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Sources of German Unemployment: Evidence from a Structural VAR Model

Tobias Linzert

Non-Technical Summary

The problem of high and persistent unemployment belongs doubtlessly to one of the most debated economic issues in Germany. The unfavorable evolution of the German unemployment rate is quite striking. After a period of negligible unemployment in the 1960s and the beginning of the 1970s, the unemployment rate more or less trended upward ever since. This paper addresses the question what role macroeconomic shocks play in explaining the historical record of the unemployment rate.

Starting point of the present analysis is a small macroeconomic model as introduced by Dolado and Jimeno (1997). The objective of the model is to determine the shocks that might affect the labor market equilibrium. In particular, the model is solved as to express the variables productivity, real wage, prices, employment and unemployment solely in terms of shocks to technology, wages, prices, aggregate demand and labor supply.

The empirical part of the present paper is devoted to reveal the impact of the above mentioned shocks on unemployment as well as their relative importance in explaining the unemployment rate. A structural VAR model is estimated using data from 1969:1 to 1998:4 to relate the shocks to the evolution of unemployment. Since the German data has been found to be cointegrated, it is possible to incorporate the additional information gained from the long run relationships. Thus, two identification problems are solved in this paper. First, the cointegrating vectors are identified and interpreted as long run economic equilibria. Second, using the residuals from the error correction estimation, the structural VAR is identified exploiting the restrictions derived from the macroeconomic model.

The results indicate that two economically meaningful long run equilibria exist in the data, namely a labor demand and a wage setting scheme. The dynamics of the model are displayed by means of impulse response functions and the forecast error variance decomposition. Technology and wage shocks were found to exhibit only short run effects on unemployment. 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. A shock to labor supply significantly increases unemployment over a horizon up to three years. Price shocks exhibit the most persistent effect on unemployment with unemployment returning to its pre-shock level after 6 years. The forecast error variance is mainly explained by labor supply, price and demand shocks.

Although macroeconomic shocks may very well account for rising unemployment and its persistence, the analysis also points to open questions. While the responses of the unemployment rate to the shocks under study seem economically plausible, the stylized fact of differences in the unemployment rate across regions and demographic groups in Germany are hard to reconcile with a pure macro-based explanation.

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Abstract

This paper analyzes the dynamic effects of different macroeconomic shocks on unemployment in Germany. In a first step, a cointegration analysis of productivity, prices, real wages, employment, and the unemployment rate reveals two long run relationships, interpreted as a labor demand and a wage setting scheme. Secondly, a structural VAR model is identified using the restrictions suggested by a single macroeconomic model. The impulse response analysis and the forecast error variance decomposition display that price, demand, and labor supply shocks affect unemployment significantly in the short/medium run. Interestingly, however, wage and technology shocks do not seem to play a dominant role.

Keywords: Unemployment, Structural VAR, Cointegration
JEL classification: J60, E24

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1 Introduction

In Germany, the unemployment rate is one of the most discussed economic indicator and its development is followed with great attention by the media and the public. The particularly high interest in the unemployment problem stems from persistent labor market slack in Germany. In fact, unemployment rose since the early 1970s reaching a historical record of almost 12% in 1998. In contrast, the US unemployment rate follows a rather cyclical pattern, i.e. unemployment more or less fluctuates around a non-zero mean. It seems that a thorough understanding of the dynamics of unemployment is important to draw the appropriate conclusions for economic policy. To that aim, this paper investigates the dynamics of unemployment and tries to shed more light on the possible sources of high and persistent unemployment in Germany.

After the oil price shocks and the productivity slowdown in the 1970s the importance of shocks for the labor market is widely acknowledged.[1] In that sense, macroeconomic shocks propagated in the labor market may be part of an explanation for rising unemployment in Germany (Blanchard and Wolfers, 2000). The objective of the present study is, therefore, to analyze the impact of shocks to technology, wages, prices, aggregate demand, and labor supply on unemployment and their relative importance for the rise in the unemployment rate. The natural framework to investigate the role of shocks to the labor market and their possible persistence is a structural VAR model.[2] The structural VAR approach is particularly suited to account explicitly for the contemporaneous interactions among the variables. Unlike the traditional VAR framework, a corresponding structural VAR uses restrictions from a macroeconomic model to give a distinct behavioral interpretation to the dynamics of the system. Therefore, the structural VAR allows to examine how certain macroeconomic shocks are propagated in the economy.

The present analysis builds on Dolado and Jimeno (1997) who estimated a structural VAR for the Spanish economy. Despite the common theoretical setup, the empirical part of this paper differs in an important aspect. Whereas Dolado and Jimeno (1997) did not find any long run relationships in the Spanish data and, thus, estimated a structural VAR in first differences, the relevant macroeconomic variables, i.e. productivity, prices, real wages, employment, and unemployment are cointegrated in Germany. In line with earlier findings by Carstensen and Hansen (2000) for West-Germany, there are two cointegration relations identified as a labor demand and a wage setting scheme. Consequently, one has to estimate an error correction

[1] See Lindbeck (1992) and Bean (1994) for surveys on the theory of unemployment and the role of shocks for the labor market.

[2] See Bernanke (1986), Blanchard and Watson (1986) or Blanchard and Quah (1989) for early applications of the structural VAR method.

model first to account for the equilibrium relationships in the system (Giannini, Lanzarotti and Seghelini, 1995). The cointegrated structural VAR not only increases the efficiency of the estimate but also enhances the economic interpretation of the empirical results.

The remainder of the paper is structured as follows. The next section briefly reviews some stylized facts about unemployment in Germany in order to impart an impression on possible shocks that might have affected the labor market. A small macroeconomic model suggested by Dolado and Jimeno (1997) is presented in Section 3. Section 4 illustrates the structural VAR approach and Section 5 presents the empirical results of the paper. Having analyzed the long run relationships, a structural ECM estimate displays the dynamics of the model by means of impulse response functions and the forecast error variance decomposition. A summary of the main results and some conclusions are given in Section 6.

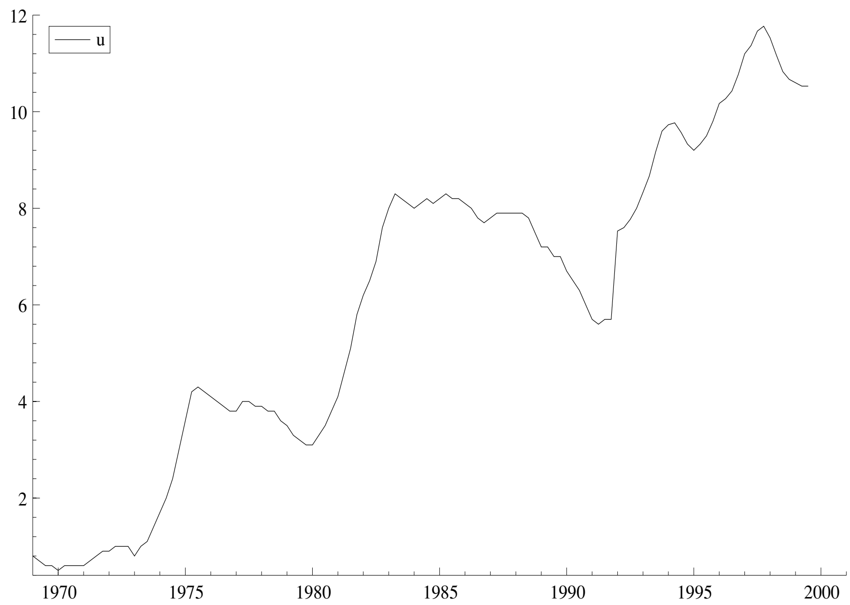
2 Unemployment in Germany

After more than a decade of negligible unemployment in the 1960s, unemployment in Germany has been rising dramatically since the early 1970s. Today, the unemployment rate is ten times larger than in the beginning of the 70s. To get a clearer picture of the historical record, this section provides some stylized facts. Figure 1 shows the evolution of unemployment in Germany. Apparently, the course of the German unemployment rate 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.

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. Moreover, 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 reduce inflation. By the end of the 1970s, however, unemployment decreased mildly.

In the early 1980s the second oil price shock struck the German economy when the oil price increased by 24% in 1979. Women's labor force participation rose considerably during the 1980s. Overall this period was characterized by low growth boosting unemployment up to 9%. By the mid 1980s Germany started to recover from the recession relaxing the situation on the labor

Figure 1. Unemployment rate for Germany



Notes: The unemployment rate is expressed in terms of the civilian labor force. From 1991:1 the data refers to unified Germany. Data source: OECD

market.

In 1990 the German unification took place and the economy, in particular the West-German economy was booming as Gross Domestic Product (GDP) soared 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. Especially the transition process of the East-German economy forced many businesses to layoff large parts of their workforce.

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 30% in 1997 (Bundesanstalt für Arbeit, 1997). Long term unemployed persons exhibit quite specific characteristics. Older persons, women and persons without an apprenticeship are more likely to be unemployed longer than a year than others.[3] Also striking in this respect is the average duration of unemployment, which

[3] See Hunt (1995) and Steiner (1997) for microeconometric studies on the duration of unemployment.

amounted to 32 weeks in 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%.

While regional diversity and differences across demographic groups are interesting features of German unemployment, they are beyond the scope of the macroeconomic approach of this paper. To wind up, Germany's unemployment rate is hit by several macroeconomic shocks leading to an overall rise in unemployment. The corresponding increase in long term unemployment shows that the unemployment rate is unable to return to its pre-shock level. To analyze the shocks that have led to rising unemployment in Germany the next section introduces a macroeconomic model as a framework for the following empirical analysis.

3 A Small Macroeconomic Model

The theoretical framework for the following empirical analysis is the augmented Blanchard and Quah (1989) model by Dolado and Jimeno (1997). The objective of the model is to determine the shocks that might affect the labor market equilibrium. The shocks are defined as shocks to technology, nominal wages, prices, aggregate demand, and labor supply.

The Dolado and Jimeno (1997) model starts with the following three equations:

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

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

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

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 an aggregate demand function with $\phi > 0$ just described by an aggregate demand index (d). The production function given in Equation (2) assumes constant returns to scale and labor augmenting technical progress is modelled 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. Equation (3) represents a so-called price setting scheme in an imperfect competitive framework. In line with e.g Bean (1994) the price is set by firms allowing for a non zero markup over costs.

Dolado and Jimeno (1997) further characterize the supply side of the model by:

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

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

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

Equation (4) is a labor supply (l) function expressed in terms of the real wage ($w-p$), unemployment (u) and a stochastic shift parameter (τ). The labor supply relation is augmented by a wage setting function given in Equation (5) where w^* denotes the targeted nominal wage and ϵ_w, ϵ_d and ϵ_p are *i.i.d.* shocks to wages, demand and prices that are further defined below. "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 targeted nominal wage is determined by Equation (6). According to the standard model of insider-outsider wage bargaining the wage is set depending on the expectations with respect to labor demand as in Equation (6), (Blanchard and Quah, 1989).

Finally, the stochastic processes governing the evolution of shocks are specified assuming all to 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, technology, prices, and labor supply.

Solving the model under the full hysteresis assumption ($\lambda = 0$) yields the following system, in which the variables can be expressed purely through structural shocks:

$$\begin{aligned}
\triangle e &= \phi(1-\gamma_1)\epsilon_d + (\phi-1)\epsilon_s - \phi(1+\gamma_2)\epsilon_p - \phi\epsilon_w && (11)\\
\triangle y &= \phi(1-\gamma_1)\epsilon_d + \phi\epsilon_s - \phi(1+\gamma_2)\epsilon_p - \phi\epsilon_w && (12)\\
\triangle w &= \gamma_1\epsilon_d + \gamma_2\epsilon_p - \phi\epsilon_w && (13)\\
\triangle p &= \gamma_1\epsilon_d - \epsilon_s + (1+\gamma_2)\epsilon_p - \phi\epsilon_w && (14)\\
\triangle u &= (1-b)^{-1}\{-\phi(1-\gamma_1)\epsilon_d + [\phi(1+\gamma_2) - c]\,\epsilon_p \\
&\quad +(1+c-\phi)\epsilon_s + \epsilon_l + \phi\epsilon_w\} && (15)
\end{aligned}$$

According to Equations (11)-(15), 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. Technology shocks (ϵ_s) in this model depend on the size of parameter ϕ. If $\phi > 1$ then output and employment rise while unemployment will rise if $\phi < 1$.

The next section describes the econometric approach to analyze the dynamics of the above macroeconomic model. It will be shown how the theoretical model is used to obtain the required restrictions for a structural VAR estimate.

4 The Structural VAR Model

To analyze the structural shocks within a statistical model the following VAR process is considered:[4]

$$A(L)x_t = \nu_t \tag{16}$$

where x_t is a vector of time series including $[y-e, p, w-p, e, u]$, $A(L)$ is a matrix of polynomials in the lag operator L, and ν_t is a vector of $i.i.d$ residuals with covariance matrix Σ_ν.

The interpretation of the instantaneous relations is problematic in such a reduced form framework since the correlations are hidden in the covariance matrix of the reduced form residuals. In contrast, a corresponding structural form of the VAR in Equation (16) allows for feedback effects, i.e. for contemporaneous interactions between the variables. The associated residuals, i.e. structural shocks exhibit the unexpected autonomous changes in x_t in period t. In that sense, the structural form represents the complete behavioral relations of the set of variables which will be exploited for the dynamic analysis of Sections 5.2.1 and 5.2.2.

To recover the structural shocks from the residuals of the reduced form ECM estimate, the residuals, ν_t, are assumed to be linear combinations of the structural disturbances, ϵ_t:

$$\nu_t = C\epsilon_t \tag{17}$$

where C is assumed to be an invertible (5×5) mapping matrix to be estimated.[5] 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.[6]

[4] See Breitung (1998) and Favero (2001) for an introduction to structural VAR econometrics.
[5] This modelling framework corresponds to the C-model as presented by Amisano and Giannini (1997).
[6] In a system of dimension n, the number of restrictions is given by n^2, i.e. $5^2 = 25$ for the present system.

The structural disturbances are assumed to be orthonormal implying $E[\epsilon_t \epsilon_t'] = I$. Given the covariance matrix of the residuals, Σ, and using Equation (17) implicitly imposes a set of $n(n+1)/2$ restrictions. Given also the total number of necessary restrictions, n^2, still leaves $n(n-1)/2$ restrictions, i.e. ten more restrictions to impose. Notice that the restrictions on the matrix C do not necessarily have a triangular form but may have non-recursive structures as long as they satisfy the order and rank criterion (Amisano and Giannini, 1997).

The restrictions in this paper are derived from the economic model given in Section 3. From the solution in Equations (11)-(15) we know that the demand shock (ϵ_d) enters the employment as well as the real output equation with the same coefficient. Similarly, this accounts for the wage (ϵ_w) and the price shock (ϵ_p) coefficients in those equations. In the wage and the price equation the demand as well as the wage shock coefficient enter with the same magnitude. These equality restrictions can be transformed into exclusion restrictions by subtracting the employment from the real output and the price from the wage equation, which yields:

$$\triangle(y-e) = \epsilon_s \tag{18}$$

$$\triangle(w-p) = \epsilon_s - \epsilon_p \tag{19}$$

$$\triangle p = -\epsilon_s + (1+\gamma_2)\epsilon_p + \epsilon_w + \gamma_1 \epsilon_d \tag{20}$$

$$\triangle e = (\psi - 1)\epsilon_s - \psi(1+\gamma_2)\epsilon_p + \psi\epsilon_w + \phi(1-\gamma_1)\epsilon_d \tag{21}$$

$$\begin{aligned} \triangle u = {} & (1-b)^{-1}\{(1+c-\phi)\epsilon_s + [\phi(1+\gamma_2) - c]\,\epsilon_p \\ & + \epsilon_l + \phi\epsilon_w - \phi(1-\gamma_1)\epsilon_d\} \end{aligned} \tag{22}$$

From the above structure of the model it is possible to obtain 9 contemporaneous (within 1 quarter) restrictions:

1. ϵ_d (demand shock) does not have an instantaneous effect on productivity $(y-e)$ and real wages $(w-p)$.
2. ϵ_p (price shock) has no instantaneous effect on $y-e$.
3. ϵ_w (nominal wage shock) has no instantaneous effect on $y-e$ and $w-p$.
4. ϵ_l (labor supply) does not affect $y-e$, $w-p$, p, and e in the short run.

These restrictions can be understood as firms and wage setters responding with a delay of one quarter to changes in the overall economic environment which is reasonable to assume. To satisfy the requirement to impose ten restrictions on the matrix C it is additionally assumed that ϵ_d

does not affect prices in the initial quarter.[7]

Usually structural VARs are estimated in levels of the data series if stationary and in first differences if non-stationary. This kind of procedure is justified since an estimation of a VAR with integrated time series is consistent regardless of whether the series are cointegrated. If, however, the data is cointegrated, one may want to include the additional information gained from the long run relationships. Indeed, it is possible to reconcile both approaches, the cointegration and the structural VAR analysis, by simply solving two identification problems (Giannini et al., 1995). First, the cointegrating vectors are identified and a properly defined error correction model is estimated. Second, the residuals from the ECM estimation are used to identify the structural shocks.

Before turning to the estimation of the structural VAR it is necessary to obtain an efficient estimate of the reduced form residuals. Since neglecting the long run properties would harm the efficiency of the estimate, the next section analyzes the cointegration properties of the above set of variables.

5 Empirical Results

5.1 The Long Run Relationships: Cointegration

The purpose of this section is to specify and to estimate an error correction model to reveal the long run behavior 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 series of productivity $(y - e)$, prices (p), real wages $(w - p)$, employment (e) and the unemployment rate (u). The seasonally adjusted quarterly data series range from 1969:1 to 1998:4 (see Appendix A). All series were clearly I(1) except the price variable was borderline I(1)/I(2).[8]

Inference on the cointegration rank is drawn using the Johansen test procedure where a deterministic trend and a step dummy have been restricted to the cointegration space.[9] An impulse dummy enters the model unrestrictedly. The usual asymptotic reference distributions are not

[7] 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.

[8] This is a well known problem in the empirical literature as inflation rates are well described by different orders of integration depending on the sample range, see Hassler and Wolters (1995). The unit root results are available on request.

[9] If the trend is not restricted it would be possible to generate quadratic trends, which seems inadequate for the present set of variables. Moreover, 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.

Table 1. Trace test for the cointegration rank of $x_t = (y - e, p, w - p, e, u)'_t$

H_0: rank=r	Test statistic $-T\sum log(.)$	Critical values by Osterwald-Lenum (1992)	Simulated critical values (95% quantiles)
r=0	139.5**	87.3	98.28
r≤1	86.08**	63.0	72.15
r≤2	43.25	42.4	49.72
r≤3	23.47	25.3	31.02
r≤4	8.064	12.3	15.53

Notes: ** and * denote significance at the 1% and 5 % level respectively. Critical values were simulated according to Nielsen (1994). The error correction model subject to the cointegration test is given by: $\Gamma(L)\triangle x_t = \mu + \gamma d91_t + \alpha\beta' x^*_{t-1} + \nu_t$, where $\Gamma(L) = I - \Gamma_1 L - \ldots - \Gamma_4 L^4$ and $x^*_t = (y-e, p, w-p, e, u, t, sd91)'_t$. Notice that the lag order has been chosen according to the usual lag selection criteria and to the results of the VAR equation residual analysis. See Table 4 in Appendix A for data definitions.

appropriate in this case. Therefore the correct critical values were obtained simulating 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 (Johansen and Nielsen, 1993). The test results are reported in Table 1 and indicate a cointegration rank of two.

Additional evidence comes from the Saikkonen and Lütkepohl (2000) (henceforth SL) test. This test is directed to the application in the case of cointegrated time series with a structural shift. The SL-test finds also two cointegration relations (cf. Table 4 in Appendix B).

To give a distinct economic interpretation to the long run structure of the vector $x_t = (y-e, p, w-p, e, u)'_t$ it is necessary to identify the cointegrating vectors. The mere estimation of the ECM gives the maximum likelihood estimates of the unrestricted cointegrating relations and is therefore useless in terms of an economic interpretation. Just-identification of the cointegration relations requires to impose one normalization and additional $(r-1)$ restrictions on each cointegrating vector (Johansen and Juselius, 1994).

Labor market theory suggests that in a labor market there will be a labor demand and a wage setting relation, see e.g. Bean (1994).[10] A general specification of a labor demand schedule is

[10] There has been a huge empirical research effort to analyze the specification of labor demand and wage setting. See for example Manning (1993), Tyrväinen (1995), Andersen and Hylleberg (1998) and for Germany Hansen (2000).

given by:

$$e_t = \beta_{1,0} + \beta_{1,1} y_t + \beta_{1,2}(w-p)_t + \beta_{1,3} z_t + \nu_{1,t} \tag{23}$$

where z_t summarizes all variables that might influence the labor demand e.g. technological progress, raw material prices, other intermediate input prices, import prices, interest rates, etc. The wage setting relation can be derived from a maximization problem of a representative household. In an aggregate form the relation can be written as:

$$(w-p)_t = \beta_{2,0} + \beta_{2,1} u_t + \beta_{2,2}\beta_{2,3} z_t + \nu_{2,t} \tag{24}$$

where z_t captures all other variables that have an influence on the wage setting. In this setup the real wage is also related to the unemployment rate reflecting the impact of the outsiders on the wage setting process (Hansen, 2000).

Table 2 reports the results of the identification procedure. The first hypothesis is to find a labor demand relation. Thus, the first cointegrating vector is normalized on the productivity variable. While unemployment is assumed not to affect the labor demand, all further variables are not restricted at this stage. The second equilibrium that is reckoned to be found is a wage setting 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 unrestrictedly.

In the case of overidentification the restrictions on the parameter space can be tested. The results are also shown in Table 2. The two economic plausible equilibrium relationships, i.e. a labor demand and a wage setting scheme are as follows:

$$e_t = y_t - 0.75(w-p)_t + 0.08 p_t - 0.002t + 0.05 sd91_t + ec_t^1 \tag{25}$$

$$(w-p)_t = 1.16(y-e)_t - 1.43 u_t + 0.04 sd91_t + ec_t^2 \tag{26}$$

where ec_t^1 and ec_t^2 denote the error correction terms of the two cointegration relations.

The labor demand equilibrium (25) displays a negative relation of employment (e) and real wages ($w-p$) and a positive relationship between employment and real output (y). Moreover, employment is negatively related to a linear trend (t), which may reflect growth in total factor productivity (TFP) from cumulative human and physical capital or technological progress (Doornik, Nielsen and Hendry, 1998). In the wage setting equilibrium (26) real wages are positively related to productivity ($y-e$) while negatively to the unemployment rate (u).[11] As Carstensen and Hansen (2000) emphasize it is not possible from these relationships to infer

[11] Hansen (2000) interprets the significance of the unemployment coefficient as the influence of outsiders on the wage bargaining process.

Table 2. Restrictions on the cointegration space of $x_t = (y-e, p, w-p, e, u)'_t$

	Just-identified cointegrating vector							
	$y-e$	p	$w-p$	e	u	t	$sd91$	LR-test
$\beta_{ld,1}$	1	1.75	-0.96	-4.95	0	-0.003	1.16	
		(0.51)	(0.63)	(1.48)		(0.005)	(0.3)	
$\beta_{ws,1}$	-1.1	-0.07	1	0.17	1.54	0	-0.09	
	(0.06)	(0.06)		(0.12)	(0.31)		(0.03)	
	Overidentified cointegrating vector							
$\beta_{ld,2}$	1	0.08	-0.75	0	0	0.002	0.05	
		(0.03)	(0.04)			(0.0003)	(0.006)	
$\beta_{ws,2}$	-1.16	0	1	0	1.43	0	-0.04	$\chi^2(3) = 7.24$
	(0.04)				(0.26)		(0.007)	p-value = 0.065

Notes: Standard errors are provided in parentheses. The LR statistics of the overidentifying restrictions is χ^2 distributed, see Doornik and Hendry (1997).

on possible causal relationships since the variables are all endogenous. For example, observed changes in unemployment may either be a cause or an effect of changes in the real wage.

Summing up, the ECM estimate revealed two reasonable labor market equilibria, namely a labor demand and a wage setting relation. The parameter estimates appear economically plausible and are broadly in line with Carstensen and Hansen (2000) who, however, confine their analysis to West-German data.

5.2 The Short Run Analysis: Identification of a Structural VAR

The structural VAR model is estimated by maximum likelihood using the restrictions derived from the macroeconomic model of Section 3. Recall that identification requires to impose ten restrictions on the matrix C of Equation (17). Table 5 in Appendix C reports the estimate of the just-identified C matrix with the associated t-statistics.

If more than $n(n-1)/2 = 10$ restrictions are imposed these overidentifying restrictions can be tested via a LR test. Any further restrictions on the matrix C, however, were not motivated by economic theory but merely simplify the model by setting the insignificant parameters to zero.[12] According to the LR test the overidentifying restrictions cannot be rejected at the 5% significance level and the signs of the parameters are consistent with economic reasoning.

Of course, the estimate of the instantaneous relations is not sufficient to represent the dynamics of the model. To that aim, impulse response functions and the forecast error variance decompositions have to be calculated from the estimate. This will be done in the next two sections.

5.2.1 Impulse Response Analysis

The impulse response analysis is a device to display the dynamics of the variables tracing out the reaction of each variable to a particular shock at time t. The impulse response functions shown in Figures 2 – 4 of the unemployment rate generally allow a sensible economic interpretation.

According to Figure 2(a) a positive technology shock affects unemployment only in the short run as unemployment falls significantly within the first 4 quarters. The impulse responses show that there is no long run impact of technology shocks on unemployment which is consistent with most empirical studies (Lindbeck, 1993).[13] This suggests that firms and workers might be too slow to adapt to a technology shock as wages and prices adjust slowly and therefore allow for short run effects on unemployment. Note that the results of the impulse responses of a technology shock run counter to the findings of Dolado and Jimeno (1997) who find technology shocks to increase unemployment. Carstensen and Hansen (2000) on the other hand find technology shocks to have a long run negative effect on unemployment for the West-German labor market.[14]

As the impulse responses in Figure 2(b) show, a wage shock increases unemployment in the initial period, but the effect vanishes after about 4-5 quarters. This suggests that in the long run wage shocks are supposedly fully compensated by productivity changes without an effect on the employment situation. The results on wage shocks confirm the findings by Carstensen and Hansen (2000). Dolado and Jimeno (1997), however, find that wage shocks show a long run effect on Spanish unemployment.

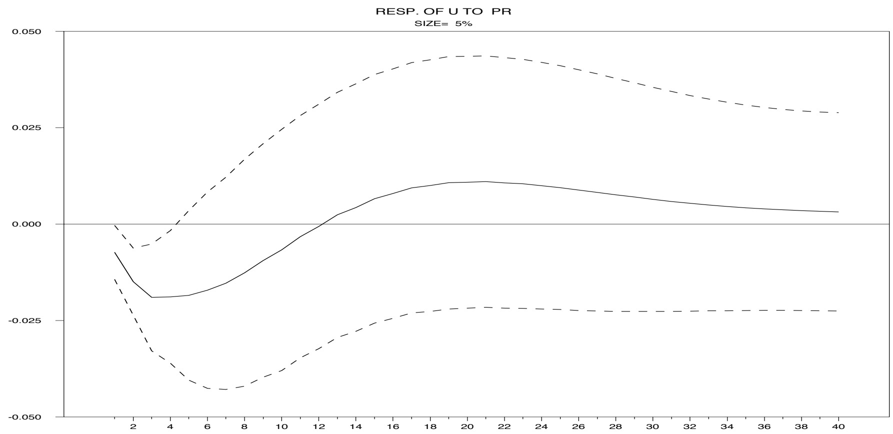
Price shocks (cf. Figure 3(a)), for example from increased prices for imported inputs, significantly increase unemployment. It appears that price shocks are a crucial factor for increased and

[12] The estimate is reported in Appendix C. Note that the results of the estimate as well as the corresponding impulse response functions do not differ much from the just-identified model.

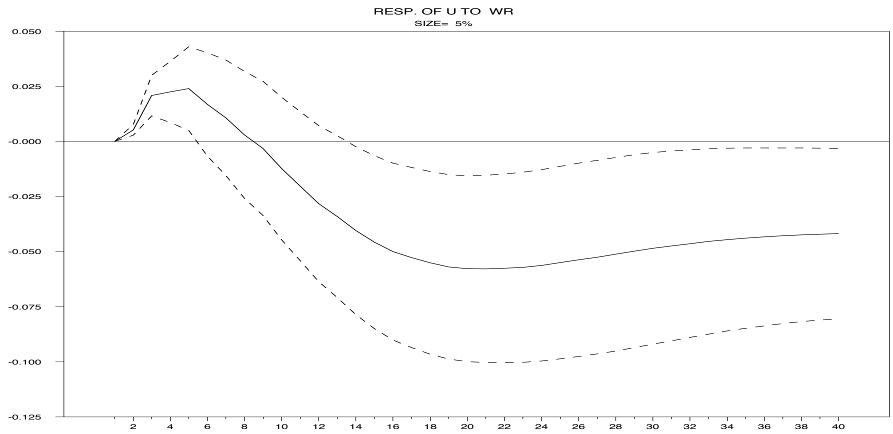
[13] If technology shocks had indeed a long run effect on unemployment the steady rise of the productivity trend suggests indefinitely falling unemployment. Thus, a long run relationship between unemployment and the productivity trend should not be expected. Overall, the theoretical and empirical literature on the impact of productivity on unemployment remains puzzling (Franz, 1996).

[14] This is not surprising since Carstensen and Hansen (2000) restrict technology shocks to have a permanent effect on unemployment.

Figure 2. Impulse responses of unemployment



(a) Response of unemployment to a technology shock

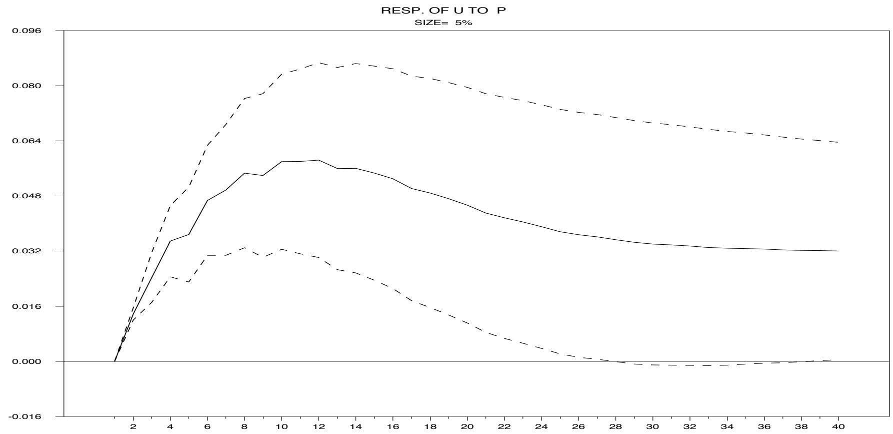


(b) Response of unemployment to a wage shock

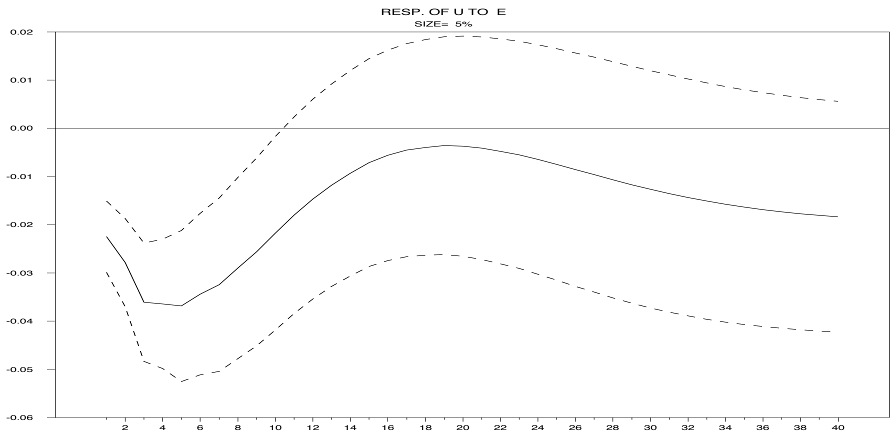
Notes: Impulse responses to a unit standard deviation shock with 95% asymptotic confidence intervals.

persistent unemployment as unemployment rises gradually and returns to its pre-shock level not before 6 years. Apparently, increased prices translate into higher costs so that firms adjust labor demand accordingly. In addition wage setters may not respond immediately to this productivity slowdown and exacerbate the effect on unemployment. The effect of the price shock established here is in accordance with the results of Dolado and Jimeno (1997) for the Spanish economy.

Figure 3. Impulse responses of unemployment



(a) Response of unemployment to a price shock

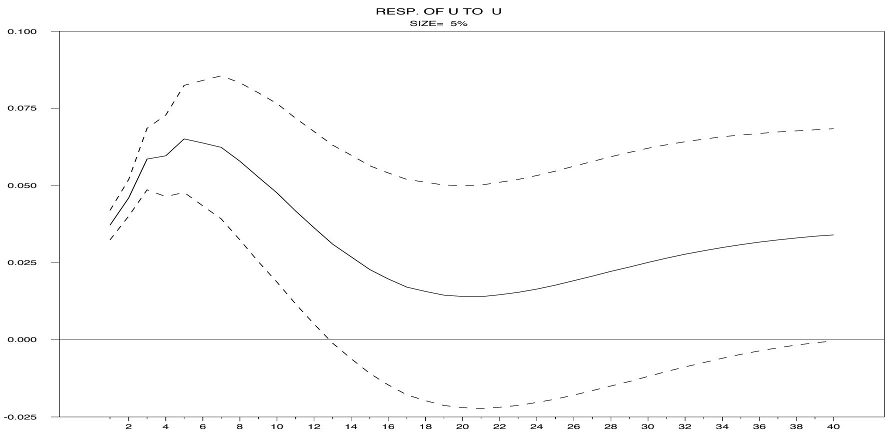


(b) Response of unemployment to a demand shock

Notes: Impulse responses to a unit standard deviation shock with 95% asymptotic confidence intervals.

Figure 3(b) shows that a demand shock apparently lowers unemployment in the short/medium run significantly, which is consistent with standard economic theory. Unemployment initially falls after a demand shock and returns to its pre-shock level after about 10 quarters. The more recent work on nominal rigidities is well corroborated by the impulse response analysis. The impulse responses reveal that prices rise gradually in response to a demand shock rather than jumping upward instantaneously (see Figure 7 in Appendix D). The response of the real wage is

Figure 4. Impulse responses of unemployment



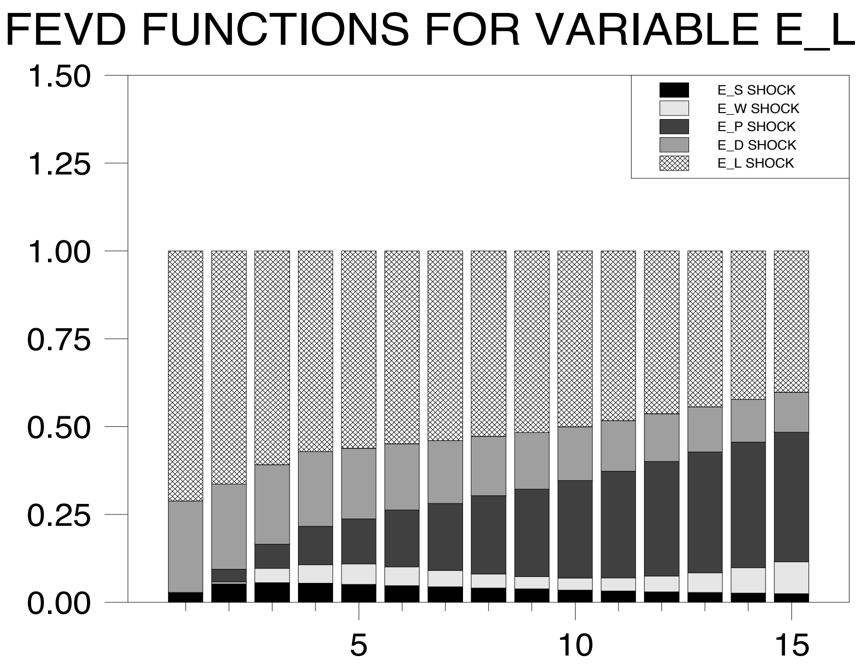
(a) Response of unemployment to a labor supply shock

Notes: Impulse responses to a unit standard deviation shock with 95% asymptotic confidence intervals.

not significantly different from zero, which indicates that nominal wages move at the same speed of adjustment, leaving real wages unaffected (see Figure 7). Theoretically speaking, when prices and wages adjust slowly, a demand shock leads to an outward shift of the labor demand curve and thus decreases unemployment. Once wages and prices have adjusted to the new situation, the effect on unemployment vanishes. The finding of a permanent demand effect by Dolado and Jimeno (1997) for Spain is, however, at odds with the results of this paper.

Finally, as shown in Figure 4(a) a positive shock to labor supply leads to a significant increase in unemployment returning to its pre-shock level after about 13 quarters. In contrast, labor supply shocks have permanent effects on unemployment in the studies by Carstensen and Hansen (2000) 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 allow a plausible interpretation. Especially price, demand and labor supply shocks seem to be decisive factors explaining unemployment, while technology and wage shocks are less crucial.

Figure 5. Forecast error variance decomposition for the unemployment rate



Notes: E_S, E_W, E_P, E_D, E_L denote shocks to technology, wages, prices, aggregate demand, and labor supply respectively.

5.2.2 Forecast Error Variance Decomposition

Another tool for interpreting VAR models is the forecast error variance decomposition (FEVD) which provides complementary information on 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, $\epsilon_s, \epsilon_w, \epsilon_p, \epsilon_d$ and ϵ_l. When calculated by the structural shocks as in the present case, the FEVD provides information on the importance of various structural shocks explaining the forecast error variability of the unemployment series.[15]

The FEVD for the unemployment rate is depicted in Figure 5. It can be seen that in the present model the forecast error variance of the unemployment series is mainly determined by labor supply shocks and to a lesser extent by demand shocks. The importance of demand shocks

[15] Note, however, that 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.

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. Technology and wage shocks only have a negligible but relatively constant influence on the forecast error variance of unemployment.

The FEVD suggests that demand shocks account for unemployment fluctuations in the 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.

6 Conclusions

Germany has experienced a huge increase in its unemployment rate over the last decades reaching historical records in the late 1990s. This paper analyzed the impact of various macroeconomic shocks as a source of high and persistent unemployment in Germany. The particular interest was to investigate how certain shocks propagate to the labor market and their relative importance for the rise in German unemployment. Using the theoretical framework offered by Dolado and Jimeno (1997), a structural error correction model was estimated using data for Germany from 1969 to 1998, including unified Germany from 1991:1.

In contrast to Dolado and Jimeno (1997), the German data was found to be cointegrated. The specification of the cointegrating vectors revealed two economically meaningful equilibrium relations, namely a labor demand and a wage setting schedule. The dynamics of the present model were displayed by means of impulse response functions and the forecast error variance decomposition. Technology and wage shocks were found to exhibit only short run effects on unemployment. 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. A shock to labor supply significantly increases unemployment over a horizon up to three years. Price shocks exhibit the most persistent effect on unemployment with unemployment returning to its pre-shock level after 6 years. The forecast error variance is mainly explained by labor supply, price and demand shocks.

The following conclusions can be drawn from the foregoing analysis. First, the empirical results suggest that it might be too simple blaming solely high wages for unemployment in Germany. In line with findings by Carstensen and Hansen (2000), wage shocks have been demonstrated to be of only minor importance in explaining unemployment fluctuations and affect unemployment only in the short run. Second, demand, price and labor supply shocks appear to be important short/medium run determinants of unemployment. In that sense, price shocks like the oil price crises in the 1970s together with a large productivity slowdown certainly contributed to the initial rise in unemployment during that period. Moreover, adverse demand shocks from tight macroeconomic policy in the post unification era might have played a dominant role in explaining high unemployment in the 1990s. Third, unemployment persistence can be explained by a series of long lasting shocks as for example price, demand and labor supply shocks return only slowly to their pre-shock levels.

The analysis casts some doubt on the popular labor market flexibility notion explaining high and persistent unemployment in Germany entirely by rigid wages and labor market institutions. This paper illustrated that macroeconomic shocks can very well account for rising unemployment over the sample period. While macroeconomic shocks are able to explain large fluctuations and upward jumps in unemployment such sudden changes are hard to reconcile with a pure micro-based explanation since most of the labor market institutions were already in place even before unemployment started to rise. In general, macroeconomic distortions are more likely to prevail when unemployment persists for many years and unemployment spells are long, which is exactly the case in Germany (Lindbeck, 1993).

Yet, explaining the German unemployment experience by shocks is certainly not the whole story. As mentioned in Section 2 there are large differences in unemployment across regions in Germany, which are difficult to justify in terms of macroeconomic shocks that should affect the entire economy homogeneously. Macroeconomic 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.

Since we fail to observe a decline in unemployment to levels like in the beginning of the 1970s or 1980s, the exact mechanisms of unemployment persistence remain puzzling. Further research needs to be directed towards the combination of shocks and institutions in a time series framework.[16] Moreover, the inclusion of a monetary sector into the theoretical model might help to understand the transmission process of monetary shocks, such as unexpected increases in the money supply or interest rates to the labor market.

[16] See Blanchard and Wolfers (2000) for a panel data approach on the impact of shocks and institutions on unemployment.

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A Data and Variables

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. The periodicity of the data is quarterly and it is seasonally adjusted. The series are for Germany and range from 1969:1 to 1998:4, including unified Germany from 1991:1. Notice that all variables, except the unemployment rate, are expressed in logarithms.

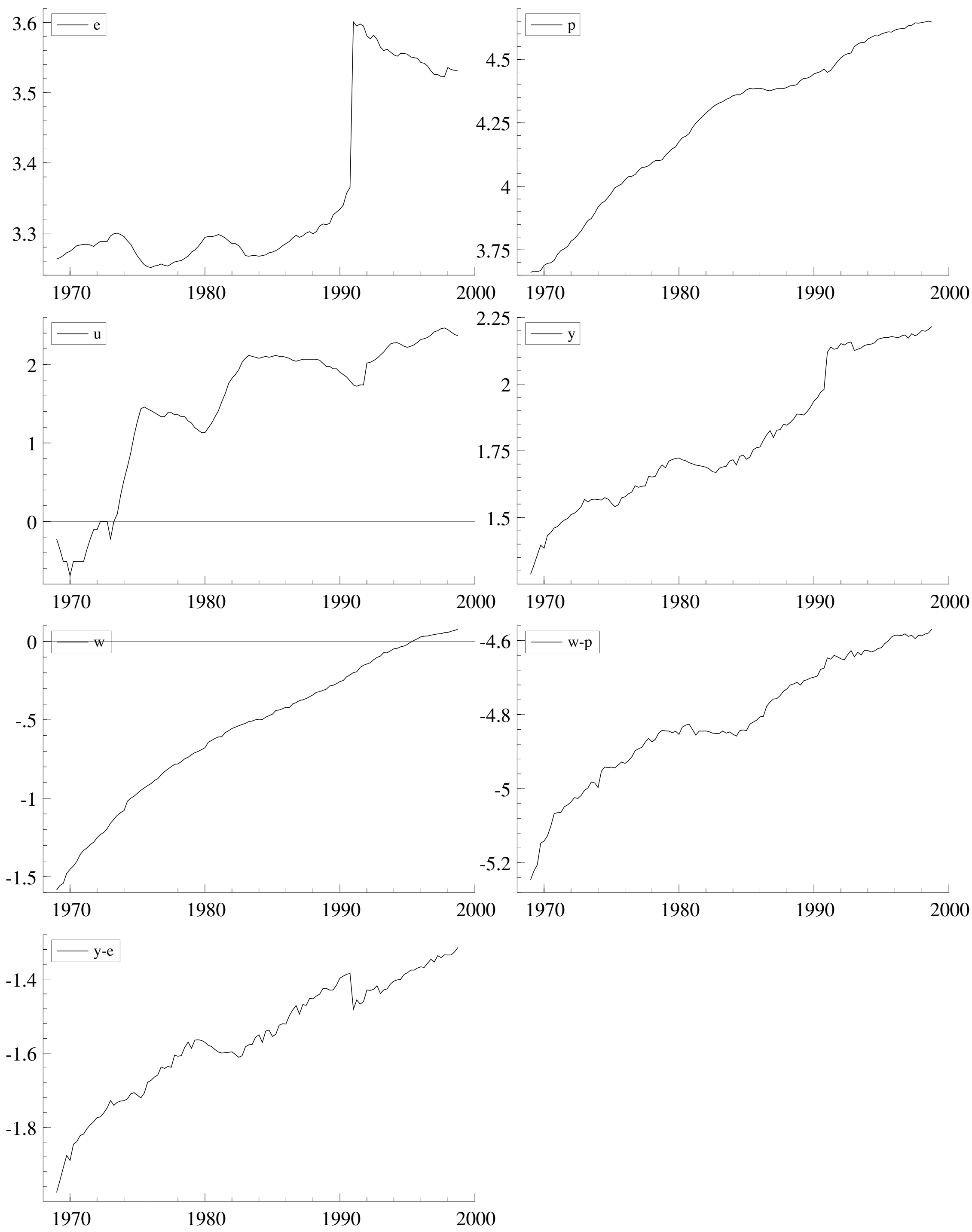
Table 3. Data definitions and labels

e	Total employment (employees and self employed)
p	Consumer price index (CPI) with base year 1995
u	Unemployment rate as percentage of the civilian labor force as measured by the Federal Labor Office[17]
y	Real gross domestic product (GDP) (ratio of nominal GDP and the CPI)
w	Nominal hourly wages in the manufacturing sector
$w-p$	Real wage[18]
$y-e$	Productivity
$sd91$	Step dummy (0: until 1990:4, 1: from 1991:1) to account for the level shift due to the German unification
$d91$	Impulse dummy for 1991:1

[17] The same definition of the real wage is used by Dolado and Jimeno (1997). Blanchard (1989) employs the PCE deflator and notes that the differences in the results when using the CPI were minor.

[18] Notice, that measuring unemployment by the persons being registered as unemployed like the Federal Labor Office differs considerably from the standardized unemployment rate published by EUROSTAT. Although the two unemployment rates differ substantially in their levels their dynamics are fairly similar. 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.

Figure 6. The data series for employment (e), prices (p), unemployment (u), real output (y), wages (w), real wages ($w-p$), and productivity ($y-e$)



B Saikkonen-Lütkepohl Cointegration Rank Test

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

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

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

C Structural Identification Estimate

Table 5. Structural identification estimate (just-identified model)

Equation	$\nu_t = C\epsilon_t$						
$(y-e)$	$\nu_{(y-e)}$	=	$0.009\epsilon_s$				
			(15.17)				
$(w-p)$	$\nu_{(w-p)}$	=	$0.002\epsilon_s$	$+0.007\epsilon_p$			
			(3.25)	(15.17)			
p	ν_p	=	$-0.002\epsilon_s$	$-0.002\epsilon_p$	$+0.003\epsilon_w$		
			(-5.15)	(-5.24)	(15.17)		
e	ν_e	=	$0.0001\epsilon_s$	$-0.001\epsilon_p$	$-0.0001\epsilon_w$	$+0.003\epsilon_d$	
			(0.21)	(-2.95)	(-0.36)	(15.17)	
u	ν_u	=	$-0.010\epsilon_s$	$-0.006\epsilon_p$	$-0.003\epsilon_w$	$-0.022\epsilon_d$	$+0.037\epsilon_l$
			(-2.38)	(-1.46)	(-0.84)	(-5.92)	(15.17)

Notes: t-statistics are reported in parentheses.

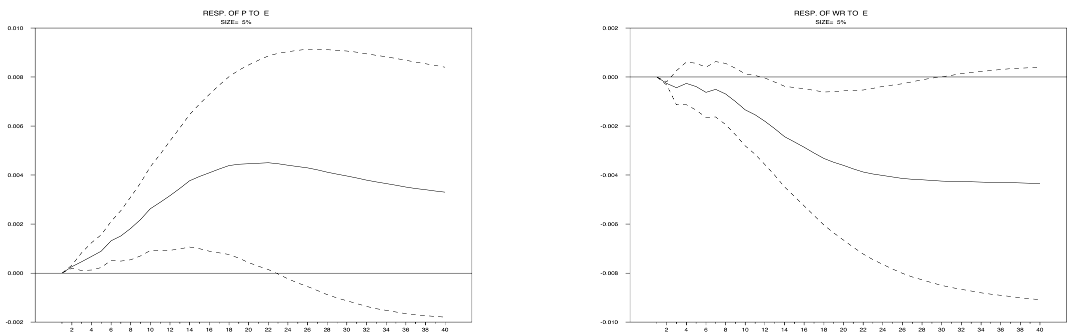
Table 6. Structural identification estimate (overidentified model)

Equation	$\nu_t = C\epsilon_t$				
$(y-e)$	$\nu_{(y-e)}$	$=$	$0.009\epsilon_s$		
			(15.17)		
$(w-p)$	$\nu_{(w-p)}$	$=$	$0.002\epsilon_s$	$+0.007\epsilon_p$	
			(3.25)	(15.17)	
p	ν_p	$=$	$-0.002\epsilon_s$	$-0.002\epsilon_p$	$+0.003\epsilon_w$
			(-4.97)	(-5.88)	(15.17)
e	ν_e	$=$	$-0.001\epsilon_p$	$+0.003\epsilon_d$	
			(-4.25)	(15.17)	
u	ν_u	$=$	$-0.010\epsilon_s$	$-0.022\epsilon_d$	$+0.037\epsilon_l$
			(-2.05)	(-5.96)	(15.17)

Notes: t-statistics are reported in parenthesis.

D Responses of Prices and Wages to a Demand Shock

Figure 7. Impulse responses of prices and the real wage



(a) Response of prices to a demand shock

(b) Response of the real wage to a demand shock

Notes: Impulse responses to a unit standard deviation shock with 95% asymptotic confidence intervals.

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