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A Bankruptcy Constraint and Asymmetric Influence of the real Interest Rate on Unemployment

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A BANKRUPTCY CONSTRAINT AND ASYMMETRIC INFLUENCE OF THE REAL INTEREST RATE ON UNEMPLOYMENT

by

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ABSTRACT

In this paper, we consider a simple model of the firm based on the neoclassical presumptions and include a bankruptcy constraint. This inclusion implies a different reaction of unemployment to the interest rate. Whereas the neoclassical theory suggests a negative relation to reflect substitution between labor and capital when the interest rate is high, inclusion of the bankruptcy constraint implies a positive unemployment-interest rate relation, caused by the threat of bankruptcy when the interest rate, and thus interest payments on debt, is high. This gives rise to two employment regimes, one where the bankruptcy constraint is nonbinding and one where it is binding. An empirical cointegration model, based on quarterly data for the USA and the Netherlands, is specified, which is capable of representing these regimes. It appears that the interest rate is particularly influential when the bankruptcy constraint is binding, i.e., when the threat of bankruptcy is eminent.

AUTHOR'S NOTE

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1. INTRODUCTION

Employment and unemployment are usually studied in the context of the neoclassical theory. However, recent inquiries have shown that augmenting the usual neoclassical theory of the firm with a bankruptcy constraint can generate quite strong results, contradicting some of the results of the standard neoclassical theory. The standard neoclassical theory predicts a negative relation between unemployment and interest rate. A high interest rate implies that capital becomes more expensive and labour will be substituted for it, hence it increases employment.

However, inclusion of a bankruptcy constraint in the model gives rise to increasing interest costs, when interest rates increase. In its turn this increases the danger of bankruptcy. Farmer (1985) proves, in an implicit contract theory with asymmetric information and a bankruptcy constraint, that an interest rate increase leads to less efficient employment contracts and hence lower employment or more layoffs. Wadhwani (1987) also considers the threat of bankruptcy to have an important influence on labour demand of firms. He finds a negative relation between the interest rate and employment, which implies a positive relation between unemployment and interest rate. Finally, the managerial model of Baumol (1959), which includes a bankruptcy constraint, is shown to give a possible explanation for a positive unemployment-interest rate relation. Cf. Bierens and Broersma (1991).

In this paper, we introduce a simple model of the firm with a neoclassical objective function, which is subjected to a bankruptcy constraint. We derive an unemployment function that depends on the real
wage when there is no threat of bankruptcy. If the bankruptcy constraint becomes binding, it can be shown that the employment function depends on real wages, real output, real interest rate and debts of the firm. The cointegration method of Boswijk (1991) is applied to an empirical version of this model. Dummies based on the turning points of the composite index of leading indicators are used to represent the two employment regimes. Implications of our theoretical model cannot be rejected by this empirical model.

In section 2, we set out the theoretical model of the firm and we derive an unemployment equation. In section 3, we apply a seasonal unit root test in order to determine whether the time series we use contain (seasonal) unit roots. We also briefly discuss our cointegration method based on Boswijk (1991) and show the estimation and test results in section 4 and 5. Finally, section 6 contains some concluding remarks.

2. A MODEL OF UNEMPLOYMENT

We assume our representative firm to be a price taker and its price to be known. The firm has borrowed the amount $D$ to help finance the fixed amount of capital needed for production. The firm is required to pay $RD$ interest payments each period. We assume a standard production function $F(K, L, l)$, which depends on the predetermined capital stock $K$, employment $L$ and the labor effort rate $l$. The concept of labor effort implies that not only the actual amount of workers $L$ determines the level of output, but also their effort. Labor effort is a known concept from labor economics and psychology and is associated with motivation of the

We also assume that the firm faces a bankruptcy constraint. This implies that after wage and interest payments, the firm should be left with a sufficient amount of money to pay dividends to stockholders or to do necessary investments. The importance of the risk of bankruptcy in microeconomic models is also stressed by Stiglitz (1992).

The firm will choose its employment level \( L \) to maximize

\[
\pi = PF(K, L, l) - WL,
\]

where \( P \) is the price level and \( W \) the money wage rate, subject to the bankruptcy constraint

\[
PF(K, L, l) - WL - RD > \pi,
\]

where \( \pi \) is the minimum amount needed for dividends or investments.

We can now distinguish two regimes, one where (2) is not binding and one where it is binding. We call the first the good state of nature and the second the bad state of nature. This also implies two regimes for employment, \( L^* \) and \( L^{**} \). In the good state of nature, i.e., when (2) is satisfied, we have

\[
F_L = \frac{\partial F(K, L^*, l)}{\partial L} = \frac{W}{P} = w.
\]

This is the familiar neoclassical labor demand relation, where employment is determined by the real wage rate \( w \).
On the other hand, we can have a bad state of nature, i.e., (2) is not satisfied or

\[ PF(\bar{R}, L^*, l) - WL - RD < \bar{\pi}. \]

In this case the firm has to reorganize to avoid bankruptcy and employment \( L^{**} \), will be such that labor effort is at its fixed maximum rate \( \bar{l} \) and

\[ PF(\bar{R}, L^{**}, \bar{l}) - wL^{**} - RD = \bar{\pi}, \]

or in real terms, where \( r = \bar{R}/\bar{P} \),

\[ F(\bar{R}, L^{**}, \bar{l}) - wL^{**} - rD = \bar{\pi}/\bar{P}. \] (4)

Hence, in good states of nature, the neoclassical labor demand schedule is operative, whereas in bad states of nature we have a different process determining employment, where less labor is needed and effort is high. In bad states the effort can be this high, because workers fear of losing their job. Therefore no high monitoring costs are necessary to avoid shirking. Cf. Shapiro and Stiglitz (1984). It is obvious that \( L^{**} < L^* \) and hence \( F_L < w \), when \( L^{**} \) prevails.

Since firms may differ in their values of \( D, L, W, P \) and \( y \), where \( y = F(\bar{R}, L, l) \) is the real output, in an aggregate situation, we may observe both types of regimes \( L^* \) and \( L^{**} \). In a bad state of nature, it is likely that more firms face the risk of bankruptcy and switch from
regime (3) to regime (4). When, ultimately, the wage rates drop, due to the high unemployment in regime (4), we might have a situation where $F_L > w$ at $L = L^{**}$ and so a switch to regime (3) is made as increasing employment raises profits, until $F_L = w$.

In regime (4), the comparative static implications of this model are

\[
\frac{\partial L}{\partial y} = \frac{-1}{G_L} \bigg|_{L=L^{**}} > 0 \quad (5a)
\]

\[
\frac{\partial L}{\partial w} = \frac{L}{G_L} \bigg|_{L=L^{**}} < 0 \quad (5b)
\]

\[
\frac{\partial L}{\partial r} = \frac{D}{G_L} \bigg|_{L=L^{**}} < 0 \quad (5c)
\]

\[
\frac{\partial L}{\partial D} = \frac{r}{G_L} \bigg|_{L=L^{**}} < 0, \quad (5d)
\]

where we have used the fact that $G_L = F_L - w < 0$ at $L = L^{**}$.

Equation (5a) and (5b) merely state the familiar notions of the positive relation between employment and real output and the negative relation between employment and real wages. Equation (5c) differs from the neoclassical assumption in the sense that we now have a negative relation between employment and the real interest rate. In a neoclassical setting, a positive relation might be expected as capital becomes more expensive and is substituted for labor. In our model, however, a higher interest rate implies higher interest costs and hence a higher risk of bankruptcy, which has a negative effect on employment. Moreover, we assume a fixed capital stock $K$, so there is no substitution. Finally, (5d) reflects the notion that an increase in the debts of a
firm, increases the risk of bankruptcy and hence lowers employment.

We can thus write the labor demand equation of the firm in general terms as

\[ L = f(y, w, r, D). \]  
(6)

This implies that we assume employment to be a function of real output \( y \), real wages \( w \), real interest rate \( r \) and debts \( D \), where + or - denotes the sign of the effect.

If we assume an exogenous labor supply, an unemployment relation based on this theory can be written as

\[ U = g(y, w, r, D). \]  
(7)

Of course (7), or (6) for that matter, are unlikely to be adequately specified, since they are static.

In order to possibly arrive at a model that is adequate, we assume a steady state relation between the variables in (7) to exhibit in the long run, thus

\[ u_t - \beta_1 y_t - \beta_2 w_t - \beta_3 r_t - \beta_4 D_t = c, \]  
(8)

where \( c \) is a constant and \( \beta_1 > 0, \beta_2 < 0, \beta_3 < 0 \) and \( \beta_4 < 0 \). Equation (8) represents long-run equilibrium between unemployment and real output, real wages, the real interest rate and debts.

However, in a dynamic world, it cannot be assumed that this long-
run equilibrium path (8) is actually ever reached. Equation (8) is not capable of representing adjustment costs, habit persistence, decision lags and aggregation over firms with different dynamic responses.

In order to construct a dynamic unemployment model while retaining (8), we use a so-called error correction specification

$$
\phi(L) \Delta u_t = \mu + \alpha_1(L) \Delta y_t + \alpha_2(L) \Delta w_t + \alpha_3(L) \Delta r_t + \alpha_4(L) \Delta D_t + 
\gamma [u - \beta_1 y - \beta_2 w - \beta_3 r - \beta_4 D]_{t-k},
$$

where $\gamma < 0$, $\mu$ is a constant, possibly including seasonal dummies or structural shifts, $L$ is the lag operator $L^j z_t = z_{t-j}$. The lag polynomials $\phi(L)$ and $\alpha_i(L)$ are describing the short term dynamics and are defined as $\phi(L) = 1 - \sum_{j=1}^{p} \phi_j L^j$ and $\alpha_i(L) = \sum_{j=0}^{q_i} \alpha_{i,j+1} L^j$, where $\phi(L)$ and $\alpha(L)$ contain no unit roots ($i = 1, \ldots, 4$).

Economic theory has provided us with unemployment equation (7), but no dynamics could be derived from it. Hence $p$ and $q_i$, the order of the lag polynomials $\phi(L)$ and $\alpha_i(L)$ and the lag $k$ of the error-correction, are still unknown and have to be determined empirically. This flexible functional form of equation (9) was also used by Saikonen and Teräsvirta (1985). In the sequel, we test for the presence of (seasonal) unit roots in the time series variables we use. Next, we estimate (9) moving from a general to a simple specification and applying the Boswijk (1991) test on whether there is cointegration.
3. EMPIRICAL ANALYSIS

3.1. Testing for unit roots

We start our empirical analysis by applying the seasonal unit root test of Hylleberg et al. (1990) to the quarterly time series we use. The data for the USA were taken from the *Main Economic Indicators* of the OECD and the *Survey of Current Business* of the U.S. Department of Commerce. The sample period is 1970.1-1991.4. The time series for the Netherlands were obtained from the *Main Economic Indicators* of the OECD and the *Kwartaalbericht* of De Nederlandsche Bank, the Dutch central bank. Here, the sample period is 1971.1-1989.4. The seasonal unit root test procedure of Hylleberg et al. (1990) is applied to these data.

The advantage of the test of Hylleberg et al. (1990) compared to other seasonal unit root tests, like Dickey et al. (1984) is that in this case the transformations to remove possible seasonal unit roots follow directly from the procedure and do not have to be set a priori. The test amounts to estimating an auxiliary regression, which may also contain deterministic elements, like constant, trend and seasonal dummies. This auxiliary regression is

\[ \varphi^*(L)y_{4t} = \pi_1y_{1t-1} + \pi_2y_{2t-1} + \pi_3y_{3t-2} + \pi_4y_{3t-1} + \mu + \epsilon_t, \]

where \( \varphi^*(L) \) is a lag polynomial function of \( y_{4t} \) in order to whiten the errors, \( \mu \) is the deterministic part and...
\[ y_{1t} = (1+L+L^2+L^3)z_t \]
\[ y_{2t} = -(1-L+L^2-L^3)z_t \]
\[ y_{3t} = -(1-L^2)z_t \]
\[ y_{4t} = (1-L^4)z_t, \]

where \( z_t \) is the time series being tested.

To test for unit root 1, this is simply to test for \( \pi_1 = 0 \) and for \(-1\) it is \( \pi_2 = 0 \). For the two conjugate complex roots \( i \) and \(-i\) a joint \( F \)-test for testing \( \pi_3 = \pi_4 = 0 \) is suggested. Critical values of this unit root test are presented by Hylleberg et al. (1990). The results are in table I for the U.S. data and in table II for the Dutch data.

Table I. Results of Hylleberg unit root test for US data.

<table>
<thead>
<tr>
<th>t-statistic</th>
<th>( ur_t )</th>
<th>( rr_t )</th>
<th>( \ln y_t )</th>
<th>( \ln w_t )</th>
<th>( \ln D_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \pi_1 )</td>
<td>-3.035</td>
<td>-2.210</td>
<td>-1.867</td>
<td>-2.686</td>
<td>-2.199</td>
</tr>
<tr>
<td>( \pi_2 )</td>
<td>-1.664</td>
<td>-7.557†</td>
<td>-2.557</td>
<td>-4.330†</td>
<td>-6.300†</td>
</tr>
<tr>
<td>( \pi_3 )</td>
<td>2.569</td>
<td>-6.904†</td>
<td>0.481</td>
<td>-0.014</td>
<td>-3.091†</td>
</tr>
<tr>
<td>( \pi_4 )</td>
<td>-7.933†</td>
<td>-3.852†</td>
<td>-5.016†</td>
<td>-4.243†</td>
<td>-4.460†</td>
</tr>
</tbody>
</table>

| F-statistic       | \( 38.70† \) | \( 31.15† \) | \( 15.65† \) | \( 12.67† \) | \( 18.05† \) |

filter: \( (1-L^4) \) \( (1-L) \) \( (1-L^4) \) \( (1-L) \) \( (1-L) \)

\( ^† \) significant at 5 percent

\( ur_t \): US unemployment rate (percentage of the civilian labor force)
\( rr_t \): US real prime interest rate (percentage per annum)
\( \ln y_t \): logarithm of US index of real industrial production
\( \ln w_t \): logarithm of US index of real hourly earnings in manufacturing
\( \ln D_t \): logarithm of US index of debts of nonfinancial enterprises

Source: OECD, Main Economic Indicators; US Dept. of Commerce, Survey of Current Business. See appendix.

In all cases but the real interest it sufficed to set \( \varphi^*(L) = 1 + \varphi_1 L + \varphi_4 L^2 \); in case of the real interest rate we set \( \varphi^*(L) = 1 + \varphi_1 L \).
There will be no seasonal unit root if $\pi_1 = 0$ and $\pi_2 \neq 0$, $\pi_3 \neq 0$ and $\pi_4 \neq 0$ and then a $\Delta_1 = (1-L)$ filter will suffice. If $\pi_1 = 0$ and $\pi_2 = 0$ and $\pi_3 = 0$ or $\pi_4 = 0$, the presence of seasonal unit roots cannot be rejected and we will apply a $\Delta_4 = (1-L^4)$ filter to attain stationarity. In applying this test, $\mu$ consists of a constant, trend and seasonal dummies.

Table II. Results of Hylleberg unit root test for the Netherlands.

<table>
<thead>
<tr>
<th>$t$-statistic</th>
<th>$ur_t$</th>
<th>$rr_t$</th>
<th>$lny_t$</th>
<th>$lnu_t$</th>
<th>$lnD_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_1$</td>
<td>-1.47</td>
<td>-2.91</td>
<td>-2.82</td>
<td>-3.24</td>
<td>-2.88</td>
</tr>
<tr>
<td>$\pi_2$</td>
<td>-6.14†</td>
<td>-4.38†</td>
<td>-1.76</td>
<td>-3.20†</td>
<td>-5.79†</td>
</tr>
<tr>
<td>$\pi_3$</td>
<td>-1.65</td>
<td>-5.10†</td>
<td>-2.08</td>
<td>-7.08†</td>
<td>-2.58</td>
</tr>
<tr>
<td>$\pi_4$</td>
<td>-4.05†</td>
<td>-3.82†</td>
<td>-0.85</td>
<td>-3.83†</td>
<td>-5.17†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$F$-statistic</th>
<th>$\pi_3 \cap \pi_4$</th>
<th>$10.02†$</th>
<th>$30.06†$</th>
<th>$2.79$</th>
<th>$58.55†$</th>
<th>$20.82†$</th>
</tr>
</thead>
</table>

$^†$significant at 5 percent

$ur_t$: unemployment rate (percentage of the labor force)

$rr_t$: real interest rate on debts, plus mark-up (percentage per annum)

$lny_t$: logarithm of index of real industrial production

$lnu_t$: logarithm of index of real hourly rates in manufacturing

$lnD_t$: logarithm of index of credit to nonfinancial enterprises

Source: OECD, *Main Economic Indicators* and De Nederlandsche Bank, *Kwartaalbericht*.

In all cases except unemployment and real output, $\phi^*(L) = 1$ sufficed. For $ur$ we have set $\phi^*(L) = 1 + \phi_2 L^2 + \phi_3 L^3$ and for $lny$, $\phi^*(L) = 1 + \phi_1 L + \phi_4 L^4$.

3.2. Testing for cointegration

In this section, we briefly discuss the cointegration approach described by Boswijk (1991). The notion of cointegration was introduced by Granger (1981) and was further elaborated by Engle and Granger (1987),
who established the link between cointegration and error-correction models. Their approach is based on a two-step method, where the cointegration relation is estimated and later used in a dynamic model.

A second approach to cointegration was due to Johansen (1988) and extended in Johansen (1991). This method is based on a vector auto-regressive (VAR) system, which becomes an error correction model if cointegration tests cannot be rejected.

Boswijk (1991) presents a third approach, which differs from the Johansen approach in the sense that only a subsystem is analyzed instead of the full system. One of the variables is considered to be endogenous and the other variables are conditioned on this endogenous variable. This approach is in the tradition of earlier error-correction models, like Davidson et al. (1978) and Hendry and Richard (1983).

Let \( y_t \) be the endogenous variable and \( x_t \) the vector of (weakly) exogenous variables, then the model is specified as

\[
\Delta y_t = \mu + \alpha' \Delta x_t + \gamma (y - \beta' x)_{t-k} + \sum_{j=1}^{p} \Gamma_j \Delta z_{t-j} + \epsilon_t, \quad (10)
\]

where \( x_t = (y_t, x_t)' \in \mathbb{R} \times \mathbb{R}^{N-1} \), \( \alpha \) and \( \beta \) are parameter vectors, \( \gamma \) is the error correction coefficient, which determines the adjustment speed towards long-run equilibrium. Boswijk (1991) has developed a Wald test on the significance of \( \gamma \) and \( \gamma \beta' \) and has derived the empirical distribution of the test statistic \( \xi_t \). Note the similarity between (9) and (10).
4. RESULTS

4.1 The United States

Our specification analysis of the model for the USA starts with equation (9), where \( p = 5 \) and \( q_i = 3 \) for \( i = 1, \ldots, 4 \) and we set \( k = 4 \). The model contains three seasonal dummy variables. We also included a dummy variable \( D75q1 \) in the model to represent an upward shift in the natural level of unemployment due to the recession of 1975. It is 1 for 1975.1 and zero elsewhere. Cf. OECD, *Economic Surveys*, 1983 and 1985.

This general model is estimated using least squares and its specification could not be rejected. As a first step, we test whether we can validly simplify the short run dynamic part of the model. We use a simple F-test on parameter restrictions. Testing the null hypothesis \( H_0: \phi_2 = \phi_3 = \alpha_{31} = \alpha_{32} = \alpha_{33} = \alpha_{42} = \alpha_{43} = \alpha_{44} = 0, \phi_4 = \phi_5 \) and \( \alpha_{21} = \alpha_{22} = \alpha_{23} = \alpha_{24} \) in model (9), yields \( F(16, 53) = 1.50 \), which cannot be rejected at a 5 or 10 percent significance level. This implies that we can join \( \Delta_4 ur_{-4} \) and \( \Delta_4 ur_{-5} \) to \( \Delta_4 ur_{-4} \) and \( \Delta_1 lnw, \Delta_1 lnw_{-1}, \Delta_1 lnw_{-2}, \) and \( \Delta_1 lnw_{-3} \) to \( \Delta_1 lnw \) and delete \( \Delta_4 ur_{-2}, \Delta_4 ur_{-3}, \Delta_1 lr \) and all its lags and the lags of \( \Delta_1 lnD \) from the model.

We next apply the Wald test on cointegration of Boswijk (1991) to this simplified model to test whether the error-correction part is significant. This yields \( \xi = 74.39 \), which is significant at both the 5% and the 1% level. For four explanatory variables, the 5% and 1% critical values are 19.69 and 24.69, respectively. Thus, the presence of a cointegration relation cannot be rejected.
Finally, we test whether insignificant variables from this cointegration relation can be deleted. It appears that the log of debt of firms and the log of the real wage rate could validly be deleted from the error-correction part of the model, as the $F$-test on parameter restrictions yields $F(2, 69) = 0.808$, which cannot be rejected at 5 percent. The estimated model that we ultimately end up with is given in table III. For reasons of convenience the parameters of the seasonal dummies are not reported. Notice that none of the misspecification tests we apply rejects the specification of our model.

Thus, our empirical model, derived from a simple theory of the firm, based on the usual neoclassical assumptions and a bankruptcy constraint, cannot be rejected by these US data. It appears that short-term dynamics is represented by the change in real output, real wages and debts. The error-correction term, representing long-run equilibrium behavior, includes real output and the real interest rate.

Notice that the interest rate in the error-correction part appears with a positive sign. Hence in (8), the real interest rate has a positive relation with unemployment. As mentioned earlier, this is not in agreement with the effect predicted by the standard neoclassical theory. The negative influence of the interest rate on employment, via the bankruptcy constraint, is bigger than the positive influence via labor substitution for capital.

4.2 The Netherlands

We start our specification analysis for the Netherlands with the same
general specification of equation (9), where \( p = 5 \) and \( q_i = 3 \) for \( i = 1, \ldots, 4 \).

We also set \( k = 4 \). The model contains three seasonal dummy variables. We included a dummy variable \( D83q1 \) in the model to represent a major change in the definition of unemployment, which caused an upward shift in the unemployment rate from 1983.1 onwards. This implies a dummy being unity from 1983.1 onwards and zero elsewhere. However, since we transform the unemployment rate to its first order difference, we also have to transform this dummy to its first order difference. Hence \( D83q1 \) is 1 for 1983.1 and zero elsewhere.

This general model is estimated using least squares and its specification could not be rejected. As a first step, we test whether we can validly simplify this model. Two features in this model are noteworthy. First, the parameters of \( A^v_{lnw} \) and all of its lags are of approximately the same size and second, the sign of \( lniu_4 \) in the error-correction part is significantly negative. This negative sign is inconsistent with the sign expected from the neoclassical theory. However, it is possible to test, simultaneously, whether this \( lniu_4 \) can be replaced by \( A_{lnw} \), which in its turn follows from the fact that the parameters of \( A_{lnw} \) through \( A_{lnw_3} \) are approximately equal. We also test whether a large number of variables with insignificant coefficients can be deleted from the model.

We use a simple \( F \)-test on parameter restrictions. Testing the hypothesis \( H_0: \beta_2 = 0 \) and \( \phi_2 = \phi_3 = \phi_4 = \phi_5 = \alpha_{12} = \alpha_{13} = \alpha_{14} = \alpha_{21} = \alpha_{22} = \alpha_{23} = \alpha_{31} = \alpha_{32} = \alpha_{33} = \alpha_{41} = \alpha_{42} = \alpha_{44} = 0 \), and \( \beta_2 = 0 \) and \( \alpha_{21} = \alpha_{22} = \alpha_{23} = \alpha_{24} \) in model (9), yields \( F(18, 37) = 1.19 \), which cannot be rejected at a 5 or 10 percent significance level. This means that we can replace \( lnw_4 \) and \( A_{lnw}, A_{lnw_1}, A_{lnw_2}, A_{lnw_3} \) by \( A_{lnw} \).
and delete all lags of $\Delta_1 \text{ur}$, except $\Delta_1 \text{ur}_{-4}$, delete $\Delta_1 \text{rr}$ and all its lags, the lags of $\Delta_1 \text{lnty}$ and all of $\Delta_1 \text{lnD}$, except $\Delta_1 \text{lnD}_{-2}$.

We next apply the Wald test on cointegration of Boswijk (1991) to this simplified model to test whether the error-correction part is significant. This yields $\xi_t = 43.28$$^\dagger$, which is significant at both the 5% and the 1% level. Thus, the presence of a cointegration relation cannot be rejected for the Netherlands as well.

Finally, the log of debt of firms could be deleted from the error-correction part of the model, as the $F$-test on parameter restrictions yields $F(1, 55) = 1.87$, which cannot be rejected at 5 percent. The estimated model that we ultimately end up with is given in table IV. For reasons of convenience the parameters of the seasonal dummies are not reported. Notice that also this model cannot be rejected by any of the misspecification tests we apply.

Thus, also for the Netherlands, our empirical model, derived from the theory of section 2, cannot be rejected by the data. It appears that short term dynamics is represented by the change in real output, real wages and debts. The error-correction term, representing long-run equilibrium behavior, includes real output and the real interest rate.

Notice that the interest rate in the error-correction part appears with a positive sign. Hence, in equation (8), the real interest rate has a positive relation with unemployment. On the other hand, we have to notice that the interest rate parameter is insignificant at 5 percent, although not at 10 percent. This positive sign is opposite to the effect predicted by the standard neoclassical theory. However, it provides corroborating evidence in favor of our theory in section 2.
5. RESULTS IN GOOD AND BAD STATES

5.1 The United States

As a relaxation in our empirical analysis for the USA, we try to model the presence of good states and bad states of nature and the corresponding employment regimes (3) and (4). Equation (3) denotes the usual neoclassical employment schedule, whereas (4) is determined by the bankruptcy constraint. The good and bad states of nature are represented by the composite index of US leading indicators. See, e.g., Diebold and Rudebush (1989). The turning points of this index are used to represent an economic upsurge, when it moves from a trough to a peak, and an economic downturn, when it moves from a peak to a trough. The turning points are based on Diebold and Rudebush (1989) and on the Main Economic Indicators of the OECD. They are presented in table V.

Two dummy variables are created, based on table V, where one, \( D_{up} \), represents an economic upsurge or the good state of nature, and one, \( D_{downturn} \), represents an economic downturn or the bad state of nature. Our model of table III is relaxed by multiplying all variables, including the seasonal dummies to infer whether seasonal effects differ between an economic upswing or downturn, with these two dummies in order to be able to represent the two regimes. We expect in particular that the interest rate is more effective in the bad state.

First, we estimated this model and determined the long-run effect of an increase in the real interest rate on unemployment in the two regimes. In a good state of nature a one percentage point increase in
rr yields an increase in ur of 0.10 percent. In a bad state of nature a one percentage point increase in rr yields an increase in ur of 0.22 percent. With a US civilian labor force of about 125 million people, this means an increase of some 300,000 unemployed in a bad state. Also the long-run effect of Iny on ur differs in both regimes.

Second, we tested this model for the validity of simultaneously deleting some variables with insignificant parameters. The F-test for deleting $D_{down} \Delta_1 \Delta_4 ur_{-4}$ and $D_{up} rr_{-4}$ from the model, yields $F(2,59) = 1.67$ and cannot be rejected. Hence indeed, the interest rate is significant in a bad state of nature, whereas it is insignificant in a good state of nature. This corroborates the theory of section 2.

Third, we tested the validity of significant differences between the two regimes. It appeared that in the short term dynamics part of the model the hypothesis of equating the seasonal dummies over the two regimes and taking $D_{up} \Delta_4 ur_{-1}$ and $D_{down} \Delta_4 ur_{-1}$, $D_{up} \Delta_1 \ln D$ and $D_{down} \Delta_1 \ln D$ and $D_{up} \Delta_4 \ln w$ and $D_{down} \Delta_4 \ln w$ together, cannot be rejected; $F(7,61) = 0.99$. However, there is a difference in the impact of $\Delta_1 \ln y$ on $\Delta_4 ur$ in the two regimes. Moreover, in the error-correction part we could not accept the hypothesis of equating $D_{up} ur_{-4}$ and $D_{down} ur_{-4}$, since $F(1,68) = 5.35$ is significant. Hence, we have two long term equilibrium relations: one corresponding to a good state of nature in which only the log of real output plays a role, and one corresponding to a bad state of nature in which both the log of real output and the real interest rate plays a role. Thus, the effect of the real interest rate on unemployment is asymmetric. This final model is presented in table VII.
5.2 The Netherlands

We will apply the same relaxation in our model for the Netherlands as the one of the previous subsection. The good and bad states of nature are represented by the composite index of leading indicators in the Netherlands. This index is taken from the Main Economic Indicators of the OECD. The turning points of this index are used to represent an economic upsurge, when it moves from a trough to a peak, and an economic downturn, when it moves from a peak to a trough. These turning points are presented in table VI.

The same dummies $D_{up}$ and $D_{down}$ are created, based on table VI, representing an economic upsurge and an economic downturn respectively. Our model of table IV is relaxed by multiplying all variables, including the seasonal dummies to infer whether seasonal effects differ between an economic upswing or downturn, with these two dummies in order to be able to represent the two regimes. We expect in particular that the interest rate is more effective in the bad state.

First, we estimated this model and determined the long-run effect of an increase in the real interest rate on unemployment in the two regimes. In a good state of nature a one percentage point increase in $rr$ yields an increase in $ur$ less than 0.01 percent. In a bad state of nature, however, a one percentage point increase in $rr$ yields an increase in $ur$ of 1.1 percent. With a labor force of about 6 million persons, this means an increase of some 65,000 unemployed in a bad state. In a good state this number is negligible.

Second, we tested whether we could validly delete variables with
insignificant parameters from this general model. The $F$-test of deleting $D_{up}^{rr-4}$ from the error-correction part of the model yields $F(1, 45) = 0.768$, which cannot be rejected. So also for the Netherlands the real interest rate only has a significant effect in the bad state and its effect is negligible in a good state. This result is in agreement with the theory in section 2.

Third, we tested whether there were significant differences between the two regimes. Testing the equality of the short-run dynamic variables among the two regimes yields $F(8, 46) = 1.27$. Next, we tested whether there is a difference between the parameters of the error-correction variables $D_{up}^{ur-4}$ and $D_{down}^{ur-4}$. We find $F(1, 54) = 2.05$, which cannot be rejected. Conditional on this equality, we test the equality of $D_{up}^{lny-4}$ and $D_{down}^{lny-4}$, which gives $F(1, 55) = 0.002$. The test on simultaneous equality for the dynamic and error-correction part gives $F(10, 46) = 1.23$. Thus, we find only a significant difference between the two regimes for the interest rate variable. So also for the Netherlands the real interest rate appears to have an asymmetric effect on unemployment. This final model is presented in table VIII.

5. CONCLUSIONS

The first conclusion of this paper is that inclusion of a bankruptcy constraint in a model of the firm yields different results concerning the sign of the effect the (real) interest rate has on (un)employment compared to the usual neoclassical effect. Inclusion of such a bankruptcy constraint does seem to be realistic considering the reaction of
firms when the threat of bankruptcy is eminent. These reactions may range from some layoffs to large scale reorganizations or closure. Hence, the threat of bankruptcy and a bankruptcy constraint might be an important issue on the labor market, which should be reflected in economic models.

Second, inclusion of a bankruptcy constraint in a basically neoclassical model of the firm, yields two regimes for its employment decision. One where the bankruptcy constraint is not binding, representing a good state of nature where the usual neoclassical labor demand relation is operative, and one where the bankruptcy constraint is binding, representing a bad state of nature. In that case labor demand is determined by a combination of real output, real wages, real interest rates and debts of the firm.

We have constructed a cointegration model of U.S. and Dutch unemployment, which were capable of distinguishing between a good and a bad state of nature. It appeared that indeed the interest rate had a positive impact on unemployment in the bad state, whereas in the good state its influence was insignificant. This result is in agreement with our theoretical starting point.

ACKNOWLEDGEMENTS

Valuable comments of Philip Hans Franses, Peter Boswijk and Frank den Butter on an earlier version of this paper are gratefully acknowledged.
REFERENCES


APPENDIX. DATA

The United States

The data we used to estimate and test (9) for the USA were taken from the OECD, Main Economic Indicators (MEI) and the U.S. Department of Commerce, Survey of Current Business (SCB). It concerns time series from 1970.1–1991.4 on

\( ur: \) unemployment as percentage of the civilian labor force (MEI)
\( R: \) prime interest rate in percentage per annum (MEI)
\( Y: \) index of total industrial production (MEI)
\( W: \) index of hourly earnings in manufacturing (MEI)
\( P: \) index of producers prices of finished goods (MEI)
\( RD: \) interest payments on debts of nonfinancial enterprises (SCB)

The variables we used were constructed as follows:

\[
\begin{align*}
r &= R - \dot{p}, \\
\text{where } \dot{p} &= \left(\frac{P - P(-4)}{P(-4)}\right) \times 100 \\
\ln y &= (\ln Y - \ln P) \\
\ln w &= (\ln W - \ln P) \\
\ln D &= \ln(RD/R)
\end{align*}
\]
The Netherlands

The data we used to estimate and test (9) for the Netherlands were taken from the OECD, *Main Economic Indicators (MEI)* and from De Nederlandsche Bank, *Kwartaalbericht (KB)*. It concerns time series from 1971.1 to 1989.4 on

- $ur$: unemployment as percentage of the total labor force (*MEI*)
- $R$: interest rate on debts, including mark-up, in percentages (*KB*)
- $Y$: index of total industrial production (*MEI*)
- $W$: index of hourly rates in manufacturing (*MEI*)
- $P$: index of total consumers prices (*MEI*)
- $D$: bank credit to nonfinancial enterprises (*KB*)

Two major breaks in $D$, due to definition changes, were removed. One from 1988.1 to 1989.4 and one from 1989.1 to 1989.4.

The variables we used were constructed as follows:

\[
    r = R - \dot{p},
\]

where $\dot{p} = [(P-P(-4))/P(-4)] * 100$

\[
    \ln y = (\ln Y - \ln P)
\]

\[
    \ln w = (\ln W - \ln P)
\]
Table III. Estimation and test results of (9) for the USA.

\[
\begin{align*}
\Delta_4ur_t &= .788 + .785 \, D75q1 + .571 \, \Delta_4ur_{t-1} - .249 \, \Delta_4ur_{t-4} - \\
&\quad [0.273] \quad (0.278) \quad [0.038] \quad [0.055] \\
&\quad -.079 \, \Delta_4\ln y_t + .009 \, \Delta_1\ln D_t + .072 \, \Delta_4\ln w_t - \\
&\quad [0.088] \quad [0.002] \quad [0.015] \\
&\quad -.160 \, ur_{t-4} + .019 \, \tau_{t-4} - .363 \, \ln y_{t-4} + \varepsilon_t \\
&\quad [0.032] \quad [0.009] \quad [0.210]
\end{align*}
\]

\[
S.E. = .231 \quad R^2 = .969 \quad T = 84 \quad (1971.1-1991.4) \quad DW = 1.61
\]

Normality: \( \chi_{norm}^2(2) = .157 \)

Autocorrelation: \( F_{AR}(4, 67) = .93 \quad F_{AR}(8, 63) = 1.96 \)

ARCH: \( F_{ARCH}(1, 69) = .001 \)

Heteroskedasticity: \( F_{X_i^2X_j^2}(20, 50) = .501 \)

Functional form: \( F_{X_i^2}X_j^2(27, 48) = .926 \)

RESET: \( F_{RESET}(1, 70) = 1.29 \)

Predictive failure: \( F_{CHOW}(16, 55) = .89 \quad X_{forec}^2(16)/16 = .99 \)

Estimation and testing was performed using PC-GIVE. Estimation is by least squares and the heteroskedasticity consistent standard errors of White (1980) are in squared brackets, except for \( D75q1 \) where the usual standard error is presented. \( F_{AR} \) is the Lagrange Multiplier test on residual autocorrelation. \( F_{ARCH} \) is the ARCH test of Engle (1982). The normality test of Jarque and Bera (1980) is denoted by \( \chi_{norm}^2 \). \( F_{X_i^2} \) tests on heteroskedasticity due to squares of regressors and \( F_{X_i^2X_j^2} \) is the heteroskedasticity test of White (1980). \( F_{RESET} \) is the RESET test, \( F_{CHOW} \) is the Chow test on predictive failure and \( X_{forec}^2(m)/m \) is the predictive failure test of Hendry (1979), divided by its number of degrees of freedom. This is an index of predictive failure, where values exceeding 2 imply poor forecast performance. \( S.E. \) is the regression standard error, \( R^2 \) is the coefficient of determination, \( T \) is the number of observations used for estimation and testing and \( DW \) is the Durbin-Watson statistic. Finally, \( ^* \) indicates significance at 5%.
Table IV. Estimation and test results of (9) for the Netherlands

$$\Delta_t u_t = 0.661 + 2.23 D83q1 + 0.403 \Delta_t u_{t-4} - 0.036 \Delta_t \ln y_t +$$

$$[.236] \quad [.299] \quad [.090] \quad [.009]$$

$$+ 0.041 \Delta_t \ln w_t + 0.035 \Delta_t \ln D_{t-2} -$$

$$[.016] \quad [.011]$$

$$- 0.079 \ u_{t-4} + 0.027 \ r_{t-4} - 2.16 \ \ln y_{t-4} + \epsilon_t$$

$$[.017] \quad [.016] \quad [.567]$$

$$S.E. = .233 \quad R^2 = .907 \quad T = 68 \ (1973.1-1989.4) \quad DW = 1.69$$

Normality: $$\chi^2_{\text{norm}}(2) = 1.27$$

Autocorrelation: $$F_{AR}(4,52) = .665 \quad F_{AR}(8,48) = .489$$

ARCH: $$F_{ARCH}(1,54) = .034$$

Heteroskedasticity: $$F_{X2}(18,37) = .979$$

RESET: $$F_{RESET}(1,55) = 1.49$$

Predictive failure: $$F_{CHOW}(16,40) = .559$$

$$\chi^2_{\text{forc}}(16)/16 = .590$$
### Table V. Turning points of composite US index of leading indicators.

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<table>
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<td>trough:</td>
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<td>peak:</td>
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<tr>
<td>trough:</td>
<td>1991.2</td>
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Source: Diebold and Rudebush (1989) and OECD, *Main Economic Indicators*.

### Table VI. Turning points of composite index of leading indicators of the Netherlands.

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<td>trough:</td>
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<td>trough:</td>
<td>1982.1</td>
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</table>

Source: OECD, *Main Economic Indicators*. 
Table VII. Estimation and test results of model for the USA with regime dummies.

\[
\Delta_4w_t = 1.04 + 0.631 D75q1 + 0.616 \Delta_4w_{t-1} - 0.302 D_{up}\Delta_1\Delta_4w_{t-4} - \\
[.173] \quad [.307] \quad [.043] \quad [.061] \\
- 0.069 D_{up}\Delta_4lny_t - 0.092 D_{down}\Delta_4lny_t + \\
[.007] \quad [.010] \\
+ 0.009 \Delta_4lnD_t + 0.070 \Delta_4lnw_t - \\
[.002] \quad [.015] \\
- 0.185 D_{up}w_{t-4} - 0.660 D_{up}lny_{t-4} - \\
[.026] \quad [.143] \\
- 0.224 D_{down}w_{t-4} - 0.797 D_{down}lny_{t-4} + 0.041 D_{down}r_{t-4} + \epsilon_t \\
[.028] \quad [.278] \quad [.014] \\
\]

S.E. = .221  \quad R^2 = .973  \quad T = 84 (1971.1-1991.4)  \quad DW = 1.77  

Normality:  \quad \chi^2_{norm}(2) = 5.92  

Autocorrelation:  \quad F_{AR}(4,64) = .57  \quad F_{AR}(8,60) = .40  

ARCH:  \quad F_{ARCH}(1,66) = .10  

Heteroskedasticity:  \quad F_{X_i^2}(26,41) = .331  

Functional form:  \quad F_{X_i^*X_j^+}(27,48) = .611 \quad (\text{upsurge variables}) 
\quad F_{X_i^*X_j^+}(27,48) = .662 \quad (\text{downturn variables})  

RESET:  \quad F_{RESET}(1,67) = .239  

Predictive failure:  \quad F_{CHOW}(16,52) = .76  
\quad \chi^2_{forced}(16)/16 = .92
Table VIII. Estimation and test results of model for the Netherlands with regime dummies.

\[
\Delta_t ur_t = .510 + 2.42 D83q^1 + .356 \Delta_t ur_{t-4} - .018 \Delta_t \ln y_t + \\
[.199] (.261) [.081] [.007] \\
+ .046 \Delta_t \ln w_t + .037 \Delta_t \ln D_{t-2} - \\
[.014] [.010] \\
- .057 ur_{t-4} - 1.90 \ln y_{t-4} + .064 D_{\text{down}} + \epsilon_t \\
[.016] [.473] [.011]
\]

S.E. = .201 \quad R^2 = .931 \quad T = 68 (1973.1-1989.4) \quad DW = 2.16

Normality: \quad \chi_{\text{norm}}^2(2) = .222

Autocorrelation: \quad F_{AR}(4, 52) = .257 \quad F_{AR}(8, 48) = .277

ARCH: \quad F_{ARCH}(1, 54) = 2.30

Heteroskedasticity: \quad F_{X^2}(18, 37) = 1.26

RESET: \quad F_{RESET}(1, 55) = 1.33

Predictive failure: \quad F_{\text{CHOW}}(16, 40) = .938 \quad \chi_{\text{forcing}}^2(16)/16 = 1.10