March 19, 2001
Preliminary! Please do not quote!

Sources of German Unemployment: Evidence from a Structural VAR model [1]

Tobias Linzert

Institute for Applied Macroeconomics
Department of Economics
Johann Wolfgang Goethe-Universität Frankfurt/Main

Abstract

This paper investigates the determinants of German unemployment in the context of a small macroeconomic model. In particular, the model is estimated using a cointegrated structural VAR methodology to analyze the dynamic effects of different shocks on unemployment. The procedure is in two steps: First, the long run relationships of the variables real output, wages, prices, employment and unemployment are identified via a cointegration analysis. It can be shown that the variables in the model are integrated and jointly cointegrated whereby the model exhibits two equilibrium relationships, namely a labor demand and a wage setting relation. Second, a structural VAR model is identified using the restrictions suggested by the macroeconomic model to gain insights into the contributions of several shocks on unemployment. The impulse-response analysis and the forecast error variance decomposition reveal that especially price shocks have a persistent effect on unemployment. Moreover labor supply and demand shocks affect unemployment significantly in the short/medium run. The impulse-responses confirm that nominal price and wage inertia probably resembles each other since the real wage seems unaffected by a demand shock and facilitate the effect on unemployment. Interestingly, wage and productivity shocks do not seem to play a dominant role.

Keywords: Unemployment, Structural VAR, Cointegration

JEL classification: J60, E24

[1] I especially wish to thank Jörg Breitung for encouraging me to work on this topic and for numerous helpful comments and support. I am grateful to Christian Müller and Carsten Trenkler for support with the econometric software and other practical issues. And, finally, I wish to thank Regine Spector, Felix Elwert and Stephan Schmidt for proofreading the manuscript. All remaining errors are mine, of course.

1 Introduction

The inquiry must be one into unemployment rather than into the unemployed.
(William Beveridge)

In the last decades, the focus of labor economic research and policy debate in the industrialized countries has centered around the problem of unemployment. In Germany the unemployment rate is one of the most discussed economic indicator. Every month the Federal Labor Office (Bundesanstalt für Arbeit) publishes the official unemployment rate.[1] The media reports in depth on this monthly event analyzing and discussing the recent labor market developments. The unemployment rate is a key indicator of economic performance for the stock market, for policy makers and for investors.

High unemployment implies a substantial waste of resources as it results in a loss of output, increased income inequality, and the erosion of human capital. It creates social and political tensions and incurs a high social burden in terms of psychological costs to bear by the unemployed discouraging them from the labor market with damaging long run consequences.

The particularly high interest in the unemployment problem stems certainly from persistent labor market slack in Germany. Many policies have failed in combating unemployment, which puzzles economists as well as policy makers. A new attempt was made by the social democratic Schröder administration as the emphasis of their pre-election campaign was the reduction in unemployment. A labor market program for job entrants, a tax reform as well as the establishment of the ”Alliance for Employment” (Bündnis für Arbeit), a concerted action by the government, trade unions and business organizations on wage bargaining, labor market policies, and legislation are the main attempts so far to reduce unemployment. The success of the government will probably be measured by the success of significantly reducing unemployment. A thorough understanding of the dynamics of unemployment is important to draw the appropriate conclusions for economic policy.

One popular notion explaining high and persistent unemployment in Europe, and in particular Germany, has been to blame inflexible labor markets for keeping wages from falling, as the demand for especially unskilled labor fell.[2] Supposedly, the same demand shift occurred in all industrialized countries to which the US labor market responded with higher wage inequality.[3] While wages of unskilled workers fell dramatically, unemployment remained relatively low.[4] Paul Krugman (1994) has dubbed this notion as the ”two sides of the same coin hypothesis”, which states that an economy facing a demand shift can either opt for more inequality and working poor or unemployment, especially among the unskilled.[5]

According to Krugman (1994) high taxes and labor market regulations such as employment protection laws in Europe have driven down the wage employers are willing to pay for labor. On the other hand high unemployment benefits increased the worker's reservation wage. This wedge would then explain high unemployment. Horst Siebert (1997) agrees with that view and writes that ”the combination of intensified competition and labor saving technologies requires more flexibility of the labor market, in particular

[1] See, for example, the official homepage of the Federal Labor Office under: http://www.arbeitsamt.de/hst/services/statistik/kurzinformation/bundesgebiet/index.html.

[2] See for example The Economist from October 11^th, 1997 p. 100 or from February 7^th 1998, p.17 for articles blaming the inflexible German labor market for high unemployment.

[3] See Gottschalk and Smeeding (1997) for a survey of cross-national comparisons of income inequality. Levy and Murnane (1992) review the literature documenting the rise in income inequality in the US.

[4] Some studies, however, cast doubt on the notion that demand shifts led to higher inequality. Fortin and Lemieux (1997) hint to falling minimum wages and decreasing union density as sources of increased inequality.

[5] See Howell, Duncan and Harrison (1998) for a critical assessment of that hypothesis in their review of the empirical literature on inequality in the US and unemployment in Europe.

wages". Siebert (1997) concludes that a cut in institutions is necessary to overcome high unemployment.[6]

Although this interpretation on the causes of unemployment has its intuitive appeal since it is in line with the Walrasian market notion, a couple of authors have cast serious doubt on this explanation. Stephen Nickell (1997) shows that the institutional frameworks in Europe are too similar as to explain the differences in the unemployment histories. The answer on the impact of institutions on labor market outcomes is more complicated than the broad-brush view that they are all bad.[7] Secondly, Nickell and Bell (1996) assert that there is relatively low unskilled unemployment in Germany despite of higher wages relative to the US, which does not fit into the "two side of the same coin" notion. They conclude that there have been major neutral shocks hitting all groups of the labor market equally.

A brief look into history also casts doubt on the labor market flexibility notion. Most of the labor market institutions were established or further extended in the 1950s and 1960s. These institutions reached their peaks, for example the replacement ratio, in the 1970s. Since the early 1980s labor market institutions have been fairly stable or even declining. This historical record raises two puzzling questions. First, why did unemployment increase so much although the institutions were already in place when unemployment was low? Second, why did unemployment remain high and even rose in the 1980s and 1990s when institutions declined? To postulate rigidities as the root of the problem seems a bit too simple as they are hard to reconcile with the history of the institutions. In fact, focusing only on institutions is not enough to account for the substantial increases in unemployment.

This paper is directed to the issue why unemployment increased to such historical records as in recent years. More specifically, the empirical investigation will be into the sources of unemployment in the context of a macroeconomic model. The question will be how certain macroeconomic variables are related to high and persistent unemployment. To understand the evolution of unemployment it is possible to think about shocks that have affected the German labor market. The most prominent shock to think of is the oil price crisis in the beginning of the 1970s, which triggered an initial rise in unemployment. Several other shocks were in place as well. An interesting question in that context is why we fail to observe a decline in unemployment to levels like in the beginning of the 1970s or 1980s.

Shocks to the labor market and their possible persistence are analyzed in the following study using a structural error correction model. This model is suited to reveal the dynamics of a system of variables and the transmission of shocks. The empirical method allows to address the following questions: What is the relative importance of supply and demand factors that lie behind high unemployment? How quickly does unemployment respond to shocks to technology, wages, prices, demand or labor supply? And finally, what are the long run relationships governing the labor market and in particular unemployment?

A similar approach was taken by Dolado and Jimeno (1997) who estimated a structural VAR model for the Spanish economy. Evidence for Germany is so far weak with the exception of a paper by Carstensen and Hansen (1998) who choose a somewhat different approach to answer the questions also addressed in this study.[8]

The next section delineates the key facts about unemployment in Germany. It is important to understand the evolution of unemployment and which groups are hit by unemployment most severe. The section imparts

[6] See also Berthold and Fehn (1996) who postulate that a higher wage dispersion in Germany would lower unemployment.

[7] For example Cohen, LeFranc and Saint-Paul (1997) show that not minimum wages and unemployment benefits but rather slow growth and high firing costs are responsible for the French US differences in their unemployment histories.

[8] The discussion paper has recently been published addressing only the West German labor market. See Carstensen and Hansen (2000).

an impression on possible shocks that affected the German labor market in the sample range from 1969 until the fourth quarter of 1998.

Motivating the empirical part of the paper a small macroeconomic model is presented in section three. The theoretical model was introduced by Dolado and Jimeno (1997) describing the Spanish economy by the following variables: real output, real wages, prices, employment and unemployment. Using the German counterparts the model is applied in this study and serves as a basis for the empirical analysis. In particular, the model is solved as to identify the shocks that are crucial in explaining the dynamics of the above variables. For the unemployment rate the models reveals that the dynamics can be represented by shocks to technology, wages, prices, demand and labor supply.

Section four presents the empirical part of the present paper. Despite the common theoretical setup the empirical analysis differs in a number of aspects from the one by Dolado and Jimeno (1997). After an univariate checking on the different time series, the main empirical analysis is in two steps: First, the long run relationships of the variables real output, wages, prices, employment and unemployment are analyzed via a cointegrated error correction model. In contrast to the Spanish case the model exhibits two equilibrium relationships, identified as a labor demand and a wage setting relation.

In a second step a structural VAR model is built for the set of variables. Following the contributions of Blanchard (1989), Gali (1992) and Amisano and Giannini (1997) this study analyzes the dynamics of the error structure governing the variables of the system. The structural VAR tries to use economic theory or models to derive the necessary constraints on the parameters to recover the structural shocks from the innovations of the ECM. This a priori information about the behavior of certain variables improves the precision of the estimate and facilitates an interpretation of the instantaneous linkages between the variables.

Finally, section four also presents the dynamic responses of unemployment of shocks to output, technology, wages, prices and employment by the means of impulse-response functions. Moreover, the forecast error variance decompositions (FEVD) provide information on the role played by different structural shocks in explaining the variability of unemployment at different forecast horizons. Overall, demand shocks have been found to have a significant short run effect on unemployment while price and labor supply shocks lead to a medium/long term increase in unemployment.

The final section provides an evaluation of the results in the light of the historical record of unemployment in Germany. It draws general conclusions and indicates problems for further research.

2 Unemployment in Germany

After more than a decade of negligible unemployment in Germany in the 1960s, unemployment has been rising dramatically since the early 1970s. Unemployment rose continuously over the past three decades resulting in an unemployment rate that is today ten times larger than in the beginning of the 70s. Therefore it seems necessary to deal with the historical record and the decomposition of unemployment in order to understand the complexity of the unemployment problem in Germany. This section provides some stylized facts on the unemployment situation.

Figure 1 shows the evolution of unemployment in Germany. It can be seen from the graph that unemployment has been rising steadily over the whole period. A particular feature of German unemployment obviously is that it is characterized by great upward jumps in the beginning of the 1970s, the 1980s and the 1990s. Only in the sub-periods from 1975-1980 and 1985-1990 unemployment declined but not enough to break the upward trend. For a comparison, the US unemployment rate follows a rather cyclical pattern, i.e.

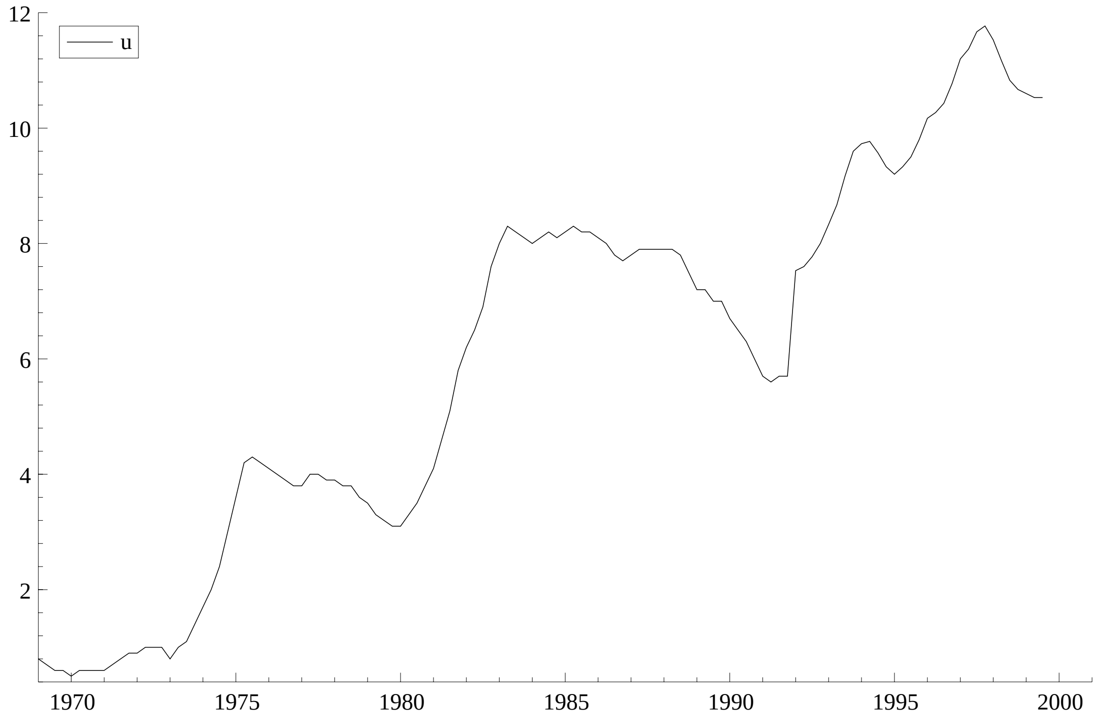

Figure 1. *German unemployment rate from 1969:1 until 1998:4.*

unemployment more or less fluctuates around a nonzero mean.

The first surge in unemployment in Germany corresponds to the time when the first oil price shock in 1973 drove the economies of the industrialized countries into a deep recession. Furthermore in the 1970s the baby boom generation entered the labor force and had to be absorbed by the labor market, subsequently. By that time around 3.5 Million guestworkers (Gastarbeiter) had already been integrated into the labor market as in the late 1960s and beginning of the 1970s Germany was facing a labor shortage. The oil price shock of 1973 coincided with a switch to a more restrictive monetary policy by the German Bundesbank to bring down inflation. The recession resulted in excess labor supply and unemployment rose respectively. By the end of the 1970s unemployment decreased mildly.

In the early 1980s the second oil price shock shook the German economy when the oil price increased by 24% in 1979. Women's labor force participation rose considerably during the 1980s. Moreover, the current account swung into a deficit, which caused the Bundesbank to follow a tight monetary policy. The Bundesbank policy was accompanied by fiscal contraction, which led to a period of low growth and unemployment up to 9%.[9] By the mid 1980s Germany started to recover from the recession relaxing the situation on the labor market.

In 1990 the German unification occurred and the economy, in particular the West-German economy was booming as Gross Domestic Product (GDP) rose due to excessive consumption. This resulted in a decrease in unemployment especially in West-Germany. In 1992/93 Germany was hit by a severe recession resulting in large scale employment reductions.

To understand better the structure of German unemployment, a few remarks are added on the decomposition

[9] Blanchard and Summers (1986) advocated that adverse demand shocks like tight monetary policy and fiscal contraction paired with real wage rigidities caused the high unemployment in the 1980s.

of unemployment. While youth unemployment is considerably low in comparison with other European countries or even the United States, elderly people are especially hit by unemployment (cf. (Martin, 1994)).

A bulk of Germany's unemployment is long term unemployment, i.e. persons who are out of work for longer than a year. Parallel to the increase in unemployment the share of long term unemployed increased sharply from 5.3% in 1971 to around 50% in 1997.[10] Long term unemployed persons exhibit quite specific characteristics. Older persons, women and persons with no apprenticeship are more likely to be unemployed longer than a year than others.[11] Also striking in this respect is the average duration of unemployment, which amounted to 32 weeks in 1997 (cf. (Bundesanstalt für Arbeit, 1997)).

In addition to differences in unemployment among different demographic groups, unemployment displays a great regional diversity. While Bavaria's unemployment rate was around 7% in 1998, the unemployment rate in Saxony-Anhalt came up to 20%. In general, unemployment in West-Germany hovered around 9% while in East-Germany around 18%.

To sum up, Germany's unemployment is characterized by several shocks hitting the labor market and thus steadily increasing unemployment. The corresponding increase in long term unemployment shows that the unemployment rate is unable to return to their pre-shock levels.

3 A Small Macroeconomic Model

The following model is taken from Dolado and Jimeno (1997) and will be used as a theoretical basis for the empirical model in this study. From the theory of unemployment as reviewed by Bean (1994) or Lindbeck (1992) we know that certain shocks are perceived to affect the labor market equilibrium. Together with mechanisms of unemployment persistence the shocks may explain the determination and evolution of unemployment since it is very unlikely that the huge surges in unemployment in the mid 1970s and 1980s are due to sudden changes in wage bargaining or other institutional changes.

The objective of the model is to determine the shocks that might affect the labor market. The shocks are defined as shocks to aggregate demand, wages, prices, productivity and labor supply. Note, however, that the model does not identify a monetary shock and therefore lacks a modeling of the money market. In my view, neglecting the monetary sector is justified in terms of simplicity of the model but seems inappropriate when monetary shocks are also transmitted to the labor market.

According to Dolado and Jimeno (1997), the model is fairly standard and is represented by six equations, which are as follows:

$$y = \phi(d - p) \tag{1}$$

$$y = e + \theta \tag{2}$$

$$p = w - \theta + \mu \tag{3}$$

where y, p, e, w, and $(d - p)$ denote the logs of output, price level, employment, nominal wages and real aggregate demand respectively. Equation (1) is a aggregate demand function with $\phi > 0$ just described by an aggregate demand index.[12]

[10] The numbers correspond to the statistics published by Eurostat (1997).
[11] See Hunt (1995) and Steiner (1997) for microeconometric studies on the duration of unemployment.
[12] Other authors like Blanchard (1989) and Giannini, Lanzarotti and Seghelini (1995) prefer modeling aggregate demand as $y = m - p$ where m is the nominal money stock.

Equation (2) represents a log-linearized Cobb-Douglas type production function, which is expressed for simplicity in terms of employment (e) neglecting the capital stock. The production function assumes constant returns to scale and technical progress is modeled as labor augmenting technical progress represented by the stochastic shift parameter θ. At any point of time capital is given, so firms are left to choose the amount of labor to hire.

The usual optimality condition for firms, i.e. price equal to marginal costs does not apply to this model. Equation (3) represents a so-called price setting scheme in an imperfect competitive framework. The price is set by firms allowing for a non zero markup over costs. Labor demand can be easily derived from the price setting equation.[13]

To further characterize the supply side of the model, the following equations are added:

$$l = c(w - p) - bu + \tau \tag{4}$$

$$w = w^* + \epsilon_w + \gamma_1 \epsilon_d + \gamma_2 \epsilon_p \tag{5}$$

$$w^* = arg\{n^e = (1 - \lambda)n_{-1} + \lambda l_{-1}\} \tag{6}$$

where l is the log of the labor force, n^e is the expected value of log employment, u is the unemployment rate, τ a labor supply shift parameter and ϵ_w, ϵ_d and ϵ_p are $i.i.d.$ shocks to wages, demand and prices.

Equation (4) is a labor supply function expressed in terms of the real wage and unemployment. This equation can be interpreted as the wage setting equation, stemming from the bargaining strength of the collective wage bargaining parties, insider-outsider considerations or efficiency wages.[14] Here, the labor supply relation is augmented by a wage setting function given in equation (5).

Wages are determined by the targeted nominal wage w^* described by equation (6) and the influence of different shocks to wages, demand and prices. ”Wage push” factors or wage shocks can be institutional changes such as union strength, employment protection or changes in the generosity of unemployment benefits. Some kind of wage indexation is allowed if γ_1 and γ_2 are greater than zero, i.e. sudden changes in demand and prices will have an influence on wages. The standard model of insider-outsider wage bargaining assumes that the wage is set according to the expectations with respect to labor demand as in equation (6).

To close the model, the stochastic processes governing the evolution of shocks have to be specified. Dolado and Jimeno (1997) simply assume that they all evolve as random walks:

$$\triangle d = \epsilon_d \tag{7}$$

$$\triangle \theta = \epsilon_s \tag{8}$$

$$\triangle \mu = \epsilon_p \tag{9}$$

$$\triangle \tau = \epsilon_l \tag{10}$$

where ϵ_d, ϵ_s, ϵ_p and ϵ_l are uncorrelated shocks to demand, productivity, prices and labor supply.

Solving Equations (7)-(10) for unemployment yields:

$$\begin{aligned} (1 - \rho L)u \quad &= \quad (1 + b)^{-1}\{-\phi(1 - \gamma_1)\epsilon_d + [\phi(1 + \gamma_2) - c]\,\epsilon_p \\ &\quad +(1 + c - \phi)\epsilon_s + \epsilon_l + \phi\epsilon_w\} \end{aligned} \tag{11}$$

where L is the lag operator and $\rho = (1 + b - \lambda)/(1 + b)$. Unemployment is therefore influenced by all of the above shocks and their persistence.[15]

---

[13] See Bean (1994) for a formal treatment of that problem.

[14] See Bean (1994), Franz (1995) or Lindbeck (1992) for details.

[15] Note that under the full hysteresis assumption unemployment must be $I(1)$, which will be later shown to be correct for the German unemployment series ($\lambda = 0$).

Solving the model under the full hysteresis assumption yields the following system where the variables can be expressed purely through structural shocks:

$$\begin{aligned}
\triangle e &= \phi(1-\gamma_1)\epsilon_d + (\phi - 1)\epsilon_s - \phi(1+\gamma_2)\epsilon_p - \phi\epsilon_w && (12)\\
\triangle y &= \phi(1-\gamma_1)\epsilon_d + \phi\epsilon_s - \phi(1+\gamma_2)\epsilon_p - \phi\epsilon_w && (13)\\
\triangle w &= \gamma_1\epsilon_d + \gamma_2\epsilon_p - \phi\epsilon_w && (14)\\
\triangle p &= \gamma_1\epsilon_d - \epsilon_s + (1+\gamma_2)\epsilon_p - \phi\epsilon_w && (15)\\
\triangle u &= (1-b)^{-1}\{-\phi(1-\gamma_1)\epsilon_d + [\phi(1+\gamma_2) - c]\,\epsilon_p \\
&\quad +(1+c-\phi)\epsilon_s + \epsilon_l + \phi\epsilon_w\} && (16)
\end{aligned}$$

According to this theoretical model displayed in equations (12)-(16) aggregate demand shocks (ϵ_d) increase output and consequently employment while decreasing unemployment. Price shocks (ϵ_p) have a negative sign in the output equation and hence decrease output and employment, while they have a positive effect on prices and wages. The effect on unemployment depends on the relative size of c, i.e. the labor supply elasticity. Wage shocks (ϵ_w) decrease output and employment and increase prices, wages and unemployment. Productivity shocks in this model depend on the size of parameter ϕ. If $\phi > 1$ then output and employment rise while unemployment will rise if $\phi < 1$. Under full hysteresis all shocks may have permanent effects on unemployment.

4 Empirical Results

4.1 Data and Variables

This section gives some descriptive information on the data used for the empirical analysis. The choice of variables is motivated by the theoretical model presented in section 3. Table 1 summarizes the variables and the corresponding labels that are used in the present paper.

The series for gross domestic product (GDP) and the consumer price index (CPI) were taken from the International Monetary Fund (IMF) International Financial Statistics (IFS) database. The data series for unemployment and wages come from the OECD while the employment series was taken from the Bundesbank database.[16] The periodicity of the data is quarterly and it is seasonally adjusted. Note also that the series are for unified Germany and range from 1969:1 to 1998:4.

To obtain the variables for the empirical model, several transformations were made. Notice first that all variables are expressed in logarithms. The variable real output was calculated from the series of nominal GDP divided by the consumer price index (CPI). The CPI was employed to represent the variable prices. The data series on wages in manufacturing was used to proxy the variable wages. A variable on real wages was constructed as the quotient of wages over the CPI.[17]

Employment is measured by total employment referring to the number of employees plus the self employed. While the employment variable is expressed by the number of persons being employed one could alterna-

[16] The databases are available on CD ROM of the International Statistical Yearbook (ed. 2000), the OECD Statistical Compendium (ed 2000) and "Fünfzig Jahre Deutsche Bundesbank, Monetäre Statistiken", Beck Verlag, (1998), respectively.

[17] The same definition of the real wage is used by Dolado and Jimeno (1997). Jacobson, Vredin and Warne (1998) use nominal wages deflated with the Producer Price Index (PPI) instead. Blanchard (1989) employs the PCE deflator and notes that the differences in the results when using the CPI were minor.

Table 1. Data definitions and labels

e	logarithm of total employment (employees and self employed)
p	logarithm of the consumer price index (CPI) with base year 1995
u	logarithm of the unemployment rate as percentage of the civilian labor force
y	logarithm of real gross domestic product (GDP)
w	logarithm of nominal hourly wages in the manufacturing sector
$w - p$	logarithm of the real wage
$y - e$	logarithm of productivity
$sd91$	step dummy (0: until 1990:4, 1: from 1991:1)
$d91$	impulse dummy for 1991:1

tively measure employment by the number of hours worked.[18] Since unemployment is also measured in persons it makes more sense to use persons for employment as the corresponding variable.

The unemployment rate is used as the measure for unemployment. More specifically, the OECD reports the non-standardized unemployment rate in terms of the civilian labor force calculated by the German Federal Labor Office that measures unemployment by the number of persons being registered as unemployed. Notice that this unemployment rate differs considerably from the standardized unemployment rate published by EUROSTAT.[19] In contrast to the German official rate the standardized rate is obtained from a household survey employing the unemployment concept by the International Labor Organization (ILO). For example, in 1998 the unemployment rate as published by the German Federal Labor Office was 11.1% while the standardized rate published by EUROSTAT was only 9.4%. Although the two unemployment rates differ substantially in their levels their dynamics are fairly similar (cf. (Mayer, 1990)). Since in this study no comparison is made with other countries and the primary interest lies in the history and the dynamics of unemployment, it seems appropriate to use the non-standardized unemployment rate.

The German unification generated a level shift in several German time series. Two dummy variables, one shift ($sd91$) and one impulse dummy ($d91$), enter the data analysis to remove the impact of outliers due to the German unification. The variables employment, prices, unemployment, real output, wages, real wages and productivity are depicted in figure 2

[18] Only Jacobson, Vredin and Warne (1997) and Jacobson et al. (1998) use the number of hours worked as a measure for employment while the majority of the empirical studies on that topic use the number of persons employed.

[19] The "Harmonized Unemployment Rates" from EUROSTAT were only available from 1990:1.

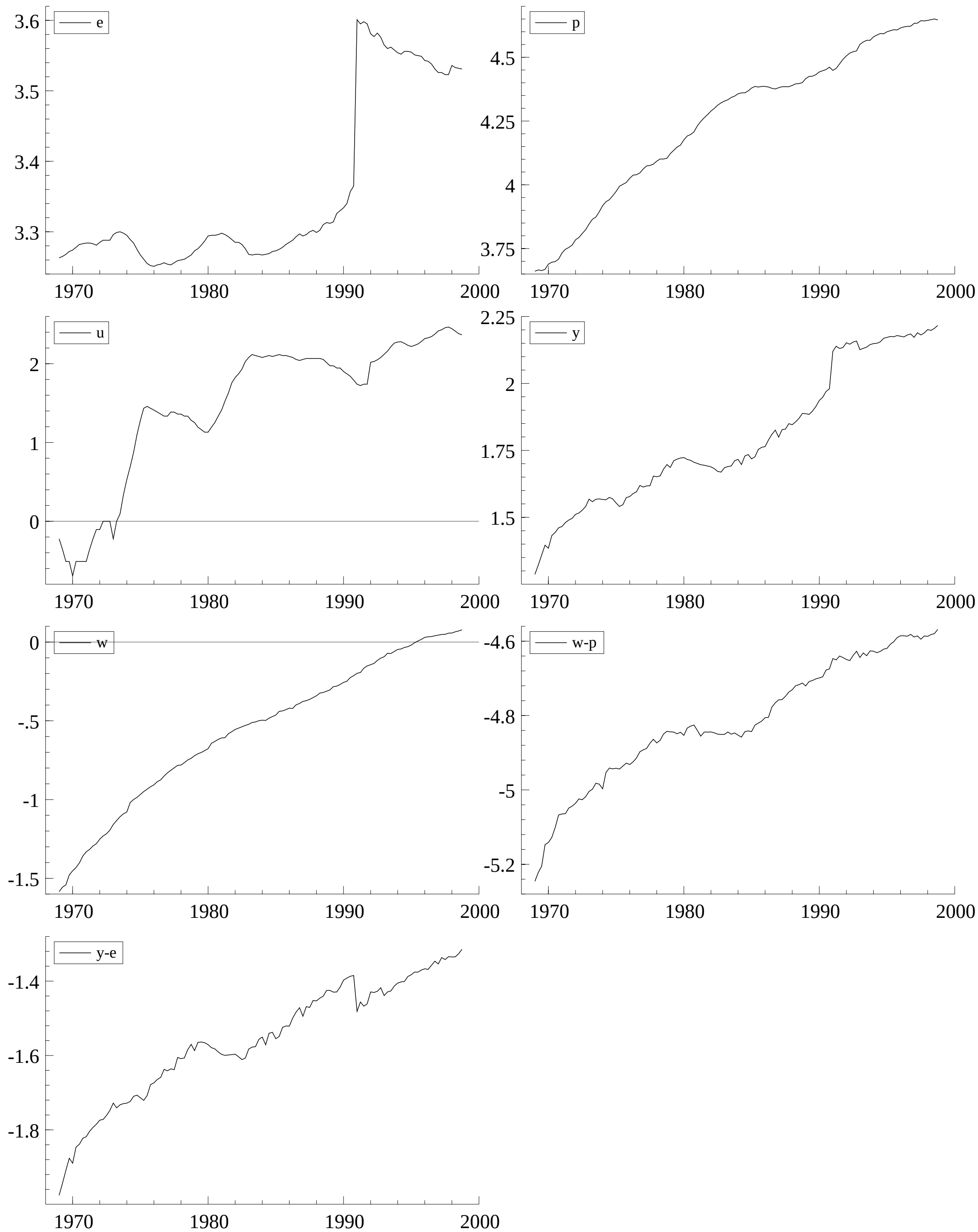

Figure 2. *The data series for employment (e) , prices (p), unemployment (u), real output (y), wages (w) , real wages ($w - p$) and productivity ($y - e$).*

From the plots we can see that the series of real output (y), the price index (p), productivity ($y - e$), wages (w) and real wages ($w - p$) are rising steadily. The similarity of the upward trend in real wages and productivity, both having a lower slope in the 1980s, is evident. The GDP, employment and productivity series show a significant break in the first quarter of 1991. From this date the IMF, the OECD and the Bundesbank have recorded data for the unified Germany. While the GDP and employment series exhibit an upward jump, the productivity series drops significantly since the rise in employment through the East German work force more than outweighed the increase in GDP.

Interestingly the wage and price series do not show such a structural break. The unemployment series and the employment series exhibit large fluctuations. These labor market outcomes are a result of various oil price shocks, government policies, restrictive monetary policies and changes in labor market legislation.

The question is whether the time series that are shown in figure 2 are stationary or non-stationary. Judged by simple visual inspection the series appear non-stationary. A formal test of this is executed in the next section.

4.1.1 Unit Root Tests

Cointegration analysis requires that all time series included in the analysis must be integrated of the same order. To test whether the time series are non-stationary the Augmented Dickey-Fuller (ADF) test is employed. The ADF test statistic is given by:

$$\triangle y_t = \mu + \beta t + \gamma y_{t-1} + \sum_{j=1}^{p} \alpha_j \triangle y_{t-j} + \epsilon_t \tag{17}$$

The null hypothesis is the joint hypothesis that $\beta = \gamma = 0$.[20] If so, the process has a unit root and the time series is non-stationary. If $\gamma < 0$, then the time series is considered to be stationary.

The quick look at the current data suggests the necessity to include a constant (c) as well as a deterministic trend (t) in the test regressions since the time series are all trending in some way.[21] For the output, employment and productivity series a dummy for the unification break in 1991:1 is added to the test regression. All other series do not seem to be affected by that event.

Table 2 shows the results of the unit root tests for the time series used in the present paper.[22] The lag lengths for the Augmented Dickey-Fuller test regressions were chosen by the Akaike and Schwartz criterion as to arrive at white noise residuals with autocorrelation not significantly from zero.[23]

In all cases the test is carried out by calculating the t-statistics of the parameter γ. Critical values are tabulated for example from response-surface simulations by MacKinnon (1991).[24] The critical values for the test statistics with a dummy are taken from Perron (1989) who tabulated critical values for models

[20] Assuming $\beta = 0$ gives rise to a trend in the original series due to the inclusion of a constant. Alternatively, One could also construct a different test statistic assuming $\beta \neq 0$. In this case the asymptotic distribution is standard normal. However, this strategy has not been very successful in the empirical literature. See Patterson (2000) for details.

[21] For the employment series it is not so clear whether to include a trend or not since only the unification break shifts the series significantly upward. But to avoid misspecification of the model, a trend is included at the potential cost of overspecifying the test equation.

[22] The tests have been conducted with the software package Eviews 2.0.

[23] Note that the lag order should not be too large as with increasing length the sample decreases and the test looses power.

[24] The critical values essentially depend on the deterministic elements included in the test statistic regression.

Table 2. Augmented Dickey-Fuller test results

Variable	Deterministic	Lags	t-Statistics	Critical value
e	$c, t, st91, d91$	4	-2.92	3.80^A
p	c, t	4	-1.40	3.45
u	c, t	5	-2.35	3.45
y	$c, t, st91, d91$	4	-2.85	3.80^A
w	c, t	4	-0.46	-3.45
$w - p$	c, t	0	-3.03	-3.45
$y - e$	$c, t, st91, d91$	4	-2.41	3.80^A
$\triangle e$	$c, d91$	0	-8.45**	-2.89
$\triangle p$	c	3	-2.15	-2.89
$\triangle u$	c	4	-3.53*	-2.89
$\triangle y$	$c, d91$	4	-4.05**	-2.89
$\triangle w$	c	4	$-2.64^{\dagger}$	-2.89
$\triangle w - p$	c	0	-12.0**	-2.89
$\triangle y - p$	$c, d91$	0	-11.19**	-2.89

Note: ** and * denote significance at the 1% and 5 % level respectively. † denotes significance at the 10% level. Critical values are taken from MacKinnon (1991). The critical values that are marked with an A are from Perron (1989), Model A for time series with a structural break with $\lambda = 0,7$.
c=constant, t=trend, $st91$=stepdummy, $d91$=dummy for 1991:1

with structural breaks. In this particular case model A from Perron (1989) is employed that incorporates a dummy into the usual ADF regression.

For all series the null hypothesis of a unit root cannot be rejected at the 5% significance level (cf. table 2). To determine the degree of integration the ADF test is conducted for the first differences of the series. The tests indicate that for the first differences of the employment, output, real wage and productivity series the unit root hypothesis can be rejected at the 1% significance level. For the unemployment series the null hypothesis is rejected at the 5% level. These series can be regarded as integrated of order one, i.e. $I(1)$.

However, the tests of the first differences of the wage and the price series suggest the series to be $I(2)$ since the hypothesis of a unit root cannot be rejected. For the wage series this evidence is not too compelling as the test statistic value is significant at the 10% level. For both series the evidence of non-rejection hinges on the number of lags chosen for the test regression. Generally these lags were selected by the Akaike and Schwartz criterion but if one is to deviate from the suggestions, it is possible to reject the null hypothesis when choosing a smaller lag length.

Dolado and Jimeno (1997) also face the problem of $I(2)$ price and wage series. In their study the $I(2)$ character of the time series was removed after including a dummy for 1978:1. According to the graphs in figure 2 an inclusion of a dummy seems not appropriate for the German series. I will proceed assuming that a $I(1)$ series is a good approximation to the $I(2)$ case hence assuming wages and prices being $I(1)$ in the following cointegration analysis.

At a later stage the model will be transformed into real variables, which is the most convenient way to remove the problem of $I(2)$ series. Further research would be possible estimating an $I(2)$ cointegration model for the above variables. This is, however, far beyond the objective of the present paper. In the next section an error correction model is specified in order to determine the long run characteristics of the data. To specify the model, the appropriate lag length, the deterministic elements as well as the cointegrating rank has to be found.

4.2 Specification of the Empirical Model

The purpose of this section is to specify an error correction model, which can be used to gain insights into the dynamics of the variables of interest. In particular, the question will be whether there are any cointegration relations, i.e. long run equilibria in the data. The model from section 3 by Dolado and Jimeno (1997) requires the following variables: real GDP (y), prices (p), wages (w), employment (e) and unemployment (u).

Prior to any further analysis it is necessary to choose the deterministic parts that should enter the model. The deterministics are crucial for the behavior of the process and an appropriate formulation of the model is important to ensure that it approximates the ”true” data generating process. A deterministic trend, a step dummy and an impulse dummy for the unification break were chosen to enter the error correction model. Later the trend will be restricted only to the cointegration relation to model trending behavior in the levels of the variables. If the trend is not restricted it would be possible to generate quadratic trends in the level representation of the model, which seems inadequate for the present set of variables. On economic grounds a linear trend in the cointegration relation reflects growth in total factor productivity (TFP) from cumulative human or physical capital, which would surely affect labor market outcomes.[25]

The impulse dummy enters the model unrestricted while the step dummy will also be restricted to the cointegration space. An unrestricted step dummy could generate breaks in the trending behavior of the data series. Such an effect can be ruled out for the unification break as it did not affect the slope of the time trend but merely the level.

The choice of the deterministic elements was confirmed by a likelihood ratio test available in the software package MALCOLM.[26] The likelihood ratio test checks restrictions on the deterministic trend coefficients.[27] The tests show that a model with a constant and a trend cannot be rejected while other model specifications were clearly rejected against the specification suggested above.

The tools for the determination of the lag order implemented in MALCOLM are the information criteria by Akaike (AIC), Hannan-Quinn (HQ) and Schwartz (SC), a likelihood ratio test as well as the Godfrey (1978) Portmanteau test.[28] Estimating an unrestricted error correction model and employing the AIC, the HQ and the SC criteria reveals that they all point to different lag orders. While the AIC criterion proposes the lag order five, the HQ as well as the Schwartz criterion point to only one lag. Due to that ambiguous evidence

[25] See Doornik, Nielsen and Hendry (1998) for details. However, it would certainly enhance the model by directly including TFP as a variable (cf. Blanchard and Wolfers (2000)).

[26] The specification analysis of the determination of the deterministics as well as the lag length was conducted with MALCOLM for RATS by Mosconi (1998).

[27] For known and fixed r, the test is χ^2 distributed. Note also that the current version of MALCOLM allows only unrestricted impulse dummies. See Mosconi (1998) for details.

[28] See Lütkepohl (1993) for a detailed discussion on the choice of the lag length.

Table 3. Trace test for the cointegration rank of $y_t = (e, p, u, y, w)'_t$

H_0: rank=r	Test statistic $-T \sum log(.)$	Test statistic using T-nm	Critical values by Nielsen (1994) (95% quantiles)
r=0	182.9**	143.2**	98.28
r=1	107.1**	83.84**	72.15
r=2	54.52**	42.67*	49.72
r=3	29.48	23.07	31.02
r=4	12.02	9.41	15.53

Note: ** and * denote significance at the 1% and 5 % level respectively.

the likelihood ratio test and the Godfrey-Portmanteau test were carried out. The Godfrey Portemanteau test checks for autocorrelation of the residuals up to a given lag. Both tests, the LR test as well as the Godfrey Portemanteau test indicate that the appropriate lag for the system is five. Therefore the system will be estimated with lag order five.

The next step of the specification procedure is to test whether there are any cointegration relations in the five variable system, $y_t = (e, p, u, y, w)'_t$.[29] The concept of cointegration is particularly important since it reveals the existence of long run equilibrium relationships among the non-stationary variables.

The results of the Johansen-trace test are shown in table 3. The trace test was applied exclusively without reporting the maximum eigenvalue test statistics. The critical values of the test statistics are taken from Nielsen (1994) since the usual critical values from the asymptotic reference distributions by Osterwald-Lenum (1992) are not appropriate when a dummy is included into the system. Therefore the correct critical values were obtained executing routines of the program DisCo by Nielsen (1994). The program simulates the 95% quantiles of the asymptotic distribution under the restriction that a constant, a trend as well as a dummy are included into the data generating process.[30]

The results show that there are three cointegration relations in the five variable system since $r = 2$ could be rejected at the 1% significance level. The value of the degrees of freedom corrected test statistic only gives two cointegration relations. Some experimentation with three cointegration relations did not produce satisfactory results in terms of plausible economic equilibrium relationships. There are basically two possible explanation for this result. Either the cointegration test correctly chooses three cointegration relations, which might just not be plausible or alternatively, the tests could be distorted by factors like sample size, inclusion of dummies, and the use of $I(2)$ variables (prices and wages) so that the determined rank is possibly incorrect.

Additional evidence on the cointegration rank of the current system comes from the Saikkonen and Lütkepohl (2000) test. This test is directed to the application in the case of cointegrated time series with a structural shift. For the Saikkonen and Lütkepohl (henceforth SL) test the deterministic elements are estimated first, are then subtracted from the original series, and finally a LR type test is conducted on the adjusted system. The SL-test finds two cointegration relation for the five variable system (cf. table 4). Still, due to the mixed

[29] Note that in this notation y_t denotes the vector of variables while y is the label used for the real output series.
[30] The simulation is based on 400 observations and 10.000 repetitions. See Johansen and Nielsen (1993) for further details.

Table 4. SL-test for the cointegration rank of $y_t = (e, p, u, y, w)'_t$

H_0: rank=r	Test statistic $-T \sum log(.)$	Critical values (95% quantiles)
r=0	79.20**	65.69
r=1	46.39*	45.13
r=2	26.93	28.47
r=3	5.40	15.92
r=4	1.19	6.83

Note: ** and * denote significance at the 1% and 5 % level respectively.

evidence of the Johansen and SL-test procedures I decided to transform the five variable system into real variables. In this case nominal wages and prices no longer enter the model separately and instead enter as the real wage, $w - p$.

Choosing the lag order for the new system with $y_t = (e, u, y, w - p)'_t$ indicates a lag order five, too. The results of the Johansen-trace test are presented in table 5. As the results show the system exhibits two cointegration relations, i.e. the cointegrating rank equals two. The identification of the cointegration vectors below will show that this result is more reasonable than a cointegration rank of three as indicated for the five variable system.

Therefore the model to be estimated will be the vector $y_t = (e, u, y, w-p)'_t$. The deterministic components of the VAR include: a constant, a linear trend and a step dummy restricted to the cointegration space, and an unrestricted impulse dummy for 1991:1. The error correction representation of such a specification is given by:

$$\Gamma(L)\triangle y_t = \mu + \gamma d91_t + \alpha\beta' y^*_{t-1} + \epsilon \quad (18)$$

where

$$\Gamma(L) = I - \Gamma_1 L - \ldots - \Gamma_4 L^4$$

and the vector y^*_t containing the deterministic parts restricted on the cointegration space is given by:

$$y^*_t = (e, u, y, w - p, t, sd91)_t.$$

4.3 The Long Run Structure of the Model: Cointegration

To analyze the long run structure of the specified statistical model of the vector $y = (e, u, y, w - p)'_t$ it is necessary to identify the cointegrating relations. The mere estimation of the ECM leaves the cointegrating relations unidentified and is therefore useless in terms of an economic interpretation. To just identify the cointegration relations it is necessary to impose one normalization and additional $(r - 1)$ restrictions on each cointegrating vector.

Table 5. Trace test for the cointegration rank of $y_t = (e, u, y, w-p)'_t$

H_0: rank=r	Test statistic $-T\sum log(.)$	Test statistic using T-nm	Critical values by Nielsen (1994) (95% quantiles)
r=0	111.2**	91.88**	72.15
r=1	54.29**	44.85*	49.72
r=2	25.2	20.82	31.02
r=3	5.54	4.57	15.53

Note: ** and * denote significance at the 1% and 5 % level respectively.

In the following I will adopt economic arguments to impose restrictions on the cointegrating vectors of the form:

$$\beta = (H_1\varphi_1, \dots, H_r\varphi_r)$$

where the matrices $H_1, \dots, H_r$ express linear economic hypothesis to be tested against the data.[31]

Economic theory of the labor market suggests that in a labor market there will be a price setting and a wage setting relation as suggested for example in Bean (1994).[32] The most common specification of a price setting or labor demand relation is due to Layard and Nickell (1985) and has the form:

$$e_t = \beta_0 + \beta_1 y_t + \beta_2 (w-p)_t + \epsilon_t \tag{19}$$

The wage setting or labor supply relation can be derived from a maximization problem of a representative household. In an aggregate form the relation can be best described by:

$$(w-p)_t = \alpha_0 + \alpha_1 u_t + \alpha_2 x_t + \epsilon_t \tag{20}$$

where x_t summarizes all variables that might influence the wage setting, e.g. productivity, import prices, interest rates, etc. In this setup the real wage is also determined by the unemployment rate reflecting the impact of the outsiders on the wage setting process.

Having characterized a set of possible equilibrium relationships among the variables the objective is now to see whether they can be identified in the present error correction model. Table 6 reports the results of the identification procedure. Just-identification for the present system requires one normalization plus one additional exclusion restriction on each cointegrating vector. Since just-identification does not change the value of the likelihood function, no testing is involved in this case.

The first hypothesis is to find a labor demand relation as suggested in equation (19). For that reason the first cointegrating vector is normalized on the employment variable. As in equation (19) labor demand equilibrium includes real wages as well as demand factors reflected here by real output. Unemployment is assumed not to affect the labor demand and is restricted to zero accordingly. Moreover, the cointegration space contains a linear trend, which represents total factor productivity growth or technological progress. The unification break is modeled by a step dummy that is also included in the cointegration relation.

[31] See Johansen and Juselius (1994) for details on the identification procedure of cointegrating vectors.

[32] There has been a huge empirical research effort to analyze the specification of labor demand and labor supply. See for example Manning (1993), Amano and Wirjanto (1997), Tyrväinen (1995) and for Germany Hansen (2000).

Table 6. Restrictions on the cointegration space of $y_t = (e, u, y, w-p, t, sd91)'_t$

	Cointegration vector						
	e	u	y	$w-p$	t	sd91	LR test
$\beta_{ld,1}$	1	0.01	-1.37	1.11	0.002	0.03	
$\beta_{ws,1}$	1.19	-0.04	-1.51	1	0.004	-0.05	
$\beta_{ld,2}$	1	0	-1.34	1.05	0.002	0.02	
			(0.10)	(0.11)	(0.0003)	(0.01)	
$\beta_{ws,2}$	0.72	0.04	-1.06	1	0	0.08	
	(0.31)	(0.01)	(0.10)			(0.05)	
$\beta_{ld,3}$	1	0	-1.31	1	0.002	0.009	
			(0.05)		(0.0003)	(0.003)	
$\beta_{ws,3}$	0.75	0.04	-1.07	1	0	0.08	$\chi^2(1) = 0.033$
	(0.30)	(0.01)	(0.10)			(0.05)	p-value = 0.85
$\beta_{ld,4}$	1	0	-1.23	1	0.002	-0.008	
			(0.04)		(0.0002)	(0.009)	
$\beta_{ws,4}$	1	0.03	-1	1	0	0.02	$\chi^2(3) = 4.19$
		(0.006)				(0.009)	p-value = 0.24

Note: Standard errors are provided in parenthesis.

The second equilibrium that is reckoned to be found in the set of variables is a wage setting or labor supply scheme. Therefore the corresponding cointegrating vector is normalized on the real wage variable. To reach just-identification it is assumed that the wage setting is not affected by the linear trend, which is set to zero. All other variables enter the equation unrestricted.

The exactly identified system reveals fairly plausible results, which can be expressed by the following equations:

$$e_t = -1.05(w-p)_t + 1.34y_t - 0.002t - 0.02sd91_t + ec^1_t \quad (21)$$

$$(w-p)_t = 1.06y_t - 0.72e_t - 0.04u_t - 0.08sd91_t + ec^2_t \quad (22)$$

where ec^1_t and ec^2_t denote the error correction terms of the two cointegration relations respectively.

The labor demand equilibrium displays a negative correlation of employment and real wages $(w-p)$ and a positive relationship between employment and real output (y). In the wage setting equilibrium real wages are positively correlated with productivity $(y-e)$ while negatively with the unemployment rate (u).

In the case of overidentification the restrictions on the parameter space can be tested. The results are shown in table 6. The significance of the unemployment parameter in all three specifications indicates that there is an outsider component in the German wage setting equilibrium. This rejects the hypothesis of a mainly insider driven wage setting as the main cause for the persistence in German unemployment.

Table 7. Restrictions on the cointegration space of $y_t = (e, p, u, y, w, t, sd91)'_t$

	Cointegration vector							
	e	p	u	y	w	t	$sd91$	LR-test
$\beta_{ld,1}$	1	-1.59	-0.05	-2.77	2.14	0.003	0.27	
$\beta_{ws,1}$	1.08	-1	0.02	-1.39	1	-0.002	0.03	
$\beta_{ld,2}$	1	-1.11	0	-1.71	1.26	0.002	0.10	
		(0.07)		(0.12)	(0.06)	(0.0008)	(0.02)	
$\beta_{ws,2}$	1.08	-1	0.02	-1.39	1	-0.002	0.03	
	(0.07)		(0.004)	(0.10)		(0.0006)	(0.02)	
$\beta_{ld,3}$	1	-0.91	0	-1.49	1.12	0.0008	0.07	
		(0.09)		(0.08)	(0.08)	(0.0005)	(0.01)	
$\beta_{ws,3}$	1.41	-1	0.04	-1.41	1	0.0008	0.07	$\chi^2(1) = 1.01$
			(0.006)	(0.09)		(0.0004)	(0.01)	p-value = 0.31

Note: Standard errors are provided in parenthesis.

To sum up, the system estimate revealed two labor market equilibria, namely a labor demand and a wage setting relation. The parameter estimates appear fairly plausible and are generally consistent with other studies' results.[33] For Germany, Carstensen and Hansen (1998) find three cointegration relations using a different data set. They identify a labor demand and a wage setting relation, which look similar to those found in the present study.[34]

Interestingly, if one conducts an identification procedure with the five variable system, i.e $y = (e, p, u, y, w)'_t$, then assuming a cointegration rank of $r = 2$ gives very much similar results as in the four variable case. As table 7 reveals, a labor demand and a wage setting can be identified as well. These apparently robust results for a cointegration rank $r = 2$ necessitate a few comments on the appropriateness of the cointegration tests used above.

4.3.1 Robustness of the Long Run Results

In the four variable as well as in the five variable system at least two cointegration relations could be identified. A third cointegration vector was indicated by the Johansen test for the five variable case but did not produce any economically plausible equilibria. The cointegrating vectors of a labor demand and a wage setting relation appear to be quite robust. Some experimentation with reducing the sample size as well as reducing the lag length did not destroy the identification of the above labor market equilibria. The same exercise, which revealed the robustness of the equilibrium relations on the other hand generated

[33] Note that estimating the model with hours worked as a proxy for employment instead of the number of persons being employed, does not yield plausible long run relationships. Apparently, the variable hours worked is not able to display the long run properties of the labor market.

[34] Carstensen and Hansen (1998) interpret their third cointegration relation as a goods market equilibrium.

very volatile cointegration test results. Reducing for example the sample size led to results of the Johansen trace test ranging from one to two cointegration relations in the four variable case and from two to three cointegration relations in the five variable case.

This adds up to the conclusion that the cointegration tests have difficulties with the present system of dimension four or five, order five and 120 observations. In fact, according to Doornik et al. (1998) the determination of the cointegration rank remains a subtle task depending on various modeling considerations. Most importantly, the tests are very much influenced by the inclusion of deterministic elements. As Monte Carlo experiments by Doornik et al. (1998) revealed, the Johansen test is somewhat oversized when a trend is restricted to the cointegration relation and a constant enters the system unrestricted. This accounts especially for the case that two cointegration relations in favor of three are rejected a bit too often.[35]

A further problem arises from the inclusion of dummies. Again, Monte Carlo simulations by Doornik et al. (1998) show that the test statistics are heavily oversized when dummies are included into the data generating process. One solution to overcome this problem was already presented in section 4.2 where different critical values were calculated for the case with a dummy. However, the problem of the effect of deterministic parts on the asymptotics of the test statistics does not vanish when considering finite sample cases as in this paper.

The above cited Monte Carlo experiments confirm that especially for samples with less than 150 observations the problem of an increased test size becomes more prominent. In the case of a deterministic trend and more importantly with the inclusion of a step dummy restricted to the cointegration space the Johansen test rejects the hypothesis $r = 2$ far too often, although the true rank is equal to two. The question arises whether the asymptotic corrections for the deterministics as suggested by Johansen and Nielsen (1993) are appropriate for the present finite sample process.

Small sample simulations by Lütkepohl, Saikkonen and Trenkler (2000) indicate that the Johansen test displays a size distortion and rejects far too often in the case of high correlation between the innovations. However, the simulations by Lütkepohl et al. (2000) were not carried out for large systems (dimension and order five) as considered here. The authors refer to a study by Gonzalo and Pitarakis (1999) who find size distortions especially in large systems even without a level shift.

Another distortion to the test statistics that might be relevant is the use of $I(2)$ variables. Doornik et al. (1998) doubt the adequacy of the asymptotic critical values as a guide to finite samples, in particular, in the presence of series that are close to $I(2)$ or $I(2)$. Some small sample corrections have been suggested in the literature, which involves a so-called degrees of freedom correction.[36] The test statistic is scaled by $(1 - ns/T)$ where n is the dimension of the system and s the lag length. The correction increases the acceptance region of the null hypothesis and so less cointegration relations are found like in this study (cf. table 3). The drawback of these corrections is that they are not theoretically founded and in a sense ad-hoc. Therefore the degrees of freedom correction might not work well in practice and the results have to be treated with caution.

To conclude, the Johansen cointegration tests did not produce consistent and robust results. The source of such irregularities remains unclear while a test correction appears questionable. Backed by the SL cointegration test results I will proceed assuming a cointegration rank equal to two in both systems.

[35] Note that the same results apply when the trend is included in the cointegration space but the true data generating process does not contain a deterministic trend. Hence the overspecified model does not harm the results asymptotically as well as for small samples.

[36] This is the test statistics reported in column three of tables 3 and 5. See for example Reimers (1992) for reference.

4.4 The Short Run Analysis: Identification of a Structural VAR

The previous discussion on the robustness of the cointegration results suggests that it might well be adequate to use both systems for the long run analysis. Therefore it does not seem harmful to the examination of the short run to identify the structural VAR in the five variable system. In this section I will study the short run dynamics of the variables employment, prices, unemployment, real output and wages adopting the modeling framework suggested by Dolado and Jimeno (1997)

To understand how the previous section's results are incorporated into the following analysis recall that the reduced form ECM was estimated assuming two cointegration relations given by:

$$\Gamma(L)\triangle y_t = \mu + \gamma d91_t + \alpha\beta' y^*_{t-1} + \epsilon \tag{23}$$

where

$$\Gamma(L) = I - \Gamma_1 L - \ldots - \Gamma_4 L^4$$

and the vector y^*_t containing the deterministic parts restricted to the cointegration space is given by:

$$y^*_t = (e, p, u, y, w, t, sd91)_t$$

The interpretation of the instantaneous relations, i.e. short run dynamics is problematic in a reduced form framework since the correlations are hidden in the covariance matrix of the reduced form residuals. On the other hand a corresponding structural form of the ECM given in equation (23) allows for feedback effects, i.e. for contemporaneously correlated variables. In that sense the structural form represents the complete behavioral relations of the set of variables which will be necessary for the dynamic analysis of section 4.4.1. For that reason it is necessary to recover the structural shocks from the estimated ECM given in equation (23).

The residuals, ϵ_t, of the reduced form ECM estimate are assumed to be linear combinations of the structural disturbances, e_t:

$$\epsilon_t = Ce_t \tag{24}$$

where C is a (5×5) mapping matrix.[37] Equation (24) does not explicitly model the instantaneous relations between the variables but rather shows how the structural shocks, e_t, affect the behavior of the variables. Implicitly these effects are modeled via the inverted matrix C, i.e. $C^{-1}\epsilon_t = e_t$. To recover the structural shocks from the estimate is is necessary to estimate the parameters of the reduced form ECM as well as a matrix C. However, it is only possible to obtain an unique estimate of the 25 elements of the matrix C by imposing enough restrictions on the model.[38] The aim of the structural VAR is to use economic theory to recover the structural shocks form the residuals ϵ_t.

We start by assuming the structural disturbances to be uncorrelated, i.e. orthogonal. Assuming further that the diagonal elements of the covariance matrix are normalized to one implies that $E[e_t e_t'] = I$. Given the covariance matrix of the residuals, Σ, and using (24) still leaves $n(n-1)/2$ restrictions, i.e. ten more restrictions to impose.

The restrictions are derived from the economic model by Dolado and Jimeno (1997) given in section 3. The solution of the model was given in equations (12)-(16) in terms of the shocks to aggregate demand (ϵ_d), technology (ϵ_s), wages (ϵ_w), prices (ϵ_p) and labor supply (ϵ_l). The required restrictions to identify the model can be easily obtained from these equations.

---

[37] This modeling framework corresponds to the C-model as presented by Amisano and Giannini (1997).

[38] In a system of dimension five the number of restriction is given by n^2, i.e. $5^2 = 25$ for the present system.

Table 8. Structural identification estimate (just-identified model)

Equation	$\epsilon = Ce$						
$(y-e)$	$\epsilon_{(y-e)}$	=	$0.008e_s$				
			(15.2)				
$(w-p)$	$\epsilon_{(w-p)}$	=	$0.003e_s$	$+0.007e_w$			
			(4.13)	(15.2)			
p	ϵ_p	=	$-0.002e_s$	$-0.002e_w$	$+0.003e_p$		
			(-5.31)	(-4.85)	(15.2)		
e	ϵ_e	=	$0.0001e_s$	$+0.0003e_w$	$-0.001e_p$	$+0.003e_d$	
			(0.88)	(-0.68)	(-3.12)	(15.2)	
u	ϵ_u	=	$-0.010e_s$	$-0.004e_w$	$-0.006e_p$	$-0.022e_d$	$+0.037e_l$
			(-2.37)	(-0.87)	(-1.44)	(-5.90)	(15.2)

Note: Calculated t-statistics are reported in parenthesis.

From the solution in equations (12)-(16) we know that the demand shock enters the employment as well as the real output equation with the same coefficient. Similarly, this accounts for the wage and the price shock coefficients in those equations. In the wage and the price equation the demand as well as the wage coefficient enter with the same magnitude. The equality restrictions can be transformed into exclusion restrictions by subtracting employment from real output and price from the wage equation, which yields:

$$\begin{aligned} \triangle(y-e) &= -\epsilon_s && (25)\\ \triangle(w-p) &= \epsilon_s - \epsilon_p && (26)\\ \triangle p &= \gamma_1\epsilon_d - \epsilon_s + (1+\gamma_2)\epsilon_p + \epsilon_w && (27)\\ \triangle e &= \phi(1-\gamma_1)\epsilon_d + (\psi-1)\epsilon_s - \psi(1+\gamma_2)\epsilon_p + \psi\epsilon_w && (28)\\ \triangle u &= (1-b)^{-1}\{-\phi(1-\gamma_1)\epsilon_d + [\phi(1+\gamma_2)-c]\,\epsilon_p \\ &\quad +(1+c-\phi)\epsilon_s + \epsilon_l + \phi\epsilon_w\} && (29) \end{aligned}$$

From the above structure of the model it is possible to obtain 9 short run restrictions:

1. ϵ_d does not have an instantaneous effects on productivity $(y-e)$ and real wages $(w-p)$.
2. ϵ_s has no instantaneous effect on the wage share.
3. ϵ_w has no instantaneous effect on productivity and real wages.
4. ϵ_l does not affect y,e,w, and p in the short run.

To satisfy the ten restriction on the matrix C an additional short run restriction is imposed, which assumes that ϵ_d does not affect prices in the initial quarter.[39] This imposes a further zero restriction on the the price equation by assuming the coefficient of ϵ_d, γ_1 being zero.

[39] This has been confirmed empirically by numerous studies. One prominent study by Carlton (1986) on the basis of firm level data shows that prices are indeed sticky in the short run.

Table 9. Structural identification estimate (overidentified model)

Equation	$\epsilon = Ce$				
$(y-e)$	$\epsilon_{(y-e)}$	=	$0.008e_s$		
			(15.2)		
$(w-p)$	$\epsilon_{(w-p)}$	=	$0.003e_s$	$+0.007e_w$	
			(4.13)	(15.2)	
p	ϵ_p	=	$-0.002e_s$	$-0.002e_w$	$+0.003e_p$
			(-5.22)	(-5.65)	(15.2)
e	ϵ_e	=	$-0.001e_p$	$+0.003e_d$	
			(-4.41)	(15.2)	
u	ϵ_u	=	$-0.008e_s$	$-0.022e_d$	$+0,037e_l$
			(-2.23)	(-5.89)	(15.2)
LR Test for 4 overidentifying restrictions: $LR(4) = 5.09$, p-value=0.28					

Note: Calculated t-statistics are reported in parenthesis.

Table 8 reports the estimate of the just-identified C matrix with the associated t-statistics. From the results in table 8 it is evident that most of the coefficients seem plausible from an economic point of view. However, the t-statistics indicate that there are several insignificant parameters in the estimate. Due to the just-identification a test on the overall adequacy of the zero restrictions cannot be conducted.

If more than $n(n-1)/2$ restrictions are imposed these overidentifying restrictions can be tested via a LR test (cf. (Amisano and Giannini, 1997)). All further restrictions are not motivated by economic theory but merely simplify the model by setting the insignificant parameters to zero. The estimate of the overidentified system is given in table 9. The LR test indicates that the overidentifying restrictions cannot be rejected at the 5% significance level.

In this model all parameters are significantly different from zero and their signs are consistent with economic reasoning. The estimate of the instantaneous relations is not sufficient to represent the behavior of the model. Thus in order to fully analyze the short run dynamics impulse-response functions and forecast error variance decompositions are calculated from the estimate. This will be the topic of the next section.

4.4.1 Impulse-Response and Forecast Error Variance Decomposition Analysis

The impulse-response analysis is a device to represent the reaction of each variable to a unit change in one of the other variables. It is therefore a way to display the short run dynamics between the variables. A VAR process can be expressed in its moving average (MA) representation, which allows to trace out the time path of the shocks on the variables contained in the VAR system.

The identification of a structural VAR based on economic reasoning was adopted in section 4.4 and is used here to compute the impulse-responses of the model. Notice that the impulse-responses heavily depend on the restrictions that were imposed on the model structure. If those assumptions are questionable from an economic as well as statistical standpoint the interpretation of the impulse-responses may be misleading.

Amisano and Giannini (1997) argue that one drawback of the VAR modeling that cannot be overcome through the structural VAR is the usual overparameterization of the VAR model. Therefore when calculating the confidence intervals for the impulse-responses it comes at no surprise that they are quite large. In this paper the confidence intervals are calculated by asymptotic theory as suggested by Amisano and Giannini (1997).

The impulse-response functions for the present set of variables are given in figures 3-5. The graphs depict the dynamic responses of each variable to a unit innovation in each identified structural shock. The impact of the different shocks on the variables are interpreted with an emphasis on unemployment.

In figure 3 it can be seen that a productivity shock initially increases productivity. But the effect vanishes (becomes insignificant) after about 10-15 quarters. The initial productivity increase corresponds to a rise in real wages, which is significantly different from zero for about 20 quarters. The graph in figure 3 indicates that productivity gains are translated into price cuts. Employment and unemployment are only affected by a productivity shock in the short run. While employment rises in the first four quarters the reverse is true for the response of unemployment. The impulse-responses show that there is no long run impact of productivity shocks on employment, nor on unemployment. Overall, this suggests that firms and workers might be too slow to adapt to a productivity shock as wages and prices adjust slowly and therefore allow for short run effects on employment and unemployment.[40] The reverse was true for example in the 1970s when negative productivity shocks significantly pushed up unemployment. The results of the impulse-responses of a productivity shock run counter to the findings in Dolado and Jimeno (1997). In the impulse-responses for the Spanish economy productivity shocks lead to an increase in unemployment and to a corresponding decrease in employment in the medium term. Note that Carstensen and Hansen (1998) in agreement with the results presented here find a negative but insignificant impact of technology shocks on unemployment for the German labor market.

According to the impulse-responses, wage shocks have a long run effect on productivity, real wages and prices (cf. figure 3). The wage shock leads to almost similar responses of productivity and real wages both increasing significantly without returning to their pre-shock levels. A wage shock decreases employment and increases unemployment in the initial period, but the effect vanishes after 5-10 quarters (cf. figures 3 and 4). This suggests that wage shocks are only important for an initial unemployment increase but do not exhibit any long run effects. In the long run wage shocks are therefore fully compensated by productivity changes without an effect on the employment situation. The results on wage shocks are in agreement with the findings by Carstensen and Hansen (1998). Dolado and Jimeno (1997), however, find that wage shocks exhibit a long run effect on Spanish unemployment.

Price shocks in my model have a significantly negative impact on productivity and real wages only in the short run. It seems that falling real wages are more than compensated by productivity losses as employment and unemployment are also affected (cf. figure 4). Employment falls due to a price shock while unemployment rises in the medium/long term and returns to its pre-shock level after about 10 years. Higher prices shift labor demand down because firms face increased costs. A shift in labor demand implies lower wages and higher unemployment, which is confirmed by the impulse-responses. We can only speculate on the origin of the price shock. The two oil price crises in the early and late 1970s certainly are the most promis-

[40] If productivity shocks have indeed a short run effect on unemployment the steady rise of the productivity trend suggests indefinitely falling unemployment. The explanation that productivity gains are all compensated by real wage increases does not sound too compelling as well (cf. (Franz, 1995)). Overall, the theoretical and empirical literature on the impact of productivity on unemployment remains puzzling.

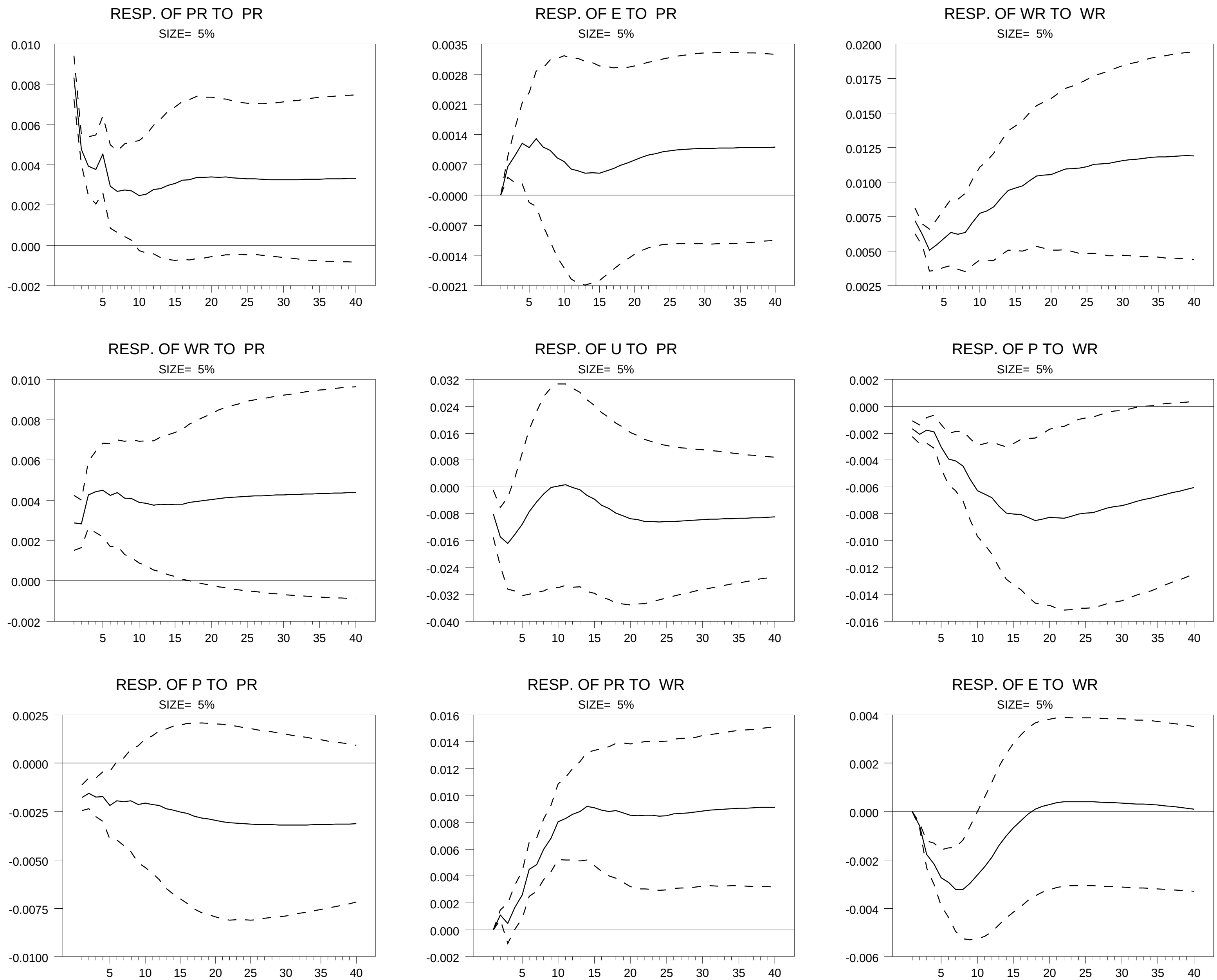

Figure 3. *Responses of the variables productivity* (pr), *real wages* (wr), *prices* (p), *employment* (e) *and unemployment* (u) *to impulses in the respective structural shocks.*

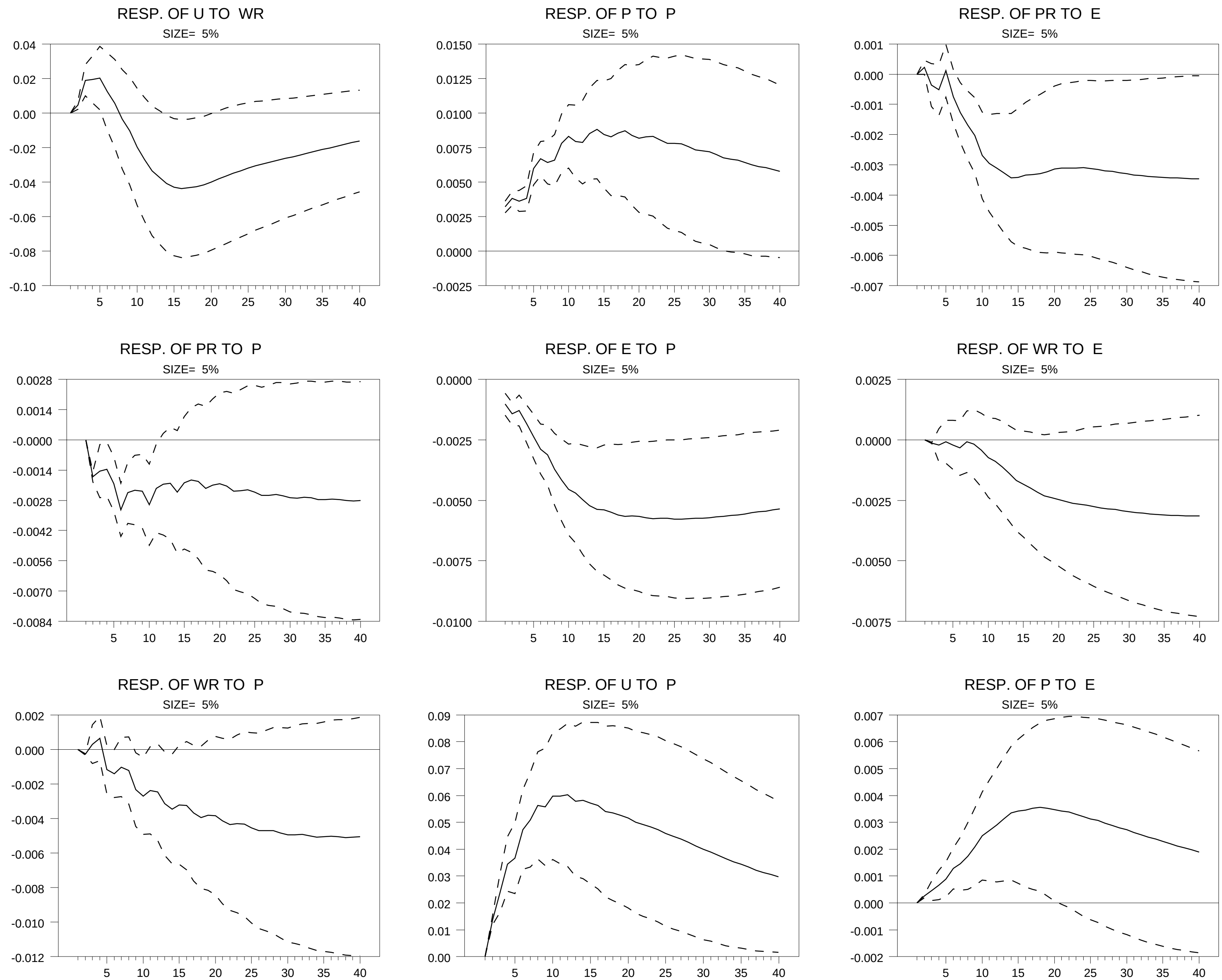

Figure 4. *Responses of the variables productivity (pr), real wages (wr), prices (p), employment (e) and unemployment (u) to impulses in the respective structural shocks (continued).*

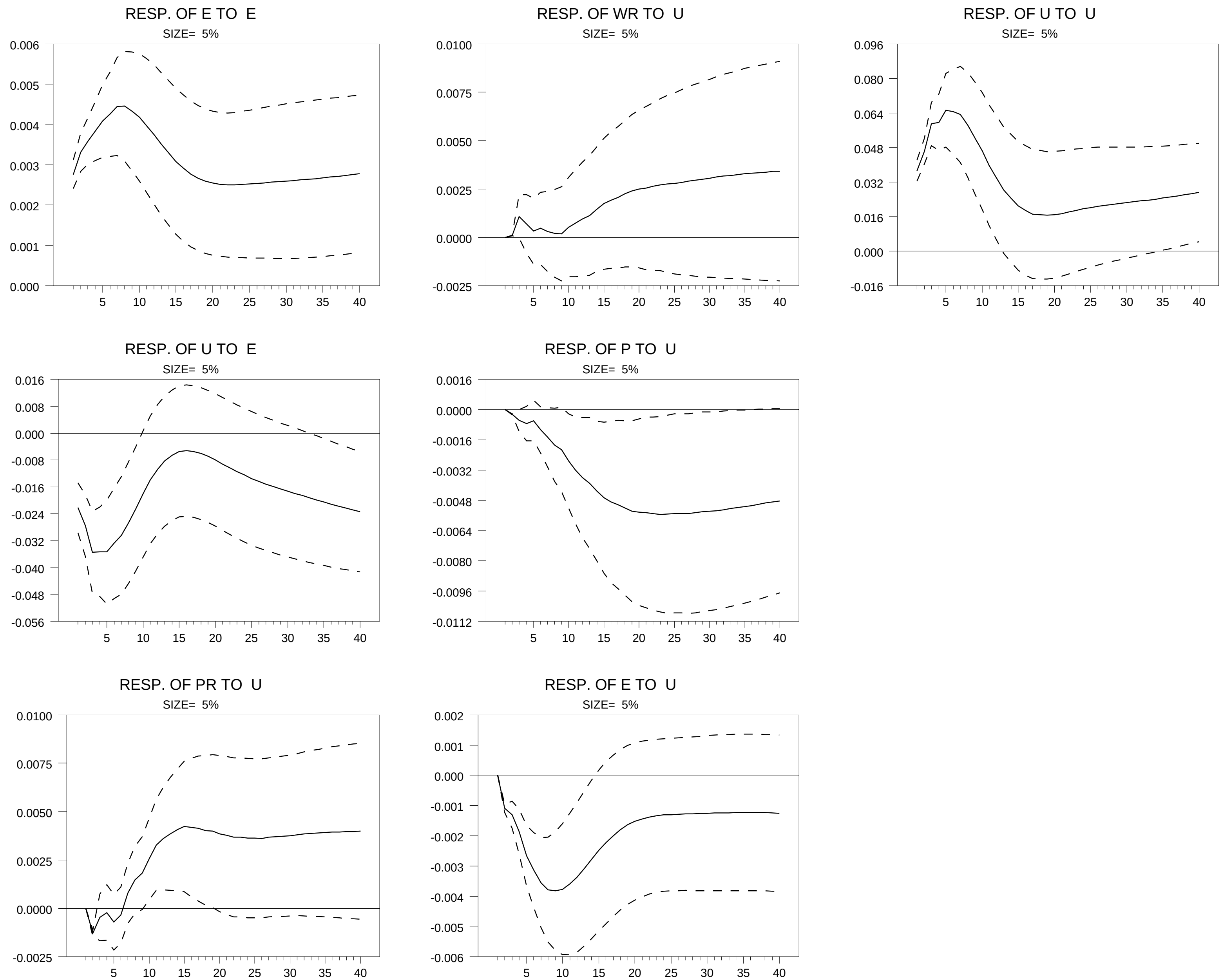

Figure 5. *Responses of the variables productivity* (pr)*, real wages* (wr)*, prices* (p)*, employment* (e) *and unemployment* (u) *to impulses in the respective structural shocks (continued).*

ing candidates. Also interesting in that respect is the discussion of Fitoussi and Phelps (1988). According to the authors higher interest rates may lead firms to increase their markups and hence increase unemployment. It seems plausible that the driving force behind the price shock is the real interest rate. High interest rate affect unemployment further via lowered capital accumulation. It remains unclear, however, which of the above effects is ultimately responsible for increased unemployment. Still, according to this analysis price shocks seem to be a crucial factor for increased and persistent unemployment. The effect of the price shock established here is in perfect agreement with the results of Dolado and Jimeno (1997) for the Spanish economy.

Demand shocks apparently have a negative effect on unemployment in the short/medium run, which is consistent with standard economic theory (cf. figure 5). The more recent work on nominal rigidities is nicely corroborated by the impulse-response analysis. This theory suggests that prices and wages are set in advance, which leads to substantial inertia in those variables. The effect of a demand shock on employment and unemployment depends on the relative speed of adjustment of prices and wages. As the graphs in figure 4 reveal, prices rise gradually in response to a demand shock rather than jumping upward instantaneously. The response of the real wage is not significantly different from zero, which indicates that nominal wages move at the same speed of adjustment, leaving real wages unaffected. Theoretically speaking, when prices and wages adjust slowly, a demand shock leads to an outward shift of the labor demand curve and thus increases employment and decreases unemployment. Once wages and prices have adjusted to the new situation, the effect on unemployment vanishes. This result is confirmed by the findings of Dolado and Jimeno (1997). Their impulse responses for the Spanish economy show that unemployment reacts negatively to a demand shock while real wages remain unchanged. However, their finding of a permanent demand effect is at odds with the results of this paper. My results also contradict the findings of Carstensen and Hansen (1998) who find an initial increase in unemployment, which cannot be reconciled with economic theory.

Finally, labor supply shocks mainly affect employment and unemployment. In fact, a positive shock to labor supply leads to a significant increase in unemployment returning to its pre-shock level after about 15-20 quarters. In contrast, labor supply shocks have permanent effects on unemployment in the studies by Carstensen and Hansen (1998) as well as Dolado and Jimeno (1997). To sum up, the impulse-responses concerning the reaction of the unemployment rate appear to be all consistent with economic theory and give a plausible interpretation.

Another tool for interpreting VAR models is the forecast error variance decomposition (FEVD) providing complementary information for a better understanding of the dynamic behavior of the variables in the system. It is possible to decompose the forecast variance into the contributions by each of the different shocks. Dividing by the overall forecast variance gives the percentage contribution. When calculated by the structural shocks as in the present case, the FEVD provides information on the importance of various structural shocks in explaining the variability of the series. The FEVD depends on the economic identification of the model. Especially in a small macroeconomic model framework as considered here additional variables that possibly affect the system might also change the forecast errors significantly. Therefore the interpretation of the FEVD should always be restricted to the model under consideration.

The FEVD for the unemployment variable is shown in figure 6. From that figure it is possible to conclude that in the present model the forecast variance of the unemployment series is mainly determined by labor supply and to a lesser extent by demand shocks. The importance of demand shocks declines with rising forecast horizon. In contrast, price shocks are irrelevant for the short term prediction while they gain importance when predicting the forecast error variance for more than a year ahead. Productivity and wage shocks only have a negligible but relatively constant influence on the forecast error variance of unemployment

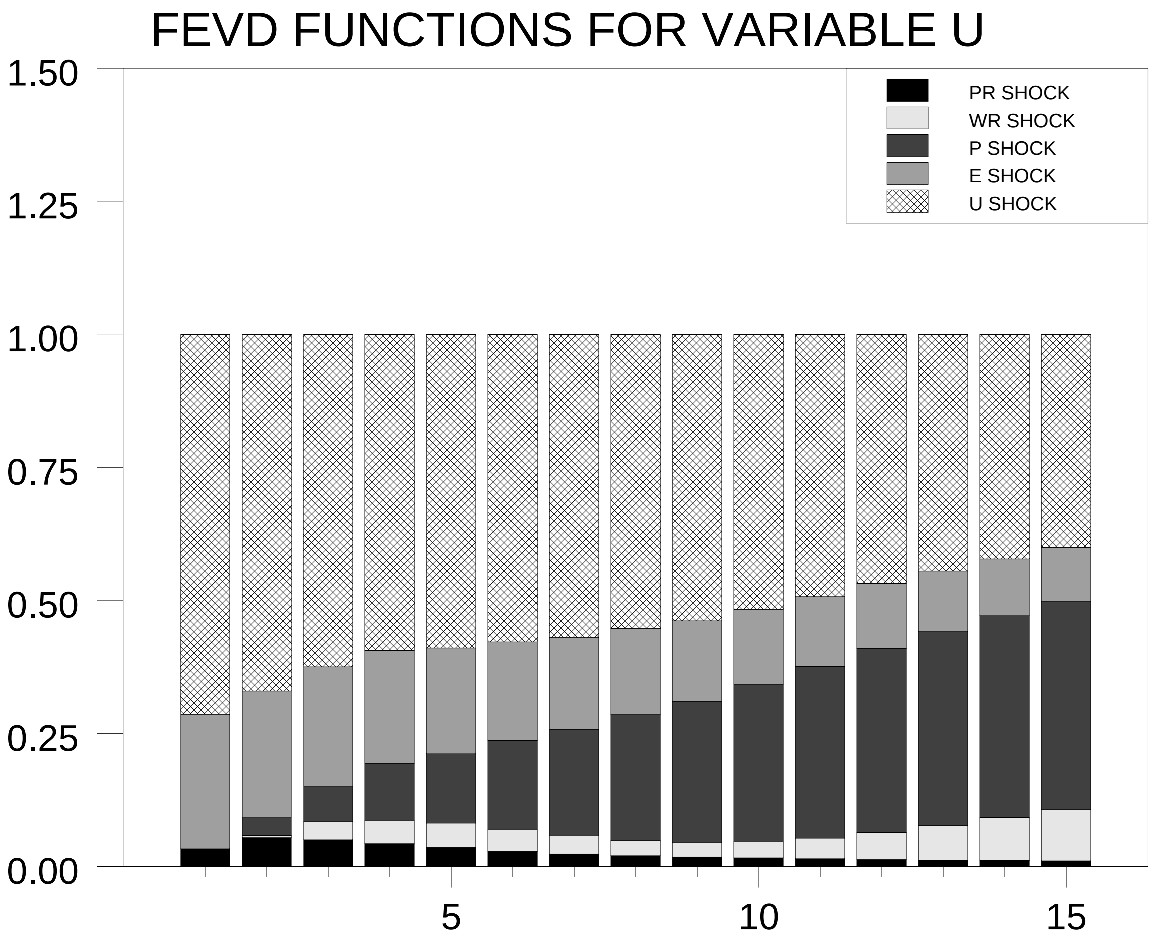

Figure 6. *Forecast error variance decomposition for the unemployment rate.*

Interpreting the results the FEVD suggests that demand shocks account for unemployment fluctuations in short run, which is consistent with standard economic reasoning. In the long run, however, demand factors loose importance and the unemployment variability is predominantly explained by supply factors like labor supply and price shocks. Similar results were obtained for the forecast of Spanish unemployment by Dolado and Jimeno (1997). The authors report the forecast error variance decomposition for the infinite horizon, which reveals that apart from the wage shocks all shocks have similar variance shares.

5 Conclusions

This study was concerned with the questions raised about the shocks that have affected the German labor market, their relative importance in explaining unemployment, the transmission process of the shocks as well as the long run relations that govern the labor market. To answer these questions a structural error correction model has been estimated that was quite successful in giving an economically plausible interpretation of the results.

The estimate of the error correction model revealed that the variables are integrated of order one and jointly cointegrated. The analysis has proven that the determination of the cointegration rank is a subtle task, depending on numerous factors such as the inclusion of a deterministic trend or a dummy variable. The Johansen test indicated three cointegration relations for the five variable system with real output, real wages, prices, employment and unemployment. However, it was not possible to identify these cointegration relations as plausible economic equilibria. Therefore the system was transformed into real variables, dropping the variable prices to yield a cointegration rank equal to two.

Restrictions were imposed on the cointegration relations so as to specify two equilibrium relations that were interpreted as a labor demand and a wage setting schedule. These relationships have been found to be relatively robust even though the unification break was included in the time series. The fact that the unemployment variable enters significantly into the wage setting equilibrium proves that wage setting in Germany contains an outsider component. This rejects the hypothesis of purely insider driven wage bargaining.

Almost identical equilibrium relationships were found in the five variable system under the assumption of a cointegration rank equal to two. This suggests that labor demand and wage setting are robust equilibria in the four as well as the five variable system, although the Johansen cointegration tests may not indicate this clearly. In chapter five I reckoned that the tests are distorted by the use of variables being close to $I(2)$ or $I(2)$ (the wage and the price series) and that the asymptotic distributions of the test statistic may not be valid in the case of a high dimensional, high order and finite sample process as considered in the present study.

In this paper I further identified a structural VAR model of the German economy to gain insights into the contributions of several shocks on unemployment. In particular, shocks to productivity, wages, prices, demand and labor supply were analyzed in terms of their impact on unemployment.

The impulse-response analysis has shown that productivity and wage shocks have only short run effects on unemployment. While a positive productivity shock lowers unemployment within about two to four quarters the reverse is true for a wage shock. A demand shock displays the expected effect as unemployment is significantly lowered in the short/medium run while the effect vanishes in the long run. The impulse-responses confirm that nominal price and wage inertia probably resembles each other since the real wage seems unaffected by a demand shock and facilitate the effect on unemployment. A shock to labor supply significantly increases unemployment over a horizon up to three years. The most persistent effect on unemployment comes from a price shock. A positive price shock leads to an initial rise in unemployment and it takes about 10 years unemployment to return to its pre-shock level. In terms of forecasting unemployment the forecast error variance is mainly explained by labor supply shock and technology shocks.

The following conclusion can be drawn from the foregoing analysis. First, it is too simple to blame high wages for unemployment in Germany. Wage shocks have been demonstrated to be of only of minor importance in explaining unemployment fluctuations and also affect unemployment in the short run. Second, demand shocks appear to be an important short/medium run determinant of unemployment. Third, price shocks have played a dominant role explaining shocks to unemployment but also display a persistent impact. Assuming prices and interest rates to have similar effects on unemployment, lowering interest rates could probably boost investment and thus lower unemployment significantly.

Explaining the German unemployment experience by shocks is certainly not the whole story. As mentioned in section two there are large differences in unemployment across regions in Germany, which are hard to reconcile with macroeconomic shocks that should affect the entire economy homogeneously. Also the mechanisms that keep unemployment from falling remain to be explained. The shocks can probably account for the common movements in unemployment but cannot explain why different regions react so differently to those shocks and why certain groups in the labor market are affected by unemployment more than others. These differences can only be explained by individual and societal values as well as institutions that govern the labor market and the economy as a whole. Nevertheless, so far there is no unequivocal evidence that institutional factors can account for the persistence in unemployment.

What policy conclusions can be drawn from the foregoing analysis? Many economists favor a so-called two handed approach. Demand management policies appear appropriate to achieve a short run softening of the labor market situation. The European Central Bank can help by lowering interest rates to stimulate investment and growth at the costs of accepting slightly higher inflation. On the other hand, policies must be directed towards increasing investment incentives in the product market by removing overly restrictive barriers to investment and encouraging a competitive economic environment. The result that productivity shocks have a short run effect on unemployment suggests that government programs to stimulate R&D investments are helpful as well.

Further research will be necessary to strengthen and to extend the results of the present paper. My particular interest lies in the role of the central bank and its monetary policy on the labor market. To include the monetary sector, more variables ought to be incorporated into the model. This will be a challenging task. Moreover, microeconometric research directed toward the incentive structure of the unemployed will be useful in establishing an overall explanation for German unemployment including shocks as well as individual and institutional constraints.

References

Amano, R. A. and Wirjanto, T. S. (1997). An empirical study of dynamic labor demand with integrated forcing processes, *Journal of Macroeconomics* **19**: 697–715.

Amisano, G. and Giannini, C. (1997). *Topics in Structural VAR Econometrics*, second edn, Springer, Berlin.

Bean, C. R. (1994). European unemployment: A survey, *Journal of Economic Literature* **32**: 573–619.

Berthold, N. and Fehn, R. (1996). Arbeitslosigkeit oder ungleiche Einkommensverteilung - ein Dilemma, *Aus Politik und Zeitgeschichte - Beilage zur Wochezeitung Das Parlament* **B26**: 14–24.

Blanchard, O. J. (1989). A traditional interpretation of macroeconomic fluctuations, *American Economic Review* **79**: 1146–1164.

Blanchard, O. J. and Quah, D. (1989). The dynamic effects of aggregate supply and demand disturbances, *American Economic Review* **79**: 655–673.

Blanchard, O. J. and Summers, L. H. (1986). Hysteresis and the European unemployment problem, *NBER Macroeconomics Annual* pp. 15–78.

Blanchard, O. J. and Wolfers, J. (2000). The role of shocks and institutions in the rise of European unemployment: The aggregate evidence, *The Economic Journal* **111**: 1–33.

Bundesanstalt für Arbeit (1997). *Der Arbeitsmarkt*, Nürnberg.

Carlton, D. (1986). The rigidity of prices, *American Economic Review* **76**(4): 637–658.

Carstensen, K. and Hansen, G. (1998). Cointegration and common trends on the German labour market, *Working Paper 117*, Institut für Statistik und Ökonometrie, Universität Kiel.

Carstensen, K. and Hansen, G. (2000). Cointegration and common trends on the West German labour market, *Empirical Economics* **25**: 475–493.

Cohen, D., LeFranc, A. and Saint-Paul, G. (1997). French unemployment: Why France and the USA are alike, *Economic Policy* pp. 267–291.

Dolado, J. J. and Jimeno, J. F. (1997). The causes of Spanish unemployment: A structural VAR approach, *European Economic Review* **41**: 1281–1307.

Doornik, J., Nielsen, B. and Hendry, D. (1998). Inference in cointegrating models: UK M1 revisited, *Journal of Economic Surveys* **12**: 533–572.

Eurostat (1997). *Labour Force Survey*, http://europa.eu.int/comm/eurostat/eurostat.html.

Fitoussi, J.-P. and Phelps, E. S. (1988). *The Slump in Europe*, Basil Blackwell, Oxford, New York.

Fortin, N. and Lemieux, T. (1997). Institutional changes and rising wage inequality: Is there a linkage, *Journal of Economic Perspectives* **11**: 75–96.

Franz, W. (1995). Theoretische Ansätze zur Erklärung der Arbeitslosigkeit: Wo stehen wir 1995?, *Diskussionspapier 27-1995*, Fakultät Wirtschaftswissenschaften Universiät Konstanz.

Gali, J. (1992). How well does the IS-LM model fit postwar U.S. data?, *Quarterly Journal of Economics* **107**: 709–738.

Giannini, C., Lanzarotti, A. and Seghelini, M. (1995). A traditional interpretation of macroeconomic fluctuations: The case of Italy, *European Journal of Political Economy* **11**: 131–155.

Godfrey, L. (1978). Testing for higher order serial correlation in regression equations when the regressors include lagged dependent variables, *Econometrica* **46**: 1303–1310.

Gonzalo, J. and Pitarakis, J. (1999). Dimensionality effects on cointegration analysis, *in* R. Engle and H. White (eds), *Cointegration, Causality, and Forecasting: A Festschrift in Honour of Clive W.J. Granger*, Oxford University Press, pp. 212–229.

Gottschalk, P. and Smeeding, T. (1997). Cross-national comparisons of earnings and income inequality, *Journal of Economic Literature* **35**: 633–687.

Hansen, G. (2000). The German labour market and the unification shock, *Economic Modelling* **17**: 439–454.

Howell, D. R., Duncan, M. and Harrison, B. (1998). Low wages in the US and high unemployment in Europe: A critical assessment of the conventional wisdom, *Working Paper 5*, Center for Economic Policy Analysis, New York.

Hunt, J. (1995). The effect of unemployment compensation on unemployment duration in Germany, *Journal of Labor Economics* **13**(1): 88–120.

Jacobson, T., Vredin, A. and Warne, A. (1997). Common trends and hysteresis in Scandinavian unemployment, *European Economic Review* **41**: 1781–1816.

Jacobson, T., Vredin, A. and Warne, A. (1998). Are real wages and unemployment related?, *Economica* **65**: 69–96.

Johansen, S. and Juselius, K. (1994). Identification of the long run and the short run structure: An application to the IS/LM model, *Journal of Econometrics* **63**: 7–36.

Johansen, S. and Nielsen, B. (1993). *Asymptotics for Cointegration Rank Tests in the Presence of Intervention Dummies - Manual for the Simulation Program DisCo*.

Krugman, P. (1994). Past and prospective causes of high unemployment, *in* Federal Reserve Bank of Kansas City (ed.), *Reducing Unemployment*, pp. 68–81.

Layard, R. G. and Nickell, S. J. (1985). Unemployment, real wages and aggregate demand in Europe, Japan and the United States, *Carnegie-Rochester Conference Series on Public Policy* **23**: 143–202.

Levy, F. and Murnane, R. (1992). US earnings levels and earnings inequality: A review of recent trends and proposed explanations, *Journal of Economic Literature* **30**: 1333–1381.

Lindbeck, A. (1992). Macroeconomic theory and the labor market, *European Economic Review* **36**: 209–235.

Lütkepohl, H. (1993). *Introduction to Multiple Time Series Analysis*, second edn, Springer Verlag, Berlin.

Lütkepohl, H., Saikkonen, P. and Trenkler, C. (2000). Comparison of tests for the cointegration rank of a VAR process with a structural shift, *Discussion Paper 10*, SFB 337, Humboldt Universität Berlin.

MacKinnon, J. (1991). Critical values for co-integration tests, *in* R. Engle and C. Granger (eds), *Long-Run Economic Realtionships*, Oxford University Press, pp. 267–276.

Manning, A. (1993). Wage bargaining and the Phillips curve: The identification and specification of aggregate wage equations, *Economic Journal* **103**: 98–118.

Martin, J. P. (1994). The extent of high unemployment in OECD countries, *in* Federal Reserve Bank of Kansas City (ed.), *Reducing Unemployment*, pp. 5–40.

Mayer, H.-L. (1990). Entwicklung und Struktur der Erwerbslosigkeit, *Wirtschaft und Statistik* **1**: 16–30.

Mosconi, R. (1998). *MALCOLM (MAximum Likelihood COintegration analysis of Linear Models) The theory and practice of cointegration analysis in RATS*, Cafoscarina.

Nickell, S. and Bell, B. (1996). Changes in the distribution of wages and unemployment in the OECD countries, *American Economic Review* **86**(2): 302–308.

Nickell, S. J. (1997). Unemployment and labor market rigidities, *Journal of Economic Perspectives* **11**(3): 55–74.

Nielsen, B. (1994). *DisCo*, Institute of Mathematical Statistics, University of Copenhagen.

Osterwald-Lenum, M. (1992). A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics: Four cases, *Oxford Bulletin of Economics and Statistics* **54**(3): 461–472.

Patterson, K. (2000). *An Introduction to Applied Econometrics: A Time Series Approach*, Macmillan Press Ltd.

Perron, P. (1989). The great crash, the oil price shock and the unit root hypothesis, *Econometrica* **57**: 1361–1401.

Reimers, H. (1992). Comparisons of tests for multivariate cointegration, *Statistical Papers* **33**: 335–359.

Saikkonen, P. and Lütkepohl, H. (2000). Testing for the cointegration rank of a VAR process with structural shifts, *Journal of Business and Economic Statistics* **18**(4): 451–464.

Siebert, H. (1997). Labor market rigidities: At the root of unemployment in Europe, *Journal of Economic Perspectives* **11**(3): 37–54.

Steiner, V. (1997). Unemployment duration in Germany, *Diskussionspapier 14*, ZEW.

Tyrväinen, T. (1995). Wage setting taxes and demand for labor: Multivariate analysis of cointegrating relations, *Empirical Economics* **20**: 271–297.