SERIE RESEARCH MEMORANDA

WAGE RIGIDITY AND THE PERSISTENCE OF UNEMPLOYMENT

K.A. Springer

Research Memorandum 1989-41 Augustus 1989

VRIJE UNIVERSITEIT
FACULTEIT DER ECONOMISCHE WETENSCHAPPEN
EN ECONOMETRIE
AMSTERDAM
Wage Rigidity and the Persistence of Unemployment

Preliminary version of a paper presented at the Fourth Annual Congress of the European Economic Association, Augsburg, Germany, September 2-4, 1989

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This paper studies the process of wage formation in a model with nonopolistic competition in the goods market. After a discussion of the literature on real wage rigidity and hysteresis or persistence theories, a (partial equilibrium) model is presented based on both efficiency-wage and insider-outsider theory. In this model the firm and the union negotiate on the wage level. Given the outcome of this (Nash) bargaining process, the firm sets the price of its product, its output and employment level. The dynamic properties of the model are further analyzed in the setting of an intertemporal disequilibrium macroeconomic model. Although it is not possible to solve this model analytically, the time-paths of the variables after a shock to the economy can be traced numerically by applying the method of multiple shooting. The paper presents some results of these simulation experiments.

The author wishes to thank Frank den Butter, Bernard Compaijen and Jan van Ours for their comments and Gerard Staarink for providing the multiple shooting routine.
1. Introduction

It is widely recognized that the assumption of wage rigidity is central to the explanation of unemployment. If wages are sticky, the labour market will fail to clear when (effective) demand is low, and a decline in (effective) demand will raise unemployment and lead to reductions in output. After the war the conventional Keynesian approach was to express nominal wage stickiness by means of a Phillips-curve relationship in which wages and prices adjust gradually during unemployment. More recently, this approach has been modified such that in the long run the unemployment rate converges to a slowly evolving natural rate which is determined by the composition of the labour force and the structure of the labour market. However, the concept of slow wage adjustment has been severely criticized, because it lacks a solid microfoundation based on the optimizing behaviour of economic agents.

This paper provides a microfoundation for wage rigidity along the lines of new Keynesian macroeconomics in order to account for involuntary unemployment. Starting-point is the macroeconomic model with monopolistic competition and price rigidity outlined in Van de Klundert and Peters (1988). Our purpose is to incorporate into this model a process of wage formation which generates wage stickiness. Moreover, the microfoundations of this wage formation process are specified in such a way that we are able to account for the possibility of persisting unemployment.

In section 2 we study some recent literature on wage rigidity and unemployment. Especially, the literature on the different variants of efficiency wages and hysteresis or persistence theories is analyzed. Following the exposition of section 2 with its separate discussions of main ingredients, section 3 provides a synthesis model in which these theories are regarded as complementary to each other. Subsequently, section 4 deals with the dynamics of the disequilibrium model with monopolistic competition in which now not only prices, but also wages are determined endogenously.

The final section of this paper gives a summary of main results and conclusions.
2. Efficiency wages and hysteresis theories

The surveys by Fischer (1988) and Katz (1988) discuss some recent developments in labour economics which are important for modern macroeconomics. They examine several explanations for wage rigidity and persistently high unemployment. With respect to wage rigidity the main contenders are: labour contracts, unions and efficiency wages. In this section we restrict ourselves to the latter, because in our opinion the efficiency-wage hypothesis is the more promising approach\(^1\). This is not to say that both contracting and unions are irrelevant to wage formation. In fact, both elements may be largely complementary to the approach based on efficiency wages. The role played by unions is of particular interest in theories of hysteresis. These theories are, as explanations of persistently high unemployment, the subject of the second part of this section.

2.1 Efficiency wages

The key relationship in efficiency-wage theories of unemployment is that the productivity of workers is a function of the wage paid. In this case, firms are unwilling to lower wages, even when there is an excess supply of labour, because lowering the wage may lower productivity more than proportionately, so that labour costs are actually increased. When the efficiency wage is higher than the market-clearing wage, involuntary unemployment results. The literature discusses four different microfoundations for this phenomenon\(^2\) (see Akerlof and Yellen (1986)). These microeconomic explanations are related to four benefits of paying higher wages: reduced shirking by employees due to a higher cost of job loss, lower turnover, improvement in the average quality of job applicants, and improved morale. Although the four theories differ in a number of respects, they have a common mathematical structure. In its simplest form this structure is given by the wage-productivity curve:
where \( e(\omega) \) is the effort (or efficiency) of a worker receiving a real wage \( \omega \) \((=w/p)\). If the (representative) firm sets the wage, it chooses a wage that minimizes the wage costs per efficiency unit,
\[
\min \frac{\omega}{e(\omega)}
\]
Solving (2) yields the result:
\[
(\omega/e)_e = 1
\]
This equation is known as the 'Solow condition' (see Solow (1979)): the elasticity of effort with respect to the wage is unity. Let \( \omega^* \) be the solution to (3), then \( \omega^* \) is the efficiency wage. In figure 1 it is shown that the efficiency wage is given by the point in which a line through the origin is tangent to the wage-productivity curve. In this point the first derivative of \( e(\omega) \) is equal to \( e(\omega)/\omega \).
Assume that the firm operates with a production function given by \( y = f(e,n) \), where \( n \) is the number of workers. With output as our numeraire, the firm will pay a wage \( \omega^* \) and will optimally hire labour up to the point where the marginal product of labour is equal to the real wage \( \omega^* \):
\[
e(\omega^*)f'(e(\omega^*), n) = \omega^*
\]

\[\text{Figure 1. The graphical determination of the efficiency wage (see Stiglitz (1986, p. 183))}\]
Of course the firm only starts production if there is a profit to be made, so that labour productivity has to be higher than the real wage: \( f(e(\omega^*), n)/n > \omega^* \).

In the aggregate, when labour demand falls short of labour supply and \( \omega^* \) is higher than labour's reservation wage, the firm will be unconstrained by labour market conditions in pursuing its optimal policy, so that a disequilibrium results which is characterized by involuntary unemployment.

The four microfoundations given for the efficiency-wage hypothesis, actually suggest a more general formulation of the effort function in eq. (1). Most arguments, e.g. those based on labour turnover and workers' morale, suggest that rather than depending on absolute wages, effort depends on the relative attractiveness of opportunities inside and outside the firm. Opportunities outside the firm in turn depend on the general prevailing wage as paid by other firms, the unemployment rate and the level of unemployment benefits. Therefore, we should more generally specify \( e(.) \) as a function which also includes these outside variables in its arguments. An illustrative example in this context can be found in Summers (1988). In his article \( e \) is determined by \( (\omega_i - x)^\nu \), \( os_i \), where \( \omega_i \) is the wage paid by firm \( i \) and \( x \) reflects workers' outside opportunities:

\[
x = \omega(1 - U) + bU = \omega(1 - (1 - \rho)U)
\]

where \( \omega \) is the general prevailing (real) wage (or the average real wage paid by other firms), \( U \) is the unemployment rate, \( b \) represents real unemployment benefits, and so \( \rho = b/\omega \) which stands for the replacement ratio. The efficiency-wage level of \( \omega_i \) may then be calculated as \( x/(1 - \nu) \), so that the firm pays its workers their opportunity costs plus a premium whose magnitude depends on the size of \( \nu \), which measures the productivity-enhancing effects of paying higher wages. An interesting implication of this model is that, since all firms are identical (so that in equilibrium \( \omega_i = \omega \)), we may obtain a very simple expression for the market equilibrium rate of unemployment \( (U^*) \):

\[
U^* = \nu/(1 - \rho)
\]
The equilibrium rate of unemployment thus depends positively on the size of the productivity-enhancing effects of wage increases and on the attractiveness of unemployment. From this it is clear that any efficiency-wage model with $e$ specified as $e(\omega_1/\omega, U, \rho)$, immediately implies an equilibrium unemployment rate.

The efficiency-wage model generates a number of testable predictions about the existence of non-competitive wage differentials. E.g. since the relationship between productivity and wage may differ from industry to industry, wages for similar workers may differ from industry to industry. Therefore, it is not surprising that there is a growing empirical literature studying the interindustry wage structure (see Katz (1988)). These studies, which are mainly based on US data, show that there indeed are large interindustry wage differences for observationally equivalent workers and that these wage differentials are very persistent. Moreover, lower quit rates are observed in high-wage industries suggesting that workers in these industries are earning rents. Empirical evidence suggests a positive relationship between wage differentials on the one hand and industry profitability, monopoly power, capital intensity and average education on the other hand. High-wage industries tend to pay all types of workers high wages. The evidence on the relationship between product market characteristics and wages and the similarity in differentials across occupations points to rent-sharing explanations of wage differentials, i.e. if a firm has been making money in its output market it should share these benefits with its workers. Rent sharing is a corner-stone of the fair-wage efficiency-wage model (see Akerlof and Yellen (1988)) in which effort is stimulated by improved morale due to the payment of higher wages. When efficiency-wage considerations are present, firms may be able to survive by rent sharing, since wage increases then lead to less than proportionate increases in labour costs. In this respect Krueger and Summers (1988, p.280) correctly stipulate that "rent sharing is less expensive for firms in an efficiency-wage environment where changes in wages have no first-order effect on costs than it would be in a standard competitive situation".

Subsequently, efficiency-wage models also provide potential mechanisms through which cyclical fluctuations in output can be
generated by aggregate demand shocks. In this case, similar to the mechanism described in models with monopolistic competition on the product market, the failure of firms to adjust wages to small shocks leads to only second-order losses. However, this behaviour may generate first-order results at the macroeconomic level.

It should of course be noted that efficiency-wage theories account for real rather than nominal wage rigidity. Since many macroeconomists believe that it is nominal rigidities, not real rigidities, that are to be explained, we are not to obfuscate this issue. Our own view may be characterized as largely pragmatic. First of all, as also noted by Stiglitz (1986), the evidence on the crucial importance of nominal rigidities is not wholly convincing and still subject to further empirical research. In order to avoid a lengthy discussion of this matter here, we restrict ourselves to the observation that economies that have practised extensive indexing, so that real wages were rigid, have experienced episodes of unemployment just as economies in which indexing was not so widespread. Moreover, a number of important studies has stressed the decisive role of real wage rigidity, especially in European labour markets, in the explanation of the general rise of unemployment during the past two decades. Secondly, the use of efficiency-wage models does not preclude any role of nominal wage rigidity. For example, one could think of the fair-wage variant of these models. In this case, if each firm believes that all others are going to leave money wages unchanged, because individual workers have come to believe that money wage reductions are unfair, it would not be in the interest of any firm to change its money wage. Nominal wage rigidity then results from the difficulty of coordinating wage cuts across decentralised firms. In an economy with a history of low inflation rates, it may be natural to focus on the nominal wage, while in other economies with extreme indexing, it may be the real wage that is rigid.
2.2 Hysteresis and persistence theories

The gloomy labour market situation of persistent mass unemploy­ment in many industrialized countries, particularly in Europe, has been a strong stimulus for the development of the so-called 'hysteresis theory'. At the heart of this theory is the idea that the equilibrium rate or so-called natural rate of unemployment depends on the history of the actual unemployment rate. With respect to unemployment, the notion of hysteresis may be illustrated by means of a general formulation of the Phillips curve:

\[ \dot{P}_t = \dot{p}_t - \alpha(U_t - \overline{U}^*) \] (7)

where \( t \) is a time subscript, \( \dot{P} \) and \( \dot{p}^* \) represent, respectively, the actual and the expected rate of inflation. In this context, the equilibrium or natural rate of unemployment \( \overline{U}^* \), which corresponds to the steady-state solution, is usually called the NAIRU, i.e. the non-accelerating-inflation rate of unemployment. Now let, according to some theory, \( U_t = bZ_t \), where \( Z_t \) is a vector of relevant variables. The possibility of hysteresis then arises if the contemporaneous NAIRU \( (U_t^*) \) is also a function of past unemployment:

\[ U_t^* = aU_{t-1} + bZ_t \] (8)

Substitution of (8) in (7) then gives:

\[ \dot{P}_t = \dot{p}_t - \alpha(U_t - aU_{t-1}) + abZ_t \] (9)

Hysteresis occurs if \( \alpha = 1 \). Imposing the steady-state conditions \( \dot{P}_t = \dot{P}_e \) and \( U_t = U_{t-1} \), we obtain the existence requirement that \( Z \) has an asymptotic value of zero, and no restriction on \( U \). There is no longer a unique NAIRU. Any value is possible and actually depends upon the path of \( Z_t \), so that any temporary disturbance to \( Z \) will have a permanent effect on the NAIRU:

\[ \overline{U}^* = U_0 + b\sum_{t=0}^{\infty} Z_t \] (10)

Of course, if \( \alpha = 0 \), we still have the case of the standard natural rate with NAIRU: \( \overline{U}^* = bZ \). More interesting and probably the most realistic, is the intermediate case \( 0 < \alpha < 1 \). In this case there is
no complete hysteresis, because $U^* = \frac{bZ}{(1-a)}$. Then the contemporaneous NAIRU eventually converges to its steady-state level whereas the speed of adjustment depends on $a$. The higher is $a$, the more slowly the NAIRU evolves to its steady-state level. The latter case is usually referred to as the case of persistence (or partial hysteresis) to distinguish it from the case of hysteresis, which strictly occurs when $a=1$. However, the literature does not apply this distinction very strictly and frequently uses the notion of hysteresis in cases where partial hysteresis or rather persistence may actually be meant.

Recent literature (e.g. see Franz (1987)) suggests three types of explanations of hysteresis/persistence in unemployment, which may provide microfoundations for a relation like eq. (8). These refer to

1) the shortage of physical capital;
2) the process of wage bargaining;
3) the depreciation of human capital.

With respect to the first set of explanations we want to be brief. The basic idea of this approach is that supply and demand shocks in the 70s and 80s have decreased the rate of capital accumulation and have resulted in a shortage of capital. The scrapping of capital has reduced employment and, therefore, unemployment has risen. Consequently, hysteresis in capital formation has probably led to hysteresis in unemployment. The high utilization rates of the capital stock in the past few years combined with high unemployment or underutilization of labour, indeed point to the relevance of this capital-shortage hypothesis. In a recent study Burda (1988) concludes on this issue that the shortage of capital has largely contributed to the rise of unemployment in Europe during the last fifteen years. He also outlines the mechanism that has been responsible for this development, namely, the interaction of wage formation and investment behaviour. Investment behaviour is very sensitive to properties of the production function, since the smaller the possibilities for substituting labour for capital, the more likely it is that capital really acts as a constraint. However,
it is in fact the degree of real wage rigidity that is of crucial importance here (or rather capital hysteresis may be explained by unemployment hysteresis). As the other two types of explanations of hysteresis are more directly related to the structure of the labour market and to wage formation, we will concentrate on these theories, notwithstanding the apparent role of capital accumulation.

**Wage bargaining**

This explanation of hysteresis refers to the role of the unemployed in the wage bargaining process and comprises the *insider-outsider models* that have recently come to the fore. Insider-outsider theory is based on the ideas that: a) it is costly for firms to replace their incumbent employees (insiders) with unemployed workers (outsiders) and that b) insiders are able to influence wage formation without taking into account the interests of the outsiders. The first variant of insider-outsider models which are mainly based on the former idea, is denoted as the *turnover variant*. Examples of such models are to be found in Lindbeck and Snower (1987, 1988) and Solow (1985). The second variant is referred to as the *union variant* and underlies the studies by Blanchard and Summers (1986, 1987), Carruth and Oswald (1987) and Gottfries and Horn (1987).

In the *turnover variant* insiders exploit and manipulate labour turnover costs in order to raise their wage rates. In other words, turnover costs provide insiders with the leverage necessary to extract a share of the product market rents earned by firms, so that higher product demand is converted into higher wages for insiders rather than into increased access to jobs for outsiders. Several sources of turnover costs have been suggested in the literature. In order to replace an insider by an outsider costs of hiring, training and firing have to be incurred. Moreover, higher turnover may reduce workers' effort as in the efficiency-wage model, while insiders by harassing entrants may also create a positive insider-entrant productivity differential.

It should be clear that the distinction between insiders and entrants, which rests on the existence of labour turnover costs, is rather important for wage determination. When we assume that the insiders have complete market power and that each insider
views himself as the marginal employee in his firm, it is straightforward to show how the insider wage is determined\(^8\). Then the nominal insider wage will be set as high as possible, subject to two constraints. First of all, the insider must not become unprofitable to the firm, i.e. the real insider wage should be smaller or equal to the real marginal value product of (insiders') labour (with monopolistically competitive firms this also depends on the price elasticity of the firms' product demands). The second constraint is that the insider must be at least as profitable as the marginal entrant, which implies that the (nominal) insider wage should be set smaller or equal to the entrant's wage plus labour turnover costs.

If insiders have some market power in the negotiations on nominal wages, then policy-induced shocks in aggregate labour demand may induce persistent changes in the level of unemployment. In this case, there is no natural rate of unemployment, because unemployment is not necessarily at a unique rate. The degree of persistence depends on the speed with which entrants may become insiders and with which dismissed insiders may become outsiders. In this way, possible asymmetries in the response of the negotiated wage to the level of activity within the firm, can also be explained. For example, Lindbeck and Snower (1988) have argued that the upward responsiveness of wages to positive supply shocks is greater than their downward responsiveness to negative ones. Nickell and Wadhwani (1988) correctly stipulate that this asymmetric 'ratchet' occurs in Lindbeck and Snower's model, because laid-off workers immediately become outsiders whereas new entrants do not immediately become insiders (they first have to acquire firm-specific skills).

Since the turnover variant of insider-outsider theory presumes not only that turnover costs exist, but also that the insiders may influence them and firms cannot entirely pass them back on to their workers by wage reductions, the insider-outsider models of this variant clearly suggest a rationale for unionization, because unions may help to raise firms' turnover costs. This provides a strong link with the second variant of insider-outsider theory.

In the union variant of insider-outsider theory the wage is the outcome of a bargaining process between the firm and the union
acting in the interests of their members. It is usually assumed that membership is closely related to the status of insider in the firm. The role of the union is formally modelled by means of a utility function representing its preferences with respect to wages and employment. A simple example of this kind of insider-insider models can be found in Blanchard and Summers (1986) for the one-period case. In this model labour demand \( n^d \) is given by

\[ n^d = -c\omega + \epsilon \]  

where \( \omega \) is again the real wage, \( c \) is a positive constant and \( \epsilon \) is a random technology shock (uniformly distributed). The union is supposed to maximize the utility of the representative member (insider) specified as:

\[ p^n + b\omega \]  

where \( p^n \) is the probability of being employed and \( b \) is the weight for remuneration. The lower \( b \), the more importance workers attach to employment protection as opposed to the wage. If the wage is set unilaterally by the union, it is shown that the wage depends negatively on the initial number of insiders. Of course, in a more dynamic setting, there is a relation between employment in this period and the number of insiders in the next. An interesting case then is where the number of insiders equals employment. For this case with a given labour force, Blanchard and Summers (1986) derive that there is unemployment hysteresis. In a somewhat more complicated model Gottfries and Horn (1987, p. 881) reach a similar conclusion and summarize the propagation mechanism that generates persistence: ".., the smaller the number of workers employed in the previous period the higher the optimal wage, and hence the lower the expected employment level in the current period. A temporary shock in the previous period, which resulted in the layoff of some workers, will have a persistent effect in that it will reduce the expected employment level in the subsequent period, even though wage contracts have been negotiated anew after the initial contractionary shock".

Of course, in reality the process of wage bargaining is more complicated than the picture presented by the models discussed above. Some additional considerations may then have to be taken
into account. In the Netherlands, for example, unemployment benefits are financed by social security contributions by both employers and employees. Consequently, the interests of insiders and outsiders are linked together by the social security system.

Depreciation of human capital
The basic idea is that long spells of unemployment are likely to depreciate the skills of unemployed workers, which has a negative influence on the labour market position of these workers. This kind of hysteresis theory is usually referred to as duration theory. Duration theory suggests a mechanism that may be well illustrated in the context of a search model. When the lack of work experience and other forms of training decreases productivity of the long-term unemployed with unemployment duration, productivity can fall below the reservation wage of these unemployed, so that their search activities will be curtailed. This effect will be strengthened by higher unemployment benefits and will decrease effective labour supply (and increase the natural unemployment rate). Moreover, this effect can be reinforced from the demand side of the labour market if employers use unemployment experience as a screening device. Employers, having a risk averse attitude, will then view job applicants with a history of unemployment as the less promising candidates for their vacancies. This effect will be stronger the easier it is for firms to fill their vacancies.

There is an obvious relationship between long-term unemployment and outsider status, because insider-outsider theory and duration theory partly describe the same mechanism. For example, hiring the long-term unemployed requires more expenses by employers to give them proper on-the-job training than hiring short-term unemployed. Because of this rise in labour turnover costs, it can be stated that the larger the fraction of long-term unemployment in total unemployment, the smaller becomes the downward pressure of unemployment on wage formation. Therefore, the only difference between insider-outsider theory and duration theory is that the former focusses on the situation within the firm and the role of insiders, while the latter concentrates on the role of outsiders and on supply reactions in the labour market.
Finally, we want to make some further brief remarks on empirical investigations of the hysteresis phenomenon and on some recent theoretical developments that are related to hysteresis theories. A growing number of empirical studies addresses the question if there is any evidence of hysteresis in unemployment. Blanchard and Summers (1986) estimate several specifications of the wage equation and conclude that these estimations suggest a substantial degree of hysteresis in some European countries, namely Germany, France and the United Kingdom, while the results for the United States provide evidence of much less hysteresis. In a more recent study Graafland (1988) arrives at a similar conclusion. His results also show that hysteresis effects in the Netherlands are as relevant as in Germany and the United Kingdom.

According to hysteresis theory the situation on the labour market is history dependent and, therefore, very sensitive to shocks, so that some authors also speak of 'fragile equilibria'. In order to make employment equilibria fragile requires that we adduce considerations that either make labour supply potentially downward sloping or make labour demand upward sloping (see Blanchard and Summers (1988)). A relatively new approach to explaining equilibria with inefficiently low levels of employment has recently appeared in a number of papers (see Drazen (1987)). These (theoretical) papers study the existence of multiple equilibria in the level of economic activity, which opens the possibility that shocks may easily move an economy from one fragile equilibrium to another. Research on multiple equilibria actually suggests similar mechanisms as in the hysteresis theories discussed above. For example, there are multiple-equilibria models of the process of search and matching in the labour market (e.g. Diamond (1982)), where the possibility of making contact depends on the input by both sides of the market implying a sort of joint-production model for successful matches.

3. A synthesis model of wage formation

We base our discussion of wage formation with monopolistic competition in the goods market on Akerlof and Yellen (1985). In their efficiency-wage model there is a fixed number of identical
firms acting in a monopolistically competitive output market. Each firm sets its price and wage to maximize profits, under the assumption that changes in its own price will not affect the prices charged by rivals or the average price level. Accordingly, let the demand curve facing firm j be

\[ y_j = \left(\frac{p_j}{p}\right)^{-\theta} K_j \left(\frac{M}{p}\right), \quad \theta > 1 \]  

(13)

where \( y_j \) is output of firm j (as demanded by consumers), \( p_j \) is the price charged by firm j, \( p \) is the average price level, \( M \) is aggregate money supply, \( \theta \) is the elasticity of goods in utility and \( K_j \) is a constant. In long-run equilibrium all firms charge the same price so that the relation between aggregate output and aggregate money supply is consistent with a quantity theory (aggregate output is proportionate to aggregate real money supply).

The firm produces output according to the Cobb-Douglas production function:

\[ y_j = (e \cdot n)^{\alpha} k^{1-\alpha} \]  

(14)

where \( e \) is effort of workers hired, \( n \) is the number of hired workers, \( k \) is the capital stock and the parameter \( \alpha \) lies between zero and one (note that the subscript j is not used for the variables \( e, n \) and \( k \)). Effort \( e \) is assumed to depend on the real wage paid \( \omega_j \) (\( = \frac{w_j}{p} \)) according to the function \( e = e(\omega_j) \). \( e(\omega_j) \) is assumed to be a function whose elasticity with respect to \( \omega_j \) is less than unity at high \( \omega_j \) and is greater than one at low \( \omega_j \). Thus, in contrast with the model of Akerlof and Yellen (1985), production now also depends on the level of the capital stock and allows for substitution.

Using the demand function and the production function we compute the profit function \( V_j \) of firm j. Profits are equal to the price times output sold minus the money wage (\( w_j \)) times labour hired:

\[ V_j = p_j \cdot \left(\frac{p_j}{p}\right)^{-\theta} K_j \left(\frac{M}{p}\right) - \left(\frac{w_j}{e}\right) \cdot \left(\frac{p_j}{p}\right)^{-\theta/\alpha} \left(\frac{K_j \cdot M}{p}\right)^{1/\alpha} k^{(\alpha-1)/\alpha} \]  

(15)

The firm chooses the price of its own output and the wage paid to its workers, so as to maximize profits. The first-order conditions for profit maximization then yield
\[
(p_j/p) = \left[\frac{(\omega_j/e)}{(\theta/(\theta-1)\alpha)} \cdot (K_1 \cdot M/p) \cdot (1-\alpha)/\alpha \right]^{\alpha/((\theta(1-\alpha)+\alpha)} \cdot K(\alpha-1)(1+\gamma)/\theta
\]

where \( \gamma = \alpha/(\theta-1)/(\theta(1-\alpha)+\alpha) > 0 \), and:

\[
e_{\omega_j} = 1
\]

Eq. (16) states that the firm decides on its relative price \( p_j/p \) by setting some kind of a mark up on the real unit cost \( \omega_j/e \) of a labour efficiency unit. From (16) we may derive the number of hired workers:

\[
n = K_2 \cdot e^{\gamma \cdot \omega_j} \cdot (M/p) \cdot ((1-\alpha)(1+\gamma)+1)/\alpha \cdot K(1-\alpha)(1+\gamma)/(\theta-1)/\theta
\]

where \( K_2 \) is a constant that depends on \( K_1, \alpha \) and \( \theta \). Eq. (17) again represents the Solow condition. Let \( \omega^* \) denote the optimizing level of the real wage in eq. (17), i.e. the efficiency wage. Then, in long-run equilibrium, when all firms charge the same price (\( p_j = p \) for all \( j \)), the price level is given by

\[
p = \left\{\left(\frac{\omega^*/e(\omega^*)}{\theta/(\theta-1)\alpha}\right)^{\alpha/(\theta(1-\alpha)+\alpha)} \cdot K_1 \cdot M/k\right\}
\]

Consequently, it is in the interest of the firm to pin the real wage to its efficiency-wage level (real wage rigidity) and to decide on its price accordingly.

Now, the assumption that the firm also sets the wage will be altered. In order to incorporate persistence we have to allow for some influence of workers on wage formation. It is plausible then to extend the model by introducing a union that looks after the interests of the workers and negotiates with the firm on the wage level. Subsequently, the outcome of this bargaining process is taken as given by the firm in the determination of its price. Thus, the fundamental idea is that wages are bargained ex-ante, but prices, output and employment are set by the firm ex-post.

We assume that the union is concerned only with the insiders who are \( n_i \) in number. Then the union operates with a utility function which is a representation of the interests of insiders. This function is supposed to depend on renumeration and the employment probability for insiders. Of course, the introduction of such a
probability only makes sense when we assume that goods demand is stochastic, so that eq. (13) has to be multiplied by a random variable. Accordingly, also employment in eq. (18) has to be multiplied by such a random variable. To keep things simple, we suppose that both random factors have a uniform distribution with mean one, where the latter is distributed across the range \([1-r, 1+r]\). Let us define union utility in a simple way as (see Nickell and Wadhani (1988))

\[
p^{\text{un}}(w_j/p) + (1-p^{\text{un}})x
\]

where \(p^{\text{un}}\) is the probability of employment for insiders and \(x\) is the expected level of earnings if the worker is laid off as given by eq. (5). The layoff probability for insiders \(1-p^{\text{un}}\) is equal to the probability that \(n<n^T\) times the average probability of layoff conditional on this event (where \(E[n]\) represents the mathematical expectation of \(n\)):

\[
1-p^{\text{un}} = \text{Prob}(n<n^T)\left[1 - \frac{E[n \mid n<n^T]}{n^T}\right]
\]

We suppose that the outcome of the bargaining process is based on the Nash model, so that we have to establish the proper status-quo points that each side of the bargain would achieve if bargaining breaks down (see Binmore, Rubinstein and Wolinsky (1986)). In the union case this is \(x\), since the insiders can always attain this level of earnings outside the firm. For the firm case we assume that there are no fixed costs of production, so that its status-quo point is zero\(^1\). Thus the Nash objective to be maximized is (for given \(p\) and \(x\))

\[
p^{\text{un}}(w_j/p - x)(E[V_j])^\beta
\]

where the firm is concerned with expected profits and the exponent \(\beta (>0)\) is an indicator of the firm's (relative) bargaining power. The first-order condition for (22) reduces to

\[
w_j/(v_j-(p.x)) = -\beta(w_j/V_j)(\partial V_j/\partial w_j) - (w_j/p^{\text{un}})(\partial p^{\text{un}}/\partial w_j)
\]

At the RHS of eq. (23) we find the wage elasticity of the firm's profits and the wage elasticity of insiders' employment probability. The lower is \(\beta\), the more important is the latter elasti-
city. Moreover, the negotiated money wage is decreasing in $\beta$ if the wage elasticity of the firm's profits is negative\(^1\).

Analogous to the derivation by Nickell and Wadhwani (1988), it can be shown that

\begin{equation}
\frac{w_j}{V_j} \cdot \frac{\partial V_j}{\partial w_j} = -\gamma (1 - \omega_j e / e) \tag{24}
\end{equation}

and

\begin{equation}
\frac{\omega_j}{p^*} \cdot \frac{\partial p^*}{\partial w_j} = - \frac{[\mu^2 - (1 - \tau)^2]}{4\mu - (\mu - (1 - \tau))} \left[ (1 + \gamma) - \gamma \omega_j e / e \right] \tag{25}
\end{equation}

where $\mu = n^* \hat{n}$, with $\hat{n}$ mean employment ex-post. So that the elasticity of effort with respect to the wage appears in both equations. Substitution of eq. (24) and (25) in (23) now gives

\begin{equation}
\frac{\omega_j}{p^*} = \beta \gamma (1 - \omega_j e / e) + \frac{[\mu^2 - (1 - \tau)^2]}{4\mu - (\mu - (1 - \tau))} \left[ (1 + \gamma) - \gamma \omega_j e / e \right] \tag{26}
\end{equation}

Eq. (26) completes the model and represents a combination of both the efficiency-wage and the insider-outsider model of wage formation. Clearly, the Solow condition plays an important role. E.g. if the real wage is lower than the efficiency wage, so that $1 - \omega_j e / e < 0$, then the negotiated money wage is increasing in $\beta$, while it is decreasing in $\beta$ for real wages higher than the efficiency wage. Consequently, the firm tries to bargain the money wage towards the level $p^* \omega^*$. On the other hand, the union tries to earn rents on behalf of the insiders in the firm. This endeavour is facilitated by the fact that wage increases lead to less than proportionate increases of labour costs, because of the efficiency-wage relationship. (Moreover, small shocks in aggregate demand have only second-order effects on the firm's profits).

In order to clarify the role of insiders, we have to find some expression for $\mu$. Note that the combination of eq. (13) and (14) gives

\begin{equation}
p = p_j \cdot (K_j \cdot M / p)^{-1 / \theta} \cdot (e, n) \frac{a / \theta}{K} \cdot (1 - \alpha) / \theta \tag{27}
\end{equation}

Substituting this equation in (18), we obtain after some manipulations (for given $p$)

\begin{equation}
\mu = n^* \hat{n} = K_j \cdot (w_j / (e, p_j))^{1 / (1 - \alpha)} \cdot (n^* / k) \tag{28}
\end{equation}
where \( K_3 \) is a constant that depends on the parameters. Thus, besides the more familiar factors as wages and prices, wage formation is also determined by the ratio between the number of insiders and the available capital stock. If we log-linearise (26), making use of (5), (28) and substituting the function \( e(\omega_j) \), we arrive at an expression for \( \omega_j \), as a function of \( w, p, U, \rho \) and the ratio of insiders and the level of the capital stock.

Then \( U \) appears in the wage equation as a consequence of the specification of union utility instead of being a result of efficiency-wage considerations. In long-run equilibrium when all firms charge the same price \( p \) and pay the same wage \( w \), we may solve for the equilibrium rate of unemployment by using the price rule (eq. (16)), the wage equation (eq. (26)) and the labour demand equation (eq. (18)) accompanied by some assumption concerning labour supply.

It is clear that with eq. (26) duration theory has receded somewhat into the background. However, section 2.2 illustrates that insider-outsider and duration theory are closely related, since duration theory describes how workers may become outsiders. Moreover, it is fairly straightforward to introduce duration elements in the present model. For example, by assuming that the union takes account of short-term unemployment in its utility function instead of total unemployment.

4. Simulations with a macroeconomic model under perfect foresight

In this section we show the consequences of incorporating efficiency wages and insiders' influence on wage formation in a macroeconomic model with quantity rationing. We implement these features in the intertemporal disequilibrium model presented by Van de Klundert and Peters (1988). This model is very similar to that of Meydam (1987), but it ignores the possibility of a repressed inflation regime with excess demand on both the labour and the goods market, so that the problematic switch between the Keynesian unemployment and the repressed inflation regime is excluded. The remaining regimes are both characterized by unemployment (classical or Keynesian) which represents our main
line of interest. Both former models may be considered as a further development of the model presented by Blanchard and Sachs (1982).

Van de Klundert and Peters (KP) apply virtually the same specification of monopolistically competitive behaviour of the (representative) firm in the goods market as given by eq. (13) in section 3. However, in their model also attention is given to the dynamics generated by investment and price adjustment. We now discuss the various equations in this model and indicate where changes with respect to the previous KP-model are implemented.

Capital accumulation is assumed to depend on gross investment, \( i_j \), and depreciation at an exponential rate \( \delta \):

\[
k_j = i_j - \delta k_j, \quad \delta > 0
\]

In order to derive a well-behaved investment function (with investment increasing in the shadow price of installed capital or Tobin's \( q \)), installation costs of capital are introduced. The investment expenditure function including these costs is specified as

\[
g_j = g(i_j, k_j), \quad \delta_i > 0, \quad \delta_k < 0, \quad \delta_{i_k} > 0
\]

The function \( g \) is assumed to be convex in \( i_j \) and homogeneous of degree 1 in its arguments \( i_j \) and \( k_j \).

The adjustment of prices is assumed to be costly and speed-dependent, as customers prefer small and recurrent price changes to larger but more sudden changes. The (quadratic) cost of adjustment function is then given by

\[
h_j = \frac{1}{2\psi_j} s_j^2
\]

where \( s_j = p_j/p \) with \( p_j = dp_j/dt \), and \( \psi_j \) is a parameter.

In order to allow for efficiency wages the production function in the KP-model is amended and written as

\[
y_j = f(e_j, n_j, k_j)
\]

so that production is a function of capital and labour in efficiency units, where also a more general specification is added for the effort function \( e_j \):
\[ e_j = \omega_j(U), \quad \omega, \omega', \omega'' > 0, \quad (33) \]

so that effort also depends on the unemployment rate. We assume that for any \( U \in (0, 1) \) there is an efficiency wage \( \omega_j^*(U) \).

Denoting the discount factor by

\[ d(t) = \exp(-\int_0^t R_s ds), \quad (34) \]

the value of the firm (at the average price level) which is to be maximized is

\[ V_j(0) = \int_0^\infty \left[ y_j(t) \frac{d_y(t)}{p(t)} - n_j(t) \frac{g_j(t)}{p(t)} - \delta_j(t) - h_j(t) \right] d(t) dt \quad (35) \]

Decisions made by the representative firm with regard to its product price and employment level are supposed to have only a negligible effect on their aggregate counterparts. Since the nominal wage \( w_j \) is given to the firm from the bargaining process with the local union, the effort level of its workers is also given to the firm.

The firm now maximizes \( V_j \) subject to the constraints given by eq. (29), (30), (31), (32) and a possible demand constraint as visualized by eq. (13). We assume that the supply of labour is infinitely elastic, so that the firm cannot be rationed on its labour demand (and the regime of repressed inflation is excluded). The firm's model resembles an optimal control problem with instrument variables \( n_j, i_j, e_j \) and state variables \( k_j \) and \( p_j \). The Hamiltonian of this problem is

\[ H_j = \frac{d}{dt} \left[ y_j \frac{d_y}{p} - n_j \frac{w_i}{p} - g(i_j, k_j) - \frac{1}{2} s_j^2 + q_j(i_j - \delta k_j) \right] + u_j s_j + \lambda_j (K_j(p_j/p)^{-\theta} - f(e_j, n_j, k_j)) \quad (36) \]

where the costate variables \( q_j \) and \( u_j/p \) are adjoint to the state variables \( k_j \) and \( p_j \). \( K_j \) represents \( K_j(M/p) \) from eq. (13), while \( \lambda_j \) is the Lagrangean multiplier related to the demand constraint that is to be interpreted as a shadow price.

Apart from the production technology with a variable effort level, the model is similar to that of the KP-model. This
alternative production technology has only minor consequences for the specification of the model equations, since the effort level is given to the firm, so that for derivations we refer to the KP-article. Given the paths of \( w_j, p, \) the nominal rate of interest \( R \) and initial values \( k_j(0) \) and \( p_j(0) \), the model gives a solution for \( y_j, n_j, k_j, i_j, p_j, q_j, u_j \) and \( \lambda_j \) for \( t>0 \).

In order to arrive at the formulation of a macroeconomic model, we assume that demand elasticities are uniform across firms. It can be shown that eq. (13) then changes in

\[
y_j = \left( \frac{y}{N} \right) \left( \frac{p_j}{p} \right)^{-\theta}, \quad j=1,\ldots,N \tag{37}
\]

where \( N \) denotes the number of firms in the economy. The average price level is then represented by the following index of firms' prices:

\[
p = \left[ \frac{1}{(1/N) \cdot \sum_{j=1}^{N} p_j^{1-\theta}} \right]^{1/(1-\theta)} \tag{38}
\]

The demand system defined by eq. (37) and (38) is consistent with maximization of the consumers' utility function \( UT \):

\[
UT = \sum_{j=1}^{N} \frac{y_j^{1/(1-\theta)}}{\theta} \tag{39}
\]

subject to the expenditure constraint

\[
\sum_{j=1}^{N} p_j y_j = py \tag{40}
\]

In the (macroeconomic) Nash equilibrium all firms choose the same price: \( p_j = p \) for all \( j \). The individual firm's model can then be generalized to the macroeconomic level, where total demand equals the sum of aggregate investment expenditure and aggregate consumption.

To simplify, consumer behaviour in the KP-model is not modelled consistent with eq. (39), instead a standard consumption function is used:

\[
c = c(y, R, \Omega), \quad c_y > 0, \ c_R \leq 0, \ c_{\Omega} > 0 \tag{41}
\]

where \( \Omega \) symbolizes real wealth: \( k^{+}(M/p) \).
Whereas the supply of money \( (M) \) is exogenous, the demand for money follows from the standard specification:

\[
\frac{(M/p)}{\theta} = m(y,R,n), \quad \pi > 0, \quad \pi < 0, \quad \pi \geq 0
\]  

(42)

The macroeconomic model is complete, when also wage behaviour is described. Van de Klundert and Peters use a traditional Phillips-curve equation, in which the nominal wage rate responds to excess demand in the market for labour over time. Of course, the bargaining process as given in eq. (26) is essentially different from wage behaviour represented by a Phillips curve. We apply a wage equation that is in the spirit of eq. (26).

It is not possible to simply adopt the complete specification of eq. (26) in the present macroeconomic model. First of all, the fact that the latter is a perfect foresight model interferes with the stochastic element which underlies the derivation of eq. (26), especially the factor that depends on \( \mu \) and \( \pi \). Secondly, the nominal wage rate given by eq. (26) is based on a one period model. Consequently, in the intertemporal setting of firm behaviour, wage behaviour does abstract from the fact that today's decisions affect tomorrow's outcomes and may therefore be considered as myopic. Thirdly, if one prefers to hold the real wage within a close range of its efficient level, eq. (26) gives rise to huge unemployment rates, especially when effort does not depend on unemployment, or very large values for \( \beta \) and \( \gamma \), which seems rather unrealistic. A related aspect is the aggregation of firms. Eq. (26) is actually based on the bargaining process on the individual firm level between the firm's management and the local union representing the firm's insiders. Thus, if we apply eq. (26) in a macroeconomic model with \( w_j = w \), then we implicitly assume that bargaining takes place at the central level. An interesting result in this respect is the conclusion of Hoel (1988) that in the presence of efficiency wage considerations, provided the labour demand elasticity is not too much larger than one, local wage bargaining gives a higher negotiated wage than central wage bargaining, resulting in higher unemployment.

With the foregoing problems in mind, we postulate a wage equation which retains the main characteristics of and is derivable from eq. (26). These characteristics are: a) the firm trying to nego-
tiate the wage towards its efficient level; b) the union securing employment for its members at the highest possible wage. We may then write the negotiated wage \( w^* \) as a weighted average of the (nominal) efficiency wage \( (w^* - w^*) p \) as preferred by the firm and the union's target wage \( w^u \), with the weights depending on relative bargaining strength:

\[
\frac{w^u}{t} = \beta_1 w^* + \beta_2 w^u, \quad \beta_1 + \beta_2 = 1
\]

(43)

Assuming that the actual wage is continuously adapted to the outcome of wage negotiations, a specification for a wage equation is given by

\[
\dot{w} = \beta_1 (w^* - w) + \beta_2 (w^u - w)
\]

(44)

where \( \dot{w} = dw/dt \). We assume that the difference between the union's target wage and the actual wage is proportionate to the difference between the actual employment level and the number of insiders, and write (44) as

\[
\dot{w} = \beta_1 (w^* - w) + \beta_2 w(n - n^i)
\]

(45)

The latter assumption is mainly justified on grounds of the union's endeavour to maintain insiders' employment. If total labour in efficiency units \( e.n \) is taken as given by the union, it may compute the desired wage rate in order to equalize the number of hired workers and the number of insiders by (for given \( p \) and \( u \))

\[
\frac{n - n^i}{n} = \left[ \frac{w^u - w}{w} \right] \cdot (\omega/e) \cdot (\delta e/\delta \omega)
\]

(46)

Thus, \( w(n - n^i) \) may be regarded as an approximation of \( (w^u - w) \), when \( n=1 \) and the real wage lies close to the efficiency wage, so that the (partial) elasticity of effort with respect to the real wage is close to one. Consequently, union behaviour has a positive effect on the wage rate whenever the employment level rises above the number of insiders and a negative effect whenever employment falls below insiders' employment.
Because of the influence of insiders on wage behaviour, the wage equation has to be supplemented by some membership rule. We will assume here that the number of insiders follows the level of employment so that:

\[ n^1 = \nu(n-n^1), \quad 0 \leq \nu \leq 1 \quad (47) \]

The full macroeconomic model is now written in table 1. The equations (a)–(o) in table 1 are identical to the equations in the KP-model except for the functions \( f(.) \) and \( \varepsilon(.) \), while the eq. (p) and (q) are different.

It is clear that two regimes are possible, depending on the values of the exogenous variables and the parameters of the model. When \( \lambda = 0 \), consumers are rationed, because labour is too expensive to produce according to demand. Then, demand is not binding and firms equate the marginal product of labour with the real wage. Under these circumstances, the economy is in the classical regime. When \( \lambda > 0 \), the demand constraint is binding, so that aggregate demand determines what can be supplied. In this case the Keynesian regime prevails.

In a stationary state we have: \( k=q=p=u=w=n^1=0 \). Substituting these conditions in the model equations of table 2 gives the following long-run solutions: \( u^* = 0, \quad \lambda^* = 1, \quad n^1 = n^*, \quad i^* = \delta k^* \). Apparently, in the long run the demand constraint is always binding, so that the stationary state is characterized by Keynesian unemployment.

In order to study the short-run impact of changes in exogenous variables and the adjustment process towards a new long-run equilibrium, we apply the method of multiple shooting as explained in Lipton, Poterba, Sachs and Summers (1982). This method generates a path from the initial stationary state to the new stationary state, which is consistent with the dynamic properties of the model. An essential assumption here is that of saddlepoint stability, i.e. the number of eigenvalues with a positive real part must be equal to the number of non-predetermined state variables in the system (\( q \) and \( u \)). This saddlepoint property has been checked for all our numerical simulations given below.
Table 1: The full macroeconomic model (or amended KP-model)

(a) \( y^d = c^d + g(i,k) \) effective demand
(b) \( n^d = n^d(y^d,k) \) Keynesian demand for labour
(c) \( n^v = n^v(w/p,k) \) demand for labour in case of rationing in the goods market
(d) \( y^v = f(e.n^v,k) \) output in case of rationing in the goods market
(e) \( y = \min(y^d,y^v) \) actual output
(f) \( n = \min(n^d,n^v) \) actual employment
(g) \( c^d = c^d(y,R,k) \) consumption function
(h) \( g_k(i,k) = q \) investment function
(i) \( M/p = m(y,R) \) LM curve
(j) \( \lambda = \max \left[ 0, \Theta(1 - \frac{w}{p_f(e.n^d,k)}) \right] \) shadow price of the sales constraint
(k) \( c = c^d - (y^d - y) \) rationing rule for consumption
(l) \( k = i - \delta k \) capital accumulation
(m) \( q = (R+\delta)q - (1 - \frac{\lambda}{\Theta})f_k(e.n,k) + g_k(i,k) \) costate variable for \( k \)
(n) \( p = \psi w \) price formation
(o) \( u = (R + (p/p))u - (1 - \lambda)y \) costate variable for \( p \)
(p) \( w = \beta_1(w^* - w) + \beta_2w(n - n^1) \) wage formation
(q) \( n^1 = \nu(n - n^1) \) membership rule

Where the following specifications are applied:

\( c^d = Ty \) consumption function
\( f(e.n,k) = e(e.n)^{\alpha}k^{1-\alpha} \) production function
\( e = a + b(U^o/(1-U^o))^{\sigma} \) effort function (with outsiders unemployment)
\( g = i[1 + \Theta(i/k)] \) investment expenditure function
\( M/p = \chi y R^{-\zeta} \) liquidity preference function
The parameter values for our macroeconomic model are listed in table 2. These values have been chosen equal to the ones used by Van de Klundert and Peters (1988) and may be considered as fairly realistic (for a country like the Netherlands during the mid-eighties). The parameters \(a, b, r\) and \(\sigma\), all referring to the efficiency-wage relationship (see table 1), were set at such values that the initial stationary state is similar to the one in the KP-model with respect to both nominal \((R, p, w)\) and real variables \((k, n, y, c, i)\). The latter parameters are not claimed to be realistic. In the case of \(\sigma\), Weinrich (1988) uses a somewhat smaller order of magnitude. The parameters \(\beta_1\) and \(\beta_2\) which represent bargaining strength have a similar arbitrary nature.

Our model also exhibits an equilibrium unemployment rate, as effort also depends on unemployment. Equilibrium unemployment is equal to 14% of the labour force and \(n^*\) was fixed accordingly. The assumption was made here that effort depends on the unemployment rate of outsiders instead of the actual unemployment rate. This may be justified by taking into consideration that workers will be less afraid of unemployment as long as they remain insiders, since the union will try to protect insiders' employment. The denomination 'unemployment rate of outsiders' is not very precise, because outsiders are not necessarily unemployed, whereas insiders may also be unemployed (\(\nu<1\)). If insiders are

<table>
<thead>
<tr>
<th>Table 2. Parameter values used in computations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters:</td>
</tr>
<tr>
<td>(a = 0.625)</td>
</tr>
<tr>
<td>(\delta = 0.1)</td>
</tr>
<tr>
<td>(\theta = 5)</td>
</tr>
<tr>
<td>(\chi = 0.25)</td>
</tr>
<tr>
<td>(a = -4.0)</td>
</tr>
<tr>
<td>(\sigma = 0.125)</td>
</tr>
<tr>
<td>(\epsilon = 1)</td>
</tr>
<tr>
<td>(\beta_1 = 0.5)</td>
</tr>
<tr>
<td>(\xi = 0.15)</td>
</tr>
<tr>
<td>(\zeta = 0.15)</td>
</tr>
<tr>
<td>(\theta = 5)</td>
</tr>
<tr>
<td>(\psi = 0.1)</td>
</tr>
<tr>
<td>(b = 6.6919301)</td>
</tr>
<tr>
<td>(r = 0.2)</td>
</tr>
<tr>
<td>(\nu = 0.33)</td>
</tr>
<tr>
<td>(\beta_2 = 0.5)</td>
</tr>
<tr>
<td>Values of exogenous variables:</td>
</tr>
<tr>
<td>(n^* = 1.1627906)</td>
</tr>
<tr>
<td>(M = 100)</td>
</tr>
</tbody>
</table>
laid off, a number of them may be considered as temporarily unemployed, since they are perceived to be put to work in due time. On the other hand, outsiders that have found a job, are not readily accepted as insiders, because their employment may be regarded as transitory. Therefore, $U^o$ is actually equal to the percentage of outsiders in the labour force. In fact, $U^o$ functions as a contemporaneous equilibrium unemployment rate (see section 2.2).

The results for a once and for all 5 per cent decrease in the money stock ($M$) at $t=0$ are presented in table 3, both for our model as well as for the Van de Klundert and Peters model (KP-model). Clearly, money is not neutral in the short run if price changes are costly. However, whereas the resulting price rigidity causes a recession with a substantial decline in output and employment in the KP-model, this recession is at the outset much milder in our model and transforms into a prolonged cyclical movement towards the new stationary state. This cyclic behaviour is reminiscent of Weinrich (1988). He also used a model based on monopolistic competition and labour effort depending on the real wage and the unemployment rate. Like in our model, a demand shock urges firms to adjust output and employment. But as the unemployment rate changes, the efficiency wage changes too. This causes firms to adjust their nominal wages and prices and, accordingly, to revise their labour and production decisions. Weinrich showed that the resulting dynamics is typified by counterclockwise movements in the output-inflation-plane. He concluded that size and length of these movements depend on the elasticity of effort with respect to the unemployment rate, so that the relatively high value of $\sigma$, may account for the strong cyclicity of our model.

Nominal wage behaviour in the KP-model is simply governed by unemployment and only indirectly influenced by price changes. In our model, nominal wage changes reflect the outcome of a continuous bargaining process between employers and union with a more complicated background. Employers want to adjust the nominal wage in order to reach the efficient real wage, while the union tries to insure employment of insiders and to enforce favourable wage settlements, which may intensify cyclical movements. It is
Table 3. A 5 per cent decrease in money

3a. Results for the model of table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>consumption</td>
<td>-1.3</td>
<td>1.4</td>
<td>2.8</td>
<td>1.1</td>
<td>-1.3</td>
<td>-0.9</td>
<td>0</td>
</tr>
<tr>
<td>investment</td>
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<td>1.1</td>
<td>2.2</td>
<td>0.9</td>
<td>-1.0</td>
<td>-0.6</td>
<td>0</td>
</tr>
<tr>
<td>output</td>
<td>-1.3</td>
<td>1.4</td>
<td>2.8</td>
<td>1.1</td>
<td>-1.3</td>
<td>-0.9</td>
<td>0</td>
</tr>
<tr>
<td>employment</td>
<td>-2.1</td>
<td>-2.3</td>
<td>-1.7</td>
<td>0.8</td>
<td>-0.1</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>interest</td>
<td>29.0</td>
<td>17.6</td>
<td>4.0</td>
<td>-17.8</td>
<td>11.4</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td>( \lambda^b )</td>
<td>1.03</td>
<td>1.08</td>
<td>1.11</td>
<td>1.07</td>
<td>0.92</td>
<td>0.96</td>
<td>1</td>
</tr>
<tr>
<td>capital</td>
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<td>0.0</td>
<td>0.2</td>
<td>0.6</td>
<td>0.1</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Tobin's q</td>
<td>-0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.2</td>
<td>-0.5</td>
<td>-0.4</td>
<td>0</td>
</tr>
<tr>
<td>price</td>
<td>0.0</td>
<td>-4.0</td>
<td>-7.1</td>
<td>-8.7</td>
<td>-2.2</td>
<td>-4.0</td>
<td>-5</td>
</tr>
<tr>
<td>( u^b )</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.3</td>
<td>0.1</td>
<td>-0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>wage rate</td>
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<td>-2.3</td>
<td>-5.5</td>
<td>-10.2</td>
<td>-1.4</td>
<td>-4.3</td>
<td>-5</td>
</tr>
<tr>
<td>insiders</td>
<td>0.0</td>
<td>-0.6</td>
<td>-1.0</td>
<td>-0.5</td>
<td>0.6</td>
<td>0.3</td>
<td>0</td>
</tr>
</tbody>
</table>

3b. Results for the KP-model

<table>
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<tr>
<th>Variable</th>
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<th>2</th>
<th>5</th>
<th>10</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>consumption</td>
<td>-4.1</td>
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<td>-1.4</td>
<td>-0.3</td>
<td>-0.1</td>
<td>0</td>
</tr>
<tr>
<td>investment</td>
<td>-3.1</td>
<td>-1.9</td>
<td>-1.1</td>
<td>-0.3</td>
<td>-0.2</td>
<td>0</td>
</tr>
<tr>
<td>output</td>
<td>-4.1</td>
<td>-2.4</td>
<td>-1.4</td>
<td>-0.3</td>
<td>-0.1</td>
<td>0</td>
</tr>
<tr>
<td>employment</td>
<td>-6.5</td>
<td>-3.7</td>
<td>-2.0</td>
<td>-0.2</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>interest</td>
<td>6.4</td>
<td>4.0</td>
<td>2.7</td>
<td>0.8</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td>( \lambda^b )</td>
<td>1.10</td>
<td>1.07</td>
<td>1.05</td>
<td>1.01</td>
<td>1.00</td>
<td>1</td>
</tr>
<tr>
<td>capital</td>
<td>0.0</td>
<td>-0.2</td>
<td>-0.4</td>
<td>-0.4</td>
<td>-0.3</td>
<td>0</td>
</tr>
<tr>
<td>Tobin's q</td>
<td>-1.6</td>
<td>-0.8</td>
<td>-0.4</td>
<td>0.1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>price</td>
<td>0.0</td>
<td>-2.0</td>
<td>-3.3</td>
<td>-4.7</td>
<td>-4.8</td>
<td>-5</td>
</tr>
<tr>
<td>( u^b )</td>
<td>-0.3</td>
<td>-0.2</td>
<td>-0.1</td>
<td>-0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>wage rate</td>
<td>0.0</td>
<td>-2.5</td>
<td>-3.8</td>
<td>-5.0</td>
<td>-5.0</td>
<td>-5</td>
</tr>
</tbody>
</table>

a. In percentage deviations from the original stationary state.
b. In levels (\( \lambda \) and \( u \) are shadow prices).
therefore not surprising to see a rising real wage in period 1 and 2 in our model, while it is falling in the KP-model. The rise of the nominal interest rate when the shock occurs (29%), may appear relatively large. However, it only amounts to about one percentage point (see the appendix). The results for a supply shock are listed in table 4. This shock is in the form of a permanent decline in total factor productivity (\(\epsilon\)) of 5 per cent at \(t=0\). Then in both models, output and the capital stock decrease at the same rate in the long run. However, in our model also employment falls in the long run. Again, in our model, there is cyclic convergence towards the new stationary state. With respect to output the initial decline is larger in our model than in the KP-model, because of a more severe reduction of profitability due to the fall in productivity. Therefore, the initial rise of employment is much lower in our model. Clearly, our model is in the long run more sensitive to a supply shock. The adjustment process lasts for some time in both cases. Just as in the KP-model the demand constraint is less binding \((\lambda<1)\) during the first few periods, because supply is depressed by the cost increase. As \(\lambda\) is positive, firms produce what can be sold in both models. In the model with efficiency wages and insiders' influence the process of adjustment is generally more prolonged. However, there is no hysteresis in the unemployment rate. Unemployment just cyclically converges towards its new equilibrium rate. When, for example, the firms would have no influence on wage bargaining \((\beta_x=0)\), there would be a zero root in the dynamic system of our model, so that hysteresis would be the case. It is interesting to note that the results for our model are in several ways qualitatively different from those for the KP-model. Nevertheless, both models are largely similar with respect to their dominance of the Keynesian regime.

5. Conclusions

In this paper we have outlined some major theories which account for the existence of (real) wage rigidity and the persistence of
### Table 4. A 5 per cent decrease in productivity

#### 4a. Results for the model of table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>consumption</td>
<td>-4.9</td>
<td>-7.3</td>
<td>-8.2</td>
<td>-6.3</td>
<td>-6.8</td>
<td>-7.5</td>
<td>-9.7</td>
</tr>
<tr>
<td>investment</td>
<td>-3.7</td>
<td>-5.6</td>
<td>-6.5</td>
<td>-5.3</td>
<td>-5.9</td>
<td>-7.0</td>
<td>-9.7</td>
</tr>
<tr>
<td>output</td>
<td>-4.9</td>
<td>-7.3</td>
<td>-8.2</td>
<td>-6.3</td>
<td>-6.8</td>
<td>-7.5</td>
<td>-9.7</td>
</tr>
<tr>
<td>employment</td>
<td>0.2</td>
<td>0.1</td>
<td>-0.1</td>
<td>-2.9</td>
<td>-0.9</td>
<td>-1.8</td>
<td>-1.9</td>
</tr>
<tr>
<td>interest</td>
<td>-28.2</td>
<td>-16.8</td>
<td>-5.2</td>
<td>4.4</td>
<td>-18.9</td>
<td>-8.3</td>
<td>0</td>
</tr>
<tr>
<td>(\lambda^b)</td>
<td>0.79</td>
<td>0.81</td>
<td>0.82</td>
<td>0.97</td>
<td>1.04</td>
<td>1.03</td>
<td>1</td>
</tr>
<tr>
<td>capital</td>
<td>0</td>
<td>-0.5</td>
<td>-1.0</td>
<td>-2.3</td>
<td>-3.4</td>
<td>-5.8</td>
<td>-9.7</td>
</tr>
<tr>
<td>Tobin’s q</td>
<td>-1.8</td>
<td>-2.6</td>
<td>-2.8</td>
<td>-1.5</td>
<td>-1.3</td>
<td>-0.7</td>
<td>0</td>
</tr>
<tr>
<td>price</td>
<td>0</td>
<td>4.9</td>
<td>8.1</td>
<td>7.4</td>
<td>3.9</td>
<td>6.7</td>
<td>10.7</td>
</tr>
<tr>
<td>(u^b)</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
<td>-0.2</td>
<td>0.1</td>
<td>-0.0</td>
<td>0</td>
</tr>
<tr>
<td>wage rate</td>
<td>0</td>
<td>1.3</td>
<td>3.8</td>
<td>4.3</td>
<td>-3.3</td>
<td>-0.3</td>
<td>2.0</td>
</tr>
<tr>
<td>insiders</td>
<td>0</td>
<td>0.1</td>
<td>0.1</td>
<td>-1.2</td>
<td>-1.7</td>
<td>-1.9</td>
<td>-1.9</td>
</tr>
</tbody>
</table>

#### 4b. Results for the KP-model

<table>
<thead>
<tr>
<th>Variable</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>consumption</td>
<td>-2.7</td>
<td>-4.8</td>
<td>-5.7</td>
<td>-6.0</td>
<td>-6.1</td>
<td>-7.9</td>
</tr>
<tr>
<td>investment</td>
<td>-2.0</td>
<td>-3.7</td>
<td>-4.5</td>
<td>-5.0</td>
<td>-5.4</td>
<td>-7.9</td>
</tr>
<tr>
<td>output</td>
<td>-2.7</td>
<td>-4.8</td>
<td>-5.7</td>
<td>-6.0</td>
<td>-6.1</td>
<td>-7.9</td>
</tr>
<tr>
<td>employment</td>
<td>4.0</td>
<td>0.6</td>
<td>-0.7</td>
<td>-0.7</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>interest</td>
<td>-16.5</td>
<td>-12.3</td>
<td>-10.1</td>
<td>-7.7</td>
<td>-6.7</td>
<td>0</td>
</tr>
<tr>
<td>(\lambda^b)</td>
<td>0.73</td>
<td>0.86</td>
<td>0.93</td>
<td>1.00</td>
<td>1.00</td>
<td>1</td>
</tr>
<tr>
<td>capital</td>
<td>0</td>
<td>-0.3</td>
<td>-0.7</td>
<td>-1.7</td>
<td>-3.1</td>
<td>-7.9</td>
</tr>
<tr>
<td>Tobin’s q</td>
<td>-1.0</td>
<td>-1.7</td>
<td>-1.9</td>
<td>-1.7</td>
<td>-1.2</td>
<td>0</td>
</tr>
<tr>
<td>price</td>
<td>0</td>
<td>3.0</td>
<td>4.3</td>
<td>5.1</td>
<td>5.4</td>
<td>8.6</td>
</tr>
<tr>
<td>(u^b)</td>
<td>0.4</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>wage rate</td>
<td>0</td>
<td>1.0</td>
<td>0.9</td>
<td>-0.5</td>
<td>-1.1</td>
<td>0</td>
</tr>
</tbody>
</table>

---

a. In percentage deviations from the original stationary state.
b. In levels (\(\lambda\) and \(u\) are shadow prices).
unemployment. Two of these theories, namely efficiency-wage and insider-outsider theory, were combined in one model based on monopolistic competition in the goods market and wage bargaining between the firm and the local union. Whereas the firm tries to bargain the nominal wage towards its efficient level, the union weighs higher wages for its members against the possibility of members being laid off.

This bargaining process was incorporated in a macroeconomic, intertemporal disequilibrium model. The effects of a demand and a supply shock in this model were compared with the adjustment process for a similar model in which wage behaviour was governed by the traditional Phillips curve.

Our main result is that, whereas the convergence process towards the new stationary state in the latter model is mainly monotonic, the adjustment process in the former model is generally much more prolonged and has cyclic features. The latter characteristic depends to a large extent on the elasticity of effort with respect to unemployment.

The combination of cyclical and prolonged adjustment appears to be more in accordance with recent labour market experience than adjustment behaviour in the KP-model. This leads us to conclude that both efficiency-wage and insider-outsider theory are important for macroeconomic modelling.

It should be emphasized that the model simulations serve to demonstrate important differences in adjustment behaviour and their actual relevance is rather limited. Only basic relationships are modelled, while the applied (constant) parameters should be determined empirically, because the values of the parameters greatly influence the dynamics of the model.

Further research is also needed in order to assess the importance of central relative to local wage bargaining. Since the efficiency-wage relation is basically a microeconomic concept, it should be examined whether unions prefer local wage bargaining when effort functions differ from industry to industry, and, accordingly, whether a macroeconomic effort function is relevant or not.

Clearly, the fact that the classical regime does not appear in our simulations, urges us to believe that there are still some important elements missing in the model. International compe-
tition is probably one of these elements, since, in a more competitive world with price inflexibility, an adverse supply shock (like a decrease in productivity) is likely to result in classical unemployment.
Stationary-state values up to four digits for the macroeconomic model in table 1 (denoted by a "*"):

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>consumption</td>
<td>$c^* = 0.9507$</td>
</tr>
<tr>
<td>investment</td>
<td>$i^* = 0.1584$</td>
</tr>
<tr>
<td>output</td>
<td>$y^* = 1.1884$</td>
</tr>
<tr>
<td>employment</td>
<td>$n^* = 1.0$</td>
</tr>
<tr>
<td>labour force (exogenous)</td>
<td>$n_s^* = 1.1627$</td>
</tr>
<tr>
<td>unemployment</td>
<td>$U^* = 0.14$</td>
</tr>
<tr>
<td>nominal interest rate</td>
<td>$R^* = 0.0375$</td>
</tr>
<tr>
<td>capital</td>
<td>$k^* = 1.5845$</td>
</tr>
<tr>
<td>Tobin's q</td>
<td>$q^* = 2.0$</td>
</tr>
<tr>
<td>output price</td>
<td>$p^* = 205.6844$</td>
</tr>
<tr>
<td>wage rate</td>
<td>$w^* = 122.2178$</td>
</tr>
<tr>
<td>number of insiders</td>
<td>$n_1^* = 1.0$</td>
</tr>
<tr>
<td>shadow price of the sales revenue</td>
<td>$\lambda^* = 1.0$</td>
</tr>
<tr>
<td>shadow price of a price increase</td>
<td>$u^* = 0.0$</td>
</tr>
</tbody>
</table>

These values are identical to the ones for the KP-model except for $n_s^*$ and $U^*$. $n_s^*$ is 1.0 and $U^*$ is 0.0 in the KP-model.
For a comparison of unemployment theories based on implicit contracts and efficiency wages we refer to Stiglitz (1986).

Stiglitz (1986) actually sums up five. He also mentions a nutritional variant.

In a recent study Wadhwani and Wall (1988) also present evidence for the efficiency-wage hypothesis based on micro-data. However, they use a somewhat different approach. They attempt to test the efficiency-wage model by examining some of its predictions for the determinants of a firm's productivity.

For an illustration we refer to Weinrich (1988).


Friedman (1968) gave the standard definition of the natural rate of unemployment as "the level that would be ground out by the Walrasian system of general equilibrium equations, provided there is imbedded in them the actual structural characteristics of the labour and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labour availabilities, the cost of mobility and so on."

For a more general formulation see Giavazzi and Wyplosz (1985) and Wyplosz (1987).

For this derivation we refer to Lindbeck and Snower (1988).


For a more detailed discussion of the Dutch wage equation making use of the cointegration technique see Graafland and Huizinga (1988).

This approach is related to that of Holt (1980) who discusses labour-market allocation both by wages and job availability.
12. $K_t$ is derived in Blanchard and Kiyotaki (1987) to depend on the number of firms and the parameter that describes the relative weights of goods consumption and real money balances in the consumers' utility function.

13. This assumption has no consequences for the derived bargaining outcome.

14. This can be seen by writing $w_j/(w_j - px) = f(\beta)$. Then $w_j = -f(\beta) \cdot px/(1 - f(\beta))$, so that:
$$
\frac{dw_j}{d\beta} = -f'(\beta) \cdot px/(1 - f(\beta))^2.
$$

15. In this section a variable $x$ with a "••" does not denote a relative change in $x$, but it represents $dx/dt$.

16. In fact, eq. (29) would suggest to use the specification $(dk/dt - dn^I/dt)$ instead of $(n-n^I)$. However numerical simulations give qualitatively similar results for this specification.

17. The roots in the case of a 5% decrease in the money stock are (where the first item in the vector is the real part and the second one denotes the imaginary part): $(0.67, 1.11)$, $(0.67, -1.11)$, $(-0.75, 0.0)$, $(-0.07, 0.55)$, $(-0.07, -0.55)$ and $(-0.05, 0.0)$; and in the case of a 5% decrease in productivity: $(0.60, 1.03)$, $(0.60, -1.03)$, $(-0.08, 0.55)$, $(-0.08, -0.55)$, $(-0.73, 0.0)$ and $(-0.04, 0.0)$. Thus, there are four roots with negative real parts and two roots with positive real parts.
LITERATURE


Burda, M.C., 1988, "Is There a Capital Shortage in Europe?", Weltwirtschaftliches Archiv, pp. 38-57.


---------, ---, and ---------, ---, 1988, "Long-Term Unemployment and


