RATIONAL DYNAMIC DISEQUILIBRIUM MACRO MODELS WITH WAGE, PRICE AND INVENTORY ADJUSTMENT

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SUMMARY

This thesis presents original and significant research on the foundations of dynamic disequilibrium macroeconomics and on the implications of such a modelling strategy. It represents a continuation of current research to provide an acceptable alternative to New Classical macroeconomics. Disequilibrium economics, contrary to New Classical economics, does not assume markets continually clear, and is concerned, in principle, with the dynamic response of an economy to disequilibrium by way of both price and quantity adjustments. It is only recently, however, that the early static disequilibrium models have been extended to include dynamics via price adjustment and other intertemporal linkages. This thesis furthers this line of research.

Initial chapters concentrate on developing a rational basis for quantity constrained models, while subsequent chapters develop and analyse specific open and closed economy dynamic disequilibrium models. Chapters 2-4 critically assess New Classical economics; show that imperfect price adjustment can be derived from rational economic behaviour, given the presence of imperfect information and learning, incomprehensively indexed contracts, and small-menu costs; and discuss various disequilibrium modelling strategies. Chapters 5-6 employ the chosen modelling strategy (based on Sneessens, 1981) to develop dynamic disequilibrium models. Intertemporal linkages are established via wage, price and inventory adjustment. These models are used to test the robustness of previously derived results and provide new results. Significant insights are gained into the possibility of long-run non-Walrasian equilibria, the existence of limit cycles, the importance of wage and price adjustment, and the behaviour of exchange rates within regime switching models. Further these models aid our understanding of trade and inventory cycles. Finally we analyse the effectiveness of government policy in the various disequilibrium models. Not all the New Classical policy conclusions remain valid when imperfect price adjustment is modelled consistently.

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CONTENTS

CHAPTER I

INTRODUCTION

The microeconomic foundation of macroeconomics has two fairly well articulated paradigms. The New Classical paradigm is "equilibrium economics", a theoretical model concerned with proving that the economic system has an inherent tendency toward a full-employment equilibrium. As Patinkin (1965) summarized it, "Equilibrium means full employment, or, equivalently, unemployment means disequilibrium". The two basic assumptions of this synthesis are (1) expectations about the future of economic variables are formed rationally, in the sense that they embody all currently available information about the structure and past behaviour of the economy in a (statistically) optimal way, and (2) all prices are perfectly flexible, adjusting to equate supply and demand in their respective markets. If equilibrium is perturbed by an exogenous shock, there will be unemployment, but merely as a transient and temporary phenomenon lasting only as long as it takes the economy to settle down again to its full employment state. The New Classical analysis, equipped with a methodology unsuitable for the study of disequilibrium situations, gives very limited insight into what happens during this "transitional phase". The analysis of the dynamic responses to disequilibrium is carried out only in terms of price adjustment, completely ignoring any quantity adjustments.

The Keynesian paradigm on the contrary is concerned, in principle, with the dynamic response of an economy to disequilibrium by way of both price and quantity adjustments. What has come to be known as "disequilibrium economics" began with Clower's (1965) paper on the Keynesian counter-revolution, and was an application of the Hicksian fix-price method. This methodology has subsequently been developed by Barro and Grossman (1971, 1976), Bénassy (1974), Drèze (1975), Malinvaud (1977) and others. The first generation disequilibrium models were static, prices assumed to be fixed and other intemporal linkages, such as inventories and expectations, ignored. Such models have been very successful at generating traditional Keynesian results and do so in a way that is completely rigorous, once we accept the assumption that prices are fixed. One of the major issues in disequilibrium theory, however, is whether the states described by Clower and his successors can be validally described as equilibrium states or are they only transitory once price adjustment and other dynamics are introduced. Only recently have authors began to develop dynamic disequilibrium models to answer this and other questions.

The postulate that prices adjust imperfectly and do not necessarily equate demand and supply involves the introduction of concepts that have no equivalent in Walrasian models. The postulate implies, for example, that all trade offers will not usually be satisfied so that the quantity transacted by an agent may not coincide with his demand or supply. The quantity he will eventually be able to exchange will remain unknown until we specify how the prevailing rationing scheme allocates available resources among agents. Additional concepts will also be required with respect to the individual agent himself. We now have to specify the way he will react to the occurance of quantity rationing. The rationing prevailing on a given market will generally affect the behavior of agents on the other markets as well. These spillover effects mean that traditional demand functions become useless. One now has to distinguish Walrasian (or notional) demands, which are valid provided only there is no rationing, and effective demands, which explicitly account for the effects of quantity constraints. Finally as prices can no longer be defined as those equating demand and supply more theory is also needed about price formation. In this thesis we present original and significant research on the foundations of dynamic disequilibrium macroeconomics and also on the implications of such a modelling strategy for closed and open economy models. Thus it represents a continuation of current research attempting to provide an acceptable alternative to New Classical macroeconomics.

In Chapter 2 we critically examine the rational expectations hypothesis and its conjunction with the continuous market clearing assumption. Contrary to the analysis of some previous studies we conclude that New Classical results are crucially dependent upon this second assumption. Imperfect price adjustment, via resulting disequilibrium, gives rise to quantity adjustments and these need to be taken into consideration if disequilibrium is to be modelled consistently. This implies that we cannot merely appended the assumption of imperfect price adjustment on to an otherwise market clearing model. Before presuming, however, that a disequilibrium framework with quantity adjustments is appropriate, it is first necessary to determine if, and why, prices are less than perfectly flexible. This issue of price adjustment is considered in Chapter 3. Here a broad approach to wage and price adjustment is adopted and various theories are critically assessed and extended. Initially we examine the theory that prices do adjust perfectly so as to continuously equate supply and demand. This is argued to be unsatisfactory, it not being derived from maximizing behaviour, nor does it indicate how the economy moves from one equilibrium to another.

Subsequently we analyse two competiting theories of imperfect wage and price adjustment. The first is that prices respond to disequilibrium, equilibrium, assuming stability, being the limit of this process. This is found to be ad hoc and incompatible with full rationality of agents. The second theory of imperfect wage and price adjustment is that there are explicit reasons for why prices do not adjust instantaneously. Three such reasons are analysed; imperfect information and the learning process, multi-period wage and price contracts with incomprehensive indexation, and the presence of costs associated with changing individual prices ("small-menu" costs). Each of these considerations is sufficient to explain individual wage and price stickiness and the consequent disequilibrium and quantity adjustment. It is further shown that, given plausible assumptions, such imperfect price adjustment and disequilibrium persists over aggregation. It is concluded that rational economic behaviour is capable of providing an adequate basis for disequilibrium theory.

Having demonstrated that disequilibrium theory is an appropriate area for economic research Chapter 4 critically examines early attempts to model such disequilibrium. This is done in order to lay a proper basis for the development of the subsequent dynamic macroeconomic models. Initially work by Clower (1965) is discussed, both his critique of classical economics and his proposed modelling strategy for disequilibrium economic, the "dual decision hypothesis". It is argued that though Clower's critique of classical economics is valid the dual decision hypothesis is unsatisfactory for a number of reasons. Similarly more rigorous attempts to model "temporary equilibrium with quantity adjustment" associated with Benassy (1975,

1976) and Dreze (1975) are argued to have major shortcomings. It is concluded that what is needed is a complete respecification of the way disequilibrium is modelled. It is here that the work by Sneessens (1981) is presented, which attempts such a respecification. It is argued that many of the previous problems are overcome. For this reason Sneessens's modelling strategy and basic underlying assumptions are employed in the subsequent chapters. Finally in Chapter 4 we examine the consequences of introducing international trade into a disequilibrium framework. Results derived here are made use of in Chapter 6.

In Chapter 5 we develop and analyse two rational closed economy dynamic disequilibrium models. Intertemporal links are established via wage, price and inventory adjustments. These models are used to assess the robustness of results derived from fix-price models. Insights are gained into the nature of possible short-run equilibria, the nature and stability of long-run equilibria, the possibility of limit cycles and the importance of alternative wage and price adjustment mechanisms.

Chapter 6 extends the main closed economy model of Chapter 5 by introducing international trade. Three alternative open economy models are developed. Again the robustness of previous results is analysed, and in particular further insight into exchange rate determination and dynamics is gained. Because of the complexity of some of these models computer simulation techniques are employed to analyse the dynamic properties of two of these open economy models.

In Chapter 7 we incorporate the public sector into the previously developed disequilibrium framework. This is done with the aim of analysing the effectiveness of government policy. Not all the

New Classical policy conclusions remain valid. In particular it is shown that, in general, both systematic fiscal and monetary policy can influence the dynamic path of real variables. This result is not dependant on the government having superior information, nor on the formation of non-rational expectations, nor on the necessity of the government misleading other agents, but rather is the consequence of modelling quantity adjustments in a consistent way in response to imperfect wage and price adjustment.

In the final Chapter we summarise the argument of preceeding Chapters, offer a final assessment of the research presented in this thesis and suggest areas for further study.

CHAPTER 2

RATIONAL EXPECTATIONS AND NEW CLASSICAL ECONOMICS

In this Chapter we critically assess both the rational expectations hypothesis and its conjunction with the continuous market clearing assumption - New Classical economics. In Section 2.1 we analyse the assumption of rational expectations, and in Section 2.2 a simple model illustrating New Classical results is presented and discussed. In Section 2.3 it is argued that New Classical results are crucially dependant upon the assumption of perfect price flexibility. This is discussed with reference to contract based macroeconomic models and also McCallum's (1977, 1978) argument that price level stickiness does not in and of itself negate New Classical results. Section 2.3 concludes that the assumption of imperfect price adjustment cannot be merely appended on to an otherwise market clearing model. Imperfect price adjustment, via. resulting disequilibrium will give rise to quantity adjustments and these need to be explicitly taken into account if disequilibrium is to be modelled consistently. Final conclusions to the Chapter are given in Section 2.4.

2.1 The Rational Expectations Hypothesis

In rational expectation models, as originally defined by Muth (1961), expectations are true mathematical expectations of future variables conditional on all variables in the model which are known to an agent at time t. Thus the rational expectation hypothesis assumes that "expectations, since they are informed predictions of future events, are essentially the same as the predictions of relevant economic theory", and hence depend "specifically on the structure of the relevant system describing the economy" (Muth, 1961). In its simplest form rational expectations is the assumption that individuals do not make systematic forecasting errors. This does not imply that individuals invariably forecast accurately in a world in which some random movements are inevitable, rather it asserts that estimates about the future must be correct on average if individuals are to remain satisfied with their mechanism of expectation formulation.

Let I_t denote the information set available at time t. This information set has three components: knowledge of the structure of the model; knowledge of government policies in operation; and knowledge of the past values of economic variables. We may write $E(y_{t+k}|I_t)$ as the expectation of variable y for time period t+k conditional on the information set I_t available at time t. As the rational expectation is the true mathematical expectation implied by the model conditional on available information the following four properties will be true.

Property I: $E\{[E(y_{t+i+j}|I_{t+i})]|I_t\} = E(y_{t+i+j}|I_t)$

The right hand side is the best estimate of individuals at time t about the value of y at time t+i+j. The left hand side is the rational expectation of the best estimate for the same variable y_{t+i+j} at some intermediate date t+i, conditional on information available at time t. If individuals knew at time t they would have changed their minds by time t+i, they would be knowably mistaken at time t. Property I asserts that individuals have no basis for predicting how they will change their expectation about future variables such as y_{t+i+j}.

Property II: $E\{[y_{t+i} - E(y_{t+i}|I_t)]|S_t\} = 0$

Let S_t be some subset at time t of the full information set I_t actually used by individuals at that date. Ex post, actual forecasting errors are given by $y_{t+i}-E(y_{t+i}|I_t)$. Property II states that this forecasting error is uncorrelated with each and every component S_t of the information set I_t. This property asserts that no information available at the date expectations are formed may be used systematically to improve forecasting errors if expectations are rational. Since one kind of information available is data on previous forecasting errors, a special case of Property II is

Property III: $\{ y_{t+i} - E(y_{t+i}|I_t)\}$; $i \geq 1$ is serially uncorrelated with zero mean at lag i or greater. Although there is autocorrelation up to i-1 this cannot be used to improve the forecast at time t.

A final property that may be stated follows from Property I but here relates only to linear models.

Property IV: rational expectations satisfy the Chain Rule of Forecasting.

This is best described by means of an example. Suppose it is known that:

$$y_t = ay_{t-1} + U_t$$

where a is a constant positive fraction and U_t is a random disturbance which is serially uncorrelated with mean zero. I_t comprises past values of U_t and of y_t, but the former are of no use in predicting current and future values of U_t. At the beginning of time t, before U_t is known, the rational expectation of y_t is given by:

$$E(y_t|I_{t-1}) = E(ay_{t-1} + U_t|I_{t-1}) = ay_{t-1}$$

At the same date the rational expectation of y_{t+1} may be formed thus:

$$E(y_{t+1}|I_{t-1}) = E(ay_t + U_{t+1}|I_{t-1}) = aE(y_t|I_{t-1}) = a^2y_{t-1}$$

In general it can be seen that:

$$E(y_{t+i}|I_{t-1}) = a^{i+1}y_{t-1}$$

Thus we may use the Chain Rule of Forecasting to build up expressions for expectations at time t for all future values of y. In every case, the solutions must be expressed only in terms of variables already known at time t.

Reasons for employing the rational expectations hypothesis

Rational expectations has its uses in theoretical work and there are several reasons for its adoption. One important reason for using the hypothesis is that it accords with the economist's usual practise of assuming that people behave in their own best interests. This is not to deny that some people are irrational and neurotic, but we have no reason to believe that these irrationalities cause systematic and predictable deviations from rational behaviour. In this regard it should be noted that the rational expectations hypothesis does not require that people's expectations equal the realized values of variables, only that they equal the conditional mathematical expectation. Thus expectations will deviate from realized values by what may be a large random error term (random with respect to conditional information). Each alternative expectational hypothesis, in general, explicitly or implicitly posits the existence of some particular pattern of systematic expectation error.

Moreover the rational expectations hypothesis seems especially appropriate for analysis concerned with macroeconomic stabilization policy, for policy is inherently forward looking. Thus the relevant question is, what pattern of expectations will be found in the examination of data to be generated in the future? It is, for example, hard to believe that any policymaker would want to base his actions on the presumption that some particular error pattern will obtain in the future. In this respect Currie (1985) argues that:

> "In assessing policies under consistent expectations, one is testing them under conditions where their effects are understood. I submit that a good performance under these conditions is a necessary condition for a satisfactory policy. For if a policy performs badly under these circumstances, but well under different ones, it can only be because it works through systematic forecasting errors by the private sector. But since there will be an incentive for the private sector (or its forecasting agents) to alter its forecasting method if it generates systematic error, this is a rather weak and vulnerable basis for policy. A policy that performs badly when its effects are understood must be unsatisfactory."

Furthermore, it is not clear that policy actions designed to exploit a "known" error pattern would enhance social welfare. Barro (1976) in considering the role of monetary policy in a rational expectations framework, proposed, as a criterion for evaluating policy, the minimization of the expected squared gap between actual and full information output in each market. The basic idea for this measure is that it should serve as an approximation to the expected loss of consumer surplus. (Ideally the criterion would have been based directly on the behaviour of individuals expected utilities, but his model was not set up to handle this.) Given this welfare measure and his model of the economy, Barro is able to show that monetary policy is best when it is most predictable. In particular he shows that an increase in money variance is non-neutral and leads to an increased variance of output about its full information position, hence a welfare loss, because money variance clouds the real picture in the sense of making current information about prices a less accurate signal for market participants. Barro concludes that to the extent that the variance of money can be controlled, the smallest possible value would be optimal. (If there are significant money control type costs associated with reducing money variance, then these costs would have to be weighted against the benefits from a lower variance. This sort of trade off would lead to the choice of a positive value for money variance.)

A second reason for employing the rational expectations hypothesis is that it is consistent with the finding that large parts of macroeconometric models typically fail tests for structural change (essentially versions of the Chow test). If expectations are rational and properly take into account the way policy instruments and other exogenous variables evolve, the coefficients in certain representations of the model (e.g. reduced forms) will change whenever the processes governing those policy instruments and exogenous variables change. A major impetus to work on rational expectations is thus that it offers one reason, but probably not the only reason, why macroeconomic models fail tests for structural change. Lucas (1976) has used such an argument to provide a forceful critique of econometric policy evaluation. Lucas argued that the kind of short run policy analysis that is usually undertaken with macroeconometric models is incapable of giving reliable results. The conventional approach to the quantitative evaluation of alternative economic policies is to take an estimated macroeconomic model and examine the implied behaviour of the endogenous variables under alternative specifications of future values of policy instruments. Lucas criticises such comparisons of alternative policy rules on the grounds that the "structure" of econometric models is not invariant to changes in policy. The elements of such models are behavioural relationships derived from optimal decision rules of economic agents, based in part upon expectational variables. Changes in the nature of these movements cause changes in the optimal decision rules, thus "any change in policy will systematically alter the structure of the econometric models" (Lucas, 1976). Some have misinterpreted Lucas's critique to mean that econometric policy evaluation is impossible. What the criticism instead implies is only that it is impossible to evaluate policy without taking into account the effects of a policy rule on the expectations mechanism.

A third reason for using the rational expectations hypothesis is that in estimating econometric models it is a source of identifying restrictions. The usual method of modelling expectations in macro-econometric models - via a distributed lag on the own variable - leaves it impossible to sort out the scalar multiplying the public's expectations from the magnitude of the weights in the distributed lag. Therefore, the coefficients on expectations are generally under-identified econometrically. The way out of this has usually been to impose a unit sum on the distributed lag whereby expectations are formed. The problem with this is that it is in general incompatible with the formation of rational expectations. The use of the rational expectations hypothesis can supply alternative identifying restrictions.

A final reason for adopting the hypothesis of rational expectations, related to those already given is the value of the questions it forces us to face. We must specify exactly the horizon over which the expectations are cast and what variables people are assumed to observe and when. This leads rational expectation models to be, in general, more explicit and less ad hoc about the assumptions being made than many other macroeconomic models.

Objections to the rational expectations hypothesis

Despite these important reasons supporting the adoption of the rational expectations hypothesis, it should not be supposed that the hypothesis is without any shortcomings, where further improvement is needed.

The question of how agents learn about their economic environment is rarely addressed in rational expectations research. Rational expectations is justified by the argument that agents will learn the exact nature of the world in which they live. However at present this argument is ill-founded in theory for it must be shown that agents could learn. This except for examples has not been demonstrated. An important issue here is that of identification, whether in principle it is possible to disentangle from the data separate estimates of all relevant theoretical parameters of the model. This is not a trival problem; expectations based on an incorrect view of the model will affect behaviour and hence the data to be used in the empirical work which seeks to quantify the model itself. Given a sufficiently complicated dynamic structure identification will be impossible. This problem is further considered with reference to price setting behaviour in section 3.3.

Another problem with rational expectations is related to the non-uniqueness of rational expectation equilibria. Because of the self-fulfilling feature of rational expectations there is generally a continuum of solutions to rational expectation models. One method of obtaining uniqueness is to assume stability (i.e. no speculative bubbles) of the paths of expectations of variables. In a wide range of models this does ensure uniqueness. However, if the steady state is "too stable" an infinite number of convergent paths, or non-explosive self-fulfilling expectations exist. Alternatively if the steady state is "insufficiently stable" all paths will explode. Because of this problem of non-uniqueness Burmeister (1980) has argued that the practical usefulness of the rational expectations hypothesis is severely constrained. When faced with the problem of an infinite number of stable solutions, researchers have often imposed other restrictions on the model ensuring a unique solution. These restrictions are usually in the form of transversality conditions. It is important to realise that these conditions are only relevant in an optimizing context. Hahn (1982) has criticized the use of transversality conditions by New Classical economists seeking to demonstrate the efficiency of the market mechanism, stating that "their explanation is implicitly that the economy must behave as if someone performed an infinite optimization exercise on it. But that is precisely the issue at hand - indeed it is at the very heart of Keynes".

A third problem with the rational expectation approach is that it implicitly assumes that agents expect that other agents have the same view of the economic environment as they do. In cases where events are recurrent, such as the business cycle phenomena this assumption seems reasonable. But for unusual events it may be questioned. For a detailed discussion of these problems

See Frydman and Phelps (1983).

Conclusions

Although the objections to the rational expectations hypothesis discussed above are important and whilst further research needs to be directed to resolving them we do not believe they demand the complete rejection of the rational expectation approach. Economic theory necessarily involves some simplification. The rational expectations hypothesis is useful in theoretical work in that it allows us to examine economies free from expectational disturbances and isolates other sources of ill behaviour. It also allows us to sidestep an issue which is enveloped in ignorance, namely how expectations are actually formed. Furthermore, models with rational expectations produce such striking results that they deserve extensive theoretical study and empirical testing. For these reasons the rational expectations hypothesis is employed in subsequent chapters of this thesis. This has the further advantage that when it is incorporated into disequilibrium models we can clearly see the consequences of abandoning the assumption of infinite price flexibility used in New Classical economics.

2.2 New Classical Macroeconomics

A basic tenet of classical economics is that real economic behaviour depends only on relative prices. A change in the general price level accompanied by an equiproportional change in all prices should not change the real equilibrium of the economy because real behaviour responds to relative prices rather than to absolute prices. An immediate corollary is that a doubling of the quantity of money, which doubles all prices and therefore also the general price level, does not affect the equilibrium values of real economic variables. Money is neutral in the sense that it affects the absolute price level but not relative prices or other real variables that are independent of the quantity of money. In more technical terms, the economy is dichotomized; real variables, including the real quantity of money are determined independently of the nominal quantity of money, which affects only the general price level. A classic description of such a model of the economy appears in Patinkin (1965).

The existence of a Phillips curve, expressing a relation between the rate of inflation and the rate of unemployment is a clear violation of the netrality of money, because it involves a systematic relationship between the rates of change of nominal variables (inflation) and a real variable (unemployment). In a series of very influential papers, Lucas (1972a, 1972b, 1973), Sargent (1973), Sargent and Wallace (1975) and Barro (1976) attempted to reconcile the netrality of money with the existence of a Phillips curve by combining two distinct hypotheses: (i) that expectations are rational, and (ii) that the aggregate supply curve is inelastic with respect to expected changes - or rates of change - in the aggregate price level. Condition (ii), which suggests that shifts in aggregate demand will affect output only when the resulting price level differs from the expected, is a standard neoclassical notion. Thus it is assumed that the positive relationship between aggregate prices and output is due to movement along the producers supply curve. For this reason, the version of the Phillips curve which has emerged from this research has come to be called the Lucas supply curve. As movements along the aggregate supply curve can only occur if there is an increase in the relative price it is necessary to impose informational constraints on suppliers. These constraints give rise to a perception of a relative price increase when in reality there is none. Firm's are assumed to have difficulty obtaining information about what is going on outside their own markets. These assumptions lead to results that are controversial and dramatic. The reasoning is as follows. An implication of the rational expectations assumption is that monetary and fiscal policy cannot systematically induce expectational errors on the part of producers. Thus, given condition (ii), there is no way for the government to design policies to have systematic effects on output or employment. Indeed it is not only impossible for them to keep output permanently high, it is also impossible to reduce the magnitude of output fluctuations around the "natural rate of unemployment". While a one-period output inflation "trade off" exists because of informational constraints and random, unexpected shocks, policy makers cannot exploit this trade off in any useful way. This result has been termed the "Lucas Sargent Proposition" (LSP) and provides support for Milton Friendman's (1968, 1969) well known proposal that the monetary (and fiscal) authorities abandon attempts to pursue activist counter-cyclical policies.

As the main purpose of this Chapter is to offer an assessment of these developments a simple macroeconomic model highlighting these results is now presented.

An information based model

The economy is composed of a large number of firms. The quantity supplied by each firm is the product of a normal or secular component and a cyclical component. Letting i index firms and using y_{it}^{n} and y_{it}^{c} , respectively, to denote the logs of these components, the supply of firm i is:

$$y_{it}^{s} = y_{it}^{n} + y_{it}^{c} \;;\; i = 1, \ldots\ldots, m \qquad (2.1)$$

The cyclical component of supply is assumed to depend positively on the expected relative price, while the secular component is assumed, for simplicity, to be constant over time. Equation (2.1) is thus rewritten as:

$$y_{it}^{s} = y_{i}^{n} + c[p_{it} - E(p_t | I_{it-1})] \;;\; c > 0 \qquad (2.2)$$

where p_{it} is the i-th firms price in period t, $E(p_t | I_{it-1})$ is the i-th firms expectation of the general price level in period t, p_t, conditional on information available to that firm at the end of the previous period, I_{it-1}, and c is a parameter. Equation (2.2) states that a firm will produce more if the price of its product is expected to rise relative to the generalprice level. According to (2.2) a general price rise, which is fully perceived by all firms, will not affect production, because p_{it} and $E(p_t | I_{it-1})$ would move together.

In order to explain the Phillips curve New Classical macroeconomists have concentrated upon the confusion on the part of producers about what is happening to prices outside the particular market they operate in. It is assumed that individuals temporarily confuse aggregate and relative price movements. The argument is as follows. Typically individuals have more timely information on the price of the goods they sell than on the general price level. Knowing that their price partially reflects movements in the general price level, they use it to improve their estimate of the current price level. This in turn affects their views about the relative price of the goods they sell and the supply of that good. When an unexpected increase in the money supply pushes up the general price level, suppliers of different goods partially interpret the increase in the prices of their respective products as relative price increases and react by producing more. It is this that creates a temporary positive relationship between unexpected increases in the money supply and the level of employment and output even though money is neutral in the absence of this aggregate - relative confusion.

Due to the information constraint the firm faces an elementary signal extraction problem and its behaviour can be formalized by assuming that the firm extracts the signal optimally. This can be derived most easily using a bivariate normal model. The algebraic representation of the individual firm's price p_{it} relative to the general price level p_t is written as:

$$p_{it} = p_t + \varepsilon_{it} \qquad (2.3)$$

where ε_{it} is an additive relative price shift. With prices treated as a random variable with a normal distribution the best estimate of the aggregate price level, given the information constraint, from the viewpoint of firm i is the conditional expectation of p_t given p_{it}. That is $E(p_t|I_{it-1}) = E(p_t|p_{it})$. If p_t and p_{it} are jointly normal distributed, then this expectation can be easily derived from well known properties of the normal distribution. Define the mean and variance of p_t and ε_{it} as $Ep_t = \hat{p}_t$, $Varp_t = \sigma_p^2$, $E\varepsilon_{it} = \hat{\varepsilon}_{it}$ and $Var\varepsilon_{it} = \sigma_\varepsilon^2$. Since ε_{it} represents relative price fluctuations it is appropriate to assume that these average out to zero for each firm and are uncorrelated with the general price level. That is $\hat{\varepsilon}_{it} = 0$ and Cov $(p_t, \varepsilon_{it}) = 0$. In order to calculate $E(p_t|p_{it})$ we need to calculate the mean and variance of p_{it} and the covariance between p_{it} and p_t. From Equation (2.3) the mean of p_{it} is given by:

$$Ep_{it} = \hat{p}_t \tag{2.4}$$

and the variance of p_{it} is:

$$Var\ p_{it} = Varp_t + Var\ \varepsilon_{it} \tag{2.5}$$

$$= \sigma_p^2 + \sigma_\varepsilon^2$$

The covariance between p_{it} and p_t is then computed as:

$$Cov\ (p_{it}, p_t) = E(p_{it}-\hat{p}_t)(p_t-\hat{p}_t)$$

$$= E(p_t + \varepsilon_{it} - \hat{p}_t)(p_t-\hat{p}_t)$$

$$= E(p_t - \hat{p}_t) + E(p_t-\hat{p}_t)\ \varepsilon_{it}$$

$$= \mathrm{Var}p_t + \mathrm{Cov}\,(p_t, \varepsilon_{it})$$

$$= \sigma_p^2 \tag{2.6}$$

These variables p_t and p_{it} are viewed as jointly normally distributed with these means, variances and covariances. From the properties of the normal distribution the conditional expectation of p_t given p_{it} can be computed from the formula.

$$E(p_t|p_{it}) = E(p_t) + \frac{\mathrm{Cov}(p_{it}, p_t)}{\mathrm{Var}p_{it}} (p_{it} - Ep_{it}) \tag{2.7}$$

Substituting in the means and variances gives

$$E(p_t|p_{it}) = \hat{p}_t + \frac{\sigma_p^2}{\sigma_p^2 + \sigma_\varepsilon^2} (p_{it} - \hat{p}_t) \tag{2.8}$$

Substituting (2.8) into (2.2) yields:

$$y_{it}^s = y_i^n + c(1-b)(p_{it} - \hat{p}_t) \tag{2.9}$$

where $b = \dfrac{\sigma_p^2}{\sigma_p^2 + \sigma_\varepsilon^2}$

The behaviour of output for the economy as a whole can now be obtained by aggregating over all the producers

$$y_t^s = y^n + \gamma(p_t - \bar{p}_t) \tag{2.10}$$

where $\gamma = c(1 - b)m$.

This is the Lucas supply function. To complete the specification of the model we need to add an equation for aggregate demand, and equations describing policy rules. However the remarkable implication of equation (2.10) is that under rational expectations no matter how we define the rest of the model, and no matter which systematic parts of the policy rules are changed, there will be no effect on the path of output. Suppose we write down a particular model, including the equations which describe policy. By Property II of Section 2.1, if a unique rational expectation solution exists, it must have the property that:

$$p_t = E(p_t | I_{t-1}) + \eta_t \qquad (2.11)$$

where η_t has mean zero and is uncorrelated with all information available at t-1, including $E(p_t | I_{t-1})$. The rational expectations forecasting errors arise because of unforeseeable deviations of random disturbances at t from their mean values of zero. These disturbances come from structural equations and from any non-systematic component of policy equations. Equation (2.11) asserts that individuals do not make mistakes which are knowable at time t-1 when expectations are formed.

Substituting (2.11) into (2.10) yields

$$y_t^s = y^n + \gamma\eta_t \qquad (2.12)$$

Under rational expectations output deviates from the natural rate, y^n, only because of random shocks which are not foreseeable at the date expectations are formed. The policy implications also follow from (2.12). If monetary policy is perfectly anticipated then output does not deviate from normal levels, except for when there are structural disturbances. Anticipated changes in policy do not affect output; they only affect the price level. Put differently only unanticipated policy changes affect output. This is the central policy ineffectiveness result established by Sargent and Wallace (1975). Announced (and believed) policy changes can only affect prices (and therefore inflation) with no real output effects. This result depends crucially on the Lucas aggregate supply equation in which only forecasting errors for the price level matter. Under rational expectations the consequences of a policy change for p_t are completely discounted in $E(p_t | I_{t-1})$ and so forecasting errors are unaffected. To the extent that a policy change is not immediately recognized by individuals in the economy, expectations may not immediately discount the full effects on p_t. A systematic policy change will then be able to affect y_t^s until individuals have fully recognized the change in policy. While it would be difficult to maintain that all systematic policy changes are immediately understood by the private sector, the spirit of analysis is that demand management can, at best, have only temporary effects. Individuals, by observing data on government behaviour and by taking account of government statements concerning policy intentions, can quickly infer the policy rule in operation.

What are the consequences of purely stochastic changes in policy? Suppose the government increases the variability of policy by making it less predictable. Since this has no affect on the mean of η_t, nor on its rational expectation $E(\eta_t | I_{t-1})$, the form of equations (2.11) and (2.12) remains the same, but the forecasting error will now deviate more in both directions from its mean of zero. Thus more random policies increase the ex-post variation of output around its mean level. Sargent and Wallace (1975) used this analysis to argue that policy rules should be as predictable as possible. Since systematic policy has no effects on real output and random policies merely increases the variability of output, this analysis can be used to justify the prescription of Friedman (1959) that the monetary authority should adopt a constant rate of money growth. Attempts to maintain full employment by fine tuning should be abandoned.

As has already been noted the policy implications of New Classical macroeconomics are crucially dependent on the Lucas aggregate supply function and on the rational expectations hypothesis. In turn the Lucas supply function is justified by assuming that prices are perfectly flexible in the sense of adjusting so as to equate aggregate supply and demand in each period. Critics of this New Classical macroeconomics fall into two groups: those who reject rational expectations as a plausible model of actual behaviour, and those who find the hypothesis attractive but nevertheless are troubled by the results it generates when applied within the market clearing models. It is both possible and important to distinguish between the assumption about expectation formation and the assumption about the structure of the underlying model in which the expectations assumption is embedded. Critics within the second group cited above have gradually realized that it is the structure of the underlying model, and in particular the assumption of market clearning under flexible prices, to which they really wish to object. It is argued that in actual economies prices are too sticky (adjust to sluggishly) to effect a period by period equalization of supply and demand. The Lucas market clearing type model has not been the only rational expectation model developed. However the task of reassessing the role of rational expectations, and the New Classical policy conclusions, in models which do not assume continuous market clearing has only just begun.

An alternative rational expectation approach has been developed based on contracts. Rather than describing price movements using market clearing assumptions, these models contain explicit mechanisms to describe how prices (or wages) are determined. The rigidities in these models are contract based in that there is a finite period of time over which a nominal wage or price is fixed and transactions are assumed to take place at that price. The terminology does not mean that formal contracts are involved; wage setting customs are sufficient. These models give rise to a quite different mechanism for price and output fluctuations than those developed by New Classical economists, and their properties and policy implications are very different. In particular in these less than perfect price adjustment models anticipated and perceived changes in government policy can affect output and employment. In order to highlight the importance of price flexibility these contract based models are discussed next.

2.3 The Importance of Price Adjustment

2.3i Contract based models

The crucial difference between the models of aggregate supply in this section and the information based New Classical models is that prices are sticky. Prices do not instantaneously adjust to clear all markets. One approach used in the literature to model price stickiness is to assume that prices are set at least one period in advance of when they will apply. This assumption has been used by Fischer (1977), Gray (1976) and Phelps and Taylor (1977). One can think of this as a contract in that the price is set in advance, but there is no presumption that actual contracts are written. The distinguishing feature of this approach is that prices or wages are assumed to be set as if they were expected to clear markets during the period in which they will apply. Economic agents are assumed to make conditional rational forecasts of supply and demand conditions. Actual supply and demand will differ from these forecasts because of unexpected events, such as productivity or policy shocks. Because of these unforeseen shocks, actual demand will not equate actual supply, as prices are fixed at the wrong level. The usual assumption made has been that the demand side rules the market. This assumption, of course, implies that there are always sufficient stocks and enough excess productive capacity so that the required supply is feasible. As these models are stochastic the advantage of using the "demand is determining" rule is that it preserves linearity, unlike the "min" condition, which states that the realized transaction in a market is equal to the minimum of demand and supply.

This general approach has been applied in a number of ways. Phelps and Taylor (1977) assume that the aggregate price level is set so that expected total aggregate demand is equal to expected total aggregate supply. Aggregate demand depends negatively on the price level through the usual real balance effect: a higher price level reduces real money supply and raises real interest rates; expected aggregate supply is assumed to always equal the unconditional average or normal level of supply. Although interest rate determination as well as the dynamics of inventory behaviour are modelled explicitly, the basic mechanism can be explained using the following simple aggregate demand equation:

$$y_t^d = a_o + a_1 (M_t - p_t) \tag{2.14}$$

where M_t is the logarithm of the money supply and other notation is as in the previous section.

If normal or capacity output is equal to the constant y^n then from (2.14) the price level which is expected to clear markets in any period is given by:

$${}_{t-1}p_t = a_1^{-1} [a_o + a_1 E(M_t|I_{t-2}) - y^n] \tag{2.15}$$

The prefix t-1 on the price term p_t indicates that it is set at the start of the previous period. $E(M_t|I_{t-2})$ is the expectation of the money supply to prevail in period t based on information available when the price level is set. Equation (2.15) states in a very simple way how the price setting is anticipatory, and is essential to the predictions of the model. Substituting (2.15) into (2.14) yields:

$$y_t^d = y_t^s = a_1[M_t - E(M_t|I_{t-2})] + y^n \tag{2.16}$$

As (2.16) indicates, output deviates from full capacity output by the amount that the money supply differs from what was expected at the start of the previous period. Hence an increase in the money supply which is announced and perceived at the start of the current period (after prices have been set) will affect output. It is in this sense that anticipated changes in the money supply can affect output - as long as they are not anticipated for a period longer than the time that prices are fixed. Monetary policy has effect in this model because by assumption the monetary authorities have a shorter lead time in their money supply decisions than do firms in their pricing decisions. In the flexible price, market clearing models this lead time is ruled out by assumption.

The rational expectations models by Fischer (1977) and Gray (1976) assume that wages are sticky, while other prices are perfectly flexible. Changes in the real wage rate are the source of output fluctuations. Wage determination in these models is analogous to the price determination in the Phelps-Taylor model. Fischer also assumes that wage setting is staggered over time, but this does not affect the conclusions of his analysis. Again anticipated monetary policy can affect real variables if the monetary authorities can act with less lead time than wage setters.

It should be noted that a feature of these models is that monetary policy is neutral in the long run. In fact output returns to normal after only one period in the model described by equations (2.14) to (2.16). This corresponds to the single period price setting assumption. Serial correlation of output (more specifically the autocorrelation function) cannot be longer than the length of the longest contract in these models, unless other sources of persistence are added. However in the short run monetary policy is effective and the LSP is not valid. Further because the government is able to respond to present period structural disturbances it is able to stabilize output and employment at their natural rates by employing a suitable feedback rule offsetting any rational expectation errors. The success of such a policy depends crucially on the ability of the government to make quick and accurate inferences about the precise nature of the current shocks.

In conclusion these contract based models seem to indicate that once imperfect price adjustment is introduced into a rational expectations model the New Classicial policy prescriptions in general and the LSP in particular are no longer valid. In a series of papers McCallum has disputed this conclusion. His argument is now considered.

2.3ii McCallum's reply

In response to the development of contract based models McCallum (1977) introduced price level stickiness into a model similar to the one used by Sargent and Wallace (1975). He argued that "recognition of price level stickiness does not, in and of itself, negate the Lucas Sargent Proposition". Similarly in McCallum (1978) he "attempted to establish the basic compatibility of sluggish price adjustments and the LSP". It is clear that these conclusions need to be reconciled with the earlier contrary conclusions of Fischer and Phelps and Taylor.

The essence of the argument in McCallum (1977 and 1978) is that a model can be built incorporating a Lucas supply function, a quantity theory of money demand equation and an imperfect price adjustment equation so that output depends only on the unexpected component of the money stock - the LSP. In order to understand this argument a simplified version of a model used by McCallum (1978) is presented.

The model is as follows:

$$y_t^s = \alpha_1 + \alpha_2 [p_t - E(p_t \; I_{t-1})] + U_t \qquad (2.17)$$

$$y_t^d = \beta(M_t - p_t) + V_t \qquad (2.18)$$

$$p_t - p_{t-1} = \lambda(p_t^* - p_{t-1}) \;; \quad 0 < \lambda < 1 \qquad (2.19)$$

where p_t^* is the logarithm of the market clearing price in period t, U_t and V_t are serially uncorrelated disturbance terms with zero means, α_1, α_2, β are positive constants, and other notation is the same as used previously. Since we define p_t^* as that p_t which equates y_t^s to y_t^d we can solve (2.17) and (2.18) for p_t^*. Using this result for p_t^* in (2.19) yields:

$$p_t = (1 - \lambda)p_{t-1} - \delta_1\alpha_1 + \delta_1\beta M_t + \delta_1\alpha_2 E(p_t|I_{t-1}) + \delta_1(V_t - U_t) \qquad (2.20)$$

where $\delta_1 = \lambda/(\alpha_2 + \beta)$

Assuming monetary policy is non-stochastic, with rational expectation $E(M_t|I_{t-1}) = M_t$ and using (2.20) to solve for $E(p_t|I_{t-1})$ we obtain:

$$p_t = \delta_2 p_{t-1} - \delta_3 \alpha_1 + \delta_3\beta M_t + \delta_1 (V_t - U_t) \qquad (2.21)$$

where $\delta_2 = (1-\lambda)/(1-\delta_1\alpha_2)$ and $\delta_3 = \delta_1/(1-\delta_1\alpha_2)$. Using (2.21) in (2.17) gives:

$$y_t^s = \alpha_1 + \alpha_2\delta_1(V_t - U_t) + U_t \qquad (2.22)$$

McCallum concluded that (2.22) "illustrates vividly" the LSP in that systematic changes in monetary policy have no affect on output, even in the short run. Output is only away from its natural rate, here α_1, when the economy is disturbed by random shocks. The validity of this argument does seem to have been widely accepted. For example Blinder and Fischer (1978) state that McCallum has demonstrated in his (1977) paper that "some types of non market clearing still do not permit any role for monetary policy in affecting output". However, Gordon (1977) has argued that the Lucas supply function is incompatible with imperfect price adjustment. Frydman (1981) has developed a formal statement of the same criticism of McCallum's argument and has shown that when a more reasonable output determination equation is adopted McCallum's conclusion concerning "the basic compatibility of sluggish price adjustments and the LSP" is not valid. The problem with McCallum's model is that it does not take into account the quantity adjustments resulting from sluggish price adjustment. Due to imperfect price adjustment there will be disequilibrium and thus producers will generally experience a discrepancy between aggregate demand and supply. This disequilibrium will result in either inventory accumulation or decumulation. The inventory changes are the necessary outcome of sluggish price adjustment. The Lucas supply function implies absurdly irrational behaviour on the part of producers given imperfect price adjustment by implicitly assuming that producers do not respond to inventory changes. The Lucas supply function cannot be combined with an imperfect price adjustment equation.

Frydman (1981) shows that if a more reasonable output determination equation replaces the Lucas supply function when there is imperfect price adjustment then the LSP does not hold. Frydman modifies equation (2.17) in the following way:

$$y_t^s = \alpha_1 + \alpha_2[p_t - E(p_t|I_t)] - \alpha_3(N_{t-1} - N^*) + U_t \qquad (2.23)$$

Now output supplied is negatively related to the difference between the stock of inventory at the end of the previous period, N_{t-1}, and the optimal stock of inventory, N*. For simplicity Frydman assumes N* to be a constant in the short run. To close the model it is assumed that the quantity sold in each period is equal to demand, that is $y_t^d < y_t^s + N_{t-1}$, and inventories adjust passively according to:

$$N_t = N_{t-1} + y_t^s - y_t^d \qquad (2.24)$$

Repeating the analysis of McCallum's model this modified model implies that real output is given by:

$$y_t^s = \alpha_1 - \alpha_3(N_{t-1} - N^*) + \alpha_2\delta_1(V_t - U_t) + U_t \qquad (2.25)$$

and demand is given by:

$$y_t^d = \beta[\delta_2 M_t - \delta_2 p_{t-1} + \delta_3\alpha_1 - \delta_3\alpha_2(N_{t-1} - N^*)]$$

$$+ V_t - \beta_2\delta_1 (V_t - U_t) \qquad (2.26)$$

From (2.26) it is clear that aggregate demand y_t^d depends on the parameters of the monetary rule. With imperfect price adjustment aggregate demand differs from aggregate supply in the short run and so from (2.24) the time path of inventories depends also on the parameters of the monetary rule. Finally this implies from (2.25) that output depends on systematic monetary policy. With a more reasonable output determination equation than the Lucas supply function, in a model with imperfect price adjustment, the LSP is not valid.

Instead of just dismissing McCallum's arguments it is important that we learn from his mistakes. Firstly, it highlights that we cannot casually use the Lucas supply function in conjunction with imperfect price adjustment. The Lucas supply function is not a universal statement about the behaviour of optimizing agents, but is in fact a reduced form equation derived by Lucas (1972a) on the basis of a restrictive set of assumptions, and it loses its validity if those assumptions - particularly instantaneous markets clearing by price adjustment - are violated. Secondly, and relatedly, when there is imperfect price adjustment then the resulting disequilibrium situation will cause quantitites to be constrained rather than chosen voluntarily. These quantity constraints and quantity adjustments need to be incorporated in the model if disequilibrium is to be modelled consistently. This conclusion has been known for sometime but seems to be ignored by some New Classical economists. The body of analysis pioneered by Patinkin (1965) and Clower (1965) and developed by Leijouhufvud (1968), Barro and Grossman (1976) and Malinvaud (1977), now termed disequilibrium economics, was all directed to showing that if prices are slow, relative to quantities, to respond to shifts in demand, then quantities rather than prices play the role of equilibrating factors in the markets.

2.4 Conclusions

This Chapter has critically assessed the rational expectations hypothesis and its conjunction with the market clearing assumption - New Classical economics. Although the rational expectations hypothesis was shown to have important shortcomings, where further research is needed, it was argued that the hypothesis is nevertheless useful in theoretical work. The main conclusions, however, relate to New Classicial macroeconomics. New Classical results are crucially dependent on the assumption of perfect price flexibility, and the assumption of imperfect price flexibility cannot merely be appended on to an otherwise market clearing model. Imperfect price adjustment, via resulting disequilibrium will give rise to quantity adjustments and these need to be explicitly taken into consideration if disequilibrium is to be modelled consistently.

CHAPTER 3

PRICE ADJUSTMENT AND DISEQUILIBRIUM

The analysis of the previous Chapter forced us to conclude that the assumption of imperfect price flexibility cannot be merely appended on to an otherwise market clearing model as some researchers have tried to do. Imperfect price adjustment, via resulting disequilibrium, gives rise to quantity constraints and adjustments, these need to be explicitly taken into account if disequilibrium is to be modelled consistently. However before presuming that a disequilibrium framework with quantity rationing is appropriate it is necessary to determine whether prices are less than perfectly flexible, and if so why. This issue is considered in this Chapter by critically assessing and extending recent work on price and wage adjustment.

In the first section the assumption of perfectly flexible prices ensuring continual equilibrium is discussed, with the conclusion that this approach is unsatisfactory. What is needed is a theory of how prices are formulated by agents and how these plans are revised in the light of new information. There are two alternative theories of imperfect price adjustment. The first states that prices respond to disequilibrium, with equilibrium being the limit of this process, assuming stability. The other is conversely that disequilibrium occurs because prices for some reason(s) do not instanteously adjust to their equilibrium values.

The theory that prices respond to disequilibrium is considered in Section 3.2. This process is found to be ad hoc and incomptabile with full rationality of agents. In order to develop a satisfactory theory of price adjustment explicit reasons why prices do not instantaneously adjust to their equilibrium values need to be examined. Within Section 3.3 three broad reasons for imperfect price and wage adjustment are analysed: imperfect information and the learning procedure, contract theory and the presence of costs of changing individual prices ("small-menu" costs). It is shown that each of these three considerations is sufficient to explain individual price stickiness, giving rise to disequilibrium and the consequent quantity adjustments.

In Section 3.4 we aggregate over individual prices taking separately into account each of the three reasons for imperfect price adjustment considered in Section 3.3, in order to derive the implications for aggregate price adjustment and disequilibrium. Actual price or wage dynamics depend on the reason why prices and wages are inflexible in that particular market. There is no one price adjustment mechanism. However for each of the reasons considered disequilibrium persists, given plausible assumptions, over aggregation. Finally, in Section 3.5, the main conclusions to the Chapter are stated.

3.1 Perfectly flexible prices

Barro argues that the appealing feature about the market clearing assumption is that "the equation of supply to demand implies that the market transactions have proceeded to the point where perceived mutually advantageous trades have been exhausted... the "disequilibrium" literature postulates arbitrary dynamic processes for price formulation and arbitrary rules for determining quantities in non-market clearing situations. This modelling implies easily correctable ways in which private markets malfunction" (1979, pp. 28-29).

Yet the "law of supply and demand" cannot be so easily accepted. Following Arrow (1959) we first write demand and supply functions respectively for competitive consumers and producers:

$$D = f(P) \quad ; \quad S = g(P) \tag{3.1}$$

where D is the demand for the commodity, S its supply, and P its price. Since (3.1) is incomplete, with two equations in three unknowns, the model is usually completed by adding the condition of equality between supply and demand.

$$D = S \tag{3.2}$$

Equilibrium protogonists regard the sin qua non of an acceptable theory to be not only the absence of unrealized gains, but also the grounding of all decisions in "choice-theoretic foundations". The problem with (3.2), however, is that it is not derived from maximizing behaviour, instead it is assumed to be self evident. Further, nothing is included in (3.2) that can tell us how a market may move from one equilibrium to another. What is needed is a theory of how plans are formed by various agents in the market and how plans are revised in the light of new information.

3.2 Price adjustment in response to disequilibrium

The usual defence made for (3.2) is that it is the limit of a trial-and-error process in which price adjusts by the following rule whenever (3.2) does not hold

$$dP/dt = h\ (S-D) \qquad (3.3)$$

where $h' < 0$; $h(0) = 0$ (h' being the rate of change of the function h with respect to an increase in the excess supply).

This equation, describing a market diseqilibrium, states that the change in price is a function of the difference between supply and demand. A market clearing equilibrium occurs, with no unrealized gains from trade, only in the limit of a dynamic process in which (if it is stable) there is no pressure for any of the three endogenous variables to change. Again, however, the mechanics of price change are essentially ad hoc. Such devices as an auctioneer and recontracting have been introduced to rationalize this type of mechanism, but it seemingly reflects no one's maximizing behaviour. Thus Arrow (1959) writes "it is not explained whose decision it is to change price in accordance with [equation (3.3)]".

It has been argued that the distinctive feature of this type of model is that variations in price are generated by the workings of the "market", and are therefore separate from the actions of individual market participants. However from the contributions of Goldman (1972), Black (1972, 1974) and Mussa (1981), it is known that serious theoretical difficulties are encountered in models that combine the notion that prices respond to excess demand over time, and the notion that agents have rational expectations. In order to highlight the theoretical difficulties encountered when rational expectations are imposed on excess demand models we follow Mussa (1981) and examine a model initially developed by Cagan (1956).

It is assumed that prices respond to excess demand according to:

$$dP/dt = \alpha(\text{excess demand}) \tag{3.4}$$

Suppose that the demand for money is given by:

$$m^d = k + p - \eta\pi$$

where m^d is the log of nominal money balances, p the log of the price level, π the expected rate of inflation, k represents all other factors affecting real money demand other than π, and $\eta > 0$ is the semi-elasticity of demand for money with respect to π.

Given the log of the nominal money supply, m , the price level which yields equilibrium in the money market is:

$$\bar{p} = m - k + \eta\pi$$

Assuming that the only alternative to holding money is spending on goods and that the pressure of excess demand in the goods market is proportional to $m-m^d$, with a factor of proportionality of β, the rule (3.4) becomes:

$$dP/dt = \alpha\beta\,(m - m^d) = \alpha\beta\,(\bar{p} - p) \tag{3.5}$$

Under certainty rational expectations requires that the expected rate of inflation, π, equal the actual rate of inflation, dp/dt. Imposing this requirement on (3.5) yields the following differential equation:

$$dp/dt = \gamma(Z - p) \tag{3.6}$$

where $Z = m - k$ and $\gamma = \alpha\beta/(1 - \alpha\beta\eta)$. The solution of (3.6) is

$$p(t) = p(o)\exp(-\gamma t) + \int_o^t \gamma Z(s)\exp[\gamma(s - t)]ds \tag{3.7}$$

where p(o) is the initial value of p that is fixed by past history under the assumption that prices are sticky.

This solution for p(t) is not a satisfactory description of the path of the price level under rational expectations. If $\gamma < 0$, then (3.7) is unstable, and we have the highly unsatisfactory situation that p(t) diverges to infinity, as determined by $p(o)\exp(-\gamma t)$, regardless of the behaviour of Z(s). Indeed as the speed of adjustment to disequilibrium becomes large, the parameter tends to minus infinity. Thus according to (3.7) when α is large, the rational path for the price level is necessarily unstable.

If $\gamma > 0$ then (3.7) is stable, but it is still not satisfactory. The basic problem now is that eventhough expectations of the future inflation rate are rational and affect the price level through their effect on money demand, the known future behaviour of Z(s) for $s \geq t$ has no effect on p(t). One manifestation of this basic problem is p(t) does not, in general, converge to its equilibrium value, $\bar{p}(t)$, even in the long run. For example, if Z grows at a constant rate μ, then the inflation rate, dP/dt, converges to its appropriate long run value, $dP/dt = \mu$, but p(t) does not converge to $\bar{p}(t) = Z(t) + \mu\eta$. Instead a permanent divergence between $\bar{p}(t)$ and p(t) is required to sustain the long run inflation rate at $dP/dt = \alpha\beta(\bar{p} - p) = \mu$.

Another manifestation of this basic problem is that, contrary to the fundamental spirit of rational expectations, $p(t)$ does not react to perfectly foreseen changes in the rate of monetary expansion until the change actually occurs. In particular, suppose $Z(s) = m(s) - k(s)$ is constant up to some time T, and then grows at a constant rate $dZ/dt = \mu$ for $s > T$. According to (3.7) the path of $p(t)$ up to T is independent of the value of μ to $t > T$.

From this model we can see that there are serious theoretical difficulties in combining rational expectations with the assumption that prices respond to excess demand. The fundamental reason for these problems occuring is that the theory of price adjustment in response to disequilibrium is incompatible with full rationality of agents. Rationality implies anticipating future events and, in general, responding to them. The problem with equations such as (3.3) is that prices are assumed to respond to current variables (disequilibrium) ignoring possible future events. In order to develop a price adjustment rule that circumvents these difficulties it is necessary to examine how prices would be set if there were explicit reasons why prices should not instaneously adjust to their expected market clearing levels. Prices here do not rise in response to excess demand, but there is excess demand (or excess supply) because prices do not fully adjust to their equilibrium values. This interpretation actually goes to the root of the question why disequilibrium exists.

3.3 Disequilibrium due to imperfect price adjustment

Within this section we analyse three broad reasons for why prices may not adjust instaneously to their equilibrium values. First the role of imperfect information and learning is examined. Second, the reasons why exchange contracts, that exhibit imperfect price adjustment may be developed are explored. Finally the affects of costs of changing individual prices ("small menu" costs) are analysed. Each of these considerations is able to explain why disequilibrium exists. These theories should not be considered as competitive but rather as complementary and taken together possible of explaining price stickiness for a broad range of markets.

3.3i Imperfect information and learning

An obvious reason for why agents may not set prices at their equilibrium levels is because they do not know what these values are due to imperfect information. This is not to say that economic agents are irrational, but it does imply that the assumption of "rational expectations" as proposed by Muth (1961) is inappropriate for analysis of the short-run. Rational expectations, by Muth's definition, yield predictions of future events which differ from the corresponding eventual outcomes only by errors which are themselves independent of the variables used to generate the predictions. However, as was noted in Section 2.1, what is typically missing in "rational expectations" macroeconomics is a clear outline of the way individuals derive the knowledge which they use to formulate expectations meeting this requirement. A distinction is needed between (a) the general assumption that economic agents use efficiently whatever information is available and (b) a specific assumption identifying the available set of information. For expectations to exhibit the error orthogonality property, enabling agents to set, on average, equilibrium prices agents need to have "correct" information on the values of economic variables as well as the structure of the economy, including both its functional form and parameter values. These are strong informational requirements.

As related in Section 2.2 New Classical economics has concentrated on the ability of agents to observe certain economic variables, especially policy variables. Thus in New Classical macroeconomics agents fail to set equilibrium prices because of a specific information constraint giving rise to aggregate-relative price confusion. However given the frequent publication of economic statistics, New Classical economists argue that this confusion is likely to be short lived and that the resulting disequilibrium is insignificant and need not be modelled. It is argued here that there are alternative, more important, information constraints that give rise to significant and persistent disequilibrium.

As already noted in order for agents to hold expectations that exhibit the error orthogonality property they need to know the structure of the economy. If individuals have imperfect information concerning either the structural specification of the economy or some parameter value then a learning procedure is required. However, accepting the need for a learning procedure does not imply that the revised expectations are rational, nor even that multiple revisions will eventually lead to rational expectations. The difficulty is that in many models with rational expectations the objective distribution of variables depends upon the agents' subjective beliefs about the distribution. Outside a rational expectations equilibrium the objective distribution of variables differ both from agents' subjective belief, and from the objective distribution which would prevail in a rational expectations equilibrium. Agents may learn about the relationship between variables, given their current beliefs. However, when they modify their beliefs in the light of what they have learnt, the relationship changes. As Lucas (1976) pointed out so forcefully in his critique of econometric policy evaluation, the reduced form of an econometric model is not stationary if people change the way in which they form expectations. Because of this endogenity the adjustment of expectations is a complex problem. The work on this problem involves an examination of the stability of the expectations that agents need if a rational expectations equilibrium is to result. Although there have been numerous approaches to this problem there are two broad frameworks that characterize most of the literature.

In one framework agents are learning about parameters of a distribution using a correctly specified likelihood function. This framework includes papers by Arrow and Green (1973). Blume and Easley (1981), Bray and Kreps (1981), Cyert and De Groot (1974), Friedman (1979), Frydman (1981), Kihlstrom and Mirman (1975), Taylor (1975) and Townsend (1978, 1981). For example Taylor (1975) used a continuous time model, in which agents already knew all aspects of the economic system except the value of a single parameter in the (correctly specified) equation describing the behaviour of the monetary policy authority, to investigate what happens as they gradually discover it. His results showed that agents beliefs about this parameter value will eventually converge to the true value, so that their expectations will eventually become "rational"; until convergence is complete, however, agents will not form their expectations "rationally", and systematic monetary policy is able to influence real economic variables. Models set in this framework show that rational expectations are a long run rather than a short run phenomenon.

In the other framework agents are not assumed to have correctly specified likelihood functions. This approach includes papers by Blume and Easley (1982), Blanchard (1976), Bray (1982), Cyert and DeGroot (1974), DeCanio (1979) and Radner (1982). From these papers it has been shown that in some cases learning based on standard statistical techniques generate rational expectations in the limit, but in other cases such learning does not generate rational expectations. In these models stability depends upon the specific learning procedure, parameter values and priors, but as yet there is no general theory about what distinguishes these cases. It should be noted here that these models have been criticized in that they do not employ a fully rational learning procedure, as they do not allow for hypothesis testing and model revision. Thus Bray and Kreps (1981) argue that in general the Martingale convergence theorem implies that Bayesian posteriors must converge and that, given further assumptions (in particular, continuity), this convergence generates rational expectations in the limit. While it is true that if agents follow a correct Bayesian learning procedure convergence to a stationary rational expectations equilibrium is ensured, it may be argued that applying this assumption to the very complicated situations that can be generated, even by rather simple models with learning, is pushing the general presumption of optimizing behaviour to the point where it loses many of its attractions. Further even with fully rational learning procedures it is clear that rational expectations are a long run phenomenon.

Given these results it is clear that information constraints relating to the structure of the economy can lead to individuals holding incorrect expectations for prolonged, even infinite, periods. With incorrect expectations agents will not set wages and prices at their equilibrium values leading to persistent, rather than short-lived disequilibrium.

3.3ii Contract theory

There have recently been attempts to explain price and wage contracts, that exhibit sluggish price adjustment, as the result of microeconomic optimizing behaviour. The proponents of the contractual view do not claim that contracts are universal, but rather analyse factors which cause some product and labour markets to be governed by contracts and slow price adjustment.

Contracts may be either explicit or implicit. This distinction, however, can be exaggerated: long term contracts have an implicit element in the sense that they specify only a limited number of contingencies to which wages and prices will be adjusted. Moreover, the implicit contracting branch of the literature has pushed in the direction of implying that explicit contracts observed, for example in the union sector of the labour market, may be formalizations of common informal arrangements in the non-union sector, so that differences between the sectors in the behaviour of wages, prices and quantity adjustment may be more apparent than real.

Three general explanations for why agents may have incentives to develop contracts have emerged in the literature. These are usually regarded as complementary rather than competing theories.

The first approach, arising from the "contracting" literature (for example see Klein et al., 1978 and Wachter and Williamson, 1978) highlights the role of costly information and worker-job-product heterogeneity. Thus in the presence of idiosyncratic exchange contractual arrangements are developed in order to economize on transaction costs. Broadly speaking transaction costs refer to the "cost of running the economic system" (Arrow, 1970), and include the cost of planning, adopting and monitoring task completion. Idiosyncratic exchange refers not to superficial variants of a standardized product but instead to that which entails non-trival investments in item specific human and physical capital. As a consequence, short term exchange is not feasible for such items, since short term exchange does not offer sufficient incentives to invest in specific capital. Spot markets for such non-standard items thus do not exist. The relevant contracts to be considered here, are strictly long term.

For clarity, we consider how such an argument may be applied to the labour market. Here the central hypothesis of the theory of idiosyncratic exchange holds that an important part of the product of a worker is the return to specific human capital. A worker produces more in his present job than he would as an inexperienced employee of another firm. Under competition there is a "zone of indeterminacy" (Okun's words) within which the wage can vary: a worker will quit if paid less than the wage of inexperienced workers elsewhere, but the current employer should be willing to pay up to the worker's marginal product if necessary. To avoid costly bargaining with individual workers over the division of the return to specific capital, institutions have evolved for treating workers equitably and in a way that is well understood from the beginning of their employment. Unexpected wate changes would be a violation of these rules. Wages continue on a smooth trajectory, with labour getting a larger share of the return to specific capital when the market is slack and employers the larger share when demand is strong. This theory thus explains both upward and downward rigidity of wages to market pressure. A similar argument can be made for non-standard intermediate products.

In short, it is argued that obligational market contracting, whether explicit or implicit, is the only feasible mode of exchange for non-standard items. This reflects the mutual interests of the parties in continuing the exchange and the desire to economize on transaction costs.

The second approach to explain the presence of long term contracts follows from the simultaneously written and independent contributions of Azariadis (1975), Baily (1974) and Gorden (1974). This approach emphasises the efficient risk bearing aspects of contractual arrangements. Most of the work on efficient risk sharing contracts has been set within the context of the labour market. This is called the "implicit contract" theory of wages, and argues that workers are more risk averse than firms and that therefore firms will find it less costly to hire labour if they provide some degree of income insurance against fluctuations in demand, which would otherwise lead to fluctuations in the demand for labour. Thus risk averse workers deal with risk neutral entrepreneurs whose firms consist of three departments: a production department, that purchases labour services and credits each worker with his marginal revenue product (MRP); an insurance department, that sells actuarilly fair policies, and depending on the state of nature, credits the worker with a net insurance idemnity (NII) or debits him with a net insurance premium; and an accounting department, that pays each employed worker a wage with the property that W = MRP + NII in every state of nature. Favourable states of nature are associated with high values of MRP; in these the net indemnity is negative, and wages fall short of the MRP. Adverse states of nature correspond to low values of MRP, to positive net insurance indemnities, and to wages in excess of MRP. A contract is then a description, made before the state of nature becomes known, of the labour services to be rendered to the firm in each state of nature and the corresponding payments to be delivered to the workers.

An immediate consequence of this framework is that, again, wages are disengaged from the marginal revenue product of labour. Wages will be less flexible than in the Walrasian model, and in the extreme will be rigid. Such analysis has recently been extended to consider intermediate product exchange. For example Azariadis and Cooper (1985) demonstrate that the efficient sharing of social risks may lead to contracts being developed and trades occuring at a price that does not respond to realizations of random events.

The third approach explaining the development of contracts is related to the efficiency-wage literature. According to the efficiency wage hypothesis labour productivity depends upon the real wage paid by the firm. This theory has been developed to explain involuntary unemployment in an equilibrium context. It attempts to answer the question: Why don't firms cut wages in the face of involuntary unemployment thereby increasing profits? The efficiency wage theory argues that firms may be reluctant to lower wages because to do so might lower productivity more than proportionately, resulting in increased labour costs. Within this framework competitive equilibrium is consistent with a situation of excess supply of labour. The efficiency wage theory thus provides an explanation for a natural rate of involuntary unemployment. However as they stand these models have no wage or price stickiness, as wages and prices respond instantaneously to new information. Although there is a natural unemployment rate there is no disequilibrium adjustment. These simple models may, however, be extended to give a theory as to why firms may desire to develop wage contracts.

In most jobs, workers have some discretion concerning their performance. Lazear (1981) has shown that an implicit contract relating to seniority wages provides workers with the incentive to work rather than shirk. The gap between a wage and marginal product here reflects a performance incentive. Workers are paid a wage less than their marginal product when they are first employed with a promise that their earnings will increase over time and eventually exceed their marginal product. Again unexpected wage changes would be a violation of this contract.

So far we have examined three alternative theories for why agents may develop contractual exchange arrangements, that lead to either wage or price stickiness, relating to idiosyncratic exchange, efficient risk sharing, and efficiency wage arguments. We now need to consider whether such contracting produces disequilibrium quantity adjustments. This issue was first raised by Barro (1977). Barro pointed out that both parties to exchange have an incentive to devise complex contracts which maximize the "size of the pie". Such contracts will stipulate optimal adaptations to real shocks as well as neutralize the effects of purely monetary disturbances. Comprehensive indexing is an attractive theoretical abstraction which, were it feasible, would alleviate the need for quantity adjustments to carry the burden of contractual flexibility.

Thus although disequilibrium quantity adjustments have often been attributed to wage and price contracts, these contracts by themselves may not be sufficient to generate disequilibrium. It is necessary to identify the circumstances under which contracts will give rise to quantity adjustments. In particular we consider the implications of three sources of restrictions on the set of feasible contracts.

(i) Observability and verification

Implicit contracts can only be "written" on the basis of information which is available or can be inferred by both parties to the exchange; explicit contracts require, in addition, that any contingency provision be observable to an outside party. This leads to the distinction between verifiability and observability. This implies two kinds of difficulties in maintaining complex contracts. First one would have to disclose the state of nature at each delivery date, and as Meade (1971) notes, contingent claims contracts are infeasible when it is impossible on the contract execution to ascertain unambiguously and without contradiction the true state of the world (e_i). Second, even if no problem of this kind arose there is still the matters of monitoring delivery: was item or activity x_i supplied under environmental condition e_i as agreed, or was variant x_j offerred instead?

(ii) Enforcement

Implicit contracts differ from explicit contracts in that there is no legal mechanism for enforcement. Two alternative mechanisms are available: reputation and self-enforcement. For example in the labour market bad behaviour by firms may be either punished by increasing costs of recruitment and/or by the withdrawal of effort by current workers. Both mechanisms require long lived agents. For the enforcement mechanisms to be effective in prohibiting contract breaking the punishment costs must be greater than the benefits of breaking the contract, and also it must be in the interest of the injured party to punish the offender. These problems apply not only to implicit contracts. With explicit contracts it is costly to use the legal system and thus if the damages done by the breach of contract are small, it will not be employed. Such problems of enforcement again place restrictions on the set of feasible contracts.

(iii) Transaction costs

Contracts are cheaper to evaluate and implement when they are defined by a few simple numbers rather than by functions of variables. Transaction costs of writing and securing agreement to the complex contract may be excessive. For example bounded rationality makes it very costly, or even impossible, to identify all relevant future contingencies and to specify, ex ante, appropriate adaption to them. Further even supposing that exhaustive complex contracts could be written at reasonable expense a problem incomprehensibility, due to bounded rationality, may arise and impede reaching an agreement. If one of the parties is unable to assess meaningfully the implications of the contract to which he is being asked to accede, the contract may fail to go through, or to have its intended effect. By bounded rationality we mean that economic agents are "intendedly rational, but only limitedly so" (Simon 1961). Such limited rationality should not be confused with irrationality, which is a psychological term reserved for an "impulsive response to affective mechanisms without an adequate intervention of thought" (Simon, 1976). Rather bounded rationality refers to cognitive limits of human agents in relation to the complexity of the problems with which they are confronted. Considering this issue Wachter and Williamson (1978) write "The prohibitive cost and/or infeasibility of complex contingent claims contracting is mainly attributable to bounded rationality. Incomplete contracting, in which terms of the contract are sometimes vague and many contingencies are ignored, and non market modes of organization are institutional responses to this condition".

Having considered these three sources of restriction on the set of feasible contracts, restrictions on information, enforcement and complexity, what are their implications?

The accepted contract is the best contract, subject to the constraint that it is feasible and in the best interests of both parties to carry out the terms of the contract. Neither party will accede to a contract which the other has an incentive to breach. Contract formulation should be modelled as perfect equilibria of repeated games. In a recent paper Newbery and Stiglitz (1985) examine the consequences for involuntary unemployment of the above three restrictions on the feasible set of contracts, within the context of a simple general equilibrium model. They first show that in the absence of problems of observability, enforcement, and complexity, contract theory though explaining wage rigidity does not give rise to disequilibrium quantity adjustment.

Secondly, they show, that natural restrictions on enforceability alone or on the degree of complexity alone do not lead to unemployment, but that limited observability may lead to unemployment, though, as Newbery and Stiglitz state, in their model only under conditions that do not seem very convincing. What does give rise to unemployment, however, is the failure of two or more of these assumptions to be satisfied, and in particular, they demonstrate that restrictions on the complexity of a contract and its enforceability may lead to periodic unemployment.

In reality all of the above mentioned limitations are present at the same time. Thus though comprehensive indexing would alleviate the need for disequilibrium quantity adjustments, it is merely a theoretical abstraction, ignoring many realistic limitations on the set of feasible contracts. Contract theory, therefore, either derived from idiosyncratic exchange theory, efficient risk sharing considerations, or efficiency wage arguments, is capable of explaining both wage and price inertia in certain markets, as well as disequilibrium quantity adjustments.

3.3iii "Small-menu" costs

Another approach in the literature to explain imperfect price adjustment has been to consider the affects of small menu costs. The essential assumption is that there are costs associated with changing individual prices. These costs range from the cost of changing tags and printing new catalogues to gathering the information needed to choose the new prices, informing customers of these prices and so on. The question is whether these costs, which cannot be very large, can have important macroeconomic effects. It may be noted here that this work is related to the analysis of Akerlof and Yellen (1985a, 1985b) who have emphasised the potential macroeconomic effects of "near rationality".

Decision makers are said to be "near rational" if they react to changes in the environment only if not reacting would entail a first order loss. As Akerlof and Yellen point out, however, near rationality can be described as full rationality subject to second-order costs of taking decisions, so that their analysis is directly relevant to this section.

Given the presence of "small menu" costs, it is optimal to adjust individual prices only at discrete intervals and by finite amounts, and to permit disequilibrium during the intervals between price changes. The optimal frequency of price change balances the marginal gains from reducing the losses due to disequilibrium (by changing prices more often) with the marginal cost of changing prices more frequently.

Recent Work

Mussa (1981) derives a price adjustment rule from a microeconomic model in which there is an explicit cost to changing individual prices. Mussa assumes that the frequency of individual price adjustment is fixed in advance. Analytically this makes his model similar to the Tobin-Baumol model of the transactions demand for cash. From an economic view there are a number of unsatisfactory features with Mussa's approach.

First Mussa assumes perfect competition even when firms face disequilibrium. Arrow (1959) has pointed out that the existence of disequilibrium (excess supply or demand) is inconsistent with certain assumptions of the perfectly competitive model. For example, the firms assumption that it is confronted with a perfectly elastic demand curve must be discarded in disequilibrium if the firm is ever to change price. Further if price decisions are taken neither continuously nor in perfect synchronization, as in Mussa's model, then the process of adjustment of all prices to a new nominal level will imply temporary movements in relative prices. It might then well be that, to avoid incurring costs associated with these movements in relative prices each price setter will want to move his own price slowly. The result will be slow movement of all prices to their new nominal level, and greater price level inertia than Mussa's paper suggests. Thus the response of prices to disequilibrium is essentially a temporary monopolistic phenomenon even if the individual units perform as perfect competitors in equilibrium. Therefore it seems clear that a theory of monopolistic price adjustment is a prerequisite to a general theory of price adjustment.

The second assumption that is unsatisfactory in Mussa's analysis is that of a fixed interval between price changes. An alternative approach could be based on the Millor-Or model of the transactions demand for cash. Here price setters follow a strategy of changing prices when the divergence from equilibrium becomes sufficiently large to justify the cost of making the change. The firm adopts a policy of "(s,S)" form. Scarf (1959) presents an optimality proof for the (s,S) policy rule in a similar context. More recently Sheshinski and Weiss (1983), Danziger (1984) and Caplin and Sheshinski (1986) consider the conditions for optimality of (s,S) policy in a stochastic setting. In accordance with this type of policy, the firm selects ceiling and floor values for its own price, relative to the equilibrium or desired price, at which price adjustment occurs. That is each firm changes its nominal price whenever its relative price (relative to the equilibrium price) falls below some predetermined level, s, or exceeds a similarly predetermined level, S. The duration of the period with fixed nominal price is thus random given there are random shocks affecting the equilibrium price. With firms following the (s,S) policy rule, the resulting general price adjustment path is quite different to that derived from Mussa's analysis (see Section 3.4).

Blanchard (1982, 1983, 1985) in a series of papers has considered the first criticism made of Mussa's approach, that it, does not take into account changes in relative prices and the resulting market power of firms whilst the general price level adjusts towards the market clearing level. In these papers Blanchard shows that, even if all price decisions are taken frequently, if the number of price decisions is large, asynchronization will lead to substantial price level inertia. This suggests that asynchronization may indeed help to explain price level inertia and thus generate macroeconomic fluctuations, with all prices moving slowly towards their equilibrium values.

Although Blanchard meets the first criticism levied at Mussa's approach, he still assumes that the interval of price change is fixed, that is the pricing rule is time rather than state dependent. As yet there has been no incorporation of the optimal (s,S) policy rule for firms into a monopolistic competition model with asynchronization of price decisions. Having stated this however, Sheshinski and Weiss (1977, 1979, 1983) have analysed the (s,S) policy rule for price adjustment in order to examine the real effects of inflation. Their analysis may be extended to determine the effects of (s,S) policy rule for individual price setting on the aggregate price level. Initially within this section we analyse the (s,S) policy rule for the individual firm, while aggregation over firms is examined in Section 3.4.

Basic model of the firm

In the following model two basic assumptions are made. First apart from the costs of production the firm is assumed to incur only two other costs. One relates to the changing of the firms price for an individual commodity (the small menu cost). If there were no such cost there would be no reason for prices ever to diverge from their equilibrium levels. The other cost the firm incurs results from allowing price to diverge from the equilibrium level, further this loss is assumed to be an increasing function of the magnitude of the divergence from equilibrium. This loss provides the incentive for the adjustment of price. This first assumption rules out the firm taking into consideration the prices set by other firms in the market when setting its own prices. The only cost it incurs with respect to its price level is related to the equilibrium value, not its price relative to others. By this assumption we highlight the role of the (s,S) policy rule in price setting, ignoring the first criticism made against Mussa's analysis. The second assumption is that the equilibrium price level increases at a constant rate of inflation, with random jumps to the level caused by exogenous shocks to the market. Thus the firms rational expectation is that its own relative price (relative to the equilibrium price) will fall constantly over the period its price is held fixed.

Notation:

P_t = nominal price charged by the firm at time t.

g = expected rate of change of the equilibrium price.

$\bar{P}_t = e^{gt}$ = expected equilibrium price at time t, formulated at t_o: by normalization $\bar{P}_o = 1$.

$Z_t = P_t/\bar{P}_t$ = expected relative price at time t, formulated at t_o.

q_t = $f(Z_t)$ = expected quantity demanded.

cq_t = expected cost of production

$F(Z_t)$ = $[Z_t - cf(Z_t)]f(Z_t)$ = expected real profit

β = real cost of nominal price adjustment, ($\beta > 0$)

r = real rate of interest

V_o = present discounted value of real profits at time t_o.

Suppose at t_o the firm plans to adjust its nominal price at the points of time

$$t_o \le t_1 \le t_2 \le \ldots\ldots \le t_\sigma \le t_{\sigma+1} \le \ldots\ldots$$

Denote the nominally fixed price in the interval $[t_\sigma, t_{\sigma+1}]$ by P_σ. Then $P_\sigma e^{-gt}$ is the expected relative price at t in this period. Accordingly, expected total real profits of the firm during this period, including the cost of price adjustment at time $t_{\sigma+1}$, discounting to t_o, are given by:

$$\int_{t_\sigma}^{t_{\sigma+1}} F(P_\sigma e^{-gt})\ e^{-rt}dt - \beta e^{-rt_{\sigma+1}} \qquad (3.8)$$

Summing over σ in (3.8) yields

$$V_o = \sum_{T=0}^{\infty} [\int_{t_\sigma}^{t_{\sigma+1}} F(P_\sigma e^{-gt})e^{-rt}dt - \beta e^{-rt_{\sigma+1}}] \qquad (3.9)$$

where the initial price, P_σ, is assumed to be given and $t_o = 0$.

The objective of the firm is to choose the sequence $\{t_\sigma\}$ and $\{P_\sigma\}$, $\sigma = 1,2$ ..... that maximizes V_o. It is assumed that F(.) is differentiable, strictly quaisi-concave, that there exists a number $S^* > 0$, and that any Z for which F'(Z) exists:

$$F'(Z) \gtreqless 0 \text{ as } Z \gtreqless S^* \qquad (3.10)$$

Thus F(Z) attains a unique maximum at S*. Further assumptions are required in order to insure that $V_o \geq 0$ at the optimum, specifically the adjustment cost β should be small relative to F(S*).

Assuming that an interior maximum exists the first order conditions are:

$$\partial V_o / \partial t_\sigma = [- F(P_\sigma e^{-gt}) + F(P_{\sigma-1} e^{-gt}) + \beta r] e^{-rt} = 0 \qquad (3.11)$$

$$\partial V_o / \partial P_\sigma = \int_{t_\sigma}^{t_{\sigma+1}} F'(P_\sigma e^{-gt}) e^{-(r+g)t} dt = 0 \qquad (3.12)$$

$$\sigma = 1,2 \ldots\ldots$$

From (3.12) it can be seen that when g = 0, there will be a unique optimal price P*, such that f' (P*) = 0 which holds for all σ. Consequently, $\partial V_o / \partial r_\sigma > 0$ for any σ, which means that it is never optimal to change price in the absence of shocks to the economy. It can similarly be seen that if $\beta = 0$ the nominal price will change continuously so as to keep price at its equilibrium level. The subsequent analysis will focus on the non-trival case of $g \neq 0$ and $\beta > 0$.

Sheshinski and Weiss (1977) show in their appendix that for any initial price P_o a solution to the system (3.11)-(3.12) must have an expected periodic (or recursive) form:

$$P_\sigma = P_{\sigma+1}e^{g\varepsilon} \text{ and } t_{\sigma+1} = t_\sigma + \varepsilon; \ \sigma = 1,2... \qquad (3.13)$$

where $\varepsilon > 0$ and is constant.

This property follows directly from the independence of the real optimal policy evaluated at any σ, of initial conditions. Due to the recusive nature of the solution, the relative price in each period is expected to move between two fixed values (s,S) where $S = se^{g\varepsilon}$. Changing variables by the transformation $Z = P_t e^{-gt}$ conditions (3.11)-(3.12) can be expressed in terms of relative price (Z_t) instead of time.

$$F(s) - F(S) + r\beta = 0 \qquad (3.11')$$

$$\int_s^S F'(Z)\, Z^{r/g} dZ = 0 \qquad (3.12')$$

Conditions (3.11') and (3.12') are two equations to determine the bounds (s,S) on the relative price movement.

The value of the expected discounted real profit at the time of the first price change, V_1, is given by:

$$V_1 = \frac{1}{1 - e^{-r\varepsilon}} \left[\int_0^\varepsilon F(P_1 e^{-gt}) e^{-rt} dt - \beta \right] \qquad (3.14)$$

Using the same transformation as above (3.14) becomes:

$$V_1 = \frac{1}{g(S^{r/g} - s^{r/g})} \left[\int_s^S F(Z).Z^{(r/g)-1} dZ - \beta g S^{r/g} \right] \qquad (3.15)$$

Differentiating (3.15) partially with respect to S and s, and equating to zero, we obtain the first order conditions:

$$F(S) - rV_1 - \beta r = 0 \tag{3.16}$$

$$- rV_1 + F(s) = 0 \tag{3.17}$$

which are equivalent to (3.11') and (3.12'), as can be seen by integrating the latter by parts. We also find that any points (s,S) which satisfies conditions (3.16)-(3.17);

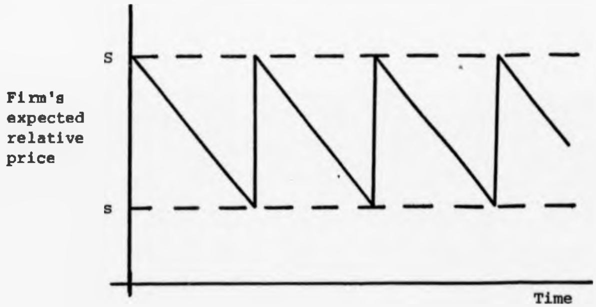
$$\partial^2 V_1/\partial s^2 = \frac{F'(s)s^{(r/g)-1}}{g(S^{r/g} - s^{r/g})} < 0$$

$$\partial^2 V_1/\partial S^2 = \frac{F'(S)S^{(r/g)-1}}{g(S^{r/g} - s^{r/g})} < 0$$

where by (3.10) and (3.12'), $F'(S) < 0$ and $F'(s) > 0$. Thus at any stationary point the second order conditions are satisfied. This implies that the solution to (3.16)-(3.17) is unique. Note also that if there exists a solution to (3.16)-(3.17) with $F(s) > 0$ then in view of (3.17) $V_1 > 0$ at the optimum. Conversely, any solution to (3.16)-(3.17) which entails $F(s) < 0$ cannot be globally optimal. The interpretation of these equations and the properties of the optimal plan are straightforward. The firms price is expected to be held fixed over an interval ε. The relative price drifts continuously (if there are no shocks to the market) from the initial level S to the level s at the end of the period, at which point a jump occurs and the relative price is again set at S. The gains from postponing a price change are the profits just prior to the change, F(s), and the interest saved on the adjustment cost, $r\beta$. The losses from such a postponement are the profits just after the change, F(S). Condition (3.11') states that at the optimum these gains and losses should be equal. Equation (3.12') states that the nominal price should be set at such a level that the marginal profits due to the change in relative prices will average to zero. In view of (3.11) we have from (3.12) that $s < S^* < S$, i.e. the firm operates initially with negative marginal profits and with positive marginal profits towards the end of the period.

The firms expected path for its relative price, which is realized if there are no shocks to the equilibrium price is illustrated in Figure 3.1.

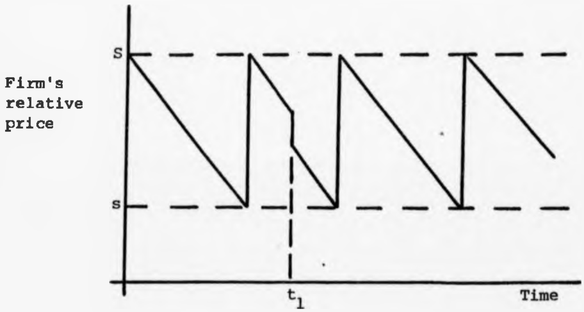
Figure 3.1



The presence of "small menu" costs is thus seen to be able to provide an explanation of why firms do not set prices continually equal to the equilibrium, market clearing level. With relative price alternating around the equilibrium price the individual firm experiences alternating disequilibrium regimes of excess supply and excess demand.

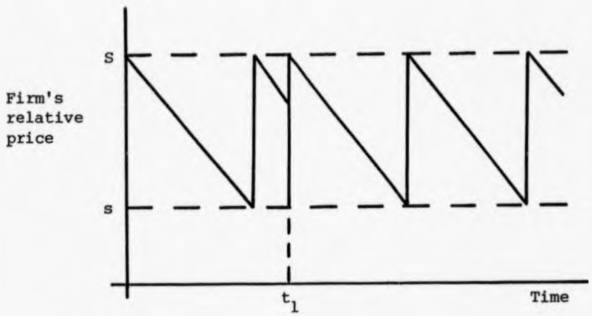
What are the consequences of introducing shocks to the market equilibrium price? Whether a firm changes its nominal price in response to a shock depends upon the firms relative price at the time of the shock, and the size of the shock itself. In Figure 3.2 there is illustrated the effect on the firms relative price due to a shock to the market that increases the equilibrium price at time t_1. Due to this positive shock to the equilibrium price.

Figure 3.2



the firm's relative price instantaneously falls at t_1. As shown in Figure 3.2 however the shock is not large enough to reduce the firms relative price below s, thus the firm does not immediately change its nominal price, but instead waits until its relative price falls further to s before again setting relative price equal to S. If the firms relative price had been close to s at t_1, or the shock was larger, then the shock may have caused the firm to immediately increase its relative price to S. This case is seen in Figure 3.3.

Figure 3.3



Similar results can be shown for negative shocks to the market equilibrium price. In this case the firm will observe that its relative price increases at the time of the shock. If the shock is great enough the firms relative price may jump above S. Here the firm will either reduce their nominal price, so that their relative price equals S, or they will allow the relative price to fall gradually towards s, depending upon the relative costs.

The affect, therefore, of shocks to the market equilibrium price on the firm's nominal price path, is to make both the duration for which it is held constant and the level to which it is adjusted random variables. Further the individual firm will, in general, experience alternating excess supply and excess demand. Whether this result continues to hold across firms is explored in the next section.

3.4 Aggregate wage and price dynamics

In the previous Section we considered three broad reasons for why individual agents may not set the price of their good at the equilibrium level. Here we examine the consequences of these theories for aggregate wage and price dynamics, and aggregate disequilibrium

3.4i Imperfect information and learning

in Section 3.3i imperfect information related to individuals having incorrect knowledge about either the values of economic variables, or the structure of the economy, including both specification and parameter values. Due to the frequent publication of official statistics imperfect knowledge concerning variables was argued to be short lived and insignificant, we therefore confine our attention to the consequences of imperfect information concerning the structure of the economy.

With incorrect knowledge about the structure of the economy individual's expectations will not exhibit the error orthogonality property, thus giving agents the incentive to improve their forecasting ability. Agents will only change their believed model if the new model produces improved forecasting, and, if there are no costs involved in learning, they will continually change their views about the economy until the believed model converges upon the "true" model. However, as related in Section 3.3i if agents are not assumed to have correctly specified likelihood functions, and learning is based upon standard statistical techniques, then convergence to rational expectations is not assured, with stability dependant on the specific learning procedure, parameters and priors.

What does this imply about aggregate disequilibrium and price level adjustment? Agents set prices on the basis of their expectations. Given incorrect expectations, individual prices will not be set at their equilibrium values. However, will it not be the case that these forecasting errors will tend to cancel each other out as we aggregate over individuals, implying that on average prices are at their equilibrium levels, and consequently there is no aggregate disequilibrium? It is argued that, in general, this will not be the case. Suppose that individuals initially know the structure of the economy, which is in a rational expectations equilibrium. Now consider that some aspects of the economy undergoes a structural change, which agents cannot directly observe, either a parameter change or an equation is re-specified. Because of this unforeseen change all individuals will make forecasting errors that are qualitatively the same. Thus following this change there will be aggregate disequilibrium, with all prices being either above or below their market clearing value. As expectations improve so prices will adjust though typically in a complex way, but in general aggregate disequilibrium will persist. For example, Friedman (1979) shows that for the model he developes (a discrete time model where agents know the correct structural specification of the economy but need to learn the value of the parameters using standard least squares estimation procedures) the adjustment of expectations resembles the adaptive expectations mechanism. In this case aggregate prices are seen to move toward their equilibrium values over time, reducing the extent of disequilibrium, which nonetheless persists.

In conclusion, imperfect information and the problems of learning the structure of an economy, is able to explain the presence of aggregate disequilibrium and why this may persist, even indefinitely.

3.4ii Contract theory

As shown in Section 3.3ii agents have various incentives to develop exchange contracts. Further there are limitations on the set of feasible contractual arrangements, causing contracts to be incomprehensively indexed to contingencies. This results in wages and prices in certain markets, being inflexible for sustained periods of time, giving rise to disequilibrium subsequent to a shock to that market.

In order to examine the consequences for aggregate wage and price dynamics a number of simplifying assumptions are made. We thus assume that all contracts relating to a particular market, have the same frequency of revision, f; that revision of contracts is asynchronized; and that the rates of change of equilibrium prices are the same, following a shock. This framework is identical to Mussa (1981), except that he justifies, incorrectly, his assumption on fixed contract length by reference to "small menu" costs, instead of contract theory. Mussa (1981) shows that the rate of change of the general price level is given by:

$$\partial P/\partial t = \pi(t) + \delta\ (\bar{\bar{P}}(t) - P(t)) \qquad (3.18)$$

where $\delta = 2/T$; $T = 1/f$ is the length of the interval for which the price is held constant. $\bar{\bar{P}}$ is the equilibrium price level. The first term in the adjustment rule for the general price level, $\pi(t)$, is the expected rate of change of the equilibrium price level. The term keeps the price level diverging further from its equilibrium level. The second term, $(\bar{\bar{P}}(t) - P(t))$, drives the price level toward the equilibrium if it is not already there. The average lag in reaching the equilibrium is $1/\delta = T/2$; that is, the average lag is equal to the time it takes for the prices of one half of the individual "commodities" to adjust to their equilibrium levels.

It is apparent that there is an important qualitative difference between adjustment of individual prices and adjustment of the aggregate price level. Individual prices are held constant over a finite interval, and then adjusted by discrete amounts to their expected (average) equilibrium levels for the subsequent interval. In contrast, the general price level moves continuously and adjusts gradually toward its equilibrium level following a shock. This behaviour of the aggregate price level reflects the fact that it is an average of prices which are revised at different points in time. The price adjustment mechanism derived from contract theory shows that the aggregate price level will eventually converge upon the equilibrium level. Again we are able to explain why aggregate prices (and wages) may only move slowly toward their market clearing values, and also why aggregate disequilibrium persists.

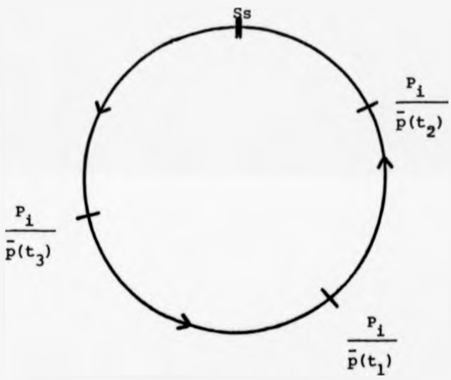
3.4iii "Small-menu" costs

In Section 3.3iii we demonstrated that, if in response to cost of changing prices, firms adopt the (s,S) pricing rule, then individual prices will remain fixed for prolonged periods. Thus as with imperfect information and contracts these rules appear to have the potential to explain aggregate price level inertia. However, in a recent paper Caplin and Spulber (1986) have shown that this is not necessarily the case. This has led Blanchard (1987) to write of "the failure of individual nominal rigidities to generate aggregate price inertia under simple (s,S) rules".

In their paper, Caplin and Spulber derive the aggregate behaviour of prices and output in response to changes in nominal money when there is a continuum of identical price setters following the (s,S) rule. To develop their model they make three basic assumptions. First they assume that the money supply process is increasing over time and does not make discrete jumps. That is they assume monotonicity and continuity for the money supply process. Second the aggregate price index is assumed to depend only on the frequency distribution over nominal prices, and satisfy homogeneity; when nominal prices double, so does the index. Third firms' initial real prices are assumed to be uniformly distributed over the range (s,S). This implies that price changes are uniformily staggered over time. Given these assumptions Caplin and Spulber show that real balances and aggregate output are invariant to monetary shocks. Price stickiness disappears in the aggregate.

This neutrality result may be understood by observing that the (s,S) policy moves real prices around a circle. The method of proof is easily illustrated using Figure 3.4 (which corresponds to Figure 2 in Caplin and Spulber). Points on the circle represent the range of the

Figure 3.4



firm's real prices. At the apex of the circle, the outer limits of the range are adjacent. At time t_1, $Pi/\bar{p}(t_1)$ is firm i real price. Inflation occuring between time t_1 and t_2 reduces the real price to $Pi/\bar{p}(t_2)$ as indicated by the counter clockwise motion. Between time t_2 and t_3 inflation drives the real price down to s, the price is then readjusted to S and further inflation drives the real price to $Pi/\bar{p}(t_3)$. It is critical to note that, given a continuous money supply process, a change in monetary policy only causes the firms real price to rotate around this circle faster. The initial distribution of real prices is preserved and the aggregate nominal price index exactly reflects any nominal money shock. The aggregate price level remains at its equilibrium level, and there is consequently no aggregate disequilibrium. As can be seen, and as Caplin and Spulber note, this result is only valid under the restrictive assumption that monetary policy does not cause the money supply, and hence the equilibrium price level to change by discrete amounts. We now examine the consequences when this assumption is relaxed. As do Caplin and Spulber we assume that price adjustments are initially uniformly distributed over time. Given this assumption any initial shock to the market equilibrium causes the aggregate price index to jump above the new equilibrium level, given a continuum of firms. To see why this is so we first consider the example of an upward jump in the equilibrium price. If the shock is sufficiently large then all firms increase their nominal and relative price instantaneously, so that their new relative price equals S, above the new equilibrium value, and price adjustments are now synchronized. Obviously here the general price level jumps above the new equilibrium level. Alternatively if the shock is infinitely small then the aggregate price remains equal to its equilibrium value. With the number of firms increasing their price being uniquely and linearly related to the size of shock any positive shock to the equilibrium price causes the general price index to jump above the new equilibrium level.

The argument is similar for a negative shock to the equilibrium price level. In this case a proportion of firms observe that their relative price has increased above S. Here the firm either reduces its nominal price, so that its relative price equals S, or they allow the relative price to fall gradually due to the increasing equilibrium price, depending upon relative costs. However, whatever the firm decides its relative price will have, in general, increased, and therefore the aggregate price index will now be above its equilibrium level.

Therefore, with a uniform distribution of price adjustment, any shock causes the aggregate price to jump above the new equilibrium price. This result is due to the fact that now the degree of synchronization increases whenever there is a shock, and because firms always adjust their nominal price to a level above the market clearing value. It is noted, therefore, that the assumption of uniform distribution of price adjustment is less plausible given the presence of continuing shocks. Indeed with random shocks price adjustments will become perfectly synchronized over time. As price adjustments become synchronized so the qualitative difference between aggregate and individual prices is reduced, and in the limit, i.e. when price adjustment is perfectly synchronized, they are identical. Thus with continuing shocks the aggregate price path approaches a step function. However if firms pursue slightly distinct (s,S) policies or randomize on their choice of s, as in Benabou (1985), then in the absence of shocks price adjustment again tends towards asynchronization over time and the aggregate price path becomes continuous. Despite this any shock will tend to increase synchronization of price adjustment and, in general, cause the aggregate price level to be away from its market clearing level. Typically the aggregate price path will be complicated leading to alternating periods of excess demand and supply. Monetary policy is now effective.

In conclusion "small-menu" costs, by explaining why firms may adopt an (s,S) policy rule, in conjunction with discrete changes in equilibrium values, is able to explain why aggregate prices may not be at their market clearing levels, and thus why we may observe aggregate disequilibrium.

3.5 Conclusions

This Chapter has critically assessed and extended recent work on wage and price adjustment and shown that rational economic behaviour can provide an adequate basis for disequilibrium theory. The first theory examined was that prices respond so as to ensure continual equilibrium. This was found to be unsatisfactory with agent's decisions not based on "choice theoretic foundations". What is needed is a theory of how plans are formulated by agents and how these plans are revised in the light of new information. There are two alternative theories of imperfect price adjustment. The first states that prices respond to disequilibrium, with equilibrium being the limit of this process, assuming stability. This theory was found to be ad hoc and incompatible with the assumption of full rationality of agents. The other theory is that disequilibrium occurs because prices for some reason do not instantaneously adjust to their equilibrium values. This interpretation actually goes to the root of the question why disequilibrium exists. In order to develop this theory we analysed three broad reasons which have been proposed in the literature to explain why individual prices may not be set at their market clearing values; imperfect information and learning, contracts, and the presence of "small-menu" costs. It was shown that each of these considerations gave rise to imperfect price adjustment, and to disequilibrium at the individual agent level. It was further demonstrated that such disequilibrium persists, given plausible assumptions over aggregation. Actual wage and price dynamics depend upon the reasons for why individual wages and prices are inflexible.

One of the main innovations of this Chapter has been its broad approach to wage and price adjustment, and disequilibrium.

Instead of concentrating on one particular theory, to the exclusion of others, we critically examined each of the main theories recently advanced, clearly stating where theories are mutually exclusive and where they may complement each other. As well as providing a general overview of wage and price adjustment, the Chapter has developed and extended previous theories. The main contribution here is with respect to recent work on the effects of "small menu" costs. By relaxing restrictive assumptions it was shown that previously held results are not robust. For example by incorporating the (s,S) policy rule for price adjustment into a model where there are discrete shocks it was shown that disequilibrium persists in the aggregate and that monetary policy is non-neutral.

CHAPTER 4

SINGLE PERIOD QUANTITY RATIONING MODELS

Having argued in Chapter 3 that disequilibrium theory is an appropriate area for economic research, we now critically examine some of the first generation quantity constrained models, and develop the basis for modelling disequilibrium dynamics in subsequent chapters.

As stated in Chapter 2 the assumption of imperfect price adjustment cannot merely be appended on to an otherwise market clearing model. This is because limited price adjustment, via resulting disequilibrium, gives rise to quantity adjustments which need to be explicitly taken into account if disequilibrium is to be modelled consistently. Temporary equilibrium models with rationing (sometimes termed "disequilibrium models") have been proposed to examine the consequences of imperfect price adjustment. . Most of these models have been single period or static models, in the sense that prices are assumed to be fixed with equilibrium being established solely via quantity adjustments. This Chapter surveys and evaluates some of these static models.

Clower (1965) argued that classical economics was unable to provide useful insights into disequilibrium states. Wage and price rigidity might lead to conditions of unemployment, yet the general paradigm gives a general theory only of equilibrium states. It can yield no information about the magnitude of realised, as opposed to planned, transactions under disequilibrium conditions. To obtain these spillover effects between markets one has to do away with the "strong assumption of instantaneous price adjustment". If trading should be occuring at false prices, all desired transactions may not

not take place. Transactors who fail to realise their desired sales may then curtail their effective demand in other markets. Clowers attack on classical economics is presented in Section 4.1 within the context of Walrasian equilibrium. Clower's proposed modelling strategy for studying disequilibrium the "dual decision hypothesis" is also presented and critically assessed. It is argued that whilst Clowers critique of classical economics is valid the dual decision hypothesis is an unsatisfactory basis for disequilibrium economics.

Section 4.2 examines more rigorous attempts to model temporary equilibrium with quantity adjustment. The two main formulations of effective demand and equilibrium employed in the literature, associated with Bénassy (1975, 1976) and Drèze (1975), are considered. It is shown that both formulations have major shortcomings specific to each. However a more fundamental criticism is the fact that there is a multiplicity of effective trade offer definitions leading to the problem of indeterminacy and arbitrariness. Due to this problem it seems that a complete respecification of the way disequilibrium is modelled is needed. At the end of Section 4.2 work by Sneessens (1981) is reported which attempts to provide a proper basis for a disequilibrium model. It is this basic modelling strategy that is used in subsequent Chapters of this thesis.

Finally in Section 4.3 we examine the consequences of introducing international trade into a disequilibrium model. This section along with Section 4.2 provides the basis for Chapter 6 where various open economy disequilibrium models are developed. Conclusions to the Chapter are presented in Section 4.4.

4.1 The dual decision hypothesis

In 1965 Robert Clower published a paper attacking the classical features that had crept back into the Keynesian paradigm. Clower's main criticism of classical economics was that it made the incorrect assumption that the model of consumer behaviour which is appropriate in equilibrium is also appropriate in disequilibrium. Clower presented this criticism by attacking the most precise and elegant representation of classical theory, Walrasian equilibrium, and in particular the validity of Walras's law. To illustrate these criticisms we use a model of pure exchange, that is an economy in which the economic agents are all consumers who exchange and consume the existing stock of commodities but do not engage in production.

There are assumed to be n consumers, indexed $i = 1, \ldots\ldots, n$ and $\ell + 1$ commodities, indexed $h = 1, \ldots\ldots, \ell$, with the $(\ell + 1)$ th being a distinguished commodity which may be thought of as "money". The i-th consumer initially holds $e_h^i \geq 0$ units of commodity, $h = 1, \ldots\ldots, \ell$ and $\bar{m}^i \geq 0$ units of "money" so his initial endowment can be represented by the ordered pair (e^i, m^i) where $e^i = (e_1^i, \ldots\ldots, e_\ell^i)$. His preferences are represented by a utility function u^i. If he consumes $x_h^i \geq 0$ units of commodity $h = 1, \ldots\ldots, \ell$ and m_i units of money and p_h is the price of good h, then the consumer's utility is $u^i(x^i, m^i, p)$ where $x^i = (x_1^i, \ldots\ldots, x_\ell^i)$ and $p = (p_1, \ldots\ldots, p_\ell)$. The appearance of prices in the utility function is explained by the fact that it is only real balances that matter to the consumer.

The consumer observes the prevailing prices and chooses to make those trades in money and commodities which will maximize his utility subject to the usual budget constraint. That is for each $i = 1, \ldots\ldots, n$ it is assumed that:

(x_i, m_i) maximizes $u^i(x^i, m^i, p)$ subject to the budget constraint (4.1)

$$\Sigma_{h=1}^{\ell} p_h x_h^i + m^i \leq \Sigma_{h=1}^{\ell} p_h e_h^i + \bar{m}^i$$

The decision problem described in (4.1) always has a solution if u^i is continuous in (x^i, m^i) and the price of each good is positive. If u^i is strictly quasi-concave in (x^i, m^i) then the solution is unique. Making these assumptions let p be any vector of strictly positive prices and let $f_h^i(p)$ (respectively $f_o^i(p)$) denote the optimal excess demand $(x_h^i - e_h^i)$ for commodity $h = 1, \ldots\ldots, \ell$ (respectively the optimal excess demand $(m^i - \bar{m}^i)$ for "money"). Let $f^i(p) = (f^i(p), \ldots\ldots, f_\ell^i(p))$ and $\hat{f}^i(p) = (f_o^i(p), f^i(p))$. A Walrasian equilibrium is defined to be a price vector p* at which each market clears. Demand equals supply in each market if and only if the sum of individual consumers' excess demands are zero, that is:

$$\Sigma_i^n \quad \hat{f}^i(p^*) = 0 \tag{4.2}$$

Condition (4.2) may therefore be treated as a definition of equilibrium.

The object of Clower's attack on the classical system was not the definition of equilibrium but what it implied about the behaviour of the economy in disequilibrium. If a consumer is not satiated, then he will spend all his income. Precisely, if his utility function is monotonic then:

$$\Sigma_{h=1}^{\ell} \quad p_h x_h^i + m^i = \Sigma_{h=1}^{\ell} p_h e_h^i + \bar{m}^i$$

at an optimum. This equation can be written more compactly in vector notation as $p\,x^i + m^i = pe^i + \bar{m}^i$. It is easy to see that this is equivalent to writing $pf^i(p) + f_o^i(p) = 0$, since $f^i(p) = x^i - e^i$ and $f_o^i(p) = m^i - \bar{m}^i$. Using the notation $f(p) = \Sigma_{i=1}^n f(p)$ and $f_o(p) = \Sigma_{i=1}^n f_o^i(p)$, we have

$$\Sigma_{i=1}^n [pf^i(p) + f_o^i(p)] = 0$$

$$\therefore \quad p\Sigma_{i=1}^n f^i(p) + \Sigma_{i=1}^n f_o^i(p) = 0$$

$$\therefore \quad pf(p) + f_o(p) = 0$$

The relation $pf(p) + f_o(p) = 0$ is known as Walras's law. It holds for any value of p, not just in equilibrium. In other words, it says the values of aggregate excess demands, summed over all markets, is zero. It implies that if there is aggregate excess supply in one market there must be aggregate excess demand in another. For if $f_h(p) < 0$ for all $h = 1, \ldots\ldots, \ell$ and $f_h(p) \leq 0$ for some h then $pf(p) + f_o(p) < 0$ since $p > 0$. But this condition contradics Walras's law and so establishes the claim.

The importance of Walras's law in the context of Keynesian economics is that it apparently rules out the possibility of a general glut of commodities. For every excess supply there must be an equal (value of) excess demand somewhere in the system. Corresponding to an excess supply of labour there must be an excess demand for goods. The former will drive down the level of money wages while the latter raises money prices. The resulting fall in the real wage will increase the demand for labour and lead the economy back to full employment.

The fallacy in this argument, that Clower noted, is that it assumes that the model of consumer behaviour which is appropriate in equilibrium is also appropriate in disequilibrium. In the decision problem (4.1), the consumer is assumed to choose (x^i, m^i) subject only to the budget constraint imposed by his wealth. In other words, he makes the usual competitive assumption that he can trade as much as he likes at the prevailing prices. But if p is not an equilibrium price i.e. $\bar{f}(p) \neq 0$, then consumer's plans are inconsistent. They cannot all trade as much as they would like to. Once they recognize this fact, their behaviour will change. Then (4.1) is no longer an appropriate description of their behaviour. It is clear that the argument used to prove Walras's law is flawed. The Walrasian theory of equilibrium does not provide a satisfactory account of how agents will behave in disequilibrium. But what is to replace (4.1)? In an attempt to answer this question Clower introduced the dual decision hypothesis (DDH). The simplest way to understand the DDH is to see it as an extension to the Walrasian tâtonnement. In the classical tâtonnement the fictional auctioneer calls out a vector of prices, the consumers respond by expressing their (Walrasian) excess demands and the auctioneer then adjusts prices. If the aggregate excess demand is positive then he raises the price, if it is negative he lowers the price. Walras's law ensures that there are always some prices rising and some falling in disequilibrium. Furthermore because consumers always express excess demand derived from (4.1) the only possible resting point of this process is the Walrasian equilibrium defined by (4.2).

Clower introduced the following innovation. After the auctioneer calls out the price p and consumers have responded with excess demands, $f^i(p)$, the auctioneer notes the goods markets on which there is excess supply. If $f_h(p) < 0$ for some $h = 1, \ldots\ldots, \ell$, he rations the consumers on the long side of the market. The auctioneer informs each consumer of the value of the ration he has assigned and the consumer is then allowed to revise his excess demands. In effect there is the added constraint that the consumer must choose an excess demand to his ration, if he would have been unable to sell as much as he wished in the first round. These excess demands Clower calls effective excess demands because in deriving them he has taken account of the fact the consumer would have been unable to sell as much as he wanted to in the first round. In general the effective demands will differ from the first round Walrasian (or notional) demands. It is clear that rationing adds another level of complexity to our modelling. It is necessary to include income effects that are ignored in general equilibrium theory, being determined by prices and quantities. Thus while classical economists may have recognized that with wage rigidity unemployment is possible, their restriction to considering only notional supplies and demands means they have no way of determining what will happen when full employment is indeed not reached - effective demands are outside their purview. Classicial economics then becomes a special case of the Keynesian alternative, relevant only when notional demands equal effective demands, when no markets are out of equilibrium. It should be noted here that Arrow and Hahn (1971) in their definitive work on classical general equilibrium theory suggests that one of its main uses is to show the strength of the necessary assumptions involved in its results and deter those who see it as a final answer, rather than a beginning, even if an elegant one.

The next stage in Clowers tâtonnement is to adjust the prices. Here it is assumed that the auctioneer changes prices in response to effective, rather than notional, excess demands. The relevance of this assumption to Keynesian economics is clear. If consumers find in the first round that they could sell less than they had planned, then they will be forced, in the second round, to buy less than they had planned. Clower presented, but did not make precise, the argument that it is possible that excess demand fail to appear anywhere in the system, implying that prices will not move to clear markets.

Although Clower has introduced the distinction between effective and notional demands, essential for any satisfactory theory of disequilibrium there are a number of criticisms to be made of the way he does so. First there is no reason to suppose that consumer's plans will be consistent after the second round. If not there may be further rationing, leading to further revisions of effective demands. This process may continue indefinitely. Second there is no obvious reason for rationing excess supplies and not excess demands. Third Clower assumed that rationed consumers must always offer to sell exactly the amount they were able to sell in the first round, this seems unduly restrictive. In any case the contraint is quite arbitrary and may even be inconsistent with rational behaviour. Other criticisms of Clower's tâtonnement process are that the effective excess demand is not necessarily less than the Walrasian excess demand for every commodity and also the DDH has nothing to say about what is considered to be an equilibrium of the system.

Clowers initial criticisms of classical theory are valid, but because of these reasons the DDH is no longer considered a serious part of disequilibrium theory. What is needed is a satisfactory theory of effective demand.

4.2 Quantity rationing models

Many of the existing disequilibrium models follow the work done by Barro-Grossman (1971), Bénassy (1975) and Malinvaud (1977). They embody very similar assumptions which can be summarised as follows:

A1: the rationing schemes in force satisfy:

(a) voluntary exchange

(b) feasibility

(c) market by market efficiency (i.e. only one side of the market is rationed).

A2: rationing schemes are perceived as non-manipulable and deterministic. (By non-manipulable it is meant that the trade a single agent realizes if he is rationed is independent, except via aggregates, of the effective demand he expresses. While deterministic means that the rationing scheme is a known function of individual and aggregate excess demands.)

A3: trading does not take place out of equilibrium.

By assumption A1 aggregate realized transactions will always be the minimum of aggregate (effective) demand and aggregate (effective) supply. By assumption A2 agents believe that they are facing exogenous quantity constraints. Expectations about these constraints are held with certainty. From A3 we know that these expectations will not be invalidated by realized transactions; an individual who expected to be rationed is actually rationed by the amount he expected and vice-versa. Each agent will thus believe that his perception of the economic environment is correct and, ceteris paribus, he has no incentive to revise his trade offer. An equilibrium will prevail. Assumption A3 is equivalent to assuming that prices are held constant until quantities have fully adjusted.

Only then are prices allowed to adjust. This is Hicks' fixed price assumption. Looked at in this light the DDH is the first step in a tâtonnement of quantities while prices are held constant. The trouble with the DDH has been supposed to be that it does not allow the tâtonnement to go far enough. There is no reason to expect the effective excess demands generated at the second round to be the ones actually observed in equilibrium. Thus it seemed natural for economists to examine the consequence of holding prices constant until quantities have fully adjusted to the fact of disequilibrium and are consistent with one another.

Although many of the existing disequilibrium models make use of the assumptions A1-A3 there is a difference in the way they determine the constrained optimization of the utility function. Indeed, because of this there are two basic models of effective demand and equilibrium that have been employed, one associated with Bénassy (1975, 1976) the other with Drèze (1975). We examine each of these in turn.

4.2i Bénassy equilibrium

The Bénassy equilibrium was the result of the first really rigorous attempt to model an equilibrium of the quantity adjustment process with fixed prices. We again make use of the pure exchange economy introduced in the previous section. Although there are $\ell + 1$ commodities there are assumed to be only ℓ distinct markets, one for each commodity, $h = 1, \ldots\ldots, \ell$. "Money", instead of being traded in a market of its own is traded against each of the other commodities in their respective markets. Let $\tilde{z}_h^i$ denote the number of units of the h-th commodity that the i-th consumer offers to trade. By convention, positive numbers represent demands and negative numbers supplies. Let $\tilde{z}^i = (\tilde{z}_1^i, \ldots\ldots, \tilde{z}^i)$ be the vector consisting of the i-th consumer's offer to trade commodities $h = 1, \ldots, \ell$. Let $\tilde{z} = (\tilde{z}^1, \ldots, \tilde{z}^n)$ be an array of these trade offers, one for each consumer $i = 1, \ldots, n$.

The final net trades of each consumer are determined by a rationing scheme $\{F^i\}_{i=1}^n$. For each consumer $i = 1, \ldots, n$, F^i is a function which assigns a final net trade, $z^i = F^i(\tilde{z})$, to the i-th consumer, for each array of trade offers $\tilde{z}$. The rationing scheme represents the disequilibrium allocation process of the market.

Consumers observe prices, make offers to trade and then observe the actual trades they could have been able to make. From this experience, i.e. from the comparison of $\tilde{z}^i$ and z^i and perhaps from observing the experience of other consumers, they form an impression of the trading possibilities in the market at that time. Since final net trades are functions of $\tilde{z}$, the constraints perceived by the consumer must be a function of $\tilde{z}$ also. For each commodity, $h = 1, \ldots, \ell$, the i-th consumer perceives that his net supply is bounded below by $\underline{z}_h^i \leq 0$ and his net demand is bounded above by $\bar{z}_h^i \geq 0$. These constraints are determined by the equations $\underline{z}_h^i = \underline{G}_h^i(\tilde{z})$ and $\bar{z}_h^i = \bar{G}_h^i(\tilde{z})$. The functions $\{(\underline{G}_h^i, \bar{G}_h^i)\}$ are part of the description of the economy or, equivalently, part of the agent's characteristics. Bénassy assumed that in any market agents can send offers violating their constraints. That is, effective demand for commodity h is based on constraints perceived on other markets, but ignoring the constraints on commodity h. The trade offer for each commodity is determined independently. The trade offer $\tilde{z}^i$ is the result of these uncoordinated decisions. For each $h = 1, \ldots, \ell$,, look at the h-th component of the vector z^i such that

$$z^i \text{ maximises } u^i\ (e^i + z^i, m^i - pz^i, p)$$

subject to the constraints $\underline{z}_k^i \leq z_k^i \leq \bar{z}_k^i$ for all $k \neq h$.

In order to choose this optimum the agent needs to know the quantity constraints which will be imposed in disequilibrium, with the constraints being jointly determined by the trade offers of all consumers. Hence in equilibrium the trade offers must simultaneously maximize utility subject to the perceived constraints and generate the perceived constraints via the rationing scheme. One should note that in a Bénassy equilibrium one does not require the actual trades to be equal to effective demands only that effective demands "reproduce" themselves.

The main problem with this theory of disequilibrium is that the consumer solves a different decision problem to arrive at his trade offer for each commodity h. This may be visualized as follows. The consumer goes from market to market expressing offers to trade various commodities. When he arrives at the h-th market he forgets about the possible constraint on that market and offers to trade the quantity which would maximise his utility, if he were subject to perceived constraints on all markets but this one. When we combine these offers derived in these separate maximization problems there is no reason to think it represents the behaviour of a rational consumer. There is no coherent decision problem behind the consumers derivation of his trade offers. It does not necessarily maximize the consumer's utility within the available set of trades. And the final net trade resulting from the offers may not even be feasible for the consumer.

Since the trade offer may not be feasible for the consumer one needs to be careful in using them in order to gain a measure of excess demand. In general the agents trade offers generated in Bénassy equilibrium are unrealiable as a measure of underlying disequilibrium. For example, suppose that there are two goods which are perfect substitutes.

If excess demand is constrained on both markets, the effect is simply to cause consumers to increase their demands on the other market. Indeed the effective trade offers for each commodity may even be greater than the sum of the individual Walrasian excess demands for them. The degree of disequilibrium implied by these effective trade offers is greater than that suggested by the initial Walrasian excess demands. This is obviously a serious problem of one wishes to introduce price adjustment in response to effective excess demands.

Despite these shortcomings there have been several applications of the fixed price method using Bénassy effective demands, including Glustoff (1968), Bénassy (1978) and Malinvaud (1977).

4.2ii Drèze equilibrium

The alternative Drèze formulation allows the agent when forming his excess demand for each commodity to consider the quantity constraints on all markets, including the commodity in question. Thus the i-th consumer is assumed to choose a final net trade

z^i to maximize $u^i(e^i + z^i, \bar{m}^i - pz^i, p)$

subject to the constraints $\underline{z}_h^i \leq z_h^i \leq \bar{z}_h^i$

for all $h = 1, \ldots\ldots, \ell$.

An equilibrium is here defined as a set of perceived constraints and actual trades such that each market clears, only one side of the market is constrained, and only voluntary exchange takes place. This concept of equilibrium does provide a coherent description of a disequilibrium state. Each agent is behaving rationally with respect to his preferences for final net trades and the plans of all agents are consistent.

A basic problem with the Drèze equilibrium, however, is that since agents are assumed to express demands satisfying perceived constraints, it does not generate an exchange of information concerning the magnitude of disequilibrium that agents face. Since each agent regards the quantity- constraints as parameters no-one attempts to break them. Agents are constrained in the messages they can send. In economic terms this means, for example, that a man who does not receive a job does not offer to work. His behaviour is quite rational in this context, but it does not provide a good description of how markets with rationing work. The cause of unemployment is not that unemployed workers are not allowed to search for jobs. Certainly with the Drèze formulation the final net trades cannot be interpreted as effective excess demands if the effective excess demands are supposed to be the appropriate signals for price adjustment. Since final net trades sum to zero, aggregate excess demands would be zero so there would be no sign of disequilibrium. This is unacceptable on both theoretical and practical grounds.

Another problem with the basic Drèze model is that it does not specify the actual rationing scheme. Many equilibria are possible depending on the specific rationing scheme. This problem of specification can be viewed in two ways. First one may argue that we are concerned with the aggregate constraint, it being of secondary importance which specific agents face rationing. One's concern is then limited to ensuring that the actual rationing schemes be internally consistent. Alternatively, one could say that the existence of equilibrium with aggregate constraints depends crucially on the specific rationing scheme. How job shortages are allocated is crucial in determining whether an unemployment equilibrium is a viable or even sensible concept. Under this view, failure to consider actually observed methods of rationing is a serious drawback of some quantity constrained models.

4.2iii <u>Indeterminancy</u>

It has been seen that both the Bénassy and the Drèze formulations of effective demand and equilibrium have major shortcomings specific to each model. However a more fundamental criticism of these approaches relates to the basic fact that there is a multiplicity of effective trade offer definitions each producing a quantity rationing model exhibiting unique properties. This difficulty was first pointed out by Bénassy (1977) who nevertheless concluded that the Bénassy concept of effective demand seemed to be the most natural one. This conclusion was thereafter challenged by Svensson (1980). According to Svensson, an assumption like A2, that the rationing schemes on markets are perceived as non-manipulable and deterministic, make indeterminacy unavoidable and leaves no a priori reason to prefer one concept to the other.

In order to highlight this problem of indeterminacy we shall examine a simple two market model for goods and labour. Aggregation problems will not be considered and only two types of agents will be distinguished: producers and consumers. Producers buy labour from the consumers and sell their output to consumers. Their behaviour is purely atemporal, which implies the absence of inventories and investments. It also means that labour is seen as a freely variable input. The goal is profit maximization subject to the technical constraint:

$$y_t = F(\ell_t)$$

where y_t is the quantity of goods produced and ℓ_t is the quantity of labour used in the production process. We assume that F is concave and strictly increasing in each argument.

Given this model and the three assumptions A1-A3 we are able to distinguish four possible regimes. Each regime is identified by the relative magnitude of the effective demand and supply on each market as is shown in Table 4.1.

Table 4.1

Goods / Labour	$y_t^d < y_t^s$	$y_t^d > y_t^s$
$\ell_t^d < \ell_t^s$	Keynesian Unemployment	Classical Unemployment
$\ell_t^d > \ell_t^s$	Underconsumption	Repressed Inflation

y_t^d, y_t^s are the effective demand and supply on the goods market, and ℓ_t^d, ℓ_t^s are the effective demand and supply on the labour market.

In keeping with the now well established terminology we shall call them respectively Keynesian Unemployment (KU), Classical Unemployment (CU), Repressed Inflation (RI) and Underconsumption (U).

The assumptions A1-A3 also contain some information about the specification of effective trade offers and of expectations. The equilibrium assumption introduces the link between expected constraints and realized transactions. For the unconstrained agent it means that the anticipated constraint was larger than or equal to his actual trade. As assumption A1 implies that all constrained agents are on the same side of the market, one also has the following aggregate relation:

$$\begin{aligned} &\bar{y}^d_t \geq y_t \quad \text{if } y_t = y^d_t \\ &\bar{y}^s_t \geq y_t \quad \text{if } y_t = y^s_t \\ &\bar{\ell}^d_t \geq \ell_t \quad \text{if } \ell_t = \ell^d_t \\ &\bar{\ell}^s_t \geq \ell_t \quad \text{if } \ell_t = \ell^s_t \end{aligned} \tag{4.3}$$

where y_t and ℓ_t are the transacted quantities on the goods and labour market respectively, $\bar{y}^d_t$, $\bar{y}^s_t$ are the aggregate quantity constraints perceived on demand and supply on the goods market, and $\bar{\ell}^d_t$, $\bar{\ell}^s_t$, are the aggregate quantity constraints perceived on the labour market. (The perceived aggregate constraints are defined as the sum of the individual constraints.)

If equilibrium is given a stronger content, meaning also that on a seller's (buyer's) market, each buyer (seller) is aware that he could not exchange more, the following identities also hold:

$$\bar{y}^d_t = y_t \quad \text{if} \quad y_t = y^s_t$$

$$\bar{y}^s_t = y_t \quad \text{if} \quad y_t = y^d_t$$

$$\bar{\ell}^d_t = \ell_t \quad \text{if} \quad \ell_t = \ell^s_t \qquad (4.4)$$

$$\bar{\ell}^s_t = \ell_t \quad \text{if} \quad \ell_t = \ell^d_t$$

Putting together the definitions of Table (4.1) and restrictions (4.3)-(4.4) leads to the following regime characteristics.

KU-equilibrium

$$y_t = y^d_t \qquad \bar{y}^d_t \geq y_t \qquad \bar{y}^s_t = y_t$$

$$\ell_t = \ell^d_t \qquad \bar{\ell}^d_t \geq \ell_t \qquad \bar{\ell}^s_t = \ell_t$$

CU-equilibrium

$$y_t = y^s_t \qquad \bar{y}^d_t = y_t \qquad \bar{y}^s_t \geq y_t$$

$$\ell_t = \ell^d_t \qquad \bar{\ell}^d_t \geq {}_t \qquad \bar{\ell}^s_t = \ell_t$$

RI-equilibrium

$$y_t = y^s_t \qquad \bar{y}^d_t = y_t \qquad \bar{y}^s_t \geq y_t$$

$$\ell_t = \ell^s_t \qquad \bar{\ell}^d_t = \ell_t \qquad \bar{\ell}^s_t \geq \ell_t$$

U-equilibrium

$$y_t = y_t^d \qquad \bar{y}_t^d \geq y_t \qquad \bar{y}_t^s = y_t$$

$$\ell_t = \ell_t^s \qquad \bar{\ell}_t^d = \ell_t \qquad \bar{\ell}_t^s \geq \ell_t$$

It is noteworthy that the fourth regime is in fact irrelevant in the context of our assumptions. By definition the Underconsumption regime appears when producers are constrained on both markets simultaneously, that is when y_t and ℓ_t are smaller than y_t^s and ℓ_t^d respectively. The latter quantities, however, are also related to ℓ_t and y_t respectively through the production function. - It follows that an underconsumption equilibrium could only appear for

$$y_t < y_t^s = F(\ell_t) \quad \text{and} \tag{4.5}$$

$$\ell_t < \ell_t^d = F^{-1}(y_t) \tag{4.6}$$

These are obviously two contradictory statements. Intuitively, it means that "with full employment of labour, output is practically determined in the shortrun by the labour supply; since demand for labour by firms is rationed, they cannot have a higher output than the one they sell, hence they cannot be considered as rationed sellers" Malinvaud (1977).

A meaningful underconsumption regime could still be obtained in a more detailed model. Weddepohl (1980) has shown that a fourth regime reappears as soon as aggregation problems are explicity considered. It is then possible for some firms to be constrained in the goods market while others would be constrained on the labour market, due to the fact that the rationing of goods leads to another allocation among firms than the rationing of labour. An Under-consumption regime would also arise in a model with inventories. A firm could then find it more advantageous to produce more than the required amount this period to sell next period and might be constrained simultaneously on the goods and labour markets (see for example Muellbauer and Portes, 1978). These complications are not introduced here. Instead we follow Gourieroux, Laffont and Monfort (1980) (henceforth GLM) and Ito (1980) and simply proceed as if the four regimes were all relevant. From a purely technical point of view, this choice can be rationalized either by assuming that money enters as a second factor in the production function (as in GLM) or by noticing that hiring and firing costs may well force producers to be off their production function (as in Ito, 1980). In both these cases restrictions (4.5) and (4.6) no longer hold.

Studying the preceding characterization of the four possible regimes it appears that not all the perceived constraints and effective demands are defined. When, for instance, consumers are constrained on the labour market, but not on the goods market, then obviously their optimal demand for consumption goods is uniquely defined and is of the Bénassy type as it only depends on the constraint perceived on the other market. Assuming a linear relationship we write:

$$y_t^d = y_t^{wd} + \alpha_1(\bar{\ell}_t^s - \ell_t^{ws})$$

$$\bar{\ell}_t^s = \ell_t$$

where the upper script w denotes a Walrasian (or notional) trade offer and α_1 is the spillover coefficient. Yet their optimal supply of labour is not defined. As consumers believe no trade offer could allow them to sell more than ℓ_t, their supply may be any quantity larger or equal to that amount. A similar reasoning applies to the other cases as well, so that the general form of the linear relationship model induced by assumptions A1-A3 is:

kU-equilibrium:

$$y_t = y_t^{wd} + \alpha_1(\ell_t - \ell_t^{ws})$$

$$y_t^s \geq y_t$$

$$\ell_t^d = \ell_t^{wd} + \alpha_2(y_t - y_t^{ws})$$

$$\ell_t^s \geq \ell_t$$

CU-equilibrium

$$y_t^d \geq y_t$$

$$y_t^s = y_t^{ws}$$

$$\ell_t^d = \ell_t^{wd}$$

$$\ell_t^s \geq \ell_t$$

U-equilibrium:

$$y_t^d = y_t^{wd}$$

$$y_t^s \geq y_t$$

$$\ell_t^d \geq \ell_t$$

$$\ell_t^s = \ell_t^{ws}$$

RI-equilibrium:

$$y_t^d \geq y_t$$

$$y_t^s = y_t^{ws} + \beta_1(\ell_t - \ell_t^{wd})$$

$$\ell_t^d \geq \ell_t$$

$$\ell_t^s = \ell_t^{ws} + \beta_2(y_t - y_t^{wd})$$

where α_1, α_2, β_1, β_2 are the spillover coefficients. Any specification of the undefined perceived constraints and effective demands will be acceptable provided only it satisfies the required inequalities. In order to complete the model subsequent restrictions need to be imposed. Portes (1978) has reviewed three possible formulations over the goods and labour markets, those by GLM (1980), Ito (1980) and one presented by Portes himself.

Both G^LM and Ito choose to specify all the effective trade offers as Bénassy ones. The effective demand and supply on a given market is thus a function of the constraint perceived on the other market only. The model reads:

$$y_t^d = y_t^{wd} \qquad \text{if } \bar{\ell}_t^s > \ell_t^{ws}$$

$$= y_t^{wd} + \alpha_1(\bar{\ell}_t^s - \ell_t^{ws}) \qquad \text{otherwise}$$

$$y_t^s = y_t^{ws} \qquad \text{if } \bar{\ell}_t^d > \ell_t^{wd}$$

$$= y_t^{ws} + \beta_1(\bar{\ell}_t^d - \ell_t^{wd}) \qquad \text{otherwise}$$

$$y_t = \min(y_t^d, y_t^s)$$

$$\ell_t^d = \ell_t^{wd} \qquad \text{if } \bar{y}_t^s > y_t^{ws}$$

$$= \ell_t^{wd} + \alpha_2(\bar{y}_t^s - y_t^{ws}) \qquad \text{otherwise}$$

$$\ell_t^s = \ell_t^{ws} \qquad \text{if } \bar{y}_t^d > y_t^{wd}$$

$$= \ell_t^{ws} + \beta_2(\bar{y}_t^d - y_t^{wd}) \qquad \text{otherwise}$$

$$\ell_t = \min(\ell_t^d, \ell_t^s)$$

where the definitions of the perceived constraints have to satisfy (4.3) and (4.4).

GLM and Ito, however, use different definitions for the undefined perceived constraints. GLM consider that the (passive) constraint a buyer (seller) perceives on a buyer's (seller's) market is always larger than the Walrasian trade offer. This amounts to strengthening (4.3) to:

$$\bar{y}_t^d > y_t^{wd} \qquad \text{if } y_t = y_t^d$$

$$\bar{y}_t^s > y_t^{ws} \qquad \text{if } y_t = y_t^s$$

$$\bar{\ell}_t^d > \ell_t^{wd} \qquad \text{if } \ell_t = \ell_t^d$$

$$\bar{\ell}_t^s > \ell_t^{ws} \qquad \text{if } \ell_t = \ell_t^s$$

This choice satisfies the restrictions imposed on the perceived rationing scheme by Bénassy (1975) and Malinvaud (1977). The model is now completely (though arbitrarily) defined and can be written as:

$$y_t^d = y_t^{wd} \qquad \text{if } \ell_t = \ell_t^s$$

$$= y_t^{wd} + \alpha_1(\ell_t - \ell_t^{ws}) \text{ otherwise}$$

$$y_t^s = y_t^{ws} \qquad \text{if } \ell_t = \ell_t^d$$

$$= y_t^{ws} + \beta_1(\ell_t - \ell_t^{wd}) \text{ otherwise}$$

$$y_t = \min(y_t^d, y_t^s)$$

$$\ell_t^d = \ell_t^{wd} \qquad \text{if } y_t = y_t^s$$

$$= \ell_t^{wd} + \alpha_2(y_t - y_t^{ws}) \text{ otherwise}$$

$$\ell_t^s = \ell_t^{ws} \qquad \text{if } y_t = y_t^d$$

$$= \ell_t^{ws} + \beta_2(y_t - y_t^{wd}) \qquad \text{otherwise}$$

$$\ell_t = \min(\ell_t^d, \ell_t^s)$$

Alternatively Ito, following Quandt (1978), assumes that perceived constraints are always equal to actual transactions.

$$\bar{y}_t^d = \bar{y}_t^s = y_t$$

$$\bar{\ell}_t^d = \bar{\ell}_t^s = \ell_t$$

In this way the model simplifies to:

$$y_t^d = y_t^{wd} + \alpha_1(\ell_t - \ell_t^{ws})$$

$$y_t^s = y_t^{ws} + \beta_1(\ell_t - \ell_t^{wd})$$

$$y_t = \min(y_t^d, y_t^s)$$

$$\ell_t^d = \ell_t^{wd} + \alpha_2(y_t - y_t^{ws})$$

$$\ell_t^s = \ell_t^{ws} + \beta_2(y_t - y_t^{wd})$$

$$\ell_t = \min(\ell_t^d, \ell_t^s)$$

Finally Portes' specification relies upon the same definition of perceived constraints as Ito but not the same concept of effective demand. It entails that the trade offer made on a given market is a function of the perceived constraints on both markets. This model may be written as:

$$y_t^d = y_t^{wd} + \alpha_1(\ell_t - \ell_t^s)$$

$$y_t^s = y_t^{ws} + \beta_1(\ell_t - \ell_t^d)$$

$$y_t = \min(y_t^d, y_t^s)$$

$$\ell_t^d = \ell_t^{wd} + \alpha_2(y_t - y_t^s)$$

$$\ell_t^s = \ell_t^{ws} + \beta_2(y_t - y_t^d)$$

$$\ell_t = \min(\ell_t^d, \ell_t^s)$$

The affect of this may be seen more clearly by substituting for ℓ_t^s in the demand function for goods. The effective demand is now of the form:

$$y_t^d = y_t^{wd} + \alpha_{11}(y_t - y_t^{wd}) + \alpha_{12}(\ell_t - \ell_t^{ws})$$

where α_{11} and α_{12} are restricted to:

$$\alpha_{11} = -\alpha_1\beta_2(1 - \alpha_1\beta_2)^{-1}$$

$$\alpha_{12} = \alpha_1(1 - \alpha_1\beta_2)^{-1}$$

and similarly for other cases.

It may seem that this indeterminancy is not a very serious problem. Indeed Portes (1977) has shown that the three specifications presented will always yield the same regime classification and observed transactions and so fall into the same equivalance class. However it must be remembered that many other specifications that could have been used, being compatible with assumptions A1-A3, would not result in the same regime classification and observed transactions. Indeed two sets of effective demand and supplies $(y_t^d, y_t^s, \ell_t^d, \ell_t^s)$ and $(\hat{y}_t^d, \hat{y}_t^s, \hat{\ell}_t^d, \hat{\ell}_t^s)$ will generate the same regimes and observations if and only if

$$\min(y_t^d, y_t^s) = \min(\hat{y}_t^d, \hat{y}_t^s)$$

$$\min(\ell_t^d, \ell_t^s) = \min(\hat{\ell}_t^d, \hat{\ell}_t^s) \text{ and}$$

$$y_t^d > y_t^s \rightleftarrows \hat{y}_t^d > \hat{y}_t^s$$

$$\ell_t^d > \ell_t^s \rightleftarrows \hat{\ell}_t^d > \hat{\ell}_t^s$$

The three models defined by GLM, Ito and Portes satisfy this requirement. But this will not always be the case and so regime classification depends on the (arbitrary) choice of model.

One possible way to overcome this problem of indeterminancy is to reinterpret assumption A2 in a less stringent way. Indeed Svensson (1981) has shown that Bénassy effective trade offers may arise as a limit case of a more general concept using stochastic perceived rationing schemes. The result however is valid if and only if Bénassy trade offers can always be afforded, which is not always the case. It seems therefore that to avoid indeterminacy and arbitrariness requires a complete respecification of the model. The issue is thus to know whether the assumptions underlying many of the existing quantity rationing models can be modified so as to allow the derivation of well defined trade offers. One approach that has attempted to answer this question has been presented by Sneessens (1981) and which we now consider.

4.2iv A disequilibrium rationing model

Sneessens (1981) attempts to replace assumptions A1-A3 by an alternative set of assumptions so that the resulting quantity constrained model will exhibit well defined effective trade offers, thus avoiding the necessity of imposing further arbitrary restrictions. In his alternative formulation Sneessens allows expectations about the constraints to be incorrect, abolishing the equilibrium assumption. Specifically he proposes the following assumptions:

A4: the rationing schemes satisfy

(a) voluntary exchange

(b) feasibility

(c) market efficiency

A5: (a) consumers always believe they will not be rationed on the goods market. They perceive the allocation procedure on the labour market as non-manipulable and stochastic. More precisely, the amount of labour they expect to sell obtains as

$$\ell_t = \min(\bar{\ell}^s_t, \ell^s_t) \text{ with probability } (1 - pr_1)$$

$$= \ell^s_t \qquad \text{with probability } pr$$

with pr_1 strictly positive.

(b) producers perceive both allocative procedures as non-manipulable and stochastic:

$$y_t = \min(\bar{y}^s_t, y^s_t) \text{ with probability } (1-pr_2)$$

$$= y^s_t \quad \text{with probability } pr_2)$$

$$\ell_t = \min(\bar{\ell}^d_t, \ell^d_t) \text{ with probability } (1- pr_3)$$

$$= \ell^d_t \quad \text{with probability } pr_3$$

where pr_2 and pr_3 are strictly positive.

A6: trading occurs sequentially, first on the labour market, then on the goods market.

By assumption A5(a) it is considered that the rationing of goods has been so rare and temporary as not to affect the supply of labour. This is partly justified from the existence of many substitutes to any specific commodity. For instance, a consumer who is unable to buy his most preferred cigarettes will simply switch to another brand. This kind of rationing will not appear in aggregate data and will not affect the supply of labour. Moreover if the economy is considered to be open then any domestic shortage may be assumed to be compensated by increased imports. A further argument supporting assumption A5(a) is that the relevant constraint in the consumer's labour supply is the long run or "permanent" constraint and not the short one. If consumers expect to be presently rationed in their consumption of goods their supply of labour will still remain almost unchanged as long as they believe rationing will not persist in the future.

The last assumption mirrors Clower's dual decision hypothesis. It's main effect is that when traders meet on the goods market they already have an accurate knowledge of the constraint prevailing on the labour market. This seems a natural assumption to make implying that when producers go to the goods market to sell their output, the production process is already taking place so that producers have a correct idea of what they can sell. Correspondingly, consumers already know their labour income.

It can be shown that assumptions A4-A6 taken together make possible the derivation of the following well defined trade offers:

(i) The effective trade offer of consumers are the Walrasian supply on the labour market and the Bénassy demand on the goods market.

(ii) The effective trade offers of producers are the Bénassy demand on the labour market and the Drèze supply on the goods market provided pr_2 is sufficiently close to zero.

Following Sneessens (1981) a formal proof is given in Appendix 1, but the result is intuitively clear. As consumers believe that there is always a positive probability to obtain what they want on the labour market, their best strategy is to ignoreany possible constraint on that market. As they moreover expect not to be rationed on the goods market, consumers will supply ℓ_t^{ws} . On the contrary if $\bar{y}_t^s$ is smaller than y_t^{ws} producers will have to account for the fact that it will be almost ($pr_2 \approx 0$) impossible for them to sell more than $\bar{y}^s_t$. Accordingly producers will only seek to employ the amount of labour required to produce $\bar{y}^s_t$. Their optimal trade offer is thus the Bénassy demand. This implies that actual production will be at most as large as $\bar{y}^s_t$, depending on whether producers are rationed or not on the labour market. The supply of goods thus accounts for the constraints prevailing (or expected to prevail) on both markets. Finally as consumers do not anticipate any rationing on the goods market thier demand for goods will be a function of the labour constraint only.

By assuming linearity we can write this model as follows:

$$y^d_t = y^{wd}_t + \alpha_1(\bar{\ell}^s_t - \ell^{ws}_t) \text{ if } \bar{\ell}^s_t < \ell^{ws}_t$$

$$= y^{wd}_t \quad \text{otherwise}$$

$$y^s_t = y^{ws}_t + \beta_1(\ell_t - \ell^{wd}_t)$$

$$y_t = y^s_t$$

$$\ell^d_t = \ell^{wd}_t + \alpha_2(\bar{y}^s_t - y^{ws}_t) \text{ if } \bar{y}^s_t < y^{ws}_t$$

$$= \ell^{wd}_t \quad \text{otherwise}$$

$$\ell^s_t = \ell^{ws}_t$$

$$\ell_t = \min(\ell^d_t, \ell^s_t)$$

where $\alpha_2\beta_1 = 1$ ensures that the effective supply of goods is of the Drèze type.

It is this model that forms the basis for the dynamic disequilibrium models developed in subsequent chapters. Whether one considers this procedure any less arbitrary than the previous ones is somewhat an open question. However the strength of this modelling strategy is that assumption A4-A6 can be justified and are complete, ensuring the derivation of well-defined trade offers, thus avoiding the necessity of imposing further ad hoc restrictions.

4.3 Open economy quantity constrained models

The models so far examined in this chapter are all closed economy models. We shall now study the consequences, for quantity constrained models, of assuming that the economy is open, and in particular the effects on the number of possible regimes that may be observed.

It is convenient to start by considering a small open economy. The term "small open economy" is used to describe an economy that (i) faces a price of the tradeable good that is fixed in foreign currency terms p^*, and (ii) can buy or sell as much of this good as it wishes at the prevailing world price.

The simplest open economy quantity constrained model is that developed by Dixit (1978) in which there is a single tradeable commodity. From the assumption that the economy is small the foreign net supply curve is perfectly elastic at p^*. This implies that quantity rationing never occurs in the goods market even though it is in some sense a "fixed price" market from the domestic country's point of view. This specification of the goods market serves to make this model considerably simpler than its closed economy counterparts. With short run wage rigidity in the labour market there are only two disequilibrium regimes that are possible, Classical Unemployment and Repressed Inflation. In particular Keynesian Unemployment - caused by a deficiency of demand for domestic output - can never occur. Because of this traditional aggregate demand management policies have no effect on domestic output or employment.

The reason for these classical type results is not because Dixit's model only contains a single traded good. Even if this good was disaggregated, into, say, importables and exportables, quantity constraints in goods markets would still be ruled out by the small economy assumption, and there would still be no possibility of either Keynesian Unemployment or Underconsumption. However, making the fundamental distinction in an open economy between traded and non-traded goods allows the possibility of disequilibrium in the markets for domestic output. All the regimes described for the closed economy models are possible once tradeable and non-tradeable goods are distinguished. (The reason that a good is not traded internationally may be due to transportation costs or other impediments to international trade. See Prachowny, 1975.) Such a model with both tradeable and non-tradeable goods has been presented by Neary (1980). The reason why all four regimes are again possible is simple. While it is still true that neither domestic firms nor consumers face rationing in the traded goods market this is not the case in the non-traded goods market. Producers of non-traded goods may face a sales constraint because of lack of domestic demand, and similarly consumers may be constrained in the amount of the non-tradeable good they can buy. In affect there are now three markets, one each for labour, tradeable goods and non-tradeable goods. With rationing possible on two of these three markets all four regimes may be observed.

In the Neary type model only in the non-tradeable goods market does the possibility of quantity constraints on supply and demand arise. There are, however, important situations where one can reasonably expect quantity constraints in the market for tradeable goods. Even if the economy produces only a single traded good (no non-tradeables), and is small in the sense that changes in the domestic supply have an imperceptable influence on the world price of its exportable good, domestic producers or consumers may face rationing if the world price is slow to adjust to eliminate world excess supply or demand. A good example of such a situation would be a small oil exporting nation facing a world price and sales constraint imposed by the OPEC oil cartel.

Quantity constraints in tradeable goods markets can also arise in situations where the country in question is not large if it imposes import quotes coupled with domestic price controls. This may result in domestic rationing of the imported goods, yet the country might be small in both the importable and exportables markets in the sense that it would in the absence of distortionary policies perceive perfectly elastic world supply or demand curves for these products at prevailing world prices.

Finally, it is important to consider situations where the price of a tradeable good is fixed in terms of the domestic currency in the short run. In such cases, the domestic economy typically faces a downward sloping export demand curve rather than the perfectly elastic demand curve. This combination of a price fixed in a domestic currency and a less than perfectly elastic export demand curve has been referred to as the large-country assumption.

The large country assumption opens up new possibilities in the fixed price model even if the economy produces only a single tradeable good. Authors using the large-country assumption typically take a somewhat different and mixed approach. Cuddington (1980) for example distinguishes between exportables and importables, assuming that the economy is small and unrationed in the market for the importable good. By admitting the possibility of world excess supply or demand of exportables on the other hand, he is able to distinguish both Classical and Keynesian Unemployment regimes in a model that does not incorporate a non-traded goods sector.

It should be noted that the exportables-importables model is very similar to the tradeables non-tradeables model of Neary (1980). If one was to assume that the foreign demand for "exportables" in Cuddington's model was identically equal to zero, that good would, in effect, become the "non tradeable" good in Neary's specification. Cuddington's other good, the importable, then becomes the only tradeable good and performs the same role as the tradeable good in Neary's model. Thus models based on distinguishing between tradeable and non-tradeable goods can easily be reworked in an exportables-importables context merely by relabelling non-tradeables as exportables (and allowing for foreign demand) and tradeables as importables (retaining the small country assumption in the latter case).

In Chapter 6 the closed economy disequilibrium model developed in Chapter 5 is extended to include international trade. By making use of the large country assumption all four regimes of the closed economy, two market model are still observed.

4.4 Conclusions

This Chapter has provided the base from which we develop a dynamic temporary equilibrium model with quantity rationing in subsequent Chapters. Initially we presented Clower's attack upon classical economics, within the context of Walrasian equilibrium, and then assessed his dual decision hypothesis. It was argued that this hypothesis is an inadequate foundation on which to build a "disequilibrium" model. Because of this we then examined both the Bénassy and Drèze formulations of effective demand and equilibrium. Again, due to shortcomings related to each, and the more fundamental problem of indeterminacy and arbitrariness, it was argued these were unacceptable. What is needed is a complete respecification of the way disequilibrium is modelled. One such respecification examined is presented by Sneessens (1981). In his alternative formulation Sneessens replaces the usual assumptions behind rationing models by others and in particular allows expectations about constraints to be incorrect, abolishing the equilibrium assumption. Sneessens's approach overcomes the problem of indeterminacy and arbitrariness, allowing the derivation of well defined effective trade offers without having to impose ad hoc restrictions. For this reason Sneessens's modelling strategy and assumptions are used as the basis for developing a two market model in subsequent Chapters.

Finally, we examined the consequences of introducing international trade into a disequilibrium model. The main result here was that by making use of the "large country" assumption all four regimes of the closed economy two market model are observed. This result is made use of in Chapter 6.

CHAPTER 5

DISEQUILIBRIUM DYNAMICS WITH INVENTORIES AND WAGE AND PRICE ADJUSTMENT IN A CLOSED ECONOMY

Sneessens(1981) writes in conclusion to his research, presented in the previous Chapter, that it "demonstrates that the quantity rationing approach is indeed a useful and workable tool of analysis". He then goes on to state that his "disequilibrium reformulation seems also well fitted for future developments introducing price changes and inventories", and that this would be "an interesting starting point for future research". This Chapter takes up these recommendations by developing and analysing a dynamic disequilibrium model based on Sneessens's reformulation. The model presented here analyses the dynamic behaviour of a closed economy where changes in inventories, wages and prices constitute the main intertemporal links. Further, because this Chapter represents a continuation of research concerned with analysing the properties of disequilibrium macroeconomic models that incorporate price adjustment and inventories we are able to examine the robustness of previous results. In particular the research presented in this Chapter is compared with the work of Honkapohja and Ito (1980), Green and Laffont (1981) and Eckalbar (1985). Indeed in Section 5.1 the recent theoretical developments in dynamic macroeconomic disequilibrium modelling is critically assessed, with particular emphasis being placed upon price adjustment and expectations.

The model predominately used in this Chapter is developed and contrasted with previous models in Section 5.2. Section 5.3 analyses the types of short run and long run equibria that may be observed. Attention is given to the effects of introducing inventories as buffer stocks, and wage and price adjustment into a disequilibrium model.

In particular it is shown that there is a unique long run equilibrium, which is the Walrasian equilibrium. The dynamics of the model are analysed in Section 5.4. It is shown that the economy is either stable or exhibits a limit cycle, and that the parameter space has a significant subset in which limit cycles are certain. This result is due to explicit consideration of regime switching and the non-negativity of inventories. In Section 5.5 the importance of wage and price adjustment is considered by employing alternative wage and price adjustment mechanisms. Instead of assuming that wages and prices adjust imperfectly toward their market clearing values, we allow wages to respond to excess demand in the labour market, and prices to excess demand in the money market. While the nature and number of long run equilibria is unaffected, the dynamics and stability of the model is greatly changed, there now being a "saddlepoint" solution, with limit cycles impossible. In order to ensure stability the structure of the economy is altered so as to allow agents to have forward looking expectations, thus allowing the possibility of the economy jumping instantaneously on to the stable manifold.

5.1 Critical appraisal of recent theoretical developments in dynamic macro-disequilibrium modelling

The first generation of disequilibrium macroeconomic models such as Barro and Grossman (1971, 1977), Bénassy (1975), Drèze (1975) Malinvaud (1977) and others were static, and therefore suffered from two general defects. First they gave limited insight into what many would consider to be major questions to be answered: questions relating to the behaviour of variables such as employment, output, inventories, wages and prices; the likelihood of an economy being in a particular regime; as well as even tougher questions of what data would allow us to discriminate between market and non-market paradigms. These may be considered model output issues. A second defect concerns the structure of the model, an issue of model inputs. With few exceptions inter-temporal linkages via inventories and expectations were missing. Perhaps the most common criticism concerns their failure to consider price movements. Further there was generally no incorporation of a market considered to be market cleaning at all times, for example an asset market such as the foreign exchange market.

An early paper which attempted to meet some of these criticisms was Honkapohja and Ito (1980). The aim of their paper was to analyse both static and dynamic features of a disequilibrium model incorporating inventories as buffer stocks. The closed economy they consider consists of an aggregate labour market and an aggregate goods market, where apart from exogenous government, two hypothetical economic agents operate, one being the representative consumer, who supplies labour and demands goods, the other the representative producer who supplies goods and demands labour. The model has two stores of value money and inventories, which interact together with the flow demands and supplies on the labour and goods markets to determine a short run equilibrium. The level of employment is determined as the minimum of supply and demand for labour. The firms produce the consumption good by using labour as the only input. Initial inventories and current production make up the current supply of goods. The trading of goods is in turn determined as the minimum of supply and demand for goods, while their difference determines the initial inventory stock of the following period. This serves as the main source of dynamics in the model, as wages and prices are assumed fixed for the central sections of their paper. The two major concerns of their paper are the effects of introducing buffer stocks into a disequilibrium macroeconomic model and to analyse the resulting dynamics. First, the introduction of inventories affects the classification of the short-run states of the economy into different regimes. Malinvaud (1977) and Muellbauer and Portes (1978) argue that the introduction of inventories into a disequilibrium macroeconomic model leads to the regime of Underconsumption, in addition to the other three well known regimes. However, these authors view inventories as wealth and overlook the role of buffer stocks. Honkaphoja and Ito observe that inventories as buffer stocks can alter spill over effects by eliminating some of the rationing of the demand for goods. Consequently the classification criteria and the regimes are likely to change. It turns out that the region of Classical Unemployment shrinks and even disappears in certain circumstances.

Second Honkapohja and Ito analyse the dynamic behaviour of inventories and employment beyond the short run. In simple aggregate models such as Metzler (1941) and Lovell (1962) the stability of inventory fluctuations necessitates a relatively slow speed of adjustment for inventories. These models do not take into account the problem of regime switching and the non-negativities of employment and inventories. Incorporating these aspects results in significant modifications. Honkapohja and Ito show that, assuming fixed wages and prices, steady states are in general either in the region of Keynesian Unemployment or Repressed Inflation and both possibilities are stable for many parameter configurations. Moreover, the non-negativities of employment and the regime of Underconsumption exert stabilizing influences so that otherwise unstable oscillations result in limit cycles. Similar results have recently been provided by Eckalbar (1985). Again the main intertemporal linkage in Eckalbar's disequilibrium macroeconomic model is via inventories, with firms trying to maintain a fixed ratio of expected sales to inventory stocks. Wages and prices are again assumed to be fixed. The two main results of Eckalbar's analysis are that his model exhibits a unique equilibrium that may either entail full employment or unemployment of labour, and that when the desired inventory sales ratio is large the model produces limit cycles. Here the cycles are generated by regime switching, expectations, and explicit stock building considerations.

Virtually all economic models which can yield oscillations of constant amplitude, as Honkapohja and Ito, and Eckalbar do, do so in only an improbably small subset of the parameter space, generally at points on a line, "a knife edge" line. For example see the famous papers by Samuelson (1939) and Metzler (1941). Goodwin (1951), Ichimura (1955) and Torre (1977) give further examples of systems that display limit cycles. This might lead one to believe that regular, uniform cycles are highly unlikely. Interestingly, for Honkapohja and Ito, and Eckalbar's models the parameter space has a significant subset in which cycles are certain. This approach of studying regime switching within disequilibrium macroeconomic models thus seems to offer a possible explanation of inventory cycles.

Though Honkapohja and Ito have attempted to meet some of the criticisms of the "first generation" single period disequilibrium models, by incorporating an intertemporal link, via inventories, there are a number of criticisms that can be made of their model.

Price adjustment

The applicability of Honkapohja and Ito, and Eckalbar's, results are limited by their assumption of constant wages and prices. Within Section Six of their paper, however, Honkapohja and Ito, briefly discuss some of the modifications to their previous analysis resulting from wage and price flexibility. First, the parameters in the behavioural functions are dependent on the level of wages and prices. Second, the behaviour of optimal inventories may undergo a major change, as now there will be a speculative motive for holding inventories. Honkapahja and Ito only consider the first of these issues. In order to complete the dynamics given wage and price flexibility the evolution of real wages over time needs to be determined. Here Honkapohja and Ito follow earlier work on disequilibrium dynamics (see Bohm 1978, Honkapohja 1979,1980, Ito 1978, 1979 for examples) by postulating ad hoc adjustment rules for real wages for each regime. The modifications caused by wage and price flexibility are in accordance with intuition if the earlier literature on disequilibrium dynamics is adhered to and if persistent inflation or deflation is not present so that speculative inventory holding plays only a slight role. However, Honkapohja and Ito do admit that "the postulated wage and price adjustment rules do not have strong justifications, so that the results must be considered very tentative". They conclude their paper by stating that "better theories of price and wage setting with inventories are imperative".

An alternative approach to incorporating price adjustment within disequilibrium models is used by Green and Laffont (1981). They assume that prices are fixed at the beginning of the period at the level which would be the Walrasian equilibrium if all random factors in the economy had their average levels. This they refer to as anticipatory pricing. There is thus a tendency toward market clearing, but the short run disturbances continually keep it from being achieved. Prices move fully to clear markets between periods for the expected value of the stocks. This has two somewhat troubling implications of which Green and Laffont are aware. First is that the nature of the equilibrium will be independent across periods. Keynesian Unemployment is as likely to follow a period of Repressed Inflation as any other regime. One may note that the reasonableness of this feature depends on the length of the periods. The second somewhat disturbing feature is that prices are completely rigid within a period but adjust fully to expected market clearing levels between periods. Green and Laffont argue that this is but one polar case among a range of flexibility assumptions. Such a sharp distinction in the degree of price flexibility intra- and inter-period raises a special problem. The usual argument is that this is simply descriptive, that a sufficiently short period of time is being considered. This is less compelling here, since, as already noted, regimes are independent across periods. These assumptions are thus seen to be incompatible for a disequilibrium regime switching model. One way to overcome this incompatibility is to allow prices to adjust only slowly towards the market clearing level, thus allowing the possibility of serially correlated regimes, while retaining the assumption that there is no price adjustment within the period. It is not considered that prices respond to excess demand, but rather there are explicit reasons why prices do not instantaneously adjust to their equilibrium values. This price adjustment process is thus broadly consistent with the analysis of Chapter 3.

Expectations

A further criticism of Honkapohja and Ito's analysis is their neglect of expectations of future prices and quantity constraints, and in particular the simplistic way inventories are included in their model. In an optimizing model the firm's demand for inventories must depend on the expectations of product demand and input costs in the future. As always, the nature of behaviour in Honkapohja and Ito's paper, if seen as the result of implicit optimization, reflects the assumptions of the model. Thus the simplistic specification of inventory behaviour is justified mainly be the assumption of fixed wages and prices. In a model where there is persistence of regimes the firm will have to consider the probability of various sorts of disequilibrium in the future as well as future prices. The first depends both on what types of shocks the economy experiences and on the dynamic properties of the economy. So, for example, demand for inventories this period will be high if the firm anticipates being rationed in factor markets next period (or expects factor markets to clear at a higher input wage), but will be low if it expects to be rationed in its sales of output. In general inventory holding cannot be divorced from the nature of price determination and the nature of the stochastic processes generating shocks to the economy.

Given these criticisms of previous research into the dynamic properties of disequilibrium models, incorporating inventories, the robustness of their results needs to be examined.

5.2 The Model (Model 5.1)

The model derived here is an extension of Sneessens's (1981) model, derived from the assumptionsA4-A6 of Section 4.2iv. We do not present the maximization problems of the agents again, instead we simply postulate piecewise linear decision rules that are consistent with the model of Section 4.2iv, given certain further assumptions. All variables are measured in logarithms.

The model has two sectors - the household and the firm - and two stores of value - money and inventories. Within the period there are random disturbances to supply and demand for labour and goods. Money and inventories interact together with the flow demands and supplies on the goods and labour markets to determine a short-run equilibrium. Wages and prices adjust only gradually toward their market clearing levels. Successive short run equilibria are linked by changes in inventories, wages and prices.

Inventories are accumulated as the result of an excess of output over sales to consumers. It is assumed that such sales of output are entirely consumed within each period; the inventories are owned exclusively by firms. Similarly money balances are held only by households.

For simplicity we assume, following Green and Laffont (1981) and Eckalbar (1985), that the firms always pays dividends equal to its profits. (It should be mentioned here that this formulation does not treat the role of firm's profits and their imputation back to the household sector in a consistent fashion. Implicitly any money balances accumulated by firms are immediately transferred back to the household sector, but these profits are not anticipated at all. Under competitive conditions, that is with many households, each of whom treats profit income as independent of their own actions, this formalisation is consistent with a 100% profits tax and a monetary policy designed to keep the nominal stock of money constant.)

Because firms wish to maintain some inventories part of planned production may be intended for inventory accumulation. An increase in inventory shocks is not by itself sufficient to indicate that firms could not sell all they wanted to. The actual variation in these stocks is a composite of the intended and unintended changes.

The wage and price setting process is conceptualised as follows. The expected market clearing levels for both wages and prices are known at the beginning of each period. Wages and prices are then assumed to adjust over time towards these values. Actual equilibrium values differ from their expected values because of unforeseen random shocks to the economy within the period. The conceptualization allows the possibility of serially correlated regimes, while modelling random shocks as essentially uncorrelated, and retaining the assumption that there is no adjustment of wages and prices within the period.

By assumption A6 the household and the firm first meet on the labour market, where consumers offer their Walrasian supply, ℓ_t^{ws}. We assume that this is a constant, thus:

$$\ell_t^s = \delta_o \tag{5.1}$$

Household effective demand for goods, y_t^d, is assumed to be a linear function of the wage rate, w_t, the price level p_t, and a spillover effect if the households are constrained in the labour market:

$$y_t^d = \beta o + \beta_1 w_t + \beta_2 p_t + \beta_3 (\ell_t - \ell_t^s) \tag{5.2}$$

with consumption a normal good we have $\beta_1 > 0$ and $\beta_2 < 0$. It is assumed that $\beta_o > 0$ and $\beta_3 < 0$. From assumptions A4-A6 we obtained:

$$\begin{aligned} y_t^d &= y_t^{wd} + \alpha_1 (\bar{\ell}_t^s - \ell_t^{ws}) \text{ if } \bar{\ell}_t^s < \ell_t^{ws} \\ &= y_t^{wd} \qquad \text{otherwise} \end{aligned} \tag{5.3}$$

thus in deriving (5.2) we have further assumed that:

$$y_t^{wd} = \beta_o + \beta_1 w_t + \beta_2 p_t$$

and $\bar{\ell}_t^s = \ell_t$

The Walrasian demand for goods depends only on the wage rate and the price level, whilst the perceived quantity constraint on the supply of labour when the agent arrives on the goods market ($\bar{\ell}_t^s$) is equal to the transacted quantity of labour, this is justified by the sequential nature of the model.

Turning to consider the firm, and ignoring inventories for the moment, it is initially assumed that labour demand, ℓ_t^d, is determined by the firm planning to cover its expected sales, $E(y_t^d)$. Output is assumed to be solely a function of labour, $y_t^s = A\ell_t$. It is assumed that the price of the good, p_t, is always kept high enough relative to the wage, w_t, so as to induce a positive output. Therefore

$$\ell_t^d = A^{-1} \left[E(y_t^d)\right] \tag{5.4}$$

Substituting (5.2) into (5.4) and taking the rational expectation yields:

$$\ell_t^d = A^{-1} (\beta_o + \beta_1 w_t + \beta_2 p_t) + A^{-1} \beta_3 (\ell_t - \ell_t^s) \tag{5.5}$$

Again from assumptions A4-A6 we obtained:

$$\begin{aligned} \ell_t^d &= \ell_t^{wd} + \alpha_2(\bar{y}_t^s - y_t^{ws}) \text{ if } \bar{y}_t^s < y_t^{ws} \\ &= \ell_t^{wd} \qquad\qquad \text{otherwise} \end{aligned} \tag{5.6}$$

It is easily shown that (5.5) is consistent with (5.6). As the firm attempts to meet demand then the Walrasian supply of goods must equal the Walrasian demand for goods, thus:

$$y_t^{ws} = \beta_o + \beta_1 w_t + \beta_2 p_t$$

Further from the production function:

$$\ell_t^{wd} = A^{-1}(\beta_o + \beta_1 w_t + \beta_2 p_t)$$

this is the first term in (5.5).

Substituting for y_t^{ws} in $\alpha_2(\bar{y}_t^s - y_t^{ws})$ yields $\alpha_2\ (\bar{y}_t^s - \beta_o - \beta_1 w_t - \beta_2 p_t)$. As $\bar{y}_t^s$ is the perceived sales constraint this equals the expected demand for goods, which with rational expectations is given as $\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \ell_t^s)$. Thus we obtain $\alpha_2(\ell_t - \ell_t^s)$ as the spillover term, which corresponds to $A^{-1}\beta_3(\ell_t - \ell_t^s)$ in (5.5). As already stated the resulting supply of goods can only be:

$$y_t^s = A\ell_t \tag{5.7}$$

Upon introducing inventories equations (5.4) and (5.7) are modified as follows:

$$\ell_t^d = A^{-1}\left[E(y_t^d) + S_t^* - S_{t-1}\right] \tag{5.8}$$

and $$y_t^s = A\ell_t + S_{t-1} \tag{5.9}$$

where S_{t-1} is the amount of inventories carried over from the previous period and S_t^* is the desired level of inventory stock for this period. Equation (5.8) states that labour demand is now determined by firms calculating the amount of labour required to produce enough output to cover both expected sales and the desired inventory level. The effective supply of goods is now equal to the production within the period plus the beginning of period inventory level.

The optimal level of inventories is postulated to be:

$$S_t^* = a + bE(y_t^d); \quad a, b > 0 \tag{5.10}$$

It is acknowledged that this function is very limited and ignores many of the possible determinants of the optimal inventory level. However it does have its advantages. First it is extremely easy to work with. Other functions for the optimal inventory level were examined, such as introducing both current and expected future wages and prices, but such modifications greatly increased the complexity of solving the model. Second since the desired inventory level is an increasing function of expected sales, it is in the spirit of the micro level inventory literature, see Schutte (1983). And third, it is at least roughly in line with the facts in that the actual stock sales ratio has been trendless for the past forty years.

Assuming, again, that firms have rational expectations and substituting (5.10) into (5.8) yields.

$$\ell_t^d = A^{-1}\left[a + (1 + b)y_t^d - S_{t-1}\right] \tag{5.11}$$

The transacted amount of labour (employment) is given as the minimum of labour demand and supply:

$$\ell_t = \min(\ell_t^d, \ell_t^s) \tag{5.12}$$

Similarly for the goods market we write:

$$y_t = \min(y_t^d, \; y_t^s) \qquad (5.13)$$

This last equation differs from Sneessens's equivalent equation which states that transacted goods equals the supply of goods. This difference is due to the introduction of inventories, now the supply of goods may be greater than the demand.

We now consider how inventories, wages and prices change over time. Actual inventories are accumulated as the result of an excess of output over sales to consumers, thus:

$$S_t = y_t^s - y_t \qquad (5.14)$$

This equation implies that inventories cannot be negative, that is firms are assumed not to accumulate back orders. Wages and prices are assumed to be imperfectly flexible adjusting only slowly over time to their respective market clearing values w_t^* and p_t^*. w_t^* is that value of wages that is expected to clear the labour market and ensures that actual inventories equals planned inventories. Setting expected labour supply equal to expected labour demand yields:

$$A\delta_o = E(y_t^d) + S_t^* - S_{t-1}$$

Using (5.10) we get:

$$(1 + b)\; E(y_t^d) \;=\; A\delta_o + S_{t-1} - a$$

Taking the rational expectation we get:

$$(1 + b)\; (\beta_o + \beta_1 w_t^* + \beta_2 p_t) \;=\; A\delta_o + S_{t-1} - a$$

$$\therefore \quad w_t^* = \left[\frac{A\delta_o + S_{t-1} - a}{(1 + b)\ \beta_1}\right] - \left[\frac{\beta_o + \beta_2 p_t}{\beta_1}\right] \tag{5.15}$$

p_t^* is that value of prices which clears the money market, where to close the model the money supply, M_t^s, is exogenously determined and the nominal demand for money is a positive fraction of labour supply, $c\delta_o$. Therefore, we have:

$$M_t^s = p_t^* + c\delta_o$$

$$\therefore \quad p_t^* = M_t^s - c\delta_o \tag{5.16}$$

As a first approximation to more complicated processes describing the dynamics of wages and prices we assume the following partial adjustment equations:

$$w_t = \lambda_w(w_t^* - w_{t-1}) + w_{t-1}; \quad 0 < \lambda_w < 1 \tag{5.17}$$

$$p_t = \lambda_p(p_t^* - p_{t-1}) + p_{t-1}; \quad 0 < \lambda_p < 1 \tag{5.18}$$

The model as described so far is fully deterministic. In order to make the model stochastic we introduce random shocks to the demand and supply functions on the goods and labour markets. Thus we rewrite these functions respectively as follows:

$$\bar{Y}_t^d = Y_t^d + \eta_t^1 \tag{5.19}$$

$$\bar{Y}_t^s = Y_t^s + \eta_t^2 \tag{5.20}$$

$$\bar{L}_t^d = \ell_t^d + \eta_t^3 \qquad (5.21)$$

$$\bar{L}_t^s = \ell_t^s + \eta_t^4 \qquad (5.22)$$

where $\bar{Y}_t^d$, $\bar{Y}_t^s$, $\bar{L}_t^d$, $\bar{L}_t^s$ denote the resulting stochastic variables, and η_t^i; $i = 1, \ldots, 4$ represent the unique stochastic disturbance term corresponding to its respective variable. It is assumed that these disturbance terms are independently distributed with the property that $E(\eta_t^i) = 0$ for all $i = 1, \ldots, 4$. Although each of the η_t's are independent, due to the interaction of variables within the model this is not the case with the disturbance terms relating to the final stochastic variables (which take account of these interactions). To see this we write these final stochastic variables as follows:

$$Y_t^d = y_t^d + \varepsilon_t^1 \qquad (5.23)$$

$$Y_t^s = y_t^s + \varepsilon_t^2 \qquad (5.24)$$

$$L_t^d = \ell_t^d + \varepsilon_t^3 \qquad (5.25)$$

$$L_t^s = \ell_t^s + \varepsilon_t^4 \qquad (5.26)$$

where upper case letters denote the resulting stochastic variable, composed of the deterministic variable (lower case letter) and the stochastic disturbance terms ε_t^i; $i = 1, \ldots, 4$. Due to the structure of the model the ε_t's are related to the η_t's, with the exact relationship depending, in general, on whether there is full employment or unemployment of labour. For example consider the firm's supply of goods. If there is full employment then from (5.9) we may write

$$y_t^s = A\ell_t^s + S_{t-1}$$

Further from equation (5.20) we may rewrite this as:

$$\bar{Y}_t^s = A\ell_t^s + S_{t-1} + \eta_t^2 \qquad (5.27)$$

however this equation only incorporates the disturbance term uniquely related to the supply of goods (η_t^2), ignoring the disturbance to labour supply (η_t^4). Substituting this disturbance into (5.27) we may write the final stochastic equation for the supply of goods as:

$$Y_t^s = A(\ell_t + \eta_t^4) + S_{t-1} + \eta_t^2$$

$$\therefore \qquad Y_t^s = y_t^s + A\eta_t^4 + \eta_t^2$$

Thus we note that with full employment of labour

$$\varepsilon_t^2 = A\eta_t^4 + \eta_t^2$$

Alternatively if there is unemployment then the deterministic supply of goods is given by

$$y_t^s = A\ell_t^d + S_{t-1}$$

Performing similar operations as previously we derive the final stochastic supply of goods as:

$$Y_t^s = y_t^s + A\eta_t^3 + \eta_t^2$$

Hence with unemployment of labour

$$\varepsilon_t^2 = A\eta_t^3 + \eta_t^2$$

Corresponding relationships may be derived for each of the other supply and demand functions on the goods and labour markets. Table 5.1 shows the complete set of relationships between the ε_t's and the η_t's.

Table 5.1

	Full Employment	Unemployment
$\varepsilon_t^1 =$	η_t^1	$\beta_3(\eta_t^3 - \eta_t^4) + \eta_t^1$
$\varepsilon_t^2 =$	$A\eta_t^4 + \eta_t^2$	$A\eta_t^3 + \eta_t^2$
$\varepsilon_t^3 =$	η_t^3	η_t^3
$\varepsilon_t^4 =$	η_t^4	η_t^4

This completes the specification of the model

5.3 Short-run and long-run equilibrium

Having described the structure of the model we now examine the various types of short run equilibria, and the effects that buffer stocks have on these equilibria. It is recalled that in a two market disequilibrium model there are in general, excluding boundary conditions, four distinct regimes each identified by the relative magnitudes of effective demand and supply in each market. Whether all these regimes may be observed depends on the structure of the model, including both the inherent dynamics and the stochastic processes. For example Honkapohja and Ito (1980) assume that the only shock to the economy is unexpected changes in the demand for goods (in our model this corresponds to η_t^1). As firms are further assumed to attempt to produce enough to cover the upper bound of demand fluctuation, if firms are not rationed in the labour market, then a stock out is impossible. This means that in their model the region of Classical Unemployment disappears. Sneessens (1981) and Eckalbar (1985) similarly, have models where goods supply cannot be less than demand for goods, and thus the only regimes possible are Keynesian Unemployment and Underconsumption. In Sneessens this is because the model is deterministic and there are no inventories of finished goods. In Eckalbar it is because he assumes that stocks are always sufficiently large for firms to be able to meet demand.

Within our model, however, all four regimes may be observed depending on the shocks that have disturbed the economy both in the present period and in previous periods. This is because all supply and demand functions for goods and labour are subject to random shocks, stock outs are possible, and wages and prices adjust only slowly towards their market clearing values. What then are the effects of introducing inventories as buffer stocks into a stochastic disequilibrium model? First, as mentioned in Section (5.1) their presence allows the possibility of Underconsumption as now the production function does not provide a unique relationship between transacted labour and supply of output. Second by eliminating some of the rationing of the demand for goods the region of Classical Unemployment is reduced. Further, in this model, if there are no shocks in the present period then Classical Unemployment is impossible. This is proved as follows:

Classical Unemployment is defined as:

$$\ell_t^d + \varepsilon_t^3 < \ell_t^s + \varepsilon_t^4 \text{ and } y_t^d + \varepsilon_t^1 > y_t^s + \varepsilon_t^2$$

With excess supply in the labour market, supply of output (5.9) may be written as

$$y_t^s + \varepsilon_t^2 = A\ell_t^d + S_{t-1} + \varepsilon_t^2$$

Substituting in for ℓ_t^d from (5.8) yields

$$y_t^s + \varepsilon_t^2 = E(y_t^d) + S_t^* + \varepsilon_t^2$$

Taking the rational expectation of $E(y_t^d)$ gives us

$$y_t^s + \varepsilon_t^2 = y_t^d + S_t^* + \varepsilon_t^2$$

With excess demand in the goods market we obtain the condition

$$y_t^d + \varepsilon_t^1 > y_t^d + S_t^* + \varepsilon_t^2$$

$$\therefore \quad S_t^* < \varepsilon_t^1 - \varepsilon_t^2$$

Using Table 5.1 this condition may be rewritten as:

$$S_t^* < \beta_3(\eta_t^3 - \eta_t^4) + \eta_t^1 - A\eta_t^3 - \eta_t^2$$

As S_t^* is always positive, if there are no shocks in the present period (i.e. $\eta_t^i = 0$; $i = 1, \ldots\ldots, 4$) Classical Unemployment is impossible. (The reason why Classical Unemployment is impossible in Honkapohja and Ito (1980), even allowing for disturbance within the present period is clearly seen here. They assume that $S_t^* > \eta_t^1$ and $\eta_t^2 = \eta_t^3 = \eta_t^4 = 0$.) This result is due to the firm planning to adjust inventories to their desired level within the period, and is made use of in the next section when the dynamics and stability of the economy are considered.

Having examined the short-run equilibrium of the economy we now analyse the long run dynamic equilibrium. This occurs when wages, prices and inventories are equal to their respective long run equilibrium values, that is when the following equations hold simultaneously:

$$w_t = w_t^* = \frac{A\delta_o + S_{t-1} - a}{(1 + b)\beta_1} - \frac{\beta_o + \beta_2 p_t}{\beta_1}$$

$$p_t = p_t^* = M_t^s - c\delta_o$$

$$S_t = S_t^* = a + bE\,(Y_t^d)$$

If any of these equations do not hold then there will be adjustments made by either wages, prices and/or inventories, even in the absence of disturbances, showing that the economy was not initially in long-run equilibrium. By suitable substitution and rearrangement we are able to derive the following necessary and sufficient long-run equilibrium conditions:

$$w_t = \beta_1[A\delta_o - \beta_o + \beta_2(M_t^s - c\delta_o)] \tag{5.28}$$

$$p_t = M_t^s - c\delta_o \tag{5.29}$$

$$S_t = a + bA\delta_o \tag{5.30}$$

Given a specific value for the money supply, M_t^s, each of these conditions is single valued implying that there is a unique long-run equilibrium. Furthermore as the conditions ensure that all markets clear the long-run equilibrium of the model can only be the Walrasian equilibrium. A change in the money supply only affects the equilibrium values of nominal variables, real variables are unaffected in long-run equilibrium. This result is contrary to many previous disequilibrium models where wages and prices are assumed fixed, for example as in models presented by Honkapohja and Ito (1980) and Eckalbar (1985), (see Section 5.1). Thus the introduction of wage and price adjustment toward their expected market clearing values rules out the existence of a long-run non-Walrasian equilibrium, hence the results of these previous models arenot robust in this respect.

5.4 Regime switching and stability

Within this section the dynamic regime switching and stability properties of the model are examined. The economy is supposed to experience random shocks to the supply and demand functions for goods and labour, $(\eta_t^i \neq 0;\ i = 1, \ldots\ldots, 4)$, in the first period, thereafter there are no further disturbances; the resulting dynamics are explored. First the regimes are defined with respect to real wage-inventory space. Second the dynamics are determined within each of the various regimes. Initially, for simplicity, it is assumed that the money market is continually in equilibrium with the money supply fixed at M^s, therefore $p_t = p_t^* = M^s - c\delta_o$. Later this assumption is relaxed in order to derive general results.

The various short-run equilibrium regimes subsequent to the first period may be defined as follows:

Underconsumption (U)

$$\text{i} \quad \ell_t = \ell_t^s < \ell_t^d$$

$$\text{ii} \quad y_t = y_t^d < y_t^s$$

From i $\quad \delta_o < A^{-1}\left[E(y_t^d) + S_t^* - S_{t-1}\right]$

$$\therefore \quad A\delta_o + S_{t-1} - a < (1 + b)(\beta_o + \beta_1 w_t + \beta_2 p_t)$$

$$\therefore \quad w_t > \frac{A\delta_o + S_{t-1} - a - (1 + b)\beta_o}{\beta_1(1 + b)} - \frac{\beta_2 p_t}{\beta_1} = w_t^*$$

$$\therefore \quad (w_t - p_t) > \frac{A\delta_o + S_{t-1} - a - (1 + b)\beta_o}{\beta_1(1 + b)} - \frac{(\beta_1 + \beta_2)p_t}{\beta_1}$$

$$\therefore \quad (w_t - p_t) > \frac{A\delta_o + S_{t-1} - a - (1 + b)\beta_o}{\beta_1(1 + b)} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

From ii $\quad \beta_o + \beta_1 w_t + \beta_2 p_t < A\delta_o + S_{t-1}$

$$\therefore \quad w_t < \frac{A\delta_o + S_{t-1} - \beta_o - \beta_2 p_t}{\beta_1}$$

$$\therefore \quad (w_t - p_t) < \frac{A\delta_o + S_{t-1} - \beta_o \quad - \quad (\beta_1 - \beta_2)(M^s - c\delta_o)}{\beta_1}$$

<u>Repressed Inflation (RI)</u>

i $\quad \ell_t = \ell_t^s < \ell_t^d$

ii $\quad y_t = y_t^s < y_t^d$

From i $\quad (w_t - p_t) > \dfrac{A\delta_o + S_{t-1} - a - (1 + b)\beta_o}{\beta_1(1 + b)} - \dfrac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$

From ii $\quad (w_t - p_t) > \dfrac{A\delta_o + S_{t-1} - \beta_o - (\beta_1 - \beta_2)(M^s - c\delta_o)}{\beta_1}$

Keynesian Unemployment (KU)

$$\text{i} \quad \ell_t = \ell_t^d < \ell_t^s$$

$$\text{ii} \quad y_t = y_t^d < y_t^s$$

From i $\delta_o > A^{-1}[E(y_t^d) + S_t^* - S_{t-1}]$

$$\therefore \quad A\delta_o + S_{t-1} - a > (1 + b)[\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \ell_t^s)]$$

As $\beta_3(\ell_t - \ell_t^s) < 0$ then

$$w_t < \frac{A\delta_o + S_{t-1} - a - (1+b)\beta_o}{\beta_1(1 + b)} - \frac{\beta_2 p_t}{\beta_1}$$

$$\therefore \quad (w_t - p_t) < \frac{A\delta_o + S_{t-1} - a - (1 + b)\beta_o}{\beta_1(1 + b)} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

From ii $\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \ell_t^s) < A^{-1}[E(y_t^d) + S_t^* - S_{t-1}]$

$$+ S_{t-1} < A\delta_o + S_{t-1}$$

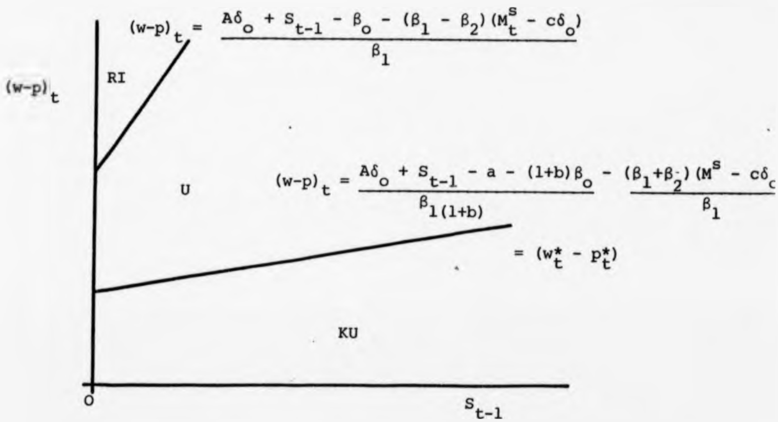
Again as $\beta_3(\ell_t - \ell_t^s) < 0$ then

$$w_t < \frac{A\delta_o + S_{t-1} - \beta_o - \beta_2 p_t}{\beta_1}$$

$$\therefore \quad (w_t - p_t) < \frac{A\delta_o + S_{t-1} - \beta_o - (\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

As shown in Section (5.3) if there are no shocks to the economy within the present period then Classical Unemployment is impossible, therefore the three regimes considered above cover all the real wage-inventory space. These results are illustrated in Figure 5.1.

<u>Figure 5.1</u>

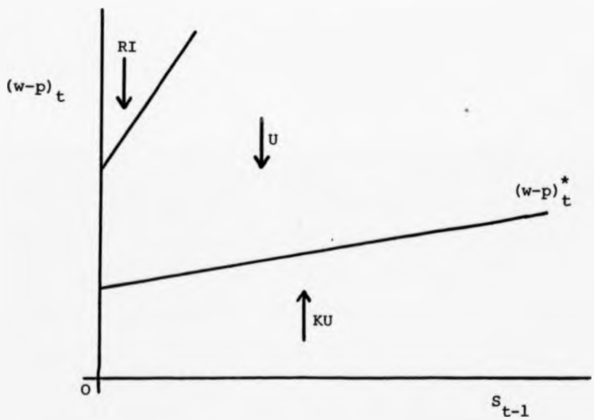


Having related the possible regimes to real wage-inventory space we now consider the dynamics of the economy within this space for each regime. This involves looking at the adjustment paths of both the real wage rate and inventories.

As the real wage rate adjusts to correct the discrepancy between $(w - p)_t$ and $(w_t^* - p_t^*) = (w - p)_t^*$ when the money market is in equilibrium, then the switching locus is defined as $(w - p)_t = (w - p)_t^*$. This locus can be seen from Figure 5.1 to be the boundary between the Underconsumption and Keynesian Unemployment regimes.

Thus the direction of adjustment for the real wage rate may be determined with reference to which regime the economy is in; the real wage rate is falling in either the Underconsumption or Repressed Inflation regimes and rising in the Keynesian Unemployment regime. These directional movements are represented in Figure 5.2 by the arrows. It should be noted here, or rather confessed, that this wage adjustment mechanism is counter-intuitive, with real wages rising when there is excess supply of labour and falling when there is excess demand. This

Figure 5.2



result arises because of the way the demand for labour has been modelled. Instead of deriving an optimal labour demand function it was assumed (following Sneessens, 1981 and Eckalbar, 1985) that firms attempt to always meet the demand for goods. Given this assumption labour demand is found by inverting the production function having substituted in for the demand for goods. In consequence, as the demand for goods is positively related to the real wage rate, the demand for labour also depends positively on the real wage rate. If there is excess supply in the labour market, in order to restore equilibrium, there needs to be a rise in the wage rate so as to raise the demand for goods and hence the demand for labour. This is a special case. In Chapter 6, in response to this result, an open economy model is developed where the demand for labour is more conventionally assumed, over a certain range, to depend negatively on the real wage rate. In that model wage rate dynamics accord with intuition. The present closed economy model is maintained for a number of reasons: (1) it seems the most obvious extension to a number of previous dynamic disequilibrium models developed in the literature (Honkapohja and Ito 1980, Green and Laffont 1981 and Eckalbar, 1985) and so is useful in testing the robustness of these models and the results derived from them; (2) it provides the basis for subsequent (open economy) models, where as noted above, the dynamics of wage adjustment accords with intuition; (3) many of the results concerning the dynamics of inventories and output, regime switching properties, and the possibility of limit cycles, as well as the implications for government policy, derived from the present model, continue to hold in the open economy models developed in the next Chapter. Further due to the less complex nature of this model these results are easier to perceive and understand here than in later models.

Continuing to develop the dynamics of the present model, the adjustment of inventories is more complex than wages, as the dynamic process differs for each of the possible regimes. We first consider the dynamics for inventories when there is full employment of labour $\ell_t = \ell_t^s \leq \ell_t^d$, i.e. for the regimes of Underconsumption and Repressed Inflation. As there is full employment of labour the end of period inventory level is determined by equations (5.1), (5.9) and (5.14) as

$$S_t = y_t^s - y_t = A\delta_o + S_{t-1} = y_t$$

From this equation if $y_t = y_t^s < y_t^d$ then $S_t = 0$. Thus when the economy enters the regime of Repressed Inflation inventories are immediately reduced to zero as the demand for goods exceeds the available supply. Alternatively in the case of Underconsumption $y_t = y_t^d < y_t^s$, and we may write the change in inventories as:

$$\Delta S_t \equiv S_t - S_{t-1} = A\delta_o - y_t^d$$

Substituting in for y_t^d from (5.2) yields

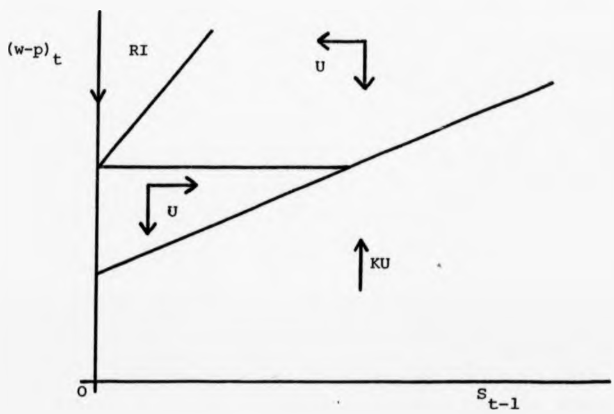
$$\Delta S_t = A\delta_o - \beta_o - \beta_1 w_t - \beta_2 p_t \qquad (5.31)$$

setting this equal to zero and rearranging gives us the following locus:

$$(\Delta S_t = 0 | \ell_t = \ell_t^s;\ y_t = y_t^d) : (w - p)_t = \frac{A\delta_o - \beta_o - (\beta_1 + \beta_2)(M^s - c\,\delta_o)}{\beta_1}$$

The value of this locus equals the intercept term of the Repressed Inflation - Underconsumption boundary, which is greater than the intercept term for the boundary between the Underconsumption-Keynesian Unemployment regimes. From equation (5.31) we derive that $\partial \Delta S_t / \partial (w-p)_t = -\beta_1 < 0$. Therefore if $(w-p)_t$ is above the locus $(\Delta S_t = 0 | \ell_t = \ell_t^s, \; y_t = y_t^d)$ then $\Delta S_t > 0$. The directional movements are combined with the real wage adjustments in Figure 5.3.

Figure 5.3



As already shown when the economy experiences Repressed Inflation inventories are reduced to zero. From Figure 5.3 inventories remain at zero until the real wage rate falls to the value of $[A\delta_o - \beta_o - (\beta_1 + \beta_2)(M^s - c\delta_o)]\beta_1^{-1}$ then the economy enters the regime of Underconsumption and inventories are built up, while the real wage rate continues to fall.

In order to complete the dynamics of the model we need to examine the behaviour of inventories when there is unemployment of labour $\ell_t = \ell_t^d < \ell_t^s$, i.e. the economy is in Keynesian Unemployment. In this regime the end of period inventory level is given by:

$$S_t = y_t^s - y_t^d = E(y_t^d) + S_t^* - y_t^d$$

With rational expectations this becomes:

$$S_t = S_t^*$$

The change in inventories is then given as:

$$\Delta S_t = S_t^* - S_{t-1}$$

Setting this equal to zero and substituting for S_t^* from (5.10) gives us the locus:

$$(\Delta S_t = 0 \,|\, \ell_t = \ell_t^d) \; : \; a + bE(y_t^d) - S_{t-1} = 0$$

$$\therefore \quad S_{t-1} = a + b[\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \ell_t^s)] \qquad (5.32)$$

As on this locus $S_t^* = S_{t-1}$, by definition, we may write employment as:

$$\ell_t = \ell_t^d = A^{-1}[\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \ell_t^s)]$$

$$\therefore \quad \ell_t = \frac{\beta_o + \beta_1 w_t + \beta_2 p_t - \beta_3 \delta_o}{A - \beta_3}$$

Substituting this into (5.23) yields

$$S_{t-1} = a + b\{\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3\left[\frac{\beta_o + \beta_1 W_t + \beta_2 p_t - \beta_3\delta_o}{A - \beta_3}\right]$$

$$- \beta_3\delta_o\}$$

Rearranging this give us

$$(w-p)_t = \frac{(A - \beta_3)(S_{t-1} - a)}{bA\beta_i} - \frac{(\beta_o - \beta_3\delta_o)}{\beta_i} \quad \frac{-(\beta_1 + \beta_2)p_t}{\beta_1}$$

Therefore the locus $(\Delta S_t = 0 | \ell_t = \ell^d_t)$ is given by $(w - p)_t =$

$$\frac{(A - \beta_3)(S_{t-1} - a)}{bA\beta_i} - \frac{(\beta_o - \beta_3\delta_o)}{\beta_1} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1} \qquad (5.33)$$

By using the equation

$$(\Delta S_t | \ell_t = \ell^d_t) = a + bE(y^d_t) - S_{t-1} \qquad (5.34)$$

we can determine the directional movements of inventories when the economy is in Keynesian Unemployment and off the $(\Delta S_t = 0 | \ell_t = \ell^d_t)$ locus. Substituting in for y^d_t from (5.2) and taking the rational expectation yields:

$$(\Delta S_t | \ell_t = \ell^d_t) = a + b[\beta_o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell^d_t - \delta_o)] - S_{t-1} \qquad (5.35)$$

From (5.1), (5.2) and (5.11) we get:

$$(\ell_t^d - \delta_o) = \frac{A^{-1}[a + (1 + b)(\beta_o + \beta_1 w_t + \beta_2 p_t)] - A^{-1}S_{t-1} - \delta_o}{1 - A^{-1}(1 + b)\beta_3}$$

Substituting this expression into (5.35) gives us $(\Delta S_t | \ell_t = \ell_t^d)$ =

$$a + b\,[\beta_o + \beta_1 w_t + \beta_2 p_t] - S_{t-1}$$

$$+ b\beta_3 \left[\frac{A^{-1}a + A^{-1}(1+b)(\beta_o + \beta_1 w_t + \beta_2 p_t) - A^{-1}S_{t-1} - \delta_o}{1 - A^{-1}(1+b)\beta_3} \right]$$

Differentiating with respect to w_t gives

$$\partial \Delta S_t / \partial (w - p)_t = b\beta_1 + \frac{b\beta_3 A^{-1}(1 + b)\beta_1}{1 - A^{-1}(1+b)\,\beta_3}$$

$$= \frac{b\beta_1}{1 - A^{-1}(1 + b)\beta_3}$$

When $b = \frac{A - \beta_3}{\beta_3}$ this differential is undefined. Note also that when $b = \frac{A - \beta_3}{\beta_3}$ the locus $(\Delta S_t = 0 | \ell_t = \ell_t^d)$ coincides with the locus $(\Delta (w - p)_t = 0)$. We continue by arguing that b can be as close to $\frac{A - \beta_3}{\beta_3}$ as we choose but not equal to it.

If $b < \frac{A - \beta_3}{\beta_3}$ then the $(\Delta S_t = 0 | \ell_t = \ell_t^d)$ locus cuts the $(\Delta(w-p)_t = 0)$ locus from below and $\partial \Delta S_t / \partial (w - p)_t > 0$. In this case if $(w-p)_t$ is above $(\Delta S_t = 0 | \ell_t = \ell_t^d)$ then inventories are being accumulated, while if below they are being run down.

If $b > \frac{A - \beta_3}{\beta_3}$ then the $(\Delta S_t = 0 | \ell_t = \ell_t^d)$ locus cuts the $(\Delta (w - p)_t = 0)$ locus from above and $\partial \Delta S_t / \partial (w-p)_t < 0$. Here if $(w - p)_t$ is above $(\Delta S_t = 0 | \ell_t = \ell_t^d)$ then inventories are falling, while if below they are rising.

The complete dynamics of the model for $b < \frac{A - \beta_3}{\beta_3}$ are shown in Figure 5.4.

Figure 5.4

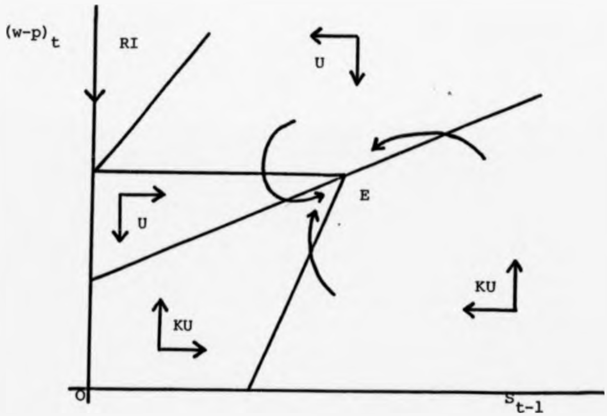


Figure 5.4 shows that there is a unique long-run equilibrium at E. This is always the case and can be shown as follows. If we set the $(\Delta (w - p)_t = 0)$ locus equal to the $(\Delta S_t = 0 | \ell_t = \ell_t^s, y_t = y_t^d)$ locus we obtain:

$$\frac{A\delta_o + S_{t-1} - a - (1 + b)\,\beta_o}{(1 + b)\,\beta_1} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

$$= \frac{A\delta_o - \beta_o - (\beta_1 + \beta_2)(M^s - c\,\delta o)}{\beta_1}$$

$$\therefore \quad \frac{(A\delta_o - a + S_{t-1})}{(1 + b)} = A\delta_o$$

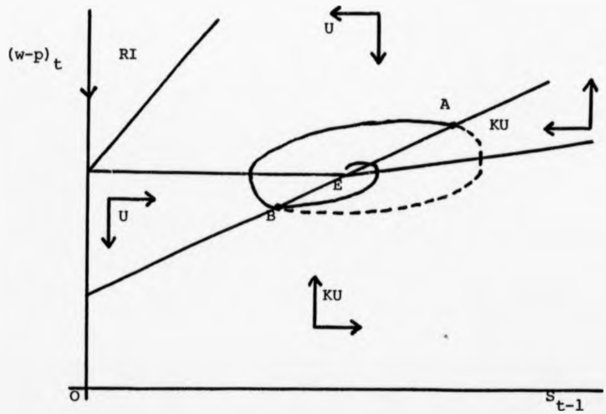
$$\therefore \quad S_{t-1} = a + bA\delta_o = S_t^*$$

As the condition $S_{t-1} = S_t^*$ always holds along the $(\Delta S_t = 0 \,|\, \ell_t = \ell_t^d)$ locus this proves there is a unique long run equilibrium. This confirms the result found in Section 5.3. However is this unique long run equilibrium stable? By examining Figure 5.4 we can see that with $b < \frac{A - \beta_3}{\beta_3}$ the long run equilibrium, E, is globally stable, although the actual path to the equilibrium may be complicated. Indeed the economy may initially move away from equilibrium before converging upon it. For example if the economy is initially experiencing Underconsumption with the real wage rate above its long run equilibrium level and inventories near to their equilibrium value, then both real wages and inventories will begin to fall before increasing back to the long run equilibrium, via. Keynesian Unemployment, with the real wage rate undershooting its long run value.

Figure 5.5 illustrates the complete dynamics for the economy when $b > \frac{A - \beta_3}{\beta_3}$.

From Figure 5.5 it is clear that the dynamic path the economy follows is further complicated when $b > \frac{A-\beta_3}{\beta_3}$.

Figure 5.5



The directional arrows indicate that in general the economy will oscillate around the equilibrium, E. However it is not clear whether these oscillations will be dampened, explosive or of constant amplitude. Assume that the economy is initially at A in Figure 5.5, on the boundary between Keynesian Unemployment and Underconsumption. The dynamics of the model will take the economy into the Underconsumption regime and the solid curve shows the path the economy would follow if the regime of Underconsumption were the only operative system. By Routh-Hurwitz this path would eventually converge upon the long-run equilibrium. (This is shown in Appendix 2.) At point B though the system of Keynesian Unemployment becomes operative. This system may carry the economy back to A, as shown by the broken curve, thus forming a limit cycle, beyond the limit cycle (the economy is unstable) or within the limit cycle (the economy is locally stable). When $b > \frac{A - \beta_3}{\beta_3}$ the economy may be either locally stable or unstable, depending on the parameters of the model. From this analysis it may seem that a limit cycle only occurs for an improbable small subset of the parameter space (points on a line). This, however, is not true, due to the non-negativity of inventories and stabilizing influence of the Repressed Inflation regime. If the economy is locally unstable with explosive oscillations, then a slight deviation from the equilibrium causes the economy to oscillate away from the equilibrium. Eventually the economy will move into the Repressed Inflation regime. Within this regime, because $y_t^s < y_t^d$, inventories are reduced to zero, while the real wage rate falls. The real wage rate continues to fall until it equals the value of $\frac{A\delta_o - \beta_o - (\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$ when the economy switches to the Under-consumption regime. Once again the economy will oscillate around the equilibrium, until it enters the Repressed Inflation regime, where the process is repeated. As the economy continually returns to the boundary between Repressed Inflation and Underconsumption with inventories zero it is clear that the economy exhibits a limit cycle.

Note also that the economy may form a limit cycle even if the equilibrium is locally stable. This will be the case if the economy experiences Repressed Inflation and the dynamics, although locally stable, return the economy to this regime. Therefore for this model the parameter space has a significant subset in which cycles are certain. The paths of inventories, employment and real wages over this cycle are shown in Figure 5.6.

Having examined the behaviour of the economy for when $b < \frac{A - \beta_3}{\beta_3}$ and when $b > \frac{A - \beta_3}{\beta_3}$ we can now comment on why this condition is so important for the stability of the economy. From Figures 5.4 and 5.5 it is clear that it is the dynamics within the Keynesian Unemployment regime that are crucial in determining the dynamic behaviour of the economy as a whole. Further it can be shown that the condition $b \gtrless \frac{A - \beta_3}{\beta_3}$ determines the stability of this regime within the period, and that it is related to the traditional Keynesian demand multiplier condition for stability. To illustrate this we examine the multiplier effects of an increase in the demand for goods on the labour market.

Within the regime of Keynesian Unemployment we may write

$$\ell_t = \ell_t^d = A^{-1}\{a + (1+b)[\beta o + \beta_1 w_t + \beta_2 p_t + \beta_3(\ell_t - \delta_o)] - S_{t-1}\}$$

Suppose there is an increase in y_t^d, represented by an increase in β_o. This has the effect of increasing ℓ_t^d and thus employment, and this in turn causes y_t^d to further increase. Whether or not this process converges or diverges depends on whether b is greater than or smaller than $\frac{A - \beta_3}{\beta_3}$

From the previous equation we derive that:

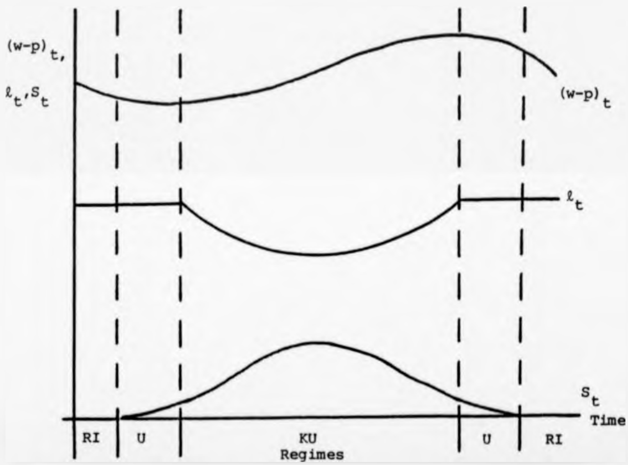
$$\ell_t^d / \ell_t = A^{-1}(1+b)\beta_3.$$

Setting this equal to unity and rearranging yields the condition $b = \frac{A - \beta_3}{3}$

Similarly when $b < \frac{A - \beta_3}{3}$ then $\partial \ell_t^d / \partial \ell_t < 1$, and when $b > \frac{A - \beta_3}{\beta_3}$ then $\partial \ell_t^d / \partial \ell_t > 1$. Thus when $b < \frac{A - \beta_2}{\beta_2}$ the successive increases in employment and demand become smaller and smaller, with the progression converging. When $b > \frac{A - \beta_3}{\beta_3}$ the increments in employment and demand become larger, causing the regime to be unstable.

Throughout this section we have, so far, assumed that the money supply is constant and that prices are set at their equilibrium level. This assumption is now relaxed. With prices adjusting according to equation (5.14) when out of equilibrium the stability results derived below continue to hold. While prices are

Figure 5.6



adjusting toward their equilibrium level the real wage rate changes, this in turn causes the nominal wage to adjust. However when prices eventually converge upon their equilibrium value, which is assured, then the analysis and stability results derived above are appropriate. Obviously a change in the money supply has short-run effects on the path the economy pursues (this is further analysed in Chapter 7), but has no effect on the stability of the economy.

This analysis has shown that explicit consideration of regime switching and inventory accumulation significantly affects the dynamics of a model. In particular, due to the stabilizing influence of the Repressed Inflation regime, an otherwise explosive model now exhibits a limit cycle. This analysis thus confirms the result found by Honkapohja and Ito, and Eckalbar, that for a significant subset of the parameter space limit cycles are certain. This previously derived result has been shown to be robust to the way wage and price adjustment has currently been introduced into the model.

5.5 <u>Alternative wage and price adjustment (Model 5.2)</u>

So far in this Chapter we have tested the robustness of previously derived results by incorporating imperfect wage and price adjustment via equations (5.17) and (5.18). The adjustment processes implied by these equations were justified in Chapter 3, where it was shown that factors such as imperfect information, incomprehensive contracting, and "small menu" costs explain why wages and prices only adjust slowly toward their market clearing values. However this is not the only imperfect price adjustment mechanism. The alternative is to assume that wages and prices adjust in response to excess demand or excess supply, i.e. disequilibrium. Although this process has been argued to be ad hoc and incompatible with full rationality of agents, it is nonetheless useful to analysis the equilibrium and stability properties of our present disequilibrium model under this alternative assumption. Accordingly we replace equation (5.17) by the following:

$$w_t = \lambda_w (L_t^d - L_t^s) + w_{t-1} \tag{5.36}$$

$$0 < \lambda_w < 1$$

with wages responding positively to excess demand in the labour market. Similarly (5.18) is replaced by:

$$p_t = \lambda_p (M_t^d - M_t^s) + p_{t-1} \tag{5.37}$$

$$0 < \lambda_p < 1$$

with prices changing in response to excess demand in the money market.

By replacing equations (5.17) and (5.18) by (5.36) and (5.37) respectively we can gain insight into how dependent the previously derived results are on our specific assumption of wage and price adjustment, and thus how important the specification of wage and price adjustment is in general. It is shown that the result that the long-run equilibrium is unique and that this is the Walrasian equilibrium still holds while the dynamics of the model and its stability properties are greatly affected.

Long-run equilibrium

With wages responding in accordance with equation (5.36) wages are stationary when the labour market clears, $L_t^d = L_t^s$. Further as labour supply is fixed this gives us a unique condition which, ignoring stochastic disturbances, may be written as:

$$w_t^* = \frac{A\delta_o - a + S_{t-1}}{(1+b)\beta_1} - \frac{(\beta_o + \beta_2 p_t)}{\beta_1}$$

This condition is the same as (5.15). Similarly prices are stationary when $M_t^s = M_t^d$ giving us the equilibrium price level as

$$p_t^* = M_t^s - c\delta_o$$

which is the same as (5.16). Finally the other long-run equilibrium condition relating to inventories is also unchanged being written as:

$$S_t^* = a + bA\delta_o$$

With the equilibrium conditions for wages, prices and inventories unchanged it is clear that there is still a unique long-run equilibrium, and that this is the Walrasian equilibrium.

Dynamics

In order to analyse the dynamic properties of this revised model we again initially assume that the money market is continually in equilibrium, that is $p_t = p_t^* = M^s - c\delta_o$. This is later relaxed so as to derive general results. As stated above the equilibrium conditions for inventories, wages and prices are still given by equations (5.10), (5.15) and (5.16) respectively, thus the division of real wage inventory space between the various possible short run regimes remains the same as in Section 5.4. Further the dynamics of inventories within each regime is unaffected by replacing (5.17) by (5.36). However, what does change is the dynamic adjustment of wages within the regimes. Now, because wages respond positively to excess demand in the labour market, we can derive the following conditions.

$\Delta w_t > 0$ if $\ell_t^d > \ell_t^s$, that is in the regimes of Repressed Inflation and Underconsumption, and

$\Delta w_t < 0$ if $\ell_t^d < \ell_t^s$, that is in the regime of Keynesian Unemployment.

These directional movements are the opposite of those derived for when wages responded to equation (5.17) and adjusted toward their market clearing value. Taking this modification into account we redraw Figures 5.4 and 5.5 respectively as Figures 5.7 and 5.8, that is initially for $b < \frac{A - \beta_3}{\beta_3}$ and subsequently for $b > \frac{A - \beta_3}{\beta_3}$.

Figure 5.7

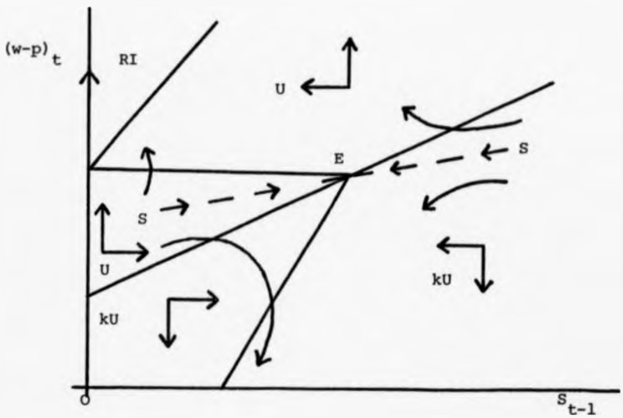
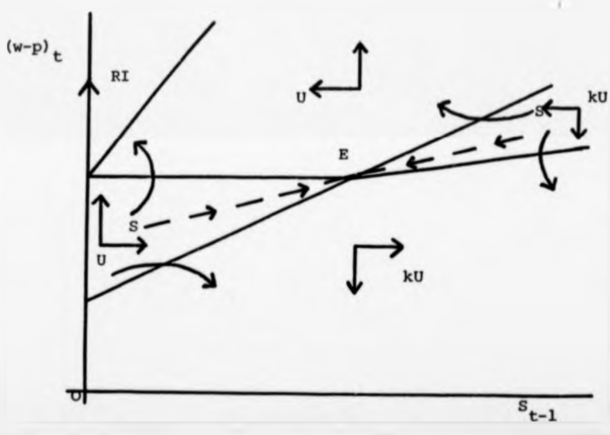


Figure 5.8



By examining Figures 5.7 and 5.8 we see that altering the wage adjustment process greatly affects the stability of the model. Now for any given value of b the model has a "saddlepoint" solution, that is there is a unique convergent path to the steady state equilibrium at E. All other paths cause the economy to steadily diverge away from the long-run equilibrium, a limit cycle is no longer possible. Further as all the state variables are predetermined the model exhibits saddlepoint instability. In order to overcome this problem of instability we need to go back and alter the microeconomic basis of the model by incorporating forward looking expectations, thus allowing the possibility for the economy to jump on to the stable manifold, SS. Here we make use of the comments already made in Section 5.1 concerning the role of expectations in determining a firms desired level of inventory holding, S_t^*. It is recalled that in an optimizing model firms will vary their demand for inventories in response to changes in their expectations of future product demand and input costs. For example it is argued here that the demand for inventories will be high if firms expect real wages to rise and low if the expectation is that real wages will fall. In this particular case we would expect the desired stock level to depend positively on the expected rate of change in the real wage rate, $E[\Delta(w-p)_{t+1}]$, where $\Delta(w-p)_{t+1} \equiv (w-p)_{t+1} - (w-p)_t$. Incorporating this into (5.10) we rewrite the demand for inventories as:

$$S_t^* = a + bE(y_t^d) + cE[\Delta(w-p)_{t+1}] ; \qquad c > 0$$

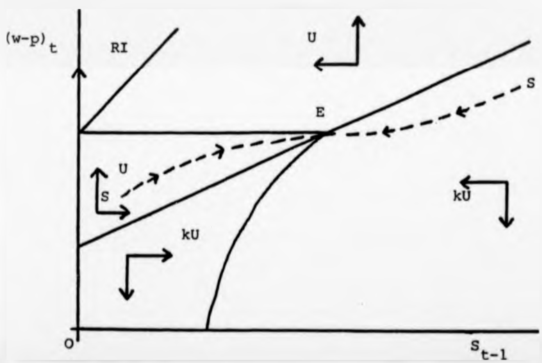
By assuming rational expectations the dynamics of the model are greatly altered, as now, via changes in S_t^* the economy can jump on to the stable manifold. Before discussing this however the regime switching loci will have been altered by introducing future expectations. This is most easily seen by first rewriting the desired inventory level as:

$$S_t^* = \bar{a} + bE(y_t^d)$$

where $\bar{a} = a + cE[\Delta(w-p)_{t+1}]$

With this formulation we need only consider the effect of $cE[\Delta(w-p)_{t+1}]$ on $\bar{a}$ in order to modify the previously derived regime switching loci. The following observations may be noted. When the economy is in Walrasian equilibrium then $E[\Delta(w-p)_{t+1}] = 0$, and so $\bar{a} = a$. Similarly when $E[\Delta(w-p)_{t+1}] > 0$ then $\bar{a} > a$ and when $E[\Delta(w-p)_{t+1}] < 0$ then $\bar{a} < a$. The degree to which $\bar{a}$ differs from a depends on the magnitude of $E[\Delta(w-p)_{t+1}]$, which in turn depends on how far the economy is from equilibrium in the labour market (we are assuming that $p_t = p_t^*$). From these observations the phase diagrams may be redrawn by noting the effects of changes of a on the regime switching loci. Figure 5.9 shows the resulting phase diagram for when $b < \frac{A - \beta_3}{\beta_3}$. A similar diagram could be drawn for $b > \frac{A - \beta_3}{\beta_3}$.

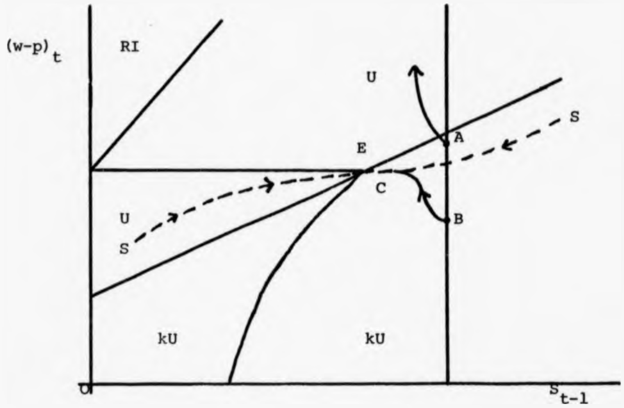
Figure 5.9



Now the stable manifold is non-linear with a point of inflection at the Walrasian equilibrium reflecting the fact that $E[\Delta(w-p)_{t+1}]$ becomes larger the further away the economy is from the $\ell_t^d = \ell_t^s$ locus. More importantly is that S_t^*, and hence wages are no longer predetermined. Stability requires that the agents are not myopic but forward looking so as to ensure that the economy is always be on the stable manifold, SS, converging toward equilibrium. The process is as follows: Producers determine their desired inventory holding with reference to the entire future real wage adjustment path, and being rational they choose that level of S_t^* that ensures stability. This involves choosing S_t^*, which affects the firms demand for labour, such that the real wage rate jumps on to the stable manifold. Thus if the economy is initially off the stable manifold S_t^*, and hence wages, will instantaneously adjust ensuring that the economy is on SS. The economy is now stable.

What are the consequences of relaxing the assumption $p_t = p_t^*$? With prices responding to excess demand in the money market then convergence of the price level to its equilibrium value is assured, and the above analysis is little affected. Now if the economy is out of equilibrium then producers again choose S_t^* so that the economy is stable. This they do by setting S_t^* at a level such that when prices do reach their equilibrium level the economy is on the stable manifold converging toward Walrasian equilibrium. This process is illustrated in Figure 5.10, where it is assumed that $b < \frac{A - \beta_3}{\beta 3}$ and that the economy is initially at A with $p_t > p_t^*$.

Figure 5.10



Given the inherent dynamics of the model at A the wage rate will fall and so will the price level (hence the movement of the real wage rate is ambiguous) while the stock of inventories will also be reduced. In Figure 5.10 we have assumed that at A the price effect dominates the wage effect and so the real wage rate increases, causing the economy to diverge away from equilibrium at E. In order for the economy not to pursue this divergent path the wage rate needs to initially fall, so that the economy moves to B. At B the price fall still dominates the wage effect, so the real wage increases. As the price level approaches p_t^* so the wage effect dominates and the real wage rate begins to fall. Point B, and hence the initial jump in w, is chosen so that when $p_t = p_t^*$ the economy is on SS, the stable manifold. In Figure 5.10 the economy jumps from A to B then moves along the path from B to C before converging along the stable manifold to E. The economy remains stable even when we relax the assumption that the money market is continually in equilibrium.

This section has been concerned to examine the consequences of modifying the wage and price adjustment processes on the existence and nature of long run equilibrium and stability. The analysis has illustrated the importance of wage and price adjustment. Although the considered modifications had no effect on the type and number of possible long-run equilibria, they were shown to have major consequences for the dynamic adjustment and stability of the model. The developed model was only shown to be stable if the microeconomic basis was altered to allow agents to have forward looking expectations, otherwise it exhibited saddlepoint instability. This section has therefore underlined the importance of developing and testing various wage and price adjustment mechanisms, with the robustness of previously derived results concerning the possibility of limit cycles dependant upon the chosen specification of wage and price adjustment.

5.6 Conclusions

This chapter represents a continuation of previous research concerned with analysing the properties of disequilibrium macroeconomic models that incorporate inventories as buffer stocks. Specifically the robustness of previous results, derived from fixed wage and price models, were examined by introducing imperfect wage and price adjustment. Initially an extension of Green and Laffont's (1981) "anticipatory pricing" was used to represent wage and price adjustment, with wages and prices assumed to move toward their expected market clearing levels over time. Justifications for such imperfect wage and price adjustment include imperfect information and learning, contract theory, and the presence of costs of changing individual prices. This approach allows the possibility of serially correlated regimes, while retaining the assumption that there is no wage or price movement within the period.

It was shown that for the model presented in Section 5.2, unlike those of Honkapohja and Ito (1980) and Eckalbar (1985), each of the four distinct regimes of Underconsumption, Repressed Inflation, Classical Unemployment and Keynesian Unemployment could be observed as the short-run equilibrium. Which regime is actually observed depends on the shocks the economy has experienced in both past and present periods. All regimes may be observed because all the supply and demand functions for goods and labour are subject to random disturbances, inventories may be reduced to zero, and wages and prices only adjust imperfectly. The main insights of this chapter, however, are related to the existence, nature and stability of the long-run equilibrium.

It is proven that there is a unique long-run equilibrium and that this is the Walrasian equilibrium, with all markets clearing.

This result is contrary to that derived by Honkapohja and Ito (1980) and Eckalbar (1985). For example, although Eckalbar's model exhibits a unique equilibrium, it is not, in general the Walrasian, and entails either full employment or unemployment of labour. Thus introducing wage and price adjustment toward their market clearing values rules out the existence of a long-run non-Walrasian equilibrium. However, such wage and price adjustment alters little the dynamics of the model, and specifically the stability of the long-run equilibrium. For simple aggregate models such as Metzler (1941) and Lovell (1962) the stability of the model is assured given that desired inventories are relatively small. However with a large demand for desired inventories (large b) the model is unstable, with these early models not taking into consideration either possible regime switching nor the non-negative of inventories. With these considerations this chapter has shown that for $b > \frac{A - \beta_3}{\beta_3}$ the economy may be either stable or exhibit a limit cycle, and that limit cycles are certain for a significant subset of the parameter space. For $b < \frac{A - \beta_3}{\beta_3}$ the economy is stable. These results confirm those found by Honkapohja and Ito, and Eckalbar. Much remains to be done before we can pretend an explanation of inventory and trade cycles, but the approach followed here of studying regime switching within a disequilibrium framework seems promising. One area that justifies further research concerns the wage and price mechanism, as results are sensitive to which of the alternative processes is adopted. Thus as shown in Section 5.5 when wages and prices respond to excess demand the dynamics and stability of the model are greatly altered, it being necessary to introduce forward looking expectations to ensure stability, otherwise the model exhibits saddlepoint instability. Under this specification limit cycles are not possible under any parameterization.

CHAPTER 6

DISEQUILIBRIUM OPEN ECONOMY MODELS WITH INVENTORIES AND PRICE ADJUSTMENT

This chapter extends the partial adjustment closed economy model developed in the previous chapter by introducing international trade. Firms are now allowed to export their output as well as supply domestic consumers and households consume foreign goods. International capital mobility ensures that the exchange rate and domestic interest rate jump instantaneously to their market clearing values. Wages and prices, however, are assumed to be predetermined at any moment in time, adjusting only slowly toward their equilibrium levels.

The open economy models developed here are used to test the robustness of results derived for the closed economy model. It is shown that, in general, the results concerning the nature of equilibrium and stability continue to hold in the open economy models. In particular the only long-run equilibrium is the Walrasian one and limit cycles are still certain for a significant subset of the parameter space. This chapter is also useful in that it extends previous work on exchange rate determination.

Recent experience with floating exchange rates has generated considerable interest in the economic forces that determine the behaviour of exchange rates. Perhaps the most striking feature of recent exchange rate behaviour is the large, apparently random, changes in exchange rates that regularly occur over short intervals of time. This behaviour is difficult to reconcile with the notion that exchange rates adjust to slowly evolving changes in fundamental economic conditions. This exchange rate behaviour contrasts with goods prices which are autocorrelated. (For a summary of empirical regularities see Frenkel, 1981 and Mussa, 1979.) As a result exchange rate innovationstend to be associated with shocks to relative prices, implying deviations from purchasing power parity. The different behaviour of the price level and the exchange rate can be explained in terms of models, like Dornbusch (1976), that recognize the possibility of sluggish price adjustment in the goods market. In such an economy the exchange rate behaves as an asset price, adjusting instantaneously to "news". The different speeds of adjustment between the goods and asset markets implies that sustained shocks to the exchange rate will result in persistent changes in relative prices. An issue that deserves further study is the path that the goods price pursues. This path ultimately underlies the evolution of the exchange rate. This chapter does this within a disequilibrium framework by presenting models where wage, price, inventory, employment and exchange rate dynamics are integrated. The models also extend previous work on exchange rate determination by explicitly considering the rationing on both the goods and labour markets. In extended versions of the "basic" open economy model the regime switching dynamics of the goods and labour markets spill-over to affect the exchange rate. This leads to the exchange rate exhibiting even greater deviations from its long-run equilibrium than previous models, such as Dornbusch (1976) and Flood and Hodrick (1983) predict. It is even possible for the exchange rate to exhibit a limit cycle.

In order to highlight the innovative features of our models, concerning exchange rate dynamics, in Section 6.1 we review earlier work on exchange rates, focusing on the role of sticky domestic goods prices and inventory accumulation in the Dornbusch,and Flood and Hodrick models. In Section 6.2 the "basic" open economy disequilibrium model is presented. The equilibrium, regime switching and stability properties of this model are also examined and compared with the closed economy results in this section.

Although the "basic" open economy model (model 6 1) is useful for analying the robustness of results derived from the partial adjustment closed economy model, and for aiding understanding of later results, there are two main criticisms that can be made of it. First it yields no new insights into exchange rate dynamics, with the path the exchange rate follows being the same as that predicted by Dornbusch's (1976) model. Second a major problem concerning the dynamics of this model is that the resulting wage adjustment is counter intuitive, rising when there is excess supply of labour and falling when there is excess demand. In response to these criticisms two further models are developed. In the first (model 6.2) an alternative demand for money equation is employed so that the money market is no longer insulated from the goods and labour markets. As a consequence the dynamic path of the exchange rate is now more complex than that predicted by either Dornbusch's model or by Flood and Hodrick's model. In the second extended open economy model the labour demand function is respecified such that the firms Walrasian demand for labour depends negatively on the real wage rate. With this modification wage dynamics are no longer counter intuitive and many of the previously derived results continue to hold, at least for certain parameterizations.

Conclusions to the Chapter are presented in Section 6.5.

6.1 Price adjustment and the exchange rate

Modelsof exchange rate dynamics with sticky prices, as characterised by Dornbusch (1976), are direct descendents of the open economy IS-LM models developed by Fleming (1962) and Mundell (1968). The Mundell-Fleming approach begins with a Keynesian economy characterised by rigid domestic prices and demand determined output; that economy is made open by introducing international trade and capital movements. Shocks to the goods and asset markets lead to once-and-for-all adjustments of the exchange rate rather than to a dynamic process of macroeconomic adjustment. These equilibrating exchange rate movements are in fact terms of trade changes which are maintained indefinitely even when the initial shock is monetary.

The static Mundell-Fleming model of exchange rate determination proved inadequate as an analytical tool in the inflationary environment of the 1970's. The dynamic Mundell-Fleming models, developed primarily by Dornbusch (1976) and Mussa (1977, 1982), extended the earlier framework in two important respects. First, while retaining the assumption that the nominal price of domestic output is fixed (i.e. predetermined) at any moment in time the dynamic models allow that price to adjust over time in response to deviations between aggregate demand and the full-employment level of output. Now a monetary expansion, for example, induces not only a temporary rise in output and a fall in the terms of trade, but also an inflationary process in which the initial expansionary impact is dissipated and purchasing-power parity is restored. Second, the dynamic models endow market participants with rational expectations of exchange rate and price movements.

Both key features of these models: instantaneous asset market clearing and perfect short-run output price rigidity, are surely, extreme characterizations of actual market adjustment. Nonetheless, these polar extremes yield an analytically tractable model that highlights neatly the dynamic implications of different adjustment speeds between markets. The most celebrated implication of this type of model is Dornbusch's (1976) finding that when the price of domestic goods is sticky, the exchange rate may overshoot its eventual level in the short run response to a permanent change in the money supply. This result is now analysed drawing on the analytical framework developed by Dornbusch (1976), and in order to highlight the key points, the model has been simplified by suppressing many of the inconsequential details.

6.1 Sticky domestic prices and overshocking

It is assumed that the economy faces a given price of foreign output and a given world rate of interest, that domestically produced goods differ from foreign goods, and that the supply of output is fixed.

Let the demand for real balances depend on real income, Y, and on the rate of interest, and let the logarithm of the demand be linear in the logarithm of income, y, and the rate of interest, i. Equilibrium in the money market obtains when

$$m - p = \emptyset y - b^{-1} i \qquad (6.1)$$

where m and p denote, respectively, the logarithms of the nominal quantity of money and the price level. Thus the equilibrium rate of interest can be written as:

$$i = b\phi y - b(m - p) \qquad (6.2)$$

The demand for domestic output, D, is composed of domestic demand and foreign demand. This demand can be expressed as the sum of total domestic absorption (domestic demand for domestic and foreign goods) and the excess of exports over imports (the trade balance surplus). Absorption is assumed to be dependent on real income, while the trade balance is assumed to depend on the relative price of domestic and foreign goods. Total demand for domestic output can therefore be written as:

$$D = A(Y) + T(EP^*/P) \qquad (6.3)$$

where A denotes domestic absorption, T denotes the balance of trade, E the exchange rate (the price of foreign exchange in terms of domestic currency), P^* the foreign price level (in terms of the foreign currency), and P the price of domestic output. For convenience, units are defined so as to equate the foreign price level to unity; therefore the trade balance may be viewed as depending on the real exchange rate, E/P.

Long-run equilibrium obtains when the demand for domestic output equals the fixed supply, that is when D = Y. In order to abstract from long run accumulation of foreign assets, it is assumed that in the long run the trade balance is zero. This assumption, made for convenience, only implies that absorption equals the given level of output, A(Y) = Y. Proceeding with the log-linear specification, the trade balance is written as:

$$T = \delta(e - p) \tag{6.4}$$

where e and p are the logarithms of E and P respectively. Substituting (6.4) into (6.3) and recalling that A(Y) = Y, the demand for output is:

$$D = Y + \delta(e - p) \tag{6.5}$$

The percentage change in the price level, $\mathring{p}$, is assumed to be proportional to excess demand (D - Y);

$$\mathring{p} = \pi (D - Y) \tag{6.6}$$

where π measures the speed of adjustment in the goods market, Substituting (6.5) into (6.6) yields

$$\mathring{p} = \alpha(e - p) \tag{6.7}$$

where $\alpha = \pi\delta$

At each moment in time, the price level is given, and its evolution is described by (6.7). The coefficient α is the product of two factors: π, the speed of price adjustment in the goods market and δ, the sensitivity of the balance of trade to the real exchange rate.

Equilibrium in the world asset market attains when the difference between the rates of interest on domestic and foreign securities, which are identical in all respects except for the currency of denomination, just equals the expected rate of change in the exchange rate. For example, when the domestic currency is expected to depreciate at the percentage rate η the long run equilibrium requires that:

$$i = i^* + \eta \tag{6.8}$$

where i^* denotes the rate of interest on assets denominated in foreign currency. It is assumed that expectations concerning the percentage rate of depreciation depend on the relationship between the equilibrium long run exchange rate $\bar{E}$ and the current rate E. Expressed logarithmically:

$$\eta = \theta(\bar{e} - e) \; ; \theta > 0 \tag{6.9}$$

where $\bar{e}$ is the logarithm of $\bar{E}$, and θ denotes the expectations adjustment coefficient, the determinants of which, given rational expectations, are analysed below. Equation (6.9) states that when the long run value, $\bar{e}$, exceeds the current value, e, individuals expect a depreciation of the currency toward $\bar{e}$, that is the expected depreciation, η, is positive.

The equilibrium that is described in equation (6.8) is attained through the mechanism of arbitrage effected by the international mobility of capital. Dornbusch (1976) assumes that there is perfect capital mobility, thus the asset market clears instantaneously and the interest parity condition, equation (6.8), holds continuously.

We are now able to analyse the equilibrium exchange rate and the relationship between the exchange rate, the price level and the speed of adjustment in the goods market. In the long run, given the quantity of money, the exchange rate equals its long run value and $i = i^*$. Substituting i^* for i in equation (6.1), the condition for money market equilibrium, the long run price level can be expressed as:

$$\bar{p} = m + b^{-1}i^* - \phi y \qquad (6.10)$$

To obtain the relationship between $\bar{p}$ and $\bar{e}$ it is noted that in the long run excess demand for goods is zero and therefore $\overset{o}{p} = 0$. It follows from (6.8) that:

$$\bar{e} = \bar{p} \qquad (6.11)$$

As may be seen from (6.10) and (6.11), the system satisfies the homogeneity postulate; a given change in the money supply results in an equiproportionate change in the long run equilibrium price level and the exchange rate.

From (6.1), (6.8) and (6.9) the money market is in equilibrium when:

$$b\phi y - b(m - p) - i^* - (\bar{e} - e) = 0$$

Using equation (6.10) this may be rewritten as

$$b(p - \bar{p}) - \theta(\bar{e} - e) = 0$$

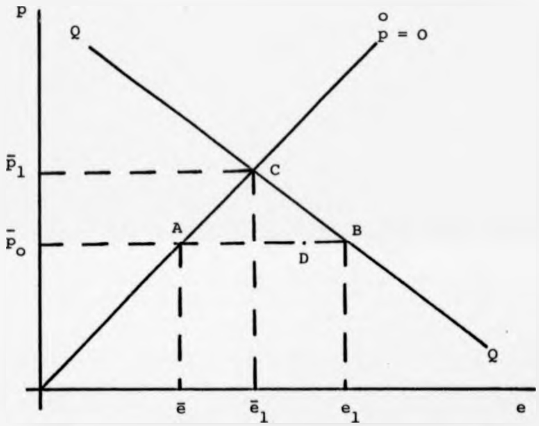
Therefore

$$e = \bar{e} + \varepsilon(p - \bar{p}) \qquad (6.12)$$

where $\varepsilon = -(b/\theta) < 0$

Equation (6.12) relates the equilibrium exchange rate to its long run value and to the discrepancy between current and long run prices. This is a reduced form relationship that holds at each moment in time. It should be noted that the price level and the exchange rate are inversely related, since $\varepsilon = -(b/\theta) < 0$. It is indeed because they are inversely related that the exchange rate overshoots its long run equilibrium before converging toward it, in response to a change in the money supply. To examine this consider the effect of a monetary expansion. The relationship between the exchange rate and the price level is characterised in Figure 6.1

Figure 6.1



In this figure the $\overset{o}{p} = 0$ schedule shows the combination of exchange rates and price levels for which there is no excess demand for domestic output. The schedule plots equation (6.8) and its slope is unity. The equilibrium relationship between the price level and the exchange rate (which must hold at each moment in time) is summarised by equation (6.12) and is plotted as the QQ schedule. The slope of this line is ε^{-1}, and is negative.

To analyse the effects of a monetary expansion, consider an initial long-run equilibrium at point A, with $\bar{p}_o$ and $\bar{e}_o$ as the corresponding price level and exchange rate. Through point A passes a QQ line (not drawn) that corresponds to the initial quantity of money. A rise in the money supply raises the long run equilibrium combination from point A to point C. The initial QQ schedule moves to the right to the position shown in Figure 6.1. Upon the change in the money supply, the price level is given at its initial value $\bar{p}_o$. Equilibrium in the money market requires that the exchange rate jump immediately to e_1, and the short run equilibrium is attained at point B, with the exchange rate overshooting its long run value. As the price level increases towards its long run equilibrium the exchange rate falls back. The economy thus converges along the QQ schedule toward the long run equilibrium at C.

The impact effect of the monetary change can be analysed in terms of equation (6.12). By the homogeneity postulate $dm = d\bar{e} = d\bar{p}$ and thus, given the price level the short run elasticity of the exchange rate with respect to the money supply is:

$$de/dm = 1 - \varepsilon = 1 + b/\theta \qquad (6.13)$$

and is greater than unity. It may be noted that the extent of overshooting depends on the magnitude of θ - the speed of adjustment of expectations, the determinants of which are analysed below. As is clear from (6.13), other things being equal, the short run elasticity gets closer to unity as the value of θ increases, thereby reducing the extent to which the current exchange rate differs from its long run value. It is also evident that as long as θ is not negative its magnitude is irrelevant for determining whether the exchange rate overshoots, and therefore, the analysis is consistent with a variety of assumptions concerning the formation of expectations. Dornbusch (1976) showed that in a model of perfect foresight the coefficient θ cannot be chosen arbitrarily, but rather that it must be consistent with the structure of the entire model. Using (6.11) in (6.7) the rate of inflation may be expressed as:

$$\mathring{p} = \alpha\{(e - \bar{e}) - (p - \bar{p})\} \qquad (6.14)$$

and using (6.12) this may be rewritten as:

$$\mathring{p} = \alpha(1 - 1/\varepsilon)\ (e - \bar{e}) \qquad (6.15)$$

The relationship between the equilibrium exchange rate and the price level that is described by (6.12) must always be satisfied. Therefore, given the long run values of $\bar{e}$ and $\bar{p}$ changes in the exchange rate and in the price level must be related such that:

$$\mathring{e} = \varepsilon\mathring{p} \qquad (6.16)$$

Substituting (6.14) for $\mathring{p}$ yield.

$$\overset{o}{e} = \alpha(1 - \varepsilon)(\bar{e} - e) \qquad (6.17)$$

Equation (6.17) describes the actual change in the exchange rate, while equation (6.9) describes the expected change. It is clear that under perfect foresight, consistency requires that the two be equal and therefore:

$$\theta = \alpha(1 - \varepsilon) \qquad (6.18)$$

Substituting for ε from (6.12) results in

$$\theta = \alpha + \alpha b/\theta$$

from which it follows that the coefficient of expectations can be obtained by solving the quadratic equation

$$\theta^2 - \alpha\theta - \alpha b = 0 \qquad (6.19)$$

From (6.19) the solution for θ (obtained by taking the positive root) is:

$$\theta = 1/2\left[\alpha + (\alpha^2 + 4\alpha b)^{1/2}\right] \qquad (6.20)$$

which expresses the coefficient of expectation as a function of the various parameters of the model, which in turn affect the extent the exchange rate overshoots its long run equilibrium.

So far in this section we have analysed the dynamics of exchange rates within a rational expectations model in which commodity prices adjust slowly, based on a simplified version of the model due to

Dornbusch (1976). The effects of a once-and-for-all unanticipated change in the money supply have been analysed. A large number of extensions of the basic Dornbusch model have appeared in the literature over the last few years. For example the analysis can be extended to examine the effects of other parametric changes such as changes in output, the foreign price level, and the foreign interest rate. Similarly Wilson (1979) and Gray and Turnovsky (1979) have examined the effects of an anticipated future change in the supply of money or in another parameter. Thus, it can be shown that an anticipated future rise in the money supply induces an immediate adjustment of the exchange rate, which jumps, for example, to point D in Figure 6.1. The extent of the jump in the exchange rate is smaller than the change that would have taken place had the money supply been expected to rise at the present. Following the initial jump in e both the exchange rate and prices proceed to rise gradually, and their path converges to the new QQ schedule (corresponding to the new quantity of money) at the point in time at which the rise in the money supply actually occurs. Thereafter, the convergence proceeds along the new QQ schedule toward the new long run equilibrium. In this case, with perfect capital mobility, the path of prices will be monotonic, while the path of the exchange rate will exhibit a turning point, that is e will initially rise and then decline.

Other extensions to Dornbusch's basic model include Mussa (1982) who presents a stochastic presentation of the framework and Niehers (1977) and Frenkel and Rodriguez (1982) who study similar models in which some asset markets adjust slowly.

Despite the large number of extensions of the basic Dornbusch model, little has been done to examine the consequences of introducing finished goods inventories into a model of exchange rate determination.

One noteable exception is a recent paper by Flood and Hodrick (1983). Their analysis is now considered.

6.1ii Inventories and exchange rates

Flood and Hodrick (1983) developed their model to match Dornbusch's with respect to initial effects of real and monetary disturbances. The dynamics of the Dornbusch model, though, result from slow price adjustment, while Flood and Hodrick's dynamics result from slow inventory adjustment. This divergence implies quite different adjustment paths for exchange rates and relative prices following initial impact effects. For example, a permanent increase in the money supply still causes the exchange rate initially to overshoot its long run value, but then, in contrast to Dornbusch's model, the exchange rate subsequently undershoots its long run value before approaching it from below, rather than directly from above. Consequently the dynamics of their model imply even greater gyrations of exchange rates than those implied by Dornbusch's model.

In Flood and Hodrick's model goods prices are set at the beginning of the period, prior to the revelation of actual values of the underlying disturbances. Thus prices are sticky in the sense that they do not respond as quickly to disturbances as they would if they were based on full information. Unexpectedly high demand is met at the pre-set prices with an increase in output and a fall in inventories of final goods held by firms. Because the demand for money in their model depends on expenditure, either a negative demand disturbance or a positive money supply disturbance will result in excess supply in the money market. In response to an unexpected increase in the money supply firms will be led to the rational but mistaken inference that there has been a decrease in the demand for domestic goods, since they are assumed to only observe the equilibrating asset price response to the excess supply. Firms therefore lower their relative price below what be optimal with full information. As the expected fall in demand for goods fails to materialize, the actual quantity demanded at the lower terms of trade is greater than firms anticipated. Firms respond by increasing output and reducing inventories. Output thus responds to unperceived monetary changes. As usual the fall in terms of trade occurs partly through a rise in the exchange rate. However the fall in inventories eventually causes an increase in the equilibrium terms of trade as firms rebuild their stocks; this increase occurs partly through a fall in the exchange rate. Thus after its initial rise at the time of the monetary expansion the exchange rate falls below its new long run equilibrium level and then rises monotanically to that level. In the Flood-Hodrick set up the persistent real effects of monetary shocks reflect the intrinsic dynamics of the model implied by the inventory adjustment process, causing greater deviations of the exchange rate from its long run value, than compared with a Dornbusch type model without inventories.

Within the Flood-Hodrick model persistence of output and exchange rate deviations from their long run values is due to inventories adjusting only slowly toward their long run equilibrium. Goods prices, however, are only away from their market clearing level within the period that the economy experiences an unexpected shock. This is contrary to Dornbusch's assumption that prices adjust slowly over time. The model to be presented in Section 6.2 returns again to this assumption by assuming that prices only partially adjust toward their equilibrium values within any one period. The model differs from Dornbusch's by allowing firms to hold inventories. It is assumed that firms desire to restore inventories to their short-run equilibrium value within the period, and will only be prevented from doing so if they are rationed in the labour market. Thus our model reverses the speed of adjustment of prices and inventories, as compared with Flood and Hodrick's model. Our model also extends previous studies on exchange rate determination by explicitly considering rationing on both the goods and labour markets. In the extended model of Section 6.4 the disequilibrium on these markets disturb the money and foreign exchange markets with the result that the exchange rate exhibits even greater deviations from its long run level following a shock than earlier models predict. Indeed it is even possible, within that model, that the exchange rate form a limit cycle.

6.2 The Model (Model 6.1)

6.2i Introduction

This section presents an extension of the closed economy disequilibrium model developed in the previous chapter by introducing international trade. Now firms export their output as well as supply domestic consumers and households consume foreign goods. International capital mobility ensures that the money market is continually in equilibrium with the exchange rate and domestic interest rate allowed to jump instantaneously to their market clearing levels. Wages and prices, however, are assumed to be predetermined at any moment in time, adjusting only slowly toward their equilibrium values.

As with the closed economy model the assumptions employed by Sneessens (1981) are used to derive the following effective trade offers. The effective trade offers of consumers are the Walrasian supply on the labour market and the Bénassy demand on the goods market. The effective trade offers of producers are the Bénassy demands on the labour market and the Drèze supply on the goods market. In describing the model we do not formulate the maximization problems of the agents in the model, but simply postulate piecewise linear behaviour functions. They should be regarded as plausible outcomes of expected profit and utility maximization. In order to make the model tractable we impose a linear structure on the demand and supply functions. All variables are measured in logarithms.

6.2ii Mathematical specification

Consider an economy that consumes two distinct goods: domestic goods (which may be exported) and imported goods. The general price level, p_t, is a weighted average of the domestic money price of these two goods:

$$p_t = \sigma p_t^d + (1 - \sigma)(e_t + p_t^f) \; ; \; 0 < \sigma < 1 \qquad (6.21)$$

where p_t^d is the price of the domestic good (in terms of domestic currency), p_t^f is the price of the foreign good (in terms of foreign currency), e_t is the exchange rate defined as the price of a unit of foreign currency in terms of domestic money, and σ is the elasticity of the general price level with respect to the domestic output price (σ is assumed to be a constant). The relative price of domestic goods in terms of imported goods is:

$$q_t = p_t^d - (e_t + p_t^f) \qquad (6.22)$$

Demand for domestic goods, y_t^d, is composed of domestic demand and foreign demand. Given that conditions in foreign countries are unchanged, demand for domestic goods is assumed to depend on the relative price of domestic goods to imported goods, q_t, the domestic real wage rate and a spill-over effect from the domestic labour market if there is unemployment. This demand function is assumed to be of the form:

$$y_t^d = \beta_o + \beta_1(w_t - p_t) + \beta_2(\ell_t - \ell_t^s) + \beta_3 q_t \qquad (6.23)$$

where w_t is the nominal wage rate, ℓ_t employment and ℓ_t^s the labour supply. The β's are constant coefficients, it being assumed that β_o, β_1, β_2 are positive and β_3 negative. As we have distinguished between imports and exports we are able to adopt the "large country assumption" as used by Cuddington (1980), the economy faces a downward sloping export demand curve, i.e. the demand for exports is less than perfectly elastic. In the market for imports the economy is assumed to be small and unrational, but we admit the possibility of world excess supply or demand for the exportable good. With this assumption we allow the possibility of disequilibrium in the goods market without having to include non-traded goods (though the present model can be easily reworked into a tradeables-non-tradeables framework). For greater discussion of the "large country assumption see Section 4.3.

Turning to the labour market it is assumed that firms attempt to meet expected demand, $E(y_t^d)$, and cover their desired inventory level, S_t^*. Labour demand is determined by inverting the production function. With the production function $Q_t = A\ell_t$, where Q_t is output, then labour demand, ℓ_t^d, is written as:

$$\ell_t^d = A^{-1}\left[E(y_t^d) + S_t^* - S_{t-1}\right] \tag{6.24}$$

where S_{t-1} is the beginning of period inventory level. It is assumed that the desired inventory level is dependent on the expected demand for goods and is written as:

$$S_t^* = a + bE(y_t^d) \; ; \quad a, b > 0 \tag{6.25}$$

Substituting (6.25) into (6.24) yields:

$$\ell_t^d = A^{-1}\left[a + (1+b)E(y_t^d) - S_{t-1}\right] \tag{6.26}$$

The Walrasian supply of labour is assumed to be constant, thus:

$$\ell_t^s = \delta_o \tag{6.27}$$

The transacted quantity of labour is the minimum of labour supply and demand

$$\ell_t = \min(\ell_t^d, \ell_t^s) \tag{6.28}$$

The supply of domestic goods, y_t^s, is the quantity of goods domestic firms have available for sale, and consists of present period production and the beginning of period inventory level, thus:

$$y_t^s = A\ell_t + S_{t-1} \tag{6.29}$$

As in the labour market the transacted quantity of goods, y_t, is the minimum of supply and demand.

$$y_t = \min(y_t^d, y_t^s) \tag{6.30}$$

The beginning of period inventory level is given by the excess of supply of goods over sales in the previous period, hence:

$$S_{t-1} = y_{t-1}^s - y_{t-1} \tag{6.31}$$

In the money market, equilibrium requires that the demand to hold domestic money equal the stock of domestic money available to be held; that is

$$M_t^d = k + p_t + \eta i_t^d = M_t^s;\ \eta > 0 \tag{6.32}$$

where M_t^d is the nominal money demand, M_t^s, the nominal money supply, i_t^d is the domestic interest rate, and k is assumed to be constant. Another requirement of assets market equilibrium is implied by the assumption that domestic securities, with forward cover are perfect substitutes for securities that pay the (exogenously given) world nominal interest rate, i_t^f. Hence the domestic nominal interest rate is linked to the world nominal interest rate through the interest parity condition:

$$i_t^d = i_t^f + \phi_t \qquad (6.33)$$

where ϕ_t is the percentage forward premium on foreign exchange which is assumed to equal the expected rate of change in the exchange rate. This equilibrium is attained through the mechanism of arbitrage effected by the international mobility of capital. (The possibility that the forward premium is influenced by a risk premium is ignored. For discussion on this issue of risk premium see Kouri, 1976 and Stockman, 1978).

It is assumed that expectations concerning the percentage rate of depreciation depends upon the relationship between the equilibrium long-run exchange rate, $\bar{e}_t$ and the current rate e_t. Hence:

$$\phi_t = \theta(\bar{e}_t - e_t) \; ; \; \theta > 0 \qquad (6.34)$$

where θ denotes the expectations adjustment coefficient. Equation (6.34) states that when the long-run value $\bar{e}_t$ exceeds the current value e_t individuals expect a depreciation of the currency toward $\bar{e}_t$, that is the expected depreciation, ϕ_t, is positive. Due to spatial arbitrage it is assumed that in the long run the law of one price holds, there being no tariffs or transport costs. Thus the long-run exchange rate, $\bar{e}_t$, is determined in accordance with the purchasing power doctrine, offsetting differences in national price levels:

$$\bar{p}_t^d - p_t^f = \bar{e}_t \qquad (6.35)$$

The strategic assumption of the model is that asset markets clear continuously whilst wages and prices adjust only slowly over time, admitting the possibility of disequilibrium in the goods and labour markets. With the asset markets clearing continuously both the money market equilibrium (6.32) and the interest parity condition (6.33) hold at all times due to the equilibrating movements in the domestic interest rate and the exchange rate.

In the long run, given the quantity of money, the exchange rate equals its long-run value and $i_t^d = i_t^f$. Substituting i_t^f for i_t^d into equation (6.32) and equation (6.21) for $\bar{p}_t$ the value for the long run price level of domestic goods is expressed as:

$$\bar{p}_t^d = [M_t^s - k + \eta i_t^f - (1 - \sigma)(\bar{e}_t + p_t^f)]\sigma^{-1}$$

Noting equation (6.35) this may be rewritten as:

$$\bar{p}_t^d = M_t^s - k + \eta i_t^f \qquad (6.36)$$

The actual price of domestic goods, p_t^d, is assumed to adjust over time toward this long run value, according to the equation:

$$p_t^d = \lambda p(\bar{p}_t^d - p_{t-1}^d) + p_{t-1}^d \qquad (6.37)$$

where λ_p is the partial adjustment coefficient for domestic prices.

Similarly wages are assumed to adjust over time toward that level that would simultaneously clear both the goods and labour markets, hence

$$w_t = \lambda_w(w_t^* - w_{t-1}) + w_{t-1} \tag{6.38}$$

where λ_w is the partial adjustment coefficient for wages, and w_t^* the equilibrium wage rate. By equating (6.27) with (6.26) we get:

$$A\delta_o = a + (1 + b)E(y_t^d) - S_{t-1}$$

Taking the rational expectation of $E(y_t^d)$ from equation (6.23) and rearranging yields the equilibrium wage rate:

$$w_t^* = \frac{A\delta_o - a + S_{t-1}}{(1+b)\beta_1} \quad \frac{-[\beta_o + \beta_1 p_t + \beta_3(p_t^d - (e_t + p_t^f))]}{\beta_1} \tag{6.39}$$

To close the model we need to determine the instantaneous exchange rate, e_t.

In the short run the price of domestic goods is predetermined and thus the current exchange rate deviates from its long run value whenever $p_t^d \neq \bar{p}_t^d$, so as to clear the money market. Equilibrium in the money market is given as:

$$M_t^s = k + \sigma p_t^d + (1 - \sigma)(e_t + p_t^f) - \eta i_t^f - \eta\theta(\bar{e}_t - e_t)$$

Substituting in for $\bar{e}_t$ from (6.35) and rearranging yields the current exchange rate

$$e_t = \left[\frac{(1 + \eta\theta)(M_t^s - k + \eta i_t^f - \sigma p_t^d)}{\eta\theta + (1 - \sigma)} \right] - p_t^f \qquad (6.40)$$

The model as described so far is fully deterministic. As with Model 5.1 in order to make this model stochastic we introduce random shocks to the demand and supply functions on the goods and labour markets. Thus we rewrite these functions respectively as follows:

$$Y_t^d = y_t^d + \varepsilon_t^1 \qquad (6.41)$$

$$Y_t^s = y_t^s + \varepsilon_t^2 \qquad (6.42)$$

$$L_t^d = \ell_t^d + \varepsilon_t^3 \qquad (6.43)$$

$$L_t^s = \ell_t^s + \varepsilon_t^4 \qquad (6.44)$$

where upper case letters denote the resulting stochastic variable, composed of the sum of the deterministic variable (lower case letter) and the stochastic disturbance term, ε_t^i, $i = 1, \ldots, 4$. It is assumed that these disturbance terms are independently distributed with the property that $E(\varepsilon_t^i) = 0$ for all $i = 1, \ldots, 4$.

6.2ii Equilibrium and dynamics

The model described above has three broad markets, an asset market, a goods market and a labour market. The asset market is kept continually in equilibrium due to international capital mobility causing the exchange rate and domestic interest rate to instantaneously adjust to their market clearing levels. By distinguishing between exportable and importable goods and adopting the "large country assumption" we admit the possibility of excess supply or demand for exportables, due to imperfect wage and price adjustment. With the labour market also able to experience disequilibrium there are, as with the closed economy model, four short run equilibrium regimes, each identified by the relative magnitude of effective demand and supply for domestic goods and labour. Whether all of these regimes may be observed depends on the stochastic structure of the model with respect to the inherent dynamics and the stochastic processes. Because all the supply and demand functions for labour and domestic goods are subject to random shocks, inventories can be reduced to zero, and wages and prices adjust only imperfectly each of the four regimes may be observed, conditional on the disturbances that the economy has experienced in present and past periods.

For the economy to be in long-run equilibrium then wages, domestic prices and inventories need to be at their long-run values, as given by equations (6.39), (6.36) and (6.25) respectively. By appropriate substitution these long-run equilibrium values may be written as:

$$w_t = \frac{A\delta_o - \beta_o}{\beta_1} + M_t^s - k + \eta i_t^f \qquad (6.45)$$

$$P_t^d = M_t^s - k + \eta i_t^f \qquad (6.46)$$

$$S_t = a + bA\delta_o \qquad (6.47)$$

As with the closed economy model these conditions are, given the value of the money supply, M_t^s, single valued, thus there is only one long run equilibrium. Furthermore, as these conditions entail market clearing in all markets,this unique equilibrian is the Walrasian one. Also from these equilibrium conditions we see that this model satisfies the homogeneity postulate; a given change in the money supply results in an equiproportionate change in the long-run equilibrium values of nominal variable, real variables remain unchanged.

In order to examine the regime switching and stability properties of this model we follow the general methodology employed in Section 5.4. First the dynamics of the model are explored under the restrictive assumption that the domestic price level is at its long-run equilibrium level, $p_t^d = \bar{p}_t^d = M_t^s - k + i_t^f$. Second we analyse the consequences of relaxing this assumption and allow prices to be out of equilibrium.

By initially assuming that the domestic price level is at its long-run equilibrium value implies that the exchange rate and the domestic interest rate are also in long-run equilibrium with $e_t = \bar{e}_t$ and $i_t^d = i_t^f$ respectively. With these variables in equilibrium the complexity of the model is reduced and may be written as follows:

$$L_t^d = A^{-1}[a+(1+b)E(Y_t^d) - S_{t-1}] + \varepsilon_t^3$$

$$L_t^s = \delta_o + \varepsilon_t^2$$

$$L_t = \min(L_t^d, L_t^s)$$

$$Y_t^d = \bar{\beta}_o + \beta_1(w_t - \bar{p}_t) + \beta_2(L_t - L_t^s) + \varepsilon_t^1$$

$$Y_t^s = AL_t + S_{t-1} + \varepsilon_t^2$$

$$Y_t = \min(Y_t^s, Y_t^d)$$

$$S_t = Y_t^s - Y_t$$

where $\bar{\beta}_o = \beta_o + \beta_3 q_t = \beta_o + \bar{p}_t^d - (\bar{e}_t + p_t^f)$

and $\bar{p}_t = \sigma \bar{p}_t^d + (1 - \sigma)(\bar{e}_t + p_t^f)$

The structure of this model is identical to that of the closed economy model when $p_t = p_t^*$. Therefore the general results obtained in Section 5.4, derived under this assumption continue to hold true for this model. In particular this open economy model is either stable or exhibits a limit cycle, and the parameter space has a significant subset in which limit cycles are certain.

We now consider the consequences of allowing domestic prices to be out of equilibrium. Although the short-run dynamics of the model are affected, due to price and exchange rate movements, and the resulting effects on other variables, the long-run dynamic results previously derived still hold true. This is because the equilibrium value for the domestic price level (as well as for the exchange rate and the domestic interest rate) is unaffected by movements in the goods and labour markets, and therefore p_t^d will eventually converge upon its long-run value in accordance with (6.37). In the long-run the condition that $p_t^d = \bar{p}_t^d$ always holds and hence the results derived under this restriction are valid for the long run. The economy is either stable or exhibits a limit cycle, with both these possibilities occuring for a significant subset of the parameter space. The short run dynamics of this model are further explored in Chapter 7 when the effectiveness of fiscal and monetary policy in both the short- and long-run is assessed.

In conclusion the results derived for the closed economy model relating to equilibrium, both short-run and long-run, and stability continue to hold true, and are therefore robust to the introduction of international trade, as undertaken in this section. It should be restated here, however, that two main criticisms can be made against this model. First it yields no new insight into exchange rate dynamics, with the path the exchange rate follows being the same as that predicted by Dornbusch's (1976) model. Second a major problem concerning the dynamics of the model is that the resulting wage adjustment is counter intuitive, rising when there is excess supply in the labour market and falling when there is excess demand. In response to these criticisms we present two extended models, the first deals with the former criticism (and aids understanding of the final model) whilst the second extended model meets both of these criticisms.

6.3 An alternative demand for money equation (Model 6.2)

As previously stated one of the main reasons for developing the open economy models of this Chapter was to gain further insight into exchange rate determination. The way the model has been presented so far, however, has yielded no new insights into exchange rate dynamics, with the path the exchange rate follows being the same as that predicted by Dornhusch's (1976) model. This is because the money market is insultated from the goods and labour markets. Although adjustments in the money market affect the goods and labour markets, there is no corresponding feedback, and hence the exchange rate is unaffected by disequilibrium regime switching and inventory movements. If this assumption that the goods and labour markets have no influence on the money market is relaxed then price and exchange rate adjustments are further complicated.

There are many ways in which the goods and labour markets may be thought to affect the money market. Here it is assumed that due to transaction purposes the demand for domestic money is linearly dependent on the expected demand for domestic goods. Thus the condition for equilibrium in the money market now becomes:

$$M_t^d = k_o + p_t + k_1 E(Y_t^d) + \eta i_t^d = M_t^s \tag{6.48}$$

By introducing this specification for the demand for money the model becomes much more complex. Now the dynamics within the goods and labour markets spill-over to affect the money market. With the exchange rate instantaneously adjusting so as to clear the money market, by incorporating $E(y_t^d)$ into the demand for money the dynamic path of the exchange rate is affected. For example suppose the economy is initially out of Walrasian equilibrium then the economy will in general oscillate around full employment either converging toward it or forming a limit cycle. Given these oscillations in employment, and also the demand for domestic goods, with imperfect price adjustment, the demand for money and the exchange rate will also oscillate around their long-run equilibrium values. The dynamic path of the exchange rate is now more complex than that implied by the Dornbusch model. The dynamics of our model also significantly differ from Flood and Hodrick's (1983) model; there an increase in the money stock causes the exchange rate to again initially overshoot its long-run value, but then it subsequently undershoots this level and approaches from below rather than directly from above. It is evident that the dynamics of our model imply even greater gyrations of the exchange rate than those implied by Dornbusch's model or Flood and Hodrick's model. Exchange rate oscillation in our model is the result of interaction between the money market and regime switching on the goods and labour markets, caused by imperfect wage and price adjustment and inventory movements. These results are further confirmed in Chapter 7 when we analyse the effectiveness of government economic policy.

By developing this integrated disequilibrium model of wage, price, inventory and exchange rate determination we have gained further insight into the dynamic path of domestic prices which underlies the evolution of the exchange rate. This has led to the exchange rate exhibiting greater deviations from its long-run equilibrium than previous models predict. It is even possible for the exchange rate to exhibit a limit cycle.

Because of the resulting complexity of the model when equation (6.32) is replaced by (6.48) in order to further examine the dynamics, stability, and also the effectiveness of government policy in the next Chapter, when the economy is out of Walrosian equilibrium, it is necessary to use computer based numerical simulation techniques.

Numerical simulation

The reason why simulation techniques are needed to further analyse the dynamics of the present "extended" model is due to the limitations of traditional comparative static methods. First, comparative static results are often indeterminate in sign, therefore implications are rather inconclusive even at the qualitative level. Second, with the demand for money equation given as in equation (6.48) stability analysis becomes extremely complicated, if not an intractable exercise, due to the feedbacks from the goods and labour markets to the money market. This is further complicated due to the basic disequilibrium nature of the model. In principle, in order to prove stability, one needs not only to prove that adjustment within each regime is stable, but also that the dynamic process must be stable as the economy moves from one regime to another. This introduces problems due to the non-differentiability and discontinuity of the differential equations describing the adjustment process at the boundaries between regimes. Third, these traditional methods tell us relatively little about the time profile of adjustment paths. Indeed it may be argued that the two extreme equilibria usually analysed are themselves of limited economic interest. The instantaneous equilibrium is too short in that it allows insufficient time for relative feedbacks to occur; the steady state equilibrium is often too long, in that it takes a prolonged time to be reached. Yet it is precisely the nature of the intermediate transaction that many feel is of prime interest and the traditional methods provide little insight into this aspect of the adjustment process.

In using simulation methods we follow the pioneering work of Nguyen and Turnovsky (1979, 1983), Camilleri et al., (1984), and Whittaker et al., (1986). In these papers simulation techniques have been used to supplement the traditional comparative static methods to investigate the behaviour of dynamic macroeconomic models. Thus simulation methods have proved useful in providing additional information on the dynamics of a model. In particular, some of the indeterminacies of the comparative statics can be eliminated or at least reduced with some confidence; more definite indications of the stability or otherwise of the system can be obtained; the time path of adjustments can be traced out thereby providing further insights into the transitional paths and how much time is required for an equilibrium to be reached.

In order to simulate the dynamic behaviour of the model we need to construct in a consistent manner a set of plausible parameter values from various empirical and statistical sources. An alternative approach was to estimate the model before simulating it. However estimation of a disequilibrium rational expectations model of the size and complexity considered here would obviously require separate and prolonged treatment. Our concern has been to examine the dynamic behaviour of an essentially theoretical model, and the adopted simulation approach should be viewed as an aid to the analysis. In constructing our basic parameter set we have where possible taken the parameter values used by Whittaker et al., (1986) which in turn were taken from a version of the Treasury macroeconomic model (Treasury, 1980). In some case the form of their model equations was incompatible with our own model and so we resorted to "informed guesswork". In this process various empirical and statistical sources were consulted, and the values chosen are as realistic as such casual empiricism allows. They are not necessarily chosen from empirical studies of disequilibrium models, nor any other particular assumption in our model. The results obtained are subjected to sensitivity analysis by considering alternative parameter sets in an attempt to consider how specific to a given parameterisation our results maybe, and hence to make our conclusions more general. It is recognized, however, that sensitivity analysis cannot prove in any sense that the chosen parameter values are "true" values, nor that the conclusions derived are completely general.

For all parameter sets the steady state output is scaled at 1000 units. Initial wages and the domestic price level are set at unity, the initial foreign price level is equal to one half, implying that the exchange rate also initially equals one half. The initial value for the economic aggregates in the basic set were selected by considering their corresponding proportions relative to national income implied by official statistics. Government expenditure is assumed to comprise of 40% and imports 25% of national income. The ratio of the money supply to national income in the basic set is assumed to be 10%. The basic parameter set together with each parameters' plausible range is given in Table 6.1.

An implicit constant term is adjusted in the equation where necessary to ensure that the equations are compatible with initial Walrasian equilibrium. Further it is assumed that inventories in Walrasian equilibrium comprise of 1% of national output. Therefore the constant term a in equation (6.25) is determined by the equation:

$$a = (0.01 - b)y \qquad (6.49)$$

Table 6.1 Parameter values for the open economy model

Parameter	Equation	"High"	"Basic"	"Low"
β_1	(6.23)	1.0	0.9	0.8
β_2	(6.23)	0.9	0.5	0.0
β_3	(6.23)	-0.5	- 0.4	-0.2
A	(6.24)	1.0	0.8	0.4
b	(6.25)	1.0	0.9	0.8
k_1	(6.48)	0.5	0.2	0.05
η	(6.48)	-0.8	-0.5	-0.3

Our numerical analysis of stability involves disturbing the model from Walrasian equilibrium and observing the resulting dynamics of the economy. To begin this is done with all parameters set at their basic values. Subsequently we attempt to mark out the stable parameter space by putting one parameter at a time to its value at either end of this range, while keeping all the other parameters at their basic values. These experiements are undertaken under the alternative assumptions that first $\lambda p = 0.8$ and $\lambda w = 0.4$, second $\lambda p = 0.4$ and $\lambda w = 0.2$, and also whether the economy is open or closed. (When the economy is closed then $\sigma = 1$, $\beta_3 = 0$ and $\eta = 0$.) Results are presented in Table 6.2.

Table 6.2 Stability under alternative parameter sets

(s = stable, L = Limit cycle)

Parameters varied from basic set	$\lambda p = 0.8$, $\lambda w = 0.4$		$\lambda P = 0.4$, $\lambda w = 0.2$	
	Open	Closed	Open	Closed
None = Basic set	s	s	s	s
β_1 - High	s	s	s	s
- Low	s	s	s	s
β_2 - High	s	s	L	L
- Low	s	s	s	s
β_3 - High	s	s	s	s
- Low	s	s	s	s
A - High	s	s	s	s
- Low	s	s	L	L
b - High	s	s	s	s
- Low	s	s	s	s
k_1 - High	L	S	L	s
- Low	s	s	s	s
η - High	s	s	s	s
- Low	s	s	s	s

From Table 6.2 it is seen that in many cases the models are stable, there being only six occurances of either model exhibiting a limit cycle, from a total of sixty experiments. However it is instructive to note when these limit cycles occur.

First, five limit cycles occur when $\lambda p = 0.4$ and $\lambda w = 0.2$, whilst only one of the limit cycles occurs when $\lambda p = 0.8$ and $\lambda w = 0.4$. This indicates that as the adjustment coefficient for wages and prices increase the economy is more likely to be stable. This accords with intuition.

Second when $\lambda p = 0.4$ and $\lambda w = 0.2$ the economy exhibits a limit cycle if β_2 is high and A is low. Indeed with $\lambda p = 0.4$ and $\lambda_w = 0.2$, the economy exhibits a limit cycle when $b > \frac{A - \beta_2}{\beta_2}$. In Chapter 5 it was shown, under the assumption that $k_1 = 0$, that when this condition was met the economy would oscillate around its long run equilibrium, either converging toward it or forming a limit cycle. The observations in Table 6.2 confirm that this condition is still important for determining the stability of the economy when $k_1 > 0$.

Third when k_1 equals 0.5 then the open economy model exhibits a limit cycle while the closed economy remains stable (other parameters are set at their basic values). From this observation it appears that, in general, introducing both the demand for (domestic) goods into the demand for money equation and making the economy open leads to the economy being less stable, increasing the probability that the dynamics of the model will produce a limit cycle.

From the observations in Table 6.2, therefore, it may be argued that the critical determinants of stability are whether the economy is open or closed, whether b is less than or greater than $\frac{A - \beta_2}{\beta_2}$, and the values of λp, λw and k_1. Importantly the result that for a significant subset of the parameter space limit cycles are certain continues to hold true for both the open and closed models when the demand for money depends upon the demand for goods.

6.4 An alternative demand for labour equations (Model 6.3)

In the previous section we extended the "basic" open economy model by incorporating the expected demand for domestic goods into the demand for money equation. This implied that the money market, and hence the exchange rate, was no longer isolated from the goods and labour market dynamics. This caused the exchange rate to exhibit greater deviation from its long-run equilibrium than previous models predict. It is even possible for the exchange rate dynamic to form a limit cycle. Thus model 6.2 met the first criticism levelled against the basic open economy model. However the second criticism made against that model still applies, that is the resultant wage dynamic is counter intuitive. As stated in Chapter 5 this problem arises because of the way the demand for labour has been modelled. Instead of deriving an optimal labour demand function it has been assumed (following Sneessens, 1981, and Eckalbar, 1985) that firms attempt to always meet the demand for goods. Given this assumption labour demand is found by inverting the production function having substituted in for the demand for goods. In consequence, as the demand for goods is positively related to the real wage rate, the demand for labour also depends positively on the real wage rate. If there is excess supply in the labour market, in order to restore equilibrium, there needs to be a rise in the wage rate so as to raise the demand for goods and hence the demand for labour. This is a special case. In this section we examine the consequences of more conventionally assuming that the demand for labour, over a certain range, depends negatively on the real wage rate.

With the production function exhibiting diminishing returns the firms Walrasian demand for labour will depend negatively on the real wage rate. Thus we may write this Walrasian demand as:

$$\ell^{wd}_t = A^{-1}\left[z_o - z_1(w_t - p_t)\right]$$

How is this demand for labour modified when the economy is out of Walrasian equilibrium? From Section 4.2iv it is recalled that given the underlying assumptions of the present disequilibrium rationing model the effective trade offers of producers on the labour market are of the Bénassy type (see Sneessens, 1981, for a formal proof of this). If the constrained goods supply, due to insufficient demand, $\bar{y}^s_t$, is less than y^{ws}_t producers will have to account for the fact that it will be almost impossible for them to sell more than $\bar{y}^s_t$. Accordingly producers will only seek to employ the amount of labour required to produce $\bar{y}^s_t$. Thus when $\bar{y}^s_t < y^{ws}_t$ then $\ell^d_t = A^{-1}\left[E(y^d_t) + S^*_t - S_{t-1}\right]$. (In deriving this demand function we have continued to assume that firms attempt to maintain a desired inventory level of S^*_t, S_{t-1} being the present inventory level carried over from the previous period.) Alternatively when $\bar{y}^s_t \geq y^{ws}_t$ then $\ell^d_t = A^{-1}\left[z_o - z_1(w_t - p_t) + S^*_t - S_{t-1}\right]$.

Incorporating these modifications into the existing open economy model we may rewrite the model as follows:

$$p_t = \sigma p^d_t + (1 - \sigma)(e_t + p^f_t); \quad 0 < \sigma < 1$$

$$q_t = p^d_t - (e_t + p^f_t)$$

$$y^d_t = \beta_o + \beta_1(w_t - p_t) + \beta_2(\ell_t - \ell^s_t) + \beta_3 q_t$$

$$y_t^s = A\ell_t + S_{t-1}$$

$$y_t = \min(y_t^d, y_t^s)$$

$$\ell_t^s = \delta_o$$

$$\ell_t^d = A^{-1}[z_o - z_1(w_t - p_t) + S_t^* - S_{t-1}]$$

$$\text{iff } z_o - z_1(w_t - p_t) \leq y_t^d$$

$$\ell_t^d = A^{-1}[\beta_o + \beta_1(w_t - p_t) + \beta_2(\ell_t - \ell_t^s) + \beta_3 q_t + S_t^* - S_{t-1}]$$

$$\text{iff } z_o - z_1(w_t - p_t) > y_t^d$$

$$\ell_t = \min(\ell_t^d, \ell_t^s)$$

$$S_t = y_t^s - y_t$$

$$M_t^d = k + p_t + \eta i_t^d = M_t^s$$

$$i_t^d = i_t^f + \phi_t$$

$$\phi_t = (\bar{e}_t - e_t)$$

$$w_t = \lambda_w(w_t^* - w_{t-1}) + w_{t-1}$$

$$p_t^d = \lambda_p(p_t^{d*} - p_{t-1}^d) + p_{t-1}^d$$

$$S_t^* = a + bE(y_t^d)$$

It is clear that in the above model, as the demand for labour is no longer uniquely related to the demand for goods, that when the wage rate is at its Walrasian equilibrium level this does not ensure that both the goods and labour markets clear simultaneously. It is now necessary to allow the price level to adjust (via changes in the domestic price level) so as to clear the goods market. As the goods market is influenced by labour market dynamics, which in turn influences the money market, inorder to study the dynamic and stability properties of this model we need to simultaneously consider inventory, wage, price, and exchange rate movements. As with Model 6.2 given the resulting complexity of this model analysis requires the use of computer based numerical simulation techniques.

In setting up the computer based model the following dynamic assumptions were employed. Wages were assumed to partially adjust each period to that level that would clear the labour market. If the firm expects to be unconstrained in the goods market then wages adjust towards the level where

$$z_o - z_1(w_t - p_t) + S_t^* - S_{t-1} = A\delta_o$$

$$\therefore \quad w_t^* = \frac{z_o + S_t^* - S_{t-1} + z_1 p_t - A\delta_o}{z_1}$$

Alternatively if producers expect to be constrained in the goods market then w_t^* is determined so that

$$\beta_o + \beta_1(w_t^* - p_t) + \beta_3 q_t = A\delta_o$$

$$\therefore \quad w_t^* = \frac{A\delta_o - \beta_o - \beta_3 q_t + \beta_1 p_t}{\beta_1}$$

Similarly domestic prices are assumed to partially adjust toward that level which would clear the goods market with neither consumers nor producers rationed in that market. If there is full employment of labour the resulting equilibrium domestic price level satisfies the following equation

$$\beta_o + \beta_1(w_t - p_t) + \beta_3 q_t = A\delta_o + S_{t-1} + S_t^*$$

Alternatively if there is unemployment of labour then p_t^{d*} is determined so that:

$$z_o - z_1(w_t - p_t) = \beta_o + \beta_1(w_t - p_t) + \beta_2(\ell_t - \ell_t^s) + \beta_3 q_t$$

Finally the exchange rate is assumed to adjust instantaneously to clear the money market. The long-run equilibrium exchange rate, $\bar{e}_t$, is determined so that when both wages and prices are simultaneously at their Walrasian equilibrium levels then the money market also clears with $e_t = \bar{e}_t$, that is $i_t^d = i_t^f$. Thus $\bar{e}_t$ is determined from the following equation:

$$M_t^s = k + p_t^* + \eta i_t^f$$

given that $\ell_t^d = \ell_t^s$

This completes the specification of this extended model. In order to implement the numerical simulation technique a plausible parameter value for z_1 needs to be adopted. Instead of employing a unique value for z_1 we have chosen two values $z_1 = 0.8$ and $z_1 = 0.4$

to cover a broad range of acceptable values. All other parameter values are set at their basic set values (see Table 6.1) unless otherwise stated. As with the previous model, inorder to assess the sensitivity of the model to a particular parameterization we vary the values of the other parameter values one at a time in accordance with Table 6.1. The results of this stability analysis are given in Table 6.3.

Table 6.3 Stability under alternative parameter sets

(S = stable; L = Limit cycle; U = Unstable)

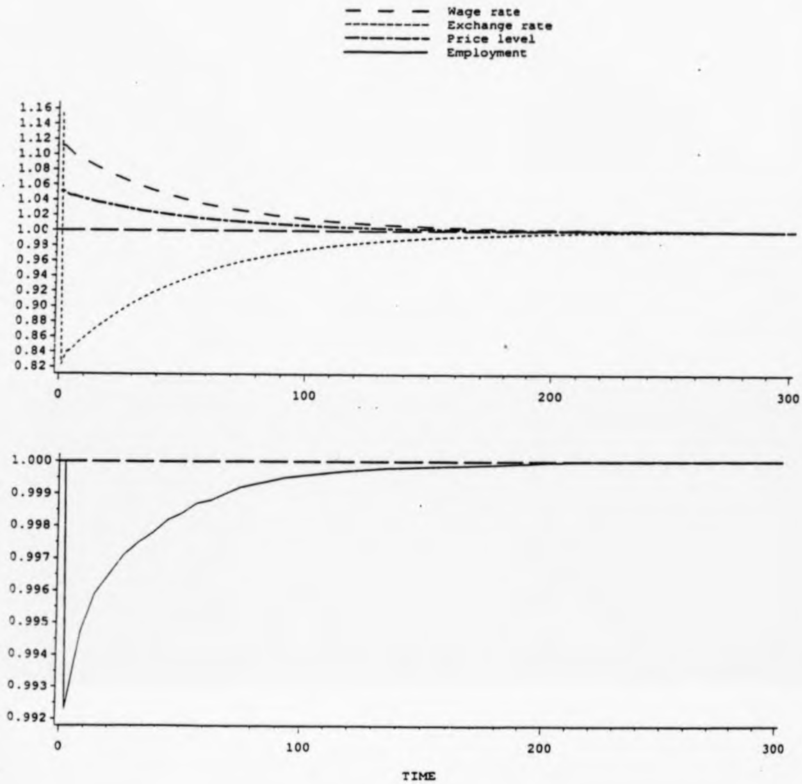
Parameters varied from basic set	$\lambda p = 0.8$	$\lambda w = 0.4$	$\lambda p = 0.4$	$\lambda w = 0.2$
	$z_1 = 0.8$	$z_1 = 0.4$	$z_1 = 0.8$	$z_1 = 0.4$
None	S	S	U	S
β_1 - High	S	S	U	S
- Low	S	S	U	S
β_2 - High	S	S	U	S
- Low	U	U	U	S
β_3 - High	S	S	U	S
- Low	U	L	U	U
A - High	U	S	U	S
- Low	L	S	U	S
b - High	S	S	U	S
- Low	S	S	U	S
η - High	S	S	U	S
- Low	S	S	U	S

As can be seen from Table 6.3 depending on the parameter values the model is either stable, unstable or exhibits a limit cycle. It is noteworthy that limit cycles are still certain for a significant subset of the parameter space, showing that this result derived earlier is robust to the current changes in the way labour demand is modelled. It is also the case that the dynamic adjustment path of the exchange rate, within this model, following a once and for all disturbance to the economy is often more complex than that predicted by earlier models. In particular when the economy exhibits a limit cycle the exchange rate dynamic also forms a limit cycle. These gyrations, as with the previous model, are due to the interaction between the money market and regime switching on the goods and labour markets, cuased by imperfect wage and price adjustment and inventory movements.

A difference between this present model and earlier models is now that the economy may continually diverge away from equilibrium. In previous models the economy was prevented from exploding by inventory stock outs causing the economy to form a limit cycle. In this model it is possible under certain parameterizations for the economy to explode with inventories, wages and prices ever increasing. These instances of instability are a cause for concern. It should be noted, however, that if the parameters are such that the economy will explode agents will modify their behaviour to avoid this occurring. For example if agents attempted to set prices in accordance with their long-run Walrasian values instead of their short-run market clearing values then the instances of explosive instability would disappear for the range of parameter values used in Table 6.1, with the economy now being either stable or exhibiting a limit cycle.

How do these modifications to the way labour demand is modelled affect specifically the dynamics of the wage rate? As the Walrasian labour demand function is negatively related to the real wage rate, wage adjustment to clear the labour market is no longer counter intuitive when the economy is near equilibrium. Now when there is unemployment of labour wages fall and when there is full employment wages either remain constant or rise. This is confirmed by Figure 6.2, where the dynamic paths of wages, prices, exchange rate and employment are shown following a once and for all reduction in the money supply of 10%. (Parameter values are set at their basic values with $\lambda p = 0.8$; $\lambda w = z_1 = 0.4$). Following the reduction in the money supply at the beginning of the first period employment immediately falls before gradually rising back to its full employment level (indexed at unity). Wages, on the other hand, fall continuously toward their new Walrasian equilibrium level (also indexed at unity). Thus by allowing Walrasian labour demand to depend negatively on the real wage rate, wage dynamics are no longer counter intuitive, whilst many of the previous results derived from earlier models continue to hold.

FIGURE 6.2


Wage rate
Exchange rate
Price level
Employment
1.16
1.14
1.12
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0
100
200
300
1.000
0.999
0.998
0.997
0.996
0.995
0.994
0.993
0.992
0
100
200
300
TIME

6.5 Conclusions

In this Chapter we have presented three open economy disequilibrium models incorporating imperfect wage and price adjustment and inventories with the aim of testing the robustness of results derived for the closed economy, to provide further insight into exchange rate dynamics and to meet criticisms made of earlier models. In general results derived for the closed economy continue to apply within these open economy models. In particular the only long-run equilibrium is the Walrasian one and limit cycles are still certain for a significant subset of the parameter space.

This Chapter has extended previous research on exchange rate determination by examining exchange rate dynamics within an explicit disequilibrium model. In extended versions of the "basic" open economy model the exchange rate is influenced by regime switching on the goods and labour markets and inventory fluctuations, causing the exchange rate to exhibit greater deviations from its long-run equilibrium than previous models have predicted. This research has thus gone some way further in explaining the recent experience of large fluctuations in exchange rates over short intervals of time.

Finally in Model 6.3 by allowing firm's notional demand to depend negatively on the real wage rate, the resulting wage dynamic is no longer counter intuitive when the economy is near Walrasian equilibrium. In this respect this final model is an improvement over previous models, but the cost of this improvement is an increased level of complexity, with each market now interdependant and wage adjustment alone no longer able to clear both the goods and labour markets simultaneously. Given the complexity of Model 6.3 the earlier models, although criticized because of their counter-intuitive wage dynamics, are seen to be useful in aiding understanding of results that persist in this final model.

CHAPTER 7

THE EFFECTIVENESS OF GOVERNMENT POLICY

One of the main motivations behind the research undertaken for this thesis was the author's belief that many of the New Classical macroeconomic policy conclusions are unrealistic, being derived from the false assumption that all wages and prices are perfectly flexible. In previous Chapters we have developed alternative models to the continual market clearing Walrasian models by allowing wages and prices to adjust imperfectly. In particular in the last two Chapters we have presented and analysed five dynamic disequilibrium models with quantity constraints; two closed economy models and three open economy models. For each of these models we assumed only two representative agents, consumers and firms, we have not as yet incorporated a public sector. In this Chapter this omission is rectified by showing that a government sector can be introduced into the existing models in a consistent fashion. This is done primarily so that we can analyse the effectiveness of fiscal and monetary policy to influence certain economic variables. It is demonstrated that within our disequilibrium models not all the New Classical policy conclusions are valid.

In Section 7.1 we introduce the public sector into the existing disequilibrium models. Also in this Section we show that within our models the government is, in general, unable to influence the long-run Walrasian equilibrium values of real variables. The government can only affect nominal variables in the long-run. This is a New Classical policy conclusion. In Section 7.2, however, we investigate the dynamic short-run consequences of fiscal and monetary policy and show that contrary to New Classical results the government can systematically control the path of real variables. This result is demonstrated for the partial adjustment closed economy model (Model 5.1) and for the three open economy models. This result is not dependent upon the government having superior information in comparison with other agents, nor on the necessity of misleading other agents, nor on assuming the formation of non-rational expectations, but rather is the direct result of introducing imperfect price adjustment and allowing for the consequent quantity adjustments. It is also shown that the government can use its policy effectiveness to achieve certain economic objectives. For example the government can, if it has perfect information and perfect control of its policy variables,eliminate unemployment in every time period. The corollary of this statement is that the government, by incorrect policy formulation, may cause unemployment and undue output fluctuation. These results are obviously very keynesian and contrary to New Classical results.

By way of comparison to these results, and again to further assess the importance of wage adjustment we analyse the effectiveness of government policy within the model presented in Section 5.5 (Model 5.2). There instead of assuming that wages and prices adjust toward their market clearing level it was assumed they respond to excess demand in their relevant market. This alternative wage and price adjustment process was shown to greatly influence the dynamics and stability of the model, there now being a saddlepoint solution. It is recalled that in order to ensure stability the structure of the model was further changed allowing agents to have forward looking expectations so that the economy could jump instantaneously on to the stable manifold. These adaptions to the model influence the effectiveness of government policy. This is examined in Section 7.3 Conclusions to the Chapter are given in Section 7.4.

7.1 Long-run consequences of government policy

It is assumed that the government has two direct influences on the economy. The government consumes goods, G_t, thus affecting the demand for goods, (in the open economy models it is assumed for simplicity that the government only buys domestic goods), and it determines the stock of money in each time period, M_t^s. From these two influences we may distinguish between fiscal and monetary policy. Fiscal policy is where the government solely changes its expenditure on domestic goods, financed by borrowing from abroad, leaving the money supply unaltered. (This method of financing a budget deficit is merely used to simplify the model, and thus the long-run implications for foreign debt accumulation are not considered.) Monetary policy is where the government changes the money supply mediated by a temporary change in public expenditure.

What are the immediate and direct consequences of these policies?

As already noted the immediate consequence of fiscal policy is to alter demand for domestic goods. For example if the government increases its own expenditure, y_t^d also increases represented as a change in βo. Thus:

$$\Delta y_t^d = \Delta \beta o = \Delta G_t$$

The immediate and direct consequence of monetary policy is to change the stock of money in the economy and also to change the demand for domestic goods, as there is a temporary change in public expenditure . Thus we may write:

$$\Delta y_t^d = \Delta\beta o = \Delta M_t^s = \Delta G_t$$

A change in the money supply always has a direct positive effect on the demand for domestic goods. We can state therefore that the direct affect of both fiscal and monetary policy is to change the demand for domestic goods, with monetary policy also affecting the stock of money in the economy.

For the open economy models a change in the money supply also has the immediate, though indirect, affect of changing the exchange rate, with the exchange rate moving instantaneously to clear the money market. This change in the exchange rate further affects the demands for goods. These affects are considered in the next section, when the short-run dynamic consequences of government policy are examined. Before this we analyse the long-run (equilibrium) affects of government policy. These affects may be stated very briefly. In both the closed and open economy models output is constrained by the labour supply and equilibrium entails full employment, thus neither fiscal nor monetary policy can affect equilibrium output. Indeed the government has no influence on the equilibrium values of any real variables, (except for the real wage rate in the closed economy models), and can only effect the equilibrium values of nominal variables. For example, for the open economy models we may note that from (6.35), (6.36) and (6.39) that:

$$\Delta M_t^s = \Delta \bar{p}_t^d = \Delta \bar{e}_t = \Delta \bar{p}_t = \Delta \bar{w}_t$$

thus the economy satisfies the homogeneity postulate; a given change in the money supply (monetary policy) results in an equiproportionate change in the long-run equilibrium price level, exchange rate and wage rate, leaving all real variables unaffected. Considering only equilibrium states our results are the same as derived from New Classical models; the government can in general, affect only nominal variables not real variables, and the only long-run equilibrium for the economy is Walrasian. Whilst the latter conclusion is true for the disequilibrium models developed in this thesis, the former is not universally true. New Classical macroeconomics states that systematic government policy is ineffective not only in the long run but also in the short run. Contrary to this result government policy in these disequilibrium models is able to have important short run effects on economic variables and thus the path the economy pursues over time. This result is true even though expectations have been assumed to be rational, and does not depend on the government misleading other agents, but specifically results from not assuming perfect price flexibility. We now consider these dynamic affects of fiscal and monetary policy respectively.

7.2 Dynamic consequences of government policy

7.21 Fiscal policy

In the previous section it was shown that the immediate consequence of a change in fiscal policy is to change the demand for (domestic) goods, this is represented as a change in β_o. In assessing the short run effectiveness of fiscal policy we first examine the results of changing β_o for the partial adjustment closed economy model.

It is recalled that this model is characterised by three regime switching loci in real wage-inventory space. These loci are reproduced here for convenience:

$$(\Delta(w-p)_t = 0):(w-p)_t = \frac{A\delta_o + S_{t-1} - a - (1+b)\beta_o}{\beta_1(1+b)} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}.$$

$$(\Delta S_t = 0 | \ell_t = \ell_t^s; y_t = y_t^d) : (w-p)_t = \frac{A\delta_o - \beta_o - (\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

$$(\Delta S_t = 0 | \ell_t = \ell_t^d) : (w-p)_t = \frac{(A - \beta_3)(S_{t-1} - a)}{bA\beta_1} - \frac{(\beta_o - \beta_3\delta_o)}{\beta_1} - \frac{(\beta_1 + \beta_2)(M^s - c\delta_o)}{\beta_1}$$

Differentiating each of these loci by β_o gives us the same value of $-{}^1/\beta_1$. Consider an increase in government spending which raises the demand for goods by the amount $\Delta\beta_0 > 0$. As $-^1/\beta_1 < 0$ then all three regime switching loci shift downward by $\Delta\beta_0/\beta_1$, while their slopes remain unaffected These affects are shown in Figure 7.1, where we have assumed that

$$b < \frac{A - \beta_3}{\beta_3}$$

Figure 7.1

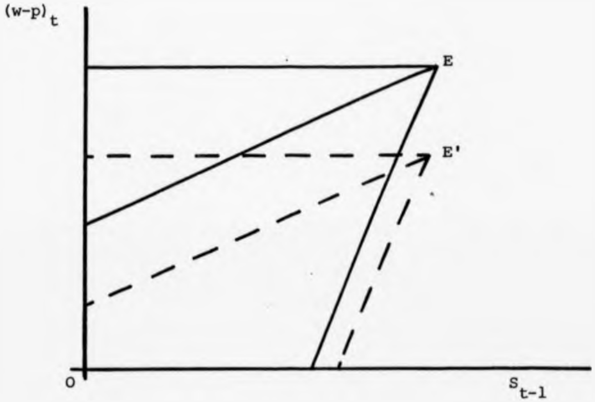


Figure 7.1 shows that as the demand for goods increases so the Walrasian equilibrium falls vertically from E to E', leaving all long-run (equilibrium) real quantities unchanged. To consider the dynamic consequences of this policy it is assumed the economy is initially in Walrasian equilibrium at E. Following the expansion in demand the economy enters the regime of Underconsumption,

or if the increase in demand is great enough Repressed Inflation. These results remain the same if $b > \frac{A - \beta_3}{\beta_3}$. However the consequent dynamics depend on the stability of the economy, and hence whether b is less than or greater than $\frac{A - \beta_3}{\beta_3}$. From Figure 5.4 when $b < \frac{A - \beta_3}{\beta_3}$ both the real wage rate and inventories will begin to fall and the economy will move into the regime of Keynesian Unemployment before converging to the new equilibrium at E'. From Figure 5.5 if $b > \frac{A - \beta_3}{\beta_3}$ then the economy will oscillate around the new equilibrium either converging upon it or forming a limit cycle around it. In this case all the disturbed economic variables oscillate around their new equilibrium levels with either dampened amplitude or form a limit cycle. Thus although government fiscal policy cannot affect equilibrium real quantities except for the real wage rate it can influence the path these variables pursue over time. This conclusion is also valid for the "basic" open economy models.

For the "basic" open economy model fiscal policy only affects the goods and the labour markets, with the price level and exchange rate remaining at their long-run equilibrium levels. Thus the effects of fiscal policy are the same as for Model 5.1. Although the government is able to influence the dynamic path of real variables in both these models, the desirability of any particular fiscal policy depends on where the economy is. If the economy is away from equilibrium, say experiencing Keynesian Unemployment, then the government, through appropriate fiscal policy can hasten the return to full employment and Walrasian equilibrium. Indeed if the government has perfect knowledge regarding the structure of the economy, the stochastic shocks that disturb the economy, and also perfect control of public expenditure and taxation, then by altering

y_t^d it can continually ensure full employment. This optimal path for government spending will differ according to whether the economy is closed or open. For the closed economy model we may derive this optimal control path for fiscal policy by setting labour supply equal to its demand. Thus from equation (5.1), (5.11), (5.25) and (5.26) we get:

$$\delta_o + \varepsilon_t^4 = A^{-1}[\, a + (1 + b)E(y_t^d) - S_{t-1}] + \varepsilon_t^3$$

Substituting in the rational expectation of y_t^d from (5.2) yields:

$$\delta_o + \varepsilon_t^4 = A^{-1}\,[a + (1+b)(\beta_o + \beta_1 w_t + \beta_2 p_t) - S_{t-1}] + \varepsilon_t^3$$

Rearranging this gives us:

$$\beta_{ot} = \frac{A(\delta_o + \varepsilon_t^4 - \varepsilon_t^3) - a + S_{t-1}}{(1 + b)} - \beta_1 w_t - \beta_2 p_t$$

where β_{ot} is the variable determined by fiscal policy in order to maintain full employment of labour. Taking the change in variables, substituting ΔG_t for $\Delta\beta_{ot}$ and rearranging gives us

$$\Delta G_t = \frac{A(\delta_o + \Delta\varepsilon_t^4 - \Delta\varepsilon_t^3) - a + \Delta S_{t-1}}{(1+b)} - (\beta_1 \Delta w_t + \beta_2 \Delta p_t) \qquad (7.7)$$

The corresponding "optimal" path for government expenditure for the "basic" open economy is:

$$\Delta G_t = \frac{A(\delta_o + \Delta\varepsilon_t^4 - \Delta\varepsilon_t^3) - a + \Delta S_{t-1}}{(1+b)} - [\beta_1(\Delta w_t - \Delta p_t) + \beta_3 q_t] \qquad (7.8)$$

For the open economy model the government's fiscal policy needs to respond to the terms of trade in order to ensure full employment. Thus, although the effects of fiscal policy are the same, the "optimal" path for government expenditure (and taxation) differs between these closed and open economy models.

The main conclusions regarding the effectiveness of fiscal policy have already been derived from models 5.1 and 6.1. Although fiscal policy cannot in general, affect the Walrasian equilibrium values of real variables, it can have important and beneficial affects on the path these variables pursue. In particular, through "optimal" use of fiscal policy the government can, under certain conditions, maintain full employment at all times, by following appropriate demand management rules. These conclusions remain valid for the extended open economy models (Models 6.2 and 6.3). To illustrate the effectiveness of fiscal policy within these models we initially present four policy simulations derived from the numerical techniques developed in Chapter 6. For each simulation the economy was set in Walrasian equilibrium and then subjected to a policy shock at the beginning of the first period. Further it is assumed that $\lambda_p = 0.4$, $\lambda_w = 0.2$ and (for model 6.3) $z_1 = 0.4$, all other parameters are set at their basic values as given in Table 6.1. Figure 7.2 shows the resulting dynamic path of the economy following a 0.2% increase in public expenditure and taxation for Model 6.2, while Figure 7.3 shows the response to a 0.2% reduction in this policy variable. Figures 7.4 and 7.5 show the corresponding simulations for model 6.3.

All four simulations show that in the long-run the exchange rate, wage rate, domestic price level and employment level converge upon their new Walrasian equilibrium values (all indexed at unity). In the short-run, however these variables deviate from their Walrasian values. In these two models the money market and foreign exchange market are interdependent with the goods and labour markets. The resulting interaction between these markets cause the dynamic

FIGURE 7.2

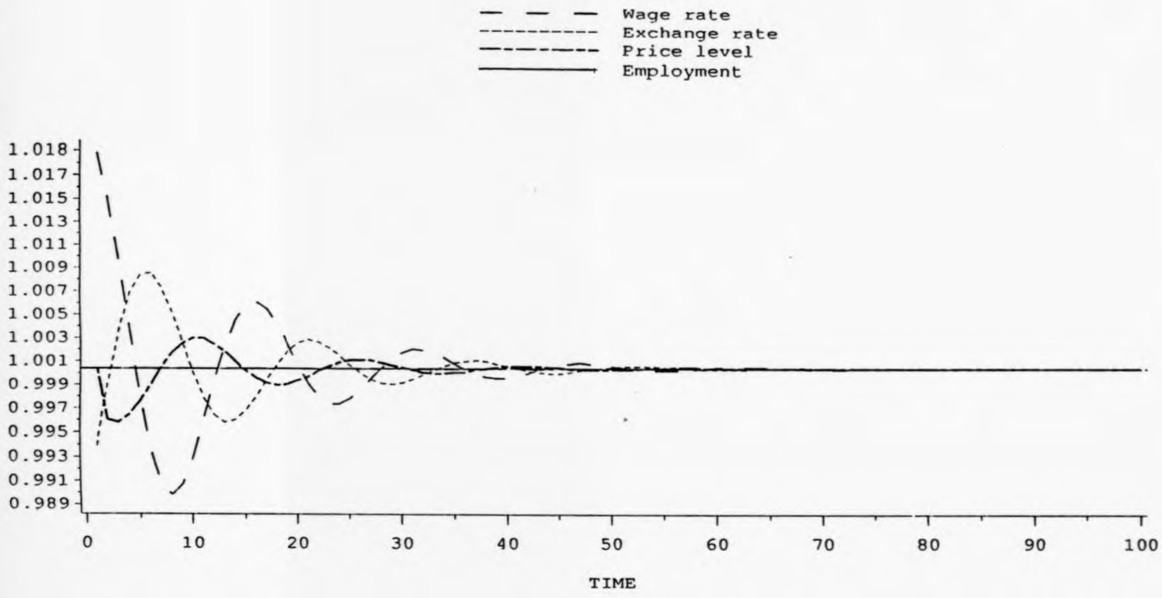
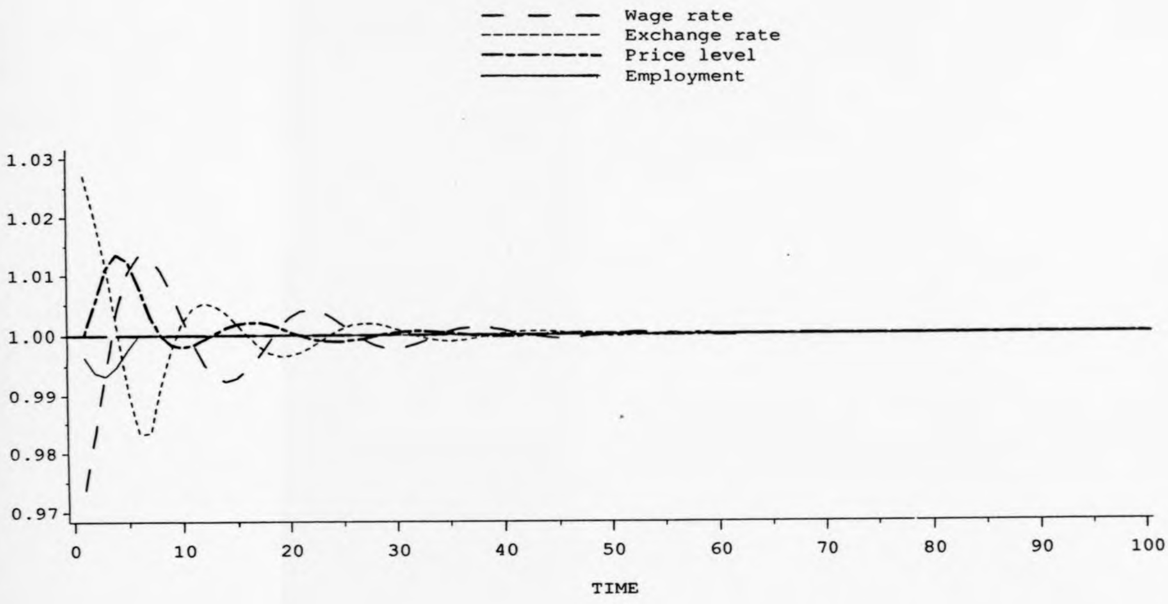
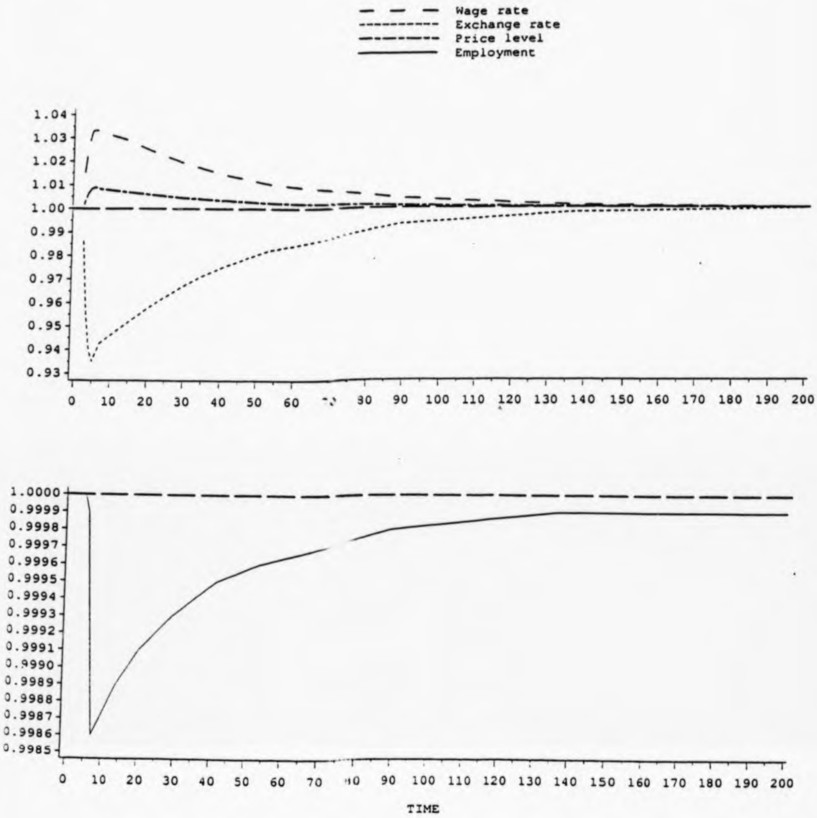

Wage rate
Exchange rate
Price level
Employment
1.018
1.017
1.015
1.013
1.011
1.009
1.007
1.005
1.003
1.001
0.999
0.997
0.995
0.993
0.991
0.989
0
10
20
30
40
50
60
70
80
90
100
TIME

FIGURE 7.3



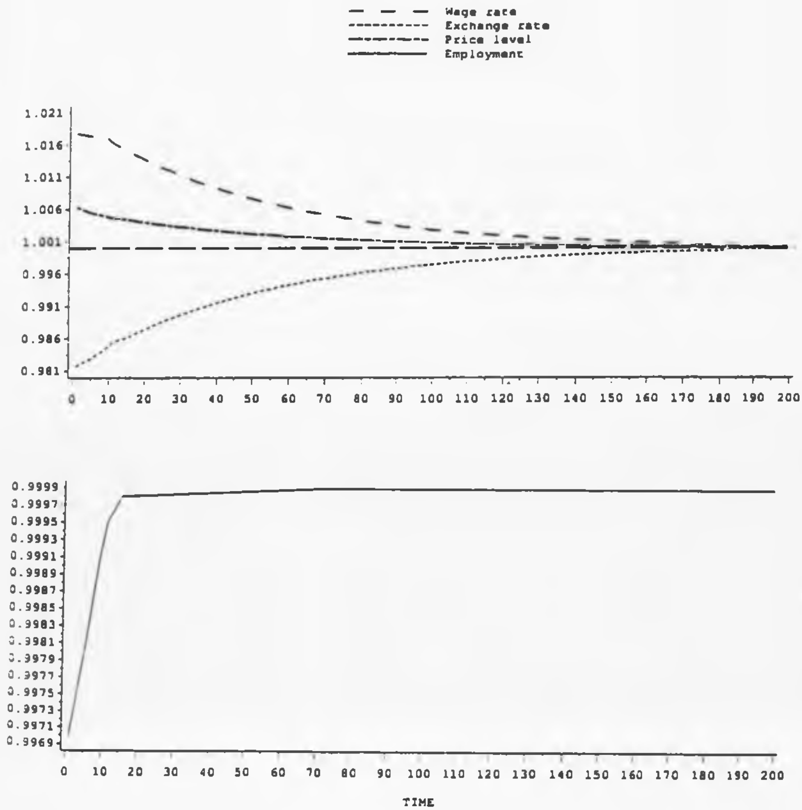
Wage rate
Exchange rate
Price level
Employment
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0
10
20
30
40
50
60
70
80
90
100
TIME

FIGURE 7.4



Wage rate
Exchange rate
Price level
Employment
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
1.0000
0.9999
0.9998
0.9997
0.9996
0.9995
0.9994
0.9993
0.9992
0.9991
0.9990
0.9989
0.9988
0.9987
0.9986
0.9985
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
TIME

FIGURE 7.5


Wage rate
Exchange rate
Price level
Employment
1.021
1.016
1.011
1.006
1.001
0.996
0.991
0.986
0.981
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
0.9999
0.9997
0.9995
0.9993
0.9991
0.9989
0.9987
0.9985
0.9983
0.9981
0.9979
0.9977
0.9975
0.9973
0.9971
0.9969
TIME

consequences of fiscal policy to be more complex than previous models. For example now the domestic price level and exchange rate also vary in response to the change in fiscal policy.

For Model 6.2, under the chosen parameterization, variables oscillate around their Walrasian equilibrium values with decreasing amplitude. The initial effect of the expansionary fiscal policy in this model is to cause the economy to enter the regime of Underconsumption. With wages and prices fixed at their previous Walrasian levels the exchange rate falls instantaneously to clear the money market. After the first period wages and prices adjust until the economy converges to equilibrium. Within this adjustment period employment is unaffected and inventory stocks remain positive (not shown), hence the economy remains in the regime of Underconsumption. For the contractionary fiscal policy the initial reduction in demand for domestic goods causes the economy to experience Keynesian Unemployment. Employment falls further before returning to its full employment level upon which the economy enters and remains in the regime of Underconsumption, until it converges to equilibrium. Thus as may have been expected a contractionary fiscal policy causes unemployment to rise temporarily before the economy returns to Walrasian equilibrium. Finally it can be noted in Figures 7.2 and 7.3 that wage adjustment is often counter-intuitive for model 6.2, rising when there excess supply of labour and falling when there is excess demand.

On considering Figures 7.4 and 7.5 it can first be noted that for Model 6.3 wages now adjust in accordance with intuition. This confirms the analysis of Section 6.4. It is further observed that the variables no longer exhibit such oscillating behaviour as for Model 6.2. This is due to the choice of parameter values rather than to the basic structure of the model. Oscillations occur for different parameterizations, and indeed as shown in Table 6.3, limit cycles are possible. Following the expansionary fiscal policy the economy initially experiences Underconsumption. Subsequent to this wages and prices rise while the exchange rate falls to maintain equilibrium in the money market. This adjustment leads the economy to enter the regime of Keynesian Unemployment. Upon the occurance of unemployment wages and prices begin to fall toward their new Walrasian levels, and the exchange rate rises to its long-run value. The economy remains in Keynesian Unemployment until it has converged upon Walrasian equilibrium. The dynamic adjustment path following the contractionary fiscal shock is similar to that observed for the expansion in demand, except here the economy immediately enters the regime of Keynesian Unemployment. Wages and prices thus continually fall toward their long run values, and the exchange rate and employment continually rise subsequent to the first period.

In contrast to Model 6.2 both a contractionary and an expansionary fiscal policy cause the economy described by Model 6.3 to experience unemployment either immediately following or subsequent to policy implementation. Again it is clear that fiscal policy can influence the dynamic path of real variables in the short-run.

These policy simulations have confirmed our earlier results that while the government cannot, through fiscal policy, influence the long run equilibrium values of real variables, (apart from the real wage rate), it can greatly affect the short-run dynamic path of such variables. Due to this effectiveness of policy the government is able to offset certain undesirable economic states caused by disturbances to the economy. In particular in these disequilibrium models with consistent quantity adjustments the government can, with fine-tuning policies, ensure continual full employment. This is obviously contrary to the New Classicial Macroeconomic policy conclusions. We now turn our attention to the effectiveness of monetary policy in the short-run.

PAGINATION
ERROR

7.2ii Monetary policy

The two immediate and direct effects of monetary policy are on the money supply and on the demand for domestic goods. Obviously a once and for all change in the money supply causes a permanent change in the money supply, while the change in demand for domestic goods, resulting from the change in public expenditure, is only temporary. To assess the effectiveness of monetary policy we initially examine some of the consequences of a specific policy on the "basic" closed and open economy models.

Consider the policy where the government increases once and for all the money supply at the beginning of the first period by ΔM^s and distributes this increase by increasing its own expenditure in the first period. If we assume that the economy is initially in Walrasian equilibrium, what are some of the consequences of this policy within the partial adjustment closed economy models?

With wages and prices set at their previous Walrasian levels in the first period the increased demand for goods will cause the economy to enter the regime of either Underconsumption or Repressed Inflation, depending on the size of $\Delta\beta_o$, inventories will be reduced, but the economy will remain in full employment. Subsequent to this period wages and prices will adjust. The price level will gradually increase until equilibrium is restored in the money market. Due to the dynamic interaction of wages, prices and inventories the adjustment process in the goods and labour markets will be typically complex. However from the analyse of Chapter 5 we know that eventually the economy will either converge upon its new Walrasian equilibrium, with real variables unaffected, or cycle around it.

What are the consequences of the above monetary policy for the "basic" open economy model? With the economy initially in Walrasian equilibrium the changed money supply results in an instantaneous jump in the exchange rate so as to equate the demand for money to its supply. From (6.40) the instantaneous change in the exchange rate is equal to:

$$\Delta e_t = \frac{(1 + \eta\theta)}{\eta\theta + (1 - \sigma)} \Delta M^s \tag{7.9}$$

As $(1 + \eta\theta) > \eta\theta + (1 - \sigma)$ then e_t overshoots its long-run equilibrium value $(\Delta\bar{e}_t = \Delta M^s)$, the degree of overshooting is given by:

$$(\Delta\bar{e}_t - \Delta e_t) = \frac{-\sigma}{\eta\theta + (1 - \sigma)} \Delta M^s \tag{7.10}$$

Again subsequent to the initial period the domestic price level coverges toward its new equilibrium level, where the money market clears with the exchange rate also being at its long run equilibrium level, and hence the foreign and domestic interest rates are equated. Therefore, in response to the supposed policy, the price level rises gradually towards its long run level, while the exchange rate initially overshoots its long run value before converging toward it. These results are qualitatively the same as the Dornbusch (1976) model. However within our model we can also analyse the consequences on the goods and labour markets. As already shown the direct and immediate affect of monetary policy within the goods market is to change the level of demand. There are, however, for this open economy model two further indirect consequences on the demand for domestic goods, resulting from the change in the exchange rate. Using (6.21), (6.22) and (6.23) we may write the effect of an exchange rate movement on y_t^d as:

$$\Delta y_t^d = -[\beta_3 + \beta_1(1 - \sigma)]\Delta e_t \qquad (7.11)$$

Exchange rate movements effect y_t^d through both changes in the terms of trade, q_t, and the general price level, p_t affecting the real wage rate. Combining equations (7.9) and (7.11) the total affect on y_t^d in the first period is:

$$\Delta y_t^d = \Delta\beta_o - \frac{[\beta_3 + \beta_1(1 - \sigma)](1 + \eta\theta)\Delta M^s}{\eta_\theta + (1 - \sigma)}$$

where for the supposed policy $\Delta\beta_o = \Delta M^s$. The qualitative affect of the monetary policy on y_t^d in the first period is now ambiguous, and we get the result that any of the four possible regimes may be observed in this period, depending on the size of the monetary change and parameter values. Given this ambiguity it is clear that the subsequent dynamic behaviour of the goods and labour markets is too complex to be analysed using traditional comparative statics.

However from the observations already made concerning these two "basic" economies we can state the important policy conclusion that monetary policy is effective, in that it can influence the dynamic path of real variables in the short-run. Again as with fiscal policy, this effectiveness may be used so as to achieve certain economic objectives. In particular the government can by monetary policy affect the level of employment, due to the direct and (for the open economy models) indirect effects on the demand for domestic goods.

In order to examine further the short-run consequences of monetary policy we return to the computer and analyse numerically various policies within the extended open economy models. For each simulation it is assumed that the economy is initially in Walrasian equilibrium and that the changed money supply is distributed solely by the government altering its own expenditure in the first period. It is again assumed that $\lambda_p = 0.4$, $\lambda_w = 0.2$ and (for Model 6.3) $z_1 = 0.4$, all other parameters are set at their basic values. Figure 7.6 shows the resulting dynamic path of the economy following an expansion in the money supply of 5% for Model 6.2, while Figure 7.7 shows the dynamic response to a 5% contraction in the money supply. Figure 7.8 and 7.9 show the corresponding simualtions for Model 6.3.

As with the policy simulations for fiscal policy it is seen that both models are stable with all variables converging to their new equilibrium levels. Considering first the simulations undertaken for Model 6.2 each variable, in general, oscillates with dampened amplitude around their long-run values. In particular the oscillations of the exchange rate confirm the analyse of Section 6.3 that for this model the dynamic path of the exchange rate, in response to a monetary shock, is more complex than that predicted either by Dornbusch's (1976) or by Flood and Hodricks (1983) model. As wages and prices are fixed in the first period at their previous

FIGURE 7.6

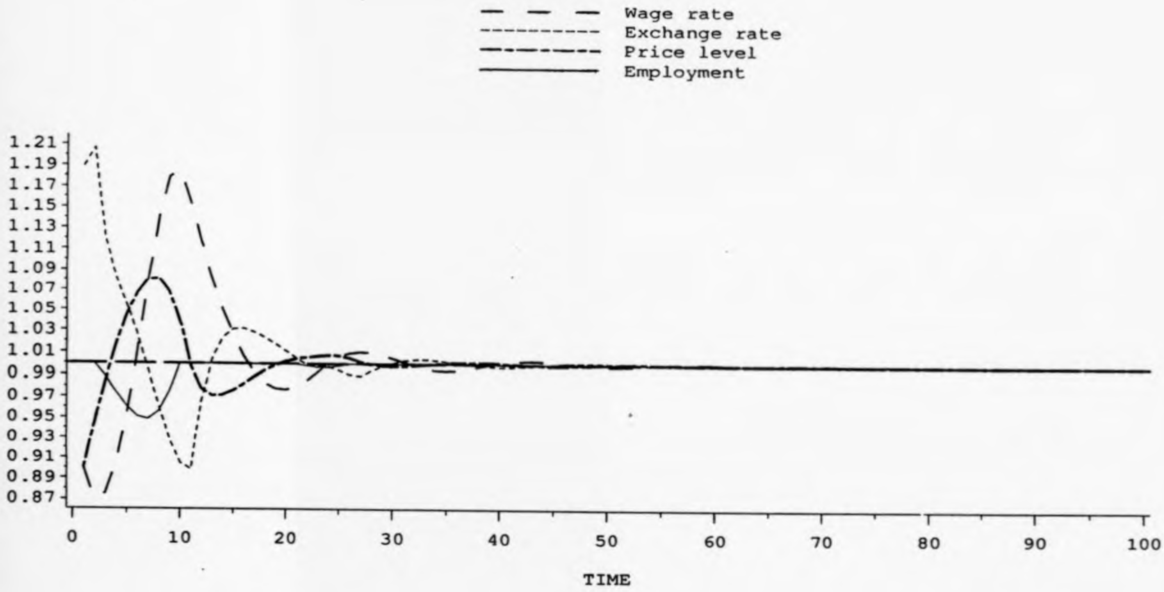

Wage rate
Exchange rate
Price level
Employment
1.21
1.19
1.17
1.15
1.13
1.11
1.09
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
0.87
0
10
20
30
40
50
60
70
80
90
100
TIME

FIGURE 7.7

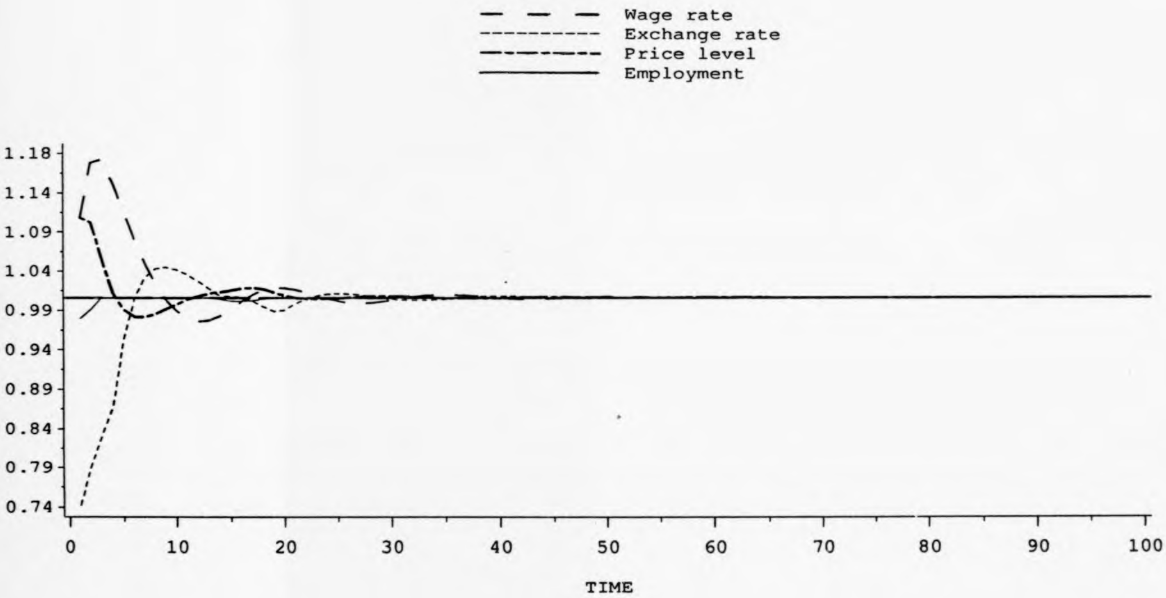

Wage rate
Exchange rate
Price level
Employment
1.18
1.14
1.09
1.04
0.99
0.94
0.89
0.84
0.79
0.74
0
10
20
30
40
50
60
70
80
90
100
TIME

FIGURE 7.8

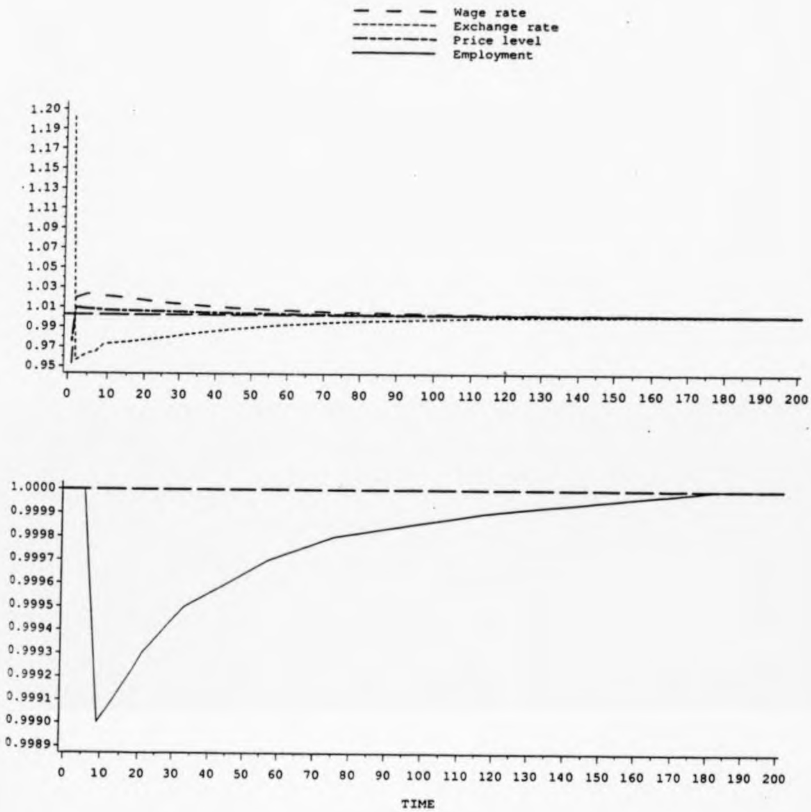
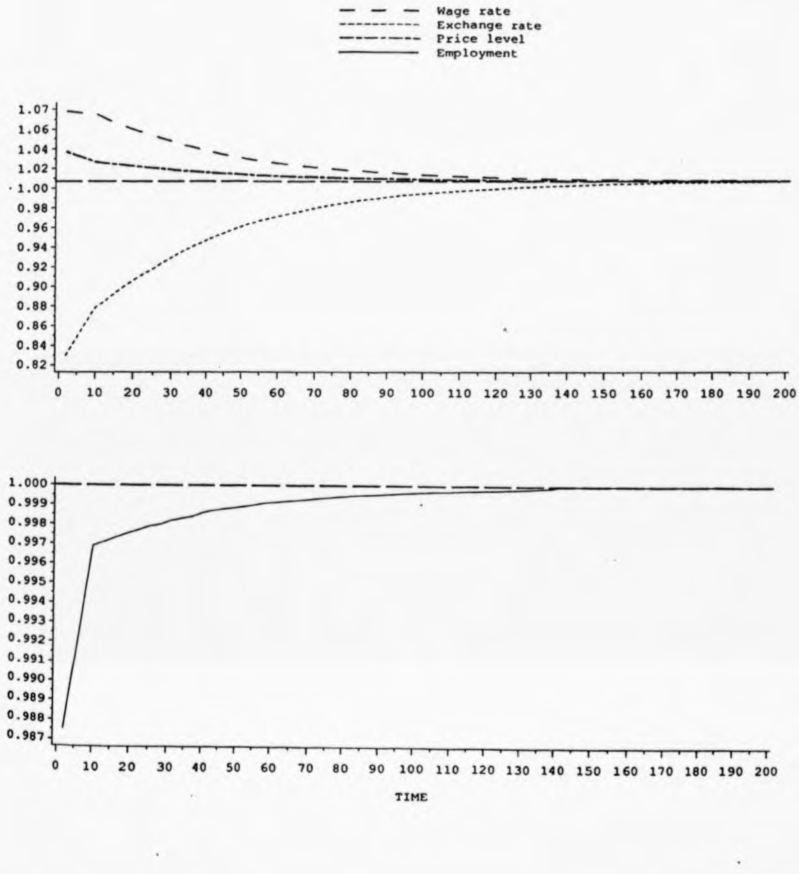

Wage rate
Exchange rate
Price level
Employment
1.20
1.19
1.17
1.15
1.13
1.11
1.09
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
1.0000
0.9999
0.9998
0.9997
0.9996
0.9995
0.9994
0.9993
0.9992
0.9991
0.9990
0.9989
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
TIME

FIGURE 7. 9


Wage rate
Exchange rate
Price level
Employment
1.07
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
1.000
0.999
0.998
0.997
0.996
0.995
0.994
0.993
0.992
0.991
0.990
0.989
0.988
0.987
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
TIME

Walrasian levels, when the money supply is increased by 5% the exchange rate overshoots its higher long-run value while the goods and labour markets are characterised by Repressed Inflation, inventories being reduced to zero. In subsequent periods wages and prices adjust and the economy moves through various regimes. Interestingly, because of the complex dynamic processes the economy experiences two prolonged periods of keynesian Unemployment following this expansionary policy. Unemployment is observed in 11 future periods, reaching a peak of 6.16% of the work force. For the contractionary policy, in the same model, the economy initially experiences Classical Unemployment followed in the second period by Keynesian Unemployment. The economy then returns to full employment before entering a longer, though less severe spell of keynesian Unemployment. Surprisingly, although unemployment is immediately experienced in response to a reduction in the money supply, the occurances of unemployment are less severe, and of shorter duration, than when the money supply is increased by the same magnitude. Thus Figure 7.8 shows there are 7 periods of observed unemployment, reaching a peak of only 2.59% of the labour supply.

We now consider the dynamic path of the economy for these policy shocks within Model 6.3. As before the exchange rate initially overshoots its long-run level following an expansionary monetary policy, with the economy experiencing Repressed Inflation. The economy then enters the regime of Underconsumption as wages and prices rise and the exchange rate falls, eventually undershooting its long-run value. These adjustments cause the economy to experience Keynesian Unemployment. Upon entering this regime wages and prices fall and the exchange rate rises to converge upon their Walrasian equilibrium values. It can be noted that the path the exchange rate follows within Figure 7.8 is qualitatively the same as predicted by Flood and Hodrick's model. This however is dependent on the parameter values of the model, with different parameter values the dynamic path of the economy will differ. Finally Figure 7.9 is qualitatively the same as Figure 6.2 both showing the response of Model 6.3 to a reduction in the money supply. Unemployment is continually observed until the economy returns to Walrasian equilibrium. Wages and prices continually fall and the exchange rate rises to their respective long-run market clearing values.

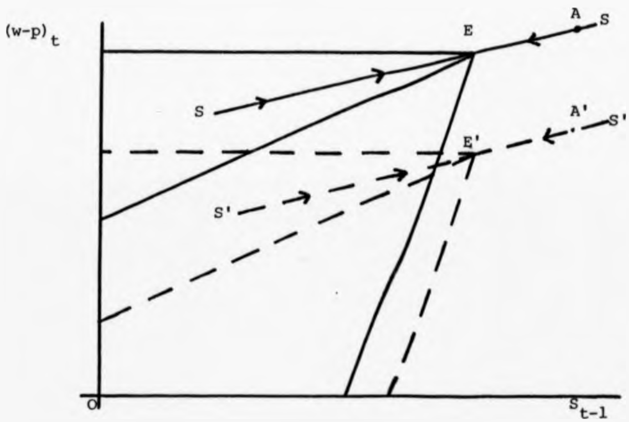
In conclusion this section has analysed the short-run dynamic effects of both fiscal and monetary policy. The central result, for the models considered, is that while systematic government policy cannot influence the long-run values of real variables other than the real wage rate it does have significant effects on the short-run dynamic path of such variables. This is contrary to New Classicial policy conclusions. With this effectiveness of fiscal and monetary policy the government is able to achieve certain economic objectives. In particular if the government has perfect information and perfect control of its policy variables then it can eliminate unemployment, by offsetting the random disturbances affecting the economy. Alternatively by pursuing mistaken policy recommendations the government may be the cause of unemployment and loss of output.

7.3 Alternative wage and price adjustment

In Section 5.5 the partial adjustment closed economy model was modified by assuming that wages and prices respond positively to excess demand in the labour and money markets respectively. In order to compare with previous results, and also to gain further insight into the importance of wage and price adjustment, this section analyses the effectiveness of government policy with this alternative model. By postulating that wages and prices respond to disequilibrium it was shown that Model 5.2 exhibited "saddlepoint instability". Stability required that agents are not myopic but forward looking so the economy can jump on to the stable manifold. This was achieved by altering how firms' determined their desired inventory level. Because agents are now forward looking, it is necessary, in analysing the effectiveness of government policy, to distinguish between anticipated and unanticipated policy changes. As before we assess first the effectiveness of fiscal policy and then of monetary policy.

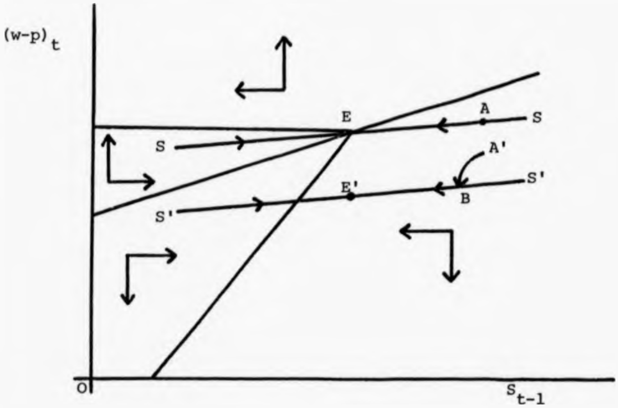
We begin by showing the surprising result that for Model 5.2 fiscal policy is unable to affect real variables, other than the real wage rate, both in the short and long run, if it is unanticipated. Unanticipated fiscal policy only affects the real wage rate, leaving the dynamic path of other real variables unaffected. This result is due to two basic properties of this model. First, as already stated, the model exhibits a "saddlepoint solution". Second, changes in fiscal policy only induce vertical shifts in the regime switching loci. This second property has already been demonstrated in Section 7.2i for the partial adjustment closed economy model. That proof applies equal for this model as none of the equations representing the regime loci are affected by changes to the wage and price adjustment mechanisms. To illustrate that unanticipated fiscal policy is ineffective we initially assume that the money market is continually in equilibrium. This assumption implies that the economy must always be on the stable manifold converging toward equilibrium. The effects of an unanticipated fiscal expansion are shown in Figure 7.10 where it is assumed that $b < \frac{A - \beta_3}{\beta_3}$

Figure 7.10



Initially the economy is characterised by the solid regime switching loci and by the stable manifold SS, with Walrasian equilibrium at E. Suppose the economy is at A experiencing Keynesian Unemployment, with both wages and inventories falling. Further suppose that in response to the observed unemployment the government expands fiscal policy. Due to this incipient increase in demand for goods all three loci shift down by the same amount to the positions now shown by the dashed regime switching loci. Consequently the long-run equilibrium and stable manifold also shift down to E' and S'S' respectively. Finally as the economy must always be on the stable manifold it jumps from A to A'. It is clear that none of the real variables, except the real wage rate is affected. The economy remains in the regime of Keynesian Unemployment and inventories are unchanged. The only consequence of the expansionary fiscal policy is to shift consumption from the private to the public sector, facilitated by the fall in the real wage rate. The government is unable to exercise demand management via. unanticipated fiscal policy, because any change in policy is completely offset by a change in the wage rate. Private consumption is completely crowded out by increased public expenditure. This result remains valid even if b is greater than $\frac{A - \beta_3}{\beta_3}$ or if the assumption that the money market is continually in equilibrium is relaxed. What is the effectiveness of fiscal policy if it is anticipated? Again for illustrative purposes we suppose the same initial conditions as shown in Figure 7.10. These are reproduced in Figure 7.11.

Figure 7.11



It is assumed agents now anticipate an expansionary fiscal policy in the future. When the change in fiscal policy is implemented the long-run equilibrium and stable manifold will shift down to E' and S'S' respectively. As this policy is anticipated agents will act in a way to ensure the economy is on S'S' when the policy is actually implemented. In order to achieve this aim the wage rate initially falls causing the economy to be on an "explosive" path that will coincide with the stable manifold S'S' when the policy is undertaken. Thus in Figure 7.11 the economy instantaneously jumps from A to A' and then due to the inherent dynamics of the economy moves to B. When the economy reaches B the fiscal policy, if correctly anticipated, will be enacted and hence the economy will converge along S'S' to E'. From the diagram it is clear that fiscal policy is now able to effect the dynamic path of real variables other than the wage rate, such as employment and inventories. Anticipated fiscal policy is effective in the short-run. Again this result is unaffected by assuming that $b > \frac{A - \beta_3}{\beta_3}$ or by relaxing the assumption that the money market is continually in equilibrium. Note that anticipated fiscal policy is effective because prior to the policy change the economy jumps on to an otherwise unstable path, along which the dynamic adjustment of real variables is different to what it would have been without the expected policy change. It is for this same reason that monetary policy, anticipated or unanticipated, is effective. The validity of this statement is demonstrated by the use of a simple argument. It is recalled from Section 5.5 that when the money market is out of equilibrium the economy will be off the stable manifold, derived under the assumption that the money market clears. The actual path followed is the one that causes the economy to be on this stable manifold when the money market does clear. Assume the money market is initially in equilibrium, and the economy is on this stable manifold. Now given a change in monetary policy, or an anticipated policy change, the economy will, via an instantaneous wage adjustment, jump on to an "unstable" path. Once again the dynamic path of real variables will be different than they would have been without the policy, and so both anticipated and unanticipated monetary policy is effective. Given this effectiveness, monetary policy may be used to help achieve certain economic objectives, such as reducing unemployment.

The alternative assumption of allowing wages and prices to respond to disequilibrium rather than allowing them to adjust imperfectly toward their market clearing levels was shown in Section 5.5 to greatly alter the dynamics and stability of the model. This section has analysed its consequences for government policy. Due to the forward looking expectation formation of agents the distinction between anticipated and unanticipated policy change becomes important. In particular only anticipated fiscal policy is effective in influencing real variables in the short-run. Unanticipated fiscal policy is ineffective, causing only a once and for all change in the real wage rate and the distribution of resources between the public and private sectors. It is interesting to note that these results for fiscal policy reverse those typically derived from New Classical models, where it is unanticipated policy that is effective, anticipated policy being ineffective (see, for example Sargent and Wallace, 1975). The New Classical policy conclusion from such results is that government policy should be set in accordance with policy rules, so as to avoid unnecessary random disturbances from equilibrium. Within the present disequilibrium model the government by allowing fiscal policy to follow a known policy rule can influence the dynamic path of real variables and so have desirable consequences. Here the policy prescription that fiscal policy be conducted in accordance with a known policy rule is not to avoid the destabilizing consequences of government policy, but rather so that fiscal policy can be effective in stabilizing the economy. The establishing of a policy rule has positive effects. However it should not be thought that the policy prescription from the present model for fiscal policy is identical to that derived from New Classical models. New Classical macroeconomists argue that to limit the destabilizing effects of government policy the policy rule should be simple. Within the present model in order for the government to maximize the beneficial effects of fiscal policy its policy rule will typically be complex. Turning to monetary policy, it was shown that both anticipated and unanticipated changes in monetary policy were effective.

This section has further highlighted the importance of the wage adjustment process, and the need to develop and test competing theories. However more importantly it has shown that even though the dynamics and stability of the model are greatly altered upon the introduction of this alternative wage and price adjustment mechanism, the main policy conclusion remains valid. Government policy, both fiscal and monetary, is effective, now under certain conditions of implementation, in influencing real variables in the short-run.

7.4 Conclusions

In this chapter we incorporated a public sector into the previously developed disequilibrium models so as to primarily assess the effectiveness of government policy, and to compare these results with New Classicial policy prescriptions. In Section 7.1 it was shown that the public sector can be introduced in a consistent way, and that it is possible to distinguish between fiscal and monetary policy. Also in this section we considered the long-run equilibrium consequences of government policy. These results are the same as those derived from New Classical models. The government is in general unable to influence real variables in the long run, only nominal variables. This result is due to the fact that for all the disequilibrium models developed there is no long run non-Walrasian equilibrium. With there being only one long run equilibrium and that being the Walrasian equilibrium then the New Classical long-run policy conclusion remains valid.

It was upon considering the dynamic short run effects of government policy that our conclusions differed from New Classical results. In Section 7.2 it was shown that for the main disequilibrium models developed in previous Chapters government policy, both fiscal and monetary is effective in altering the dynamic path of real variables. As already stated this result does not depend on the government having superior information, nor on the formation of non-rational expectations, but rather on allowing in a consistent way for imperfect wage and price adjustment and the consequent quantity adjustments. With this effectiveness of fiscal and monetary policy, the government is able to achieve certain economic objectives. Indeed if the government has perfect information and perfect control of its policy variables it can eliminate unemployment by offsetting the disturbances affecting the economy. Alternatively, because policy is effective, the government, by implementing mistaken policy recommendations may actually be the cause of unemployment and loss of output.

In many situations once the economy is disturbed from equilibrium, say by a government policy shock, then economic variables will oscillate around their Walrasian values, either with decreasing amplitude or forming a limit cycle around them. These oscillations are the result of the complex interaction between the various markets and explicit regime switching caused by imperfect wage adjustment and inventory movements. In particular for the extended open economy models it is often the case that the exchange rate once disturbed oscillates around its initial Walrasian value. This observation is qualitatively different from both the Dornbusch (1976) model and Flood and Hodrick's (1983) model, with our models allowing the possibility of even greater gyrations for the exchange rate compared to these previous models.

Finally the effectiveness of government policy was explored within the model presented in Section 5.5, where the wage rate and price level adjust in response to disequilibrium in the labour and goods markets respectively. Here the distinction between anticipated and unanticipated policy changes are important. It was shown that only anticipated fiscal policy is effective while both anticipated and unanticipated monetary policy is effective.

In final conclusion the analysis of government policy within this Chapter has provided alternative policy conclusions to those derived from New Classical models. Within the dynamic disequilibrium models developed in this thesis government policy may be usefully employed to achieve desirable short-run economic objectives concerning the dynamic path of real variables such as employment and output.

CHAPTER 8

CONCLUSIONS

We have aimed, in this thesis, to extend recent macroeconomic models in which imperfect price flexibility gives rise to disequilibrium quantity constraints and dynamic adjustment. It represents a continuation of current research to provide an acceptable alternative to New Classical macroeconomics, and is used to assess the robustness of results derived from both previous New Classical and disequilibrium models. The New Classical synthesis is "equilibrium economics" it being assumed that markets always clear, any possible disequilibrium is elimianted by instantaneous price adjustment. It is this authors belief, however, that there are compelling reasons to suppose that not all prices adjust instantaneously to clear markets. Due to its equilibrium methodology the New Classical synthesis is unsuitable to study the resulting disequilibrium situations, and gives very limited insight into what happens during this "transitional phase". The analysis of the dynamic response to disequilibrium is carried out only in terms of price adjustments, completely ignoring any quantity adjustments. By contrast disequilibrium macroeconomics is concerned, in principle, with the dynamic responses of an economy to disequilibrium by way of both price and quantity adjustments. Having stated this, the first generation of disequilibrium models, as developed by Barro and Grossman (1971, 1986), Bénassy (1974) and Drèze (1975), Malinvaud (1977) and others, were only single period models were it was assumed that prices were fixed, and other intertemporal linkages, such as inventories and expectations, were ignored. Only recently have authors began to develop dynamic disequilibrium models, incorporating price adjustment and other intertemporal linkages. This thesis has, in particular, aimed to further this line of research.

Section 8.1 summarises the argument and findings of previous Chapters and offers a final assessment of the research presented in this thesis. Finally some suggestions for future research are discussed in Section 8.2.

8.1i Summary of preceeding Chapters

In Chapter 2 we critically examined both the rational expectation hypothesis and its conjunction with the continuous market clearing assumption - giving rise to New Classical economics. In Section 2.1 it was argued that the rational expectations hypothesis has some important short-comings, the attempted correction of which was beyond the scope of this thesis. Nonetheless the hypothesis is a useful theoretical abstraction, and was employed in subsequent Chapters of this thesis. This has had the advantage that when incorporated into a disequilibrium framework we can clearly see the consequences of abandoning the assumption of perfect price flexibility. It was further argued in Chapter 2, with reference to developed contract-based macroeconomic models, and also McCallum's (1977, 1978) arguments, that New Classical results are crucially dependent upon the assumption of perfect price flexibility. It was shown that when less than perfect price adjustment is modelled consistently the New Classical policy conclusions in genral, and the Lucas-Sargent Proposition (LSP) specifically, are no longer valid. The analysis of Chapter 2 forced us to conclude that the assumption of imperfect price adjustment cannot be merely appended on to an otherwise market clearing model. Imperfect price flexibility, via resulting disequilibrium,gives rise to quantity constraints and

and adjustments; these need to be taken into account if disequilibrium is to be modelled consistently. However before presuming that a disequilibrium framework with quantity adjustments and rationing is appropriate it is first necessary to determine if and why prices are less than perfectly flexible. This issue was considered in Chapter 3. In this Chapter recent work on wage and price adjustment was both critically assessed and extended, so as to provide an economic basis for disequilibrium theory. Here a broad approach to wage and price adjustment was adopted. Instead of concentrating on one particular theory to the exclusion of others, this chapter examined each of the main theories recently advanced to explain wage and price adjustment, clearly stating where theories are mutually exclusive and where they complement each other.

As well as providing a general overview of price and wage adjustment and disequilibrium, Chapter 3 also presented advances and extensions to previous theories. The main contribution here was on the effects of "small-menu" costs. By relaxing restrictive assumptions it was shown that previously derived results are not robust. For example, by incorporating the (s,S) policy rule for price adjustment into a model where there are discrete shocks to the system, it was shown that disequilibrium persists in the aggregate, and that monetary policy is non-neutral.

In Section 3.1 the assumption of perfectly flexible prices ensuring continual equilibrium was found to be unsatisfactory, it not being derived from maximising behaviour, nor indicating how the economy moves from one equilibrium to another. What is needed is a theory of how prices are formulated by agents and how these plans are revised in the light of new information. There are two alternative theories of imperfect price adjustment. The first states that prices respond to disequilibrium, with equilibrium being the limit of this process assuming stability. In Section 3.2 this process was found to be ad hoc and incompatible with full rationality of agents. The second theory states that disequilibrium occurs because prices for some reason(s) do not instantaneously adjust to their equilibrium values. Within Sections 3.3 three broad reasons for why prices may adjust imperfectly were analysed : imperfect information and the learning process, multi-period wage and price contracts with incomprehensive indexation, and the presence of "small-menu" costs. It was shown that each of these considerations is sufficient to explain individual price stickiness. In Section 3.4 we aggregated over individual prices, taking seperately into account each of these three given reasons for imperfect price adjustment. Again, with plausible assumptions, imperfect price adjustment and disequilibrium persist. It was thus concluded that rational economic behaviour is capable of providing an adequate basis for disequilibrium theory.

Having found that disequilibrium theory is an appropriate area for economic analysis Chapter 4 critically examined some of the first generation disequilibrium models. This was done so as to lay a proper base for developing the subsequent dynamic rationing models. It was Clower (1965) who first argued that classical economics was unable to provide useful insight into disequilibrium states. Clower's attack on classical economics was presented in Section 4.1 within the context of Walrasian equilibrium. Clower's proposed modelling strategy for studying disequilibrium, the "dual decision hypothesis" was also presented. It was argued that while Clower's critique of classical economics is valid, the dual decision hypothesis is an unsatisfactory basis for disequilibrium economics. In more rigorous attempts to model temporary equilibrium with quantity adjustment one of two main formulations of effective demand have generally been employed, one is associated with Bénassy (1975, 1976), the other with Drèze (1975). In Section 4.2 it was shown that each of these formulations have major short-comings specific to each. However a more fundamental criticism is that there is a multiplicity of effective trade offer definitions. This leads to the problems of indeterminacy and arbitrariness. Due to these problems it was argued that a complete respecification of the way disequilibrium is modelled is needed. At the end of Section 4.2 the work by Sneessens (1981) was presented, which attempts to provide just such a respecification. In his alternative formulation Sneessens replaces the usual assumptions behind quantity rationing models, and in particular, allows expectations about possible constraints to be wrong, abolishing the so-called "equilibrium assumption". Sneessens's approach overcomes the problems of indeterminacy and arbitrariness, by allowing the derivation of well defined effective trade offers without the need to impose ad hoc restrictions. It is for this reason that Sneessens's modelling strategy and basic underlying assumptions were employed to develop the dynamic disequilibrium models of later chapters. Specifically the effective supply and demand functions derived from Sneessens's assumptions were used.

Finally in Chapter 4 we examined the consequences of introducing international trade into a disequilibrium framework. The main result here was that by making use of the "large-country" assumption, that a country has a tradeable good whose price is fixed and faces a downward sloping export demand curve, all four regimes previously derived for the closed economy two-market model are still observed. This result is contrary to many earlier open economy disequilibrium models and is made use of in Chapter 6.

In Chapter 5 two closed economy dynamic disequilibrium models were developed and analysed, with intertemporal linkages being established via wage, price and inventory adjustments. This Chapter represents a continuation of previous research concerned with examining the consequences of introducing inventories as buffer stocks into disequilibrium macroeconomic models. Within this Chapter we were able to assess the robustness of previous results derived from fixed wage and price models, such as Honkapohja and Ito (1980) and Eckalbar (1985), by introducing wage and price adjustment. Initially an extension of Green and Laffont's (1981) "anticipatory pricing" was used to represent wage and price adjustment, with wages and prices assumed to move toward their expected market clearing values over time. This adjustment mechanism was justified by the analysis undertaken in Chapter 3, and is a first approximation to the complicated processes derived from imperfect information and learning, contract theory, and the presence of costs of changing individual prices. This approach allows the possibility of serially correlated regimes, while retaining the assumption that there is no wage or price adjustment within the period.

It was shown that for the model presented in Section 5.2, unlike those of Honkapohja and Ito (1980), Sneessens (1981) and Eckalbar (1985), each of the four distinct regimes of Underconsumption, Repressed Inflation, Classical Unemployment and Keynesian Unemployment could be observed as the short-run equilibrium. Which regime is actually observed is dependent on the shocks the economy has experienced in both past and present periods. All regimes may be observed because all supply and demand functions for goods and labour are subject to random disturbances, inventories may be reduced to zero, and wages and prices adjust imperfectly. The main insights of this Chapter, however, relate to the existence, nature and stability of the long-run equilibrium.

It was proven that there is a unique long-run equilibrium which is the Walrasian equilibrium. This is contrary to the results derived by Honkapohja and Ito (1980) and Eckalbar (1985). Introducing wage and price adjustment excludes the possibility of a non-Walrasian long-run equilibrium. However, such wage and price adjustment alters little the dynamics of the model, and specifically the stability of the long run equilibrium. Model 5.1 is either stable or exhibits a limit cycle, with limit cycles being certain for a significant subset of the parameter space. These stability results confirm those found by Honkapohja and Ito, and Eckalbar, and reinforce the belief that studying regime switching within a disequilibrium framework is a useful approach to further understanding inventory and trade cycles.

In Section 5.5 the importance of wage and price adjustment was explored by allowing wages and prices to adjust in response to excess demand, or supply, in the labour and money markets respectively. It was shown that these modifications to the model greatly alter its stability, though not the number nor nature of possible long-run equilibrium. Now the model initially exhibits saddlepoint instability. To overcome this problem the microeconomic basis was further modified so that agends had forward-looking expectations, allowing the economy to jump on to the stable manifold. Within this model limit cycles are not possible under any parameterization.

In Chapter 6 the partial adjustment closed economy model of Chapter 5 was extended so as to include international trade. In the three models developed in this Chapter firms are allowed to export their output as well as supply domestic consumers, and households consume foreign goods. International capital mobility ensures that the money market is continually in equilibrium with the exchange rate jumping instantaneously to its market clearing value. Wages and prices, however, are still assumed to adjust only imperfectly toward their market clearing values. The resulting open economy models were used to test the robustness of results derived for the closed economy model. It was shown that, in general, the results concerning the nature and stability of equilibrium remain valid for the open economy models. The only long-run equilibrium possible is the Walrasian equilibrium and limit cycles are still certain for a significant subset of the parameter space. In two extensions of the "basic" open economy model we gained further insights into exchange rate determination. In these two models the foreign exchange market and money market were no longer isolated from the goods and labour markets. This was first achieved by allowing the demand for money to depend on consumers' demand for goods, and second by respecifying the firms' labour demand function. Due to these alterations the exchange rate is influenced by both labour and goods market dynamics. This led to the exchange rate exhibiting greater deviations from its long run equilibrium than previous models, such as Dornbusch (1976) and Flood and Hodrick (1983), predict. It is even possible for the exchange rate to exhibit a limit cycle. These models thus aid our understanding of the recently observed large fluctuations of the exchange rate over short intervals of time. A final benefit of the second extended open economy model is that wages are no longer-counter intuitive, a criticism made against the earlier partial adjustment models.

In Chapter 7 we incorporated a public sector into the previously developed disequilibrium framework, with the aim of assessing the effectiveness of government policy. In Section 7.1 it was shown that the public sector can be introduced in a consistent way, and that we can distinguish between fiscal and monetary policy. It was found that government is unable to influence, in general, real variables in the long run only nominal variables. This is a New Classical policy conclusion and follows from the fact that for all the disequilibrium models developed there are no non-Walrasian long-run equilibria. When considering the dynamic short-run effects of government policy, however, our results differ from the New Classical policy conclusions. In Section 7.2 it was shown that for the partial adjustment disequilibrium models developed in the previous Chapters, both fiscal and monetary policy are effective in altering the dynamic path of real variables. This result is not dependent upon the government having superior information in comparison with other agents, nor on the necessity of misleading other agents, nor on assuming the formation of non-rational expectations, but is rather the direct consequence of introducing imperfect price and wage adjustment and allowing for the consequent quantity adjustments. As fiscal and monetary policy are effective the government is able to achieve certain economic objectives. Indeed, if the government has perfect information and control of its policy variables, then it can eliminate unemployment by offsetting the disturbances affecting the economy. Alternatively the government by implementing mistaken policy conclusions may be the cause of unemployment and loss of output.

Finally in Section 7.3 the short-run effectiveness of government policy was explored in Model 5.2 where the wage rate and price level adjust in response to disequilibrium in the labour and goods markets respectively. Here the distinction between anticipated and unanticipated policy changes is important, it being shown that unanticipated fiscal policy is uneffective in both the short-run and the long-run. This concludes our summary of preceeding chapters.

8.1ii <u>A final assessment</u>

In this thesis we have presented original and significant research on both the foundations of dynamic disequilibrium macro-economics and on the implications of such a modelling strategy. Chapters 2 to 4 concentrated largely upon the development of a rational basis for quantity constrained models, while in Chapters 5 to 7 we developed and analysed specific disequilibrium models.

It has been argued here that disequilibrium economics is a superior alternative to the New Classical synthesis, and is capable of yielding qualitatively different results. New Classical economics is based upon the two assumptions that agents form their expectations rationally (as defined by Muth, 1961), and that all markets continually clear. However, it has been argued this second assumption, that prices adjust instantaneously to their market clearing values, is unsatisfactory, it not being derived from maximizing behaviour but instead assumed to be self-evident. Furthermore the usual defense made for this assumption, that it is the limit of a trial and error process in which prices adjust in response to excess demand, was shown to be ad hoc and incompatible with the full rationality of agents. In contrast disequilibrium economics can be derived from the rational economic behaviour of agents. Various reasons were given as to why individual wages and prices may adjust imperfectly, and these go to the root of why disequilibrium exists. It was also shown that such disequilibrium persists over aggregation. A significant advance here was the work presented on the implications of "small menu" costs. In response to costs of changing prices firms will adopt the (s,S) policy rule of price adjustment. By introducing discrete shocks in the equilibrium price level disequilibrium persists in the aggregate and monetary policy is non-neutral.

Imperfect price adjustment gives rise to quantity constraints and these need to be taken into consideration if disequilibrium is to be modelled consistently. Various modelling strategies were discussed and criticised in Chapter 4. Chapters 5 to 6 employed the chosen modelling strategy(based on Sneessens, 1981) to develop dynamic closed and open economy models. Intertemporal linkages were established via wage, price and inventory adjustments. Although much work still needs to be done these models were shown to be able to help our understanding of certain economic phenomenon such as trade and inventory cycles. The dynamic models were also used to test the robustness of previously derived results and provide new results. Significant insights were gained into the possibility of long-run non-Walrasian equilibria, the existence of limit cycles and the behaviour of the exchange rate within regime switching models. Finally we have analysed the effectiveness of government policy in the various disequilibrium models. It being shown that not all the New Classical policy conclusions remain valid when prices adjust imperfectly and quantity adjustments are modelled in a consistent way.

From the analyse of this thesis it is clear that disequilibrium economics is both a valid and fruitful area for future research. Indeed this thesis has not only provided a number of important advances over earlier research, relating to the foundations and implications of disequilibrium, but it has also highlighted the need for further research in specific areas. Some of these issues are discussed in the next section.

8.2 Suggestions for future research

The study of dynamic disequilibrium economics is still young. As related in the previous section this thesis has presented a number of advances, but it has also highlighted that much still remains to be done. In this section we outline a programme for further research. The five areas we consider are: price adjustment; the demand for inventories; the formation of expectations; multi-country disequilibrium models; and empirical estimation and hypothesis testing. Although each of these areas are discussed separately many of them overlap with each other.

One area in need of further research is that of price adjustment. Despite many recent contributions to this subject, including the analysis of Chapter 3 in this thesis, there is, as yet, no generally accepted choice-theoretic basis for the assumption of slow price adjustment in macroeconomic models. (This also applies to the opposite extreme of instantaneous price adjustment.) The important task of determining - empirically as well as theoretically - whether and why prices are fixed or sticky in the short-run remains. Further the specific reasons proposed for why prices adjust imperfectly need to be incorporated in a more consistent and thorough-going fashion into dynamic disequilibrium models. For example with the main disequilibrium models developed in this thesis it was assumed that wages and prices adjusted only partially toward their market clearing values. This should be seen as only a first approximation to the more complicated adjustment processes generated when factors such as imperfect information, learning and "small-menu" cost are explicitly incorporated into dynamic quantity constrained models. The importance of such future research was underlined in Chapters 5 and 7 of this thesis, where it was shown that alternative wage and price adjustment mechanism can greatly alter the properties of such models.

Related to this issue of price adjustment is how the demand for inventories is to be modelled and also how expectations are formulated. The treatment of adjustment dynamics as the economy moves through a sequence of temporary equilibria over time would benefit from a more thorough investigation of expectation formation. In general, the disequilibrium dynamics for quantity constrained models have embodied extremely myopic behaviour on the part of economic agents. In particular, the adjustment paths that prices follow often have no effect on agents' current decisions. This is reflected in the simplistic way the demand for inventories has been modelled in the partial adjustment models of this thesis. As previously stated in an optimizing model the firm's demand for inventories must depend on their expectations of product demand and input costs in the future. In a model where there is persistence of regimes the firm will have to consider the probability of various sorts of disequilibrium in the future, as well as future prices. The first depends on both what types of shocks the economy will undergo and on how price movements might eliminate disequilibrium. In general inventory holding cannot be divorced from the nature of price determination and the nature of the stochastic processes generating shocks to the economy. If the assumption of rational expectations (or rational constraint expectations) is to be used the solving of the resulting dynamic model will be more difficult than a standard dynamic model. In dynamic rational expectation models, in which expectations of future values of endogenous variables appear, some endogenous variables do not have natural initial conditions. Thus, in the absence of other conditions or restrictions on these variables, these models may admit an infinity of solutions. Finding "the" solution then requires the use of additional conditions, these are usually in the form of transversality conditions. There now exists a sizeable literature on the solution of linear rational expectation models containing future expectations of the endogenous variables with different solution techniques adopted by different authors. In a forthcoming book Pesaran has defined five categories of solution techniques: the method of undetermined coefficients, the operator or z-transform method, the forward recursive substitution method, the martingale method, and the martingale difference method. The problem with these solutions techniques is that they are all ad hoc, and though each may generate a unique solution, they may not yield the same unique solution, thus we still have the problem of choosing one solution from many. The reason such difficulties arise is because the model used is not derived from a dynamic optimization problem. If the model were to be derived from an optimization problem transversality conditions would be part of the characterisation of the solution. If agents have infinite planning horizons the resulting transversality conditions from the dynamic optimization provide the conditions needed for the determination of a unique non-explosive solution. It is clear that when incorporating future expectations of endogenous variables explicit dynamic optimization is required.

In Chapter 2 two further shortcomings of the rational expectations hypothesis were noted and deserve further analysis. The first concerns the question of how agents learn about their economic environment. For agents to hold expectations that exhibit the error orthogonality property they need to know the structure of the economy. If individualshave imperfect information relating to either the structural specification of the economy or some parameter value then a learning procedure is required. There have been numerous approaches to this problem but as yet there has been little or no analysis of how agents learn within an explicit disequilibrium framework. The possibility and implications of such learning seems worthy of study. The second shortcoming concerned the role of differential information. It is implicitly assumed in rational expectation models that agents expect other agents to hold the same view of the economic environment as they do. There seems a need to develop more general models in which there is sufficient disaggregation to allow different groups to have different information and form different expectations. Where differential information is likely to be important we would expect such disaggregation to lead to more realistic models.

The next area suggested suitable for research is that of open economy macroeconomics. Virtually all published work on open economy disequilibrium theory, as well as work presented in this thesis, have dealt with a single economy in an international environment. The difficult task of extending these models to two or more open economies in general disequilibrium has just begun (for example Dixit and Norman, 1980 and Lori and Sheen, 1982). The interaction between a number of fix-price economies, which may be in different disequilibrium regimes, is undoubtedly important. It will force us to pay much more attention to the specification of reasonable (world wide) rationing rules, which necessarily play a role in resolving market imbalance when prices in world markets fail to adjust instantaneously.

The final area suggested for future research is the empirical estimation and testing of disequilibrium models. The first empirical study in this direction was that by Fair and Jaffee (1972). Subsequently the estimation technique for markets in disequilibrium, subject to the "min" condition, has been developed; see for example Maddala and Nelson (1974), Quandt (1978a), Laffont and Montfort (1979), and Quandt (1982). All models in this general class share the following characteristics. First they contain inequalities as essential ingredients, since the "min" condition $Q_t = \min(D_t, S_t)$ could be rewritten as "$Q_t = D_t$ if $D_t \leq S_t$ and $Q_t = S_t$ if $D_t > S_t$". Second some agents whose behaviour the model purports to represent are usually "off their behaviour curve". Thus some endogenous variables in the model are not observed but latent. This creates a strong family resemblance between disequilibrium models and other latent variable models such as the switching regression model, the probit model or the tobit model. The principal econometric features are: (1) estimation is most frequently by maximum likelihood, although in special cases two-stage least squares methods are available; (2) in models where sample separation is unknown the likelihood functions tend to be unbounded in parameter space; (3) the likelihood functions contain integrals of density functions, with the multiplicity of the integrals depending on the number of observed endogenous variables; thus in a disequilibrium model with two interrelated markets double integrals occur in the likelihood function. A number of applications have already been carried out, mainly for models with a single market, see Quandt (1982). It would seem useful, therefore, to try to fit a two market quantity rationing model to UK data. This type of exercise may be able to provide a test of the market and non-market clearing hypothesis, and may help to quantify the issues at stake in the macroeconomic debate. Several attempts of this kind have already been carried out for the

Netherlands by Kooiman and Kloek (1980, 1981) for Belgium by Sneessens (1983), and for France by Vilares (1981) using annual data, and also for France by Artus, Laroque and Michel (1984) using quarterly data.

Many tests have been suggested for the "disequilibrating hypothesis", that is to test whether the data has been generated by an equilibrium model or a disequilibrium model. Quandt (1978b) discussed several tests and concluded that there does not exist a uniformly best procedure for testing the hypothesis that a market is in equilibrium against the alternative that it is not. A good starting point, however, for all tests of disequilibrium is to ask the basic question: What causes the disequilibrium? In the case of a partial adjustment model, such as Model 5.1 of this thesis, then the disequilibrium is clearly due to imperfect adjustment of wages and prices to their market clearing levels. In this case the proper test for the equilibrium versus disequilibrium hypothesis is to test whether or not $\lambda_w = 1$ and $\lambda_p = 1$ in the partial adjustment equations (equations 5.17 and 5.18 respectively for Model 5.1).

There was considerable discussion in Quandt's study on the question of nested or non-nested hypotheses. Quandt argued that very often the hypothesis of equilibrium versus disequilibrium is non-nested; that is the parameter set under the null hypothesis that the model is an equilibrium model is not a subset of the parameter set for the disequilibrium model. The problem in these cases may be that there is no adequate explanation of why disequilibrium exists in the first place. For example Quandt considered the following price adjustment equation:

$$\Delta P_{t+1} = \gamma(D_t - S_t) + U_t \qquad (8.1)$$

that is prices change in response to excess supply or excess demand. The limit of the likelihood function of the disequilibrium model as $\gamma \to \infty$ is not the likelihood function for the equilibrium model. The problem is that this price adjustment equation tells us nothing about what causes disequilibrium. If we view (8.1) as a forecast equation, then the disequilibrium is due to imperfect forecasts of the market equilibrating price. In this case it is clear that as $\gamma \to \infty$, we do not get perfect forecasts. What we need in order to have a nested model is a forecasting equation that for some limiting values of the parameters yields perfect forecasts at the market equilibrium prices. In conclusion, tests for disequilibrium should be based on a discussion of what causes disequilibrium. Once again this highlights the need for further research on price adjustment. The test will then be a test of a nested hypothesis, and what the appropriate test is will be obvious from a statement of the problem.

It is hoped that this thesis will be useful not only for the advances it has presented, but that it will also facilitate future research in the related areas - only some of which have been alluded to above - where work remains to be done.

APPENDIX 1

Proof that assumptions A4-A6 of Chapter 4 imply that:
(i) the effective trade offer of consumers are the Walrasian supply on the labour market and the Bênassy demand on the goods market and (ii) the effective trade offers of producers are the Bênassy demand on the labour market and the Drèze supply on the goods market provided pr_2 is sufficiently close to zero.

The proof is taken from Sneessens (1981) and follows the one used by Bênassy (1977) to prove his Proposition 5. It makes use of the backward dynamic programming technique utilized in intertemporal optimization problems.

(i) We first consider the behaviour of consumers on the goods market. The amount of work they will be able to perform is already known to be ℓ_t. As consumers do not expect to be rationed on the goods market, their optimal demand for goods obtains as:

$$\max_{y_t^d} U(y_t^d, \ell_t, M_t)$$

$$\text{s.t. } M_t = M_{t-1} + w_t\ell_t - p_t y_t^d$$

where w_t is the wage rate in period t, p_t the price of the representative good in period t and M_t is the quantity of money carried over at the end of period t. We assume that the utility function, U, is strictly concave and strictly increasing in each argument. The utility of money appears indirectly, through the amount of future consumption it represents.

This maximization problem defines y_t^d as a Bênassy effective demand, equal to the Walrasian demand when $\ell_t = \ell_t^{ws}$. Let us define the utility function:

$$V(\ell_t, m_t) = \underset{y_t^d}{\text{Max}} \; U(y_t^d, \ell_t, M_t)$$

where $m_t = M_{t-1} + w_t \ell_t$. It is the utility of a transaction ℓ_t on the labour market provided an optimal trade offer is next made on the goods market. The optimal labour supply obtains as (assuming $\bar{\ell}_t^s < \ell_t^{ws}$)

$$\underset{\ell_t^s}{\text{Max}} \; (1 - pr_1)V(\bar{\ell}_t^s, \bar{m}_t) + pr_1 V(\ell_t^s, m_t)$$

As ℓ_t^s appears only in the second term, its optimal value obtains alternatively as:

$$\underset{\ell_t^s}{\text{Max}} \; V(\ell_t^s, m_t) \quad = \underset{\ell_t^s}{\text{Max}}\left[\text{Max} U(y_t^d, \ell_t^s, M_t)\right]$$

The optimal labour supply is thus the Walrasian one.

(ii) The amount of labour a firm wishes to hire is determined by expected profit maximization

$$\underset{\ell_t^d}{\text{Max}} \; \pi = (1 - pr_2)(1-pr_3)\{p_t \min[\bar{y}_t^s, F(\min(\bar{\ell}_t^d, \ell_t^d))]$$

$$-[w_t \min \bar{\ell}_t^d, \ell_t^d]\}$$

$$+ (1 - pr_2)pr_3\{p_t \min[\bar{y}_t^s, F(\ell_t^d)] - w_t \ell_t^d\}$$

$$+ pr_2(1-pr_3)\{p_t F[\min(\bar{\ell}^d_t, \ell^d_t)] - w_t \min(\bar{\ell}^d_t, \ell^d_t)\}$$

$$+ pr_2 pr_3 \{p_t F(\ell^d_t) - w_t \ell^d_t\}$$

s.t. the technological constraint $y^s_t = F(\ell_t)$,

where F is assumed to be concave and strictly increasing in ℓ_t.

Futia (1975) has shown that this has the same solution as:

$$\max_{\ell^d_t} \pi^*_t = (1-pr_2) p_t \min[\bar{y}^s_t, F(\ell^d_t)]$$

$$+ pr_2 p_t F(\ell^d_t) - w_t \ell^d_t$$

If $\bar{y}^s_t$ is larger than the Walrasian supply of goods, the optimal labour demand is obviously ℓ^{wd}_t. In the opposite case, the firm will at least want to produce $\bar{y}^s_t$. Its demand for labour can accordingly be written as:

$$\ell^d_t = F^{-1}(\bar{y}^s_t) + d; \quad d \geq 0$$

The optimal value of d will maximize the increase in profits expected from producing more than $\bar{y}^s_t$.

$$\max_d \; pr_2 p_t F[F^{-1}(\bar{y}^s_t) + d] - w_t d$$

s.t. $d \geq 0$

The first order conditions are

$$pr_2 p_t f_t - w_t \leq 0$$

$$d(pr_2 p_t f_t - w_t) = 0$$

where f_t is the derivative of F at $[F^{-1}(\bar{y}^s_t) + d]$. Clearly, if f_t is bounded, pr_2 close to zero implies $(pr_2 p_t f_t - w_t)$ is negative and d equal to zero. Thus, to summarize, provided pr_2 is sufficiently close to zero, the effective demand for labour can be written:

$$\ell^d_t = F^{-1}[\min(\bar{y}^s_t, y^{ws}_t)]$$

After labour contracts have been made, the production process takes place. When producers meet consumers on the goods market, their supply of goods can only be

$$y^s_t = F(\ell_t)$$

As pr_2 is strictly positive, offering more than the quantity actually produced implies that the firm might be unable to honour their trade offer. As ℓ_t is the minimum of supply and demand, and because ℓ^d_t already takes account of the constraint prevailing on the goods market, the supply of goods is a function of the constraints prevailing (or expected to prevail) on both markets. For pr_2 sufficiently close to zero, it corresponds to the Drèze concept obtained from:

$$\text{Max } p_t F(\ell^d_t) - w_t \ell^d_t$$

$$\text{s.t. } F(\ell^d_t) \leq \bar{y}^s_t \qquad \text{and} \quad \ell^d_t \leq \ell_t$$

APPENDIX 2

For the regime of Underconsumption the changes in w_t (the same for $(w-p)_t$ when $p_t = p_t^*$) and S_t are given by

$$\Delta w_t = \lambda_w (w_t^* - w_t)$$

$$= \lambda_w \left[\left(\frac{A\delta_o + S_t - a}{(1+b)\,\beta_1} \right) - \left(\frac{\beta_o + \beta_2 p_t^*}{\beta_1} \right) \right] - \lambda_w w_t$$

$$\Delta S_t = A\delta_o - (\beta_o + \beta_1 w_t + \beta_2 p_t)$$

This system can be written in matrix notation as

$$\begin{bmatrix} \Delta w_t \\ \Delta S_t \end{bmatrix} = A \begin{bmatrix} W_t \\ S_t \end{bmatrix} + B$$

$$\text{Where } A = \begin{bmatrix} -\lambda_w & \lambda_w/(1+b)\beta_1 \\ -\beta_1 & 0 \end{bmatrix}$$

$$\text{and } B = \frac{\lambda_w\left[A\delta_o - a - (1+b)(\beta_o + \beta_2 p_t^*)\right]/(1+b)\beta_1}{A\delta_o - \beta_o - \beta_2 p_t^*}$$

By Routh-Hurwitz this system is locally stable as

$$Tr(A) = -\lambda_w < 0$$

$$\text{and } |A| = \lambda_w/(1+b) > 0$$

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TITLE

RATIONAL DYNAMIC DISEQUILIBRIUM
MACRO MODELS WITH WAGE, PRICE AND
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