishable from the absence of production lags. In equation 4, γ takes on an illegitimate value of greater than unity. As far as costs of adjustment are concerned, λ is not significantly different from zero in equation 2, while the significant estimate of λ in equation 4 is marred because γ is significantly greater than unity in this equation.

Turning next to the rational expectations version of this model, consider the results of Table 10.4. My procedure was to first establish that an AR(4)

TABLE 10.4

THE RATIONAL EXPECTATIONS, COSTLY ADJUSTMENT, SOPHISTICATED FRICTION MODEL

	D.W.	W_0	W_1	W_2	W_3	W_4	W_5	r_0	r_1	r_2	r_3	r_4	R^2	λ
1	2.16	-.25											.3090	.18
		(2.6)												(1.1)
2	2.02	-.10	-.16	-.21	.06	.20							.4205	.12
		(0.9)	(1.6)	(1.9)	(0.6)	(1.8)								(.7)
3	2.03	-.11	-.15	-.21	.05	.29	.04						.4219	.11
		(0.9)	(1.3)	(1.9)	(0.4)	(1.5)	(0.3)							(.6)
4	1.96	-.10	-.15	-.24	.12	.28		-.01	.03	.003	.03		.5063	.15
		(0.8)	(1.5)	(2.1)	(1.04)	(2.3)		(0.7)	(1.9)	(.18)	(2.1)			(.8
5	2.00	-.10	-.14	-.24	.11	.27		-.01	.03	-.001	.03	.006	.5083	.16
		(0.8)	(1.2)	(2.07)	(1.0)	(2.2)		(0.5)	(1.9)	(.05)	(2.2)	(0.3)		(0.9)

From equation 4, $\hat{\lambda} = .15$ if $R = 1$, $\hat{g} = \frac{(1-\lambda)^2}{\hat{\lambda}} = 4.8$

STAGE 2:

$$RL_{t+1} - (1 + R + \hat{g}) + L_{t-1} = -\hat{g}\,(\alpha + \beta W_t + \gamma(h/u)t)$$

α	β	c	R^2	D.W.
.4E-03	-0.34	-0.013	.2264	2.37
(0.25)	(3.7)	(1.04)		

Correlogram of Errors

1	2	3	4	5	6	7	8	9	10	11	12	$2/\sqrt{n}$
.07	.18	.08	.00	.17	.07	.21	.06	.05	.01	.08	.13	.33

structure was appropriate for W_t, and then to add the Ψ_{t-i} terms. From the table we see that an AR(4) structure was also appropriate for Ψ_t and therefore the estimate of λ is taken from equation 4. I assume R = 1 for step two, though the results were not sensitive to plugging in a value of R = 1.04. The interesting question is whether the estimates resulting from the rational expectations version are significantly different from those resulting from the static expectations versions. Let us compare the results:

Static Version	Rational Version
$\beta = -0.31$	$\beta = -0.34$
$c = -0.002$	$c = -0.013$
$\lambda = 0.19$	$\lambda = 0.15$

The estimates from the rational expectations version are a function of two regression coefficients, one from each step. One problem is that if the estimate of λ is not perfect in step 1, there will be omitted variable bias in step 2. However, even without this complication, the rational expectations estimates are not significantly different from the static expectations estimates. That is, assume that $\lambda = \hat{\lambda}$, the static coefficients are all within 2 standard deviations of the rational coefficients.

In particular, the 95% confidence interval for c is -0.013 ∓ 0.025, which includes the static estimate. Again, we conclude that the static version cannot be rejected, and furthermore, though the significance of coefficient c has increased, it is still insignificantly different from zero, indicating rejection of the sophisticated friction model.

10.6 Summary of the Preceding Results

Two models have been estimated both of which contain frictions in the form of vacancies and unemployment. In the first model there were no costs associated with vacancies, and the normal first order condition ($W/P = MP_L$) held. The frictions, however, prevented firms from ever being on their labour demand curve, and we calculated a correction factor to link unobserved labour demand and actual employment. This model has a theoretical problem in the lack of a microeconomic foundation for the frictions, which should be the result of some costs, yet these costs do not enter the firms profit function. The second model remedied this defect by incorporating costs associated with vacancies. This resulted in real wages being less than labour's marginal product even in full equilibrium (since the frictions were assumed to exist even in full equilibrium). In this model firms give whatever job signals are necessary to attract the desired number of workers, but in making this decision they balance both the cost of making job signals and the cost of adjusting employment, against the costs of being out of full equilibrium. These costs coupled with profit maximizing behaviour determine the firms short run demand for labour schedule, and actual employment is always on this schedule.

Both models performed poorly. The simple model performed well (in the sense that the absolute value of β was raised above 2.0, implying that the model could not be rejected on the basis of a priori information about labour's share of manufacturing income), when the constraint $L_t = \theta_t + L_t^D$ was imposed. But when the constraint that θ's coefficient be equal to unity was dropped, θ's coefficient became significantly negative and β reverted back to its previous low levels. In the sophisticated friction model the extra term reflecting the cost of making job signals was not significantly different from zero, and the value of β remained at too low an absolute level. As in Chapter 9 the static expectations costly adjustment equation was barely significant, but could not be rejected on the basis of the rational expectations costly adjustment equation, which suggests an absence of significant adjustment costs for labour in manufacturing. In addition there was no evidence for the existence of production lags. Neither the assumption of costly adjustment nor lags in production altered the estimates of β.

The poor performance of these models was investigated further. Two possiblities were considered. The first possibility is that there exists an identification problem with the models estimated in their present forms. Consider the simple frictions model with no costs of adjustment and no production lags:

$$10.6.1 \quad L_t' = a + \beta W_t' - \beta P_t^{D'} + \theta_t$$

The identification issue revolves around whether we can be sure that when we estimate the above equation, we have in fact estimated the demand curve and not the supply curve or some hybrid of the two. The fact that 10.6.1 is a valid relationship between actual employment and labour demand when there are frictions, does not guarantee that it is the demand curve we are estimating. To see this, consider the relationship which may be derived between actual employment and labour supply, using the definition of the unemployment rate:

$$(L^S - L)/L = u$$

$$\therefore L^S/L = 1 + u$$

$$\therefore L = L^S/(1 + u)$$

$$\therefore \log L = \log L^S - \log (1 + u)$$

10.6.2 $$L_t' = m + n W_t' - nP_t^{S'} - Z_t$$

where primes indicate variables logged to base 'n', and $Z_t = \log (1 + u)$. The possibility of actually estimating 10.6.2 and thinking we had estimated equation 10.6.1 arises since:

(i) θ_t and Z_t could be fairly closely negatively related[5], and since they enter their respective equations with opposite signs, they may have a similar impact upon L_t'.

(ii) It is possible to construct hypotheses about labour supply behaviour[6] such that P_t^D would appear in equation 10.6.2 rather than P_t^S. For example, job search decisions may depend on the relation between wage offers received and the expectations of average market wages, where the latter in turn, may be based on the own product price, P_t^D.

The second possibility investigated is that the estimate of the natural unemployment rate, $\bar{u}_t$

which is described in Chapter 11, is inaccurate. To check this, $\bar{u}_t$ was derived using vacancy data, and this estimate was compared with the chapter 11 estimate. Subsequently θ_t was derived using the new estimate $\bar{u}_t$. In addition, a final measure of θ_t was derived by assuming $\bar{u}_t$ to be constant at a level of 5%.

10.7 Some Diagnostic Checks

10.7.1: The full system estimate of the simple friction model begins with the rectangular hyperbolic relationship, $v \cdot u = \bar{u}^2 = H$, which may be written as:

$$\frac{(L^D - L)}{L^D} \frac{(L^S - L)}{L^S} = H$$

This equation can be rewritten in the form of a quadratic expression for L:

$$L^2 - L(L^D + L^S) + L^S L^D (1 - H) = 0$$

There are two solutions for a quadratic equation, λ_1 and λ_2, defined by

$$\lambda_1, \lambda_2 = \frac{-b \mp \sqrt{b^2 - 4ac}}{2a}$$

These two solutions correspond to the two possible positions of the rectangular hyperbola between the labour demand and labour supply curves, as illustrated in Figure 10.1.

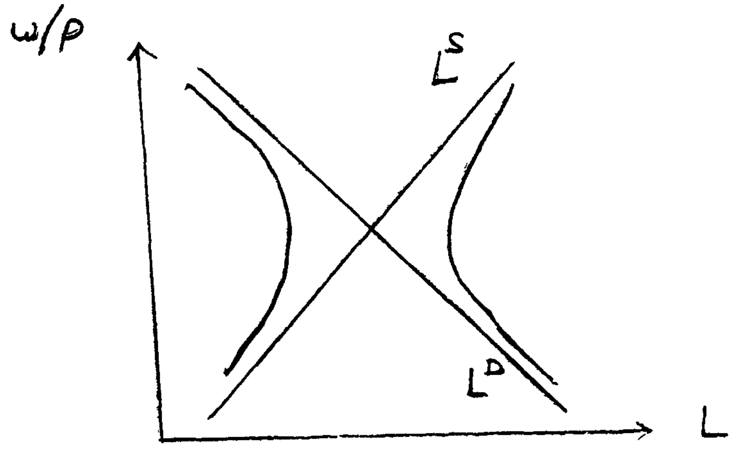


FIGURE 10.1

Since we assume the short side dominates we should take the smaller solution. Substituting into the solution for a quadratic equation, we get:

$$L = \frac{(L^D + L^S) - \sqrt{(L^D + L^S)^2 - 4(1 - H)L^D L^S}}{2} \qquad 10.7.1.$$

In this expression, since $(1 - H) > 0$, it follows that

$$(L^D + L^S) > \sqrt{(L^D + L^S)^2 - 4(1 - H)L^D L^S},$$

and that therefore, the whole expression is positive. Moreover, since the term under the square root sign can be rearranged to read, $\sqrt{(L^D - L^S)^2 + 4H\,L^D L^S}$, it follows that it must be a real number.

If we substitute in expressions for L^D and L^S (which it should be noted are not logged), and make some assumptions about the error structure, then we will have a nonlinear equation in L which we can estimate. The L^D and L^S equations are:

$$L^D = \alpha(W/P^D)^{\beta} (K)^c$$

$$L^S = m(W/P^S)^n (A)^Z$$

where P^S is the consumer price index, A is asset income, and K is the capital stock. We assume that the error is additive and is normally distributed. The equation is estimated for the simple case of no production lag or costly adjustment, since if we were to add an adjustment equation for labour demand which involved a lagged value of labour demand on the right hand side equation 10.7.1 would become intractible[7].

The equation was estimated using an algorithm described by Powell[8]. The following result was obtained:

α	β	c	m	n	z	log L
1.9E+14	.48	.5E-3	98.8	2048.	-.003	-188.7

The result is extremely disappointing. The elasticity of labour supply, n, has an unreasonably large value, and log L, the log of the likelihood function, is negative, indicating a value of the likelihood function which is **substantially less than unity.**

10.7.2 **Vacancy** data in manufacturing is available from 1970 (1) to 1978 (3). This data was divided by employment in manufacturing to calcualte the vacancy rate, v. The natural unemployment rate, $\bar{u}$, can then be calculated as

$$\bar{u} = \sqrt{uv}$$

Table 10.5 contains the calculated vacancy rate for manufacturing, the official quarterly unemployemnt rate, and the calculated **natural** unemployment rate. It can be seen that the natural unemployment rate does not vary a great deal over the eight year period, increasing from an average value of 1.8% in 1970 to a peak of 3.2% in 1973 and falling back to 2.2% in 1977. It must be suspected that these values are a little low, a problem probably caused by the fact that the vacancy data underestimates the number of vacancies available.

To compare this estimate of $\bar{u}$ with the estimate obtained from Chapter 11, the two estimates were correlated with each other, using the sample period 1970 (1) to 1978 (3). This resulted in a value of 0.25 for the simple correlation coefficient, indicating a fairly weak correlation. This suggests that we may

TABLE 10.3

THE UNEMPLOYMENT RATE, THE VACANCY RATE AND THE IMPLIED NATURAL UNEMPLOYMENT RATE

Date	v	u	$\bar{u}$
1970 (1)	.7	6.4	2.1
(2)	.6	6.3	1.8
(3)	.7	5.2	1.9
(4)	.4	5.7	1.5
1971 (1)	.4	8.0	1.9
(2)	.6	6.8	2.0
(3)	.6	5.2	1.8
(4)	.8	5.7	2.1
1972 (1)	.9	7.5	2.6
(2)	.9	6.4	2.4
(3)	1.8	5.5	3.2
(4)	1.5	5.9	3.0
1973 (1)	1.6	7.2	3.4
(2)	1.7	5.7	3.1
(3)	2.0	4.6	3.1
(4)	1.7	5.0	3.0
1974 (1)	1.8	6.7	3.5
(2)	2.1	5.4	3.3
(3)	2.3	4.5	3.2
(4)	1.2	5.2	2.5
1975 (1)	.8	8.6	2.7
(2)	.8	7.4	2.5
(3)	1.0	6.4	2.6
(4)	.9	6.7	2.4
1976 (1)	.9	7.9	2.6
(2)	.8	7.0	2.4
(3)	.9	6.8	2.5
(4)	.5	6.9	1.9
1977 (1)	.6	9.0	2.3
(2)	.7	8.0	2.4
(3)	.7	7.6	2.3
(4)	.6	8.0	2.2
1978 (1)	.6	9.6	2.4
(2)	.7	8.6	2.5
(3)	.8	7.8	2.5

get different results if we re-estiamte the equations of table 10.1 with the new estimate of $\bar{u}_t$ being used in the calculation of θ_t.

The frictional equation used is

$$L_t = L_t^D + h\,\theta_t$$

where h = 1 if the frictional model is true and h = 0 if the $L = L^D$ model is true. As before, three specifications of the adjustment equation are considered:

A. $L_t^D - L_{t-1}^D = \lambda(L_t^* - L_{t-1}^D)$, or $L_t^D = \lambda L_t^* + (1-\lambda)L_{t-1}^D$

B. $L_t^D - L_{t-1}^D = \lambda(L_t^* - L_{t-1})$, or $L_t^D = \lambda L_t^* + L_{t-1}^D - \lambda L_{t-1}$

C. $L_t^D - L_{t-1} = \lambda(L_t^* - L_{t-1})$, or $L_t^D = \lambda L_t^* + (1-\lambda)L_{t-1}$

Equation 1 is specified as the simple friction model without costly adjustment or production lags:

$$L_t = \alpha + \beta(W_t - P_t) + cK_t + h\,\theta_t \qquad [1]$$

Equations 2A, 2B and 2C incorporate costly adjustment according to the three specifications of the adjustment equation, A, B, or C:

$$L_t = \lambda(\alpha + \beta(W_t-P_t) + cK_t) + (1-\lambda)(L_{t-1} - h\theta_{t-1}) + h\,\theta_t \qquad [2A]$$

$$L_t = \lambda(\alpha + \beta(W_t-P_t) + cK_t) + (1-\lambda)L_{t-1} + h(\theta_t-\theta_{t-1}) \qquad [2B]$$

$$L_t = \lambda(\alpha + \beta(W_t-P_t) + cK_t) + (1-\lambda)L_{t-1} + h\,\theta_t \qquad [2C]$$

Equation 3 incorporates a one quarter production lag, with the future expected price being discounted to the present. The interest rate, R_t, is the quarterly treasury bill rate:

$$L_t = \alpha+\beta(W_t-P^e_{t+1}) + \beta R_t+cK_t+h\theta_t \qquad [3]$$

Equations 4A, 4B, 4C incorporate the production lag into the costly adjustment equations. The results are contained in Table 10.6.

The equations in Table 10.6 were estimated over 33 observations. Equations 1 and 3 were estimated using the Cochrane-Orcutt iterative technique and therefore the Durbin-Watson statistic is a valid test for first order serial correlation (since there are no lagged dependent variables on the right hand side). Since both these statistics are above the upper limit of the Durbin-Watson statistic (Du = 1.42 for 30 observations and 3 regressors), we reject the null hypothesis of positive first order serial correlation in these regressions. On the other hand, equations 2 and 4 do have a lagged dependent variable on the right hand side, and therefore the appropriate test for first order serial correlation is Durbin's "h" statistic[9]. This statistic is a standard normal variate, and is not significant in equations 2 and 4. The production lag used in equations 3 and 4 differs from the previous specification in two respects. First,

TABLE 10.6

Equation	α	β	c	h	λ	Q	Durbin's "h"	R^2
1	.06	-.21	.02	.02		.95	D.W. = 1.73	.9078
	(1.6)	(2.5)	(.09)	(1.2)		(18.7)		
2A	.04	-.20	.03	.01	.7	.94	h = .9	.9151
	(.5)	(1.7)	(.11)	(.6)	(3.2)	(9.1)		
2B	-.04	-.21	.06	-.005	.67	.94	h = 1.1	.9144
	(.5)	(1.6)	(0.1)	(.4)	(3.1)	(8.7)		
2C	-.01	.06	.73	.04	.27	.3	h = 1.2	.9300
	(1.2)	(.4)	(1.5)	(3.1)	(2.1)	(1.4)		
3	.06	.007	.03	.04		.96	D.W. = 1.6	.9104
	(1.1)	(2.7)	(.14)	(1.8)		(21.5)		
4A	-.03	.01	.03	.02	.7	.95	h = 1.2	.9175
	(.4)	(1.9)	(0.1)	(1.06)	(3.4)	(9.7)		
4B	-.03	.007	.08	-.001	0.6	.93	h = 1.3	.9144
	(.4)	(1.4)	(.3)	(.007)	(2.7)	(8.0)		
4C	-.01	.007	.81	.04	.3	.32	h = 1.2	.9295
	(1.1)	(0.1)	(1.8)	(2.9)	(2.4)	(1.5)		

the future expected price is discounted to the present by the inclusion of the rate of interest on a three month treasury bill, and second, the expected future price was not eliminated by use of the Koyck transformation, but rather rational expectations were assumed, and a consistent instrument was used for P^e_{t+1}.

The results turn out to be very similar to those of Table 10.6 In this case, however, the adjustment equations A and B perform better than previously, the value of λ being significantly positive throughout. This difference is probably due to the different starting date for the estimations, (1970 rather than 1961). The value of β is very close to the result previously obtained, except when a production lag is specified. The inclusion of the discount factor changes the previous borderline performance of the production lag into a clear cut negative performance. In equations 3 and 4 where a production lag was specified the value of β changes from being significantly negative to being insignificantly positive. The new coefficient, c, is significantly less than unity , indicating increasing returns to scale, in all the equations except 2C and 4C . In these latter two equations 'c' is insignificantly different from unity (which is consistent with constant returns to scale), which again seems to suggest the superiority of the third specification of the costly adjustment equation. Finally, and most importantly, though co-efficient 'h' is still significantly different from unity throughout, (which precludes an acceptance of the simple friction model over the $L=L^D$ model), it has at least become positive in all the estimations except 2B and 4B. As in the previous estimations recorded in Table 10.2, acceptance of the $L = L^D$ model is also precluded since 'h' is significantly different from zero in equations 2C, 3 and 4C.

It is possible that the small quantitative size of 'h' is due to our estimate of $\bar{u}$ being larger than the "true" $\bar{u}$, causing our estimate of θ to be larger than the "true" θ.[10] That is to say:

$$h.\theta = 1.\theta'$$

$$\text{or} \qquad h.\log\left(\frac{u_t}{\bar{u}_t^2 + u_t}\right) = \log\left(\frac{u_t}{(\bar{u}_t')^2 + u_t}\right)$$

where a dashed variable signifies the "true" value. The "true" value of $\bar{u}_t$ is then calculated as ;

$$\bar{u}_t' = \frac{u_t (1 - X_t)}{X_t} \quad ,$$

$$\text{where} \quad X_t = \left[\frac{u_t}{\bar{u}_t^2 + u_t}\right]^h .$$

Since equations 2C and 4C in Table 10.6 work best, in the sense that 'h' is significantly positive, .04 was used as the estimate of 'h'.We then calculated the "true" $\bar{u}_t$, or rather, the value that $\bar{u}_t$ would have to take in order to make co-efficient 'h' equal to unity.[11] The result of this calculation was that the natural unemployment rate would have to be less than 1% in order for the 'h' co-efficient to equal unity, and hence for the simple Hansen friction model to be accepted, rather than the $L = L^D$ model.

10.8 Conclusion

When the rectangular hyperbolic relationship is imposed on the data, the simple Hansen friction model performs well. All the variables are significant, they all have the correct signs, and in addition the absolute size of β is increased so that it corresponds more closely with labour's share in the national income, and implies decreasing returns to labour, when the log-linear demand function for labour which we use is identified as being derived from a Cobb-Douglas production function. However, when the simple friction model is tested against the $L = L^D$ model by not imposing a unity co-efficient on the frictions term, we are unable to decisively accept or reject either model. This is because the frictions co-efficient turns out to be significantly different from unity(as is implied by the frictions model) and also significantly different from zero (as is implied by the $L = L^D$ model).Various diagnostic checks were performed. We checked for problems of identification by estimating the full system,including the supply curve, and imposing the rectangular hyperbola on it, but the estimates were not encouraging.[12] We also tried alternative measures of the natural unemployment rate, and found that the estimates of the simple friction model were quite sensitive to this. Though we were able to improve the fit of the rectangular hyperbolic frictions model by generating $\bar{u}$ data by using published vacancy figures, we were not able to generate a unity co-efficient for 'h'. Indeed, it seems that the unity co-efficient requires unacceptably low values of $\bar{u}$. This evidence would seem to suggest that frictions are important, but that the simple rectangular hyperbolic model is inadequate.[13]

FOOTNOTES

Chapter 10

1. Hansen, B., "Excess Demand, Unemployment, Vacancies and Wages", Q.J.E., (1970), pp. 1-23.

2. See Brechling, op. cit. page 52.

3. See section 8.1.5. $\hat{g} = R\hat{\lambda} + \frac{1}{\hat{\lambda}} - (1+R)$

4. The instrument used was the mechanical one

$$\frac{(W_t - P_t) - \overline{(W_t - P_t)}}{\left|(W_t - P_t) - \overline{(W_t - P_t)}\right|}$$

which takes on the values +1, 0, -1, as real wages are above, equal to, or below, their average level. See also footnote 9, chapter 9.

5. The presumption of a close negative relationship between Z_t and Θ_t arises when the frictional hyperbola is defined as

$$(L_t^D - L_t)/L_t^D = \bar{u}_t^2/u_t, \text{ and therefore}$$

$$\Theta_t = (u_t - \bar{u}_t^2)/u_t \;.$$

Assuming $\bar{u}_t$ to be roughly constant at 0.5, as u_t fluctuates from .03 to .10, Θ_t fluctuates from .08 to .025, while Z_t fluctuates from .03 to .95. However, in fact the variation in $\bar{u}_t$ was sufficient to disrupt this relationship. The simple correlation co-efficient between Z_t and Θ_t turned out to be only -0.128.

6. See for example D. Burton, "Expectations and a Small Open Economy with a Flexible Exchange Rate", C.J.E., 1980, pp. 1-16.

7. For example, consider the adjustment equation:

$$L_t^D = \lambda L_t^* + (1-\lambda)L_{t-1}^D$$

where L_{t-i}^D is unobservable for all i. The standard method of solution (viz. substituting the unobservable into the equation to be estimated, and performing a Koyck transformation on this equation), plainly will not work in this case.

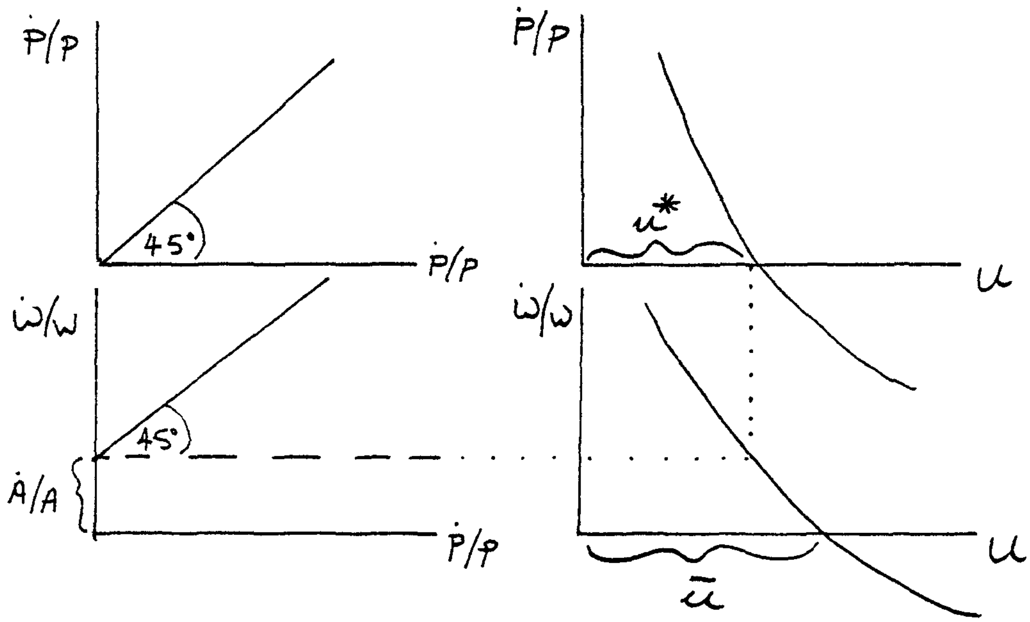
8. M.J.D. Powell,"An Efficient Method for Finding the Minimum of a Function of Several Variables Without Calculating the Derivatives", Computer Journal,1967 pp. 155-162.

9. J. Durbin, "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors Are Lagged Dependent Variables", Econometrica,1970, pp. 410-421.

10. Although there is reason to believe that the estimate of $\bar{u}_t$ from chapter 11 is an under-estimate of the "true" $\bar{u}_t$ there is no such presumption about the estimate derived from vacancy data. This difference arises since

$$\frac{\dot{P}}{P} = \frac{\dot{W}}{W} - \frac{\dot{A}}{A} ,$$

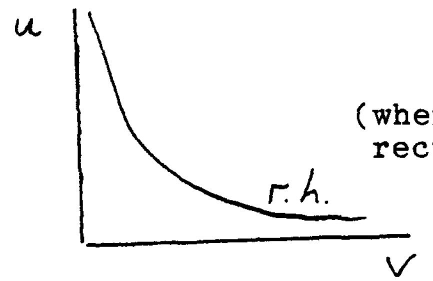
and therefore the existence of productivity change, $\dot{A}/A$, creates a wedge between the unemployment rate which is necessary to achieve $\dot{P}/P=0$, and the unemployment rate necessary to achieve $\dot{W}/W=0$. This can be clearly seen with the aid of the the four quadrant diagram below;



10.(cont'd)
The rectangular hyperbola is specified as

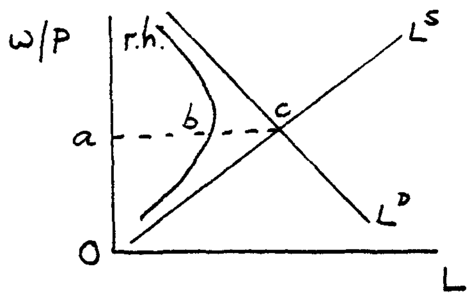
$$uv = H$$

which can be drawn in u, v space as;



(where r.h. stands for the rectangular hyperbola)

or, translated into the labour market diagram it can be drawn as;



Plainly, at a real wage of oa u=v, and therefore

$uv=H=u^2$. If the rate of change of real wages is specified as a function of the excess demand for labour, then we may write;

$$\frac{(\dot{W/P})}{W/P} = \frac{\alpha(L^D - L^S)}{L^S} ,$$

$$\text{or,}\quad \frac{\dot{W}}{W} = \frac{\alpha(L^D - L^S)}{L^S} + \frac{\dot{P}^e}{P}$$

Therefore, the unemployment rate that results when the real wage is oa is the unemployment rate which is necessary to achieve a rate of wage inflation equal to zero, which we have labelled as $\bar{u}$. Hence,

$$uv = H = \bar{u}^2 \quad .$$

It is interesting to note that though $\bar{u}$ exceeds u^* theoretically, our estimate of $\bar{u}$ in chapter 10 is less than our estimate of u* which we derived in chapter 11. This is probably primarily due to the fact that published vacancy figures underestimate the actual quantity of vacancies. Also, the fact that our estimate of $\bar{u}$ is already on the low side, does not support the conjecture that "co-efficient 'h' is too small because our estimate of $\bar{u}$ is too large".

11. The results quoted in the main text were derived from data which had been previously detrended and deseasonalised. Since the object is to find the actual $\bar{u}$ which is necessary to achieve a value of 'h' equal to unity, and not the detrended and deseasonalised $\bar{u}$ which is necessary to achieve a value of 'h' equal to unity, the estimations were repeated using raw data and including trend and seasonal dummies in the equation. This succeeded in duplicating the results quoted in the text, (which, incidentally, alleviates fears concerning the sensitivity of the results to this prior deseasonalising and detrending method). Then the actual $\bar{u}$ necessary for 'h' to equal unity was calculated.

12. The results from chapter 12 indicate that the identification issue is not a problem for the data which is used in this study. These reults indicate that a disequilibrium specification ($L=\min(L^D,L^S)$) is superior to an equilibrium specification, and that an overwhelming majority of the observations lie on the demand curve.

13. The empirical support which the rectangular hyperbola has received may be due to a failure to properly remove serial correlation. In this regard, see footnote 7, chapter 11.

CHAPTER 11

ESTIMATING THE NATURAL RATE OF UNEMPLOYMENT

To operationalise the frictional unemployment models of Chapter 10 an estimate of the Canadian natural unemployment rate is required. After briefly discussing the meaning of the natural unemployment rate in section 11.1, we move on to discuss possible estimation strategies in section 11.2. Three possible strategies are discussed; the standard Phillips curve plus dummy shift variables; R. J. Gordon's disaggregated method centered on the unemployment rate of prime aged adult males; and lastly a method used by Grubel, Maki and Sax of explaining unemployment in terms of its seasonal, structural and cyclical components. Section 11.3 implements Gordon's method, and section 11.4 implements the method of Grubel, et al. Finally Appendix I contains monthly estimates of u* that result from these methods along with data on the actual unemployment rate.

11.1 What is the Natural Rate of Unemployment

The natural rate of unemployment or the "full employment level of unemployment" is that level consistent with equilibrium in the labour market, or the absence of either excess demand or supply. From the standpoint of the modern Phillips curve, the natural rate of unemployment is the level of unemployment that the market produces when expected inflation equals actual inflation. An alternative way of looking at it, is that it is any unemployment which is not cyclical unemployment. The natural level of unemployment would comprise unemployment due to the weather (and periodic seasonal retooling); structural unemployment due to either a geographical mismatching of jobs and labour, or a mismatching of skills required compared to skills in existence; and induced unemployment related to labour turnover and job search.

11.2 Possible Estimation Strategies

11.2.1: The Phillips Curve Approach.

One way to estimate the natural rate of unemployment (hereafter referred to as u*), is simply to estimate a Phillips curve for Canada for the years 1961 to 1978. That is an equation of the form,

$$11.1. \qquad \dot{w} = a_o + a_1 \frac{1}{U_t} + \dot{p}^e$$

In equilibrium $\dot{p}^e = \dot{p}$ and $\dot{w} - \dot{p} = q^*$ where $\overset{*}{q}$ is the long term trend increase in productivity,

$$11.2 \quad \therefore u^* = \frac{a_1}{q^* - a_0}$$

We would thus emerge with a single number u*. There are two reasons why this would be of little use. First, it would obviously not reflect seasonal unemployment, and second, the period in which we are interested has been a notoriously difficult period for the Phillips curve. It has apparently been shifting due to factors such as the influx of young workers coming from the post war baby boom, and the greater participation rate of women. These factors are said to have caused u* to increase from about 4% in 1961 to about 6% in 1978 according to the estimates of the Economic Council of Canada.[1] One method to cope with such structural changes in the work force is to incorporate dummy variables into the Phillips curve. For example in a study by Gray, Parkin and Sumner (1975)[2] two dummies were used, D71-72, which equaled one in 1971 and 72 and was zero otherwise, and D68-74 which was equal to one in 1968-1974 and was zero otherwise. This use of dummy variables though is not attractive as it does not allow for gradual changes.

11.2.2: Gordon's Disaggregated Phillips Curve Approach

An alternative approach is the one followed by R. J. Gordon[3]. He postulates that prime aged males are the "core" group in the work force in that this is the group that has the preponderance of skills required, and that inflationary or recessionary pressures in the labour market are best gauged by using the unemployment rate of this group as an index. Gordon's method then, is to estimate a Phillips curve using the unemployment rate of prime aged adult males and calculate u* for this group. Gordon then assumes that in the absence of any structural factors the total unemployment rate would move in proportion to the unemployment rate of prime aged adult males, and he defines a structural shift in unemployment as a change in the total unemployment rate relative to the unemployment rate of prime aged adult males.

Aggregate u* is calculated by relating the unemployment rate of other groups to the unemployment rate of prime aged adult males (ujt) ie;

$$u_{kt} = g\ (u_{jt}\ ,\ s_{kt})$$

where s_{kt} is a structural variable, such as the relative labour force share of the k^{th} group. u^*_{kt} is found by plugging s_{kt} and u_j* into the above relation.

The final step is to form a weighted average of the calculated u^*_js, the weights being the ratios of the supply of labour of each group to the total supply of labour.

$$U_t^* = u_j^* \frac{F_{jt}}{F} + \sum_k \frac{u_{kt}^* F_{kt}}{F}$$

where F_{kt} is the kth group's labour supply and F is the total labour force.

11.2.3: Grubel's Method- Unemployment As The Dependent Variable

A different type of approach is to treat unemployment as the dependent variable composed of seasonal, structural, induced, and cyclical components, and to explain variations in unemployment with variables which reflect its composition[4]. For example, consider the following equation:

11.3. $U_t = a_o + a_1 t + a_2 \text{ Winter} + a_3 \text{ Summer} + a_4 \text{ Spring} + a_5 \frac{UCB}{AWW} + a_6 \text{ LFSMM} + a_7 \text{ PARTWMAT} + a_8 \text{ DIFFGNP} + a_9 \text{ DIFFGNP}(-1) + \varepsilon_t.$

where UCB/AWW is the ratio of unemployment compensation benefits to average weekly wages, designed to capture induced or search unemployment; LFSMM is the labour force share of mature males, designed to capture structural changes in the composition of the labour force, PARTWMAT is the participation rate of mature women, again capturing structural changes; and DIFFGNP is the difference between the per cent change in real GNP and its trend. (In fact since the per cent change in real GNP did not have any trend I used the difference between the per cent change in real GNP and the average per cent change in quarter to quarter real GNP over the entire period.)

11.3 Gordon's Method Applied to Canada

11.3.1: The first step in Gordon's method is to estimate a Phillips curve using the unemployment rate of prime aged adult males as the explanatory variable. It will be noticed, however, that an equation like 11.1.1 would yield a single number for the natural unemployment rate of prime aged adult males ($PAMU^*$) whereas if monthly or quarterly data are used we would expect PAMU to exhibit seasonal fluctuation.[5]

The investigation commenced by using monthly data and attempting to control for seasonal factors by regressing all the variables involved in the Phillips curve (per cent change in average weekly wages, per cent change in the consumer price index and PAMU, the unemployment rate of prime aged adult males) on a constant and eleven monthly dummy variables. The hypothesis here was that PAMU could be split up into two additive components, the seasonal and the non-seasonal. By subjecting the non-seasonal components to further analysis via the Phillips curve regression one could isolate the structural and induced part in this non-seasonal component; and finally one could add these parts onto the seasonal component to obtain an estimate of $PAMU^*$ which exhibited seasonal fluctuation. The monthly dummies were found to account for 15% of the variation in the inflation rate, 60% of the variation in PAMU, and 13% of the variation in the percentage change in average weekly wages. However, problems arose with extimating a Phillips curve with the resulting deseasonalised monthly data. The result was as follows:

Equation 1

$$DSPCW = \underset{(4.13)}{.584} - \underset{(-2.11)}{0.023}\left(\frac{1}{DSPAMU}\right) + \underset{(0.88)}{0.0098}\left(\frac{1}{DSPAMU(-1)}\right) + \dot{p}^e$$

$R^2 = .0614$ DW = 2.28

where,

DSPCW = deseasonalized per cent change in average weekly wages

DSPAMU = deseasonalized prime age adult male unemployment

DSPAMU(-1) = the above lagged one period

$\dot{P}^e$ = the expected rate of inflation (deseasonalised).

Sources for data and estimation techniques are discussed in the appendix to this chapter. The numbers in brackets underneath the co-efficients are t-statistics. The problems with equation 1 are that the co-efficient in front of -1/DSPAMU has the wrong sign and is significant, and that the value of R^2 is low.

A second attempt was made to estimate the Phillips curve;only this time none of the data was deseasonalised.

Equation 2

$$PCW = \underset{(-2.54)}{-2.36} + \underset{(2.62)}{9.58}\left(\frac{1}{PAMU}\right) + \dot{p}^e + e_t$$

$R^2 = .0323$ DW = 2.00 $F_* = 3.3$
$F^* 5\% \ (2,200) = 3.04$

Though using raw data solves the problem of the wrong sign for the co-efficient of (1/PAMU) the value of R^2 is still low, implying that the equation itself is barely significant at the 5% level. 6

In an attempt to obtain better explanatory power in the Phillips curve the monthly data was averaged into quarterly data and the above process was repeated. I first attempted to control for seasonality by regressing each variable on a constant and three quarterly (seasonal) dummies. The seasonal dummies now accounted for 88% of the variation in the per centage change in average weekly wages, 94% of the variation in PAMU, and 63% of the variation in the inflation rate. Using the deseasonalised variables resulted in the following Phillips curve;

Equation 3

$$DSQPCW = \underset{(-2.69)}{-0.417} + \underset{(0.53)}{0.002}\ \frac{1}{DSQPAMU} + \dot{p}^e$$

$R^2 = .1144$ F = 3.1

DW = 1.74 $F^* \ (2.48) = 3.19$ (5% level)

Equation 3 is clearly unsatisfactory since the slope coefficient is insignificant and the value of R^2 is low, implying that the whole equation is insignificant at the 5% level of significance.

Finally, a Phillips curve was estimated using raw quarterly data. Since this resulted in a Durbin Watson statistic of 3.12 the equation was re-estimated using the Cochrane-Orcutt technique.

<u>Equation 4</u>

$$QPCW = \underset{(1.06)}{0.8178} + \underset{(3.51)}{9.674}\ \frac{1}{QPAMU} + \dot{p}^e$$

$$R^2 = .4697 \qquad DW = 1.67 \qquad \rho = \underset{(5.87)}{-0.64}$$

Equation 4 is the first one to have a reasonable R^2. However, the constant term is insignificant. Various specifications were tried, the best one being equation 5.

<u>Equation 5</u>

$$QPCW = \underset{(5.8)}{5.022} - \underset{(-3.98)}{0.7716}\ (QPAMU) + \dot{p}^e$$

$$R^2 = .4981 \qquad DW = 1.66 \qquad \rho = -0.647; \left(DW^*_L = 1.44\ \ DW^*_u = 1.57\right)$$

The results have been reported in detail in order to show that the attempt to control for seasonality in the quarterly unemployment rate of mature males left no room for fitting a Phillips curve. When de-seasonalising was abandonded a reasonable looking Phillips curve could be fitted.[7]

In equilibrium $\dot{p}^e = \dot{p}$ and $\dot{w} - \dot{p} = q^*$ where q^* is the long term trend increase in productivity. Therefore equation 5 implies that $PAMU^* = \dfrac{5.022 - q^*}{0.7716}$

The estimate of q^* was obtained by dividing real GNP by total employment to obtain output per man, where both were quarterly series. The percentage quarter to quarter change in output per man was calculated and this was averaged over twenty-eight observations. This resulted in $q^* = 0.654$.

$PAMU^* = 5.66$ (for the period 1961 to 1975)

11.3.2: The second stage of Gordon's procedure was to relate the unemployment rate of other groups to that of mature males. The work force was divided into five groups:

1. Males aged 15 to 24
2. Prime aged males, 25 to 44
3. Older males, over 45
4. Young women, 15 to 24
5. Mature women, over 24

Let us take these in order.

1. Young Males

The best equation to explain the unemployment rate of young men was the following,

$$UYM = \underset{(6.32)}{2.988} - \underset{(16.8)}{1.435}\ PAMU + \underset{(4.36)}{0.37}\ PAMU(-1)$$

$$R^2 = .9124 \quad F(2,\ 171) = 890 \quad DW = 2.13 \quad \rho = \underset{(11.05)}{0.642}$$

Neither the labour force share of young men, nor the participation rate made any significant contribution. Since the situation was unchanged by averaging the data into quarters, the above equation was estimated using monthly data.

2. Older Males

The best equation to explain the unemployment rate of older males was,

$$UOM = \underset{(-4.80)}{-3.04} + \underset{(41.33)}{0.904}\ PAMU + \underset{(5.79)}{15.72}\ LFSOM$$

$$R^2 = .9684 \qquad \rho = \underset{(8.85)}{0.55} \qquad F(2,173) = 2651$$

$$DW = 1.99$$

where LFSOM - labour force share of older males.

3. Young Women

This proved to be the most difficult group to model. Like young men, the unemployment rate of this group was insignificantly related to its labour force share, and to its participation rate, but in addition was not significantly related to the current unemployment rate of prime aged males. The situation was not improved by averaging the data into quarters, so the following equation, estimated with monthly data, was used,

$$UYW = \underset{(9.72)}{6.74} - \underset{(-2.07)}{0.213}\ PAMU(-1) + \underset{(2.57)}{0.260}\ PAMU\ (-2)$$

$$R^2 = .7643 \qquad \rho = \underset{(23.8)}{0.875} \qquad F(2,171) = 277$$

$$DW = 2.39$$

4. Mature Women

For mature women both the labour force share and the participation rate were significant. Since the participation rate is likely to be influenced by the unemployment rate an instrument was used for the participation rate. The instrument used was a mechanical one equal to

$$\frac{\text{PART.MAT.W} - \text{AV.PART.MAT.W}}{\left|\text{PART.MAT.W} - \text{AV.PART.MAT.W}\right|}$$, that is the

participation rate of mature women minus the average participation rate of mature women divided by the absolute value of the same. This creates a variable equal to +1 when the participation rate is above average and equal to -1 when it is below average. The result was as follows,

$$\underset{}{\text{WMATU}} = \underset{(-0.282)}{-0.422} + \underset{(8.29)}{0.325}\ \text{PAMU} + \underset{(6.34)}{0.524}\text{PART.WMAT} - \underset{(-5.58)}{72.6}\text{LFSWMAT}$$

$$R^2 = \cdot 9296 \qquad \rho = \underset{(12.48)}{0.648} \qquad F(3,211) = 928$$

$$DW = 1.86$$

The signs are explicable since it is possible that an increase in the participation rate of mature women caused their number relative to the number of prime aged adult males to increase and thus their unemployment rate to increase. At the same time the increasing numbers of young people in the work force may have caused the share of mature women in the total work force to fall, thus producing the negative sign on LFSWMAT. Some idea of the increase in the participation of mature women may be had by considering the following table,

Table 11.1 The Participation Rate of Mature Women

	JAN.	FEB.	MAR.	APR.	MAY	JUNE
1961	25.3	25.2	24.9	25.6	25.9	25.8
1975	37.1	37.3	38.0	38.2	38.5	27.9
	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1961	25.0	24.6	25.6	25.6	26.0	26.1
1975	36.4	36.5	38.3	38.1	38.2	38.0

11.3.3: The third and final stage in Gordon's method involved plugging PAMU* into the equations in section 11.2.2 to generate the natural rate for each group. These natural rates are then averaged using each groups labour force share as weights. The resulting monthly estimates of the Canadian full employment level of unemployment are contained in **Table 11.2** and discussed in section 11.5

11.4 Grubel's Approach

Equation 11.3. was first estimated using monthly data, replacing the three quarterly dummies with eleven monthly dummies. However, the equation suffered from wrong signs and insignificant t-scores, and so the data was averaged into quarterly data.

Using the Cochrane Orcutt technique the estimated equation was,

Equation 11.4.1

$$U_t = \underset{(1.92)}{44.84} + \underset{(1.34)}{0.0758}\, t + \underset{(5.95)}{1.95}\, \text{WINTER}$$

$$\underset{(-3.04)}{-1.61}\, \text{SUMMER} + \underset{(0.467)}{0.197}\, \text{AUTUMN} + \underset{(0.67)}{2.88}\, {}^{\text{UCB}}/\text{AWW}$$

$$\underset{(-1.73)}{-97.12}\, \text{LFSMM} - \underset{(-1.75)}{0.423}\, \text{PARTWMAT}$$

$$\underset{(-1.65)}{-0.0305}\, \text{DIFFGNP} + e_t$$

$$R^2 = .9020 \qquad \rho = \underset{(15.7)}{.9}$$

$$DW = 1.94$$

This equation performed quite well apart from the sign on the co-efficient of the PARTWMAT which is wrong. Also, the co-efficients of $^{UCB}/AWW$ and the AUTUMN dummy are insignificantly different from zero. Dropping these three variables caused the co-efficient in front of the time trend to become insignificant. The final version of this equation was,

<u>Equation 11.4.2</u>

$$U_t = \underset{(2.52)}{20.76} + \underset{(9.77)}{1.87}\ \text{WINTER} - \underset{(-4.61)}{1.05}\ \text{SUMMER} - \underset{(-1.90)}{50.66}\ \text{LFSMM}$$

$$- \underset{(-3.55}{0.032}\ \text{DIFFGNP}$$

$$R^2 = .8936 \qquad \rho = \underset{(13.9)}{.87}$$

$$F(4,52) = 109 \qquad DW - 1.84$$

DIFFGNP (-1) was also included in some versions, but this variable was not significant. Equation 11.4.2 is very satisfactory. All the co-efficients are significant at the 5% level and all have the correct signs. (One would expect that the greater is the labour force share of mature men (LFSMM) the less would be total unemployment). The equation was estimated using Cochrane-Orcutt, there being no endogenous variables on the right hand side. The variable DIFFGNP has already been explained above.

. To calculate U^*, DIFFGNP was set equal to zero, (real GNP was assumed to grow at its average rate over 28 quarters). That is,

$$U_t^* = 20.76 + 1.87\ \text{WINTER} - 1.05\ \text{SUMMER} - 50.66\ \text{LFSMM}$$

The resulting estimates of quarterly U^* were then linearly interpolated to provide monthly estimates of U^*. These monthly estimates are given in **Table 11.2** along with the estimates derived by using Gordon's method, and the actual level of unemployment.

Table 11.2 Actual Employment and Two Estimates of the Natural Rate

(u_1^* via Gordon's method; u_2^* via Grubel's method)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
-	-	-	9.6	7.0	5.6	5.2	4.8	4.7	4.8	5.4	6.3
-	-	-	5.8	5.9	5.9	6.1	6.1	5.9	5.9	5.8	5.8
-	-	-	-	-	-	-	2.2	2.4	2.7	2.9	3.5
8.5	9.1	8.7	7.5	5.1	4.4	4.5	4.1	3.9	4.3	5.2	6.3
5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.1	5.9	5.8	5.8	5.8
4.1	4.7	4.2	3.7	3.2	3.0	2.7	2.5	2.7	3.0	3.1	3.7
8.3	8.4	8.4	7.1	5.2	4.4	4.2	3.8	3.7	3.9	4.5	5.1
5.8	5.8	5.8	5.8	5.9	5.9	6.2	6.1	5.9	5.9	5.8	5.8
4.3	4.9	4.4	3.9	3.4	3.2	3.0	2.9	3.1	3.4	3.7	4.3
7.0	7.0	6.8	6.0	4.3	4.0	3.7	3.4	3.1	3.7	3.7	4.1
5.8	5.7	5.8	5.8	5.9	6.0	6.2	6.2	5.9	5.9	5.9	5.9
4.8	5.4	4.9	4.4	3.8	3.6	3.4	3.2	3.4	3.7	3.9	4.5
5.9	5.8	5.6	5.3	3.7	3.5	3.3	2.8	2.5	2.4	3.1	3.5
5.8	5.8	5.8	5.8	5.9	6.0	6.3	6.3	5.9	5.9	5.9	5.9
5.1	5.7	5.2	4.7	4.2	4.0	3.8	3.6	3.8	4.1	4.3	4.9
5.1	5.0	4.8	4.1	3.3	3.0	3.1	2.9	2.7	2.6	3.2	3.6
5.9	5.9	5.9	5.9	6.0	6.1	6.3	6.3	6.0	5.9	5.9	5.9
5.5	6.1	5.9	5.1	4.6	4.4	4.2	4.0	4.1	4.4	4.5	5.1
5.2	5.3	5.3	4.9	3.9	3.7	3.5	3.0	2.8	3.3	3.7	4.6
5.9	5.8	5.9	5.9	6.0	6.1	6.4	6.4	6.0	6.0	5.9	5.9
5.7	6.3	5.9	5.4	4.9	4.7	4.4	4.2	4.4	4.6	4.7	5.3

Table 11.2 (continued)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
6.1	6.3	6.4	5.6	4.6	4.8	4.4	3.8	3.3	3.6	4.2	4.7
5.8	5.8	5.8	5.9	6.0	6.2	6.4	6.4	6.0	6.0	5.9	5.9
5.9	6.4	6.0	5.5	5.0	4.8	4.6	4.4	4.6	4.8	5.0	5.6
5.9	5.9	5.6	5.3	4.7	4.5	4.0	3.7	3.4	3.8	4.3	4.7
5.9	5.9	5.9	5.9	6.1	6.2	6.4	6.3	5.9	5.9	5.9	5.9
6.2	6.8	6.3	5.8	5.4	5.0	4.8	4.5	4.7	4.9	5.0	5.6
6.1	6.5	6.7	6.6	6.1	6.1	5.8	5.1	4.7	5.0	5.7	6.4
5.8	5.8	5.8	5.9	6.1	6.3	6.4	6.3	6.0	6.0	6.0	5.9
6.2	6.8	6.3	5.9	5.5	5.2	4.9	4.6	4.8	5.1	5.2	5.8
8.0	8.1	7.8	7.8	6.3	6.2	5.6	5.1	5.0	5.1	5.8	6.1
5.9	5.9	5.8	5.9	6.0	6.3	6.4	6.4	6.0	6.0	5.9	5.9
6.4	7.0	6.5	6.0	5.4	5.2	4.9	4.7	4.9	5.1	5.4	6.0
7.7	7.3	7.4	6.8	6.2	6.2	5.8	5.4	5.2	5.4	5.9	6.5
5.9	5.9	5.9	5.9	6.1	6.3	6.4	6.4	5.9	6.0	5.9	5.9
6.5	7.1	6.6	6.1	5.5	5.3	5.0	4.7	5.0	5.2	5.4	6.0
7.7	7.3	6.7	6.2	5.3	5.2	4.8	4.5	4.6	4.6	5.0	5.5
5.9	5.9	5.9	6.0	6.2	6.4	6.5	6.4	6.0	6.1	6.0	6.0
6.7	7.3	6.8	6.3	5.8	5.5	5.2	4.9	5.1	5.3	5.6	6.2
6.8	6.8	6.4	6.0	5.4	4.7	4.5	4.4	4.4	4.4	5.1	6.1
6.0	6.0	6.0	6.1	6.2	6.3	6.5	6.5	6.1	6.1	6.1	6.1
6.8	7.4	6.9	6.4	5.8	5.6	5.3	5.0	5.2	5.5	5.7	6.3

11.5 Concluding Remarks

Two estimates of the natural rate of unemployment have been obtained, and these are contained in Table 11.2. The estimate obtained by using Gordon's method, u_1^* , seems less plausible than that obtained from Grubel's method, u_2^* , for two reasons. First, we would expect the natural rate to contain an upward trend between 1961 and 1974, whereas u_1^* fluctuates around 6% over the whole sample period. Second, we would expect seasonal influences to work in the direction of increasing the natural rate of unemployment during the winter months, whereas u_1^* increases during the summer months.Neither of these features are displayed by u_2^* . Apart from the first five estimates in 1961, which seem a little low, the behaviour of u_2^* seems,a prioi, quite reasonable.It increases from an average value of 3.5% in 1962 to an average value of 6.0% in 1974, and its seasonal fluctuation accords with the expectation that the natural rate should decrease during the summer months. Consequently, this is the estimate of the natural rate which is used throughout the main part of chapter 10.

FOOTNOTES

Chapter 11

1. See "Au Courant", page 9, Economic Council of Canada, col. 1,No. 1, Spring 1980.

2. M.Parkin, "Inflation in the U.K.:Causes and Transmission Mechanisms", University of Manchester, mimeographed, 1975.

3. Gordon describes his proceedure in "Structural Unemployment and the Productivity of Women", which can be found in, "Stabilization of the Domestic and International Economy", editors Brunner and Meltzer,North Holland, 1977.

4. This is the approach adopted by Grubel, Maki and Sax, "Real and Insurance Induced Unemployment in Canada", C.J.E.,1975,pp 174-191. Their model is more complex than mine, and is anyway unsuited for my purposes. They use per cent changes in nominal GNP to "capture changes in unemployment due to cyclical factors". This variable is inappropriate since a fully anticipated inflation would cause nominal GNP to increase,but would not constitute a cyclical upturn.

5. This problem did not arise for Gordon because he used annual data.

6. F is calculated as $\dfrac{R^2/k}{(1-R^2)/(n-k)}$

   See Theil,"Introduction to Econometrics",North Holland, 1972,page 183.

7. These tentative results cast doubt on the reliabilty of Phillips curve estimates when raw quarterly data are used. The Phillips curve appears to fit well only because both unemployment and the percentage change in wages exhibit strong seasonal patterns. Apparently this is not a new finding. In several studies Rowley and Wilton have argued the significant levels of most of the early (i.e. good) estimates of the Phillips curve were due to a substantial amount of inherent autocorrelation in the error term.For example,in a paper called

7.(continued)
"The Empirical Foundations of the Canadian Phillips Curve",(C.J.E. May 1974), D.A.Wilton states,
"Our efficient estimates for the wage equations presented by Bodkin et. al. , Kaliski,and Helliwell et. al., indicate that there is not a significant relationship between wage changes and movements in unemployment".
Wilton concludes that the use of inefficient estimators has created the "statistical illusion" of a Phillips curve when in fact it never really existed.

CHAPTER 12

TESTING EQUILIBRIUM AGAINST DISEQUILIBRIUM IN THE LABOUR MARKET

12.1 Introduction

The purpose of this chapter is to test whether the real wage clears the market for employment in manufacturing, against a disequilibrium specification which determines employment as the minimum of supply and demand for labour. Two disequilibrium models are estimated. The first, which corresponds to Maddala and Nelson's[1] model 1, does not use any prior information as to whether an observation is on the supply or demand curves, but lets the model itself determine the probabilities of an observation belonging to each regime. The second model involves a prior search for the correct wage adjustment equation in the spirit of McCallum (1974)[2], which is then used to assign observations to the demand or supply regime. A number of tests are employed to try to distinguish between the equalibrium and disequilibrium hypotheses, one of which is to apply Pesaran's N-test to the problem.[3]

The plan of the chapter is as follows. Section 12.2 compares the most commonly used methods of testing equilibrium against disequilibrium models, with the methodological position of the N test. Section 12.3 specifies the demand and supply curves for labour, and searches for the best specification of the supply of labour equation assuming that equilibrium prevails in the labour market and that there are no costs of adjustment on the demand for labour side. Once the best specification of the supply curve is obtained under those assumptions, that specification is retained throughout. However, the equilibrium model is then re-estimated assuming costs of adjustment on the demand for labour side. Section 12.4 describes the two methods of estimating a disequilibrium labour market. Section 12.5 contains the results of the search for the appropriate wage adjustment equation first for the case where there are no costs of adjusting labour demand and then assuming such costs to be present. Section 12.6 contains the results for both disequilibrium models, and compares the results with the equilibrium model using commonly used methods. Section 12.7 employs the N-test to compare the equilibrium and disequilibrium models. Section 12.8 contains some concluding remarks.

Section 12.2 Methods for Comparing the Equilibrium and Disequilibrium Hypotheses

It is a characteristic of nested hypothesis testing that the rejection of one hypothesis automatically leads to the acceptance of its alternative. Some methods of testing non-nested hypotheses also have this characteristic. Pesaran's N-test, however, allows for the possibility of not only accepting one hypothesis and rejecting the other, but also of accepting or rejecting both hypotheses. This goes against the position that statistical inference can only reject hypotheses in favour of well defined alternative, but it is consistent with much of the experience of economics. For example, the monetarist debate has served to remove much of the previous confidence placed in simple Keynesian models without causing a massive conversion to monetarism. The explanation for this is that the insights which have been gained from Keynesian models cast doubt on many monetarist positions. Thus many economists "find themselves believing neither Keynesianism nor monetarism; each contains enough to invalidate the other."[4] It is this perspective that gives rise to the statement by Pesaran and Deaton that "the ability to make meaningful inferences about the truth of any single hypothesis demands the presence of at least one non-nested alternative."[5]

The development of the N-test certainly represents an improvement over previous methods of testing non-nested hypotheses. Quandt[6] considers five alternative methods for testing between equilibrium and disequilibrium. Of these only one has any rigorous foundation, the others being more or less accurate, and employed for indicative purposes only. The rigorous test consists of embedding the alternatives in a general combined model. Thus if Fl(y) and F2(y) are two probability density functions representing non-nested hypotheses, the compound probability density function could be written $\lambda F1(y) + (1-\lambda)F2(y)$ where λ is a parameter to be estimated. The problems with this method are that the redefinition of the problem will often involve quite a different question from the original one, and on practical gounds collinearity of the variables often prevents satisfactory estimation of the general model, especially when the alternatives involve the same variables.

Clearly the test based on embedding procedures does allow for the possibility that both hypotheses may be accepted (if λ = .5 for example). The remaining four tests considered by Quandt, however, all share the nested hypothesis testing characteristic, that the acceptance of one alternative necessarily implies rejection of the other, (and all five of Quandts alternatives have the characteristic that it is not possible to reject both alternatives.) Of the remaining four tests, two stand out as being particularly unsatisfactory. These are the test based on posterior odds and the test based on the probability that labour demand is less than labour supply. Quandt found in his monte carlo experiments that when the true residual variances were large the test based on posterior odds rejected the true model over 50% of the time. The other test is based on the observation that if the disequilibrium model were estimated from equilibrium data we would expect the estimated prob ($L^D < L^S$) to be approximately 0.5. Unfortunately, a rigorous test could not be constructed on this basis since successive values of the estimated prob ($L^D < L^S$) are not independent.

Perhaps the most useful of the tests considered by Quandt was that based on the likelihood ratio = Le/Ld where Le and Ld respectively denote the maximum of the equilibrium and disequilibrium likelihood functions. Though the usual asymptotic theory for testing - 2logL is theoretically inappropriate, it was found to be adequate as a practical matter. Using the critical values from a $X^2(1)$ distribution the average probability of type 1 error was 0.075 rather then the theoretically ideal 0.05.

The final test is based on testing whether the adjustment of market price responds infinitely fast to any momentary excess demand or supply in the market. For example consider the following disequilibrium model;-

$$D_t = b_1 + a_1 p_t + U_{1t}$$

$$S_t = b_2 + a_2 P_t + U_{2t}$$

$$Q_t = \text{Min}\ (D_t, S_t)$$

$$P_t - P_{t-1} = a_3 (D_{t-L} - S_{t-L}) + U_{3t}$$

the U's represent random error terms; D, S and Q represent respectively quantity demanded, quantity supplied, and actual quantity transacted; P_t represents the market price prevailing in period t and L represents the possible existence of a timing lag such that this period's change in price responds to last period's excess demand when L = 1.

If the model is specified with L = 0, Quandt shows that as $a_3 \rightarrow \infty$ the disequilibrium and equilibrium models become nested in a limiting sense, and that therefore, we can theoretically test whether $1/a_3$ is significantly different to zero. However, $a_3 = \infty$ need not be stochastically equivalent to the equilibrium model.

Moreover, if we specify a version of the disequilibrium model where $U_{3t} = 0$, then the hypothesis of equilibrium is not nested even in the limiting sense. As a practical matter, though, Quandt found in his monte carlo experiments that using a_3 to test the hypothesis of equilibrium led to a very high probability of type 1 error, but the power of the test when the hypothesis is false was quite satisfactory. Thus the test based on a_3 is useful in a one sided sense, (in that we would have more confidence concluding that $1/a_3$ was not significantly different from zero and accepting the equilibrium hypothesis than in concluding that $1/a_3$ was significantly different from zero and rejecting the equilibrium hypothesis).

However, a further problem with the "a_3 test" which Quandt points out but does not address in his monte carlo experiments, is that if L = 1 in the price adjustment equation the test of the equilibrium solution being achieved is whether $1-a_3(a_2-a_1) = 0$. In the event of a misspecification of the price adjustment equation a large value of a_3 may have nothing to do with rapid convergence to equilibrium. In contrast to these tests, Pesaran's N-test is rigorous and well grounded. Therefore the application of this test to the question of whether equilibrium or disequilibrium prevails in the labour market would seem highly desirable.

Section 12.3 The Demand and Supply Curves

Let us first consider the demand for labour. We are interested in estimating a short run model. Assuming Cobb-Douglas technology the labour demand curve is,

$$12.1 \qquad Lm^D_t = \quad + B\,(W^m_t - P^D_t) + cK_t + U_{1t}$$

where L^D_N is the logarithm of manufacturing employment, W^M is the logarithm of money wages in manufacturing, P^D is the logarithm of the wholesale price index, and K_t is the logarithm of the manufacturing sectors capital stock and c = 1 if constant returns to scale prevail. Quarterly capital stock estimates were generated by linearly interpolating annual figures. In addition a capital in use figure was generated by multiplying the quarterly capital stock figures by estimates of the capital utilisation rate.

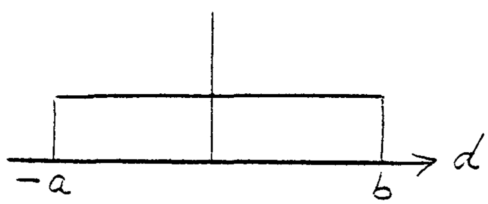
The specification of the labour supply curve poses a problem since we are dealing only with the manufacturing sector and therefore we should allow for mobility of labour between sectors. There are three possible approaches to this problem. The first is to build a simple but rigorous model of workers preferences and thus derive a sectoral labour supply function. The second is to use an aggregate labour supply equation and estimate it using manufacturing data. This is essentially assuming zero labour mobility between sectors, but is justified on the grounds of data availability. That is to say that it has been argued that manufacturing data is used because economy wide data is unreliable. If this is the case than one cannot have reliable estimates of the wage differential between manufacturing and the rest of the economy, and this is required to allow for labour mobility. A third approach is to steer a middle ground between the two previous approaches, and allow for labour mobility in a simple non-rigorous way.

The problem with building a rigorous model of workers preferences is that the resulting equation describing labour supply to the sector is almost bound to be highly non linear. For example consider the following simple model. Let the fraction of the total work force that wishes to work in the manufacturing sector, G, be a function of the real after tax wage difference between wages in manufacturing, W_t, and wages elsewhere, $\bar{W}_t$. Denoting this difference by d_t, the total labour force by N, and labour supply in manufacturing by L_t^S, we can write,

$$L_t^s = N.\ G\ (d_t)$$

And $d_t = \dfrac{(1-\theta_t)(w_t - \bar{w}_t)}{P_t^s}$

Assume a simple symmetric distribution of preferences such that when d = -a, no-one would wish to work in manufacturing and when d= +b, everyone would wish to work in manufacturing. That is, assume the following preference density function.



Since the area of a density function must equal unity the height of the function = 1/(b+a).

$$\therefore G(d) = \int_a^d \frac{1}{b+a}\ dx = \frac{d}{(b+a)} - \frac{a}{(b+a)}$$

$$\therefore L^s = N \left[\frac{d-a}{b+a}\right]$$

$$L^s = N \left[\frac{(1 - \theta_t)}{P_t^s} \left(\frac{W_t - \bar{W}_t - a}{(b+a)}\right)\right]$$

The reduced form equation for W_t would be obtained by solving the following equation for W_t,

$$d \left(\frac{W_t}{P_t^p}\right)^B (K_t)^c = N \left[\frac{(1-\theta_t)}{P_t^s} \left(\frac{W_t - \bar{W}_t - a}{(b+a)}\right)\right]$$

which is highly intractable.

Since the second approach seems to make the unwarranted assumption that "no data is better than bad data", the approach taken here is to try various ad hoc linear formulations. The formulations estimated were;

12.2 $$S_1:\quad L^s = k\left[\frac{\overline{W}_t(1-\theta_t)}{P^s_t}\right]^m A^y_t\, T^z_t \left[\frac{W_t}{\overline{W}_t}\right]^n$$

$$S_2:\quad L^s = k\left[\frac{W_t(1-\theta_t)}{P^s_t}\right]^m A^y_t\, T^z_t \left[\frac{(W_t-\overline{W})(1-\theta_t)}{P^s_t}\right]^n$$

$$S_3:\quad L^s = k\left[\frac{W_t(1-\theta_t)}{P^s_t}\right]^m A^y_t\, T^z_t \left[\frac{(W_{t+1}-\overline{W}_{t+1})^*(1-\theta^*_{t+1})}{P^{s\,*}_{t+1}}\right]^n$$

where θ_t is the ratio of personal income taxes to personal income in period t; $\overline{W}_t$ is the average economy wide weekly wage rate, obtained by dividing total monthly wages and salaries by four times the total labour force; P^s_t is the consumer price index in period t; A_t is the sum of constant dollar rent, interest and profits, divided by the total labour force and adjusted for taxes by multiplying by $(1-\theta_t)$. The (T_t) term represents all those between the ages of 16 and 65 in the population as a whole. Finally W_t

represents average weekly wages in manufacturing.

Equation S_1 could be regarded as having two components, the first part of which consists of the first four terms and represents aggregate labour supply. The last term, $(Wt/\bar{W}_t)^n$, capturing the fraction of the total work force wishing to work in manufacturing. The second equation, S_2, is more ad hoc than S_1, since it contains a mixture of aggregate and sector specific data with no clear demarcation of the specific effects captured by each term. The last term in S_2, however, postulates that labour mobility is a function of this periods' real after tax wage difference. Equation S_3 modifies S_2 in that labour mobility is assumed to be a function of next periods' expected real after tax wage difference.

The equilibrium model was used to search for the best labour supply function, and this model consists of equation 12.1, 12.2 and 12.3 below,

12.3 $$L_t^d = L_t^s = L_t$$

All three equations were logged. Using S_2 the reduced forms for W_t and L_t appear below as equations 12.4 and 12.5. To save space I have let R_t equal the real after tax wage difference.

$$12.4 \quad \text{Log } L_t = \frac{1}{(B-m)} \Big[(kB-\alpha m) + mB\,(\log 1-\theta_t) - \log P_t^s + \log P_t^d) + yB \log A_t + ZB \log T_t + nB \log R_t - mc \log K_t \Big] + n_{1t}$$

$$12.5 \quad \text{Log } W_t = \frac{1}{(B-m)} \Big[(k-\alpha) + m\,(\log (1-\theta_t) - \log P_t^s) + B \log P_t^d + y \log A_t + Z \log T_t + n \log R_t - c \log K_t \Big] + n_{2t},$$

where n_{1t} and n_{2t} are errors. To correct for serial correlation n_{1t} and n_{2t} are assumed to follow a first order Markov process of the form,

$$12.6 \qquad n_{1t} = Q\, n_{1t-1} + e_{1t}$$
$$n_{2t} = R\, n_{2t-1} + e_{2t}$$

Equation 12.4 is then lagged, multiplied by Q, and subtracted from itself, and 12.5 is lagged, multiplied by R and subtracted from itself. This results in the final reduced forms, where to save space, only one of which is written in full as equation 12.7 below.

$$12.7 \quad \text{Log } L_t = \frac{1}{(B-m)} \Big[kB-\alpha m)\,(1-Q) + mB \big[\log (1-\theta_t) - \log P_t^s + \log P_t^d\big) - m\,B\,Q \big[\log (1-\theta_{t-1}) - \log P_{t-1}^s + \log P_{t-1}^d\big] + yB \big[\log A_t - Q \log A_{t-1}\big] + ZB \big[\log T_t - Q \log T_{t-1}\big] + nB \big[\log R_t - Q \log R_{t-1}\big] - mc \big[\log K_t - Q \log K_{t-1}\big] \Big] + Q \log L_{t-1} + e_{1t}$$

Labour Supply	k	m	n	y	z	α	B	c	R	Q	R^2 for L	R^2 for W	DW for L	DW for W	Log Likelihood
S_1	390	7267	13740	-10.	.01	.01	-.23	1.2	.89	.88	.97	.97	1.5	2.1	372
	(.0002)	(.0002)	(.0002)	(.0002)	(.0001)	(.9)	(3.2)	(2.9)	(18.5)	(11.7)					
S_2	.04	1.16	-.14	.08	.02	.01	-.38	1.05	.89	.91	.93	.97	1.4	2.2	379
	(1.4)	(3.0)	(3.3)	(1.01)	(.4)	(1.0)	(4.9)	(2.8)	(17.2)	(22.3)					
S_3	.03	1.19	.69	.11	.01	.01	-.3	1.05	.92	.92	.94	.96	1.4	2.0	359
	(.98)	(2.25)	(1.8)	(1.2)	(.3)	(.7)	(3.8)	(2.8)	(46.0)	(15.6)					

There are three sets of reduced form equations, one for each version of the supply curve, S_1, S_2 or S_3. The results for these models appear in Table 12.1.

Equation S_1 performed badly in that none of its co-efficients were significantly different from zero, and the size of the co-efficients were implausibly large. There were convergence problems with this equation which were not alleviated by trying different starting values for the co-efficients. Equation S_2 is more satisfactory in that the co-efficients converge quickly to plausible values, which are significantly different from zero. However, the labour mobility term has the wrong sign, being significantly negative. This problem was solved by specifying labour mobility to be a function of next periods expected real after tax wage difference. The co-efficient in front of this term now has the expected sign and is significantly different from zero. Therefore equation S_3 was chosen as the appropriate supply function. The population term was dropped from this equation because of its small quantitative significance and its consistently low t scores. Finally it should be noted that the sign of 'y', the asset income parameter, is counter-intuitive. This phenomenon has occured in a number of previous studies, as noted by Rosen and Quandt[7], who suggest that it may be due to the fact that, in a life cycle context, asset income is determined simultaneously with work effort.

Having decided on the specification for the labour supply curve, I now move on to re-estimate the equilibrium model assuming costs of adjustment on the demand for labour side, and also replace the capital in place data with capital in use data. It should be noted that this procedure of deciding on the appropriate labour supply curve in one context and keeping that specification in different contexts has no justification except the need to keep the study manageable.

Assuming static expectations of future wages and prices the demand for labour equation becomes,

12.8 $$\log L_t^d = \lambda\alpha + \lambda B\,(\log W_t - \log P_t^d) + \lambda C \log K_t + (1-\lambda)\log L_{t-1}^d$$

Using 12.8, S_3, and 12.3 yields the following reduced forms,

12.9(a) $$\log L_t = \frac{1}{(\lambda B - m)}\Big[(kB - \alpha m)\lambda + m\,B\lambda(\log(1-\theta_t) - \log P_t^s + \log P_t^d) + y\,B\lambda \log A_t + n\,B\lambda \log R_{t+1}^* - mc(\log K_t) - (1-\lambda)m \log L_{t-1}\Big]$$

$$12.9(b)\quad \log W_t + \frac{1}{(\lambda B-m)}\Big[(k-\alpha\lambda) + m\,(\log(1-\theta_t) - \log P^s_t) + \lambda B \operatorname{Log} P^d_t + y \log A_t + n \log R^*_{t+1} - c \log K_t - (1-\lambda)\log L_{t-1}\Big]$$

Finally, allowing for first order serial correlation yields the following reduced forms;

$$12.10\quad \log L_t = \frac{1}{(\lambda B-m)}\Big\{(1-Q)\lambda(kB-\alpha m) + mB\lambda\big[\log(1-\theta_t) - \operatorname{Log} P^s_t + \operatorname{Log} P^d_t\big] - QmB\lambda\big[\log(1-\theta_{t-1}) - \log P^s_{t-1} + \log P^d_{t-1}\big] + yB\lambda(\log A_t - Q\log A_{t-1}) + nB\lambda(\log R^*_{t+1} - Q\log R^*_t) - mc(\log K_t - Q\log K_{t-1}) - (1-\lambda)\,m\,(\log L_{t-1} - Q\log L_{t-2})\Big\} + Q\log L_{t-1}$$

$$\operatorname{Log} W_t = \frac{1}{(\lambda B-m)}\Big\{(1-Z)(k-L\lambda) + m\big[\log(1-\theta_t) - \log P^s_t\big] - mZ\big[\log(1-\theta_{t-1}) - \log P^s_{t-1}\big] + \lambda B\big[\log P^d_t - Z\log P^d_{t-1}\big] + y(\log A_t - Z\log A_{t-1}) + n(\log R^*_{t+1} - Z\log R^*_t) - c(\log K_t - Z\log K_{t-1}) - (1-\lambda)(\log L_{t-1} - Z\log L_{t-2})\Big\} + Z\log W_{t-1}$$

The results in estimating equations 12.10 are contained in Table 12.2, estimation #1. All the parameters are insignificant except for the serial correlation parameters. The equation had problems converging for various initial values of the parameters.

TABLE 12.2 TESTING FOR COST OF ADJUSTMENT AND UTILISATION OF CAPITAL

Estimation	k	m	n	y	α	B	C	λ	Z	Q	R^2 for L	R^2 for W	D.W. for L	D.W. for W	Log Likelihood
#1	.05	.11	-.2	.08	.13	4.7	-.7	.13	.97	.94	.92	.93	.82	1.6	328
	(.09)	(.12)	(.07)	(.08)	(.12)	(.01)	(.07)	(.01)	(3.0)	(2.2)					
#2	.03	1.2	.7	.11	.01	-.37	-.06		.92	.92	.93	.95	1.4	2.0	357
	(.98)	(2.3)	(1.7)	(1.2)	(.07)	(3.6)	(1.7)								

The cost of adjustment parameter, λ, has the correct sign, but is insignificantly different from zero, leading to rejection of the existence of costs of adjusting employment.

Estimation number 2 replaces equation 12.8 with the original demand curve specification, but changes the capital in place term to capital-in-use. This change results in a marked deterioration in the performance of the capital term. Previously its co-efficient was insignificantly different from unity, supporting constant returns to scale. However, the capital-in-use data results in the wrong sign and an insignificant t-score. Therefore, capital in place data is appropriate.

Section 12.4 Two Methods of Estimating a Disequilibrium Model

Method 1:

This method corresponds to Maddala and Nelson's model 1. It consists only of equations 12.11, 12.12 and 12.13.

12.11 $L_t^d = B_1' X_{1t} + U_{1t}$

12.12 $L_t^s = B_2' X_{2t} + U_{2t}$

12.13 $L_t = \min (L_t^d, L_t^s)$

The demand and supply curves have been expressed in compact matrix notation to save space. It is assumed that U_{1t} and U_{2t} are independently and normally distributed with variance σ_1^2, and σ_2^2 and that they are serially independent.

The probability that an observation belongs to the demand equation is given by;

$$\begin{aligned}\Pi_t &= \text{prob } (L_t^d < L_t^s)\\ &= \text{prob } (B_1' X_{1t} + U_{1t} < B_2' X_{2t} + U_{2t})\\ &= \text{prob } (U_{1t} - U_{2t} < B_2' X_{2t} - B_1' X_{1t})\end{aligned}$$

Since U_{1t} and U_{2t} are independently and normally distributed, $U_{1t} - U_{2t} = U_t$ is normally distributed with variance $\sigma^2 = \sigma_1^2 + \sigma_2^2$

Hence,

$$12.4 \quad \Pi_t = \int_{-\infty}^{(B_2'X_{2t} - B_1'X_{1t})/\sigma} \frac{1}{\sqrt{2\pi}} \; e^{-u^2/2} \, du$$

Following Maddala and Nelson· we now define

$$f_1 (L_t) = \frac{1}{\sigma\sqrt{2\pi}} \exp \left[- \frac{1}{2\sigma} 2 \, (L_t - B_1'X_{1t})^2 \right]$$

which gives us the probability density of the random variable L_t^d at the observed L_t.

Furthermore the probability that the random variable L_t^s is greater L_t is given by

$$F_2\ (L_t) = \frac{1}{\sigma^2\sqrt{2\pi}} \int_{L_t}^{\infty} \exp \left[-\frac{1}{2\sigma_2^2} (L_t^s - B_2^1 X_{2t})^2 \right] dL_t^s$$

$f_2\ (L_t)$ and $F_1\ (L_t)$ can be defined analogously, with $f_2\ (L_t)$ equalling the probability density of the random variable L_t^s at the observed L_t, and $F_1\ (L_t)$ **equalling the probability that random variable L_t^D is greater than L_t.**

The probability of L_t, given that L_t belongs to the L^d function, is;

$$\frac{f_1\ (L_t) \cdot F_2\ (L_t)}{\pi_t}$$

Similarly, the probability of L_t, given that L_t lies on the L^s function, is;

$$\frac{f_2\ (L_t) \cdot F_1\ (L_t)}{(1 - \pi_t)}$$

These define conditional probability density functions for L_t. Since L_t lies on the demand function with a probability of π_t and on the supply function with a probability of $(1-\pi_t)$ the unconditional density function is;

$$f(L_t/X_{1t},X_{2t}) = \Pi_t\left[\frac{f_1(L_t)\,F_2(L_t)}{\Pi_t}\right]+(1-\Pi_t)\left[\frac{f_2(L_t)F_1(L_t)}{(1-\Pi_t)}\right]$$

$$= f_1(L_t)\,F_2(L_t) + f_2(L_t)\,F_1(L_t)$$

$$= G_t$$

We now maximise the log likelihood function $\mathcal{L}$, where

$$\mathcal{L} = \sum_{t=1}^{n} \log G_t$$

Method 2:

The second disequilibrium model to be estimated makes use of a wage adjustment equation to assign observations to the labour demand or labour supply curves. A general form of the wage adjustment equation is;

12.5 $$(W_t - P_t^x)-(W_{t-1}-P_{t-1}^x)=\gamma(L_{t-T}^d - L_{t-T}^s);\gamma>0$$

where P_t^x may be P_t^d or P_t^s or may refer to expected prices, or may be equal to zero if nominal wages adjust to excess demand; and T may equal 0, or 1.

Using this equation to separate the sample into periods of excess demand and supply, and then to estimate the L^d function over periods of excess supply and the L^s function over periods of excess demand, results in biased estimates as noted by Fair and Jaffee[8], since the mean of u_{1t} (respectively u_{2t}) is not independent of X_{1t} (respectively X_{2t}) over the points for which demand (respectively supply) is observed.

However, 12.15 can be rearranged to express the L^d function in terms of the L^s function and the real wage change term;

12.16 $\quad L_t^d = L_t^s + \frac{1}{\Upsilon}\left[(W_t - P_t^x) - (W_{t-1} - P_{t-1}^x)\right]$

where T has been set equal to zero. Now let

$$h_t = \left[(W_t - P_t^x) - (W_{t-1} - P_{t-1}^x)\right]$$

Since $h_t < 0$ when $L_t^d < L_t^s$ and $L_t = L_t^d$ we can define a new variable J_t,

12.17 $\quad J_t = h_t$ if $h_t < 0$

$\qquad\quad J_t = 0$ if $h_t \geqslant 0$

and we can now estimate the equation 12.18 over all the observations in the data set, where

12.18 $\quad L_t = L_t^s + \frac{1}{\Upsilon}(J_t) + U_{2t}$

since when $L_t = L_t^s$, $L_t^d > L_t^s$, $h_t > 0$ and $J_t = 0$ and when $L_t = L_t^d$, $L_t^d < L_t^s$, $h_t < 0$, $J_t = h_t$ and equation 12.16 ensures that equation 12.18 is still functionally correct.

Similarly we can estimate the L^d parameters by re-arranging 12.16 as follows;

12.16(a) $\quad L_t^s = L_t^d - \frac{1}{\Upsilon}(h_t)$

If we now define a new variable H_t such that,

12.17(a) $\quad H_t = h_t$ if $h_t \geqslant 0$

$\qquad\qquad H_t = 0$ if $h_t < 0$

we can estimate equation 12.12′ below over all the observations in the data set;

12.18(a) $L_t = L_t^d - 1/\Upsilon\ (H_t) + u_{1t}$

As the model has been described above, equations 12.18 and 12.18(a) would have to be estimated simultaneously since they share a common parameter Υ. However, there is no necessity to assume that real wages move as rapidly in an upward direction as they do in a downward direction. Allowing for different downward and upward adjustment speeds we would replace $1/\Upsilon$ with $1/\Upsilon_1$, in equation 12.18 and substitute $1/\Upsilon_2$ for $1/\Upsilon$ in equation 12.18(a). With this formulation each equation can now be separately estimated using a two stage least squares technique to take account of the endogeneity of $(W_t - P_t^x)$, J_t, and H_t. The resulting estimates are unbiased and consistent as Amemiya[9] has shown. However, the estimates are inefficient[10] since H_t and J_t are non-linear functions of $(W_t - P_t^x)$.

Section 12.5 The Wage Adjustment Equation

Before method two of the disequilibrium model can be implemented, we have to find the appropriate form for equation 12.15, the wage adjustment equation. For example, it is uncertain whether wage changes adjust with or without a lag to excess demand for labour, whether wage changes are also influenced by actual price changes or by expected price changes, and whether those price changes which influence wages refer to the consumer price index or a measure of the own product price index. These three sets of alternatives results in eight possible specifications of the wage change equation, and these are listed below;

12.19

$$\begin{aligned}
&W1:\ (W_t - W_{t-1}) = \Upsilon(L_t^d - L_t^s) + h\ (P_t^s - P_{t-1}^s)\\
&W2:\ (W_t - W_{t-1}) = \Upsilon(L_t^d - L_t^s) + h\ (P_t^d - P_{t-1}^d)\\
&W3:\ (W_t - W_{t-1}) = \Upsilon(L_t^d - L_t^s) + h\ (P_t^{s*} - P_{t-1}^s)\\
&W4:\ (W_t - W_{t-1}) = \Upsilon(L_t^d - L_t^s) + h\ (P_t^{d*} - P_{t-1}^d)\\
&W5:\ (W_{t+1} - W_t) = \Upsilon(L_t^d - L_t^s) + h\ (P_{t+1}^s - P_t^s)\\
&W6:\ (W_{t+1} - W_t) = \Upsilon(L_t^d - L_t^s) + h\ (P_{t+1}^d - P_t^d)\\
&W7:\ (W_{t+1} - W_t) = \Upsilon(L_t^d - L_t^s) + h\ (P_{t+1}^{s*} - P_t^s)\\
&W8:\ (W_{t+1} - W_t) = \Upsilon(L_t^d - L_t^s) + h\ (P_{t+1}^{d*} - P_t^d)
\end{aligned}$$

(where * indicates an expected value and all variables are expressed in logarithms)

The actual equations estimated can be obtained by substituting in the equations for L_t^d and L_t^s. Substituting equations 12.1 and 12.2 (S_3) into W_1 yields;

$$\begin{aligned}
W1'\quad (W_t - W_{t-1}) &= \Upsilon(\alpha - k) + \Upsilon(B-m)W_t\\
&\quad - \Upsilon m\left[(1-\theta_t) - P_t^s\right] - \Upsilon y\ A_t - \Upsilon nR_{t+1}^*\\
&= \Upsilon B\ P_t^d + \Upsilon c\ K_t + h\ (P_t^s - P_{t-1}^s)\\
&\quad + \Upsilon(m_{1t} - m_{2t})
\end{aligned}$$

$$\text{or W1}'': \quad (W_t - W_{t-1}) = \Upsilon(\alpha - k) + a\,W_t - b\left[(1-\theta_t) - P_t^s\right] - c\,A_t - d\,R^*_{t+1} - f\,P_t^d + g\,K_t + h\,(P_t^s - P_{t-1}^s) + e_t$$

In equations W1 to W4 it is assumed that the wage setting mechanism operates within the period (but does not succeed in clearing the market). Consequently an instrument must be used for W_t on the right hand side of these equations. In equations W5 to W8 it is assumed that supply and demand of the period are based on wages quoted at the beginning of the period. Then, on the basis of the resulting excess demand, the wage is revised for the next period. In these equations an instrument is not necessary for W_t since it is exogenous at date t. The instrument used in equations W1 to W4 was the fitted value of W_t obtained by regressing it on the other exogenous variables and its own lagged value. Similarly the values for expected prices were proxied by using the fitted values resulting from a regression of the actual prices on the exogenous variables and lagged prices[11]. The results are contained in Table 12.3.

Table 12.3 The Wage Adjustment Equation

Equation	a	b	c	d	f	g	h	Rho	D.W.	R^2
W1	-.15	-.13	.10	.02	.02	.13	-62		1.7	.5509
	(1.9)	(1.5)	(2.7)	(2.07)	(1.3)	(1.7)	(4.7)			
W2	-.3	-.11	.08	.09	-12	-.04	-.04	.66	2.3	.5867
	(3.2)	(1.5)	(2.1)	(2.5)	(2.7)	(-3)	(-6)	(7.2)		
W3	-.07	-.07	.11	.01	.005	.16	.96		1.7	.6289
	(0.9)	(.9)	(3.2)	(1.7)	(.2)	(2.1)	(6.0)			
W4	-.4	-.10	.11	.03	.16	.10	-1.1	.7	2.3	.6127
	(4.0)	(1.3)	(3.1)	(2.1)	(3.4)	(.8)	(2.0)	(8.8)		
W5	-.08	-.09	.08	.02	.03	.24	.69		2.07	.5697
	(1.5)	(1.3)	(2.3)	(2.4)	(1.5)	(3.4)	(5.9)			
W6	-.07	-.08	.09	.02	.05	.37	.08	.57	2.3	.5084
	(1.05)	(.9)	(2.2)	(2.5)	(2.8)	(4.4)	(1.2)	(5.6)		
W7	-.02	-.32	.06	.01	.01	.22	.94		1.9	.5992
	(0.4)	(.45)	(1.9)	(1.6)	(.56)	(3.1)	(6.5)			
W8	-.6	-.2	-.05	-.02	.17	-.01	-2.7	.92	1.98	.6069
	(5.2)	(2.4)	(1.4)	(1.3)	(3.4)	(.09)	(4.0)	(19.9)		

There are four possible criteria to evaluate the performance of these equations. First, a good equation should have a high R^2 value; second, it should be free of serial correlation; third, it should not contain any anomalous signs; and finally the rational expectations natural rate hypothesis suggests that h = 1: since there now exists much evidence in support of this proposition, a good equation should also contain this feature. None of the equations reported suffer from serial correlation, since where serial correlation was found using ordinary least squares, the equation was re-estimated using the Cochrane-Orutt iterative technique. Three of the equations using demand prices have the wrong sign for parameter 'h' and the remaining equation has a value for 'h' insignificantly different from zero. Of those equations using supply prices, W3 and W7 have a value for 'h' insignificantly different from unity. Of these two W3 was chosen since it has a higher R^2. Generally, the equations using supply prices perform better than those using demand prices. The former, for example, have no counter intuitive signs, whereas equations W2, W4, and W8 have incorrect signs on the capital variable and the price variable.

Next, the exercise of finding the appropriate wage adjustment equation was repeated assuming costly adjustment of labour demand. That is equation 12.1 becomes;

12.1(a) $L_t = \alpha\lambda + \lambda B(W_t - P^d_t) + \lambda c\ K_t$

$$+ (1-\lambda)\ L_{t-1}$$

and we have an extra term, $k=\gamma(1-\lambda)$, in the wage equation.

Table 12.4 The Wage Adjustment Equation Assuming Costly Adjustment of Labour

	a	b	c	d	f	g	h	k	Rho	D.W.	R^2
W1	-.2	-.10	.08	.02	.03	.09	.5	.04	.19	1.99	.5722
	(1.2)	(1.2)	(2.2)	(2.08)	1.0	(.8)	(3.1)	(.4)	(1.6)		
W3	-.01	-.06	.09	.02	-.13	.11	.93	.08		1.88	.6308
	(.09)	(.7)	(2.8)	(2.1)	(.5)	(1.2)	(6.1)	(1.2)			
W5	-.11	-.08	.07	.01	.03	.21	.74	-.02		1.94	.5582
	(1.6)	(-1.1)	(1.9)	(1.4)	(1.3)	(2.2)	(6.1)	(.3)			
W7	-.04	-.04	.07	.004	.01	.20	.99	-.01		1.83	.5820
	(.6)	(.5)	(1.8)	(.4)	(.4)	(2.09)	(6.2)	(.2)			

Because of the previous poor performance of the wage adjustment equations using demand prices, these equations were dropped. The evidence from the remaining wage change equations is not supportive of the presence of costly adjustment of employment levels; the lagged labour co-efficient, k, is not significantly different from zero in any of the equations estimated. The best wage change equation is, as before, W3, judged on the basis of the preceeding four criteria.

Section 12.6 – The Results for the Disequilibrium Models

Disequilibrium model 1 does not specify a wage adjustment term, but rather lets the model itself decide whether an observation is on the supply or demand curves. The equation for the probability of being on the demand curve was written as equation 12.14 in section 12.4 above. On the other hand, disequilibrium model II assigns observations to the demand curve when,

$$(W_t - P_t^{s*}) - (W_{t-1} - P_{t-1}^{s}) < 0$$

Table 12.5 lists the probability of being on the labour demand curve calculated from method 1, and the assignment of observations into the demand and supply regimes calculated from method 2.

Method 1 produces overwhelming evidence in favour of labour demand being always satisfied. Not a single observation is assigned to the labour supply function. On the other hand, method 2 produces a more balanced assignment of observations, putting 34 observations on the labour demand curve and 23 on the labour supply curve.

The disequilibrium model 1 was estimated twice, assuming first that there were no costs of adjustment and secondly that costs of adjustment exist on the labour

.2.5 THE ASSIGNMENT OF OBSERVATIONS TO THE L^d, AND L^s FUNCTIONS IN DISEQUILIBRIUM METHODS 1 AND 2 :- THE PROBABILITY OF AN OBSERVATION LYING ON L^D

Method 1	Method 2	Date	Method 1	Method 2	Date	1	2
1.0	L^d	67(1)	1.0	L^d	(3)	1.0	L^s
1.0	L^s	(2)	1.0	L^d	(4)	.8	L^d
1.0	L^d	(3)	1.0	L^s	73(1)	1.0	L^d
.9	L^s	(4)	1.0	L^d	(2)	1.0	L^d
1.0	L^d	68(1)	1.0	L^d	(3)	1.0	L^d
1.0	L^d	(2)	1.0	L^s	(4)	.8	L^d
1.0	L^d	(3)	1.0	L^s	74(1)	1.0	L^d
1.0	L^d	(4)	1.0	L^s	(2)	1.0	L^s
1.0	L^d	69(1)	1.0	L^d	(3)	1.0	L^s
1.0	L^s	(2)	1.0	L^d	(4)	1.0	L^s
1.0	L^d	(3)	1.0	L^d	75(1)	1.0	L^d
.6	L^d	(4)	1.0	L^s	(2)	1.0	L^s
1.0	L^d	70(1)	1.0	L^d	(3)	1.0	L^s
1.0	L^d	(2)	1.0	L^s			
1.0	L^d	(3)	1.0	L^s			
.7	L^d	(4)	1.0	L^s			
1.0	L^d	71(1)	1.0	L^s			
1.0	L^s	(2)	1.0	L^s			
1.0	L^d	(3)	1.0	L^d			
.7	L^d	(4)	1.0	L^d			
1.0	L^s	72(1)	1.0	L^d			
1.0	L^s	(2)	1.0	L^s			

demand side. These results are given in table 12.6 below;

Table 12.6 Disequilibrium Model 1

Estimation	α	B	c	k	m	n	y	λ	Log Likelihood
1	.005	-.29	.99	.09	1.4	.51	.06		186
	(.4)	(3.6)	(1.0)	(3.7)	(3.4)	(1.3)	(.06)		
2	.0003	-.28	.98	.10	1.6	.64	.007	.85	187
	(.18)	(3.7)	(3.3)	(6.5)	(7.2)	(4.0)	(.03)	(7.8)	

Testing the hypothesis of disequilibrium versus equilibrium is problematic using model 1. Because it does not include a wage adjustment term it is not possible to test whether the speed of wage adjustment to excess demand is infinitely fast. Also, because it does not include a wage term as a dependent variable (as the equilibrium model does), it has only half as many endogenous variables, and therefore a comparison of log likelihoods is not valid. On the other hand estimating the reduced form equation for employment without the reduced form equation for wages results in underidentified co-efficients. However, this would seem to be the only way to gain a method of comparing the performance of disequilibrium model 1 against the equilibrium model, by comparing log likelihoods. The employment reduced form equation resulted in a log likelihood of 184.7. Therefore $-2 \log\lambda = 2.6$. Using the critical values from a $\chi^2(1)$ distribution, as suggested by Quandt, we cannot reject the null hypothesis that equilibrium prevails at the 5% level of significance. However, it should be emphasised that this is not a rigorous test since in estimating the reduced form employment equation the cross equation restrictions from the reduced form wage equation have been ignored.

Turning to the second disequilibrium model, there are two ways of writing the entire system depending on whether we chose to use 12.18 or 12.18(a) rewritten for convenience below;

$$(12.18) \qquad L_t = L_t^s + \frac{1}{\tau}(J_t) + u_{2t}$$

$$(12.18(a)) \qquad L_t = L_t^d - \frac{1}{\tau}(H_t) + u_{1t}$$

The complete system entails either 12.18 or 12.18(a) in conjunction with equation W3 from the list of equations in 12.19;

$$(12.19 - W3) \quad W_t - W_{t-1} = (L_t^d - L_t^s) + h(P_t^{s*} - P_{t-1}^s)$$

If we substitute the L_t^d and L_t^s functions into (12.19-W3) we get;

$$\begin{aligned} W_t = \tau \Big\{ & (\alpha - k) + (B-m)\, W_t - B\, P_t^d - m\,((1-\theta_t) - P_t^s) \\ & - n\, R_{t+1}^* - y\, A_t + c\, K_t \Big\} \\ & + h(P_t^{s*} - P_{t-1}^s) + W_{t-1} + e_t' \end{aligned}$$

taking W_t to the right hand side and writing $u = 1/\tau$, we get;

$$W_t = \frac{1}{\left(1-\frac{B}{u} + \frac{m}{u}\right)} \left[\frac{(\alpha-k)}{u} - \frac{B}{u} P_t^d + \frac{c}{u} K_t \right.$$
$$- \frac{m}{u} \quad (1-0_t) - P_t^s) - \frac{n}{u} R^*_{t+1} - \frac{y}{u} A_t$$
$$\left. + h\ (P_t^{s*} - P_{t-1}^s) + W_{t-1} \right] + u_{3t} \tag{12.20}$$

Similarly substituting into 12.18(a) and first differencing to allow for serial correlation, we get;

$$L_t = \alpha(1-Q) + B\ (\hat{W}_t - P_t^d) - BQ\ (\hat{W}_{t-1} - P_{t-1}^d)$$
$$+ c\ K_t - c\ Q\ K_{t-1} - u\ \hat{H}_t - u\ Q\ \hat{H}_{t-1}$$
$$+ Q\ L_{t-1} + (u_{1t} - Q\ u_{1t-1}) \tag{12.21}$$

When equations 12.20 and 12.21 were simultaneously estimated significant serial correlation was found in 12.21. This result is reported as estimation #1. To remove this correlation, 12.21 was second differenced, the result of which is given as estimation #2. Similarly estimations 3 and 4 represent the results from using 12.18 first differenced and second differenced respectively. These results are contained in table 12.7.

The results are fairly disappointing, except for estimation number 4. The parameters B, c, m, and u have wrong signs in estimations 1 and 2, while B, m, and n

TABLE 12.7 DISEQUILIBRIUM MODEL 2

	α	B	c	k	m	n	y	u	h	Q	D	D.W. L	D.W. W	Log L
#1	.01	.6	-.1	.01	-.4	.6	.07	-.6	.5	.9		1.09	1.8	385
	(.5)	(.4)	(.5)	(.5)	(.2)	(.3)	(.4)	(1.4)	(1.8)	(15.0)				
#2	.01	.0005	-.02	.01	-.002	.002	.005	-.01	.7	.8	.5	2.1	2.2	390
	(.5)	(.2)	(.5)	(.5)	(.3)	(.5)	(.4)	(.5)	(4.0)	(9.8)	(3.2)			
#3	.02	.01	.2	.02	-.02	-.01	-.03	.7	.86	.9		1.08	2.0	386.1
	(.8)	(.6)	(1.8)	(.9)	(.6)	(1.2)	(1.0)	(2.5)	(5.8)	(23.0)				
#4	.01	-.002	.04	.01	.01	-.002	.02	.2	1.1	.8	.5	2.1	2.1	391
	(.5)	(.4)	(.9)	(.5)	(.6)	(.9)	(1.0)	(1.9)	(5.6)	(9.9)	(3.2)			

have wrong signs in estimation #3. Estimation number 4, however, shows all the co-efficients having the predicted a priori signs, though as in the other estimations the quantitative size of the co-efficients is too small, except for the co-efficient "h", showing the effect of the expected rate of price inflation on the rate of wage inflation. This co-efficient is insignificantly different from unity in estimations 3 and 4. On the other hand, though B is negative in estimation 4, its small size does not reflect labour's share in output and does not support diminishing returns. Similarly the capital co-efficient, c, is significantly different from unity, indicating decreasing returns to scale which is inconsistent with the marginal product theory of distribution.

There are two methods of comparing estimation 4 with the equilibrium model. First we can check whether $1/\tau = u$ is insignificantly different from zero. At the 5% and 10% levels of significance u is not significantly different from zero. Second, we can compare log likelihoods. We find that -2 (likelihood ratio) equals 34 rejecting the null hypothesis of equilibrium strongly. Thus we find that these two tests give opposite indications as to which is the best hypothesis, equilibrium or disequilibrium.

It should be noted that when estimating the complete system to explain both employment and wages, that there is no way to allow for different downward and upward adjustment speeds. This is so since the wage change equation is specified as a constant proportion of the excess demand for labour whether or not that excess demand is positive or negative. One possibility would be to estimate a different wage change equation when excess demand is positive and negative, but such a splicing of the data is problematic when the wage equation contains lagged variables. Consequently the possibility of different downward and upward adjustment speeds was checked by estimating equations 12.18 and 12.18(a) in isolation. Tables 12.18(a) and (b) contain the results of these estimations. As in the complete system, significant serial correlation remains after first differencing. Therefore both equations were re-estimated in a twice differenced form. These results are reported as estimations 1 and 2 respectively. After first differencing (estimations #1 in table 12.8(a) and (b)) the value of u is not significantly different from zero in either the labour demand case or the labour supply case. After second differencing the value of u is of opposite sign but has almost the same value, and identical t scores in both equations. This value of u is marginally significant, being significantly different from zero at the 10% level of significance, but not at the 5% level. Again we have results which are somewhat ambigous.

Tables 12.8 Disequilibrium Demand and Supply Functions

(a) The Demand Function

	L	B	C	u	Q	D	D.W.	R^2	Log L
#1	.01	-.23	1.09	-.24	.8		1.09	.9383	180
	(1.3)	(2.0)	(3.2)	(0.8)	(14.3)				
#2	.01	-.3	1.04	-.27	.86	.46	1.96	.9528	188
	(.6)	(3.1)	(1.9)	(1.3)	(7.1)	(2.8)			

(b) The Supply Function

	k	m	n	y	u	Q	D	D.W.	R^2	Log L
#1	.005	.66	-.003	0.23	.17	.95		1.06	.92	176.3
	(.2)	(2.4)	(0.1)	(2.4)	(.6)	(25.0)				
#2	.007	.17	.01	-.15	.23	.85	.67	1.98	.949	187.2
	(.2)	(1.9)	(1.0)	(3.8)	(1.3)	(5.4)	(3.0)			

A puzzling feature is the fact that 'u' has the wrong sign in the labour demand function. On the other hand the value of the demand function co-efficients B, and c accord with previous estimates, c being insignificantly different from unity indicating constant returns. In the supply function there are no unusual signs, though the values of m and n are lower than could be expected from previous results.

Finally the model was re-estimated assuming there to be costs of adjustment on the demand for labour side. Table 12.9 contains the results for the complete system. The employment equation in this case is,

$$L_t = \alpha + B(W_t - P_t^d) + c K_t + (1-\lambda) L_{t-1} - u\hat{H}_t + e_t$$

However, after second differencing to remove serial correlation the equation is,

$$\begin{aligned} L_t = {} & \alpha(1-Q)(1-D) + B(W_t - P_t^d) \\ & - \lambda B (Q+D)(W_{t-1} - P_{t-1}^d) + \lambda B Q D (W_{t-2} - P_{t-2}^d) \\ & + c\lambda(K_t - Q K_{t-1}) - c\lambda D (K_{t-1} - Q K_{t-2}) \\ & - u(\hat{H}_t - Q\hat{H}_{t-1}) + uD(\hat{H}_{t-1} - Q\hat{H}_{t-2}) \\ & + (1-\lambda + Q + D) L_{t-1} - \left[(1-\lambda + Q) D + Q(1-\lambda)\right] L_{t-2} \\ & + Q D L_{t-3} \end{aligned}$$

The results are given both for the case when the employment equation is first differenced and second differenced. In this case we find a significant and important change

TABLE 12.9 DISEQUILIBRIUM MODEL 2, INCLUDING COSTS OF ADJUSTMENT

	$\mathcal{L}$	B	C	λ	u	Q	D	k	m	n	y	h	D.W. for W_t	D.W. for L_t	Log Likelihood
#1	.02	-.02	-.2	.96	-.7	.94		.02	.05	.002	.009	.89	1.9	1.1	385
	(.7)	(1.2)	(1.6)	(22.2)	(2.4)	(25.7)		(.7)	(1.2)	(.3)	(.3)	(4.9)			
#2	-.003	-.01	.04	.97	.4	1.3	-.4	-.0001	.04	-.01	-.03	1.05	2.0	1.7	386
	(.2)	(1.2)	(.7)	34.2	(1.8)	(19.7)	(6.3)	(.01)	(1.2)	(1.6)	(1.3)	(5.6)			

in the results after second differencing; the value of u changes from being significantly negative to being significantly positive, the expected a priori sign. We have, therefore, a tentative explanation for the puzzling result of estimations 1 and 2 in table 12.7. The wrong sign of the speed of wage adjustment parameter, which we found when estimating the complete system using the labour demand curve, was due to the omission of costs of adjustment from this schedule. The other parameters in the second differenced version of the complete model plus costs of adjustment, have the correct signs apart from the labour mobility parameter n. Also, as in the previous results from this disequilibrium model 2, the size of the co-efficients are in general too small. That is, capital's co-efficient 'c' is significantly different from unity and indicates decreasing returns to scale, while the real wage co-efficient B, does not reflect labour's share in total output.

Finally, the labour demand curve was re-estimated without the wage equation and the implied cross equation restrictions to test for the possibility of different downward and upward adjustment speeds of money wages. These results are contained in Table 12.10.

Table 12.10 The Disequilibrium Demand Function Assuming Costly Adjustment of Labour

	α	B	C	u	λ	Q	D	D.W.	Log $\mathcal{L}$	R^2
#1	.01	-.33	1.06	-.29	.67	.90		1.7	186	.9483
	(.6)	(2.2)	(1.6)	(1.09)	(4.4)	(9.3)				
#2	.02	-.21	2.2	-.41	.5	.85	-.28	1.9	189	.9555
	(1.4)	(1.4)	(3.5)	(1.5)	(2.5)	(12.6)	(1.8)			

Once again the negative sign of the wage adjustment parameter 'u' re-emerges. This persistent result must be considered damaging for this model. It indicates that there exists a positive relationship between changes in wages deflated by the consumer price index and the level of employment, a result which is not suprising given Bodkin's results.[12] However, in the context of this model, it suggests that real wages fall when there is excess demand for labour. A possible explanation could be that the instrument used for H_t did not remove all the correlation between $\dot{H}_t$ and the error term. The instrument which was used was the fitted value of H_t which resulted from a regression of $\dot{H}_t$ on the exogenous variables, the capital stock, the tax rate, the consumer price index, unearned income, the wholesale price index, and a mechanical instrument which equals one when the variable is above its mean and minus one when the variable is below it. In addition values of the dependent variable lagged more than two periods were used.[13] To check the possibility that the negative sign of 'u' stems from simultaneous equation bias, estimation #2 was repeated with fitted values of H_t which are based on lower values of R^2 in the H_t equation. These results are contained in Table 12.11.

Table 12.11 The Effect of Changing the Instrument for H_t

	α	B	C	u	λ	Q	D	D.W.	Log $\mathcal{L}$	R^2 for H_t
#1	.02	-.21	2.2	-.41	.5	.85	-.28	1.9	189	.82
	(1.4)	(1.4)	(3.5)	(1.5)	(2.5)	(12.6)	(1.8)			
#2	.02	-.36	1.9	-.65	.56	.82		2.05	187	.41
	(1.4)	(2.2)	(2.3)	(1.6)	(4.6)	(10.2)				
#3	.03	-.15	2.7	3.3	.46	.81		2.1	188	.08
	(1.9)	(.7)	(2.5)	(2.2)	(3.7)	(10.3)				

In the presence of second order serial correlation endogenous variables lagged less than twice cannot be considered econometrically exogenous. Estimation #1 in table 12.11 is the same as estimation #2 in table 12.10

and is repeated for ease of comparison. The fitted value of H_t in this equation explains 82% of the variance in H_t. In the next estimation the lagged values of the exogenous variables were removed which lowered the goodness of fit for H_t to 41%. However, this does not change the sign or significance of 'u'. In estimation #3 the mechanical instrument was removed which caused the fitted value of H_t to explain only 8% of the variance in H_t. The fitted value of H_t is obtained in this case by regressing it only on the current exogenous variables. This change caused the sign of u to be reversed, u now being significantly positive, the correct a priori sign. Moreover, the fact that 'u' is significantly different from zero would indicate that wages move sluggishly in an upward direction when excess demand prevails.

Because of the sensitivity of the results to the instrument chosen for H_t, it was considered worthwhile to re-estimate the complete disequilibrium model using the new instrument. This result is contained in table 12.12.

These estimates represent a distinct improvement over the previous estimates. Only one parameter has the wrong sign, that being 'n', the labour mobility term. The demand parameters 'β' and 'c' are insignificant, though there is evidence of significant costs of adjustment. The parameter 'u' is significantly different to zero, indicating sluggish adjustment of wages to excess demand and supply.

Table 12.12 Disequilibrium Model 2, Re-estimated using a New Instrument for H_t

α	B	c	λ	Q	k	m	n	y
.04	-.07	1.4	.4	.85	.03	.06	-.2	-.2
(1.2)	(.3)	(1.3)	(1.7)	(4.7)	(.3)	(.3)	(2.7)	(.7)

u	h	D.W. L	D.W. W	Log L
5.2	.8	1.9	2.1	387
(2.9)	(4.5)			

It is now apparent that both the test based on the speed of wage adjustment to excess demand and supply, and the test based on log likelihood ratios lead to rejection of the null hypothesis of equilibrium.

Section 12.7 : The N Test

To overcome the lack of rigor of the preceeding methods of testing the equilibrium against the disequilibrium hypothesis, Pesaran's N-test was employed. The models tested were the disequilibrium model including costs of adjustment against the disequilibrium model without costs of adjustment. This asymmetry is due to the fact that costs of adjustment were found to be significantly present in the disequilibrium model but not in the equilibrium model.

The N test involves the following three stages.

H_o : ("True Model") $y = X\, b_o + e_o$

H_1 : ("Alternative") $y = Z\, b_1 + e_1$

I $\quad y = X\, b_o + e_o$

II $\quad X\, b_o = \hat{y} = Z\, b_1 + e_{1o}$

III $\quad e_{1o} = X\, b_o + e_{1oo}$

The first stage is to fit the "maintained" model. The second stage takes the fitted values from stage one and uses them as the dependent variable to fit the alternative model. The third stage takes the residuals from stage two to use as the dependent variable in fitting the "maintained" model.

N is defined as;

$$N = \frac{T_o}{\left[V_o\, (T_o) \right]^{\frac{1}{2}}}$$

where $T_o = \frac{n}{2} \log \left[\dfrac{\hat{\sigma}_1^2}{\hat{\sigma}_o^2 + \frac{1}{n}\, e'_{1o}\, e_{1o}} \right]$

In the application to the present problem the dependent variable y is a matrix made up of both L_t and W_t. Thus for example assuming that H_o is the equilibrium model first, then $e_o' e_o$ would be calculated by adding the sum of square residuals from the reduced form employment and wage equations. It makes no essential difference to the test that we have two dependent variables rather than one.

By taking each model in turn as the maintained hypothesis we calculate two values of N, say N_o and N_1 to represent the cases where model o and model 1 are taken as the maintained hypothesis. There are four possible outcomes.

(1) Accept Model 0 and reject Model 1
when $|N_o| < 1.96$ and $|N_1| \geq 1.96$

(2) Reject Model 0 and accept Model 1
$|N_o| \geq 1.96$ and $|N_1| < 1.96$

(3) Reject both model
when $|N_o| \geq 1.96$ and $|N_1| \geq 1.96$

(4) Accept both models
when $|N_o| < 1.96$ and $|N_1| < 1.96$

In addition, the sign of N does convey useful information. For example, a significant negative value for N_o implies rejecting the null model in favour of the alternative model, while a significant positive value for N_o can be interpreted as evidence against the null model and in favour of an alternative which differs from the null model in some sense opposite to that in which H_1 differs from H_o.

Assuming the equilibrium model is the maintained hypothesis first[14], N_o is asymptotically distributed as N (0,1), and takes a value of - 2.4. Clearly the validity of the equilibrium model can not be maintained given this evidence. Reversing the procedure and taking the disequilibrium model to be the maintained hypothesis lead to a value of N_1 of - 0.07. The disequilibrium model cannot be rejected against the evidence of these data and the equilibrium hypothesis combined. In addition the significant negative sign of N_o suggests rejecting the equilibrium model in favour of the disequilibrium model.

12.8 Concluding Remarks

The main thrust of the results from this chapter reveals that the hypothesis $L=\min(L^D,L^S)$ is superior to the equilibrium specification, and that for the data used in this study, most of the observations lie along the labour demand schedule.

The superiority of the disequilibrium specification is confirmed by the log likelihood ratio test and by the N-test. The test based on the speed of wage adjustment turns out to be very sensitive to the choice of instrument used for the schedule switching parameter, 'H_t'. The placing of the observations on the labour demand function is confirmed by both disequilibrium models estimated, model 1 placing all the observations on the L^D function, and model 2 placing 60% of the observations on the L^D function. Since model 1 is certainly the more rigorous of the two , these results must be taken as being grounds for support for working with the labour demand schedule in chapters 9 and 10 , with regard to the identification issue.

FOOTNOTES

Chapter 12

1. Maddala and Nelson, "Maximum Likelihood Methods for Models of Markets in Disequilibrium", Econometrica, November 1974, p. 1013-1030.

2. McCallum, B.T., "Wage Rate Changes and the Excess Demand for Labour: An Alternative Formulation", Economica 1974.

3. Pesaran, M.H., "On the General Problem of Model Selection", The Review of Economic Studies, 1974.

4. Pesaran, M.H. and Deaton, A.S., "Testing Non Nested Non Linear Regression Models", Econometrica, May 1978, p. 677 to 693.

5. ibid page 678.

6. Quandt, R.E., "Tests of the Equilibrium vs. Disequilibrium Hypothesis", International Economic Review, June 1978.

7. Rosen and Quandt, "Estimation of a Disequilibrium Aggregate Labour Market", Review of Economics & Statistics, 1977.

8. Fair, R.C. and Jaffee, D.M., "Methods of Estimation for Markets in Disequilibrium", Econometrics, (1972), p. 497-514.

9. Amemiya, T., "A Note on a Fair and Jaffee Model", Econometrica, 1974, p. 759-762.

10. Kelejian, H., "Two Stage Least Squares and Economic Systems Linear in Parameters but Non Linear in Endogenous Variables", Journal of the American Statistical Association, 1972, p. 373-374.

11. This results in unbiased estimates of the expected prices when expectations are rational. See McCallum, "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates", Econometrica, 1976, p. 43-52.

12. See chapter 5.

13. In the presence of second order serial correlation endogenous variables lagged less than twice cannot be considered econometrically exogenous.

14. The equations for the models tested are repeated here for convenience. The equilibrium model consists of

$$W_t = \frac{1}{(B-m)} \Big[(1-Q)(K-A) + m(T_t - P^s_t) - mQ(T_{t-1} - P^s_{t-1})$$

$$+ N(R_t - QR_{t-1}) + Y(A_t - QA_{t-1}) + B(P^d_t - Q P^d_{t-1})$$

$$- c(K_t - QK_{t-1}) \Big] + Q W_{t-1}$$

$$L_t = \frac{1}{(B-m)} \Big[(1-R)(KB - Am) + mB(T_t - P^s_t + P^d_t)$$

$$- m.B.R.(T_{t-1} - P^s_{t-1} + P^d_{t-1}) + NB(R_t - R_{t-1})$$

$$+ YB(A_t - RA_{t-1}) - cM(K_t - R K_{t-1}) \Big] + R L_{t-1}$$

and the disequilibrium model was;

$$W_t = \left(\frac{1}{u}\right) \Big[(A\lambda - K) + B\lambda(\hat{W}_t - P^d_t) + c\lambda K_t$$

$$+ (1-\lambda) L_{t-1} - m(\hat{W}_t - P^s_t - T_t) - NR_t - YA_t) \Big]$$

$$+ h(P^{s*}_t - P^s_{t-1}) + W_{t-1}$$

$$L_t = \lambda A(1-Q) + B\lambda(\hat{W}_t - P^d_t) - B\lambda Q(\hat{W}_{t-1} - P^d_{t-1})$$

$$+ c\lambda(K_t - Q K_{t-1}) + (1-\lambda + Q) L_{t-1}$$

$$- Q(1-\lambda) L_{t-2} - u(\hat{H}_t - \hat{H}_{t-1})$$

CHAPTER 13

CONCLUSION

The short run neoclassical theories of employment and distribution are based on the assumptions of perfect competition, diminishing returns and flexible coefficients of production. Procyclical real wage movements can easily be derived by abandoning any one of those assumptions, but there has been a reluctance to do so because of the costs involved. [1] In particular there is a loss of simplicity, a loss of predictive power, and even the loss of a theory of distribution. Therefore, various writers have modified the theory in other ways to make it consistent with the apparent observation of procyclical real wage movements. With regard to the standard textbook Keynesian macro model, these contributions can be grouped into those which modify the empirical testing of the standard model, and those which modify the model itself.

The modifications to the standard model were all capable of producing procyclical real wage movements, but all of them seemed to contain some other unfortunate features. Phelps' production and payment lag model was found to imply that unanticipated inflation would decrease employment, a result contrary to the position of the accelerationists, which he himself supports. Buiter and Lorie suggested modifying the specification of the labour market such that wages would have some upward and downward rigidity, and employment would be determined by the short side of the market. However, this has the unfortunate feature that it implies a fall in employment from its full equilibrium level given an increase in aggregate demand. Adding costs of adjustment did not remove this unfortunate feature since they are only operative on the demand for labour side. On the other hand adding costs of adjustment to an employment equals labour demand specification could not explain why actual employment should exceed desired labour supply. The disequilibrium models also shared the unfortunate feature of the Buiter-Lorie model, in addition to complexity.

This thesis contributed two models in response to this situation. The first model was an amended production lag model which took account of the necessity to properly discount next period's expected price back to the present. This is the simplest model yet suggested to explain pro-cyclical real wage movements. The second model was developed for two reasons. First, there seemed to be evidence supporting the existence of costs of adjustment, but the existing models incorporating them contained unappealing features. Second, none of the models were addressing the fact that we observe unemployment and vacancies co-existing in the real world. Therefore, a second model was developed which included both frictions and costs of adjustment. This completed the "theoretical" part of the thesis.

Empirically the question seemed to be whether any of these modified models performed better than the standard model once account was taken of the refinements and clarifications suggested in the literative on the proper testing of the standard model. Because the statistical clarifications and theoretical modifications proceeded simultaneously , it was an open question whether the theoretical modifications were even necessary.To resolve this question we tested four different hypotheses about the determination of employment, which were:

(i) Employment equals labour demand,

(ii) Employment lies on a frictional, rectangular hyperbola,

(iii) Employment is determined by the short side of the market,

(iv) Employment is determined by equality of demand and supply.

The standard model is properly regarded as a special case of (iii) where wages are infinitely flexible in an upward direction. Within each hypothesis additional complications were added to take into account both the statistical clarifications and the theoretical modifications suggested in the literature.

The results of chapter 12 showed that the short side of the market hypothesis dominates the equilibrium hypothesis, and in addition, most of the observations were to be found on the labour demand curve. In effect, then, hypotheses (i) and (iii) amounted to the same thing for the data which we used. (This was manufacturing data, 1961-1978). In chapter 10 we tested the frictional model against the simple employment equals labour demand hypothesis and got mixed results. If a coefficient 'h' had been equal to unity, the frictional model would have been accepted, and if 'h' had been equal to zero the employment equals labour demand model would have been accepted. However, in the majority of cases 'h' was significantly different to both zero and unity. This would seem to indicate that frictions are important, but that the simple rectangular hyperbolic formulation is inadequate. The results of chapter 12, then, would justify working with demand curves alone (for the data used in the present study) as far as the identification problem is concerned, while the results of chapter 10 would suggest that the explained variation in employment can be improved by taking account of frictions.[2]

Within each hypothesis we tested for the existence of production lags, and costly adjustment of labour under various assumptions about the formation of expectations. In general the results indicate the presence of costs of adjustment and the adequacy of the static expectations adjustment model and the absence of production lags. The most extensive estimations were done in chapter 9 which assumed employment equal to labour demand. In this chapter we could find no evidence of an overtime aggregation problem. Using annual data we found some evidence for correcting for intermediate inputs and for capital in use. However when using quarterly data, capital in place data performed much better than the capital in use data.

The most significant aspect of the results, however, is that none of these corrections made much difference to the coefficient relating real wages and employment. We estimated a log-linear demand curve derived from a Cobb-Douglas production function, and the real wage coefficient was persistently significantly different from labour's share in manufacturing and implied increasing returns to labour, though it was significantly negative. Indeed, this coefficient was also unaffected by the assumptions made about the determination of employment [3]. An interesting area for future research would be to compare the performance of alternative production functions, since the Cobb-Douglas function was rejected using this data set.[4]

Chapter 7 used the time series approach and found evidence in favour of causality flowing from real wages to employment . However, this result was found to depend critically upon which price series was used to deflate wages. When industry selling prices were used the causal relation disappears and we conclude that real wages and employment are independent. Since wholesale prices were used throughout the other empirical chapters we remain ignorant as to how sensitive our conclusions are to the price series used.

FOOTNOTES

Chapter 13

1. The post-Keynesians do take this route and they emphasize fixed coefficients of production, oligopolistic markets, and a mark up theory of pricing. This "Kaleckian" model is simple and contains predictions, but lies outside the scope of the neo-classical paradigm.

2. The omission of frictions from the labour demand curve did not result in significantly different estimates of the remaining coefficients.

3. Imposing 'h' = 1 in the frictions model did cause the real wage coefficient to move within range of labour's share in manufacturing. However, when we tested this restriction, it was rejected.

4. It is well known that the Cobb-Douglas production function requires constancy of income shares in order to fit well. Since a counter-cyclical movement of labour's share is a "stylised fact", and since we are using detrended data, the use of the Cobb-Douglas production function might be thought to be misconcieved. However, one of the points of the thesis has been to <u>critically</u> examine another, closely related, "stylised fact". It is not at all obvious that the Cobb-Douglas function would not fit the cyclical data once acount is taken of intermediate imports, overtime work, the utilisation of capital, production lags, and the different hypotheses concerning the determination of employment.

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