Zur Homepage der Dissertation

The Causes of German Unemployment
— A Structural VAR Approach

Von der Carl von Ossietzky Universität Oldenburg
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von Li Su
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Referent: Herr Prof. Dr. Klaus W. Schüler
Korreferent: Herr Prof. Dr. Heinz Welsch
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List of Abbreviations

AIC	Akaike Information Criteria
ADF	Augmented Dickey-Fuller
ANBA	Amtliche Nachrichten der Bundesagentur für Arbeit
ARIMA	AutoRegressive Integrated Moving Average
BLUE	Best Linear Unbiased Estimators
CRS	Constant Return to Scale
DGP	Data Generating Process
DIW	Deutsches Institut für Wirtschaftsforschung
ECM	Error Correction Model
ESVG	Europäisches System Volkswirtschaftlicher Gesamtrechnung
FEVD	Forecast Error Variance Decompositions
FIML	Full Information Maximum Likelihood
FPE	Final Prediction Error
GDP	Gross Domestic Product
GIVE	Generalized Instrumental Variables Estimators
GLS	Generalized Least Squares
GMM	Generalized Method of Moments
HQ	Hannan-Quinn information
IRF	Impulse Response Functions
LSE	London School of Economics
LR	sequential modified LD test statistic
MA	Moving Average
MSE	Mean Squared Error
NAIRU	Non-Accelerating Inflation Rate of Unemployment
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
SC	Schwarz information Criterion
SVAR	Structural Vector AutoRegression
VAR	Vector AutoRegression
VGR	Volkswirtschaftliche Gesamtrechnungen

List of Symbols

A	index of total factor productivity
b	effects of unemployment on the labor supply decisions
b_t	other influences on the natural rate
D_L	aggregate labor demand
D_{Li}	labor demand of firm i
d	index of nominal expenditure
e_t	vector of estimated residuals
F	function which relates real output to the inputs of K and L
h	hysteresis parameter
K	quantity of capital inputs
L (in Ch. 2)	quantity of labor inputs
L (in Ch. 6)	labor force
L_e	equilibrium employment
L_F	full employment
ΔL_i	extra unit of labor
$\tilde{l}$	log of the labor force
MC	marginal cost
MPL	marginal product of labor
N	employment
n	log of employment
n^e	expected value of (log) employment
P_i	output price of firm i
p	log of price level
ΔQ_i	output produced by an extra unit of labor
S_L	labor supply
U^*_t	natural rate of unemployment in the current period
$\bar{U}^*$	steady-state natural rate of unemployment
u	unemployment rate
u_n	natural rate of unemployment
W_i	money wages

$\dot{W}$	change rate of money wages
w	log of nominal wages
w^* (in Ch. 2)	efficiency wages
w^* (in Ch. 6)	log of targeted nominal wages
$(W/P)_e$	equilibrium real wages
Y	real output
y	log of output
Y_F	full employment output
y_t	vector of endogenous variables
z_t	vector of exogenous variables or disturbance terms
z_{kt}	Cholesky restrictions
α (in Ch. 3)	parameter which indicates how strongly wages response to changes in unemployment rate
α (in Ch. 6)	elasticity of labor supply
γ_1, γ_2	indexation coefficients
ε_d	i.i.d. structural shocks to aggregate demand
ε_l	i.i.d. shocks to labor supply
ε_p	i.i.d. structural shocks to prices
ε_s	i.i.d. shocks to productivity
ε_t	orthogonal white noise vector which represents vector of structural shocks
π^e	anticipated rate of inflation
η	price elasticity of demand
θ	proxy for productivity
τ	exogenous factors influencing labor supply
μ	exogenous mark-up factors
$\sum$	variance/covariance matrix of the estimated residuals
Ω	variance/covariance matrix of structural shocks

Chapter 1 Introduction

Unemployment is a major source of human misery.
Layard, Nickell and Jackman

1.1 Aim of the work

Unemployment, one of the main indicators of economic performance, has always drawn attention from economists of different times. Although some unemployment is necessary for an economy to function well, high unemployment involves significant economic and social costs. It results in output gap and reduces aggregate income. It increases inequality, erodes human capital and implies psychic costs as well.

Although unemployment problem had not worried German economists in the 1960s, high and persistent unemployment is nowadays one of the major macroeconomic defects in Germany. Since the mid 1970s, the German unemployment rate has been increasing.[1] German unification in 1990:3 has further boosted the unemployment rate to new records level. The unemployment rate now is ten times as that at the beginning of the 1970s. The unemployment evolution in Germany is characterized by the stepwise upward trend in the last three decades and the unemployment rate does not seem to be able to go back to the levels thirty years ago. Such dramatic increase in unemployment has naturally stimulated economists to investigate the sources of unemployment more closely. Explanations of the odd evolution of German unemployment generally focus on the stepwise jumps in the unemployment rate and its persistence.

Despite the large number of literature regarding the sources of persistently high unemployment in Germany, a consistent and general accepted framework does not exist yet. It is not surprising given the intrinsic difficulty and importance of the issue under investigation.

According to the orthodox view, a country’s ‘natural rate’ of unemployment or the NAIRU is determined by the flexibility of the labor market. Although demand management policies can push the actual unemployment rate above the NAIRU

[1] Indeed, this development has also been observed in most west European countries.

temporarily, labor market institutions will ensure the return of unemployment to its ‘natural’ rate. Therefore tight monetary and fiscal policy, for example, by the German Bundesbank in the 1980s and 1990s, can not be blamed for persistently high unemployment. In contrast to this conventional wisdom, different authors advocate an alternative opinion that the effects of fiscal and monetary policies on aggregate demand seem to matter a great deal for long-run trends in unemployment. In other words, macro policies are relevant to the persistence of high unemployment.

Although economists have pointed out rather diverse factors as roots of high unemployment in Germany, two strands of explanations could be identified which emphasize either labor market rigidities or adverse macroeconomic shocks. Conventional explanations, the so-called ‘European sclerosis’ explanation, insist that high German unemployment is due to institutional labor markets rigidities existed there: too high wage wedge, too high unemployment benefit, too strong employment protection, etc. It follows that labor market reform which eliminates these rigidities is the potential cure for persistently high unemployment in Germany, whereas demand management policies are not relevant. Explanations based on macroeconomic shocks instead regard the high unemployment as due to unfavorable shocks which have hit the German economy: inadequate aggregate demand due to restrictive monetary/fiscal policies, oil price shocks, productivity slowdown, etc. In this view, other policies than structural reform, especially more appropriate macroeconomic policies to stimulate aggregate demand, are thought to be necessary to reduce unemployment.

However, neither explanations based merely on rigid labor institutions nor those emphasize adverse macroeconomic shocks alone are able to give a convincing account of the odd unemployment development in Germany. On the one hand the standard ‘European sclerosis’ argument is too simplistic since many of the institutional aspects were already in existence when the German unemployment rate was still very low. On the other hand, although the rise in the unemployment rate may have been resulted from adverse macroeconomic shocks, it is not plausible that they could by themselves account for the persistence of the unemployment evolution for over three decades.

Indeed, these two positions should be seen as complementary rather than exclusively. The upward drift of the unemployment rate and the increasing share of long term unemployment imply that the persistently high unemployment in Germany may be the result of the interaction between negative shocks hitting the economy over time and structural elements in the labor market hindering the self-equilibrating mechanisms. It is just the prevailing rigidities of the German labor market that may have enabled adverse shocks to have long-lasting effects in influencing the unemployment rate. In other words, hysteresis mechanism comes into being. Therefore, a framework that investigates macroeconomic shocks and their persistent effects due to structural rigidities seems the most suitable one for a thorough analysis of unemployment in Germany.

Based on such a theoretical framework, this thesis aims at shedding more light on the sources of high unemployment in Germany with the help of Structural Vector AutoRegressive (SVAR) approach. Thanks to its properties, SVAR analysis is especially well-suited to track the dynamics of certain shocks that have hit the economy as regards their relative contribution and propagation mechanism.[2]

Since the influential SVAR analysis of Blanchard and Quah (1989) with long-run identifying restrictions, several studies extending the number of shocks have been used to analyze labor markets in different countries. In comparison with previous SVAR analysis of labor markets, this work is novel in that full-hysteresis of the unemployment rate is assumed and price shocks is identified as further structural shocks. In short, we try to investigate the role of price shocks, productivity shocks, aggregate demand shocks and labor supply shocks in explaining unemployment evolution in Germany since 1970. The part of institutional rigidities is captured by hysteresis mechanism.

The insight from this empirical work is rather important in the light of potential strategies against high unemployment in Germany. Due to the existence of hysteresis effects, macroeconomic shocks may have permanent effects. It follows that demand management policies (such as monetary or fiscal policies) may be very powerful even in the long-run. There is much more to the high, persistent unemployment problem than simply labor market rigidities. Aggregate demand policies are useful instruments to decrease the German unemployment rate and

[2] Besides the unemployment problem as the chief theme, econometric methodology is also a focal point of this thesis.

should be regarded as complementary rather than contrasting with structural labor market reforms.

1.2 Structure of the work

Central point of this empirical work is the insight concerning the existence of significant shocks and hysteresis mechanism behind German unemployment dynamics. According to the empirical results, the dismal performance of German unemployment can be explained as the outcome of a series of adverse shocks, which were difficult to be absorbed in a rigid system of labor market institutions.

To understand the emergence of unemployment and its evolution, one should not confine himself only to the labor market. It is indeed necessary to examine unemployment from the macroeconomic point of view. In this context, chapter 2 considers unemployment in a macroeconomic framework from the aspect of competing schools. As is well known, various schools emphasize different factors as culprits of high unemployment and propose accordingly different cures. This chapter provides a summary of how differently economists from different arrays could view the world, from the traditional controversy between the old classical school and Keynesian school to the more recent debate between the new classical and new Keynesian economics.

Based on this general theoretical background, we survey high and persistent unemployment in Germany in depth in chapter 3. Section 3.1 provides a picture of the idiosyncratic evolution of the German unemployment rate since 1970. It is shown in a dimension of time that high unemployment is not a tradition of Germany. In section 3.2, German unemployment is examined from a dimension of space. Compared with those in U.S., unemployment phenomena in Germany suffer from sclerosis. Section 3.3 then outlines current discussion about the reasons of high unemployment in Germany. Often cited labor market rigidities and macroeconomic shocks as possible sources of high unemployment are identified here. The promising view emphasizing macroeconomic shocks combined with hysteresis effects serves as the starting point of our empirical work.

Any empirical analysis of unemployment can not be carried out seriously without raising some necessary methodological issues. Therefore this thesis deals with problems of substance and methodology simultaneously. Chapter 4 and 5 present the econometric methodologies. Parallel to the diversity of economic theory, a wide spectrum also exists regarding econometric strategies. The choice of appropriate methodology is indeed prerequisite for a successful empirical work. Chapter 4 provides a brief introduction to macroeconometrics within historical context which is the foundation of the discussion of SVAR methodology. Traditional Cowles Commission approach and its empirical failure is presented. As for the different approaches developed after the breakdown of Cowles Commission approach, LSE (London School of Economics) approach and intertemporal optimization/calibration approach also find an account whereas VAR (Vector AutoRegression) approach is expounded in more detail in chapter 5.

Chapter 5 then illustrates the methodology adopted in this thesis: Structural Vector AutoRegressive (SVAR) analysis. Since the SVAR model is an extension of traditional VAR models, the traditional VAR approach is dealt with at first. The identification of the traditional VAR and its dynamic analysis techniques, namely impulse response functions (IRF) and forecast error variance decompositions (FEVD), are described. SVAR approach is depicted subsequently which has been developed to overcome the weaknesses of the traditional VAR. Besides its identification and dynamic analysis, different types of SVAR models are introduced as well.

With the theoretical discussion of unemployment and necessary methodological background at hand, we carry out the SVAR analysis for the German labor market in chapter 6. Section 6.1 takes a stock of traditional labor market modeling and points out its weaknesses and the need of modification. A review of current applications of SVAR analysis concerning unemployment is the subject of section 6.2, with the merits of SVAR approach being discussed. In section 6.3 a stylized labor market model is presented which is used to derive the identifying restrictions for the further structural analysis. The model's novelties are full-hysteresis adopted and the introduction of price shocks as a further structural shock. We estimate the VAR in four variables (the wage share, real wages, employment and the unemployment rate) in section 6.4. Using long-run identifying restrictions, four structural shocks (aggregate demand shocks, productivity shocks, price shocks and labor supply shocks) are recovered. Their contributions to explaining the unemployment development in Germany are evaluated through impulse response analysis and forecast error variance decompositions. Section 6.5 briefly concludes.

Finally, chapter 7 provides a summary. The theoretical framework and the main results are recapitulated. Political implications are also discussed.

Chapter 2 Unemployment in the Macroeconomic Framework

A study of the history of opinions is a necessary preliminary to the emancipation of the mind.
John Maynard Keynes

Unemployment arises surely not only from the defect function of the labor market. It is the result of various forces working in the whole economy. Any attempt to look into the sources of unemployment would be proved fruitless, would it not consider unemployment from the macroeconomic point of view. Therefore, this chapter provides in historical context a summary of how economists from different schools think of unemployment. It serves as the theoretical background for further analysis.

2.1 The labor market in the classical model

For the classical economists the market mechanism would operate quickly and efficiently to restore full employment equilibrium which was regarded as the normal state. Although admitting the possibility of a market economy to deviate from its equilibrium level, classical economists believed however such disturbances would only be temporary.

The classical theory starts from the short-run aggregate production function to determine the aggregate level of employment, with the capital stock and technology taken as given:

$$Y=AF(K,L) \tag{2.1}$$

where Y: real output

K: the quantity of capital inputs

L: the quantity of labor inputs

A: an index of total factor productivity

F: a function which relates real output to the inputs of K and L.

According to the rule of the marginal revenue (MR_i) equals to the marginal cost of production (MC_i), following condition to maximize profits can be derived under the assumption of competitive commodity and labor markets:

$$P_i \Delta Q_i = W_i \Delta L_i \quad (2.2)$$

where P_i: the output price of firm i

ΔQ_i: the output produced by an extra unit of labor

W_i: money wages

ΔL_i: an extra unit of labor;

or:

$$\Delta Q_i / \Delta L_i = W_i / P_i \quad (2.3)$$

So a firm should hire labor until the marginal product of labor ($MPL_i = \Delta Q_i/\Delta L_i$) equals to the real wage rate, meaning that the marginal labor curve is equivalent to the firm's labor demand curve. Making use of certain properties of short-run production function, a typical firm's demand for labor will be an inverse function of the real wage:

$$D_{Li} = D_{Li}(W_i/P_i) \quad (2.4)$$

The aggregate labor demand function is accordingly:

$$D_L = D_L(W/P) \quad (2.5)$$

As regards the supply side of the labor market, the labor supply can be expressed as a function of the real wage under the assumption that the households aim to maximize their utility:

$$S_L = S_L(W/P) \quad (2.6)$$

where the substitution effect is assumed to dominate the income effect so that the labor supply responds positively to the real wage.

Figure 2.1 illustrates the determination of equilibrium level of employment in the classical model, where the labor and commodity markets with the aggregate demand (D_L and D) and supply functions (S_L and S) are depicted. At the equilibrium real wage $(W/P)_e$, firms employ the equilibrium employment L_e in the labor market and sell at the same time all their production Y_e in the commodity market. Full employment dominates.

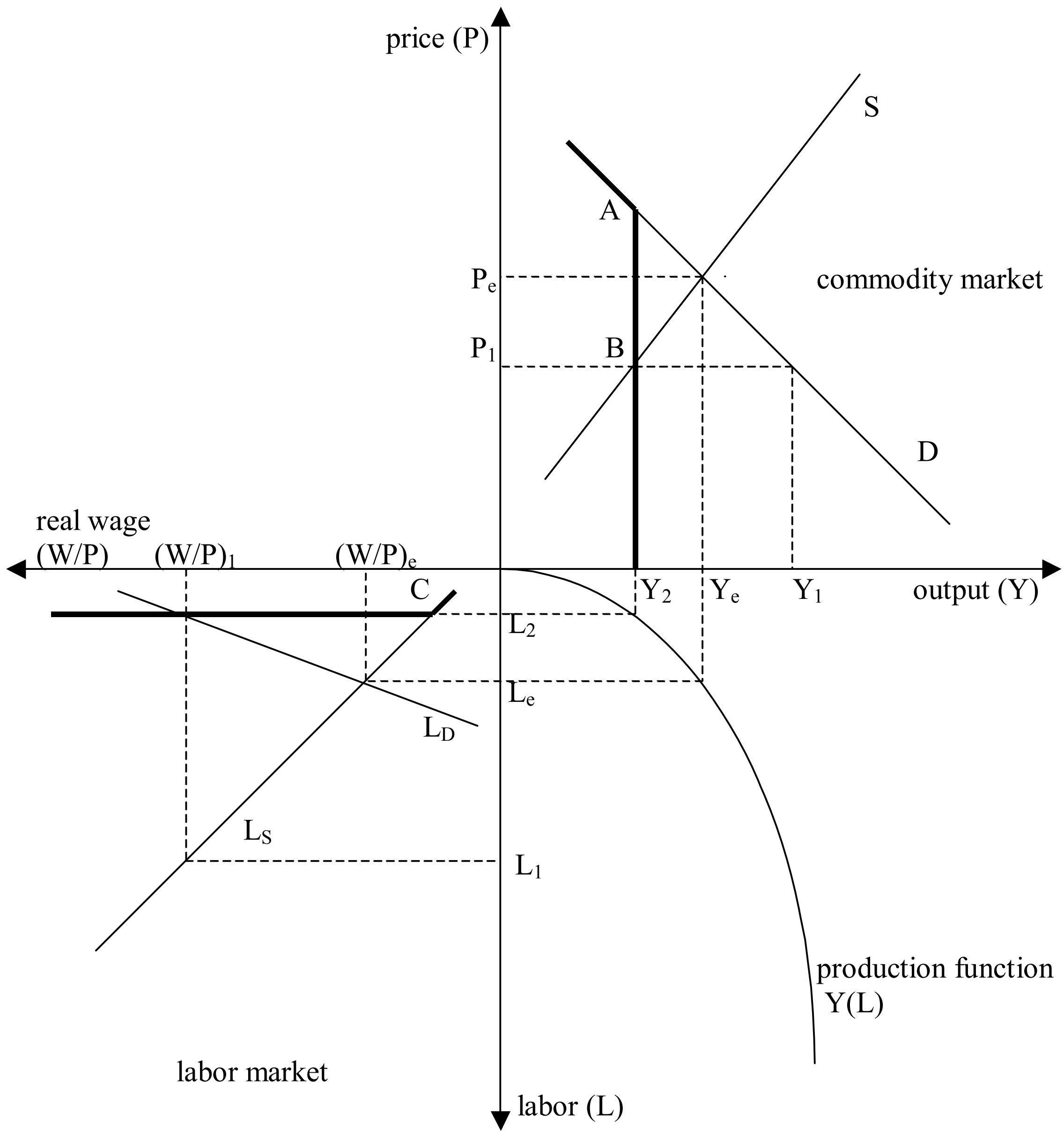

Figure 2.1 Classical Unemployment

With the real wage $(W/P)_1$ higher than market-clearing real wage $(W/P)_e$, an excess supply of labor of L_2L_1 comes into being. Firms would restrict the labor demand to L_2 and ration their commodity supply to Y_2, resulting in a supply excess in the labor market and a demand excess in the commodity market. Money wages would fall in this case, restoring the real wage to its equilibrium value $(W/P)_e$. With the real wage lower than equilibrium real wage rate, money wages would rise in response to excess demand labor until the real wage reached the equilibrium value. This process is guaranteed in the classical model because of the assumption of perfectly competitive markets, flexible prices and full information. Classical full employment equilibrium is compatible with the existence of frictional and voluntary unemployment, but does not admit involuntary unemployment.

In the classical world the real wage is the central variable to account for unemployment. Although competition in the labor market ensures full employment, the classical economists admitted that if artificial restrictions were placed on the equilibrating functions of real wages, persistent unemployment above the equilibrium level was possible. Trade union monopoly power or minimum wage legislation is possible candidates of such restrictions. If unemployment existed, the classical economists stress defects in the labor market, inflexible real wages, rigid wage structures and absence of mobility for example. The solution to such ‘classical unemployment’ was just to reduce real wages by cutting the money wage.

2.2 Keynesian view of unemployment

The inability of the classical model to give a reasonable explanation to the collapse of output and employment in the great depression provided ‘the most helpful circumstance for the rapid propagation of a new revolutionary theory’ (Johnson, 1971). In contrast to the prevailing orthodoxy, Keynes constructs in the *General Theory* the novel principle of effective demand. He insists that macroeconomic equilibrium is consistent with involuntary unemployment. The emphasis is given to quantity rather than price adjustment, which is in sharp contrast to the classical model.

To Keynes and his disciples unemployment is not the fault only in the labor market, but rather a macroeconomic problem. The labor demand and thus the level of employment depend decisively on the conditions of the commodity and money market.[1] Unemployment is thought of as due to a deficient demand for goods. Unemployment persists because the deficient goods demand arises from unemployment itself.

Keynes criticizes especially the classical equilibrium paradigm, according to which flexible prices always guarantee market-clearing and full employment. Pointing out that full employment equilibrium in the classical model is only a 'special case', Keynes insists instead that involuntary unemployment is likely to be typical of the labor market which is really the general case. By rejecting 'Say's Law', Keynes asserts that there is no guarantee that aggregate demand would be just at the level of production. He argues that if money wages are rigid, involuntary unemployment is likely to be typical of the labor market. He goes further to show that flexibility of nominal wages would be unlikely to restore economy back to full employment either.

2.2.1 Rigid nominal wages

In the case of nominal wage rigidity, Figure 2.2 shows the impact of a negative demand shock on real output and employment.[2] Starting from the initial equilibrium level of full employment (L_e) and equilibrium real wage $(W/P)_e$, a fall in aggregate demand shifts the aggregate demand curve from D_1 to D_2. If nominal wages are rigid but prices are flexible, the economy moves from E to A and firms could sell only Y_1 of the production due to the deficient demand. Firms need only L_1 of the labor force and B is the turning point of the labor demand curve. With a fall in the price level to P_1 and nominal wages remaining at W_e the real wage rises to W_e/P_1. So there is a supply excess in the labor market at this real wage and involuntary unemployment of L_1L_2 emerges.

[1] In Keynesian theories the labor market is located relatively low in the markets hierarchy.
[2] Keynes assumes at first that the money wage is constant, noting that the essential character of the argument is precisely the same whether or not money-wages are liable to change.

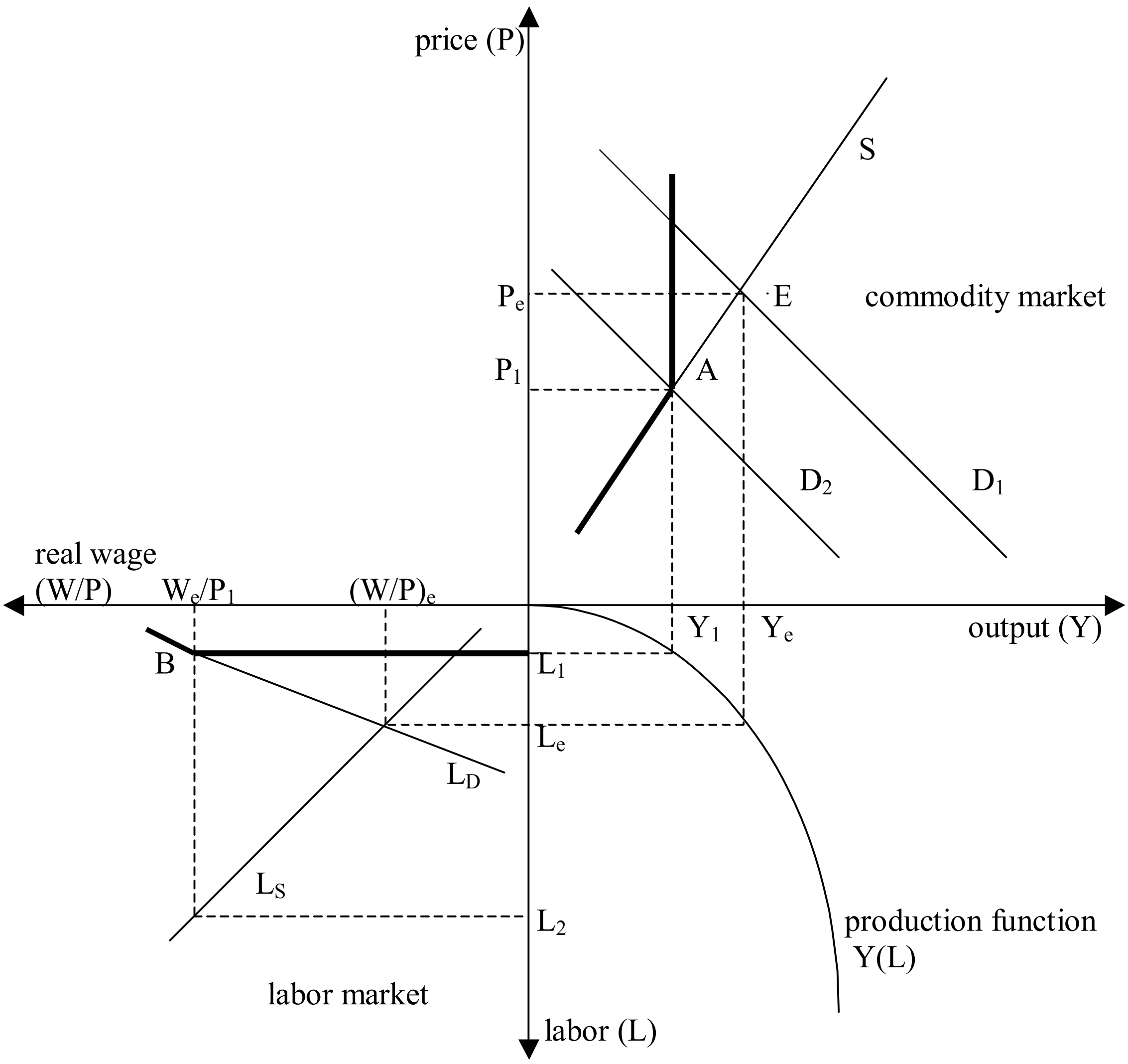

Figure 2.2 Keynesian Unemployment

In order for the real wage to be reduced and involuntary unemployment to be eliminated, either nominal wage must fall relative to the price level, or the price level must rise relative to the money wages. Keynes objects to the policy of wage cutting as viable on practical grounds by arguing that in a democracy with decentralized wage bargaining money wage cuts will be resisted. He favors instead the alternative method and proposes expansions of aggregate demand to exert upward pressure on the price level.[3] Theoretically Keynes also rejects wage

[3] Workers will not resist real wage reductions caused by a rise of the general price level because relative wages will not change in this case.

and price flexibility as a reliable method to restore the economy back to its full employment equilibrium, which will be dealt with in the next section.

2.2.2 Flexible nominal wages

Keynes argues in the *General Theory* that unemployment would be eliminated by nominal wage cuts primarily through the Keynes effect: the 'indirect' spending stimulating effect of falling money wages and prices via the interest rate. However, he introduces two cases where the 'Keynes effect' might fail: (i) the liquidity trap and (ii) interest-inelastic investment expenditure. In such cases flexibility of money wages and price can not guarantee the economy to return to its full employment equilibrium either.

2.2.2.1 The mechanism of the Keynes effect

Figure 2.3, combining the standard Hicksian IS-LM model with the assumption of flexible money wages and prices, illustrates the mechanism of the Keynes effect.

Suppose the economy is initially at E_0 which is the interaction of LM_0 and IS. Although both the goods and money market are in equilibrium, the output level Y_0 lies below the full employment output Y_F, with the according employment level L_0 lower than its full employment level L_F and real wages $(W/P)_0$ above the market clearing level $(W/P)_e$. So long as prices and money wages are perfectly flexible, the economy will self-equilibrate at full employment through the Keynes effect: At the real wage $(W/P)_0$ the excess supply of labor results in a fall in money wages W, which reduces firms' costs and causes further a fall in prices P. The fall in prices increases the real value of money supply which shifts the LM curve downwards to the right. Excess real balances are channeled into the bond market with the result that bond prices are bid up and the interest rate is bid down. The resultant fall in the rate of interest stimulates investment expenditure in turn, increasing the level of aggregate demand and therefore output and employment. The increase in aggregate demand reduces the fall speed of prices. As money wages fall faster than prices (an unbalanced deflation) the real wage falls toward its market clearing level $(W/P)_e$. This process of money wages and prices being bid down and the LM curve shifting downwards to the right will continue until full employment is restored. At E_1 the economy returns to its full employment equilibrium. In contrast to the classical theory, it is the increase in aggregate demand, via the Keynes effect, which restores the economy to full employment.

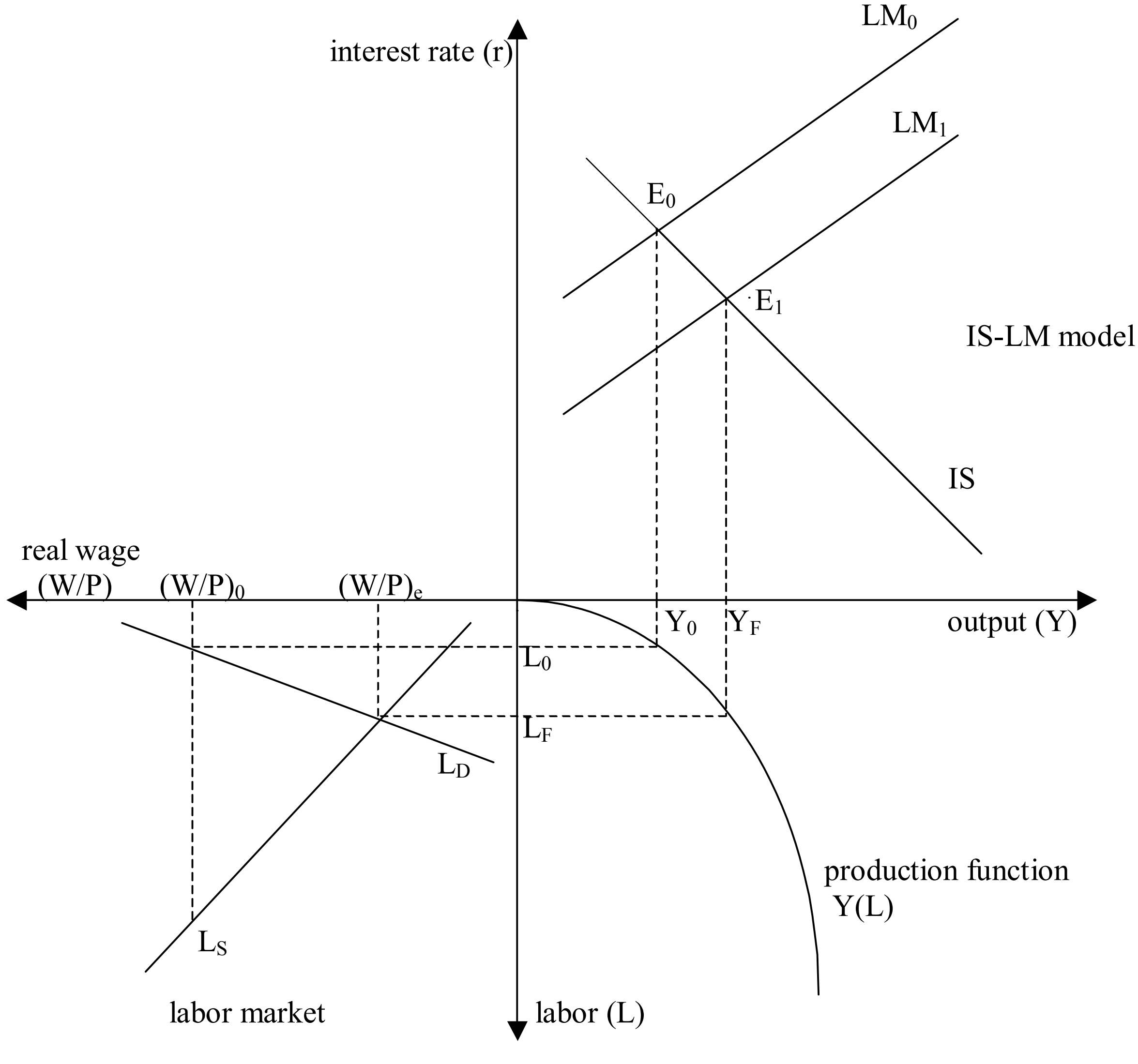

Figure 2.3 The Keynes Effect

2.2.2.2 Two cases of the Keynes effect's failure

(i) Liquidity trap

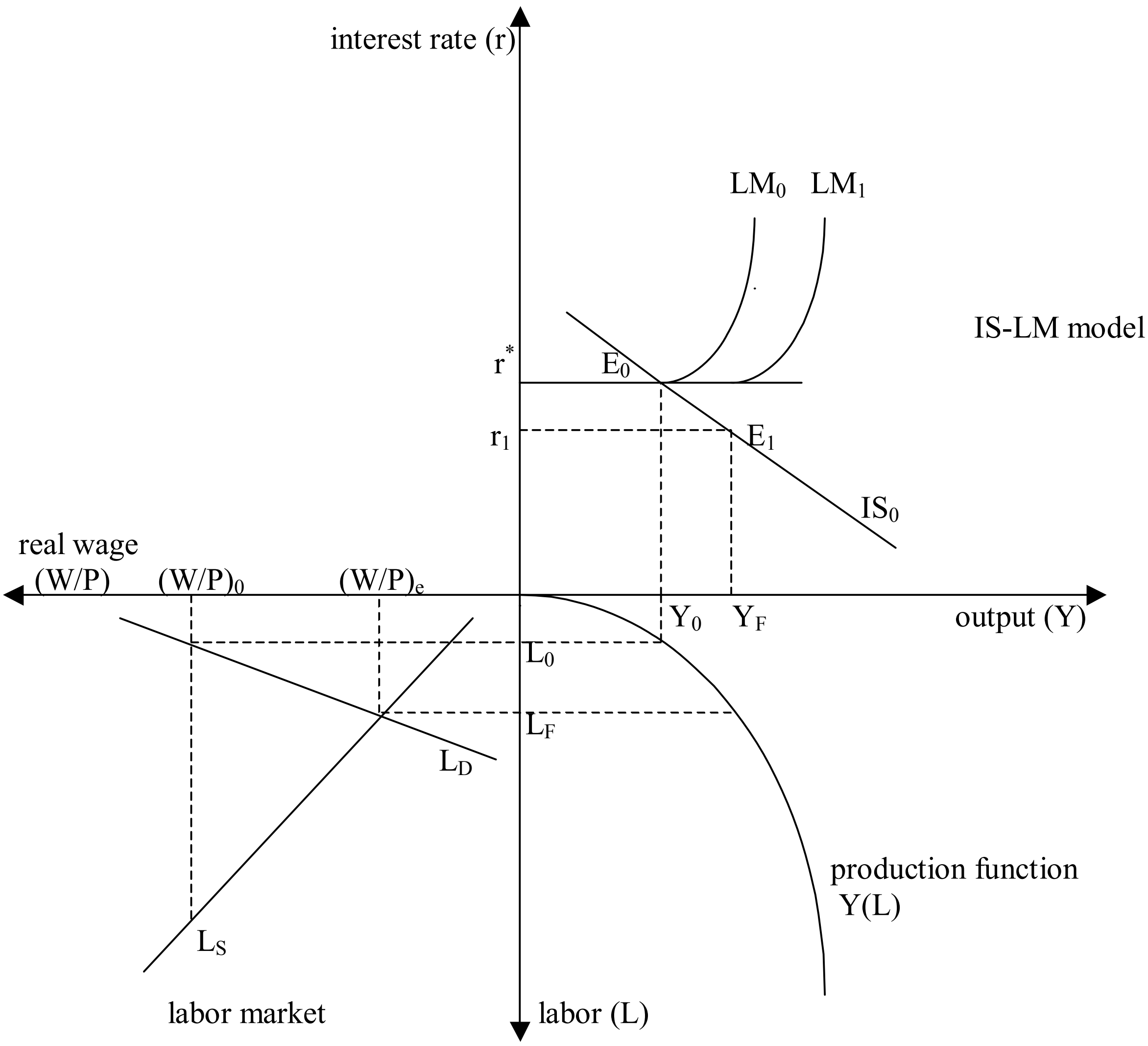

Figure 2.4 The Liquidity Trap Case

The liquidity trap case is illustrated in Figure 2.4. The initial point is E_0, with the employment L_0 lying below the full employment level L_F. The excess supply of labor results in a fall in money wages W which reduces firms' costs and causes a fall in prices. The fall in prices increases the real value of the money supply. Till now the process is the same as that in the case of Figure 2.3. But in the liquidity trap where the demand for money is perfectly elastic with respect to the interest rate at r^*, the excess real balances will not be channeled into the bond market and the LM curve is shifted outwards from LM_0 to LM_1, with the rate of interest not being reduced to r_1 (E_1). Lacking the required reduction of interest rate, aggregate demand will not be stimulated which is decisive for the economy to restore to full employment. Without increase in aggregate demand to moderate the rate of fall in prices, prices fall proportionally to the fall in money wages (a balanced deflation) and real wages remain unchanged at $(W/P)_0$, above the market clearing level $(W/P)_e$. Insufficient aggregate demand can not be stimulated to achieve full employment and the economy remains at underemployment equilibrium with persistent involuntary unemployment.

(ii) Interest-inelastic investment

In the case of interest-inelastic investment, the economy could neither self-equilibrate at full employment. As assumed before, the economy is initially at E_0 in Figure 2.5, with the level of employment L_0 below its full employment level L_F. The excess supply of labor brings about a fall in money wags and prices. The increase in real balances (which shifts the LM curve from LM_0 to LM_1) then causes the interest rate to fall. However the investment expenditure is so interest-inelastic that full employment equilibrium could only be achieved through the Keynes effect with a negative interest rate r_1. So the fall in the interest rate is insufficient to restore full employment. Theoretically the economy would come to rest at E_1 (with a zero interest rate), again a point of underemployment equilibrium Y_1 with persistent involuntary unemployment.

It can be concluded that reductions in money wages and prices will fail to restore full employment only when they are unable to increase aggregate demand via the Keynes effect. The possibility of persistent involuntary unemployment is not the general case but rather rests on two limiting cases: liquidity trap and interest-inelastic investment. This insight, together with the introduction of the Pigou effect into the analysis, promoted the emergence of the neoclassical synthesis which will be discussed in the following section.

2.3 The neoclassical synthesis

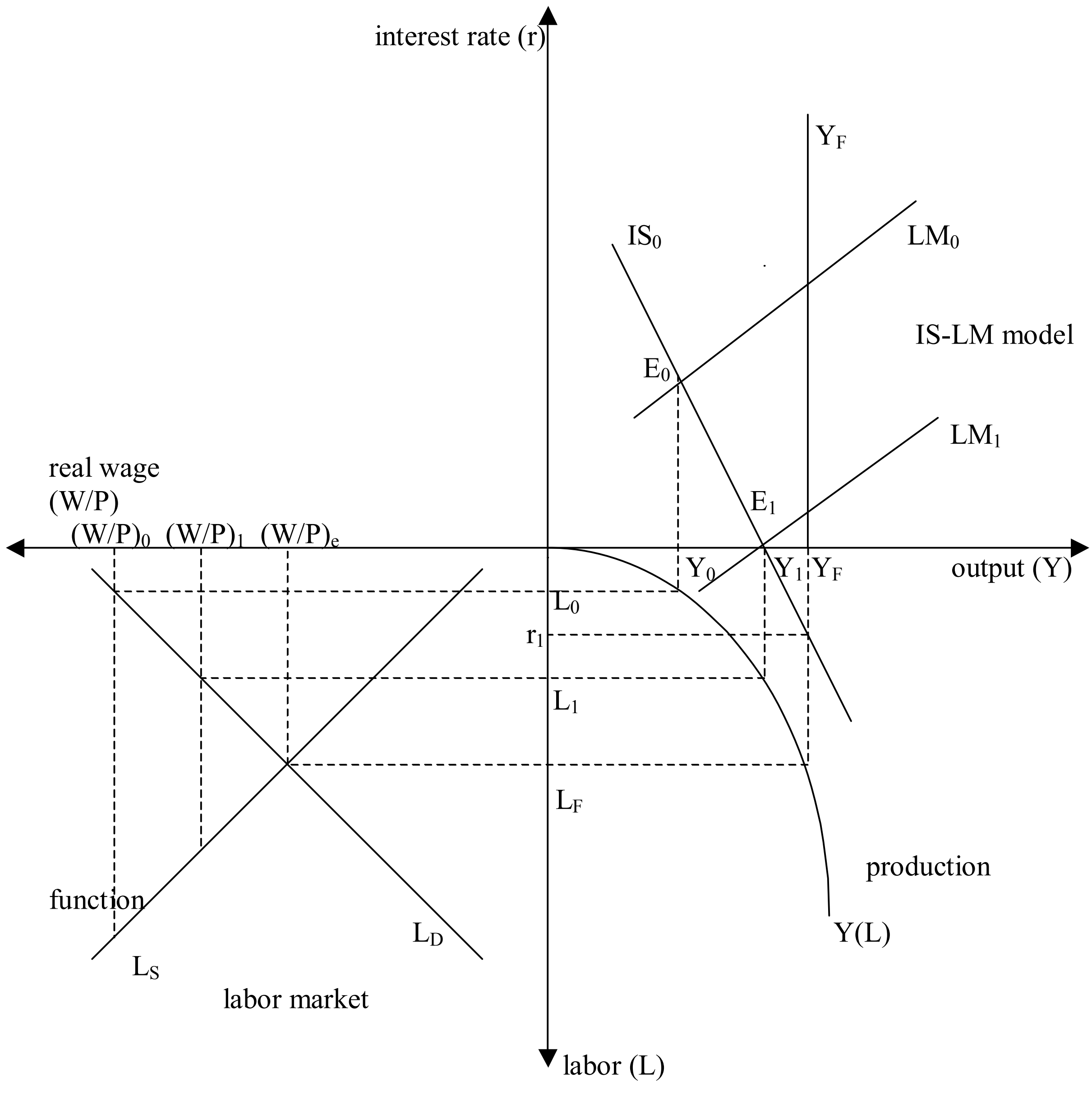

Figure 2.5 The Interest-inelastic Investment Case

The above equilibrium analysis implies the possibility of the economy to come to rest at underemployment equilibrium due to 'rigidities' in the system. Rigid money wages, the liquidity trap or the interest-inelastic investment are such 'rigidities'. Patinkin (1965) argues that unemployment is a disequilibrium phenomenon and can therefore exist even when money wages and prices are perfectly flexible. Patinkin believes however that this disequilibrium will not last forever thanks to a 'real-balance' effect or the so-called Pigou effect which is the 'direct' wealth effect.

The Pigou effect concerns the effect of falling prices on increasing real wealth, which in turn stimulates consumption expenditure and aggregate demand. Pigou argues that, if money wages and prices were flexible, the orthodox Keynesian model would not come to rest with persistent involuntary unemployment but instead adjust to achieve full employment automatically which is just the main prediction of classical economics.

In response to such debates, the so-called 'neoclassical synthesis' came into being during the late 1950s and early 1960s. It is a consensus view combining the ideas of classical economists with those of Keynes, in which the *General Theory* is regarded as a special case of a more general classical theory. In this special case the classical economy fails to adjust to full employment due to downward money wages rigidity. The neoclassical synthesis was the accepted wisdom in macroeconomics until the early 1970s.[4]

Just like the inability of the classical model to explain adequately the great depression in the 1930s prepared the way for the Keynesian revolution, the apparent failure of orthodox Keynesian theory to account for the stagflation in the 1970s made Keynesianism ripe for attack and paved the way for the monetarist and new classical counter-revolutions. In the arguments of monetarists against the orthodox Keynesian propositions, Friedman's expectations-augmented Phillips Curve plays an important role.

2.4 Unemployment in the monetarists' analysis

Providing an explanation of wage and price inflation, the Phillips Curve was incorporated into orthodox Keynesian framework in the late 1950s/early 1960s.[5] The standard Keynesian model was used to explain the determination of output and employment, while the Phillips Curve enabled the policy maker to predict the inflation rate by choosing different target levels of unemployment.

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[4] At that time the orthodox Keynesian model was the standard approach for large-scale macroeconometric models developed by Lawrence Klein and those associated with the Cowles Commission.

[5] The Keynesian idea initially emphasized demand-side factors and was associated with fiscalism.

In the 1970s, however, the simultaneous increase in both unemployment and inflation in the major industrial economies resulted in skeptics about the Keynesian IS-LM model supplemented with the Phillips Curve. Orthodox monetarists attacked Keynesianism by incorporating the expectations-augmented Phillips Curve into their analysis. A brief discussion of the Phillips Curve is given at first and the monetarists' view of unemployment will be elaborated subsequently.

2.4.1 The expectations-augmented Phillips Curve

Originally derived from a statistical investigation by A.W. Phillips (1958), the Phillips Curve is concerned with the non-linear and inverse relationship between the unemployment rate (u) and the rate of change of money wages ($\dot{W}$) in the UK from 1861 to 1957:

$$\dot{W} = f(u) \tag{2.7}$$

with $f' < 0$, $f'' > 0$.

Lipsey (1960) was able to provide an economic rationale for the Phillips Curve relationship by combining two postulated relationships: (a) a positive linear relationship between the rate of increases in money wages and excess demand, and (b) a negative non-linear relationship between excess demand and unemployment.[6] A negative relation between the unemployment rate and inflation rate can be constructed by assuming that prices are set by a mark-up to unit costs of production, the main component of which is wages.

The Phillips Curve was rapidly adopted by orthodox Keynesians and was interpreted as implying a stable long-run trade-off for the authorities. There seemed to be a menu of possible inflation-unemployment combinations for policy choice and the authorities need only to choose between different combinations of these two objectives.

[6] By regarding the level of unemployment as an indicator of the supply-demand constellation in the labor market, The Phillips Curve is the application of the classical law of supply and demand in the labor market.

However, the simultaneous rise in both inflation and unemployment by the late 1960s/early 1970s discredited the Phillips Curve empirically. Furthermore, Friedman (1968) and Phelps (1967) denied the existence of a stable long-run trade-off between inflation and unemployment by refuting its theoretical interpretation by Lipsey.

Friedman argues that the original Phillips Curve which related the rate of money wages change to unemployment was misspecified.[7] Since both employers and employees are really interested in real wages, he advocates that the Phillips Curve should be set in terms of the rate of change of real wages. He augments the original Phillips Curve with the anticipated rate of inflation (π^e) which can be expressed as:

$$\dot{W} = f(u) + \pi^e \qquad (2.8)$$

This relation means that the rate of money wage increase is equal to a component determined by the state of excess demand (as represented by the level of unemployment) plus the expected inflation rate. Introducing the expected inflation rate into the modified Phillips Curve implies that there will be a family of Phillips Curves instead of one unique Phillips Curve, as depicted in Figure 2.6. So the stable long-run trade-off between unemployment and wage inflation is rejected. The trade-off between the two variables is only short-run, with each short-run Phillips Curve corresponding to a different expected rate of inflation. The original Phillips Curve (2.7) can then be regarded as a special case of $\pi^e = 0$. The long-run Phillips Curve is instead vertical, along which the labor market remains at equilibrium and the real wage is constant.

Although the subject of the possible existence of a long-run vertical Phillips Curve was a controversial issue in the monetarist-Keynesian debate in the early 1970s, the majority of mainstream Keynesians had gradually accepted that the long-run Phillips Curve is vertical by the mid-to-late 1970s.

2.4.2 The natural rate of unemployment and its political implications

[7] It implies that workers are irrational and suffer from complete money illusion.

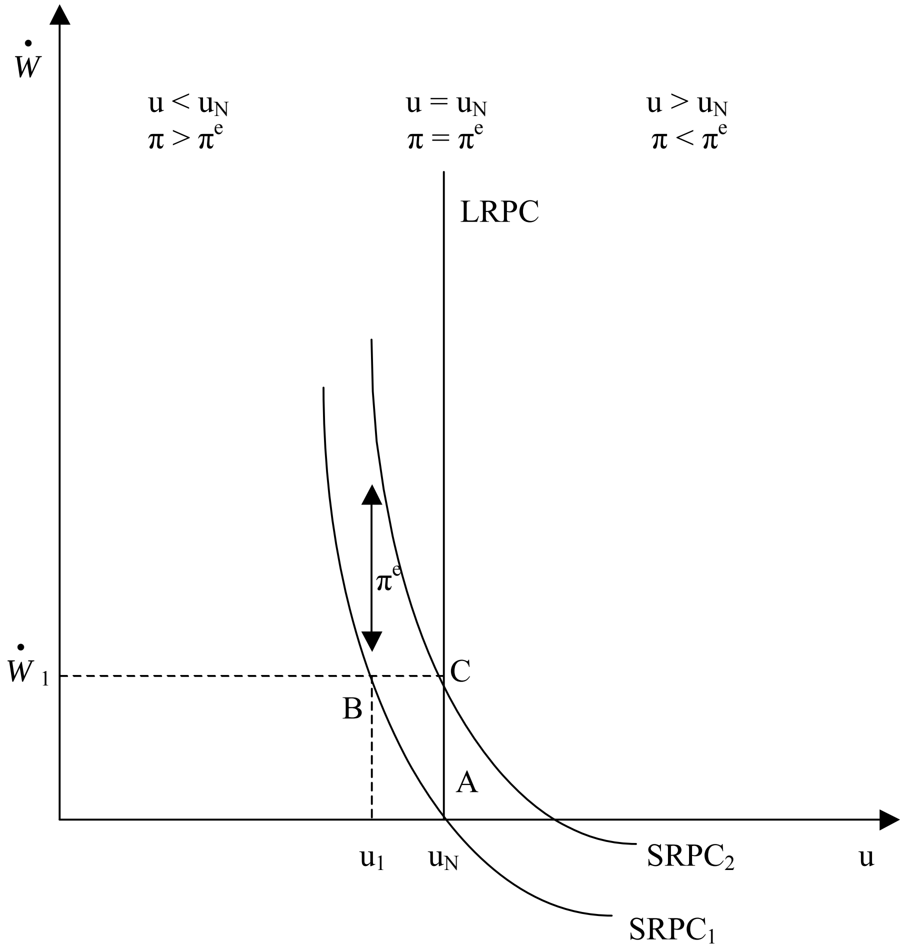

Figure 2.6 The Expectations-augmented Phillips Curve

As elaborated previously, monetarists' belief in the long-run vertical Phillips Curve means that the unemployment rate will in the long run return to its natural level u_N, which is in accordance with the labor market equilibrium. The natural rate of unemployment was defined by Friedman (1968) as 'the level that would be ground out by the Walrasian system of general equilibrium equations provided there is embedded in them the actual structural characteristics of the labor and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labor availabilities, the cost of mobility and so on'. The central proposition in the natural rate hypothesis is that fluctuations of aggregate demand can not have any effect on the natural rate of unemployment since this rate is determined merely by real supply-side factors.[8]

The natural rate concept has significant implication for economic policies. Since the economy will return to its equilibrium with the natural rate of unemployment, aggregate-demand policies can only affect the level of output and employment in the short run and they are in the long run powerless. Governments wishing to achieve higher output and employment permanently should manage to reduce the natural rate of unemployment. Supply-management policies should be pursued which are constructed to improve the structure and functioning of the labor market: (a) to increase the incentive to work, for example through reductions in marginal income tax rates, and reductions in unemployment and social security benefits; (b) to increase the flexibility of wages and working practices, for example by curtailing trade union power; (c) to increase the occupational and geographical mobility of labor, for example through greater provision of government retraining systems in the former case; (d) to increase the efficiency of markets for goods and service, for example by privatization.

Originated from the influential work of L.M. Friedman, monetary economists attacked the orthodox Keynesianism successfully. Monetarists' ideas were rapidly propagated in the early 1970s. But soon the prominence of monetarism was undertaken by a powerful wave of new classical contributions.

2.5 The new classical view of economic fluctuations

With the pioneering and innovative work of Robert Lucas (1972) as its symbol, the new classical macroeconomics applies the concept of the natural rate of unemployment from Friedman and Phelps and combines it with the rational expectations hypothesis. Although Keynesian economists regard business cycles as disequilibrium phenomena, new classical economists have managed to develop an equilibrium account of aggregate instability.

The central assumption underlying the new classical explanation of fluctuations is that aggregate supply depends on relative price. In new classical world, unanticipated aggregate demand shocks (coming mainly from unanticipated

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[8]The possibility of aggregate demand to influence the actual unemployment rate in the short run is however recognized.

monetary disturbances) cause errors in price expectations by rational agents and result in output and employment deviating from their natural levels (which are also long-run equilibrium levels).

In the next section, the aggregate supply hypothesis and the assumption of continuous market clearing as the central theoretical propositions underlying new classical models will be elaborated.[9] Political implications and an assessment are subsequently discussed.

2.5.1 The central propositions of new classical models

2.5.1.1 The aggregate supply hypothesis

Among the various explanations of the new classical aggregate supply hypothesis, two main approaches can be identified which are based on two orthodox microeconomic assumptions: (a) rational decisions taken by workers and firms reflect optimizing behavior on their part and (b) the supply of labor/output by workers/firms depends on relative prices.

Originated from the work of Lucas and Rapping (1969), the first approach focuses on labor supply. It is concerned with the intertemporal labor substitution hypothesis and explains changes in employment as the ‘voluntary’ choices of workers who change their supply of labor in response to perceived temporary changes in the real wage. This hypothesis will be elaborated later in real business cycle theory.[10]

The second approach to aggregate supply is also derived from the influential work of Lucas (1972, 1973). It implies that a firm has to decide whether a rise in the current market price of its output reflects a real shift in demand towards its product or not. Only in the case of the price of its output increasing relative to the price of other goods, should the rational firm increase its output. Note that this analysis also conforms to the expectations-augmented Phillips Curve.[11]

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[9] The rational expectations hypothesis is another central theoretical proposition of the new classical macroeconomics.

[10] See section 2.6.1.2.

[11] The relationship $Y\text{-}Y_N=\alpha(P\text{-}P^e)$, also the so-called Lucas ‘surprise’ function, can be expressed as $Y\text{-}Y_N=\alpha(\pi\text{-}\pi^e)$ which turns out to be a restatement of the expectations-augmented Phillips Curve.

2.5.1.2 The hypothesis of continuous market clearing

The assumption of continuous market clearing states that all markets continuously clear in line with the Walrasian tradition. The economy is thought of as being in a continuous state of equilibrium, both in the short-run and long-run.

This assumption implies that prices are free to adjust instantaneously to clear markets and contrasts the assumption in both orthodox Keynesian and monetarist models. Based on the assumption of slow prices adjustment, Keynesian models predict the economy to be probably in a state of continuous disequilibrium. Orthodox monetarists believe instead that prices adjust rather rapidly. With the admission of possible short-run disequilibrium, they argue that the economy will automatically return to macroeconomic equilibrium at the natural rate of output and employment in the long run.

The assumption of continuous market clearing is, however, often objected to due to its deficiency of reality, especially with respect to the labor market. New classical economists insist that anyone wishing to work can find employment at the market-clearing equilibrium wage. In other words, in the new classical models unemployment is entirely a voluntary phenomenon.

2.5.2 Policy implications

The new classical approach has a number of important policy conclusions. Those concerning unemployment and econometric models will be elaborated here.

With regard to reducing unemployment permanently, new classical economists have brought the possibility of using aggregate supply policies much more to the forefront. As illustrated earlier, in new classical models changes in output and employment are considered to reflect the equilibrium decisions of firms and workers, based on their perceptions of relative prices. The labor market continuously clears. Unemployment is viewed as an equilibrium outcome reflecting the optimal decisions of workers in response to movements in current and expected future real wages and involuntary unemployment does not exist. If the authorities wish to increase output and reduce unemployment in the long run, they should pursue those policy measures that increase the microeconomic incentives for firms and workers to supply more output and labor.

Another influential contribution of the new classical economics is the Lucas critique which attacks the standard approach of using large-scale macroeconometric models for policy evaluations. Lucas denies the underlying assumption of Keynesian disequilibrium models that the model's parameters remain constant when there is a policy change. Identifying the treatment of expectations as a major defect in the micro foundation of Keynesian-type models, he insists that economic agents with rational expectations may adjust their behavior to the new environment quickly so that the parameters of large-scale macroeconometric models may not remain unchanged in the face of policy changes. By focusing on individuals' objectives and constraints, equilibrium theorizing instead is much more likely to result in models containing structural relations which are invariant to policy changes.

2.5.3 An assessment

The 1970s saw the dominance of new classical equilibrium approach in the macroeconomics discussion. Besides the policy ineffectiveness proposition stating that anticipated monetary policy will be ineffective, the insight of rational expectations and its integration into the macroeconometric models brought about the so-called 'rational expectations revolution'. This has furthermore led economists to reconsider the role and conduct of macroeconomic stabilization policy.

However, models based on the new classical theory had reached both a theoretical and an empirical impasse by the early 1980s. Theoretically, the deficiencies mainly lay in the utilization of both the assumption of continuous market clearing and that of imperfect information. On the empirical front, the proposition that only unanticipated monetary surprises have real output effects did not prove to be robust. A macroeconometric model with rational expectations still brings about Keynesian result: Monetary and fiscal policies are effective with respect to real variables. In response to these criticisms, some economists have developed equilibrium real business cycle theory since the mid-1980s.

2.6 The real business cycle theory

In the wake of the monetary surprise explanation losing its dominance, the influential work of Kydland and Prescott (1982), together with that of Long and Plosser (1983), signaled the era of real business cycle theory. This non-monetary equilibrium model retains and develops the propagation mechanisms of the earlier new classical models, while the impulse mechanism (unanticipated monetary shocks) is replaced by supply-side shocks in the form of random changes in technology.[12] With large random fluctuations in the rate of technological progress as the underlying assumption, rational agents change their decisions of labor supply and consumption in response to the altered structure of relative prices. Fluctuations in aggregate output and employment are thus generated.

The development of real business cycle theory is stimulated by two important facts. The two oil price shocks in the 1970s and the apparent failure of the demand-oriented Keynesian model to give an adequate account for rising unemployment accompanied by accelerating inflation have forced macroeconomists to be more aware of the importance of supply-side factors. In addition, the seminal work of Nelson and Plosser (1982) suggested that the real shocks may be much more important than monetary shocks in explaining the aggregate output development over time.[13]

2.6.1 Core propositions in the real business cycle theory

2.6.1.1 Technological shocks as the impulse mechanism

Real business cycle models are typically driven by real supply shocks, mainly exogenous productivity shocks resulting from large random variations in the rate of technological change.

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[12] To equilibrium theorists an impulse mechanism is the initial shock which causes a variable to deviate from its steady state level. A propagation mechanism is thought to consist of forces which carry the effects of an impulse forwards over time and cause the deviation from the steady state to persist.

[13] In their influential work, it is argued that most macroeconomic time series are better described as a random walk, rather than as fluctuations or deviations from deterministic trends.

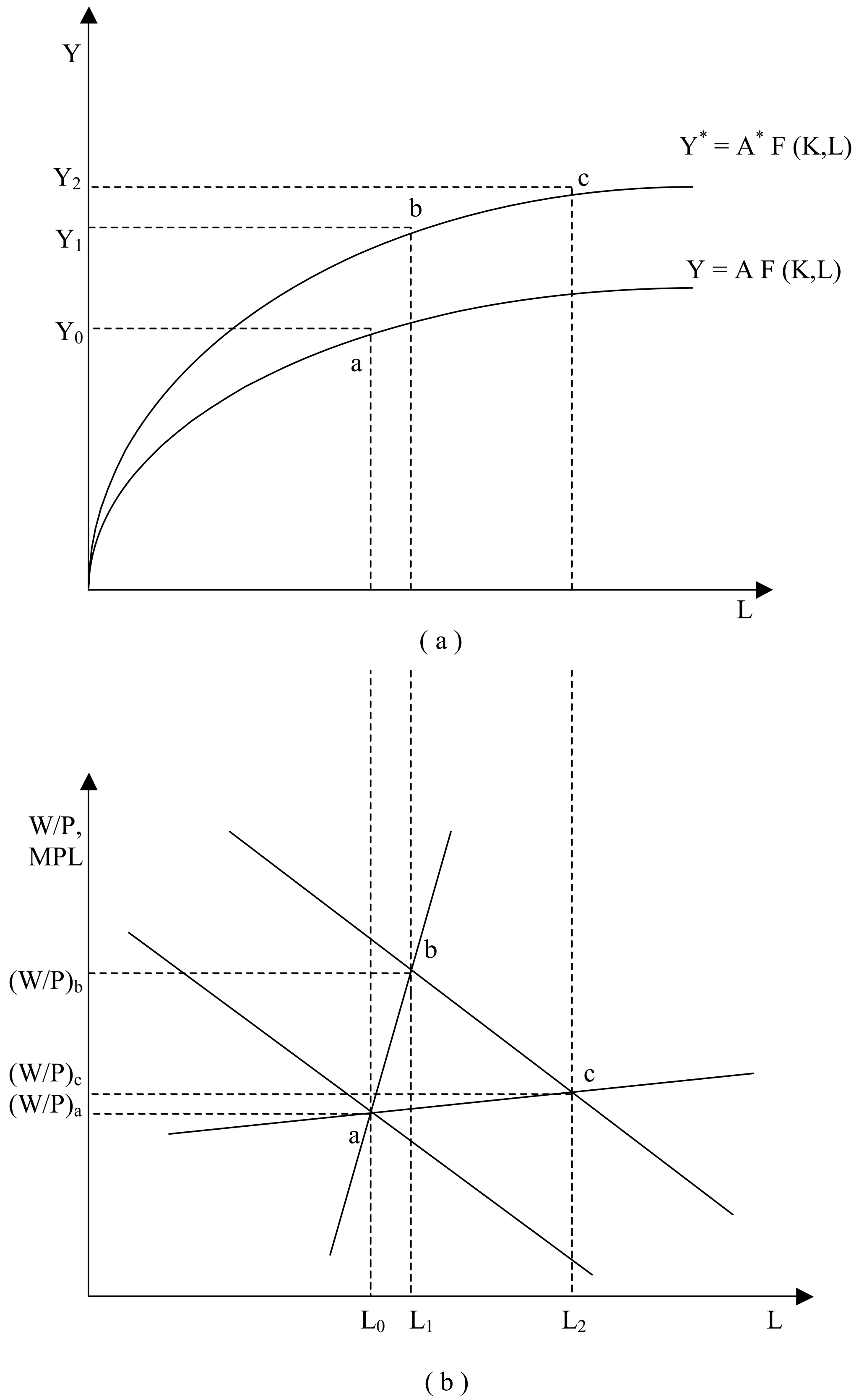

Figure 2.7 Output and Employment Fluctuations Caused by a Technological Shock

Figure 2.7 shows how real business cycle theory explains aggregate fluctuations. In panel (a) the production function is shifted from Y to Y^* by a beneficial technological shock. Panel (b) illustrates the impact of this shift on the marginal product of labor and hence labor demand. Following a beneficial productivity shock, employment and output will rise because of the increase in labor demand. The scope of the employment expansion will depend on the elasticity of labor supply at the current real wage. If the labor supply schedule is relatively inelastic with respect to the current real wage, as indicated by S_{L1} in panel (b), the economy will come to stay at point b. In this case a technological shock will result in large variations of the real wage and small changes in employment. If the labor supply schedule is instead highly elastic like S_{L2}, a technological shock will cause output to expand from Y_0 to Y_2, with the real wage increasing from $(W/P)_a$ to $(W/P)_c$ and employment from L_0 to L_2. This is consistent with the 'stylized facts' that small procyclical variations in the real wage are associated with large procyclical variations of employment.

Therefore, for real business cycle theory to account for the substantial variations in employment observed during aggregate fluctuations, the labor supply schedule is required to be highly elastic with respect to the real wage. This requires significant intertemporal substitution of labor as propagation mechanism, which is elaborated in the next section.

2.6.1.2 The intertemporal labor substitution hypothesis

The main proposition of the intertemporal substitution of labor is that households shift their labor supply with respect to real wages over time. The underlying assumption is that households would be more ready to work when real wages are temporarily high and be willing to work less when real wages are temporarily low.

In the intertemporal labor substitution hypothesis, cases of permanent and temporary changes in the real wage are differently treated. If a technological shock is transitory, the current above-norm real wage offers will be temporary. Rational maximizing workers will in this case offer more labor, substituting work for current leisure. Real business cycle theory hence insists a large response in labor supply to temporary changes in the real wage. On the other hand, a permanent technological shock will raise the future real wages and will tend to reduce current labor supply through wealth effects.

In addition to real wages, the impact of real interest rates on labor supply in flexible price models has also been emphasized. Since an increase in real interest rate implies the rising of value of income earned from current relative to future employment, it will encourage agents to supply more labor now.

In this way workers choose unemployment or employment in accordance with their preferences and fluctuations in employment reflect merely changes of people's preference to work.

2.6.2 The real business cycle view of real wages and unemployment

2.6.2.1 The cyclical behavior of real wages

The expanding business cycle literature in recent years has seriously called into question much of the well established wisdom with respect to the 'stylized facts', among which also the agreement concerning cyclical behavior of real wages.

Orthodox Keynesian and monetarist theories identify aggregate demand disturbances as the main causes of economic fluctuations. Keynes argues in the *General Theory* that an expansion of employment is accompanied with a decline in the real wage. In the Keynesian models of the neoclassical synthesis the economy is assumed to be operating along the aggregate labor demand curve so that the real wage must vary counter-cyclical. Features implying a counter-cyclical real wage are also incorporated in Friedman's monetarism and some early new classical and new Keynesian models as well. Therefore the agreement about the cyclical behavior of real wages stated that real wages are counter-cyclical.

Kydland and Prescott (1990), however, find that the real wage is 'reasonably strong' pro-cyclical, which is consistent with shifts of the production function. The current consensus that the real wage is 'slightly pro-cyclical' challenges both traditional monetary explanations of the business cycle and real business cycle theory. If the real wage is moderately pro-cyclical, then a highly elastic labor supply curve is necessary for shocks to the production function to influence employment significantly (see panel (b) in Figure 2.7).[14]

2.6.2.2 Unemployment in the real business cycle model

Till the 1980s some consensus existed which regards fluctuations in aggregate output as temporary deviations from certain underlying trend rate of growth. Aggregate instability in the form of business cycles was thought to be socially undesirable and should be reduced by appropriate policies.

Real business cycle economists demonstrate that instability results from responses of rational economic agents to changes in the economic environment by adopting an integrated approach to growth and fluctuations. Observed fluctuations should not be viewed as welfare-reducing but rather are optimal responses to uncertainty in the rate of technological progress.

In the labor market, fluctuations in employment are Pareto efficient adjustments of workers. In response to economic changes caused by shocks, workers revise their supply of labor according to intertemporal substitution hypothesis. Observed unemployment is only the result of this substitution process and hence is always voluntary. The labor market is always in equilibrium at full employment.

2.6.3 Some Criticisms

During the 1980s real business cycle theory has seriously challenged the conventional wisdom within macroeconomics. Nelson and Plosser demonstrate that shocks to aggregate output tend to have long-lasting effects which is in sharp contrast to the well accepted opinion at that time that aggregate output deviates only temporarily from a deterministic trend. This line of thought reconciles aggregate instability with equilibrium models and has a profound influence on business cycle research.

Despite these achievements, the real business cycle approach has also its deficiencies. Besides the lack of robust empirical evidence, following criticisms are often cited.

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[14] However the hypothesis of significant intertemporal substitution does not receive strong support from the empirical work, see also section 2.6.3.

A major criticism of real business cycle theory is associated with the intertemporal labor substitution hypothesis. Based on numerous econometric studies, the quantitative importance of the elasticity of intertemporal substitution in labor supply can only be regarded as insignificant, implying a weak response to transitory wage changes. In addition it was challenged that the real interest rate plays a significant role in labor supply decisions.

A second criticism relates to the issue of unemployment. Unemployment is always voluntary in real business cycle framework. The experience of the Great Depression 'defies credulity to account for movements on this scale by pointing to intertemporal substitution and productivity shocks' (Summers, 1986). The neglect of unemployment within real business cycle framework is hence regarded as a major deficiency in critics' view.

A third line of criticism concerns the finding by Nelson and Plosser that real GNP is as persistent as a random walk with drift. Critics argue that the discovery of a near unit root in the GNP series does not necessarily provide evidence for real shocks from the supply side. By showing the possibility of technological innovation to depend on the demand side factors, they demonstrate that changes on the demand side could also have long-lasting effects on real output. Permanent effects of aggregate demand could also come into being if hysteresis effects are important. This criticism brings about an important implication regarding the labor market. The natural rate of unemployment will depend on not only the development of supply-side factors, but also the history of aggregate demand disturbances.

Finally, it should be noted that a majority of economists insist that the short-run aggregate demand disturbances can have significant real effects with nominal price and wage rigidities being considered. This challenges the assumption of continuous market clearing. If market does not clear quickly, which is indeed the case, the observed fluctuations will consist of a stochastic trend around which output deviates as the result of demand shocks, given that aggregate demand disturbances and aggregate supply disturbance characterize the economy.[15]

[15] The contribution of Blanchard of Quah (1989) provides a good presentation of this consensus where they 'interpret fluctuations in GNP and unemployment as due to two types of disturbances':

2.7 The labor market in the new Keynesian economics

As illustrated previously, the orthodox Keynesian model associated with the neoclassical synthesis was challenged by orthodox monetarism during the 1970s. Although having incorporated monetarist ideas into the existing framework, Keynesian models were soon attacked by the new classical critique. In order to remedy the theoretical deficiencies and inconsistencies in 'old' Keynesian models, new Keynesian economics developed to provide firmer micro foundations of Keynesian macroeconomics.[16]

In contrast to perfectly competitive firms as price takers in new classical models, new Keynesian models prefer price-making monopolistic. Rational expectations are normally incorporated in these models. New Keynesian economists recognize both supply and demand shocks as potential sources of instability, tending to improve the supply side of Keynesian models. They also share Keynes's opinion concerning the possible existence of involuntary unemployment.

This brave new theoretical system is characterized by imperfect competition, incomplete markets, heterogeneous labor and asymmetric information. It follows that coordination failure and macroeconomic externalities are typical of the new Keynesian 'real' macro world. A 'European' brand of new Keynesian macroeconomics can be identified which stresses imperfect competition in the labor and product market, being well in line with the higher unionization rates typical of European economies. Therefore it is rather appropriate to use a bargaining approach to wage determination as a micro foundation in Europe. [17]

If the old Keynesian approach merely assumed a fixed nominal wage in their model construction, the new Keynesian economics goes further to find a theory of aggregate supply to explain the existence of wage and price rigidities which will be elaborated in the next section.

2.7.1 Rigidities in the new Keynesian framework

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supply disturbances 'those have a permanent effect on output' and demand disturbances 'those do not'.

[16] The experience of persistently high unemployment in Europe during the 1980s and 1990s provided further credibility to Keynesian theory and policy.

Because the contributions within the new Keynesian economics are extremely wide-ranging, it is convenient to divide the explanations of rigidities into two categories: one category focuses on nominal rigidities; the other on real rigidities. A nominal rigidity comes into being if some factor prevents the nominal price level from adjusting so as exactly to mimic nominal demand disturbances. A real rigidity occurs if real wages are prevented from adjusting or one wage is sticky relative to another wage, or one price relative to another.

2.7.1.1 Nominal rigidities

In contrast to the auction model with flexible price in all markets assumed by new classical theorists, new Keynesians insist instead that the labor market belongs to fix-price markets where price and wage inertia is a reality. In Keynesian models, the source of real effects (monetary non-neutrality) is the failure of nominal wages and prices to adjust quickly to clear markets after an aggregate demand disturbance. Keynesians have traditionally focused on the labor market and nominal wage rigidity to explain the tendency of market economies to deviate from their full employment equilibrium.[18]

2.7.1.1.1 Rigid nominal wages

In traditional Keynesian models it is arbitrarily assumed that the failure of money wages (which are primary costs for firms) to adjust quickly prevents the price level from falling to restore equilibrium (see Figure 2.2). During the 1970s new classical models were developed by Lucas, Sargent, Wallace and Barro to challenge the orthodox Keynesian economics and have forced Keynesians to strengthen their theoretical foundations.

Concentrating on nominal wage rigidities, Fischer (1977) and Taylor (1980) introduced nominal stickiness in the form of long-term wage contracts in their models. They argue that wages are not determined in spot markets in developed

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[17] Research on the unemployment problem in the imperfect competition framework is best represented in Layard, Nickell and Jackmann (2005).

[18] It was the first wave of new Keynesian response to the new classical critique.

economies, but tend to be settled for a certain period in the form of explicit (or implicit) contract. The existence of these long-term contracts can result in sufficient nominal wage rigidity to guarantee monetary policy effectiveness. As a result monetary policy can have real effects in the short run but it will still be neutral in the long run.

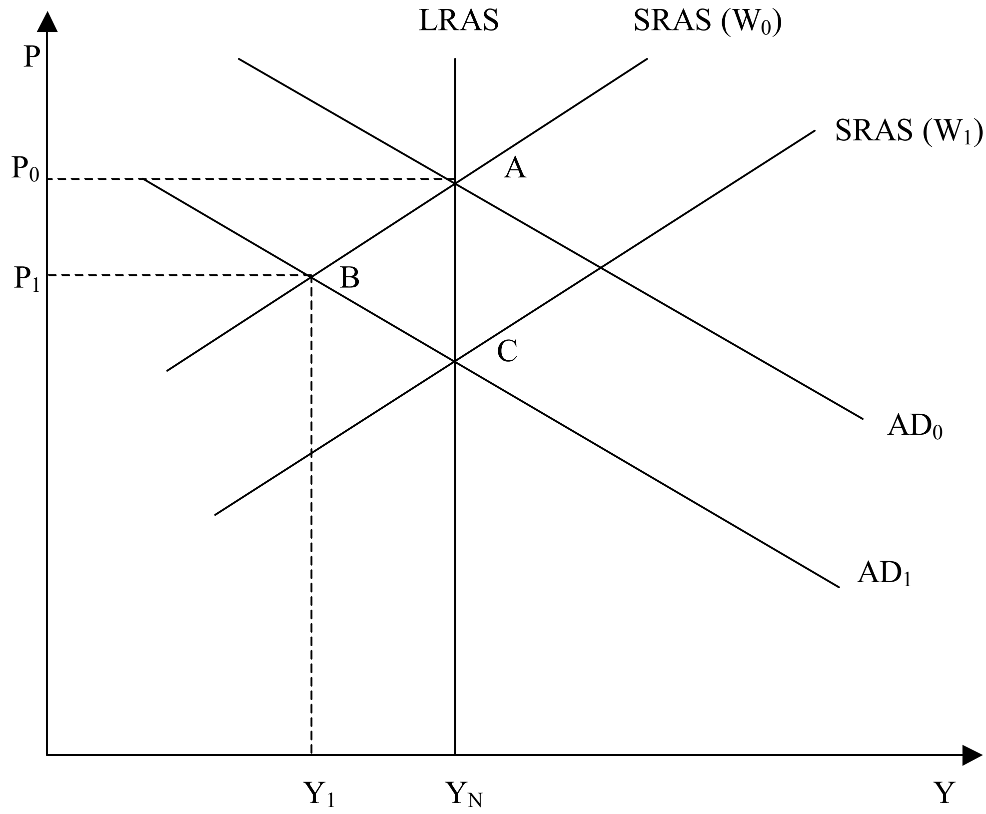


Figure 2.8 New Keynesian Model with Nominal Wage Rigidity

The analysis of Fischer is illustrated in Figure 2.8. The starting point is A, with real output at its full employment level Y_N. Suppose an unexpected nominal shock in the current period shifts the aggregate demand curve from AD_0 to AD_1. If both wages and prices were flexible, the short-run aggregate supply curve would shift down to the right from SRAS (W_0) to SRAS (W_1). The economy would come to stay at C, at the natural rate output level again. With flexible price but temporarily rigid nominal wages (remain at W_0) due to long-term contracts, however, real output will fall from Y_N to Y_1 and the economy will move to B. Therefore, if the authorities can react to nominal demand shocks more quickly than the workers in the private sector can renegotiate nominal wages, there is scope for discretionary intervention. With fixed nominal wage the monetary authorities can exert some influence on the real wage rate and hence employment and output.

Although long-term wage contracts increase macroeconomic instability, they are regarded as reasonable because of the private advantages they bring to both workers and firms.[19]

2.7.1.1.2 Rigid nominal prices

The first tide of new Keynesian development concentrated on nominal wage contracts soon received considerable criticism. It was pointed out that the existence of long-term wage contracts does not have robust microeconomic foundations. In addition, models with nominal agreements imply counter-cyclical behavior of the real wage, which contradicts the current widely accepted opinion that real wages appear to be slightly pro-cyclical.[20] In response to these criticisms, new Keynesian theorists turned their research to the goods market and attempted to provide more solid micro foundations for nominal price rigidities.

In perfectly competition markets prices change automatically to guarantee market-clearing and a firm acts as a price taker. Nominal prices would surely show a high degree of flexibility. Under imperfectly competition, however, sales of a firm will depend on its price and the existence of even small costs to price adjustment can produce significant nominal price rigidity which is referred to as the ‘PAYM insight”, coming from its initiators Akerlof and Yellen (1985), Mankiw (1985) and Parkin (1986).[21]

The crucial element of the PAYM insight is the presence of menu costs, which are defined as frictions to price adjustment. Menu costs consist of the physical costs of resetting prices and scarce time used up to supervise and renegotiate purchases and sales contracts. An influential implication of the PAYM insight is

[19] Wage negotiations are generally costly; there also exists the potential for such negotiations to break down; to ‘jump’ its wage rates to the ‘ultimate’ equilibrium facing a negative demand shock is likely to increase labor turnover for a firm.

[20] For cyclical behavior of real wages, see also section 2.6.2.1.

[21] Similar with long-term wage contracts, firms also enjoy many advantages by making long-term prices agreements between them. A mark-up pricing approach is typically used to set prices in advance.

that the small private cost of nominal rigidities to the individual firm (menu costs) can produce large macroeconomic instabilities.

2.7.1.2 Real rigidities

The menu costs approach was in turn criticized for the implausibility of parameter values implied from this theoretical framework. It is argued instead that real rigidities combined with small frictions to nominal adjust can lead to substantial nominal rigidities.[22]

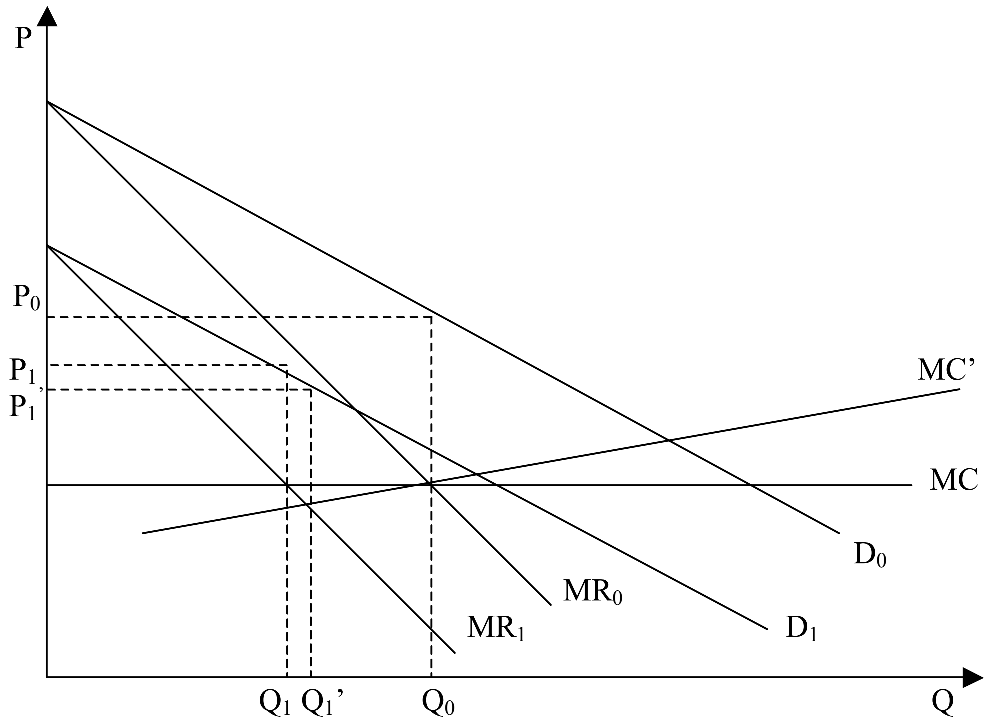
2.7.1.2.1 Real price rigidity

One important new Keynesian explanation of real price rigidity relates to the cyclical sensitivity of marginal cost and the size of demand elasticity. Slight sensitivity of marginal cost to output variations and pro-cyclical behavior of the size of demand elasticity will contribute to real price rigidity.[23]

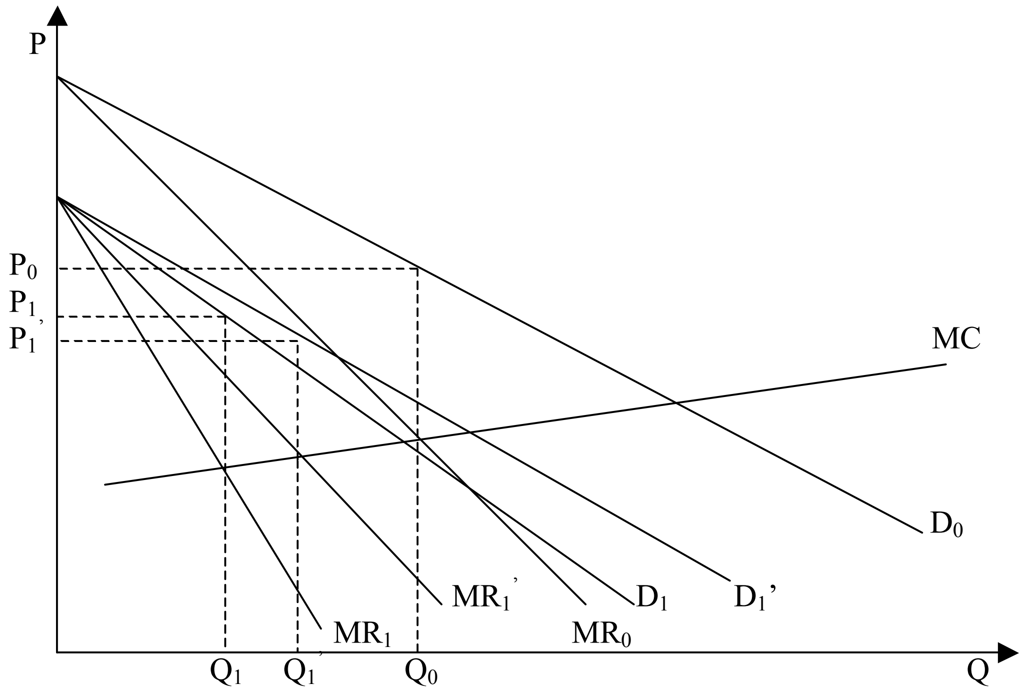
If nominal prices in an economy were perfectly flexible, the real equilibrium would remain unchanged after a purely nominal shock. However with real prices and wages rigidity existed, the non-neutrality resulted from small nominal frictions will be magnified.

The significance of this point can be illustrated by considering the impact of a decline in money supply. With the supposed presence of menu costs (small nominal frictions), firms will be initially deterred from reducing their prices in response to the nominal disturbance and real output will decline as a result. As all firms produce less output, the labor demand declines in turn. If labor supply curve is relatively inelastic, the decline in labor demand will lead to a large decrease in real wages, implying a decline in marginal cost which will be further strengthened if the marginal product of labor rises sharply as the labor input decreases. With an upward-sloping marginal cost curve, firms would be more inclined to reduce price and there would be no plausible barriers to nominal adjustment.

[22] Indeed the interaction between nominal and real imperfections is identified as a distinguishing feature of the new Keynesian economics.
[23] New Keynesian economists have also pointed out several other potential sources of real rigidity in the product market: the existence of thick market externalities, the characteristics of customer markets, the input-output theory, the counter-cyclical capital cost, etc..



(a) mild cyclical sensitivity of marginal cost



(b) pro-cyclical size of demand elasticity

Figure 2.9 Two Cases of Real Price Rigidity

However, if marginal cost does not fall significantly following an output decline and/or marginal revenue does fall significantly, then nominal shocks are to have large real consequences. The first case of cyclical insensitive marginal cost is shown in panel (a) of Figure 2.9. If the marginal cost curve is upward-sloping (like $MC^{'}$), firms will have more incentive to reduce price till $P_1^{'}$ for example. However, with a constant marginal cost curve (as indicated by MC), price will merely be reduced to P_1 (which is above $P_1^{'}$). Panel (b) of Figure 2.9 illustrates the case associated with the elasticity of demand. If the size of demand elasticity (whose value is negative) at the existing price declines (the rotation of demand curve from $D_1^{'}$ to D_1 in panel (b)) due to the left movement of a firm's demand curve so that its marginal revenue curve also shifts to the left, the firm would not tend to reduce its prices (price will only be reduced to P_1 rather than $P_1^{'}$).[24]

The above analysis can also be carried out algebraically by referring to the mark-up pricing equation of a monopolistically competitive firm. Starting from the profit maximization condition that marginal revenue equals marginal cost (MC):

$$P+P(1/\eta)=MC \tag{2.9}$$

where P: price of the firm

η: price elasticity of demand, $\eta < 0$,

price can be expressed as a mark-up of marginal cost:

$$P=MC(1/(1+(1/\eta))) \tag{2.10}$$

Combine equation (2.10) with the relation that marginal cost is the nominal wage (W) divided by the marginal product of labor (MPL):

$$P=W(1/(1+(1/\eta)))/MPL \tag{2.11}$$

The term $1/(1+(1/\eta))$ represents the mark-up, which varies inversely with the size of demand elasticity $|\eta|$. The two cases when large nominal rigidities occur in

[24] Real price rigidity is high the smaller is the cyclical sensitivity of marginal cost and the greater is the cyclical sensitivity of the size of demand elasticity.

the face of negative demand shocks (when P will not fall considerably) correspond to the cases when MC does not decline sufficiently and when $|\eta|$ does fall sufficiently (implying a significant rise of the mark-up).

2.7.1.2.2 Real wage rigidity

Not only are potential sources of real rigidity in the product market examined, new Keynesian literature has also provided important contributions to real rigidities in the labor market. In fact, if real wages are inertia, a firm's incentive to vary its price in response to demand disturbances will be substantially reduced. With the existence of real wage rigidity in a new Keynesian world, the labor market can reach its equilibrium status at a real wage different from the market-clearing real wage.[25] By demonstrating that the economy may come to stay at its equilibrium level with involuntary unemployment, new Keynesian models are able to reconcile involuntary unemployment with long-run equilibrium.

New Keynesian explanations of real wage rigidity can be generally divided into three groups: (1) implicit contract theories, (2) efficiency wage theories, and (3) inside-outside theories.

(1) Implicit contract theories

Implicit contract models aim to find out what keeps workers and firms together in long-term relationships generally observed in the labor market whose central assumption is that firms are risk-neutral while workers risk-averse with respect to income. To avoid labor turnover costs, firms are inclined to enter into implicit agreements concerning the terms of working relationship with their workers. Risk-averse workers would like to accept this 'invisible handshake' because they are thus provided with assurances under various working circumstances. Rather than a highly varying and unpredictable wage rate that would be determined by market forces, workers would prefer a constant real wage, even if this fixed wage rate is lower than the expected value of the rate determined by an auction market.

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[25] In contrast to the traditional wisdom that equilibrium is always associated with the status that demand equals supply, new Keynesian economists have defined the market equilibrium as a state where no agents are inclined to change their behavior.

Although it is viewed as a plausible hypothesis to explain wage rigidities, this theory is developed outside collective agreements, thus only appropriate for non-union sectors which are unusual in Germany. Furthermore, it has not explained why unemployed workers can not bid down wages to achieve their employment and is thus unable to provide an acceptable account of persistent involuntary unemployment.

(2) Efficiency wage theories

Efficiency wage theories seek to find out why unemployed workers are powerless to underbid real wages from the side of firms. According to efficiency wage theorists, real wages and worker effort are interdependent. Therefore firms aiming to maximize their profits are reluctant to cut real wages because the effort (thus productivity) of workers will decrease in this case. The deviation of wages from marginal productivities is also legitimated in this framework.

To achieve profit maximization, the firm should not only offer such an efficiency wage w^* that the elasticity of effort with respect to the wage is unity but also hire labor up to the point where the labor marginal product is equal to this efficiency wage.[26] If the aggregate demand for labor at the efficiency wage is unable to absorb the aggregate supply of labor (the efficiency wage w^* exceeds the market clearing (Walrasian) real wage w as in Figure 2.10), then the economy will reach its equilibrium with involuntary unemployment. A shock shifting the labor demand curve from D_{L1} to D_{L2} will increase involuntary unemployment because the efficiency wage is rigid at w^*.

A crucial assumption in the above analysis is that worker effort/productivity is related to real wages positively. The explanation relating to developing economies focuses on the increase of workers' physical well-being through higher nutrition thanks to higher real wages. In the developed country, explanations are concerned with the issues of selection and incentive and fall into four groups: the adverse selection model, the labor turnover model, the shirking model and the fairness model.

[26] In this way the setting of efficiency wage is not influenced by the labor market constellation (the relation between labor demand and supply) directly.

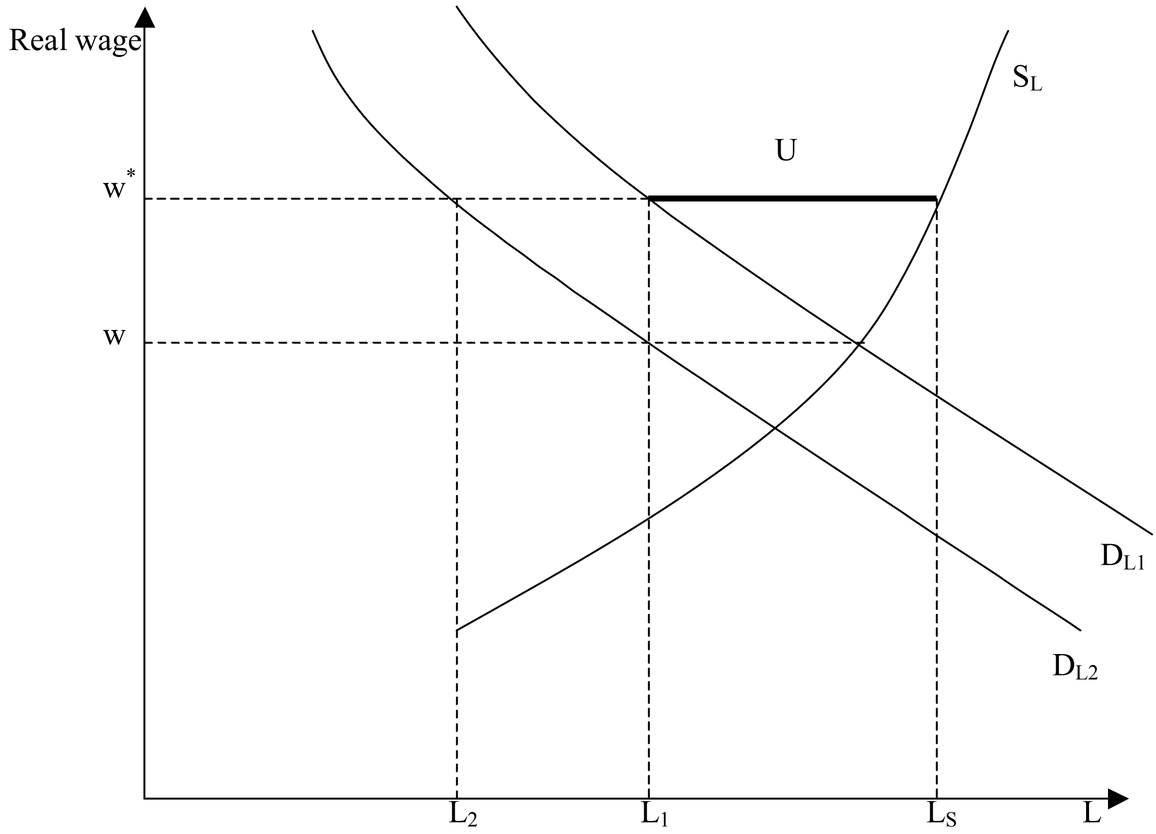

Figure 2.10 Underemployment Equilibrium in the Efficiency Wage Model

(3) Insider-outsider theories

Initiated by Lindbeck and Snower (1985, 1986, 1988), the insider-outsider theory also aims to explain why wage rigidity persists with the presence of involuntary unemployment. Although efficiency wage models argue that it is in the employer's interest to pay efficiency wage higher than the market-clearing wage, the insider-outsider approach emphasizes the interest of employed insiders. The word insiders are used to represent the incumbent employees, who are thought being engaged in the wage and employment determination at least partially; whereas the outsiders to represent the unemployed workers.

The central point in the Lindbeck-Snower model is the insider power emerging from turnover costs. Theses turnover costs usually consist of hiring and firing costs, training costs for new employees as well. They also arise from the insiders' ability and incentive to cooperate or harass new workers. Suppose a firm has to lay off its workforce due to negative shocks, with unemployment as the consequence. When the economic climate becomes better, the firm would expand employment accordingly if insider power did not exist. However, with insider power existed, employee could make negotiated wages exceed the market-clearing level. Being powerless in wage negotiations, unemployed outsiders remain further unemployed.

Besides the model of Lindbeck and Snower, other variants of insider-outsider theories are also developed to explain why outsiders become less competitive in the labor market. In the Solow (1985) model, special human capital is the central point, which outsiders lose due to becoming unemployed. Blanchard and Summer (1986) emphasize instead unions in their model and outsiders lose union membership because of being dismissed.

For all these reasons, a firm is reluctant to exchange its current employees for unemployed outsiders. Unions strengthen insider power via their ability to threaten strikes and work-to-rule forms of non-cooperation. So a labor market equilibrium with wage rigidity and involuntary unemployment coexisted comes into being.

Besides providing an insight into the emergence of involuntary unemployment, insider-outsider theory has another important implication: Significant aggregate shocks which shift the labor demand may have persistent effects on wages, employment and unemployment. In countries with high labor turnover costs and powerful unions such as in some west European countries, this 'persistence' effect will be important.[27]

2.7.2 Economic fluctuations in the new Keynesian economics

[27] See Appendix A for the difference between hysteresis and persistence. Section 2.7.3 and section 3.3.2 deal with hysteresis effects in unemployment.

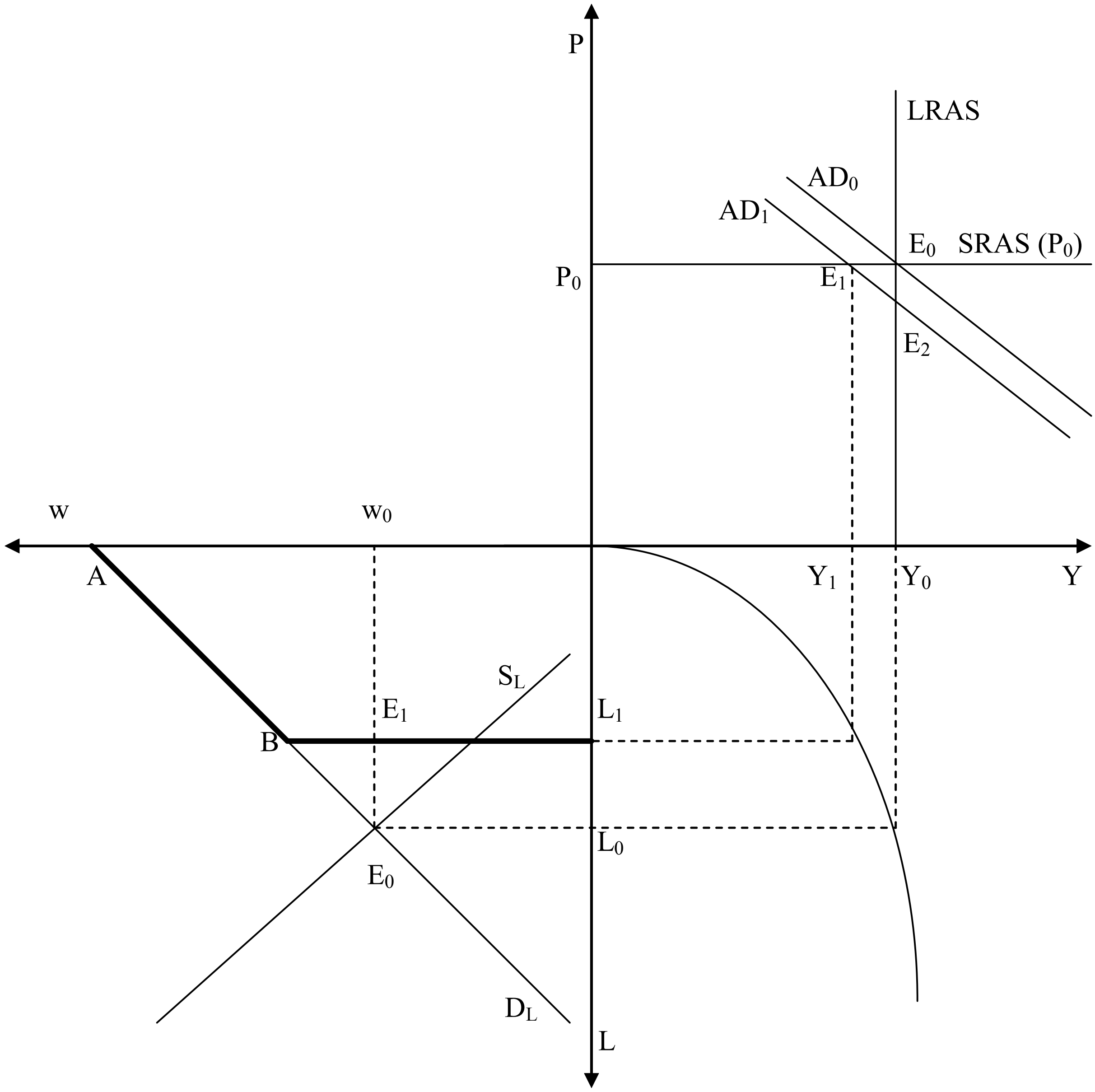

Figure 2.11 New Keynesian Analysis of Aggregate Fluctuations with Nominal Rigidities

For new Keynesians, large fluctuations in real output and employment arise as a result of shocks (from the supply or the demand side) being amplified by frictions and imperfections within the economy. The predominant research approach in this respect emphasizes the importance of nominal rigidities, which is illustrated in Figure 2.11. Suppose a decline in the money supply shifts aggregate demand curve from AD_0 to AD_1. The price level is rigid at P_0 due to menu costs and real rigidity.[28] The equilibrium will move from E_0 to E_1 along the short-run aggregate supply SRAS (P_0). The output fall from Y_0 to Y_1 reduces the effective demand for labor to L_1. Given the inertia of prices and the real wage (fixed at P_0 and w_0, respectively), firms move away from the notional labor demand curve D_L, operating instead along the effective labor demand curve ABL_1. The negative demand shock has thus led to an increase in involuntary unemployment of L_0 - L_1. In the new Keynesian model, short-run aggregate supply curve SRAS (P_0) is perfectly elastic at the fixed price level. Although downward pressure on price and wages would move the equilibrium from E_1 to E_2, new Keynesians insist that this process will last an unacceptably long period of time. Therefore it is necessary to take measures to push the aggregate demand curve back to AD_0.[29]

Another new Keynesian strand does not rely on nominal wage and price rigidities, whereas real rigidities play an important role. According to this view, output and employment would still be rather unstable even with completely flexible prices and wages. Indeed price inertia may mitigate aggregate fluctuations.

Note that a counter-cyclical real wage is not implied by new Keynesian models, which is different from the old Keynesian models. With sticky nominal prices being introduced, the real wage in new Keynesian models can be pro-cyclical or acyclical. If the efficiency wage is sensitive to the rate of unemployment, real wages will tend to be slightly pro-cyclical.

2.7.3 Unemployment and hysteresis effects

The close tie between unemployment and inflation has been much discussed following the influential contributions of expectations-augmented Phillips Curve developed by Friedman and Phelps independently. Friedman has put forward the concept of natural rate of unemployment which is a market-clearing rate associated with a stable rate of inflation.[30] Keynesian economists, instead, prefer the term NAIRU (Non-Accelerating Inflation Rate of Unemployment) whose

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[28] Firms' failing to cut prices is associated with coordinate failure, which is the fundamental source of macroeconomic instability in new Keynesian economics.

[29] In the new Keynesian model, money is non-neutral in the short run, with monetary shocks having real effects. It remains however neutral in the long run, which is indicated by the vertical long-run aggregate supply curve LRAS.

micro foundations relate to imperfect competition in the labor and product market. The NAIRU is that rate of unemployment which reconciles the target real wage of workers with the feasible real wage determined by labor productivity and a firm's mark-up.

Although the natural rate of unemployment (or NAIRU) was initially assumed to be constant, the dramatic rise in unemployment rates, especially in Europe since the 1980s, has put this idea in question. Indeed the natural rate of unemployment (or NAIRU) seems to have risen.[31] Two strands of ideas have been put forward to explain this phenomenon.

One explanation attributes this high level of unemployment to specific changes which have increased the labor market rigidity. These changes are generally thought to include more powerful trade unions, higher unemployment compensation, minimum wage laws, excessive regulations and higher taxation. Although the rise of unemployment rates in the 1970s may be accounted for by some of these factors, it is not convincing that they offer a plausible and complete explanation of the unemployment development in the 1980s.[32]

A second explanation is developed which relates to hysteresis theories. The central idea is that the equilibrium natural rate depends on the development of the actual unemployment rate till now. According to hysteresis theories, the natural rate of unemployment (or NAIRU) will increase if the actual rate of unemployment in the previous period exceeds the so-called steady-state equilibrium level.[33]

In order to account for the observed hysteresis effects, two major explanations are developed by new Keynesian economists: insider-outsider theories and duration theories. As illustrated in the insider-outsider analysis before, insider power hinders the downward adjustment of wages in the face of high unemployment. As a consequence, unemployed outsiders are unable to bid down wages in order to get employed following a rise in unemployment. Thus insider-outsider theories emphasize the influence of employed insiders. Duration theories instead pay much attention to unemployed workers. It is argued that if the actual rate of unemployment exceeds the steady-state equilibrium level, the problem of

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[30] See section 2.4.2 for the natural rate of unemployment.
[31] This view has been confirmed by econometric studies.
[32] This issue is elaborated in more detail in section 3.3.1.

structural unemployment is exacerbated because the human capital of unemployed will deteriorate. Thus unemployed worker become increasingly unemployable. In addition, a high rate of unemployment tends to generate more long-term unemployment. Since these long-term unemployed exercise only little influence on wage negotiations, the natural rate of unemployment is raised again.

2.7.4 Unemployment and macro policy coordination

High importance is assigned to the coordination of monetary and fiscal policies in the new Keynesian approach. In new Keynesian view, these policies have a common responsibility for employment and should be coordinated to achieve high employment.[34]

In new Keynesian economics, the development of aggregate demand determines production and employment in the short run. Effective demand and hence monetary and fiscal policies thus impact on production and employment at least in the short run because prices and wages are assumed to adjust rather showly to their long-run equilibria. The short run is assumed to last at least several years although its exact duration is not clear.[35] Monetary policies' interest rate setting and firms' profit expectations affect private investment which for its part is a central determinant of effective demand and economic growth. Fiscal policy is also an important determinant of aggregate demand working through channels of both tax and expenditure, in particular through publich investment. It is effective demand via the level of aggregate output which determines the level of actual empoyment in the labor market. In the long run, unemployment is determined by the NAIRU which may depend on structural factors. In this way, monetary and fiscal policies are able to stimulate demand and employment when the economy is in a slump. The coordination of these policies plays an important role in influencing output, employment and thus unemployent. With hysteresis effects taken into account, the coordination is especially important since the

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[33] See also section 3.3.2 and appendix A for hysteresis effects.
[34] Monetary and fiscal policies should be coordinated not only at the national level, but also at the international level, especially in currency areas with a common monetary policy.
[35] Post-Keynesian economists insist instead that monetary and fiscal policies have such effects also in the long run.

NAIRU will depend on the evolution of the actual unemployment rate which is affected by macro policies.

Chapter 3 Unemployment in Germany: Taking Stock

The message goes squarely against the cliché that high and persistent unemployment is entirely or mainly a matter of worsening function of the labor market.
Robert M. Solow

3.1 Idiosyncrasy of German unemployment development

Until the end of the 1960s, unemployment was very low in West Germany and also in Europe. It was the ‘European unemployment miracle’ to American economists. However, the miracle came to an end in the 1970s. Unemployment in Germany has been rising steadily since the middle of the 1970s. The unemployment rate now is ten times larger than that at the beginning of the 1970s. Figure 3.1 gives us a clear picture of the evolution of German unemployment rate.

The development of the unemployment rate in Germany is characterized by the stepwise upward trend in the last three decades, with great jumps in the mid-1970s, early 1980s and early 1990s. Curiously, once the unemployment rate has reached a higher level, it stayed at this level till the next surge. Despite the quite mild decline in the unemployment rate in the late 1970s, late 1980s and late 1990s, unemployment does not seem to tend to go back to the levels that were commonplace thirty years ago.

In the 1960s and early 1970s, the unemployment rate in West Germany was very low, with 1% as the average level. Occasionally it reached an even lower level of 0.7% (in 1970). Only in the recession of 1967/1968, the rate of unemployment was a little higher, lying at 2.1% and 1.5% respectively (ANBA).

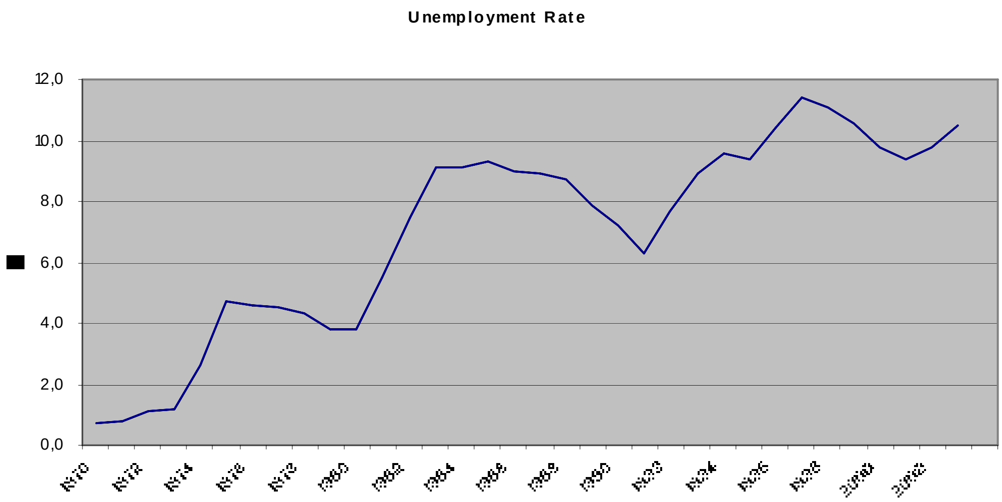

Figure 3.1 The Unemployment Rate in Germany (1970-2003)

Note: 1) For West Germany, the unemployment rate is the proportion of registered unemployment of employmed civil labor force; for unified Germany, it is the proportion of registered unemployment of total civil labor force.

2) The data refer to West Germany from 1970-1991; they refer to unified Germany from 1992 onwards.

3) The data are temporary results from 2001.

Source: Sachverständigenrat.

The mid-1970s saw the first jump in the unemployment rate in West Germany, which corresponds to the time when the first oil price shock in 1973/74 drove the advanced industrial economies into a deep recession. Since 1974/75 the unemployment rate rose to nearly 5% (ANBA). In addition, the baby boom generation entered the labor force and had to be absorbed by the labor market then. By that time about 3.5 million guest workers (Gastarbeiter) had already been integrated into the labor market because of the labor shortage in the late 1960s and the beginning of the 1970s. Coincidental with the oil price shock of 1973/74 was a switch to a more restrictive monetary policy by the German Bundesbank to reduce inflation. However, the unemployment rate decreased lightly by the end of the 1970s.

The unemployment rate in West Germany declined till about 4% (ANBA) in 1981 and since then experienced its second surge following the second oil price shock of 1979/80, which hit the Germen economy once more. Moreover, women's participation rate rose considerably at that time. The rate of unemployment jumped till beyond 9%. The period from 1983 to 1988 was characterized with low growth and high unemployment rate remaining at about 9%. From the mid-1980s onwards West Germany started to recover from the recession, with the labor market situation being relaxed.

German unification took place in 1990 and the economy, especially the West German economy was booming as GDP soared thanks to excessive consumption. The unemployment rate decreased as the consequence, in particular in West Germany. In 1992/93 Germany was struck by a severe recession resulting in large scale employment reductions, corresponding to the third jump in the unemployment rate. It was especially serious in East Germany for the transition process of the economy forced many businesses to layoff part of their workforce.[1]

It should be pointed out that a bulk of German unemployment is the so-called long term unemployment, which is defined as those unemployed workers who are without work for more than one year. Parallel to the dramatic increase in the unemployment rate, the share of long term unemployed increased sharply. Long term unemployed persons exhibit quite specific characteristics which made it difficult for them to be employed.

Although unemployment problem did not present a serious issue confronting German economists and policy makers in the 1960s, the unfavorable development of the unemployment rate in Germany has made it nowadays one of the most discussed subjects within macroeconomics. Explanations of the odd evolution of German unemployment rate generally focus on following phenomena: the stepwise jumps in the unemployment rate and its persistence tendency in the 1980s despite an economic growth.

3.2 German unemployment in comparison with that in U.S.

[1] It should be noted that there is substantial discrepancy in macroeconomic performance between West and East Germany. In terms of unemployment, the unemployment rate in East Germany is about three times higher than that in West Germany.

As compared with the unemployment development in U.S., following points concerning the development of German unemployment rate over the last 30 years should not be neglected:

(1) High unemployment is not a tradition of Germany.

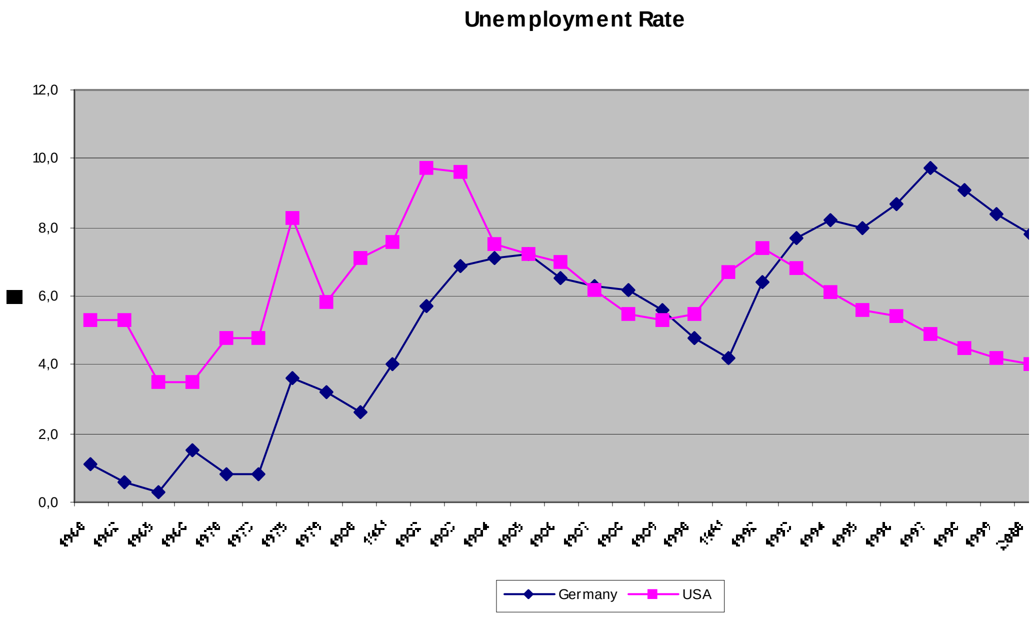

Figure 3.2 The Unemployment Rate in Germany and the U.S. (1960-2003)

Note: 1) The unenployment rate is unemployment as the percentage of labor force. From 1960 till 1979, the data are standardized from OECD; from 1980 till 2003, they are harmonized unemployment rate from the EU according to guidelines of the International Labor Office (ILO-concept).

2) The data refer to West Germany till 1990; they refer to unified Germany from 1991 onwards.

3) The data are temporary results from 2000.

Source: 1960-1979: Layard et al. (2005), Annex 1.6, Table A3.

1980-2003: Sachverständigenrat.

Although the misery of German unemployment development has become one of the most discussed issues for economists, it is in no way a tradition of Germany. Figure 3.2 shows the evolution of the unemployment rate in Germany and that in U.S. since 1960.

It can be seen apparently that high unemployment is not born to Germany. In 1971 for example, the unemployment rate was only 0.9 percent in West Germany, whereas U.S. had an unemployment rate of 5.8 percent. This applies also to some other West European countries. In fact, Europe used to have very low unemployment rate till the end 1960s/early 1970s. The talk then was of the 'European unemployment miracle'.[2]

However, things have changed since the 1970s. German unemployment development seemed to have a strong upward trend. The unemployment rate increased in the 1970s steadily and kept increasing till the 1990s except a slightly fall in the late 1980s and the mid-1990s.[3] In sharp contrast to this development, there is little upward trend in U.S. unemployment rate during this period. The difference between German unemployment rate and that in U.S. seems to be growing. In November 2005, the unemployment rate in Germany is 10.9% whereas 5.0% in U.S.[4]

Table 3.1 provides a picture of the unemployment development in some OECD countries. Note that the upward trend in the unemployment rate can also be observed in some other European countries. In 2004 the unemployment rate for the Euro Area stands at 8.9%.

(2) German labor market suffers from sclerosis.

German labor market is generally thought to be characterized with sclerosis. The word 'sclerosis' is borrowed from medicine where it means the hardening of arteries. This term is used within macroeconomics to indicate the phenomenon that rigidities in Germany lead to a less flexible economic structure. More accurately, sclerosis here implies the sluggish labor market in Germany where only a small amount of fluctuations take place among different groups.

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[2] At that time the American economists used to wonder what U.S. would have to do in order to reproduce the European experience.

[3] Since the early 1980s it lies above the unemployment rate in U.S.

[4] The unemployment rate for Germany is original data and from Bundesagentur für Arbeit; the unemployment rate for U.S. is seasonally adjusted and from Bureau of Labor Statistics.

Table 3.1 Standardized Unemployment Rates in some OECD Countries (%)

	1969-73	1974-79	1980-85	1986-92	1993-99	2000-03	2004
Austria	1.40	1.78	3.23	3.45	4.14	3.95	4.5
Belgium	2.38	6.32	11.28	8.86	9.24	7.20	7.8
Denmark	0.95	6.02	10.00	9.72	6.47	4.73	5.4
France	2.52	4.52	8.32	9.86	11.23	8.98	9.7
Germany	0.84	3.20	5.95	5.49	8.34	7.98	9.6
Italy	5.74	6.56	8.58	10.57	10.9	9.05	8.0
Netherlands	2.05	5.05	10.05	8.31	5.36	2.88	4.6
Spain	2.74	5.27	16.58	18.13	17.23	11.3	10.9
Euro Area	-	-	-	-	10.27	8.28	8.9
United States	4.86	6.68	8.00	6.13	5.37	5.13	5.5
Japan	1.22	1.93	2.42	2.40	3.44	5.10	4.7

Note: 1) The unemployment rates are as percentage of civilian labor force.

2) German data refer to Western Germany prior to 1993; they refer to unified Germany since 1993.

Source: 1969-1992: Bean (1994), Table 1; 1993-2004: OECD Economic Outlook 77 database and author's calculation.

As compared with situations in U.S., flows in and out of unemployment are substantially lower in Germany. Table 3.2 gives the inflow rate in Germany and in U.S.

According to Blanchard and Illing (2004), 26% of the unemployed workers in U.S. find new work per month; 18% of them withdraw from the civilian labor force. Things seem quite different in Germany where only 10% of the unemployed workers find work and 2% of them retire from the labor force each month. As far as flows in unemployment are concerned, only a smaller proportion (0.39%) of employed workers falls into unemployment in Germany, whereas the according ratio in U.S. is 1.2%.

Table 3.2 Inflow Rate in Germany and the U.S. (%)

	1979	1983	1985	1993	1994
Germany	-	0.22	0.25	0.57	-
United States	2.18	2.59	2.45	2.06	1.73

Note: 1) Inflow rate is as a percentage of source population, where source population is working age population (15-64)-unemployed.

2) German data refer to West Germany prior to 1993; they refer to unified Germany for 1993 and 1994.

Source: OECD Employment Outlook, 1995.

Sluggishness is therefore a fundamental trait of German labor market which has for itself important implications. Lower flows out of unemployment imply that those who are unemployed remain also longer unemployed in average. In other words, individual unemployment duration in Germany is substantially longer than that in U.S. at a given level of unemployment. The development of inflow rate and duration of unemployment in Germany since 1970 is given in Figure 3.3. It is evident that the increase in German unemployment reflects not a larger fraction of workers becoming unemployed, but rather a longer average duration of unemployment spells.

As compared with an increase in the inflow rate of unemployment, an increase in unemployment duration is more relevant to the rise in German unemployment rate. It is evident from Figure 3.4 which depicts the composition of unemployment in Germany according to duration. Therefore more attention should be paid to the long term unemployment. The share of long term unemployed in Germany increased sharply from 5.8% in 1970 to more than 30% now. The observed rise in the proportion of long term unemployment has become a serious problem, with many of them being without employment for even more than two years. The evolution of the share of long term unemployment is given in Figure 3.5.

Figure 3.6 provides the incidence of long term unemployment in Germany and in U.S. It can be seen that the proportion of long term unemployed in Germany is much higher than that in U.S.

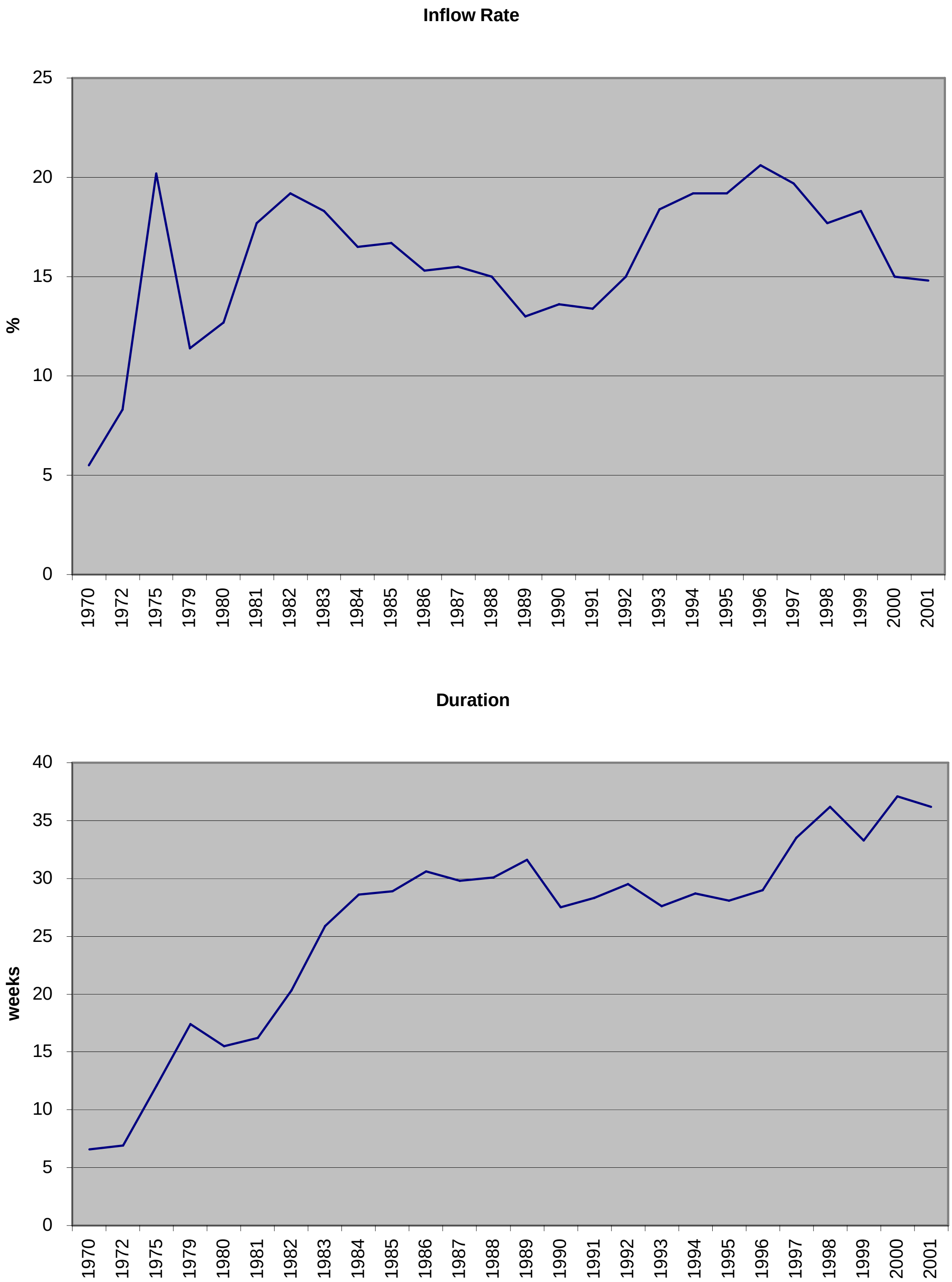

Figure 3.3 Inflow Rate and Duration of Unemployment in Germany (1970-2001)

Note: 1) Inflow rate = inflow in unemployment (cases)/employed labor force.

2) The data refer to West Germany till 1990; they refer to unified Germany from 1991 onwards.

Source: Bundesanstalt für Arbeit, Zahlen-Fibel, various issues.

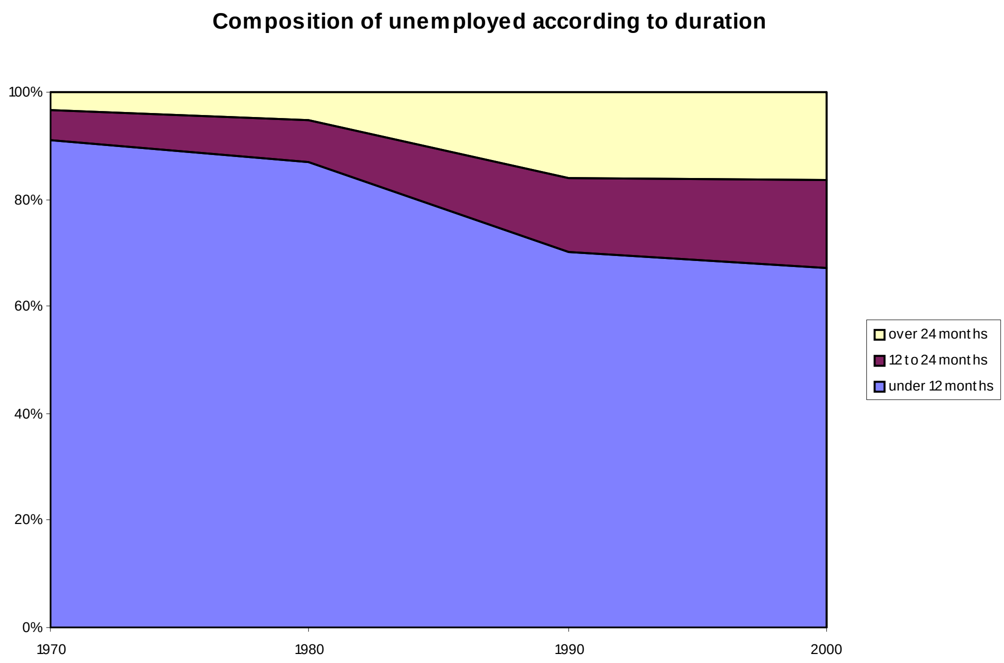

Figure 3.4 Composition of Unemployed according to Duration (West Germany)

Source: Landmann and Jerger (1999), Table 1.5.

To recap, German labor market is much less dynamic than in U.S. There are much less flows among unemployed workers and other groups. And it lasts much longer for a German unemployed to find a job.

(3) The natural rate of unemployment has risen in Germany.

As regard to the secular rise in the unemployment rate, two possibilities could serve as explanations: one possible case is the rise of the natural rate of unemployment itself; the other is that the actual rate of unemployment is much higher than the natural rate.

In order to find out which case is relevant to German unemployment problem, the development of inflation rate in Germany should be turned to. The reason for this consideration is that the change in inflation can be taken as a rough indicator of whether the actual unemployment rate is above or below the natural rate.

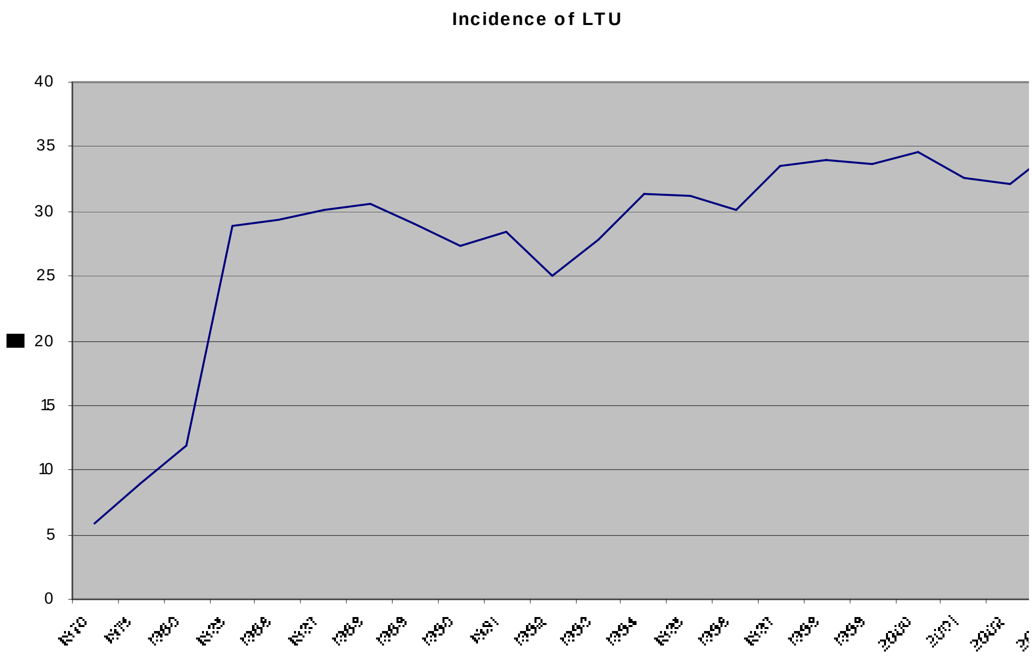

Figure 3.5 Incidence of Long Term Unemployment in Germany (1970-2003)

Note: 1) Incidence of Long Term Unemployment rate is registered long term unemployment as a percentage of registered unemployment, where the registered long term unemployment is registered unemployment for one year and over.

2) The data refer to West Germany till 1991; they refer to unified Germany from 1992 onwards.

Source: Sachverständigenrat and author's calculation.

The linkage between changes in inflation and the deviation of actual rate of unemployment from the natural rate can be illustrated algebraically. By analyzing the Phillips curve and the natural rate of unemployment, following relationship can be obtained:

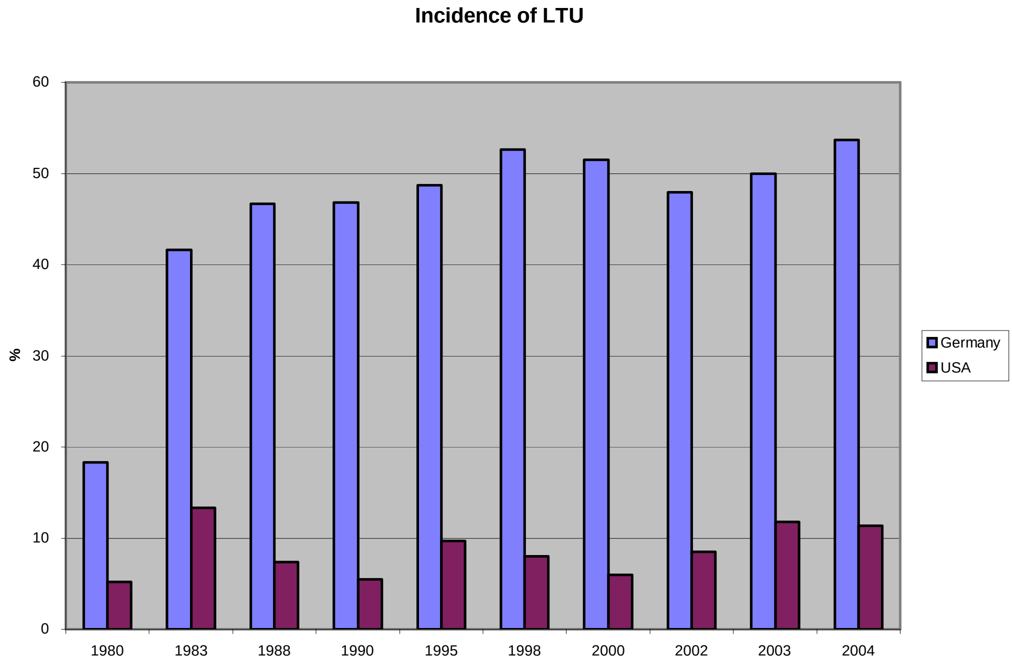

Figure 3.6 Incidence of Long Term Unemployment in Germany and the U.S. (1980-2004)

Note: 1) Incidence of Long Term Unemployment (unemployment for 12 months and over) is as a percentage of total unemployment.

2) The German data refer to West Germany till 1992; they refer to unified Germany from 1993 onwards.

Source: OECD Employment Outlook, various issues.

$$\pi_t - \pi_t^e = -\alpha(u_t - u_n) \tag{3.1}$$

where π_t: the inflation rate in period t

π_t^e : the expected rate of inflation in period t

u_t: the unemployment rate in period t

u_n: the natural rate of unemployment

α: a parameter which indicates how strongly wages response to changes in unemployment rate.

With the assumption of adaptive expectations which requirs that:

$$\pi_t^e = \pi_{t-1} \tag{3.2}$$

where π_{t-1}: inflation rate in period t-1,

equation (3.1) can be transformed to:

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n) \tag{3.3}$$

From equation (3.3), it is apparent that the change in inflation can be used to determine whether the actual unemployment rate is above or below the natural rate.

The development of the unemployment rate and the inflation rate in Germany since 1960 is given in Figure 3.7 and Figure 3.8 provides a picture for U.S.

According to the logic discussed above, following important insights can be obtained:

● There was a rise in both the unemployment rate and the inflation in the middle of the 1970s. This implies that shocks from supply side were the sources of the rise in the unemployment rate at that time. The two oil price shocks in the middle and at the end of 1970s and the slowdown of productivity growth since the mid-1970s are important suspects of such supply shocks. During this period, it was the actual rate of unemployment rather than the natural rate that has risen considerably.

● In the early 1980s, the rise in the unemployment rate was accompanied by a strong decline in the inflation rate. The rise in the unemployment rate in this period was the result of contractive money policies which attempted to reduce inflation steadily. The actual rate of unemployment lay thus above the natural rate.

● Since the end of 1980s, the rate of inflation has declined only slightly and remains stable at last. It follows that the actual unemployment rate and the natural rate are close to each other.

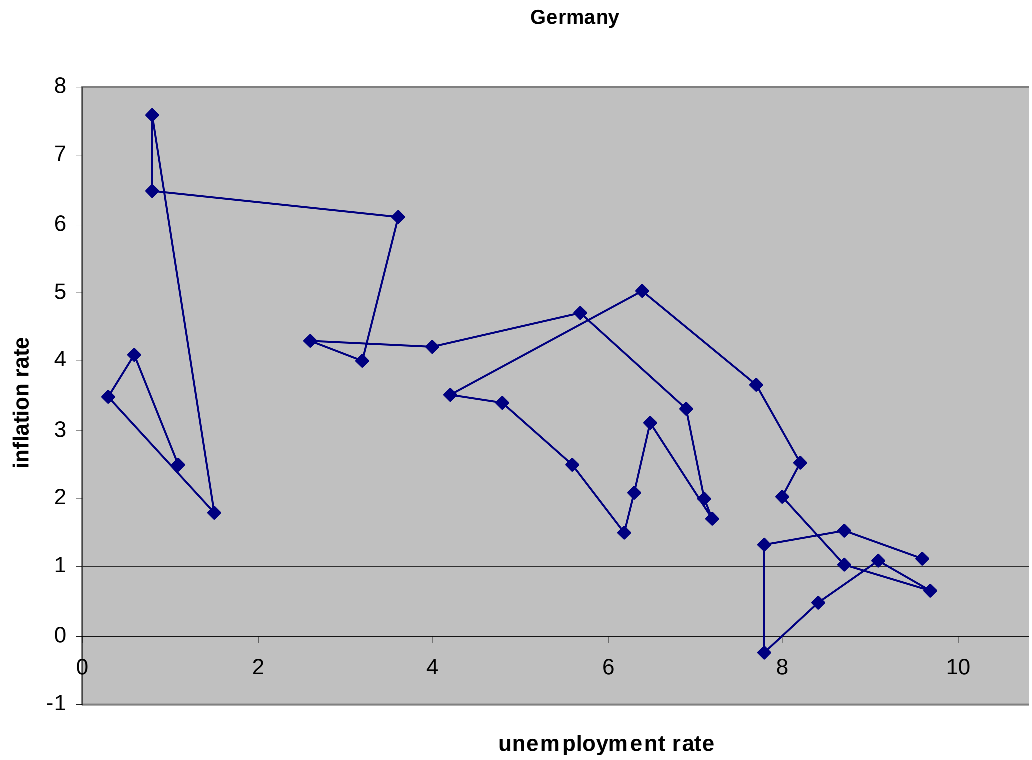

Figure 3.7 The Unemployment Rate and the Inflation Rate in Germany (1960-2003)

Note: The data refer to West Germany till 1990; they refer to unified Germany from 1991 onwards.

Source: the inflation rate: 1960-1990: Layard et al. (2005), Annex 1.6, Table A4; 1991-2003: OECD Economic Outlook 77 database. the unemployment rate: 1960-1979: Layard et al. (2005), Annex 1.6, Table A3; 1980-2003: Sachverständigenrat.

In fact, apart from cyclical movements in the early 1980s and early 1990s, the general movement in the rate of unemployment in Germany has reflected a movement in the natural rate.[5] The fact that inflation has declined only slightly over the last few years implicates furthermore that the natural rate now is close to, though lower than, the actual unemployment rate.

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[5] According to OECD, the structural unemployment rate (corresponding to NAIRU) in Germany has risen from 3.3% in 1980 till 7.7% in 2004.

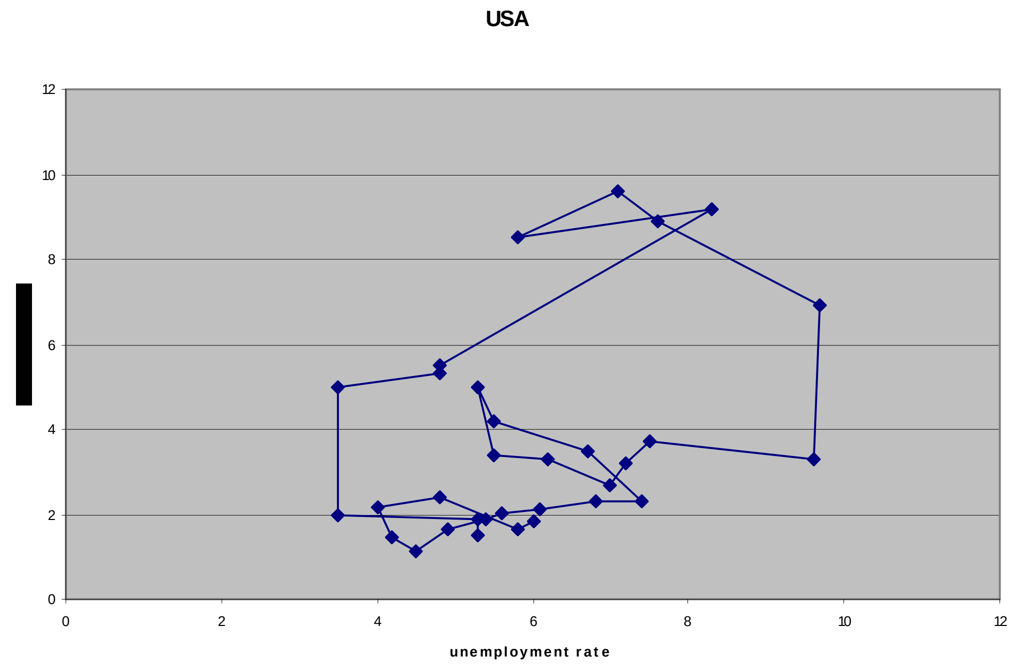

Figure 3.8 The Unemployment Rate and the Inflation Rate in the U.S. (1960-2003)

Source: the inflation rate: 1960-1990: Layard et al. (2005), Annex 1.6, Table A4; 1991-2003: OECD Economic Outlook 77 database. the unemployment rate: 1960-1979: Layard et al. (2005), Annex 1.6, Table A3; 1980-2003: Sachverständigenrat.

3.3 Current discussion about the reasons of high unemployment in Germany

The dramatic rise in German unemployment is no doubt a major puzzle for macroeconomists. Some other European countries see also such a tragic unemployment evolution. Many economists are devoted to exploring the causes of high and persistent unemployment in Germany and more generally, in Europe. There has been a lively discussion about the reasons and cures of German unemployment problem. Although there is no agreement on this issue, different views could be roughly divided into two groups:

(1) Conventional explanations focus on adverse labor market institutions. In this context, the so-called ‘European sclerosis’ is indicative of rigid and

over-regulated labor markets and too generous welfare state institutions in Europe. German economy suffers from institutions of collective wage bargaining (unions and employers' associations on the regional, sectoral or national level), labor market regulation (employment protection legislation, minimum wages, etc.) and the welfare state (unemployment benefits, social benefits and the 'tax wedge') and high unemployment is the consequence. It follows that the solution is to eliminate these rigidities. Structural reforms, deregulation of the labor market and dismantling of the welfare state are potential cures for persistently high unemployment in Germany.[6] This process is however inevitably slow and sure to be socially divisive.

(2) Other explanations criticize the above view by pointing out that many of those 'rigidities' were already in existence in the 1960s. German unemployment at that time was however negligibly low. They regard instead adverse economic shocks as the causes of high unemployment in Germany. Two oil price crises in the 1970s led to a decline in the labor demand. Inadequate macroeconomic policies are also possible culprits, especially high interest rates in the 1980s and 1990s. Deregulation in the goods market to decrease price mark-up and more appropriate macroeconomic policies are therefore thought to be capable of reducing unemployment. Dramatic labor market reforms are not necessary.

The general accepted wisdom lies somewhere between these two views. Most economists thus suggest a combination of some labor market reforms, deregulation policies in the goods market and appropriate macroeconomic policies as effective means to decrease unemployment steadily.

3.3.1 The explanation of 'European sclerosis'

As mentioned above, a predominant opinion concerning the unemployment problem in Germany insists that the high rate of unemployment is due to institutional labor markets rigidities existed there. It is argued that firms are

[6] It is the opinion of German council of economic experts, German central bank and the majority view of the leading economic research institutes in Germany.

faced with too strong restrictions such that they are hindered to adapt to changed circumstances. 'European sclerosis' is coined to characterize such encrusted labor markets in Europe.

Labor market institutions being considered in the literature are usually regulations that play a more or less direct role in the functioning of the labor market. Following factors are often pointed out as fundamental rigidities in German labor market as compared with U.S. labor market:

(1) Net wages are only a part of the whole labor costs. Income tax, non-wage benefits and social charges are much higher in Germany than in U.S. This surely makes some low-wage workers unemployable.
(2) High dismissal costs will arise if firms want to lay off workers. Due to employment protection legislation against unlawful dismissal and severance pay, complex and protracted legal procedures are necessary only to get dismissal permitted. Although such employment protection regulations could work against unemployment in the short run, the long-run effect of them is to discourage job creation and to strengthen the power of incumbent workers to protect wages at the expense of outsiders seeking employment.
(3) As compared with those in U.S., the greater density and power of trade unions in Germany enable unions to press for high wage settlements and prevent firms from adjusting to changes flexibly.
(4) Unemployment benefit is more generous in Germany than in U.S. It is easier to have a claim to unemployment benefit and the payment lasts also for a longer period of time. The natural consequence is the incentive of unemployed workers to search a new job being reduced.
(5) Minimum wages in Germany are relative high in comparison with the average wage.[7] Therefore it is unprofitable for firms to hire unskilled workers. In this way, unskilled workers remain unemployed, having neither access to training at workplace nor chance to get themselves qualified.

[7] Although Germany does not have legal minimum wages, custom and the large tax wedge must have a similar effect.

This view of 'European sclerosis' is based directly on neoclassical labor market theory. With a complete and perfect neoclassical labor market as a standard of reference, unemployment can only arise from market imperfections preventing a market clearing real wage at full employment. Institutions of collective wage bargaining, labor market regulation and the welfare state are such market imperfections and therefore creators of unemployment.

It is true that labor market institutions affect the nature of unemployment and some of them may indeed generate a high unemployment rate. In fact, explanations based on labor market rigidities have become more popular with the persistence of high unemployment for about three decades. Explanations based solely on institutions run however into both theoretical and empirical problems.

With respect to theory, if models are based on modern labor market theory instead of the traditional neoclassical labor market theory, it becomes difficult to derive unambiguous implications concerning the employment effects of labor market regulations and welfare state institutions.[8]

In terms of empirical research, results from the literature are rather mixed and far from being clear. Since the influential work of Layard *et al.* (1991) there have been a large number of econometric studies examining the influence of institutional rigidities on unemployment.[9] However, the empirical work does not provide clear and unambiguous results in favor of the institutional sclerosis view. A considerable part of the unemployment differences over time and across countries can not be explained by differences in the labor market institutions. Time and country specific factors and macroeconomic variables have to be taken into account too. Some of the empirical results supporting the institutional sclerosis view do not seem to be robust.

Finally, many of the cited rigidities were already in existence in Germany in the 1960s when German unemployment rate was still very low. The evolution

[8] Once asymmetric information, incomplete contracts and price-setting are taken into account, there are good reasons to question the institutional sclerosis opinion and its political implications.
[9] An excellent overview of the more recent econometric studies is provided by Baker et al. (2004). See also Hein and Truger (2005a) for more details.

of Germany's labor market and welfare state institutions does not correspond to the unemployment development in Germany.

The variables usually being regarded as indicative of institutional rigidities are indices of labor taxes, employment protection, union density, bargaining coordination, the benefit replacement ratio and benefit duration. Table 3.3 gives changes in these institutional indicators in Germany from the 1960s to 2000. According to Table 3.3, Germany exhibits some increase in labor taxes during the period of 1960-1995 and since then labor tax rate has been reduced a little till 2000. Index of employment protection shows employment protection has been much stricter since the 1960s.[10] As regards wage determination, union density hovered between 31% and 35% during the 1960 to 1995 period and declined to some degree from 1996 to 1998. Index of bargaining coordination has remained constant during the whole period. Unemployment benefit replacement ratios have decreased while unemployment benefit duration has lengthened during the period of 1960-1999.

To conclude, during the 1970s and the early 1980s, some of the labor market rigidities were indeed aggravated to some extent. But it is hardly plausible that these modest changes alone could have resulted in the dramatic rise in unemployment during this period. In addition, German labor market seems to have been more flexible from the late 1980s onwards. In fact, many of the rigidities are nowadays less pronounced than they were ten years ago. The coincidence of the rise in unemployment after 1990 with the labor market deregulation is in sharp contrast to the institutional sclerosis view.[11]

If the argument is correct that rigidities in the labor market are responsible for the rise in the German unemployment rate, it must be that the effects of these rigidities on unemployment have become more significant, even though the institutional regulations themselves have not deteriorated.

[10] Due to different sources, this series is not completely reliable. See Nickell (2003) for details.
[11] The unemployment increase in Germany in 1996-1997 happened at a time of wage moderation.

Table 3.3 Changes in Labor Market Institutions in Germany

	1960-64	1965-72	1973-79	1980-87	1988-95	1996-00
Total Taxes on Labor (%)	43	44	48	50	52	50
Employment Protection (Index, 0-2)	0.45	1.05	1.65	1.65	1.52	1.30
Union Density (%)	34	32	35	34	31	27
Co-ordination Index (Range 1-3)	2.5	2.5	2.5	2.5	2.5	2.5
Unemployment Benefit Replacement Ratios	0.43	0.41	0.39	0.38	0.37	0.37
Unemployment Benefit Duration Index	0.57	0.57	0.61	0.61	0.61	0.75

Note: 1) Total Tax Rate = Payroll Tax Rate + Income Tax Rate + Consumption Tax Rate; Union Density = union members as a percentage of employees.

2) Index of Employment Protection (0-2): 0=low, 2=high; Co-ordination Index corresponds to Co-ordination 2 in Nickell (2003) (Range 1-3): 1=low, 3=high.

3) The last number of Employment Protection refers to 1998, of Union Density refers to 1996-98, of Co-ordination Index refers to 1995-99, of both Unemployment Benefit indexes refer to 1999.

4) Except for Unemployment Benefit Duration Index: West Germany.

Source: Nickell (2003).

There have seen various macroeconomic shocks hitting German economy since the 1970s: oil price crises, economic growth slowdown, etc.. Taking these factors into consideration, it is possible that rigidities become more important under these changed conditions. In the face of stable demand, firms do not need to lay off workers. Protection against unlawful dismissal presents thus no obstacle for firms. However, if firms in more variable circumstances are forced to make adjustment quickly in order to revive, such rigidities could have disastrous consequences. Although rigidities in German labor market were perhaps reasonable in the 1960s, the same rigidities could prove to be inappropriate now.

Following this logic, the explanation linking rigid labor market institution with the effects of adverse shocks is rather prospective. In such s framework hysteresis mechanism plays a crucial role which is the subject of the next section. Several economic shocks mentioned in the literature as potential culprits of high unemployment in Germany will be discussed in section 3.4. Their role in influencing the unemployment development combined with hysteresis effects will be elaborated after that.

3.3.2 The hysteresis mechanism

In line with criticisms regarding the 'European sclerosis' hypothesis, an alternative explanation of unemployment evolution in Europe relates to the following phenomenon: there were a series of supply shocks in the 1970s, by which both Europe and U.S. were hit. The early 1980s saw a decline in employment during the disinflationary course through contractive money policy. In U.S., an expansive fiscal policy was carried out in combination with the contractive money policy. In Europe, however, the fiscal policy was also restrictive. As a consequence, the unemployment rate in Europe lay much higher than that in U.S.

This leads naturally to the following question: if macroeconomic policy is responsible in this respect, the actual rate of unemployment should be widely above the natural rate. A steady decline in inflation should be observed consequently. It is however not the case. Although the inflation rate in Europe is rather low, it does hardly decrease furthermore.

Based on the observation that the inflation rate in Europe does no longer decrease, the opinion has been widely accepted which states that the natural rate of unemployment (or NAIRU) in Europe has risen. The experience of simultaneous rise in the actual and equilibrium rates of unemployment has further brought about the suggestion that the development of actual unemployment can influence the natural rate (or NAIRU).

The hysteresis hypothesis accounts for this mechanism reasonably. The influential paper of Blanchard and Summers (1986), focusing on insider-outsider dynamics in wage formation, brought the term hysteresis to the forefront of labor market theory. Coming from Greece, 'hysteresis' describes in Physics the lag of impact behind its causes. The definite entry of this concept into the vocabulary of labor economics was accelerated by a volume of collected works appearing in 1988 (Cross, 1988), a special issue of

Empirical Economics on hysteresis in 1990 (Vol. 15, No. 2, reprinted in Franz, 1990) and a mini-symposium on hysteresis appearing in the *Journal of Post Keynesian Economics* in 1993 (Vol. 15, No. 3).

In fact, many economists have discussed hysteretic phenomena in the past, without necessarily using that particular label. However, a more or less unified research program did not emerge until the mid 1980s, to a large extent initiated by Blanchard and Summers (1986). The concept of hysteresis is now generally utilized for systems, whose equilibriums depend on the time path till then. The driving force of this development was the observed unprecedented behavior of European labor market. It was for a long time assumed that the natural rate of unemployment is independent on the actual development in the labor market. In contrast to this traditional wisdom, the dependence of the natural rate on the actual unemployment rate is a central point in hysteresis hypothesis. The presence of hysteresis effects predicts that a long period of high unemployment tends to cause the natural rate to rise. As the consequence, the pressure on inflation diminishes gradually given persistently high unemployment, so that inflation in Europe does not decline considerably any more. As Blanchard and Summers (1988) put it, understanding European unemployment problem would 'require economists of dispense with the natural rate hypothesis that underlies much of both Keynesian and Classical macroeconomics'.

Long term unemployment plays an important role in the argument of hysteresis. In Europe, long term unemployment has risen to account for more than 30% of the total unemployment. With longer unemployment duration, unemployed workers will lose more qualification and motivation for work and also suffer more from psychological problems. A dangerous vicious circle will naturally come into being: firms are afraid to take on long term unemployed; as a result, long term unemployed workers remain further unemployed and do not exert any influence on the process of wage formation. Firms in turn could not obtain wage concession from their workforce by means of threatening to hire long term unemployed workers.

So long as long term unemployed workers are incapable of exercising any influence on the wage process, the demanded wage is not at all affected by the large amount of long term unemployed. In this way a high level of unemployment characterized with high proportion of long term unemployment will hardly have any significance for wage formation. In other words, with increased share of long term unemployment, the wage setting curve will shift upwards. The natural rate of unemployment will rise as the consequence.

Note that explanations of 'European sclerosis' and hysteresis do not reject each other. They are rather complementary hypotheses to account for the unemployment development in Europe. The effects of hysteresis also depend on concrete institutions in the labor market. Generous regulations regarding subsidies to long term unemployed will reduce the agony of being unemployed, such that unemployed workers are declined to take on less attractive work. This could result in the vicious circle described above. A widely accepted consensus among macroeconomists has gradually come into being which emphasizes the importance of institutional regulations in the labor market. The combination of negative shocks and inappropriate institutions in the labor market provides a convincing explanation for the persistently high unemployment in many European countries.

3.4 The role of shocks

After the oil price shocks and productivity slowdown in the 1970s, the importance of macroeconomic shocks for the labor market is widely acknowledged. Some explanation attributes the high level of European unemployment to unfavorable shocks which have hit the economy. Besides the oil price shocks and productivity slowdown, these shocks may include aggregate demand shocks (restrictive fiscal and monetary policies, for example higher interest rate), wage shocks (more powerful trade unions, higher unemployment compensation, minimum wage laws, etc.) and labor supply shocks (higher participation rate etc.).

There are various shocks within macroeconomic circumstances, which have been cited by different authors to account for the evolution of German unemployment. Following adverse macroeconomic shocks should be recalled regarding the persistently high German unemployment.

3.4.1 Aggregate demand shocks

It has been a widely acknowledged wisdom that adverse aggregate demand shocks are one of the culprits for the rise in German unemployment. Aggregate demand is surely an important determinant of the level of employment, and hence unemployment. Among other influencing factors, fiscal and monetary policy has a significant impact on aggregate demand. Nowadays, the primary aim of monetary policy is to stabilize inflation at relatively low levels. If aggregate demand is low, unemployment is high and the economy is in a recession, monetary policy will be loosened to stimulate aggregate demand with a fall in unemployment as the aim. On the other hand, in anticipation of inflation moving above target, monetary policy is tightened to mitigate inflationary pressure.

Since monetary policy plays an important role in aggregate demand determination, a consideration of different monetary policies over the last three decades should be necessary to understand unemployment evolution in Germany. In fact, restrictive monetary policy by German Bundesbank has often been criticized to be responsible for high unemployment rate in Germany.[12] Although a complete characterization of monetary policies stance is beyond the range of this work, there are some episodes worth noting. The stance of monetary policy in Germany from 1960 onwards, as captured by the development of the short-term interest rate, is given in Figure 3.9.[13]

According to Figure 3.9, German Bundesbank switched to a tighter monetary policy in the latter part of the 1970s to reduce inflation arising from the first oil price shock. The rise in the short-term interest rate led to higher unemployment. In the early 1980s, the Bundesbank went on disinflating German economy to overcome the stagflationary 1970s. The central bank raised the short-term interest rate, with the jump of unemployment in that period as the consequence. Moreover, adverse demand shocks from tight macroeconomic policy in the post unification era certainly have played a dominant role in explaining high unemployment in the 1990s.

[12] See, for example, Solow (2000), Linzert (2001) and Fritsche and Logeay (2002). See also Dolado and Jemino (1997) for Spain and Fabiani et al. (2000) for Italy.

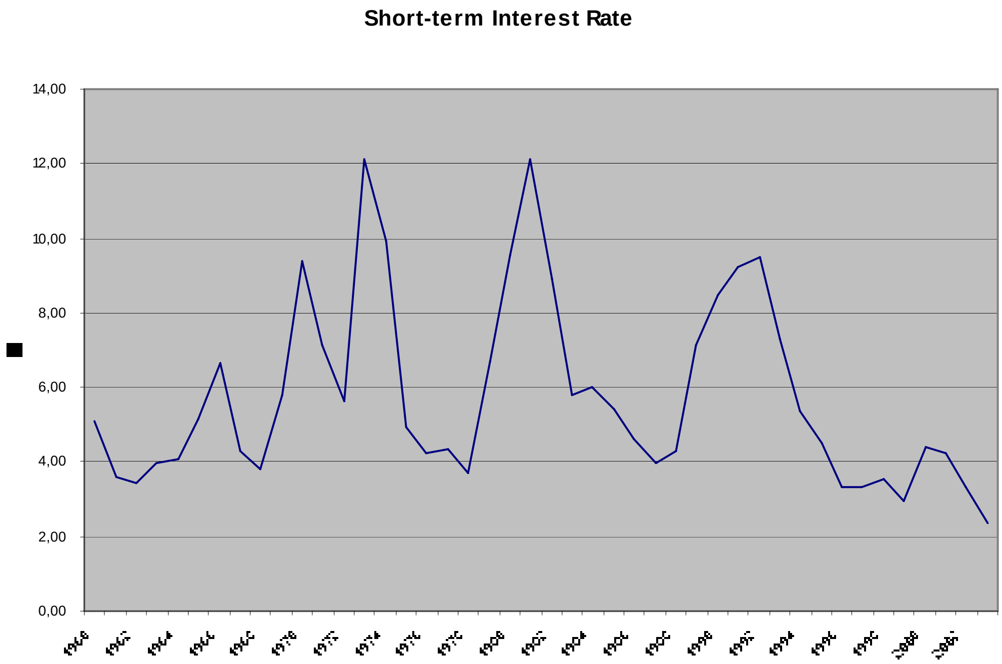

Figure 3.9 Short-term Interest Rate in Germany (1960-2003)

Note: Short-term interest rate refers to three-month money market rate.

Source: Sachverständigenrat.

Figure 3.10 shows the evolution of the real interest rate in Germany from 1960 till 2003. German unemployment development from 1970 onwards is also given here to illustrate the close correlation of these two series. It can be seen clearly that the high real interest rate in the mid-1970s, early 1980s and early 1990s correspond to the jump of unemployment in according periods.[14]

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[13] Monetary policy can be assessed by the evolution of the short-run real interest rate and modern central banks use the short-run nominal rate as an economic policy instrument.
[14] Blanchard (1999) argues that the effects of the interest rate on unemployment are likely to be slow because they are primarily through capital accumulation, see also the text.

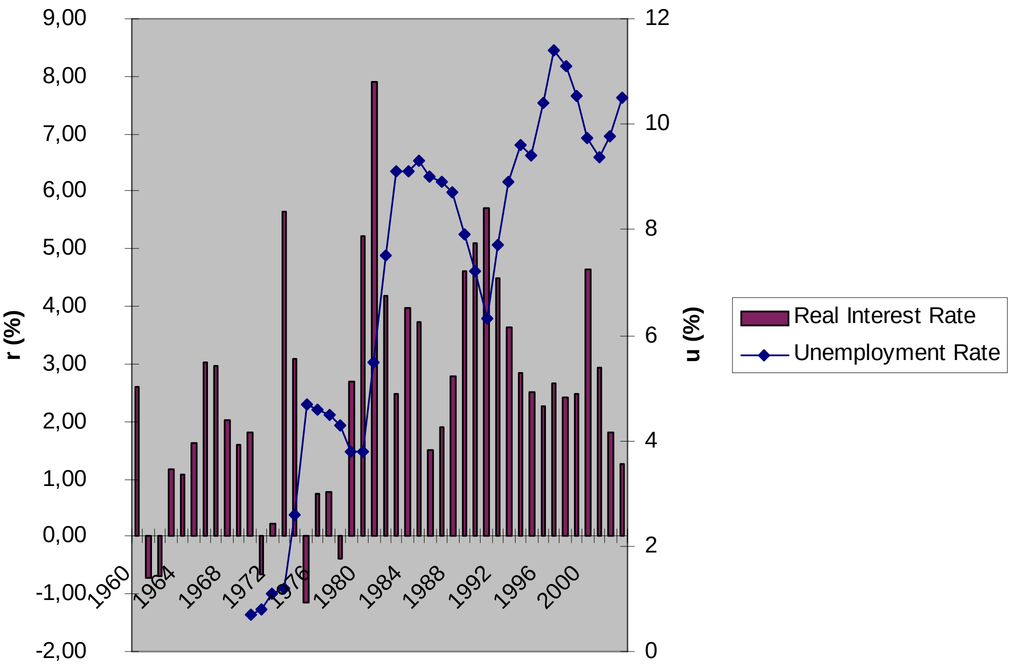

Figure 3.10 Unemployment and the Real Interest Rate in Germany

Note: The real interest rate is computed as the short-term interest rate (Dreimonatsgeld) minus GDP deflator.

Source: The unemployment rate 1970-2003: Sachverständigenrat. Short-term interest rate 1960-2003: Sachverständigenrat. GDP deflator 1960-1990: Layard et al. (2005), Annex 1.6, Table A4; 1991-2003: OECD Economic Outlook 77.

Besides monetary policies, fiscal policies also play an important role in influencing aggregate demand. Government investment is not only an essential component of aggregate demand in the short run, it also provides public infrastructure which is key to economic growth in the long run.[15] The Maastricht Treaty and the Stability and Growth Pact (SGP) have enforced budget consolidation and restrictive policies on Germany (and other EMU member countries) at least since the mid 1990s. The development of real government expenditure, in particular real government investment since the mid 1980s is depicted in Table 3.4 to capture the fiscal stance in Germany. The restrictive stance of German fiscal policies is quite obvious considering the growth rate of real public expenditure. The growth rate of real total public

[15] A positive relationship between the growth rate of public infrastructure investment and GDP growth is found for Germany. See Pfähler *et al.* (1996) and Kitterer (1998).

expenditures has declined from an annual average of 3.5% in 1985-1995 to only 0.7% in 1995-2004. More dramatic is the dectrease in the growth rate of real public investment expenditure with an annual rate of –3.7% in 1995-2004. The decline in public investment has led to a very low share of real public investment in real GDP.

Table 3.4 Fiscal Policy Indicators for Germany (annual average values, 1985-1994 and 1995-2004)

	1985-1994	1995-2004
Real total government expenditure, growth rate (%)	3.5	0.7
Real government investment, growth rate (%)	1.2	-3.7
Ratio of real government investment to real GDP (%)	2.7	2.0

Note: 1985-1991: West Germany.

Source: Hein, Truger (2005b), Table 4.

Although adverse demand shocks (come from, for example, tight monetary/fiscal policies) may have played an important role in the rise of German unemployment rate, their effects cannot account for the persistent unemployment without some mechanism to ensure that the effects are propagated over time. One possible mechanism works as follows: with the short-term interest rate being raised, a negative output gap and higher unemployment came into being. This resulted in lower inflation according to the Phillips curve. Since inflation began falling and unemployment rising, the central bank lowered the interest rate. However, the Bundesbank opted for a very gradual disinflate process as compared with the Fed in U.S. In fact, the Bundesbank maintained tight conditions over so long a period of time that the equilibrium unemployment rate followed the actual unemployment rate (hysteresis mechanism). Although the central bank finally lowered its interest rate, this did not have any significant effects on the unemployment rate, because the equilibrium rate has risen as well by then. That means, the disinflationary process initiated by the Bundesbank lasted too long such that hysteresis effects could arise.

Besides influencing unemployment through aggregate demand, monetary policy also plays a role in determining the natural rate of unemployment in two channels. One channel is that a monetary contraction will increase real wages, and thus decrease unemployment given the capital stock. The second channel functions through the effect of restrictive monetary policy in increasing the real interest rate and decreasing employment.[16] Note that both channels were clearly at work in the first half of the 1980s.

The role of interest rates in influencing employment/unemployment has been pointed out by different authors. Newell and Symons (1987) assume that firms will incur a fixed hiring and training cost only if the discounted value of future quasi-rents on new employment is high enough. For this reason, firms will reduce the rate of hiring in the face of an increase in real interest rates. If the separation rate is exogenous, labor demand for a given real wage will decline consequently.[17] Phelps (1994) emphasizes the role of the interest rate in affecting the price mark-up.[18] Blanchard (1999) focuses instead on the effect through capital accumulation. He insists that an increase in the real interest rate increases the user cost of capital, ceteris paribus. Investment decreases, resulting in lower capital accumulation, and a decrease in employment. This goes on until wages have adjusted and the increase in the profit rate matches the increase on the user cost.

3.4.2 Productivity shocks

It is widely documented that the growth rate of labor productivity throughout OECD showed a slowdown since the mid-1970s. The trend of labor productivity seems to have broken down simultaneously with the advent of the first oil shock.

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[16] Besides monetary policy, changes in the real interest rate naturally come also from shifts in the supply and demand for capital.

[17] In their empirical investigation, the effect of the real interest rate was found to be significant both statistically and quantitatively.

[18] Section 3.4.3 deals with this point more detailed.

In Germany, the glorious years from the early 1950s to the early 1970s were followed by a sharp productivity slowdown, with the slower pace continuing to this day. The growth rate weakening of labor productivity in Germany is shown in Table 3.5.

Table 3.5 Labor Productivity Growth in Germany (percentage changes at annual rates)

	1960-73	1973-79	1979-96	1997-01	2002	2003
labor productivity growth	4.5	3.1	2.2	0.9	0.7	0.9

Note: 1) Labor productivity is that in the business sector.
2) The data used for calculation refer to West Germany till 1990; they refer to unified Germany from 1991 onwards.
Source: OECD Economic Outlook (various issues) and author's calculation.

The roots of this productivity slowdown are far from being clearly understood and its implications on unemployment remain also puzzling.

Theoretical literature focuses on two channels through which productivity growth would affect the unemployment rate. The central point in the first mechanism is a process of job construction and destruction implied by productivity growth. Since a process of technological progress lies behind productivity growth, different productivity growth rates are probably associated with different rates of job flows, different paths of firms' profit, different outcomes between workers and firms as existing jobs become economically obsolete. To the extent that a decline in productivity growth comes with a lower rate of technological progress and lower job creation/destruction, the unemployment rate is likely to decrease.

The other often cited channel relies on sluggish adjustment of workers' wage aspirations. It is generally accepted that at a given rate of unemployment, the slowdown in productivity growth implies a slowdown in the feasible growth of the real wage.[19] Since it usually lasts a long period of

[19] According to Blanchard (1999), 'A slowdown of TFP growth by 2% a year for a decade implies a shortfall of 20% of real wages relative to what would have happened absent the slowdown'.

time for workers to adapt their wage claim to the decreased productivity growth, worker's reservation wages continue to rise rapidly, too fast relative to the now lower rate of productivity growth. Employment falls subsequently and so does the profit rate. Investment falls, resulting in lower capital accumulation, and a further decrease in employment. Unemployment increases as the result. Therefore, if wage aspirations do not moderate in accordance with the productivity slowdown, a rise in unemployment rate will occur consequently.[20] Although this channel may partly account for the initial increase in unemployment, the persistence of high unemployment from the mid 1980s onwards needs other sources.

Since these two channels mean opposite direction of unemployment development after a productivity showdown, theoretical implications of the productivity slowdown on unemployment are ambiguous. Empirical evidence has diffused the discussion rather than clarified it. Different authors have drawn partially contrary conclusions in this aspect. Using cross-country data, Blanchard (1998a), for example, find 'little relation between the change in the unemployment rate and the change in productivity growth'.[21]

3.4.3 Price shocks

Besides the slowdown in productivity growth, two major oil price increases is another negative supply shock during the 1970s. The first oil price crisis was triggered by the Arab oil embargo of 1973-1974; the second by the Iranian revolution in 1979 and the Iran-Iraq war of 1980. As a result, the real price of oil (in dollars) by the early 1980s stood at nearly 4 times its level at the start of the 1970s. A rise in energy prices ceteris paribus implies higher costs for firms and leads to a lower labor demand. The degree of labor demand decline depends on the elasticity of factor substitution.

The two oil price shocks, together with the commodity price explosion in 1972/73, have also brought about terms-of-trade deterioration. By enlarging the gap between value-added price and consumer price, its effect is to increase

[20] Even if workers' aspirations regarding wage may adjust adequately, the existence of an intertemporal mechanism still suggests that a productivity slowdown could lead to an increase in equilibrium unemployment rate.

the wage wedge and the equilibrium unemployment will be raised consequently. Bean (1994) concluded that there was indeed 'a fall in real purchasing power' in Europe due to 'the terms-of-trade loss' at the end of the 1970s and early 1980s which may more or less lead to the rise in German unemployment at that time.

Besides, the price mark-up presents a force shifting the price-employment schedule and will affect the equilibrium unemployment. If the mark-up of price increases implying lower real wages, labor demand will fall and equilibrium unemployment will increase.

Focusing on the role of real interest rates, Fitoussi and Phelps (1988) appeal to a 'customer market' model of pricing in which the incentive to invest in building up market share will be reduced by a real interest rates increase. An increase in real interest rates thus raises not only the amortized marginal production cost itself, but also the mark-up over marginal cost. This means a decrease in the real wage paid to workers and increased unemployment is necessary for workers to accept this lower real wage.[22] The argument that an increase in the interest rate leads to a higher price mark-up can be found in Phelps (1994) as well.

3.4.4 Labor supply shocks

Since the unemployment rate depends not only on labor demand, but also on labor supply, labor supply is a factor which should not be neglected either. In fact, adverse shocks of labor supply seem to have played an important role in generating unemployment.

The labor supply rise itself is related to a large extent to exogenous factors: demographic developments and the rise in the female participation rate. Over the 1970s, about 3.5 Million guestworkers (Gastarbeiter) had already been integrated into German labor market and the entry of the baby boom generation into working-age population meant a considerable rise in labor

[21] This point is discussed in more detail in section 6.4.3.2.
[22] They point out furthermore that in the face of the dollar appreciation during the period of 1982-1986, German firms responded by raising profit margins rather than expanding output. This, combined with the adverse effect of the dollar appreciation on the terms of trade, contributes to the unemployment development in Germany.

supply. It went hand in hand with the rise in the unemployment rate at that time. Furthermore, female participation rate has been rising since the mid-1970s which has contributed doubtless to the unemployment rise.

Table 3.6 Women's Participation Rate in Germany

	1973	1979	1983	1990	1995	2000	2004
participation rate of women (%)	50.3	52.2	52.5	55.5	61.1	63.3	66.1

Note: 1) Ratios refer to persons aged 15 to 64 years who are in the labor force divided by the working age population.

2) The data refer to West Germany till 1990; the consequent data refer to unified Germany.

Source: OECD Employment Outlook, various issues.

3.5 Shocks combined with hysteresis effects

To wind up, the upward drift of the unemployment rate and the increasing proportion of long term unemployment imply the possibility that the persistently high unemployment in Germany has been the result of the interaction between negative shocks having hit the economy over time and structural elements hindering the adjustment process. More accurately, several macroeconomic shocks have led to an overall rise in unemployment in Germany. The corresponding increase in long term unemployment shows that the unemployment rate is unable to return to its pre-shock level. Although the rise of unemployment rates may to some degree be accounted for by some of these shocks, it is not convincing that they by themselves offer a plausible and complete explanation for the persistence of unemployment evolution over three decades. Hysteresis effects function as a propagation mechanism which translates transitory shocks into permanent changes in unemployment.

More generally, as forcefully argued by some authors, one should consider the interaction between the effects of adverse shocks and the institutional rigidities of the labor market preventing the proper working of self-equilibrating mechanisms.[23]

This is just the starting point of our empirical research. Since 1970s, German economy has been hit by several macroeconomic shocks with a dramatic rise in unemployment rate as the consequence. The existence of hysteresis effects has impeded the unemployment rate to go back to its previous level even when original shocks did not exist any more. Therefore, the stepwise rise in German unemployment rate and its persistence are the result of a set of negative demand and supply shocks which are amplified by hysteresis effects.

Based on the stylized facts and discussions in this respect sketched above, our quantitative analysis focuses on developing a suitable framework whose aim is to disentangle the different sources of shocks that have driven the development of unemployment. We thus identify a variety of shocks that may affect unemployment, in order to gain more understanding about the unemployment rate evolution in Germany. More accurately, four different sources of shocks impinging on unemployment are identified which can be considered as the empirical counterpart of factors that have been pinned down in the previous discussion: aggregate demand shocks, that can be traced back to the impulses generated by monetary and/or fiscal policies; productivity shocks, corresponding to the forces affecting the permanent component of output; price shocks, arising from the oil price crisis in the 1970s and/or changes in price mark-up; and labor supply shocks, representing 'exogenous' movements in the labor force, due to demography and changes in participation behavior. A strong emphasis is placed on hysteresis in analyzing the importance of various shocks. Given the interest in shocks as causes of unemployment, the structural vector autoregression analysis is naturally the appropriate approach.

[23] See, for example, Sargent and Ljunquist (1995) and Nickell (1997).

Chapter 4 Econometric Methodology

Consensus for a research area as a whole is equivalent to stagnation, irrelevance and death.
Robert Lucas

4.1 An introduction into empirical macroeconometrics

Since the breakdown of orthodox Keynesianism in the 1970s, a number of competing schools of thought have been developed with regard to economic theory. Parallel to this development, there are also different approaches to empirical economic research. Since the profession does not share a common view on the issue of methodology, plurality features modern applied macroeconometrics. Different approaches have their own strengths and weaknesses. They coexist and are regarded as alternatives.

A review of the development of these approaches would provide the necessary background to understand the methodology choice in this empirical analysis. Therefore this chapter deals with a brief introduction into modern macroeconometrics within a historical context. Besides the traditional Cowles Commission approach, the LSE (London School of Economics) approach and the intertemporal optimization/calibration approach find also a short mention. The VAR (Vector AutoRegression) approach instead will be elaborated in chapter 5 whose central subject is the Structural Vector AutoRegressive (SVAR) methodology. The SVAR approach will then be applied to analyze German unemployment problem in chapter 6.

4.1.1 Alternative research strategies in macroeconometrics

A key concern in empirical econometrics is to develop quantitative models which are empirically relevant to match economic theories with observed data features. Empirical econometric models are systems of quantitative relationships linking observed data series. Modeling requires matching theory and data in a formal quantitative framework. Any strategy in empirical research is based on the combination of theoretical analysis and data exploration. Thus the roles of economic theory and empirical evidence and their relationships are quite important in empirical modeling.

There was a consensus on both the theoretical foundation of macroeconomics and the empirical specification of macroeconometrics modeling in the 1950s and 1960s. The consensus was built around the Cowles Commission approach. However, such a consensus broke down spectacularly at the beginning of the 1970s when it was realized that ‘the models did not represent the data…did not represent the theory…were ineffective for practical purposes of forecasting and policy’ (Pesaran and Smith (1995)). Since then different approaches have been developed to overcome the failure of this traditional approach. The Cowles Commission methodology was then substituted by a number of prominent methods of empirical research: the LSE (London School of Economics) approach, the VAR (Vector AutoRegression) approach and the intertemporal optimization/calibration approach.[1]

Initiated by Denis Sargan, the LSE approach criticizes the Cowles Commission models of not sufficiently paying attention to the statistical model underlying the particular economic structure, which is adopted to analyze the effect of alternative macroeconomic policies. Therefore the empirical failure of this approach is rooted in the lack of adequate interest in the statistical model. In line with the LSE explanation, the recipe for the Cowles Commission methodology is a careful diagnostic checking on the specification used.

Besides the LSE criticism of traditional structural modeling, two famous critiques due to Lucas (1976) and Sims (1980) are also rather influencing. In contrast to the explanation of the LSE approach, both authors attack the identification in the Cowles Commission approach by concentrating on the weak theoretical foundation of this type of structural models. According to Lucas, structural models would fail to predict the impacts of various macroeconomic policies on the macroeconomic variables if the relevant coefficient describing these impacts is not regime-invariant. In case that the coefficient of interest depends on the policy regimes, the model estimated

[1] An agreement does not exist on the issue of methodology.

under a certain regime can not be used to simulate the effects of a different policy regime. Sims criticizes the identification in the Cowles Commission models by pointing out instead that the restrictions needed to ensure exogeneity in these models are 'incredible' when agents optimize intertemporally.

Following the contribution of Sims, research program focusing on VAR models has become popular in empirical macroeconometrics. Concentrating on shocks, VAR models are estimated to yield empirical evidence concerning the response of macroeconomic variables to shocks in order to discriminate among alternative theoretical models of the economy.

Finally, the Generalized Method of Moments (GMM) is usually applied to the first-order conditions to solve intertemporal optimization problems. This method aims to obtain estimates of the deep parameters in the economy, which describe taste and technology and are independent of expectations. With such deep parameters being estimated, models based on microeconomic foundations could be calibrated and the effects of economic policies on variables of interest could be assessed consequently.

In short, the LSE approach, the VAR approach and the intertemporal optimization/calibration approach seek to rationalize the failure of the Cowles Commission methodology in different ways and are regarded as alternative strategies. The existence of such a plurality of approaches arises because economists do not share a common view on the methodology of macroeconomic modeling.[2]

4.1.2 Issue of identification in econometric modeling

There is usually more than one economic structure which can give rise to the same statistical model for the variables of interest. Identification is therefore a crucial issue in econometric modeling where the meeting of theory and statistical analysis of data takes place. The heterogeneity of research strategies currently adopted in applied macroeconometrics arises indeed from different

[2] The breakdown of the consensus has been rather dramatic, but 'even more impressive are the deep rifts that have emerged over the proper way to tease empirical facts from macroeconomic data'. (Faust and Whiteman (1997))

solutions to the identification problem. Haavelmo (1944) firstly suggested a formal framework to resolve the identification problem which has become the dominating approach in subsequent years.

Prior information plays an important role for appropriate inference from estimated economic systems.[3] With the help of prior assumptions on the underlying economic structure, any ambiguity can be removed. Generally, a structure is defined as a complete specification of the probability distribution function of the data. The set of all such possible structures S is called a model. In order to select a unique structure as a probabilistic representation of the data, it should be verified that no other structure in S leads to the same probability distribution function. In other words, an identified structure implies that there is no observational equivalent structure in S. In this case, the structure is said to be identified.

The identification strategy in the traditional Cowles Commission approach is that some variables are treated as exogenous. The Cowles Commission approach is designed to evaluate the impact of policy variables on macroeconomic variables in the system. Through the analysis of the impact of policy variables, the value assigned to these policy instruments could be determined to achieve a given target of macroeconomic variables. Variables controlled by the policy-maker are regarded as exogenous, while macroeconomic variables are assumed to be endogenous, which represent final goals of the policy-maker.

Following the breakdown of the Cowles Commission approach to the identification of structural econometric models, different methods of empirical research came into being in order to overcome the weakness of this traditional approach.

The LSE approach attacks the identification in the Cowles Commission approach by pointing out that such models are unable to represent the data. According to the LSE approach, the weakness of the traditional approach lies in that little attention is paid to the statistical model implicit in the estimated structure. In this traditional approach, the reduced form is ignored. Most of the estimators widely employed allow the derivation of numerical values for the

[3] This is indeed a typical problem when collected data are used instead of experimental data which are produced under controlled conditions.

structural parameters without considering the statistical models represented by the reduced form. The LSE methodology identifies the roots of the failure of Cowles Commission models as choosing a specification rather than accepting a general one. As a result, Cowles Commission models are ineffective for forecasting and policy evaluations.

There are several possibilities which will result in the inadequacy of statistical models implicit in structural econometric models: omission of relevant variables, omission of the relevant dynamics for the included variables or invalid assumption of exogeneity. To solve the identification problem in the Cowles Commission approach, the LSE approach put forward the theory of reduction.

While the LSE approach explains the weakness of Cowles Commission models as due to their incapability to represent the data, Lucas (1976) and Sims (1980) pay more attention to the theoretical aspect. They relate their explanations to the incapability of the traditional Cowles Commission approach to represent the theory.

The critique of Sims stresses the exogeneity assumption in the traditional approach. In Sims' view, the status of exogeneity arbitrarily attributed to some variables to achieve identification is the source of failure in structural Cowles Commission models. By pointing out that agents are forward-looking whose behavior depends on the solution of an intertemporal optimization model, Sims argues that no variable can be deemed as exogenous. The incorrect exogeneity assumption of policy variables, as in the Cowles Commission approach, will make the model invalid for policy analysis. If exogeneity is not assumed properly in the model, important feedbacks might be omitted and spurious statistic efficacies of relevant policies might arise as a consequence. In line with the Sims' critique, VAR models are developed in which all variables are treated as endogenous. Not aimed to yield advice on the best value of policy variables, VAR models are estimated to provide empirical evidence on the response of macroeconomic variables to shocks or policy impulses in order to discriminate between alternative theoretical models of the economy.

Lucas (1976) instead finds his explanation of the failure of the Cowles Commission approach to identification in that these models do not explicitly take expectations into account. Without adequate consideration of the issue of expectations, identified parameters in the Cowles Commission approach are a mixture of ‘deep parameters’ describing preference and technology in the economy and expectational parameters. These expectational parameters are certainly not stable across different policy regimes. Such instability will consequently make traditional structural macro models useless for the purpose of policy evaluation.

The Lucas critique (1976) has promoted the development of the intertemporal optimization approach, leading naturally to a framework for identification and estimation of the deep parameters of interest. In intertemporally optimized models, deep parameters independent of a particular policy regime are identified separately from expectational parameters specific to policy regimes. The identification and estimation strategy is then to derive first the orthogonality conditions for optimization and use them to pin down the structural deep parameters. This is achieved by applying the Generalized Method of Moments (GMM) which is directly based on orthogonality conditions. Numerical values to the remaining parameters in the model are then attributed. Finally, the models are simulated and evaluated by comparing actual data with simulated data.

4.2 Traditional Cowles Commission approach

4.2.1 Procedure in the Cowles Commission approach

Cowles Commission approach aims at quantitative evaluation of the effects of changing policy variables on macroeconomic variables. Three stages could be identified in the traditional Cowles Commission approach:

1. Specification and identification of the theoretical model.
2. Estimation of the relevant parameters and assessment of the model’s dynamic properties, with the long-run properties being emphasized.
3. Simulation of the effects of macroeconomic policies.

As illustrated in section 4.1.2, the Cowles Commission approach to specification and identification proceeds in the following way: the empirical model usually loosely related to the theoretical model is specified and identification is realized by imposing numerous a prior restrictions which set a number of variables to be exogenous. With a large number of over-identifying restrictions, identification is easily achieved within Cowles Commission models.

As the issue of estimation is concerned, the traditional modeling recognized the possible presence of some misspecification in the estimated equations. As a result of such misspecification, the OLS (Ordinary Least Squares) estimators are no longer Best Linear Unbiased Estimators (BLUE). The solution proposed was a modification of the estimation techniques, instead of re-specification. This point is well reflected in the structure of the traditional textbooks: the OLS estimator is usually introduced at first and different estimators are then discussed as solutions to different pathologies in the model residuals.[4] Such alternative estimators include the GLS (Generalized Least Squares) estimator, the GIVE (Generalized Instrumental Variables Estimators), the FIML (Full Information Maximum Likelihood) estimator, and so on.

After model identification and estimation of the parameters of interest, the next step in the Cowles Commission approach is simulation. For given values of parameters and exogenous variables, values for endogenous variables are recovered at this stage by finding the dynamic solution of the model.

Finally, dynamic simulation is implemented to evaluate the effect of various policies which are defined by specifying different values for exogenous variables. Policy evaluation is achieved by examining how the predicted values of endogenous variables change after some exogenous variables are modified. Therefore the model should be simulated twice. A baseline simulation is run at first. Such baseline simulation can be run within the sample where observed data for exogenous variables are available; or outside the available sample in which case values are assigned to exogenous variables. Then an alternative simulation is run, which is based on the modification of

[4] Pathologies are identified as departures from the assumptions which guarantee that OLS estimators are BLUE.

relevant exogenous variables. The results of the baseline simulation are compared with those obtained from the alternative simulation. Dynamic multipliers are usually used in policy evaluation.

4.2.2 Criticisms

The empirical failure of the traditional Cowles Commission approach in policy evaluation has naturally brought about criticisms of this approach. Many authors have criticized this approach to identification by pointing out that the empirical failure of the Cowles Commission approach lies in the imposition of too many restrictions and its inability to recover the structural deep parameters of economic interest, which describe preference of agents and the status of technology.

Discussions in this respect could be divided into two groups: one group concentrates on modifications in the estimation technique; the other suggests instead modifications in the modeling strategy. As mentioned previously, a number of estimators have been developed in the Cowles Commission approach for the case that the OLS estimator is inappropriate. However, it is now well established that correcting the estimator is a strategy inferior to the strategy of improving the specification. That is, correcting the model. For this reason, problems in simulations could in general be explained better by problems in identification and specification, rather than by problems in choosing estimation method.

In the Cowles Commission approach, the incapability of the estimated model to capture the observed dynamics of the variables of interest adequately can be explained by the following points:

1. The statistical model implied by the estimated structure is too restrictive. The excessive simplicity in the specification could be interpreted in two ways: omission of relevant variables and omission of relevant dynamics for included variables.
2. The identifying restrictions, although necessary to make the estimation meaningful, could not deliver a structure which properly describes the reality. In addition, by incorrectly assuming exogeneity, the model might

omit relevant feedback mechanism, thus introducing a spurious efficacy of macroeconomic policies in the determination of macroeconomic variables.[5]

The worse performance of the model in simulation can be explained by the following considerations:

1. Specification is incorrect. If omitted variables were not detected at the stage of estimation, this would result in parameter instability of the estimated equations in the simulation period. Incorrectly specified dynamic models feature parameter instability in out-of-sample simulations.
2. Model simulation implies considering alternative macroeconomic policy regimes. A change in regime might imply a structural shift in the parameters of the estimated equations. As a consequence, the model estimated under the 'baseline' regime cannot be used to evaluate the effect of the 'alternative' policy.[6]

4.3 LSE approach

4.3.1 Introduction

According to the LSE approach, the failure of Cowles Commission models arises from the lack of attention paid to the statistical model underlying the particular econometric structure adopted to analyze the effect of alternative macroeconomic policies. However, the LSE methodology shares with the traditional Cowles Commission approach the opinion that econometric policy evaluation is feasible. It is only the way how the Cowles Commission approach deals with policy analysis is viewed by the LSE approach as incorrect. The lack of enough interest in the statistical model is thus the source

[5] Here the Sims critique applies.
[6] It is the Lucas critique.

of the failure of this traditional approach in providing an acceptable answer to the question concerning policy evaluation.

In the Cowles Commission tradition, the starting point of econometric analysis is the belief that the structural form of the process generating the data is known qualitatively. The reduced form is then derived from such a structure. In this framework, the validity of the reduced form is not tested. The lack of validity of the reduced form is thought of by the LSE approach as undermining the credibility of the structural parameter estimates. The LSE methodology recognizes that the economic theory suggests the general specification of the relevant form, but the precise representation of the data generating process (DGP) is always unknown in advance. For this reason, modeling procedures are required to determine the credibility of estimated models.

This means that the prominence of the structural form in the Cowles Commission approach to identification and specification is reversed. In the LSE methodology, the reduced form takes a central role since it represents the crucial probabilistic structure of the data. The traditional logic of Cowles Commission models that the reduced form is derived from the structural model is no longer valid in the LSE approach.

The reduced form is specified in the LSE framework at first. This is realized by defining a system with the set of variables being considered, their classification into modeled and non-modeled variables and the specification of the lag polynomials. The basic principle of econometrics: ’test, test and test’, is then applied to the system. If the system is considered to be a congruent representation of the unknown data generating process, its long-run properties can be identified by implementing cointegration analysis. It should be noted that such analysis is completely implemented on the reduced form. In the next step, a structural model is identified and estimated. Finally, the structural model is used for forecasting and policy evaluation.

4.3.2 The process of reduction

The LSE approach attacks Cowles Commission models by showing that the validity of the reduced form is not properly addressed. By analyzing the properties of residuals, the LSE diagnosis for the empirical failure of the traditional approach is that structural inference is based on an improper statistical model. Spanos (1990) points out the problems inherent in the Cowles Commission approach by asserting that ‘not only are the statistical assumptions underlying the reduced form not tested, but the reduced form is rarely estimated explicitly.’

To solve the specification problem in the Cowles Commission tradition, the LSE approach puts forward the theory of reduction. Econometric modeling is formalized within the LSE approach as the result of a reduction process. Any econometric model is interpreted as a simplified representation of the unobservable data generating process. A model of the unknown DGP is the starting point in the reduction process. For the representation to be valid or ‘congruent’, the information lost in moving from the DGP to its representation must be irrelevant to the problem at hand. Adequacy of the statistical model can be evaluated through the analysis of the reduced form. Under the ‘general-to-specific’ methodology, the LSE approach starts its specification and identification process from a general dynamic reduced form model. In other words, the reduced form of the structure or the baseline model is generally the earliest stage of the reduction process at the empirical level.

The congruency of such a baseline model can not be directly assessed against the true, unobservable DGP. However, a series of diagnostic tests can be implemented for this purpose. The general idea underlying the application of such criteria is that congruent models should feature true random residuals. Therefore any departure of the vector of residuals from a random normal multivariate distribution should signal a misspecification. In this way, the empirical analysis begins with the implementation of a battery of diagnostic tests where the null hypothesis of interest is the validity of the baseline model as a simplified representation of the unknown DGP.

Once the baseline model has been validated, the reduction process is carried out by simplifying the dynamics and reducing the dimensionality of the model. The validity of the reduction process can be checked by ensuring that the vector of innovations possesses all the features of true statistical innovations: absence of correlation, heteroscedasticity and non-normality. Any pattern of this type or any instability in the parameters signalizes a loss of information that occurred in the reduction from the DGP to the particular specification adopted. Only by implementing diagnostic checks can invalid structural models be discarded. Testing usually concentrates on residuals because any non-randomness in residuals can be interpreted as a signal of incorrect specification of the underlying model.[7]

A further stage in the simplification process can be the imposition of the rank reduction restrictions in the matrix determining long-run equilibriums of the system and the identification of cointegrating vectors. The product of this stage is a statistical model describing the data, possibly distinguishing between short-run dynamics and long-run equilibriums.

Only after the validation procedure is the structural model identified and estimated. No further validation is possible for a just-identified model because its implicit reduced form does not impose any further restrictions on the baseline statistical model. The validity of over-identified specification can be tested by evaluating the validity of the over-identifying restrictions implicitly imposed on the general reduced form. After this last diagnostic check for the validity of the reduction process, the structural model is used for practical purposes.

4.3.3 An assessment

In short, the major strength of the LSE methodology is a careful diagnosis of the problems of the Cowles Commission approach and in the attempt to give 'scientific dignity' to the specification of dynamic econometric models.

The concept of cointegration fits naturally in the context of dynamic specification of ECM models. This research strategy implies a multi-step framework: specification of the VAR and its deterministic component, identification of the number of cointegrating vectors, identification of the parameters in cointegrating vectors, tests on the speed of adjustment with respect to disequilibria. The final results depend on the outcome of previous stages which is not established so easily and uniquely empirically.

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[7] The residuals of a statistical model are generated by the specification adopted and are combined results of omitted variables (both in the sense of omitted variables and of omitted lags of included variables) and errors-in-included-variables of several types (measurement or expectational errors).

Macroeconomists have criticized the reduction process in the LSE approach by arguing that the preferred specification which this process delivers is inclined to be 'a bit over-cooked' and this process tends to loosen the link between econometric models and economic theory considerably. The achievement of data congruency means some evident cost regarding the parsimony of the specification and economic interpretability of the results. Moreover, the LSE approach is not easily applied to systems of equations, even of very limited dimensions. The 'general-to-specific' methodology is usually applied in single-equation specification, extensions to systems become very complicated when the system exceeds only a small dimension.

4.4 Intertemporal optimization/calibration approach

4.4.1 GMM method

In line with the Lucas critique (1976), the intertemporal approach to macroeconomic theory insists that policy evaluation is a question for theoretical models rather than for empirical macroeconometric models.[8] This approach takes no interest in the parameters estimated by traditional macroeconometric modeling, since it delivers parameters which are convolutions of 'deep' and expectational parameters.[9] Only 'deep' parameters are relevant which should be estimated based on the theoretical model.

The Euler equation serves as the first-order condition for optimization. It allows identification of the 'deep' parameters and does not depend on expectational parameters. The Generalized Methods of Moments (GMM) is implemented to estimate these parameters.

However, the GMM approach has also its limitations both theoretically and empirically. The theoretical problem lies in the difficulties in implementing GMM when market imperfections are brought into the intertemporal optimization approach. Empirically, many authors point out that the parameters estimated on aggregate time-series data by implementing GMM

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[8] Empirical models are regarded as *ad hoc*.

[9] Deep parameters describe tastes and technology and are invariant to policy regimes; whereas expectational parameters are dependent on the specific policy regime.

are in general not constant over time. Such instability surely contrasts with their nature as ‘deep’ parameters describing taste and technology implied by the theoretical model.

4.4.2 Calibration

After the ‘deep’ parameters being estimated by GMM method, the theoretical model is calibrated and simulated for policy analysis. The calibration approach puts the intertemporally optimized model to the data and can be described in five steps.

1. Select a model design relevant to the economic question of interest.
2. Choose functional forms for the model primitives to find a solution of endogenous variables in terms of exogenous variables and parameters.
3. Choose parameters and stochastic processes for the exogenous variables and simulate paths of the endogenous variables.
4. Compare the outcomes of the model relative to a set of ‘stylized facts’.
5. Carry out policy analysis.

Chapter 5 SVAR Methodology

If the data were perfect, collected from well designed randomised experiments, there would be hardly room for a separate field of econometrics.
Zvi Griliches

In this chapter the philosophy of the SVAR (Structural Vector AutoRegression) methodology used in this work is introduced. The issue of identification, categorization and dynamic analysis in the SVAR approach is elaborated. We conclude this chapter by an assessment of this methodology. Since the SVAR approach is an extension of the traditional VAR (Vector AutoRegression) analysis, it is necessary to get acquaintance with the traditional VAR models at first.

5.1 The traditional VAR approach

Since the book of Box and Jenkins (1970), time series techniques have become popular for analyzing the dynamic relationship between time series. Among the general class of the multivariate ARIMA (AutoRegressive Integrated Moving Average) model, the VAR model turns out to be particularly convenient for empirical research.[1]

5.1.1 The objective of the VAR approach

As illustrated in Chapter 4, the LSE approach has interpreted the failure of traditional Cowles Commission models as resulting from using misspecified and ill identified models. However, the LSE methodology shares the belief of the traditional approach in the potential of macroeconometric modeling for policy simulation and evaluation. There is indeed no difference between these two approaches at this stage. LSE solution to the problems of the traditional econometric modeling concentrates on stages of identification and specification.

[1] Although there are important reasons to allow also for moving average errors, the VAR model is the dominant approach in the empirical multivariate time series analysis.

The congruency of specification is considered in the LSE approach as a much higher priority than the choice of the most appropriate estimator, with the importance of estimation being de-emphasized. In fact, there is no innovation of the LSE methodology at the stage of policy simulation and evaluation. That is to say, after 'test, test and test' the traditional methods are still applied in the LSE approach.

Traditional Cowles Commission models are developed to identify the impact of policy variables on macroeconomic quantities, in order to determine the value to be assigned to policy instruments to achieve a given target of macroeconomic variables. The policy variables are considered to be exogenous on the grounds that they are instruments controlled by the policy-maker. Identification in traditional structural models is obtained without assuming the orthogonality of structural disturbances. Dynamic multipliers are typical tools in the traditional modeling to describe the impact of policy variables on macroeconomic variables.

However, if policies react endogenously to macroeconomic variables, the assumed exogeneity of policy variables in the traditional approach makes the model invalid for policy analysis. Recognizing this invalid exogeneity assumption in traditional models, the LSE methodology would proceed to the identification of an alternative enlarged model.[2] Whenever the appropriate concept of exogeneity was satisfied by the adopted specification, the enlarged model would still be used for policy simulation and evaluation in the LSE approach.

The VAR methodology rejects identifying restrictions in the Cowles Commission approach as 'incredible' for reasons similar with the ones pinned down by the LSE approach. Besides attacking the traditional approach to identification and specification, the VAR approach also questions the potential of traditional macroeconometric modeling for policy simulation and evaluation. VAR models differ from previous models as to the purpose of specification and estimation. Traditionally, the objective of macroeconometric modeling is to give advice on the best macroeconomic policies. According to the VAR approach, policy suggestions should however rely on a theoretical model rather than on an

[2] It will be obtained presumably through the imposition of a priori restrictions on the dynamics of lagged variables.

empirical ad hoc macroeconometric model. The VAR approach thus fully recognizes the potential of the Lucas critique.

Within this framework, the new role assigned to empirical analysis is to provide evidence on the stylized facts to be included in the theoretical model adopted for policy analysis. Instead of yielding advice on the best macroeconomic policies, VAR models are estimated rather to provide empirical evidence on responses of macroeconomic variables to shocks in the economy in order to discriminate between alternative theoretical models of the economy. It is thus crucial to take into account the potential endogeneity of policy instruments.

It should be pointed out that VAR models concentrate on shocks. Relevant shocks are identified at first; the response of the system to shocks is then described by analyzing impulse responses (the propagation mechanism of shocks) and forecasting error variance decompositions.

5.1.2 Identification of VAR models

5.1.2.1 The VAR representation of a simultaneous equations system

The VAR approach has become popular in empirical macroeconomics.[3] The development of this approach was promoted by both the inability of economists throughout the 1970s to agree on the true underlying structure of the economy and the Lucas critique, which states that changes in policy systematically alter the structure of econometric models, with a resultant shift away from the use of large-scale macroeconomic models as forecasting tools. VAR modelers believe that VAR models are able to reveal important dynamic characteristics of the economy without imposing structural restrictions from a particular economic theory.

Sims criticized existing large-scale models by asserting that they imposed 'incredible identification restrictions' in order to derive parsimony in structure and ignored a lot of feedback effects between the variables. The modeler can choose variables that are to be included as determinants in equations and make assumptions about whether a variable is to be considered exogenous or endogenous. These assumptions come from the modeler's 'prior beliefs', or their understanding of economic theory. In order to overcome these problems, particularly in determining whether a variable should be considered endogenous or exogenous, the VAR approach attempts to 'let the data speak for themselves' by making all variables endogenous.

In the VAR methodology, each variable, no matter measured in levels or first differences, is treated symmetrically in that all variables in the system contain the same set of regressors. That means, all interactions between the variables are taken into consideration. There are no exogenous variables and no identifying restrictions in this framework. The only role for economic theory is to specify the variables to be included. Besides the need of theory for this specification, the technique is usually considered to be a-theoretic.

Generally, the specification of an appropriate reduced form VAR model as a statistical representation involves the following points:

- the choice of variables to be included in the model;
- the choice of an appropriate transformation of the variables (when necessary);
- the selection of the lag order;
- the specification of deterministic variables (dummy variables, time trends, etc.)

The VAR model is in fact a multivariate extension of the simple autoregressive model.[4] It has become an important approach in many fields of multivariate time series analysis not least because of its simplicity and intuitive appeal. In addition, a multivariate extension of Wold's theorem means that every system of stationary variables has a moving average representation that, under certain conditions, can be adequately approximated by a VAR process.

The VAR is shown to be a reduced form time series model for a linear simultaneous equations model of the economy.[5] Therefore, the standard linear, simultaneous equations model is a useful starting point to understand the VAR approach.

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[3] It has been developed in line with the contribution of Sims (1980).
[4] It could be traced back to Yule (1927).
[5] It is argued by different authors that the reduced form of a set of linear simultaneous equations can be represented as a VARMA process, with certain conditions fulfilled. Such a VARMA representation can be approximated by a VAR model with a sufficient lag order.

A simultaneous system of equations models the dynamic relationship between endogenous and exogenous variables. A vector representation of such a n-dimensional system is as follows:

$$Ay_t=C(L)y_{t-1}+Dz_t \qquad (5.1)$$

where y_t: the vector of endogenous variables, with $y_t = [y_{1t}, \ldots, y_{nt}]'$

y_{t-1}: the vector of lagged endogenous values

z_t: the vector of exogenous variables.

The elements of the square n × n matrix A are the structural parameters of the contemporaneous endogenous variables. C(L) is a pth degree matrix polynomial in the lag operator L, where p is the number of lags used in the model. That means, $C(L) = C_0 + C_1L + \ldots + C_pL^p$, where all of the C_i (i = 1,…,p) matrices are square. The square n × n matrix D contains the contemporaneous response of endogenous variables to the exogenous variables.

In theory, some exogenous variables could be observed while others could not. Observable exogenous variables typically do not appear in VAR models since Sims (1980) argued forcefully against exogeneity. Therefore the vector z is usually assumed to consist merely of unobservable variables, which are then interpreted as disturbances to the structural equations.

The problem with a simultaneous equations system as shown in (5.1) is that because the coefficients in the matrices are unknown and the variables have contemporaneous effects on each other, it is impossible to uniquely determine the values of the parameters in the model. In other words, the model in such a form is not fully identified.

However, it is possible to transform model (5.1) into a reduced form model in order to facilitate the estimation of model parameters. This transformation results in the following reduced form:

$$y_t=A^{-1}C(L)y_{t-1}+A^{-1}Dz_t \qquad (5.2)$$

where z_t: the disturbance terms.[6]

Deterministic terms like a constant or a linear time trend are neglected for notational simplicity.

In order to obtain a VAR representation, a certain structural specification for the ‘error term’ z_t is required. There are two commonly used and attractive assumptions: structural shocks have temporary effects or structural shocks have permanent effects.

If structural shocks have only temporary effects, z_t equals a serially uncorrelated vector ε_t. That is:

$$z_t=\varepsilon_t \qquad (5.3)$$

where ε_t: a orthogonal white noise vector, with $\varepsilon_t = [\varepsilon_{1t}, \ldots, \varepsilon_{nt}]'$, which captures exogenous shocks to the disturbance terms z_t.

Alternatively, if the effects of structural shocks to z_t are permanent, z_t can be modeled as a unit root process. That means:

$$z_t-z_{t-1}=\varepsilon_t \qquad (5.4)$$

Equation (5.4) implies that z is equal to the sum of all past and present realizations of structural shocks ε. Hence, shocks have permanent effects.[7]

In the case that exogenous structural shocks have temporary effects, equation (5.2) can be formulated as the standard VAR representation:

$$y_t=B(L)y_{t-1}+e_t \qquad (5.5)$$

where e_t: the vector of estimated residuals, with $e_t = [e_{1t}, \ldots, e_{nt}]'$

$B(L)$: a pth degree matrix polynomial in the lag operator L, $B(L) = B_0 + B_1L + \ldots + B_pL^p$.

Equation (5.5) is a reduced form VAR(p) representation of the vector of stochastic variables y_t. The transformation of (5.2) into (5.5) implies that $B(L) \equiv$

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[6] As illustrated earlier, unobservable exogenous variables are usually interpreted as disturbances.

[7] The assumptions in equations (5.3) and (5.4) are not so restrictive as they might appear. If the shock processes were specified as general autoregressions, the VAR models would have additional lags. However, the procedures to identify structural parameters would not be affected.

$A^{-1}C(L)$ and $e_t \equiv A^{-1}D\varepsilon_t$. Since there are no longer contemporaneous effects between variables in the standard VAR representation and each equation contains a common set of regressors, the use of OLS regression is legitimated.

Under the assumption that structural shocks have permanent effects, we can obtain the VAR model by applying the first difference operator ($\Delta = 1 - L$) to equation (5.2) and inserting equation (5.4) into the resulting expression. This procedure leads to the following equation:

$$\Delta y_t = B(L)\Delta y_{t-1} + e_t \qquad (5.6)$$

Equation (5.6) is a common VAR specification because many macroeconomic time series appear to have a unit root.

Since each variable in VAR models is a function of lagged value of all the variables, VARs are general dynamic specifications. This generality certainly comes at a cost. Because there are a number of lags of each variable in each equation, the set of variables in VARs must not be too large in order that the model would not exhaust available data.

If all structural shocks have temporary effects, equation (5.5) is estimated. If their effects are permanent, equation (5.6) is appropriate instead. Sometimes some structural shocks have temporary effects while others have permanent effects, which should also be accounted for in the empirical model.[8]

From the relationship $e_t \equiv A^{-1}D\varepsilon_t$, it is obvious that the estimated residuals e_t are linear combinations of independent structural shocks ε_t. Further assumptions require that e_t is uncorrelated to y_{t-1}, y_{t-2}, … and each individual error term e_{it} has a zero mean and a constant variance σ_i^2:

$$E(e_{it}) = 0$$

$$var(e_{it}) = \sigma_i^2$$

with i=1,…, n.

[8] See Blanchard and Quah (1989), Balmaseda, et.al (2000).

Unlike structural shocks ε_t, the error terms in e_t are correlated to each other, with σ_{ij} indicating the covariance terms. With $\sum$ symbolizing the variance/covariance matrix of the estimated residual e_t, we have

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1n} \\ \sigma_{21} & \sigma_2^2 & \cdots & \sigma_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \cdots & \sigma_n^2 \end{pmatrix}$$

where $\sigma_{ij} = (1/T)\sum_{t=1}^{T} e_{it}e_{jt}$.

Since matrix $\sum$ is symmetric, it provides $(n^2 + n)/2$ distinct estimated parameters to use in recovering the structural parameters in (5.2).

5.1.2.2 Cholesky decomposition as the identification technique

The standard VAR representation (5.5) is, however, a reduced form. Since different structural models give rise to the same reduced form, no conclusions regarding structural relationships and structural parameters of the 'true' model can be drawn from the data without additional identification assumptions. Therefore, the reduced form should be identified to obtain structural shocks ε_t, which are assumed to be unrelated to each other since they are meant to represent shocks from independent sources. Enough restrictions are necessary to achieve the identification. Since structural shocks ε_t are assumed to be white noise with zero covariance, their variance/covariance matrix Ω is a diagonal one, which contains only n unique elements. Matrices A and D each includes n^2 elements. Therefore, the total number of structural parameters to be estimated is $2n^2 + n$. As illustrated above, there are only $(n^2 + n)/2$ elements estimated from matrix $\sum$. $(3n^2+n)/2$ restrictions are therefore required for identification.

Matrices A and D are usually assumed to have main diagonal elements equal to unity. Such an assumption about matrix A means normalization on a particular endogenous variable in each structural equation; for matrix D, this is the consequence of assuming a separate shock contained in each equation. Further 2n restrictions are provided in this way. Exclusion restrictions are also imposed on D matrix in most studies, which makes it an identity matrix.[9] This provides an additional (n^2 - n) restrictions. Till now, we have [2n + (n^2 - n)] contemporaneous restrictions for the ($3n^2$+n)/2 restrictions required. There are still (n^2 - n)/2 restrictions needed for just-identification.

Identification necessitates the imposition of some structure on the system. Traditionally, the identification in VARs is realized through a mechanical technique which is thought to be unrelated to economic theory. In such a framework, restrictions required can be obtained from a 'timing scheme' for shocks. The assumption in such an identification scheme is that shocks may only directly affect a subset of variables within the current period, whereas another subset of variables is affected with a lag of time period.

In his influential article introducing VAR methodology to the profession, Sims (1980) proposed such an identification strategy based on Cholesky decomposition. The Cholesky decomposition is implemented on the variance/covariance matrix of estimated VAR residuals and corresponds to a recursive economic structure. This statistical decomposition separates the estimated residuals e_t into orthogonal structural shocks ε_t by finding the unique lower triangular matrix λ that solves the following equation:

$$\sum=\lambda\lambda' \qquad (5.7)$$

where $\sum$: the variance/covariance matrix of the estimated residuals e_t of the reduced form VAR.

The intuition behind such a decomposition technique is that shocks enter the equation in a successive form so that the second shock does not affect the variable explained by the first equation in the same period. Similarly, the shock in the third equation does not affect variables explained by the first and the second equation in the current period.[10] In general, it is associated with a causal chain from the first variable to the last variable in the system.

[9] Bernanke (1986) and Blanchard (1989) are exceptions.
[10] Such a scheme is the so-called 'Wold chain system', see Wold (1960).

Such a statistical decomposition is a just-identification scheme, which depends on the sequence in which variables are ordered in the vector y_t. It means that restrictions imposed are based on an arbitrary ordering of the variables.

In the example of a 4-dimentional model, this decomposition can be expressed as

$$e_{1t} = \varepsilon_{1t}$$

$$e_{2t} = z_{1t} e_{1t} + \varepsilon_{2t}$$

$$e_{3t} = z_{2t} e_{1t} + z_{3t} e_{2t} + \varepsilon_{3t}$$

$$e_{4t}=z_{4t}e_{1t}+z_{5t}e_{2t}+z_{6t}e_{3t}+\varepsilon_{4t} \qquad (5.8)$$

where e_{it}: the estimated residuals, i = 1, …, 4

ε_{it}: structural shocks, i = 1, …, 4

z_{kt}: the Cholesky restrictions, k = 1, …, 6.

System (5.8) implies that the first variable responds only to its own exogenous shocks; the second variable responds to the first variable plus exogenous shocks to the second variable, and so on. This leads to a lower triangular structure required for the identification, with all elements above the principle diagonal being equal to zero.

The $(4^2 - 4)/2 = 6$ restrictions needed for just-identification in a 4-dimensional system are thus provided by the Cholesky restrictions z_{kt} in the expression (5.8). However, it is just one possible ordering of the variables. In practice, a-theoretical VAR studies usually report results from various orderings. There can be totally n! possible orderings in a system with n variables. In the above system, for example, there can be 4!=24 different orderings.

If the correlation between the estimated residuals is low, the choice of ordering is usually not to be very important. Since variables included in a VAR will normally be chosen just because they have strong co-movements, the choice of ordering typically plays a crucial role. As a matter of fact, the results from VARs with Cholesky decomposition as the identification technique can be quite sensitive to the ordering imposed. For this reason, Sims (1981) suggests attempting various triangular orthogonalizations and checking whether the results are robust to the ordering of the variables. 'When results are sensitive to the ordering of the variables', he recommends as a solution that 'one may make some progress by using a priori hypotheses about the structure'.[11]

In short, a serious problem with Cholesky decomposition is that this identification scheme for shocks may sensitively depend on the ordering of the variables in the system. Therefore, results from such traditional VAR analysis may be quite difficult to interpret.

5.1.3 Dynamic analysis of VAR models

With VAR models being identified, their dynamic characteristics can be explored. Important tools for dynamic analysis of VARs are impulse response functions and variance decompositions.

Analyses of impulse response functions allow us to explain how variables react over time to innovations in another variable. FEVD is then performed in order to compare the role played by different variables in causing such reactions.

5.1.3.1 The impulse response function

VAR system (5.5) can be transformed into

$$(I-B(L)L)y_t=e_t \quad (5.9)$$

By inverting (I - B(L)L) (under the assumption that this polynomial is invertible), a dual vector moving average MA(∞) representation (Wold representation) of VAR (5.5) could be obtained:

$$y_t=\Psi(L)e_t \quad (5.10)$$

where $\Psi(L)$: an infinite matrix polynomial in the lag operator L, with $\psi(L) \equiv$ (I -

[11] The classical way to impose a priori hypotheses about the structure is to formulate a system of

$$B(L)L)^{-1} = \Psi_0 + \Psi_1 L + \ldots.$$

It is obvious that the matrix Ψ_s (s=0,1, …) has the interpretation

$$\frac{\partial y_{t+s}}{\partial e_t'} = \Psi_s \qquad (5.11)$$

That means, the (i,j) element of the matrix Ψ_s indicates the consequences of a one-unit increase in the jth variable's innovation at date t (e_{jt}) for the value of the ith variable at time t+s ($y_{i,t+s}$), holding all other innovations at all dates constant.

A plot of the (i,j) element of the matrix Ψ_s, $\frac{\partial y_{i,t+s}}{\partial e_{jt}}$, as a function of s is called the impulse response function. It describes the response of $y_{i,t+s}$ to a one-time impulse in y_{jt}. For this function of partial derivative to be meaningful, it should be guaranteed that an impulse to variable j occurs while all other shocks are kept to zero.

Note that the impulse response function of a standard reduced form VAR is slightly ambiguous. The reason is that innovations in a reduced form VAR, being linear combinations of orthogonal structural shocks, are generally correlated to each other. It follows that a VAR model could be represented with infinite impulse response functions, corresponding to arbitrary linear combinations of shocks. The data alone can not help in this respect, since different representations are observably equivalent. Therefore, it is important to uniquely pin down impulse response functions for structural shocks which are considered to be uncorrelated with each other.

Assume for example that exogenous shocks have temporary effects. Combining equation (5.1) and equation (5.3) leads to:

$$Ay_t=C(L)y_{t-1}+D\varepsilon_t \qquad (5.12)$$

simultaneous equations for the errors of the system. See the SVAR analysis below.

Equation (5.12) is interpreted as the structural form of the standard reduced form VAR model (5.5). After relevant transformation, the following moving average MA(∞) representation could be obtained:

$$y_t = \tilde{\Psi}(L)\varepsilon_t \tag{5.13}$$

where $\tilde{\Psi}(L)$: an infinite matrix polynomial in the lag operator L, with $\tilde{\Psi}(L) \equiv$

$$(A - C(L)L)^{-1}D = \tilde{\Psi}_0 + \tilde{\Psi}_1 L + \ldots.$$

Here the matrix $\tilde{\Psi}_s$ (s=1,…) is interpreted as

$$\frac{\partial y_{t+s}}{\partial \varepsilon_t{}'} = \tilde{\Psi}_s \tag{5.14}$$

The (i,j) element of the matrix $\tilde{\Psi}_s$ corresponds to the impact of an impulse in the jth structural shock at time t (ε_{jt}) on the ith variable at time t+s ($y_{i,t+s}$), holding all other structural shocks at all dates constant.

A plot of the (i,j) element of the matrix $\tilde{\Psi}_s$, $\frac{\partial y_{i,t+s}}{\partial \varepsilon_{jt}}$, as a function of s is the uniquely pinned down impulse response function which we want. It is also called an orthogonalized impulse response function, which visualizes the adjustment path after a structural shock occurs. If the variables in y are stationary, the impulse responses must approach zero as s becomes large.

5.1.3.2 Variance decomposition

Another possibility to interpret a VAR model is forecast error variance decompositions. Variance decompositions allocate each variable's forecast error variance to individual shocks. These statistics measure the quantitative effects that shocks have on the variables.

The moving average MA(∞) representation (5.13) (with orthogonal white noise innovations ε_t) can also be expressed as

$$y_t = \sum_{i=0}^{\infty} \tilde{\Psi}_i \varepsilon_{t-i} \tag{5.15}$$

Denoting the linear forecast of y_{t+s} at time t with $\hat{y}_{t+s|t}$, the error of forecasting a VAR s periods into the future could be identified as

$$y_{t+s} - \hat{y}_{t+s|t} = \sum_{i=0}^{s-1} \tilde{\Psi}_i \varepsilon_{t-i}$$

$$= \tilde{\Psi}_0 \varepsilon_{t+s} + \tilde{\Psi}_1 \varepsilon_{t+s-1} + \ldots + \tilde{\Psi}_{s-1} \varepsilon_{t+1} \tag{5.16}$$

Denoting now the (j,k) element of $\tilde{\Psi}_i$ with $\theta_{jk,i}$, the s-step forecast error of the jth component of y_t is

$$y_{j,t+s} - \hat{y}_{j,t+s|t} = \sum_{i=0}^{s-1} (\theta_{j1,i}\varepsilon_{1,t+s-i} + \cdots + \theta_{jn,i}\varepsilon_{n,t+s-i})$$

$$= \sum_{k=1}^{n} (\theta_{jk,0}\varepsilon_{k,t+s} + \cdots + \theta_{jk,s-1}\varepsilon_{k,t+1}) \tag{5.17}$$

Clearly, the forecast error of the jth variable potentially consists of all structural shocks. Since $\varepsilon_{k,t}$ are uncorrelated, the mean squared error of $\hat{y}_{j,t+s|t}$ is

$$\text{MSE}(\hat{y}_{j,t+s|t}) = E[(y_{j,t+s} - \hat{y}_{j,t+s|t})(y_{j,t+s} - \hat{y}_{j,t+s|t})']$$

$$= \sum_{k=1}^{n} \text{var}(\varepsilon_{k,t})(\theta_{jk,0}^2 + \cdots + \theta_{jk,s-1}^2) \tag{5.18}$$

Making use of the relationship below:

$$\theta_{jk,0}^2 + \cdots + \theta_{jk,s-1}^2 = \sum_{i=0}^{s-1} (l_j' \tilde{\Psi}_i l_k)^2 \tag{5.19}$$

where l_j: the jth column of the identity matrix I.

The contribution of the kth structural shock $\varepsilon_{k,t}$ to the s-step forecast error variance of the jth variable $y_{j,t}$ could be expressed as:

$$\operatorname{var}(\varepsilon_{k,t})(\theta^2_{jk,0}+\cdots+\theta^2_{jk,s-1}) = \operatorname{var}(\varepsilon_{k,t})\sum_{i=0}^{s-1}(l_j{}'\tilde{\Psi}_i l_k)^2$$

Thus equation (5.18) could be reexpressed as

$$\text{MSE}(\hat{y}_{j,t+s|t}) = \sum_{k=1}^{n}(\operatorname{var}(\varepsilon_{k,t})\sum_{i=0}^{s-1}(l_j{}'\tilde{\Psi}_i l_k)^2) \tag{5.20}$$

In this way, the forecast error variance is decomposed into components accounted for by different structural shocks in the system. We could calculate the share of total variance attributable to each structural shock. At different forecast horizons, forecast error variance decomposition gives answer to the question, which portion of the variance of the time series' stochastic part can be explained by each structural shock.

Variance decomposition makes sense only if shocks are orthogonal to each other. For only in this case, we could write the variance of total forecast error as a sum of variances resulted from the single shock.

5.1.4 Criticisms of the VAR methodology

VAR models have been pioneered by Sims (1980, 1981) and other authors as an alternative to traditional macroeconometric methodologies. Sims' main criticism of the traditional analysis is that macroeconometric models are often not based on sound economic theories or available theories are not able to provide a completely specified model. If economic theories are not sound enough to specify the model, statistical tools should be resorted to. In this case, a rather loose model is set up without imposing rigid a priori restrictions on the data generation process. VAR models represent a class of loose models and thus provide such a modeling possibility.

However, as seen from the previous elaboration, some restrictive assumptions are necessary in order to interpret such VAR models. Especially the ordering of variables often plays a crucial role in the interpretation. In this respect, Sims (1981) suggests to try different orderings and investigate the sensitivity of the conclusions to the ordering of variables in the model.

The traditional VAR approach with a Cholesky decomposition technique, which is initially believed as a-theoretic, has been criticized by Cooley and LeRoy (1985). They argue at first that if Cholesky decomposition is really unrelated to economic theory, then the recovered shocks are not structural but will generally be linear combinations of structural shocks. In this case, it is difficult to assess the dynamic effects of shocks acquired from Cholesky decomposition for they will be complicated functions of dynamic effects of all the structural shocks. As a result, the innovation accounting techniques of impulse response functions and variance decompositions associated with standard VAR analysis have no obvious economic interpretation.

Cooley and LeRoy (1985) attack the traditional VAR analysis further by arguing that the ordering imposed by Cholesky decomposition is in fact not a-theoretic. It can be interpreted as a particular type of recursive contemporaneous structure of the economy. However, most economic theories do not imply recursive contemporaneous systems. Therefore, the economic structure implied by Cholesky decomposition may be quite difficult to reconcile with economic theory.

Such criticisms of the traditional VAR analysis inspired structural approaches to VAR modeling. The SVAR approach was developed to allow researchers to recover the underlying structural shocks under the guide of economic theory.

5.2 An introduction into the SVAR methodology

Following the seminal works by Blanchard and Watson (1986), Bernanke (1986) and Sims (1986), a growing interest in the SVAR approach has developed in applied macroeconometric literature.

A common feature shared by SVAR literature is the attempt to 'organize' instantaneous correlations between relevant variables. By imposing a number of meaningful theoretical restrictions, structural analysis of VAR models tries to isolate (identify) a set of independent shocks. As the name implies, identification is done in a 'structural' theoretical sense. Previous VAR modeling is instead non-structural, where correlations are generally hidden in the variance-covariance matrix of the innovations of VAR models.

The independent shocks, which are identified in the SVAR analysis, can be regarded as the ultimate source of stochastic variations of the variables in the system. The variables can be treated as potentially all endogenous.

5.2.1 Why structural VAR analysis?

An important drawback of the traditional VAR approach is that it leads to a 'reduced form representation'. The parameters therefore do not admit a structural interpretation. However, it is important to specify both the reduced and structural representation appropriately.[12] The reduced form provides a statistical representation of the economic system, which is consistent with data. The structural form, instead, can be seen as a reformulation of the reduced form in order to impose a particular view suggested by economic theory. To overcome the weakness of traditional VARs, the gap between such reduced form VAR representations and structural models should be bridged.

5.2.1.1 Theory dependence versus sample dependence

An important issue of econometric methodology is the roles of economic theory and data in econometric modeling. All approaches in econometrics are based on a mixture of theory and evidence, with different weights assigned to these two aspects.

'Theory-driven' approaches lie at one extreme. In theses approaches, a model arises from a priori theory and data is used just to calibrate its parameters. The information hidden in data evidence is not exploited and so little is learned from the data. Such approaches are subject to theory dependence. That means, the credibility of the resulting structural models depends crucially on the credibility of

[12] The practice in econometrics to distinguish a structural model from the reduced form of an economic system traces back to Haavelmo (1944).

the theory from which they were derived. If that theory is discarded, so must be the associated 'empirical' evidence. Put it in a different way, the 'empirical' results are nothing more than a theory model in quantitative form.

At the other extreme are 'data-driven' approaches. In such approaches, structural modeling is abandoned in comparison with theory-driven approaches. Models developed are merely aimed to closely describe the data. These models suffer from sample dependence. For the reason that accidental or transient data features are embodied in the model in just the same way as permanent aspects, extensions of the data-set may result in predictive failure. In other words, the results of 'data-driven' approaches are subject to important sample vagaries. The often accusation in this case is 'data mining'.

5.2.1.2 Data modeling under the guide of economic theory

As demonstrated above, the danger of 'theory-driven' approaches is theory dependence; whereas the problem of 'data-driven' approaches lies in sample dependence. These are therefore the twin dangers of excessive theory dependence versus sample dependence in econometric modeling. Theory-based models are unable to describe the data properly and data-selected models are likely to fail when new observations appear.

This dilemma naturally leads to an interactive blend of theory and evidence. To avoid the drawbacks of theory calibration and data mining, modeling approaches are developed attempting to combine inference from data with guidelines from economic theory.

SVAR analysis, allowing for a 'theory guided view' of the data, is one of such approaches. This approach can be regarded as standing somewhere along a continuum between the a-theoretical approaches of pure time series analysis and the structured large scale macroeconomic models. It can be thought of as a bridge between economic theory and multiple time-series analysis in order to trace the dynamic response of variables to various disturbances, or shocks, that occur in the economy.

5.2.2 Some aspects of structural VAR analysis

5.2.2.1 About shocks

As is well known, VAR models concentrate on shocks. Structural shocks occupy then a central place in the SVAR model.

These structural shocks are the input of a linear dynamic system, which represent the driving force behind the stochastic dynamics of the n-dimensional time series y_t. They are unpredictable with regard to the past of the process. These structural shocks are generally attached with a certain economic meaning such as an oil price shock, a productivity shock, an exchange rate shock or a monetary shock. Note that such shocks are not thought of as disastrous singular events. On the contrary, it is assumed that the economy is hit regularly by such shocks. The size of these shocks is, however, usually small.

Since such structural shocks can not be directly observed, assumptions are needed to identify them. A consensus has come into being which states that structural shocks should be mutually uncorrelated (orthogonal). To explain this orthogonality restriction in SVAR models, Bernanke (1986) thinks of these structural shocks 'as 'primitive' exogenous forces … which buffet the system and cause oscillations. Because these shocks are primitive, i.e., they do not have common causes, it is natural to treat them as approximately uncorrelated.' This assumption is necessary to consider the dynamic impact of an isolated shock. If the shocks were correlated, the relationship between the shocks must be taken into account and, as a result, it is impossible to distinguish the effects of different shocks.[13]

5.2.2.2 SVARs in comparison with simultaneous equation systems

Regarding the issue of identification, there are important differences between a SVAR model and a simultaneous equation model.

At first, systems of simultaneous equations are usually identified by linear (exclusion) restrictions. SVAR models, instead, assume orthogonal shocks and,

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[13] In fact, the decomposition into orthogonal components has a long tradition in statistical analysis.

hence, the structure is identified also using restrictions on the covariance matrix of the errors. This makes the estimation of such systems considerably complicated.

Secondly, much more restrictions than necessary are generally employed to identify the traditional system of simultaneous equations models. That means that these models are often highly over-identified. It is just these over restricted models that are qualified by Sims (1980) as 'incredible' in his famous critique. SVAR proponents instead try to avoid such an over-simplification of the structure and thus impose just as many restrictions as necessary to identify the structure. Consequently, most SVAR models are just identified.

However, note that just identified models are no more than convenient reformulations of the reduced form. As a result, so long as the reduced form and the just identified structure are correctly specified, it is impossible to decide between alternative identified structures on empirical grounds. SVAR models are thus used to quantify prior views of the economy and to assess the plausibility of the outcomes.

5.2.2.3 SVAR as an extension of the traditional VAR analysis

Advocated by the influential Cowles Commission, the simultaneous equation approach surely dominated the empirical research in econometrics until the late 1970s. The initial optimism about the potential of the simultaneous equation system was, however, not fulfilled. The inability of large macroeconomic models to compete with 'a-theoretic' Box-Jenkins ARIMA models on predictive grounds has led to an increased interest in time series analysis. Particularly, the seminal paper by Sims (1980) paved the way for the ultimate success of the VAR approach in empirical macroeconometrics.

The development of this approach was thus promoted by both the inability of economists throughout the 1970s to agree on the true underlying structure of the economy and the Lucas critique, which states that changes in policy systematically alter the structure of econometric models, with a resultant shift away from the use of large scale macroeconomic models as forecasting tools.

Attempting to overcome the problem of 'incredible identification restrictions' in traditional macroeconomic modeling, particularly in the determination of exogenous variables, the VAR approach takes all variables as endogenous.

Since economists could not get an agreement on the true structure of the economy, VAR models were developed with the belief that such models could reveal important dynamic characteristics of the economy, without imposing structural restrictions from a particularly economic theory. Impulse response functions and variance decompositions, which illustrate the dynamic characteristic of empirical models, were initially obtained by a mechanical technique which was often believed to be unrelated to economic theory.

However, as argued forcefully by, e.g., Cooley and LeRoy (1985), traditional VARs are of a 'reduced form' status and hence only summarize the dynamic properties of the data. Without referring to a specific economic structure, such a reduced form is difficult to interpret. For example, it is generally impossible to draw any conclusion from the bulk of coefficient estimates in a VAR system. So long as such parameters are not related to 'deep' structural parameters characterizing preferences, technologies, and optimization behavior, these parameters do not have an economic meaning.

The criticism of this traditional a-theoretical VAR method has led to the development of a new kind of econometric model, which is now known as the 'Structural' VAR approach. SVAR analysis is an extension of traditional unstructured VAR analysis. It is the imposition of a certain structure that makes SVAR different from the traditional VAR analysis.

SVAR approach allows researchers to use economic theory to transform the reduced form VAR model into a system of structural equations. The difference between the two is that within a SVAR framework, it is attempted to identify a set of independent shocks by means of restrictions under the guide of economic theory; whereas a-theoretical restrictions are used in traditional VAR analysis. As a result, SVAR approach yields impulse responses and variance decompositions that can be given structural interpretations, which is in sharp contrast with traditional VARs.

The first strand of SVAR analysis made use of economic theory to impose restrictions on the observed values of estimated residuals e_t to recover underlying structural shocks ε_t.[14] Such kind of SVAR approach estimates structural parameters by imposing contemporaneous structural restrictions based on economic theory, which is different from the arbitrary method of imposing restrictions used in traditional VAR analysis. These structural restrictions can be considered as short-run restrictions in that shocks are considered to have temporary effects. A representation of the standard VAR model in levels, as shown in equation (5.5), would apply in this context.

An alternative SVAR approach allows shocks to have permanent effects.[15] In this framework, long-run restrictions are utilized to identify the economic structure from the reduced form. This would imply that the variables are non-stationary since shocks continue to accumulate through time resulting from their permanent effects. The presence of a unit root in the variables can lead to spurious regression if the VAR is estimated in levels. It is thus necessary to use first differences to ensure stationarity when shocks have permanent effects. Here a standard VAR in first differences like that in equation (5.6) is appropriate. Such models have long-run characteristics that are more readily acquired from economic theory. They usually exhibit sensible short-run properties as well.

In short, a structural VAR is a standard VAR where restrictions needed to identify the underlying structural model are provided by economic theory. These restrictions can be either contemporaneous or long-run, depending on whether economic theory suggests the effects of the shocks are temporary or permanent.

5.2.3 Identification in structural analysis of VARs

The procedure of operating a structural analysis of VARs involves a number of discrete steps. At first, it must be determined whether the variables to be included are stationary I(0) or non-stationary I(1). A reduced form VAR representation in levels (5.5) or in first differences (5.6) is employed correspondingly.[16] Once the variables have been made stationary, the next step is to estimate the reduced form

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[14] They stemmed from the influential contributions of Sims (1986), Bernanke (1986), Blanchard and Watson (1986).

[15] See, for example, Shapiro and Watson (1988), Blanchard and Quah (1989).

[16] SVARs are usually 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 or not.

VAR using OLS, with enough lags incorporated to ensure that no serial correlation of the residuals exist. With the principle of avoiding exclusion restrictions, VARs can quickly become over-parameterized and hence lose important degrees of freedom. Therefore, tests are needed to select just the appropriate lag length.

As a ‘reduced form’ of the system, the VAR model provides a statistical description of the (linear) dynamic relationship between the time series. Since such a representation is the basis of the structural form, it is important that the reduced form VAR is correctly specified. A straightforward exercise has been developed to specify the reduced form VAR model.[17]

SVAR analysis tries to isolate a set of orthogonal shocks ε_t through a number of meaningful theoretical restrictions. These shocks are thought to be independent which are the ultimate sources of stochastic variations of variables in the system. For this reason, structural VARs may unlock economic information embedded in the reduced form time series model.

Identification is always a crucial issue in the estimation of any structural model. With the reduced form VAR being estimated, it is essential to impose sufficient restrictions to identify the structural parameters in the VAR model. In some cases, economic theory can suggest more than the necessary restrictions, so that the model is over-identified. The discussion here applies only to just-identification.

Both contemporaneous and long-run restrictions provided by economic theories could be imposed to identify reduced form VAR models. If shocks are assumed to have temporary effects on the variables, the restrictions are imposed on the contemporaneous elements contained in matrices A and D in equation (5.12) and $\sum$ (the variance/covariance matrix of the estimated residual e_t). On the contrary, when shocks are assumed to have permanent effects, the restriction are imposed on the long-run multipliers in the impulse response functions, which actually involves restrictions on the matrix polynomial B(L) in equation (5.6).

5.2.3.1 Contemporaneous restrictions

[17] See, e.g. Lüktepohl (1991) for a variety of useful devices for the specification and validation of the appropriate VAR representation.

Formulating structural equations for the errors of the system is an approach to identifying the shocks. In this case, it is convenient to think of the equation as an IS curve or a labor demand relation, for example. However, these equations are different from traditional simultaneous equations in that they apply to the unexpected part of the variables (the 'innovations') instead of the variables themselves. For this reason, the identification using a set of simultaneous equations is appealing with respect to the traditional approach advocated by the Cowles Commission. This kind of identification has become very popular in empirical SVAR analysis.

Recall the relationships from transforming structural form VAR (5.12) into reduced form (5.5): $B(L) \equiv A^{-1}C(L)$ and $e_t \equiv A^{-1}D\varepsilon_t$. Obviously, if the contemporaneous parameters in matrices A and D were known, the dynamic structure represented by the parameters in C(L) could be calculated from the estimated reduced form VAR coefficients: $C(L) = AB(L)$. And structural shocks ε_t could be derived from the estimated residuals e_t: $\varepsilon_t = D^{-1}Ae_t$.

However, the coefficients in A and D are unknown. So in order to identify structural parameters, theoretical restrictions must be imposed to reduce the number of unknown structural parameters to be less than or equal to the number of estimated parameters of the variance/covariance matrix of VAR residuals. Specifically, the variance/covariance matrix of the estimated residuals $\sum$ is

$$\sum=E(e_te_t')=A^{-1}DE(\varepsilon_t\varepsilon_t')D'A'^{-1}=A^{-1}D\Omega D'A'^{-1} \tag{5.21}$$

where E: the unconditional expectations operator

Ω: the variance/covariance matrix of structural shocks.

Using the estimate of $\sum$ from an OLS VAR estimate, estimates of A, D and Ω could be obtained through equation (5.21). The contemporaneous structural approach imposes restrictions on these three matrices. Required restrictions are often exclusion restrictions.[18] Besides the restrictions which have been discussed earlier at least $(n^2 - n)/2$ additional restrictions are to be imposed on A to achieve identification.[19] Sims (1986) suggests impose restrictions on the contemporaneous

[18] It need not be the case of course.

[19] See 5.1.2.2 for details.

information assumed available to particular economic agents. Extending this approach, Keating (1990) and West (1990) show how rational expectations restrictions can be imposed in the contemporaneous structural VAR framework.

Standard VAR tools are employed after structural parameters are estimated. Impulse response functions and variance decompositions conveniently summarize the dynamic response of the variables to structural shocks.

In contrast to a-theoretical VAR models proposed by Sims (1980), impulse responses and variance decompositions yielded in the structural approach are derived using parameters from an explicit economic model. Therefore, they can be given a direct economic interpretation. Impulse response functions, for example, can be used to test whether structural shocks affect each variable as economic theory would predict. If dynamic patterns are consistent with the structural model used for identification, evidence would be provided in support of the theoretical model. Otherwise, either the theory is invalid or the empirical model is somehow misspecified.

5.2.3.2 Long-run restrictions

An alternative method which achieves the identification of shocks using restrictions on the long-run effects of structural shocks has become popular recently.[20] In many cases, economic theory suggests that the effect of some shock on a particular variable is zero in the long-run, that is, the shock has only transitory effect with respect to this variable. Such assumptions give rise to nonlinear restrictions on the parameters, which may be used to identify the structure of the system.

In these models, identifying restrictions are imposed on long-run multipliers for structural shocks. Since there is more agreement on the long-run properties of economic theory than on the short-run, this approach can be quite attractive to economists. In addition, it has the advantage that it does not impose contemporaneous restrictions, but instead allows the data to determine short-run dynamics based conditionally on a particular long-run model.

[20] This approach to SVARs was developed by Shapiro and Watson (1988), Blanchard and Quah (1989).

If each shock has a permanent effect on at least one of the variables, the VAR should be estimated in first differences. To impose restrictions on long-run multipliers, we must know their algebra at first. For this purpose, we extend the analysis of impulse response functions for VARs in levels to the case of VARs in first differences.

Similar to the derivation of impulse response functions for the VAR in levels, following expression can be obtained for the first-differenced VAR model as in equation (5.6):[21]

$$\Delta y_t = \tilde{\Psi}(L)\varepsilon_t \tag{5.22}$$

where $\tilde{\Psi}(L)$: an infinite matrix polynomial in the lag operator L, with $\tilde{\Psi}(L) \equiv (I - B(L)L)^{-1}A^{-1} D = \tilde{\Psi}_0 + \tilde{\Psi}_1 L + \ldots$.

Equation (5.22) gives the response of Δy_t to an impulse in structural shocks ε_t.

However, the response of y_t, rather than of Δy_t, is generally of more interest to economists. Under the assumption that all the elements of ε_t at time zero and earlier are equal to zero, these impulse responses can be generated recursively. Such a recursive process leads to following result:

$$y_t = y_0 + \Gamma(L)\varepsilon_t = y_0 + \sum_{i=0}^{t-1} \Gamma_i \, \varepsilon_{t-i} \tag{5.23}$$

where $\Gamma_i = \sum_{j=0}^{i} \tilde{\Psi}_j$.

Equation (5.23) gives thus the impulse response function for y_t. The response of y_{t+i} to an impulse in the structural shocks ε_t is Γ_i. Since the differenced specification implies that Δy_t is stationary, matrix $\tilde{\Psi}_j$ goes to zero as j gets large. This means further that the long-run effect of ε_t, namely Γ_i, converges to the sum of coefficients in $\tilde{\Psi}(L)$. It is clear from the definition of $\tilde{\Psi}(L)$ that replacing L

[21] See section 5.1.3.1.

by one yields the sum of coefficients, which can be conveniently written as $\tilde{\Psi}(1)$. This matrix is then used to parameterize long-run restrictions.

The relationship between parameters of the MA(∞) representation, contemporaneous structural parameters and VAR lag coefficients is given by

$$\tilde{\Psi}(L) \equiv (I-B(L)L)^{-1}A^{-1}D \qquad (5.24)$$

The long-run multipliers are obtained by replacing L in equation (5.24) with unity.

With L set equal to unity, equation (5.24) can be solved for $A^{-1}D$:

$$A^{-1}D=(I-B(1))\tilde{\Psi}(1) \qquad (5.25)$$

where B(1): the sum of VAR coefficients.

Inserting equation (5.25) into equation (5.21)

$$\sum=E(e_t e_t')=A^{-1}DE(\varepsilon_t\varepsilon_t')D'A'^{-1}=A^{-1}D\Omega D'A'^{-1} \qquad (5.21)$$

where ∑: the covariance matrix for the estimated residuals

Ω: the covariance matrix for the shocks,

we get the following relationship after some transformation:

$$(I-B(1))^{-1}\sum(I-B(1))^{-1'}=\tilde{\Psi}(1)\Omega\tilde{\Psi}(1)' \qquad (5.26)$$

Equation (5.26) can be used to identify the parameters in $\tilde{\Psi}(1)$ and Ω. To identify long-run SVAR models, certain restrictions on the long-run response of macroeconomic variables y_t to structural shocks ε_t are necessary. Estimates of the matrices on the left side of equation (5.26) are obtained directly from the unconstrained VAR. Matrix, $\tilde{\Psi}(1)$, has n^2 elements and matrix Ω has $(n^2 + n)/2$ unique elements. The $(n^2 + n)/2$ unique elements in the symmetric matrix on the left side in a just-identified model provide us $(n^2 + n)/2$ restrictions. Thus, at least n^2 identifying restrictions must be applied to $\tilde{\Psi}(1)$ and Ω. The elements of the main diagonal for $\tilde{\Psi}$ (1) can be set to one, corresponding to the normalization used in the contemporaneous model. Since each element of ε_t is assumed to be independent, matrix Ω is therefore diagonal. Hence, $(n^2 - n)/2$ additional restrictions are needed for $\tilde{\Psi}(1)$ to identify the model.

There have been several alternative approaches to obtain structural parameters. Shapiro and Watson (1988) impose long-run zero restrictions on $\tilde{\Psi}(1)$ by means of estimating the simultaneous equations model with certain explanatory variables differenced one additional time. King, Plosser, Stock and Watson (1991) use the vector error-correction model to impose long-run restrictions, with some of the long-run features of the model chosen by cointegration regressions. Galí (1992) combines long-run restrictions with contemporaneous restrictions to identify a structural model.

In short, long-run restrictions allow for the recovery of the underlying structural shocks which can be used to obtain impulse response functions and variance decompositions to analyze the dynamic (short-run) responses of the variables to different structural shocks.

5.2.3.3 Some remarks

Using a common set of macroeconomic variables, Keating (1992) presents estimates of both contemporaneous and long-run SVAR models. By comparing these two modeling strategies, he concludes that the results for the two specifications are often similar. However, he finds that the SVAR with long-run restrictions in general 'provides empirical results that are consistent with the structural model'. In contrast, 'some of the variance decompositions and the impulse responses for the contemporaneous model were inconsistent with standard macroeconomic theory.' Furthermore, structural parameters in the long-run model were found to be more precisely estimated than parameters in the contemporaneous model. If some significant discrepancy exists between these two models, the model with long-run restrictions yields sensible results, whereas the results from the contemporaneous model are inconsistent with standard economic theories.

One may not generalize these comparisons between contemporaneous and long-run specifications to all SVAR applications. However, they do suggest that long-run structural VAR models may yield results as predicted by economic theories more frequently than VAR models identified with short-run restrictions. This result is not surprising if one considers that economic theories may often have similar long-run properties but different short-run features. Since long-run structural VARs typically do not impose contemporaneous exclusion restrictions, they may also provide superior results. Keating (1990) shows in his paper that contemporaneous 'zero' restrictions may be inappropriate if forward-looking agents have rational expectations.[22]

5.2.4 Categorization of SVAR models

5.2.4.1 Three ways of structurization

There are different ways to structurize the VAR model in empirical research. According to Amisano and Giannini (1997), three types of model would encompass all the different models used in applied literature: the K-model, the C-model and the AB-model.

To get a VAR representation consistent with that used by Amisano and Giannini (1997), equation (5.5) can be rewritten as

$$\tilde{B}(L)y_t = e_t \tag{5.27}$$

where $\tilde{B}(L) = I - B_0 L - \cdots - B_p L^{p+1}$.[23]

Assumptions about error terms e_t are the same as earlier.

(1) K-model

[22] The intuition behind this assertion is that any observable contemporaneous variable may provide information about future events.

[23] $\tilde{B}$(L) here corresponds to A(L) in Amisano and Giannini (1997).

K is a (n×n) invertible matrix

$K\tilde{B}(L)y_t = K e_t$

$Ke_t=\varepsilon_t$

$E(\varepsilon_t)=[0], E(\varepsilon_t\varepsilon_t')=I_n$ (5.28)

where ε_t: the independent (orthonormal) structural shocks.

K matrix 'pre-multiplies' the autoregressive representation and induces a transformation of the estimated residuals e_t into a vector of orthonormalized shocks ε_t.[24] Therefore, the variance/covariance matrix of structural shocks ε_t is unit matrix.

If we suppose to know the true variance/covariance matrix Σ of the estimated residuals e_t, from $Ke_t = \varepsilon_t$, we get $K e_t e_t' K' = \varepsilon_t \varepsilon_t'$. Taking expectations, following expression can be obtained: $K \sum K' = I_n$.

This equation implicitly imposes n(n+1)/2 non-linear restrictions on the K matrix, leaving n(n-1)/2 free parameters to be identified.

By transforming the system (5.28), following expression arises:

$$K\tilde{B}(L)y_t=\varepsilon_t \quad (5.29)$$

It can be seen from equation (5.29) that matrix K directly applies to the vector of observable quantities y_t. Thus, instantaneous correlations between the observable variables are organized through the structure of K matrix. Instantaneous correlations between the unobservable quantities represented by structural shocks ε_t, instead, can not be directly organized in the K-model.

(2) C-model

$\tilde{C}$ is a (n×n) invertible matrix[25]

[24] Note that here structural shocks ε_t are also assumed to be normalized.

$\tilde{B}(L)y_t = e_t$

$e_t = \tilde{C}\,\varepsilon_t$

$E(\varepsilon_t) = [0],\ E(\varepsilon_t\,\varepsilon_t') = I_n$ (5.30)

There is no theoretical reason to guarantee $\tilde{C}$ to be a square matrix of the same order as K. Since many reasons imply that the true number of originally independent shocks could be very large, $\tilde{C}$ matrix could be a n×m matrix with m much greater than n. We just assume $\tilde{C}$ matrix to be square and invertible here.

The vector of estimated residuals e_t is regarded as a linear combination of orthonormal shocks ε_t. This may have a different meaning as compared with the K-model.

As in the case of the K model, from $e_t = \tilde{C}\,\varepsilon_t$, following expression can be obtained: $e_t\,e_t' = \tilde{C}\,\varepsilon_t\,\varepsilon_t'\,\tilde{C}'$. Taking expectations, we get $\sum = \tilde{C}\,\tilde{C}'$.

Under the assumption that the variance/covariance matrix $\sum$ is known, the above equation implicitly imposes n(n+1)/2 non-linear restrictions on $\tilde{C}$ matrix, leaving n(n-1)/2 free elements in $\tilde{C}$.

Rewriting system (5.30) in the following form:

$\tilde{B}(L)y_t = \tilde{C}\,\varepsilon_t$ (5.31)

In this case, matrix $\tilde{C}$ directly applies to the vector of structural shocks ε_t which is unobservable. Since the observable variables y_t result as linear combinations of independent shocks, their instantaneous co-movements are only indirectly organized. Thus, instantaneous co-movements of the observable quantities contained in y_t can in no way be directly organized in the C-model.

(3) AB-model

[25] In order to distinguish from the symbols in section 6.4.3.1, symbol $\tilde{C}$ is used here instead of C.

$\tilde{A}$, B are (n×n) invertible matrices[26,27]

$\tilde{A}\ \tilde{B}(L)y_t = \tilde{A}\ e_t$

$\tilde{A}e_t = B\varepsilon_t$

$E(\varepsilon_t) = [0],\ E(\varepsilon_t\ \varepsilon_t') = I_n$ (5.32)

Matrix $\tilde{A}$ induces a transformation of the disturbances vector e_t, thus generating a new vector ($\tilde{A}e_t$) which can be conceived as a linear combination (through matrix B) of independent shocks ε_t. Again, this might have a different meaning as compared with the K-model and the C-model.

Similar to the previous analysis, from $\tilde{A}e_t = B\varepsilon_t$, we get $\tilde{A}e_te_t'\tilde{A}' = B\varepsilon_t\varepsilon_t'B'$. It follows that $\tilde{A}\sum\tilde{A}' = BB'$.

If the variance/covariance matrix $\sum$ is known, the above equation implicitly imposes n(n+1)/2 non-linear restrictions on the parameters of $\tilde{A}$ and B matrices, leaving $2n^2 - n(n+1)/2$ free elements.

Reformulate system (5.32) as

$\tilde{A}\ \tilde{B}(L)y_t = B\varepsilon_t$ (5.33)

Equation (5.33) shows that in the AB-model, matrices $\tilde{A}$ and B apply to the observable and unobservable quantities respectively. Therefore, this model allows the greatest flexibility.

5.2.4.2 The choice of appropriate model

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[26] In order to distinguish from the symbol of matrix A in structural form VAR, symbol $\tilde{A}$ is used here instead of A.

[27] The same argument discussed earlier on the size of matrix C also applies to matrix B.

In order to tackle the problem of which model to choose in empirical applications, one must at first find out whether the concrete problem under study admits a plausible formulation in terms of the K, the C, or the AB model.

The K-model turns out to be particularly useful if economic theory can provide some information on the magnitudes of some total multipliers on observable variables. If contemporaneous restrictions are employed to identify SVARs, the K-model is an appropriate alternative.[28]

The C-model is instead especially useful when long-run constraints have to be imposed (such as neutrality conditions). SVARs with long-run restrictions are therefore presented by the C-model.[29]

The flexibility of the AB-model makes it the most promising candidate in a number of applications.[30] Note also that it can be transformed into the version of the K-model with contemporaneous restrictions or of the C-model with long-run restrictions.

5.2.5 Dynamic analysis of SVAR models

To choose between the K, the C or the AB model and achieve its identification is, however, only the first step in SVAR analysis. The next step aims to estimate parameters of the chosen model. In this step, one should check whether all estimated parameters are statistically significant or not. If they are significant, their signs and magnitudes are economically plausible. In the case of over-identification, one should also make sure that over-identifying restrictions are accepted by the data.

If results from the estimation phrase are satisfactory, the final step is the dynamic simulation analysis carried out with techniques such as impulse response analysis and forecast error variance decomposition. Only at this step can one fully appreciate the overall working of a SVAR model.

As discussed in VAR modeling, Sims (1980) introduced the technique of impulse response analysis as a descriptive device representing the reaction of each

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[28] An empirical application is Blanchard and Watson (1986).

[29] See for example Blanchard and Quah (1989), Shapiro and Watson (1988), Balmaseda, et.al (2000).

[30] Examples are Bernanke (1986) and Blanchard (1989).

variable to a shock in each equation of the system. ‘In order to be able to see the distinct pattern of movement the system may display’, Sims (1980) argued that the shocks should be orthogonal.

However, the condition of orthogonality is never fulfilled in empirical applications. The operation to orthoganalize residuals of VAR is indispensable in this framework.

In the impulse response analysis of traditional VAR, there is no unique best way to achieve orthogonalization. If one chooses a method not explicitly based on economic theory, such as ‘Cholesky decomposition’, an incredible number of impulse response functions have to be analyzed.

Once a ‘structure’ is identified and estimated instead, only one structure is left for the variables in SVAR analysis. Consequently, we need to examine only n^2 impulse response functions (n impulse response functions for each of the n independent shocks).

Besides impulse response analysis, the forecast error variance decomposition (FEVD) technique, introduced also by Sims (1980) in his influencing paper, provides complementary information so that a better understanding of the relations between the variables of a VAR model can be obtained.

5.2.6 An assessment

In comparison with a-theoretical VAR methods, the SVAR approach provides an intuitive method of identifying macroeconomic shocks. Furthermore, it is much simpler to work with than traditional large scale macroeconomic models. The SVAR analysis is thus an important and useful tool.

The SVAR approach has become quite popular in empirical macroeconomics research in recent years. Besides the factors mentioned above, another reason may be that SVAR models fit rather well in with some recent wisdoms in macroeconomic theory. In addition, the SVAR approach takes advantage of modern developments in time series analysis.

Despite the rapid development of SVARs, this new approach has been criticized by different authors. Critics mainly attack identification in the SVAR approach and its robustness.

5.2.6.1 Problems in identification

Lippi and Reichlin (1993) criticize the Blanchard-Quah (1989) methodology by pointing out that a stationary VAR has an infinite manifold of different MA representations. Among all these possible representations, only one (the Wold or fundamental representation) has the property that the determinant of the MA polynomial has all its roots on or outside the unit circle. Non-fundamental representations, as argued by Lippi and Reichlin, in general can not be ruled out a prior. Particularly, non-fundamental representations can occur when the information space of the economic agents is different from the information space of the econometrician.

As a response to this critique, Blanchard and Quah (1993) admit that they do impose the somewhat arbitrary limitation to the fundamental representation but that it can not be considered less plausible than alternative non-fundamental representations. As a matter of fact, it is not possible to select the ‘correct’ representation on empirical grounds in most cases. Therefore it seems natural to select the most convenient one. According to the Blanchard-Quah methodology, a set of time series is decomposed formally into certain orthogonal shocks with some prespecified properties. It merely provides one admissible interpretation of the data which is generally not refutable so long as just identified structures are considered. Even if one confines oneself to the Wold representation, it is criticized further that the structural model does not need to be unique.

Another line of criticism concentrates on the use of long-run restrictions. Faust and Leeper show that in this case, additional assumptions on the short run dynamics are needed to enable reliable inference.[31] A natural remedy of this problem is to assume that the VAR has only finite lag order which is equivalent to assume that all higher autoregressive coefficients are equal to zero. As an alternative, one may assume that not only the long-run effect is zero but also the responses beyond a lag of, say, 40 periods vanish. This critique is surely important from a theoretical perspective. However, it is difficult to assess its relevance for

[31] An intuition behind this argument is that for a VAR with an infinite lag order, a small change of the model parameters has a cumulative effect on the long-run responses of the shocks.

empirical practice. Nevertheless, such kind of reasoning provides the message for practical work, which states that it may be hazardous to rely on long-run restrictions to identify the model, especially when the lag order of the VAR is large.

Finally, the problem is worth considering that the dimension of the empirical VAR is always smaller than the underlying dynamic system. As a result, the estimated shocks can only be estimated in an aggregated form. The crucial question in this case is, whether the estimated aggregated shocks show the same properties as the original shocks. In the case of the Blanchard-Quah model of two types of shocks (the demand and supply shock), for example, the question is then, whether it is possible to identify a 'joint' aggregated demand (supply) shock as a linear combination of only the original demand (supply) shocks, or whether the aggregated system mixes up both type of shocks.[32]

5.2.6.2 Issue of robustness

Recently, the SVAR approach is criticized for its lack of robustness under different structural assumptions. Uhlig puts the main point as follows: 'There is a danger here that we just get what we have stuck in, albeit a bit more polished and with numbers attached…'

However, when structural econometric models are based on prior information derived from economic theory, it is clear this kind of danger is always present. Nevertheless, a consensus seems to come into being that SVAR models are sensitive to alternative identifying assumptions and that results from an SVAR model are therefore 'unreliable' and 'fragile'.

It is also claimed that economic theory is not informative enough to achieve a unique SVAR specification. Therefore, the researcher is free to choose among a large number of possible specifications. In response to such criticism, different approaches are suggested to account for the uncertainty of model specification.

Although alternative approaches are suggested to overcome the lack of robustness in the SVAR analysis, it is however not clear, whether the claim for such kind of robustness is sensible. Since economic data are too uninformative about the underlying structure, prior information is usually necessary. Prior assumptions are therefore expected to be important for the analysis of economic data. Consequently, different assumptions may produce different results.

In a similar vein, we can not hope to be able to definitely refute economic theories by using a structural approach either. These methods should instead be seen as a more or less useful device to recover structures behind the data. That is to say, economic data is used to quantify prior beliefs about the economic system rather than to decide between alternative theories.

[32] Faust and Leeper (1997) derive conditions that guarantee the aggregated demand and supply shock to be separated reasonably. However, without knowledge of the complete dynamic process, the condition can not be verified.

Chapter 6 SVAR Analysis of German Labor Market

Sometimes it is hard to escape the thought that the single-minded focus on the labor market stems from the naïve belief that unemployment must be a defect in the labor market, as if the hole in a flat tire must always be on the bottom, because that is where the tire is flat.
Robert M. Solow

A large number of studies on German labor market have focused on the high persistence in the unemployment rate. In the extreme form of full hysteresis, past experience of high unemployment permanently raises the equilibrium unemployment rate. Statistically, full hysteresis means that the unemployment series is an I(1) process and shocks to the unemployment rate have a permanent effect.

The high persistence of unemployment relates to those factors that have a permanent or long-lasting effect on the natural rate, for example skill-biased technology shocks or wage rigidity.[1] In addition, a history of unemployment may itself generate sluggishness in unemployment. It might work through various channels: for example, skills gained during employment may erode during a period of unemployment, reducing the probability to become employed again. In line with this argument, the shock accounting and propagation literature adopts an aggregate perspective to analyze the labor market dynamics and hysteresis in unemployment. This approach is the so-called SVAR analysis.

Based on the discussion in previous chapters, now we try to shed light on the sources of labor market shocks and their propagation mechanism in German economy using SVAR methodology. Thanks to its properties, SVAR approach serves as an appropriate candidate in this framework. As illustrated previously, this method is especially well-suited to track the dynamics of a certain set of variables in view of the relative contribution of underlying shocks and their transmission effects.

6.1 Traditional labor markets modeling

[1] See Blanchard and Katz (1997).

It has become increasingly common in macroeconomics to model the determination of real wages and aggregate employment as the outcome of the interplay of an aggregate wage setting function with an aggregate price setting function. The wage setting relation describes the markup of wages over prices and the price setting relation the markup of prices over wages. The equilibrium corresponds to the level of unemployment for which these markups are consistent.

This analytical framework has some important advantages as compared to macro models in which labor market clears. First, it allows explicit determination of unemployment, in the sense of excess supply of labor. Second, the model deals explicitly with wage and price setting behavior, implying the abandonment of the mythical auctioneer in both the product and the labor market. Finally, the magnitude of changes in aggregate employment in response to demand and supply shocks is not closely tied to the elasticity of the labor supply function, as compared with market-clearing models. This is advantageous because explanations of large fluctuations in aggregate demand do not have to rely on the dubious assumption of a highly elastic supply of labor by the household sector.

Despite theses merits, such a framework needs also extensions and modifications to make it more appropriate to investigating the issue of high German unemployment rate: (1) in order to analyze the effects of product demand shocks, including monetary shocks, it is necessary to introduce the demand side in the product market more explicitly; (2) and most important, considering the unemployment persistence in Germany, it is necessary to introduce a hysteresis mechanism into the model, which will be analyzed here as the dependence of the wage setting relation on the previous development of aggregate employment or unemployment.

There has been a lot of empirical research on the causes of secular high unemployment in Germany. Most of the earlier empirical evidence comes from small econometric labor market models (with one or two equations), where many of the relevant variables (labor supply and productivity, in particular) are usually treated as exogenous. It is naturally exposed to the Sims (1980) critique.[2] Jacobson, Vredin and Warne (1997, 1998) point out that some of the variables

[2] See section 5.1.2.1 for more detail.

which are taken as exogenous in such models should be treated as endogenous. Furthermore, since we are interested in identifying the underlying shocks, such a simplification is not legitimate. In comparison with this modeling strategy, SVAR approach shows its strength in treating all variables in the system as endogenous.

6.2 SVAR analysis of unemployment: a review

SVAR analysis has gained its prevalence thanks to a number of merits. It lies somewhat between the two broad classes of empirical methodologies in the literature on unemployment: structural approach and time series analysis. Different from the structural approach which derives the equilibrium outcome from structural equations representing aggregate price and wage behavior, the SVAR model is identified through suitable assumptions on an unrestricted system rather than through restricted estimates of a two-equation system. Such a technique overcomes some of the difficulties traditionally faced when estimating small quasi-structural econometric models in line with the research summarized in Layard *et al.* (2005). More accurately, an important strength of SVAR method is that it circumvents the measurement difficulties in finding proxies for shocks and institutional changes and the arbitrariness of many of the usual identifying assumptions adopted in estimating structural price and wage equations.[3] As compared with pure time series analysis, the SVAR approach focused on several sources of shocks, attributing to each of them an explicit economic meaning. It allows us to recover the shocks which underlie the economy and disentangle them from the propagation and amplification mechanism working through the functioning of markets.

SVAR analysis, as a valid methodology to investigate the relevance of different shocks, is often based on long-run identifying restrictions as in Blanchard and Quah (1989). Blanchard and Quah analyzed the dynamic correlations of real output growth and the unemployment rate in U.S. and identified the effects of aggregate demand and supply shocks by making use of the standard neutrality restriction, which assumes that demand shocks do not affect the level of output in

[3] As Manning (1993) put it, measurement problems in the construction of many variables and dubious identification restrictions abound in this kind of modeling.

the long-run. In this line, several studies have extended the number of shocks in the system by enlarging the size of the VAR.

SVAR framework has been used to analyze labor markets in different countries. Improving on Blanchard and Quah (1989), Gamber and Joutz (1993) disentangled supply shocks into two further shocks (productivity and labor supply) to analyze shocks in U.S. economy. More accurately, they estimated a VAR model on real wage changes, real output growth and unemployment to identify a demand shock and two orthogonal supply shocks. Dolado and Jimeno (1997) investigated the sources of Spanish unemployment using a VAR in first differences. They found that unemployment is explained by a mixture of supply and demand shocks. Jacobson, Vredin and Warne (1997) used a common trends model to compare the labor markets of Scandinavian countries and concluded that the only common source of unemployment in Denmark, Norway and Sweden is shocks to wage setting. Balmaseda *et al.* (2000) extended the model of Gamber and Joutz (1993) to different OECD countries and allowing for identifying long-run restrictions derived from a theoretical model in an insider-outsider framework *à la* Blanchard and Summers (1986). Indeed, the insider-outsider bargaining framework is a more reasonable assumption when studying the functioning of labor markets in the OECD economies. Furthermore, such a modeling strategy has the advantage of not only encompassing the identification scheme of Gamber and Joutz when unemployment is stationary but also of nesting the case where unemployment has a unit root, which seemingly characterizes the high unemployment persistence in some European countries. Fabiani *et al.* (2000) found that most of the rise in Italian unemployment can be attributed to productivity shocks as well as labor supply shocks. Carstensen and Hansen (2000) analyzed West German labor market and found that unemployment is equally determined by technology and labor supply shocks in the long-run. Hansen and Warne (2001) concluded from their analysis that labor supply shocks are the primary source for unemployment in Denmark. Amisano and Serati (2003) found widespread hysteresis in four OECD countries and emphasized the role of the unions and their interaction with structural shocks and other institutions in resulting in hysteresis. Maidorn (2003) concluded that shocks of demand, productivity and labor supply are important factors in explaining Austrian unemployment. Gambetti and Pistoresi (2004) identify mark up and aggregate demand shocks as important determinants of unemployment development in Italy.

6.3 The theoretical framework

6.3.1 In comparison with previous work

As compared with previous SVAR analysis of labor markets, the theoretical framework in this work is novel in several aspects.

This work differs from that of Carstensen and Hansen (2000) in two important respects. At first, we follow the approach of Balmaseda *et al.* (2000) to achieve identification using long-run identifying restrictions as developed by Blanchard and Quah (1989), because it implies a smaller set of variables and avoids the somewhat arbitrary concept of a goods market equation. Secondly, we use data for unified Germany from 1991 onwards rather than West German data only. Over ten years after German unification it seems natural to use data for the whole economy even though this may imply some extra difficulties.

As mentioned above, the approach of Balmaseda *et al.* (2000) is the precursor of this empirical work. The analysis of Balmaseda *et al.* (2000) could indeed be regarded as a conjugation of the approach by Layard *et al.* (2005) with Blanchard and Quah's structural VAR methodology. They identify three structural shocks (aggregate demand shocks, productivity shocks and labor supply shocks) to explain the joint dynamic behavior of real output, real wages and the unemployment rate, which are key variables in the labor market modeling. Our work modifies that of Balmaseda *et al.* (2000) in two aspects. Firstly, Balmaseda *et al.* (2000) accept the hypothesis that unemployment rate is stationary, namely $u \sim I(0)$, favoring the partial-hysteresis interpretation (strong persistence). We assume in this work full-hysteresis of the unemployment rate, which is in line with the statistical characteristic of the series of German unemployment rate. Secondly, we extend the model of Balmaseda *et al.* (2000) to identify price shocks as one further structural shock in order to explore the possible effects of oil price shocks in the 1970s and mark-up shocks on unemployment. In short, our attention is focused on the responses of the unemployment rate, employment, real wages and the wage share to changes in certain shocks.

As is well known, the empirically detected non-stationarity property of German unemployment rate series seems to stand in contrast with any theory implying a constant ‘natural rate of unemployment’. It has led to theories that attempt to explain the time series properties by time-varying natural rate models, which have become popular in recent times. Such models have to explain theoretically why the natural rate follows a stochastic trend behavior.

Our framework provides another way to introduce non-stationarity of the unemployment rate on the theoretical level. It allows us to model the labor market explicitly including the possibility of long-run non-neutrality with respect to demand shocks within the insider-outsider framework. In this work, non-neutrality is introduced into the model because of the presence of full hysteresis. The economic idea behind is that within the full hystersis framework, the unemployed are completely excluded from any influence on the wage setting process. This means immediately that the labor market cannot be cleared because real wages are not allowed to fall. Therefore a very important neoclassical adjustment mechanism is not working at all. Under this identifying restriction, demand shocks surely have strong long-run effects on the unemployment rate.

The crucial point of this thesis is the role of macroeconomic shocks combined with hysteresis effects arising from institutions. This research differs from the current literature on the interactions between shocks and institutions.[4] Since the purpose is to obtain a deeper insight into the propagation of shocks and their persistence, a time series SVAR analysis on quarterly data is carried out. In comparison with Blanchard and Wolfers (2000) who use a panel data approach based on annual data, this approach is more data-instigated where shocks are identified based on their long-run properties and the data are left to say about the effects of these shocks and their relative importance to the variables being considered.

6.3.2 A stylized labor market model

Since economic theory tells more about long-run than contemporaneous relations, we prefer the long-run approach in our structural analysis of German labor

[4] Ljungqvist and Sargent (1998), Blanchard (1998a), Blanchard and Wolfers (2000) have attempted to analyze the role of interactions between shocks and institutions.

market. This preference is also supported by the finding of Keating (1992) that 'long-run structural VARs may yield theoretically predicted results more frequently than VARs identified with short-run restrictions.' It follows that the C-model is appropriate in our empirical work.

Table 6.1 The Theoretical Model

$y=ø(d-p)+a\theta$	(6.1)
$y=n+\theta$	(6.2)
$p=w-\theta+\mu$	(6.3)
$\tilde{l}=\alpha(w-p)-bu+\tau$	(6.4)
$w = w^{*} + \gamma_1\varepsilon_d + \gamma_2\varepsilon_p$	(6.5)
$w^{*}:n^{e}=\lambda\tilde{l}_{-1}+(1-\lambda)n_{-1}$	(6.6)
$u=\tilde{l}-n$	(6.7)
$\Delta d=\varepsilon_d$	(6.8)
$\Delta\theta=\varepsilon_s$	(6.9)
$\Delta\mu=\varepsilon_p$	(6.10)
$\Delta\tau=\varepsilon_l$	(6.11)

The model is quite stylized and contains a minimum of dynamics, as presented in Table 6.1. It is quite in line with the principle of SVARs with long-run restrictions, where model dynamics is determined through structural analysis. Disregarding constant terms, the model is described by following equations, where all variables but the unemployment rate are in logs and have standard economic meaning.[5]

$$y=ø(d-p)+a\theta \tag{6.1}$$

where y: the log of output

p: the log of price level.

[5] Small letters refer to logs except for u, whereas big letters refer to original time series.

Equation (6.1) is a simplified version of an aggregate demand function where $ø > 0$. θ is a proxy for productivity (technical progress and capital accumulation); (d-p) represents exogenous component of real aggregate demand (reflecting fiscal and monetary policies) with d being an index of nominal expenditure. According to this equation, aggregate demand is a function of the policy stance and productivity. Productivity is allowed to affect aggregate demand in that productivity affects permanent income and therefore consumption (e.g., through permanent income effects) and that technological innovations are incorporated into new capital.

$$y=n+\theta \qquad (6.2)$$

where n: the log of employment.

Equation (6.2) is a production function with constant return to scale (CRS) technology. Capital is given at any point of time, so firms are left to choose the amount of labor to hire.

$$p=w-\theta+\mu \qquad (6.3)$$

where w: the log of nominal wages.

Equation (6.3) represents a mark-up price setting rule in an imperfect competitive framework. In line with Bean (1994), the price is set by firms allowing for a non-zero mark-up on unit labor cost, with μ representing exogenous mark-up factors.

Further equations mean to characterize the supply side of the labor market.

$$\tilde{l}=\alpha(w-p)-bu+\tau \qquad (6.4)$$

where $\tilde{l}$: the log of the labor force

u: the unemployment rate

τ: exogenous factors influencing labor supply.

Equation (6.4) is a labor supply function which depends on real wages (w-p) and the unemployment rate u. Parameter α expresses the elasticity of labor supply;

while b captures the effects of unemployment on the labor supply decisions. There are two channels through which unemployment influences the labor supply. The discouragement effect implies a depressing effect of unemployment on the labor supply: long term unemployed become demoralized and withdraw from the labor force. The participation effect functions when the head of household loses his job and induces other household members to participate more in the labor force. If the discouragement effect dominates, b>0, and the labor force tends to reduce as unemployment increases; otherwise b<0. In addition, an exogenous labor supply term τ is taken into account, which represents institutional factors (working hours' regulations, retirement laws, etc.) and/or demographic factors (changes in population size and distribution, changes in participation rate, etc.).

$$w = w^* + \gamma_1\varepsilon_d + \gamma_2\varepsilon_p \qquad (6.5)$$

$$w^*: n^e=\lambda \tilde{l}_{-1}+(1-\lambda)n_{-1} \qquad (6.6)$$

where w^*: the log of targeted nominal wages

n^e: the expected value of (log) employment

ε_d: i.i.d. structural shocks to aggregate demand

ε_p: i.i.d. structural shocks to prices.

Equation (6.5) and (6.6) characterize the wage-setting behavior, where wages show both a backward looking component and a forward looking one. Following an insider-outsider framework proposed by Blanchard and Summers (1986), equation (6.6) indicates that targeted nominal wages w^* are chosen one period ahead to realize expected employment n^e, which is a weighted average of actual labor supply ($\tilde{l}_{-1}$, the insiders and outsiders) and actual employment (n_{-1}, the insiders).[6] Such a wage setting behavior no doubt contributes to the explanation of sluggishness in unemployment. In equation (6.5) effectively bargained wages are allowed to be partially indexed to price and demand surprises through the indexation coefficients γ_1, γ_2. If γ_1 and γ_2 are greater than zero, sudden changes in demand and prices will have an influence on wages. If $\gamma_i=0$ (i=1,2), there is no indexation; if $\gamma_i=1$ (i=1,2), indexation is complete.

[6] The insider-outsider model is the traditional framework for the analysis of hysteresis.

As is well known, the micro-foundations of equation (6.6) stem typically from an insider-outsider framework, which fits in well with the characteristic of labor markets in Germany. If $0 < \lambda < 1$, it leads to partial-hysteresis: the targeted nominal wages are set by unions in such a way that expected employment n^e is larger than employment in the previous period. If λ is close to 1, this can be identical with the assumption of high persistence. Both insiders (the employed workers) and outsiders (the unemployed) are allowed to influence wage setting. It corresponds to the assumption that the unemployment rate is an I(0) process (as in Balmaseda *et al.* (2000)). If $\lambda = 0$, full-hysteresis means that insiders set the wages at the level which guarantees that they stay employed. In this case, outsiders are excluded from the wage setting process. This assumption implies cutting a very important neoclassical equilibrating mechanism. The cut of the neoclassical equilibrating mechanism of having outsiders which can influence the wage setting is one way of introducing a high degree of non-neutrality into the model. As a result, demand shocks now have permanent effects on output, employment and thus on the unemployment rate.

$$u=\tilde{l}-n \tag{6.7}$$

Equation (6.7) is a definition of the unemployment rate. Recall that all variables are in logs, so $u \approx -\log(1-u) = -\log(N/L) = \tilde{l}-n$, where N, L are employment and the labor force.[7]

To close the model, stochastic processes governing the evolution of the exogenous factors are specified. For illustrative purposes, we assume that d, θ, μ and τ evolve as random walks. Note that we just need to assume that the exogenous factors are I(1) processes in general.[8]

$$\Delta d=\varepsilon_d \tag{6.8}$$

[7] Although the unemployment rate in Germany since the mid-1980s has been too high to guarantee this approximation (which requires that the unemployment rate is near zero), a more accurate expression would only make the model algebra much more complex whereas not change the conclusions significantly. Therefore we employ this approximation here.

[8] Assuming unit roots for exogeneous factors is sensible, which not only is in line with what has been done in many other studies but also accords with the statistical properties of the observable variables. See Appendix B for more about this.

$\Delta\theta=\varepsilon_s$ (6.9)

$\Delta\mu=\varepsilon_p$ (6.10)

$\Delta\tau=\varepsilon_l$ (6.11)

where ε_d, ε_s, ε_p and ε_l are i.i.d. shocks to aggregate demand, productivity, price and labor supply.

This theoretical framework is used to obtain identifying restrictions for the structural VAR analysis. According to restrictions to be derived later, we use the series of the wage share, real wages, employment and the unemployment rate to explore the effects of various structural shocks.

6.3.3 Insider-outsider effects in wage formation

Since insider-outsider dynamics in wage determination is central to unemployment hysteresis in our theoretical framework, it is meaningful to investigate this theory in more detail.

The core of the insider-outsider theory is the interest conflict between insiders whose positions are protected by labor turnover costs and outsiders lack of such protections in the labor market.[9] This theory is associated not only with how various types of labor turnover costs make insiders to be able to push up their wages and how insiders' activities affect outsiders, but also with macroeconomic implications of such insider-outsider interaction especially those concerning employment and unemployment dynamics.

The crucial point of the insider-outsider theory is insider market power whose microeconomic rationale is the existence of labor turnover costs. Firms face costs associated with dismissing incumbent employees and hiring/training new recruits. Two groups of labor turnover costs can be identified: those must be expended in order to make outsiders productive, also 'production-related' costs; those resulting from insiders' rent-seeking activities, so-called 'rent-related' costs. Although the production-related costs may be considered necessary for the production process, the rent-related costs come into being due to wasteful redistributive battles between insiders and outsiders.

[9] There are indeed many degrees of insiders and outsiders. The notion of homogenous 'insiders' and 'outsiders' in economic modeling is only for expositional and analytical simplicity.

Due to labor turnover costs, firm may prefer to retain the current workforce even when the insider wage is significantly above the reservation wage of outsiders. In addition to these hiring, training and firing costs, labor turn costs also include costs associated with insiders' attempts to resist wage competition from outsiders by refusing to cooperate with them or harassing them. Trade unions could play an important role in maintaining the replacement costs at a high level.

The insider-outsider theory has also important implications for the analysis of employment and unemployment dynamics. Insider-outsider models show how the surviving insiders (after a temporary downward shock), seeing their marginal productivity as increased, could force up wages without pushing up the original probability of losing job. This blocks the recovery process certainly. The dynamic implications cover the behavior of the firms, the insiders and the outsiders facing labor turnover costs.

The dynamic behavior of insiders can be demonstrated in the wage negotiation process. The insider-outsider explanation of unemployment hysteresis traced back to Blanchard and Summers (1986) and Gottfries and Horn (1987). Two basic assumptions underlie these papers. Firstly, wage setting is dominated by insiders who are currently or recently employed workers. Secondly, insiders are not replaced by outsiders. Hysteresis comes into being because the optimal insider-wage depends on the number of insiders, which in turn depends on past employment. Shocks that reduce the number of insiders in this period raise the optimal insider-wage in subsequent periods. If insider membership equals employment, employment may follow a unit root process (Blanchard and Summers (1986)).

They argue that a negative productivity shock leads firm to fire some of their insiders, and thereby raises the expected job security of the remaining insiders. In response, insiders raise their wages and consequently discourage future employment. Unemployment persistence or hystereisis arises as the consequence. This mechanism is combined with the view that the insider wage may depend inversely on the size of the insider workforce in the case of diminishing returns to labor. In this way, a negative productivity shock leading to a current contraction of the insider workforce implies also a rise in marginal product of labor. When the original shock has disappeared, the smaller insider workforce associated with a higher marginal product of labor than before will achieve a high negotiated wage and thus discourage employment in the future.[10]

Although quite a lot of insider-outsider literature has focused on the role of insiders, the dynamic behavior of outsiders should in no way be neglected. It is generally accepted that workers' skills improve during employment and they deteriorate during unemployment. Since firms hesitate to employ unskilled workers, unemployment persistence (or hysteresis) comes into being. Unemployment persistence also results from the fact that the unemployed (particularly long-term unemployed) workers are stigmatized by firms. Finally, if outsiders' effort to search jobs falls with their duration of unemployment, current unemployment also implies future unemployment.

Since the outsider's deterioration of human capital, firms' stigmatization and depressed job search from outsiders become more pronounced as the duration of unemployment prolongs, unemployed outsiders lose their abilities to compete with insiders with the passage of time. If long-term unemployment accounts for a significant proportion of total unemployment, unemployed outsiders as a whole would be ineffective at competing for jobs. Strong persistence (even hysteresis) in unemployment would arise.

Note that the insider-outsider theory does not insist that wages are influenced only by insiders. Even in the case of hystereis when outsiders are totally disenfranchised from the wage bargaining, they do in general affect insider wages via their influence on the insiders' retention probability for given insider wages and the outside opportunities of insiders. Although outsiders do not affect wage formation directly, they do have an indirect influence.

6.4 Empirical analysis of the theoretical model

The analysis is based on a structural Vector AutoRegressive model for the four variables in the theoretical framework. The SVAR model allows for richer short-run dynamics, whereas its long-run behavior can be consistent with that of the theoretical model. The empirical work is implemented by using the standard econometrics package Eviews 4.1.

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[10] These arguments have limitations. See Lindbeck and Snower (1994).

6.4.1 Preliminary data analysis

6.4.1.1 Data

Quarterly, seasonally adjusted German data from 1970:1 till 2001:2 are used for the empirical estimation.[11] The data come from DIW (Deutsches Institut für Wirtschaftsforschung) database (which is based on reports of Statistisches Bundesamt and German Bundesbank) and author's calculation. All VGR-data are of the ESVG 95 basis.

Prior to 1970, there was only negligible unemployment in Germany. Unemployment has become a major problem in Germany since the early 1970s. Therefore, we choose to use the data from 1970. From 1970:1 to 1990:4, the data refer to West Germany; from 1991:1 onwards, they refer to reunified Germany.

Real output Y is given by real GDP, price P is given by GDP deflator, wages W are given by the compensation of employees from German national accounts and divided by the number of employees; employment N is given by employees in total employment; the unemployment rate u is calculated as percentage of the sum of employees and unemployed.

The time series used in the empirical analysis are shown in Figure 6.1. A detailed description on how the series have been constructed is given in Appendix C.

6.4.1.2 Time series characteristics of the data

The specification of VAR model, its identification and the precision of the estimates rely to a large extent on maintained assumptions of the statistical properties of the variables of interest. Therefore, a clear understanding of the statistical properties of the data is of primary importance for the purpose of conducting proper inferences and deriving meaningful economic interpretations.

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[11] The end of sample period is 2001:2 because the time series of German unemployment rate shows structural break since mid-2001. For details see Franz (2003).

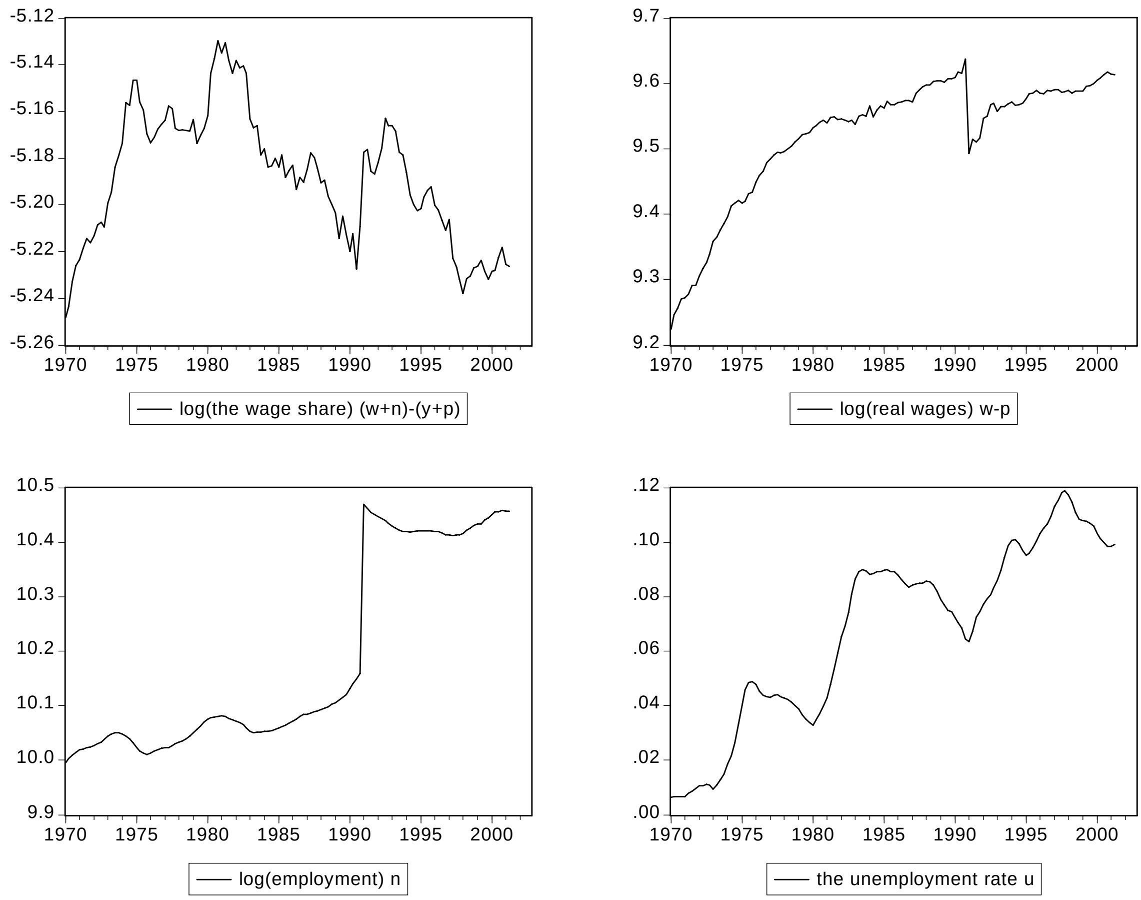

Figure 6.1 The Data Series

For this reason, the first step of empirical analysis is to investigate the integration properties of the time series. With respect to unit root tests, the traditional ADF tests are often criticized as being not powerful. Balmaseda *et al.* (2000) thus prefer to use Johansen's FIML procedure which is assumed to be more powerful than standard univariate unit root tests. However, all these tests are based on the assumption that there is no structural break in the data. Due to German unification, such tests are not appropriate for German data. Therefore, Perron (1989) unit root test is applied to take the structural break into account. It is indeed the empirical novelty of this work. In addition, seasonally adjusted data tend to bias unit root tests against rejecting the null hypothesis of a unit root (see Baltagi (2002)). Therefore, seasonally unadjusted data are used for the purpose of unit root tests.

In performing unit root tests, standard test statistics are biased toward the nonrejection of a unit root when there are structural breaks in the data. Perron criticized the traditional unit root tests and developed a formal procedure to test for unit roots in the presence of a structural change.

The implementation of Perron's technique consists of two steps:

1. Eliminate deterministic terms from the time series according to model A, B or C.
2. Apply Augmented Dickey-Fuller (ADF) test to the residuals from the above regression.

The calculated t-statistic can be compared to the critical values provided by Perron, which depend on time of the structural break.[12] If t-statistic is greater than the critical value, the null hypothesis of a unit root cannot be rejected. More details about Perron test are provided in Appendix D.

Perron considered three different models to eliminate deterministic terms from the time series. The selection of model A, B or C is based on both visual inspection of the time series and economic theory. As shown in Figure 6.1, real wages and employment series exhibit a clear level shift due to German unification. With respect to the unemployment rate series, a strong upward trend can be observed since 1990. A level shift is not as obvious as in the series of real wages and employment. The wage share series also shows a level shift and appears to trend downward since 1990.

For the unit root test, model A from Perron (1989) is appropriate for the series of real wages and employment, as it allows for a level shift. Regarding the unemployment rate and the wage share series, the most general specification model C is considered initially since it allows for a break in both the trend and the constant. Since a level shift in the unemployment rate series is insignificant according to Perron test, model B is chose to detrend this time series. The results of unit root tests are given in Table 6.2.

It can be seen from Table 6.2 that the time series of the wage share, real wages and employment are non-stationary. Unit root tests on these variables in first differences show that they are stationary. Therefore, it can be concluded that the wage share ((w+n)-(y+p)), real wages (w-p) and employment n are all I(1) process.

Table 6.2 Unit Root Tests

variable	detrending model	lags	t-statistic	5% critical value
(y+p)-(w+n)	C	1,2,4,5,7	-3.03	
Δ(y+p)-Δ(w+n)			-11.79	-4.18
w-p	A	1,4,5,8	-3.16	
Δ(w-p)		1-3,5	-3.86	-3.80
n	A	1,4,5	-3.32	
Δn		4	-6.47	-3.80
u	B	1,2,4-6	-3.41	
Δu		3,4	-5.72	-3.89

Note: Critical values are from Perron (1989) and Perron and Vogelsang (1993).

As respect to the time series characteristics of German unemployment rate, there have been a lot of discussions. Many authors came to the conclusion that the unemployment rate in Germany is non-stationary, although it seems not quite consistent with standard economic theory.

Table 6.2 indicates that unit root test on unemployment series does not reject the null hypothesis of a unit root for the level variable. Regarding the variable in first differences, non-stationary hypothesis should be rejected. Thus the series of the unemployment rate is shown statistically to be an I(1) process.

Although economic theory implies that the unemployment rate is stationary, empirical evidence shows that German unemployment rate is I(1). According to econometric tests for stationary, non-stationary of the unemployment rate represents just the most striking feature of this time series. The same evidence is also found for some other west European countries. In fact, this remains an issue

[12] The critical values in Table V.A and V.B in the original paper from Perron (1989) are false. The corrected tables are given in Perron and Vogelsang (1993).

of controversy (see Lindbeck and Snower (2002)). Given that unit root tests generally cannot distinguish between integrated and highly autocorrelated series, the results of such tests are never taken at face value, but should rather be interpreted according to our understanding of German economy. Considering hysteresis effects discussed above, we adopt the assumption that the unemployment rate u is I(1). This assumption is reasonable, at least as a local approximation for the period and the economy at hand.[13]

6.4.2 Estimation of the reduced form VAR

6.4.2.1 Partial hysteresis or full hysteresis

Based on the small labor market model discussed in section 6.3.1, variables of interest, namely the wage share, real wages, employment and the unemployment rate, can be expressed purely by orthogonal shocks to aggregate demand, productivity, price and labor supply. As regards the solution of the model, the assumption of partial hysteresis or full hysteresis plays a crucial role.

Solving equations (6.1)-(6.11) for the unemployment rate, we get

$$(1-\rho L)\ u = (1+b)^{-1}\{[ø(1+\gamma_2) - \alpha]\varepsilon_p + (1+ \alpha - ø - a)\varepsilon_s - ø(1- \gamma_1)\varepsilon_d + \varepsilon_l\} \qquad (6.12)$$

where L: lag operator

$\rho = (1+b- \lambda)/(1+b)$.

Thus, persistence of the unemployment rate (ρ) is an increasing function of both the net discouragement effect b (with the assumption that discouragement effect dominates participation effect) and the influence of lagged employment on wage determination ($1-\lambda$). Note that, for finite b, $\rho=1$ is equivalent to $\lambda = 0$. Therefore, full hysteresis hypothesis means immediately that the unemployment rate is an I(1) variable.

There are two possible solutions. First, we can assume partial hysteresis with $0<\lambda<1$. Both insiders and outsiders are allowed to influence wage setting. This is

[13] The assumption of a unit root should not necessarily be understood as a ‘true’ description of the underlying data generating process.

the assumption by Balmaseda *et al.* (2000) for German labor market. In this case, the unemployment rate u is an I(0) process.

However, from statistical analysis of the series of German unemployment rate in section 6.4.1.2, the hypothesis of a unit root cannot be rejected. Thus the unemployment rate should be characterized by an I(1) process. This legitimates full hysteresis hypothesis. With λ=0, wage setters care only about insiders in the wage bargaining. In other words, outsiders are completely excluded from the wage setting process. This assumption is identical with the cut of a very important neoclassical equilibrating mechanism. Cutting the neoclassical equilibrating mechanism which means that outsiders can influence the wage setting is one way of introducing a high degree of non-neutrality into the model. Indeed, demand shocks now have permanent effects on output.

Under full hysteresis hypothesis ($\lambda = 0$), equation (6.6) is simplified as:

$$w^*: n^e = n_{-1} \qquad (6.13)$$

To solve the model under this assumption, just replace equation (6.6) with equation (6.13).[14] The variables in the system (the wage share, real wages, employment and the unemployment rate) can be expressed purely by structural shocks as follows:

$$\Delta(y+p)-\Delta(w+n) = \varepsilon_p \qquad (6.14)$$

$$\Delta(w-p) = -\varepsilon_p + \varepsilon_s \qquad (6.15)$$

$$\Delta n = -ø(1+\gamma_2)\varepsilon_p + (ø+a-1)\varepsilon_s + ø(1-\gamma_1)\varepsilon_d \qquad (6.16)$$

$$\Delta u = (1+b)^{-1}\{[ø(1+\gamma_2) - \alpha]\varepsilon_p + (1+\alpha - ø - a)\varepsilon_s - ø(1-\gamma_1)\varepsilon_d + \varepsilon_l\} \qquad (6.17)$$

This set of equations can be formulated in more compact matrix form:

$$\begin{pmatrix} \Delta(y+p)-\Delta(w+n) \\ \Delta(w-p) \\ \Delta n \\ \Delta u \end{pmatrix} = \begin{pmatrix} * & 0 & 0 & 0 \\ * & * & 0 & 0 \\ * & * & * & 0 \\ * & * & * & * \end{pmatrix} \begin{pmatrix} \varepsilon_p \\ \varepsilon_s \\ \varepsilon_d \\ \varepsilon_l \end{pmatrix} \qquad (6.18)$$

[14] For details of the model solution, see Appendix E.

6.4.2.2 The reduced form VAR

It has been illustrated in the discussion of structural VAR methodology that estimation of reduced form residuals is the prerequisite for SVAR analysis. Therefore, to estimate the reduced form VAR properly is crucial for further structural analysis.

As mentioned in section 5.2.3, if the data series are stationary, structural VARs are usually estimated in levels; whereas differenced series are used if the variables are non-stationary.[15]

Data analysis in section 6.4.1.2 shows that all the variables of interest should be characterized by a stochastic process with a unit root. Therefore, a VAR in first differences is appropriate. In order to identify the four structural shocks defined above, we consider the following VAR model, where deterministic trends have been omitted for simplicity

$$A(L)\Delta X_t=e_t \tag{6.19}$$

where X_t: a 4 * 1 vector of variables including (y+p)-(w+n), w-p, n and u;

e_t: a vector of zero-mean i.i.d. innovations with covariance matrix $\sum$.

Since all variables in a VAR model are viewed as endogenous, variable exogeneity test should at first be carried out to check whether this starting point is appropriate. Pairwise Granger Causality tests show that no variable in this 4-dimensional VAR should be regarded as exogenous.

[15] See also footnote 16 in chapter 5.

Table 6.3 Granger Causality Tests

VAR Pairwise Granger Causality/Block Exogeneity Wald Tests
Sample: 1970:1 2002:4
Included observations: 120

Dependent variable: Δ(y+p)-Δ(w+n)

Exclude	Chi-sq	df	Prob.
Δ(w-p)	13.38004	5	0.0201
Δn	12.28912	5	0.0310
Δu	7.625162	5	0.1781
All	63.22205	15	0.0000

Dependent variable: Δ(w-p)

Exclude	Chi-sq	df	Prob.
Δ(y+p)-Δ(w+n)	11.91177	5	0.0360
Δn	42.75391	5	0.0000
Δu	4.616514	5	0.4644
All	81.60473	15	0.0000

Dependent variable: Δn

Exclude	Chi-sq	df	Prob.
Δ(y+p)-Δ(w+n)	26.68685	5	0.0001
Δ(w-p)	13.72784	5	0.0174
Δu	192.4084	5	0.0000
All	352.8787	15	0.0000

Dependent variable: Δu

Exclude	Chi-sq	df	Prob.
Δ(y+p)-Δ(w+n)	17.94052	5	0.0030
Δ(w-p)	7.450631	5	0.1892
Δn	14.35362	5	0.0135
All	63.48563	15	0.0000

It is very important to use enough lags when estimating a VAR, in order to eliminate series correlations in the estimated residuals. So the next task is to decide the lag length of model (6.19). Various tests of lag length are considered for this purpose. LR (sequential modified LD test statistic), FPE (Final Prediction Error), AIC (Akaike Information Criteria) and HQ (Hannan-Quinn information) suggest a lag length of 5; whereas SC (Schwarz information criterion) prefers only 2 lags. In line with the general-to-specific principle of modeling, all lags which may be significant should go into the VAR at the start in order to avoid the loss of information. Those lags, which are shown to be insignificant, will be eliminated later. So VAR (6.19) was estimated with 5 lags at first.

To avoid over-parameterization, insignificant lags should be excluded form VAR models.[16] Lag exclusion tests (Wald tests) indicated that all 5 lags were significant (see Appendix F). Thus VAR (6.19) should have 5 lags.

To take German unification into account, an impulse dummy also enters the model which is one in the first quarter of 1991 and zero elsewhere.

6.4.3 Identification and structural analysis

In this section, we derive identifying restrictions from the theoretical model. Based on estimates of the identified model, analysis of impulse response functions and forecast error variance decompositions for the variables in the system can be carried out. These techniques help to describe the dynamic characteristics of the system in response to structural disturbances.

Based on estimates of the just-identified structural VAR, we impose further restrictions by letting insignificant parameters to be zero. Since over-identifying restrictions cannot be rejected, it enables us to compare both alternatives (just-identified SVAR and over-identified SVAR) and to test the robustness of the model.

6.4.3.1 Identifying restrictions

[16] See the discussion in section 5.2.3.

To recover the structural shocks from estimated residuals of the reduced from VAR, residuals e_t are expressed as linear combinations of the structural disturbances ε_t:

$$e_t = \tilde{C}\,\varepsilon_t \tag{6.20}$$

where $\tilde{C}$: an invertible (4×4) mapping matrix.

This modeling framework corresponds to the C-model as presented by Amisano and Giannini (1997). From previous discussion about SVARs, we know that at least 6 restrictions are needed to identify the 16 elements in $\tilde{C}$.

The required restrictions can be obtained from the theoretical model above. In line with Blanchard and Quah (1989) and Balmaseda *et al.* (2000), structural information contained in equations (6.14)-(6.17) is used to formulate long-run restrictions. As usual, if the jth shock does not appear in one of the above equations, for example, the equation for the ith variable, it leads to the assumption that the coefficients representing the impulse response function of the ith variable (in differences) with respect to the jth shock, sum up to zero over all lags. That means the entry of the ith row and the jth column of the matrix of long-run multipliers is zero. Therefore, the jth shock does not have a permanent influence on the level of the ith variable.

Thus, to achieve just-identification, following long-run exclusion restrictions can be derived:

1. Productivity shocks ε_s have no permanent effect on the wage share –((y+p)-w+n)).

2-3. Demand shocks ε_d have no permanent effect on the wage share –((y+p)-(w+n)) and real wages (w-p).

4-6. Labor supply shocks ε_l do not affect the wage share –((y+p)-(w+n)), real wages (w-p) and employment n in the long-run.

The long-run solution of the model is then

$$\begin{pmatrix} (y+p)-(w+n) \\ (w-p) \\ n \\ u \end{pmatrix} = \begin{pmatrix} C(1,1) & 0 & 0 & 0 \\ C(2,1) & C(2,2) & 0 & 0 \\ C(3,1) & C(3,2) & C(3,3) & 0 \\ C(4,1) & C(4,2) & C(4,3) & C(4,4) \end{pmatrix} \begin{pmatrix} \varepsilon_p \\ \varepsilon_s \\ \varepsilon_d \\ \varepsilon_l \end{pmatrix} \tag{6.21}$$

where $\begin{pmatrix} C(1,1) & 0 & 0 & 0 \\ C(2,1) & C(2,2) & 0 & 0 \\ C(3,1) & C(3,2) & C(3,3) & 0 \\ C(4,1) & C(4,2) & C(4,3) & C(4,4) \end{pmatrix}$ is the long-run multiplier matrix.

With 6 long-run restrictions on the matrix of long-run multipliers, structural VAR can be identified. Estimates of the long-run multiplier matrix under just-identification are given by Table 6.4.

Table 6.4 Long-run Response of the Just-identified SVAR

Structural VAR Estimates
Sample(adjusted): 1971:3 2001:2
Included observations: 120 after adjusting endpoints
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 12 iterations
Structural VAR is just-identified

Restriction Type: long-run pattern matrix
Long-run response pattern:

C(1,1)	0	0	0
C(2,1)	C(2,2)	0	0
C(3,1)	C(3,2)	C(3,3)	0
C(4,1)	C(4,2)	C(4,3)	C(4,4)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1,1)	0.006392	0.000413	15.49193	0.0000
C(2,1)	-0.009901	0.000758	-13.05758	0.0000
C(3,1)	-5.91E-05	0.000767	-0.077000	0.9386
C(4,1)	-4.62E-05	0.000500	-0.092431	0.9264
C(2,2)	0.004470	0.000289	15.49193	0.0000
C(3,2)	-0.001189	0.000764	-1.557233	0.1194
C(4,2)	0.001034	0.000495	2.086814	0.0369
C(3,3)	0.008323	0.000537	15.49193	0.0000
C(4,3)	-0.005273	0.000354	-14.91149	0.0000
C(4,4)	0.001050	6.78E-05	15.49193	0.0000

Given that some coefficients are not significant at the 5% significance level, applying certain model reduction can be useful in this case. Further restrictions on the long-run multiplier matrix are imposed by sequentially setting the insignificant parameters to be zero. These over-identifying restrictions can then be tested via LR test.

Imposing zero restrictions on parameters C(3,1) and C(4,1) in the long-run multiplier matrix, Table 6.5 shows results acquired under over-identification:

Table 6.5 Long-run Response of the Over-identified SVAR with 2 Over-identifying Restrictions

Structural VAR Estimates
Sample(adjusted): 1971:3 2001:2
Included observations: 120 after adjusting endpoints
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 12 iterations
Structural VAR is over-identified (2 degrees of freedom)

Restriction Type: long-run pattern matrix
Long-run response pattern:

C(1,1)	0	0	0
C(2,1)	C(2,2)	0	0
0	C(3,2)	C(3,3)	0
0	C(4,2)	C(4,3)	C(4,4)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1,1)	0.006392	0.000413	15.49193	0.0000
C(2,1)	-0.009818	0.000744	-13.18882	0.0000
C(2,2)	0.004470	0.000289	15.49193	0.0000
C(3,2)	-0.001188	0.000764	-1.555547	0.1198
C(4,2)	0.001034	0.000495	2.088091	0.0368
C(3,3)	0.008323	0.000537	15.49193	0.0000
C(4,3)	-0.005273	0.000354	-14.90828	0.0000
C(4,4)	0.001053	6.80E-05	15.49193	0.0000
LR test for over-identification:				
Chi-square(2)	0.719676		Probability	0.6978

According to LR test, the over-identifying restrictions cannot be rejected at the 5% significance level.

Letting further C(3,2)=0, estimates the matrix of long-run multiplier with 3 over-identifying restrictions are:

Table 6.6 Long-run Response of the Over-identified SVAR with 3 Over-identifying Restrictions

Structural VAR Estimates
Sample(adjusted): 1971:3 2001:2
Included observations: 120 after adjusting endpoints
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 12 iterations
Structural VAR is over-identified (3 degrees of freedom)

Restriction Type: long-run pattern matrix
Long-run response pattern:

C(1,1)	0	0	0
C(2,1)	C(2,2)	0	0
0	0	C(3,3)	0
0	C(4,2)	C(4,3)	C(4,4)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1,1)	0.006392	0.000413	15.49193	0.0000
C(2,1)	-0.009812	0.000746	-13.15225	0.0000
C(2,2)	0.004471	0.000289	15.49193	0.0000
C(4,2)	0.000282	9.79E-05	2.881043	0.0040
C(3,3)	0.008408	0.000543	15.49193	0.0000
C(4,3)	-0.005326	0.000357	-14.91933	0.0000
C(4,4)	0.001053	6.80E-05	15.49193	0.0000

LR test for over-identification:

Chi-square(3)	3.139040	Probability	0.3707

LR test showed again that these 3 over-identifying restrictions cannot be rejected at the 5% significant level.

The above 3 over-identifying restrictions imply that price shocks do not affect employment and unemployment; productivity shocks do not influence employment in the long run.

For notational simplicity, this alternative of SVAR with 3 over-identifying restrictions is called SVAR2, whereas that of just-identification is called SVAR1. It can be seen that the coefficients of these two identifications are quite similar. Therefore, estimates of the model’s long-run response are robust.

In the following structural analysis, impulse response analysis and forecast error variance decompositions will be operated on both just-identified (SVAR1) and over-identified (SVAR2) version. Empirical results from these two alternatives can be compared to see whether they are robust.

6.4.3.2 Impulse response analysis

As discussed in Chapter 5, the impulse response analysis is an important device to display the model dynamics by tracing out reactions of each variable to structural shocks. Structural shocks here are represented by impulses, which are one-time.

6.4.3.2.1 The just-identified case SVAR1

The impulse responses of the unemployment rate to different structural shocks are given in Figure 6.2.

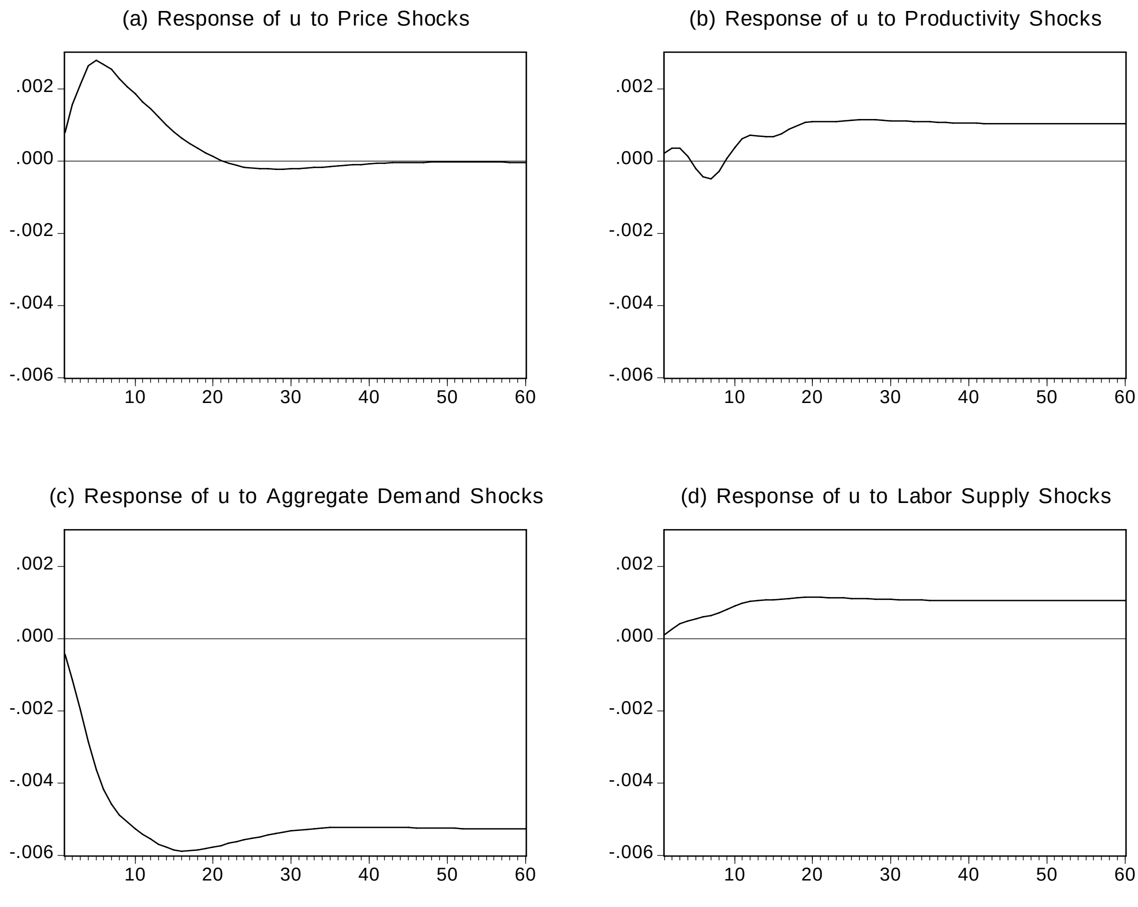

Figure 6.2 Impulse Responses of the Unemployment Rate u in SVAR1

According to Panel (a) in Figure 6.2, price shocks (for example from increased prices for imported inputs or higher mark-up) quite immediately increase the unemployment rate. Apparently, increased prices translate into higher costs so that firms adjust labor demand accordingly. This can also be seen from impulse responses of employment in Figure 6.5. After about 5 quarters, price shocks show their strongest effect. After that, the effect of price shocks dies out gradually and the unemployment rate reaches its pre-shock level in the long-run. It appears that price shocks are a crucial factor for the rise in unemployment, because unemployment rises immediately and doesn't return to its pre-shock level within 6 years. For this reason price shocks should not be neglected in any attempt to explain increased unemployment in Germany, at least in the short and medium-run. Dolado and Jimeno (1997) found instead that price shocks increase unemployment even in the long run. Gambetti and Pistorest (2004) also drew the conclusion that mark-up shocks increase unemployment in the long run.

Panel (b) in Figure 6.2 illustrates the response of the unemployment rate to productivity shocks. Positive productivity shocks increase unemployment immediately, though not significantly. The favorable effect of positive productivity shocks in decreasing unemployment is only short-lived and the impact becomes negative after 3 quarters.[17] After about 7 quarters, unemployment begins to rise again. Although unemployment reaches a new equilibrium in the long run which is higher than the pre-shock equilibrium, this effect is not significant. It can also be supported by estimates of long-run response pattern (according to Table 6.4, the long-run effect of productivity shocks on unemployment is significant at 3.69% level). Positive shocks on productivity seem to increase the unemployment rate to some extent, which supports more or less the 'technological bias explanation of unemployment'. Since the demand of new (skilled) workers does not compensate the number of unskilled workers that are unemployed due to the innovation process, skill biased technological progress increases the unemployment rate.[18]

The effects of technology shocks on economic fluctuations have been much discussed in the recent VAR literature. Dolado and Jimeno (1997) found technology shocks to increase unemployment for Spain. Balsameda *et al.* (2000) concluded that 'technological bias explanation of unemployment' is a short-run

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[17] In our insider-outsider framework where wage bargaining aims to maximize merely insider's utility, potentially favorable effects on unemployment of technological shocks are partially dissipated by the increase in real wages, see IRF of real wages to productivity shocks (Figure 6.4 (b) and Figure 6.8 (b)).

[18] The conclusion of an increase in unemployment in response to a positive technology shock has existed in a number of earlier VAR papers. See, for example, Blanchard (1989), Blanchard and Quah (1989).

phenomenon for 16 OECD countries.[19] Galí (1999) ascertained a significant and persistent decline in hours after positive technology shocks for the G-7 countries (Japan is an exception). Galí (2004) analyzed the euro area as a whole. Galí and Rabanal (2004) drew the same conclusion for U.S. data despite the finding that hours eventually return to their original level. Amisano and Serati (2003) did not find any significant effect of technology shocks on unemployment both in the short run and in the medium-long run. Francis and Ramey (2003) extended Galí (1999) and had similar results. Francis and Ramey (2004) used long-term U.S. annual time series from the late nineteenth century. Basu *et al.* (2004) found a sharp decline in inputs after technology improvements in the short-run as well despite the use of an unrelated approach. Gambetti and Pistoresi (2004) concluded that technology shocks do not significantly affect Italian unemployment in the long run. For German data, Carstensen and Hansen (2000) ascertained a decline in unemployment following positive technology shocks for West Germany. Linzert (2001) found technology shocks to decrease unemployment in the short-run without long run impact. Fritsche and Logeay (2002) concluded that productivity shocks lower probably unemployment to only a limited extent. Brüggemann (2005) found that a technology shock drives unemployment down whereas this effect is only border-line significant in the long run. In fact, the theoretical and empirical literature on the impact of productivity shocks on unemployment remains puzzling. Further evidence will be derived from impulse response analysis of the over-identified model.

Panel (c) in Figure 6.2 shows that aggregate demand shocks lower the unemployment rate sizably not only in the short and medium-run, but also in the long-run. After about 4 years, unemployment reaches its lowest level and since then increases a little. Since the new equilibrium is apparently lower than the pre-shock level, demand shocks do have a long-run decreasing effect on the unemployment rate. However, Balsameda *et al.* (2000) based their analysis on partial hysteresis assumption and draw the conclusion that the unemployment rate decreases after demand shocks only in the short and medium-run. The finding of a permanent demand effect in our work reflects full hysteresis assumption in the theoretical framework. As mentioned above, cutting an important neo-classical

[19] It is not surprising because Balsameda et al. (2000) assume that the unemployment rate is stationary.

equilibrating mechanism introduces non-neutrality in the model. It follows that demand shocks now have even a long-run effect on output and thus on the unemployment rate.

Finally, as shown in Panel (d), the unemployment rate increases gradually after positive shocks to labor supply. After about 18 quarters, it reaches its new equilibrium which is higher than the pre-shock equilibrium. Thus, labor supply shocks have a permanent effect on the unemployment rate, which is consistent with the findings of Dolado and Jimeno (1997) as well as Carstensen and Hansen (2000). Balsameda *et al.* (2000) concluded instead that labor supply does not affect unemployment permanently.

In short, impulse responses concerning reaction of the unemployment rate are consistent with economic theory and allow a plausible interpretation. From this analysis, shocks to productivity, aggregate demand and labor supply seem to be crucial factors explaining unemployment, while price shocks affect unemployment only in the short and medium-run. This is also proved by estimates of the long-run multiple matrix in Table 6.4, where the long-run effect of price shocks on the unemployment rate is not significant at all.

Figure 6.3-6.5 give impulse responses of inverse of the wage share ((y+p)-(w+n)), real wages (w-p) and employment n, respectively.

Figure 6.3 shows impulse responses of the inverse of the wage share and thus should be interpreted by its mirror image. With positive price shocks, the wage share decreases gradually and reaches its new equilibrium after about 8 years. Productivity shocks decrease the wage share on impact and after that the wage share rises gradually. It rises further till about 10 quarters, exceeding its pre-shock level. Since then the wage share decreases again and comes back to its pre-shock equilibrium in about 7 years. Shocks on productivity do not influence the wage share in the long-run since they enter labor productivity and real wages equally. Aggregate demand shocks decrease the wage share significantly in the short-run and this decreasing effect diminishes gradually. In the long-run, the wage share turns back to its pre-shock level. At last, shocks on labor supply seem to influence the wage share neither in the short-run nor in the long-run.

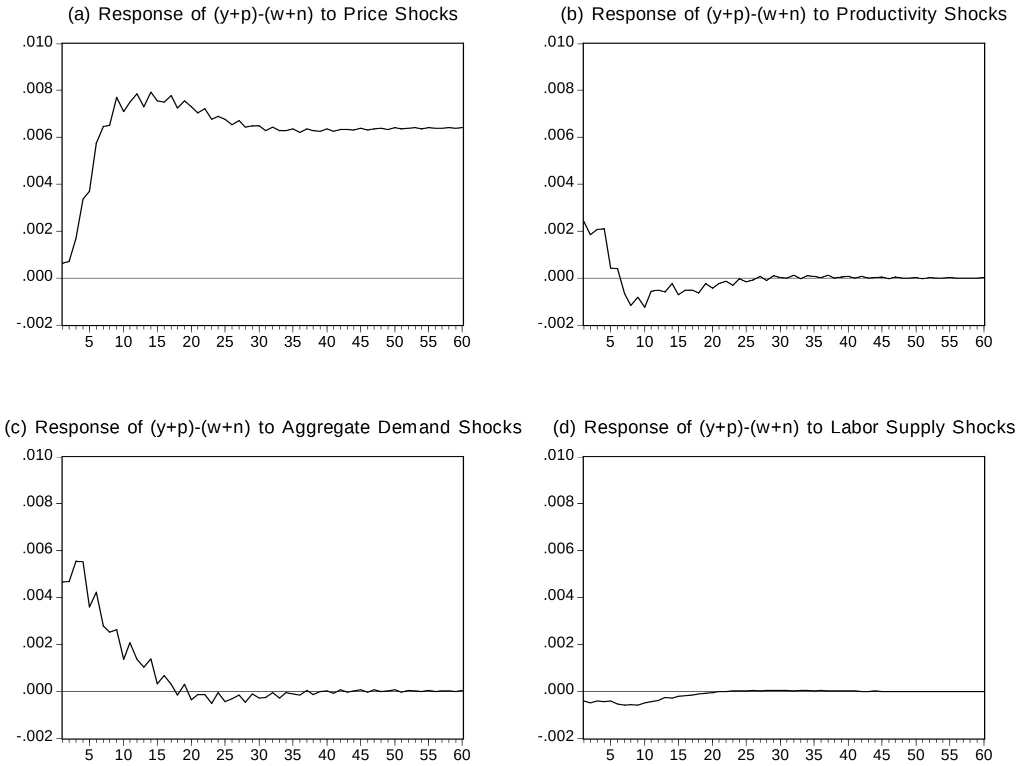

Figure 6.3 Impulse Responses of Inverse of the Wage Share (y+p)-(w+n) in SVAR1

Impulse responses of real wages are given in Figure 6.4. Price shocks decrease real wages significantly because of nominal wages rigidities. Positive productivity shocks increase real wages, which is quite reasonable. Real wages decrease immediately after positive shocks on aggregate demand, which supports the proposition of countercyclical real wages. However, they gradually come back to the pre-shock level so aggregate demand shocks have no permanent effect on real wages. As in the case for the wage share, labor supply shocks do not show any influence on real wages in either the short-run or the long-run.

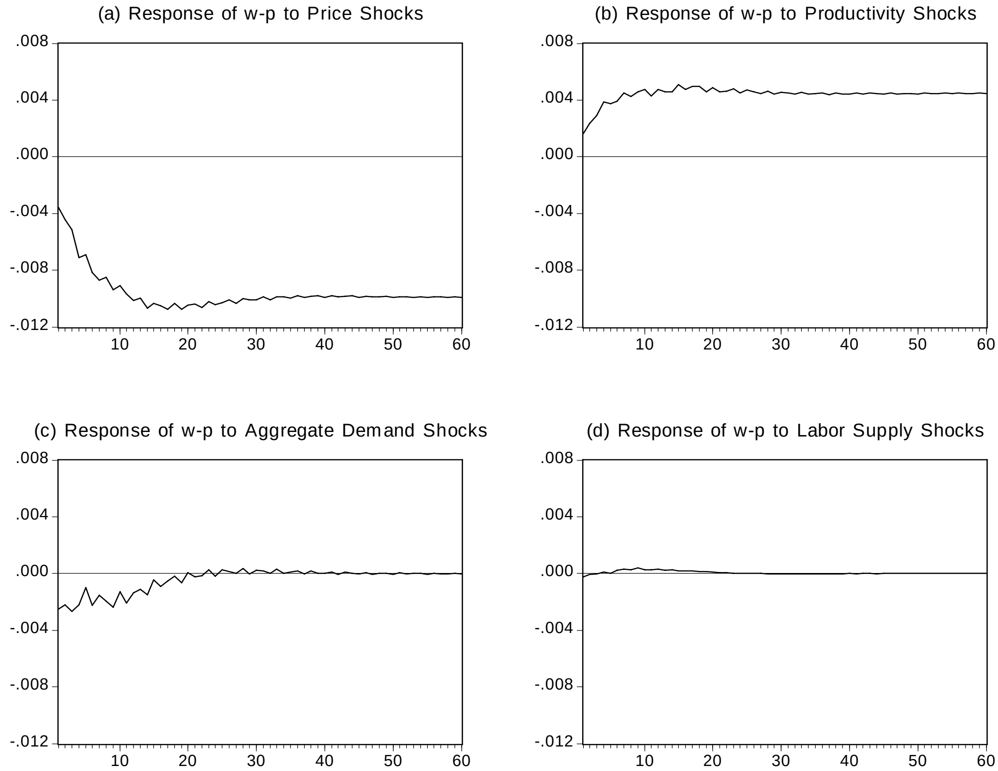

Figure 6.4 Impulse Responses of Real Wages w-p in SVAR1

From Panel (a) and (c) in Figure 6.5, impulse responses of employment to price and aggregate demand shocks mirror those of the unemployment rate. Panel (b) shows that productivity shocks have positive effect on employment in the short run and the long-run effect is insignificant at 5% level (see Table 6.3). This result is in line with the empirical uncertainty with respect to the long-run influence of productivity shocks on the unemployment rate. Panel (d) deserves some more explanation. Employment rises immediately after positive labor supply shocks. It then decreases gradually and the effect of labor supply shocks disappears after about 4 years. Therefore, labor supply shocks do not have permanent effects on employment, whereas the unemployment rate increases in the long-run. It is reasonable since the insider-outsider model in the theoretical framework assumes that only insiders can influence wage determination. Therefore, labor supply shocks increase only the unemployment rate in the long-run, without affecting employment permanently.

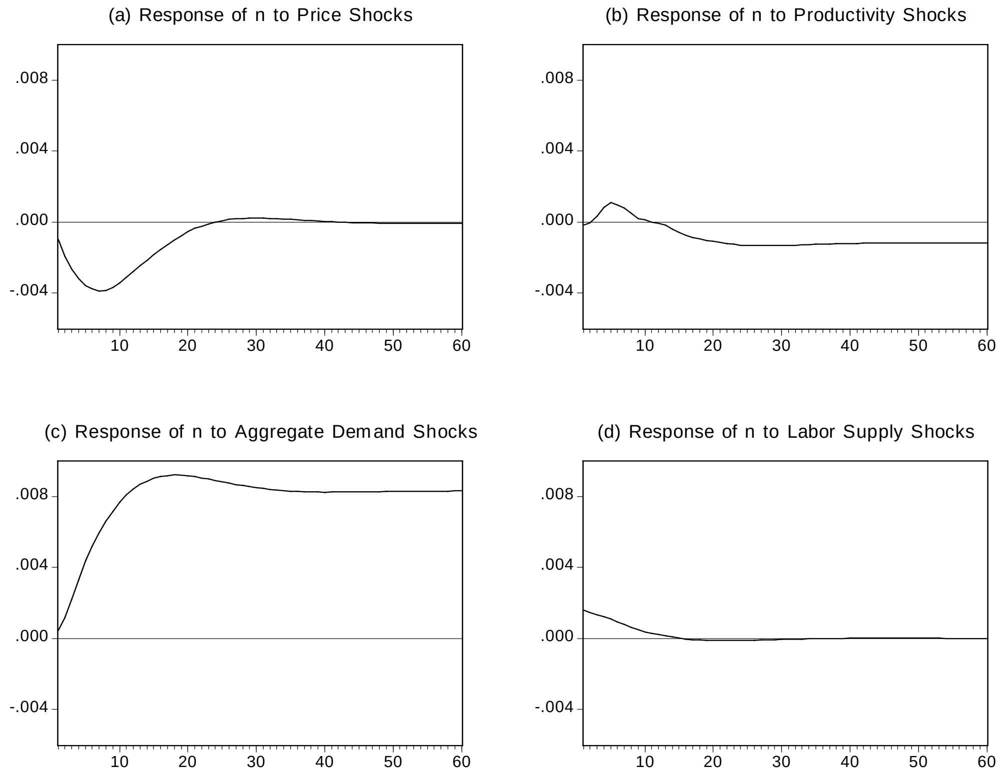

Figure 6.5 Impulse Responses of Employment n in SVAR1

To recap our results regarding the unemployment development in response to different structural shocks: price shocks are an important source of persistently high unemployment at least in the short and medium-run; productivity shocks seem to increase unemployment although this effect is not quite significant and empirical evidence in this respect is rather puzzling; aggregate demand shocks result in a sizable decline in unemployment even in the long run; labor supply shocks increase unemployment permanently. The results are reasonable and consistent with economic theory.

6.4.3.2.2 The over-identified case SVAR2

As mentioned previously, impulse responses analysis is also carried out for the over-identified alternative (SVAR2) to test the robustness of our results.

Figure 6.6-6.9 show impulse responses of the unemployment rate, the inverse of the wage share, real wages and employment.

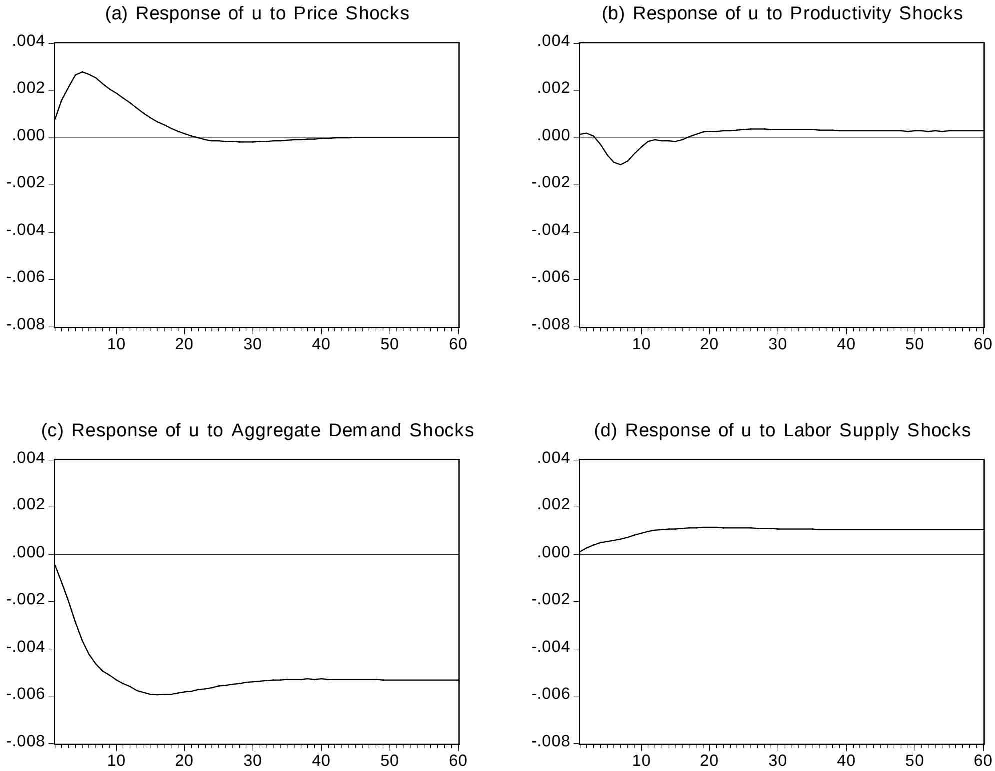

Figure 6.6 Impulse Response of the Unemployment Rate u in SVAR2

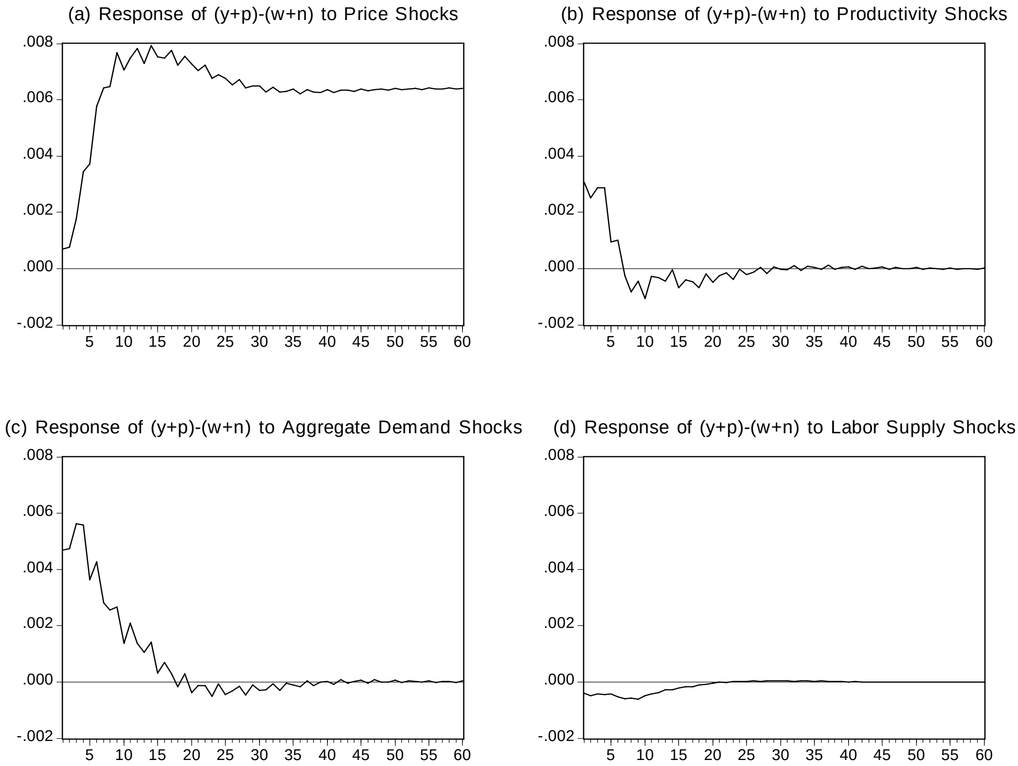

Figure 6.7 Impulse Responses of Inverse of the Wage Share (y+p)-(w+n) in SVAR2

In general, impulse responses of the over-identified model are quite similar with those of the just-identified one and thus the results of our impulse response analysis are robust. But there are differences about implications of productivity shocks. In comparison with panel (b) in Figure 6.2, panel (b) in Figure (6.6) shows that productivity shocks increase on impact unemployment only negligibly and the unemployment rate decreases in the short run. This evidence of favorable effect of positive productivity shocks on unemployment (although only in the short run) is supportive of the often cited accusation of productivity slowdown as one source of high unemployment in Germany. The effect dies out in the long run. This is in line with the generally accepted opinion that productivity growth does not influence unemployment permanently (see Layard *et. al* (2001)). Another difference regards the effect of productivity shocks on employment. Productivity shocks now have no permanent effect on employment (see panel (b) in Figure 6.9). These differences come obviously from the restriction C(3,2)=0. Since the implications of productivity growth on employment and unemployment are rather puzzling, it is not amazing when different alternatives do not offer quite the same results.

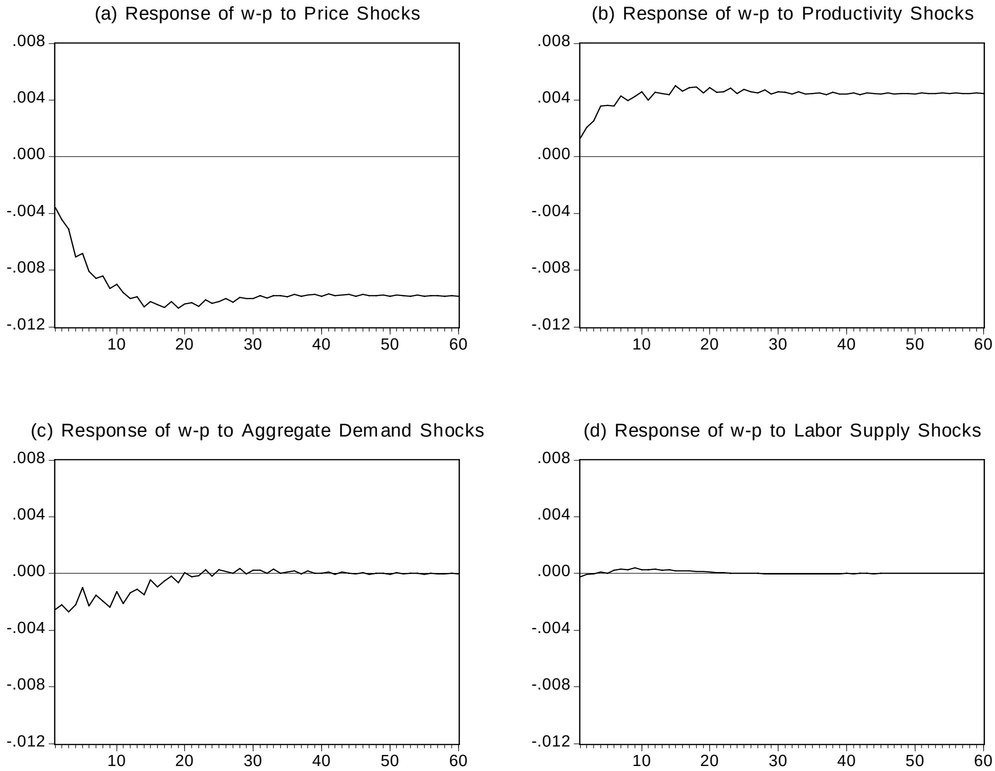

Figure 6.8 Impulse Responses of Real Wages w-p in SVAR2

To sum up, the impulse response analysis allows quite reasonable interpretations which are consistent with standard economic theory. The results are also reliable.

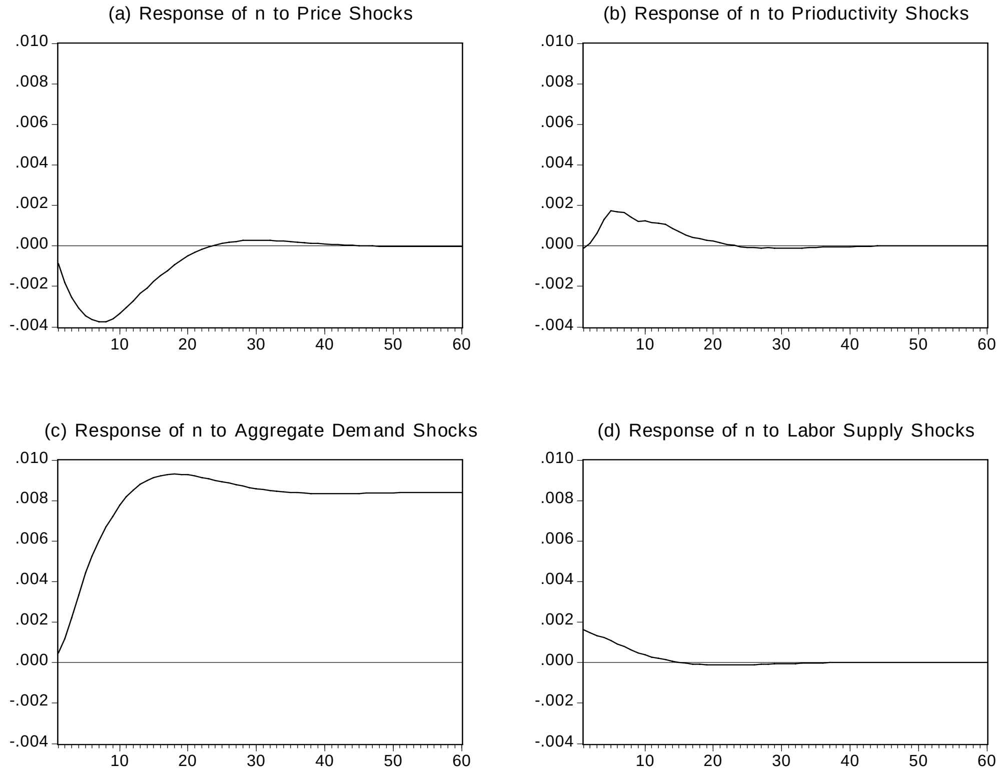

Figure 6.9 Impulse Responses of Employment n in SVAR2

6.4.3.3 Forecast error variance decompositions

Forecast error variance decomposition is another useful device to interpret VAR models. It provides complementary information on the dynamic behavior of the variables in the system. It enables us to decompose the forecast variance into contributions by each of the structural shocks. In this way, we can explore the relative importance of various structural shocks in driving the dynamics of the system. We present the forecast error variance decomposition of the four variables at various horizons representing the short-run (till one year), medium-run (till four years), and long-run (ten years and above) contributions of the shocks to explain the variability of each variable variance of the forecast errors of the variables in the VAR.[20]

6.4.3.3.1 The just-identified case SVAR1

Forecast error variance decompositions of the variables in the just-identified SVAR1 are given in Table 6.7.

Forecast error variance decompositions of the unemployment rate is central to our analysis, for they provide some insight into the importance of different structural shocks in explaining the unemployment rate.

Table 6.7 shows that price shocks and aggregate demand shocks seem to be driving forces of unemployment. In the short-run, price shocks play an important role in explaining forecast error variability of the unemployment series. They can explain the largest part (about 70%) of forecast error variance of the unemployment rate in one quarter. Their importance declines till about 43% in one year and they account for about 36% of the unemployment rate's forecast error variability in the long-run.

Another important factor is shocks to aggregate demand. They account for about 24% of forecast error variance in one quarter. Their importance increases with rising forecast horizons. In the long-run, they are the most important factor, accounting for about 53% of forecast error variability of the unemployment rate.

Productivity shocks, in contrast, can explain forecast error variance of the unemployment rate only in a limited extent. Their explanatory power is about 5.3% in one quarter, about 2.8% in one year and only about 10.0% in the long-run.

At last, labor supply shocks seem to hardly explain unemployment series' forecast error variability at any time horizon. Their proportion is only less 2% in the short and long-run.

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[20] Note that FEVD depends on the economic identification of the model. For this reason the interpretation of FEVD should always be restricted to the model under consideration.

Table 6.7 FEVD of the Just-identified SVAR1

Variance Decomposition (in % of Variable Variance)

Lags	Price Shocks	Productivity Shocks	Aggregate Demand Shocks	Labor Supply Shocks
The Wage Share				
1	1.413	20.577	77.428	0.581
4	12.794	18.552	68.128	0.526
8	18.757	21.295	59.547	0.401
12	20.615	20.527	58.459	0.398
16	21.084	20.228	58.280	0.407
60	21.706	19.864	58.028	0.402
Real Wages				
1	58.526	12.643	28.568	0.263
4	61.255	15.275	23.107	0.364
8	55.853	13.848	29.853	0.445
12	53.153	13.596	32.804	0.447
16	51.658	13.648	34.245	0.450
60	49.471	13.928	36.162	0.439
Employment				
1	25.411	0.795	5.632	68.162
4	30.874	4.950	34.138	30.037
8	23.817	5.478	48.305	22.400
12	23.743	5.743	49.945	20.570
16	25.437	6.319	48.556	19.688
60	27.013	6.452	47.450	19.086
The Unemployment Rate				
1	69.738	5.296	23.693	1.273
4	43.459	2.750	52.280	1.511
8	33.990	5.707	58.958	1.345
12	33.537	9.910	54.937	1.616
16	34.991	9.682	53.742	1.585
60	35.576	9.990	52.867	1.567

To sum up, forecast error variance of the unemployment rate in this model is mainly determined by aggregate demand shocks and price shocks. Note again that such strong and permanent effects of aggregate demand shocks are quite reasonable since non-neutrality features our model, arising from the cutting of the neo-classical equilibrating mechanism. In contrast, productivity shocks explain only a small fraction of the forecast error variance of unemployment in both the short and long-run, despite the moderate rise of their importance with increasing forecast horizons. This finding is consistent with the controversy of uncertain effects of productivity shocks on the unemployment rate. Labor supply shocks have merely a negligible, although constant, influence on the forecast error variance of unemployment at any time horizon.

6.4.3.3.2 The over-identified case SVAR2

Forecast error variance decompositions are also carried out on the over-identified SVAR2. The results are given in Table 6.8.

It is apparent that they are also similar to forecast error variance decompositions of the just-identified SVAR1 as shown in Table 6.7. This indicates that the results concerning forecast error variance decompositions are robust.

6.5 A summary

Empirical results from the previous section confirm the view put forward by Bean (1994), which states that there is no single cause of the rise in unemployment. According to him, the rise in unemployment is derived from a combination of various shocks that hit the economy. We do find empirically that different shocks can explain unemployment at different time horizons.

Table 6.8 FEVD of the Over-identified SVAR2

Variance Decomposition (in % of Variable Variance)

Lags	Price Shocks	Productivity Shocks	Aggregate Demand Shocks	Labor Supply Shocks
The Wage Share				
1	1.493	29.220	68.778	0.509
4	11.622	26.373	61.536	0.468
8	16.757	28.662	54.221	0.360
12	18.559	27.662	53.420	0.359
16	19.015	27.336	53.282	0.367
60	19.617	26.918	53.102	0.363
Real Wages				
1	61.257	8.114	30.354	0.275
4	62.778	12.498	24.347	0.377
8	56.539	11.895	31.109	0.457
12	53.270	12.442	33.834	0.454
16	51.479	12.979	35.088	0.454
60	48.839	14.072	36.651	0.439
Employment				
1	20.761	0.309	6.136	72.794
4	27.570	8.551	34.217	29.662
8	21.377	8.172	48.355	22.097
12	21.539	7.776	50.279	20.407
16	23.275	8.074	49.051	19.600
60	24.852	8.181	47.956	19.010
The Unemployment Rate				
1	71.721	2.608	24.380	1.292
4	42.779	3.771	51.969	1.480
8	32.770	8.364	57.572	1.295
12	32.516	11.532	54.375	1.577
16	33.940	11.278	53.234	1.548
60	34.482	11.591	52.396	1.530

As regards various structural shocks we considered, both impulse response functions and forecast error variation decompositions imply that demand shocks are dominant in accounting for unemployment evolution not only in the short run, but also in the medium/long-run. It can be concluded that insufficient domestic demand for goods and service, and thus for labor is one important source of continued high unemployment in Germany. Tight fiscal and monetary policies do have permanent and sharply negative effects on unemployment. Contractionary monetary policy (in the early 1980s, Bundesbank decided to disinflate German economy to overcome the stagflationry 1970s) is one possible culprit of high German unemployment rate. More recently, the imposition of the Maastricht criteria has forced European economies into fiscal consolidation and high real interest rates.[21]

Price shocks cause unemployment to increase in the short and medium run. Such a significant and long-lasting impact should not be neglected if one tries to investigate the reasons of the high and persistent unemployment rate in Germany. However, they do not for themselves influence unemployment in the long run.

Regarding the role of productivity shocks, the results are not quite clear-cut. Productivity shocks do seem to influence unemployment in the short/medium run, but the two models do not provide the same evidence in this respect. On the other hand, strong evidence for their permanent effects can not be identified. In the just-identified model, productivity shocks affect unemployment (but not significantly) in the long run; in the over-identified model, such permanent effects are neat zero. Therefore, productivity shocks may account for unemployment evolution at least in the short/medium run. As mentioned previously, implications of productivity growth on unemployment are rather diffuse both theoretically and empirically.

Labor supply shocks are shown to influence unemployment to some extent. According to impulse response functions, they increase unemployment in the long run; forecast error variance decompositions, however, imply that they can hardly account for unemployment variability.

Besides the role of structural shocks, sluggish propagation mechanisms make transitory shocks have quite long lasting effects. In other words, there is rather high degree of inertia in German labor market. This finding is in line with many previous studies (see Alogoskoufis and Manning (1988) and Layard *et al.* (1991)). In Comparison with the impulses responses computed in Jacobson *et al.* (1997, 1998) for Scandinavian labor markets, it can be seen that the adjustment process in Germany is much slower than that in Scandinavian countries.

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[21] Besides the direct effect of contractionary demand policies on an economy, Solow (2000) also points to their interaction with the supply side.

Chapter 7 Résumé

Any gain in labor-market flexibility or in product-market deregulation will be both more effective and more easily accepted if it occurs at a time when aggregate demand is strong and market prospects are favorable.
Robert M. Solow

7.1 Theoretical framework and econometric methodology

It has become almost a cliché to talk about the apparent deterioration of German unemployment performance since the 1970s. After the first oil price shock in 1973, German unemployment rate has been increasing. Although there were observed albeit quite mild decline in unemployment, the evolution of German unemployment rate during the last three decades is characterized by the stepwise upward trend and its persistence. The high and persistent unemployment is no doubt one of the major macroeconomic evils which worry German economists nowadays.

Being stimulated to investigate the sources of unemployment more closely, economists have carried out a large number of researches trying to explain the odd evolution of German unemployment. However, a consistent and general accepted framework in this regard has not been developed yet because of the intrinsic difficulty and importance of this issue.

Despite the diversity of factors being pointed out as possible culprits of high unemployment in Germany, two strands of explanations could be identified which emphasize institutions and shocks respectively. The dominant view of 'Eurosclerosis' attributes high German unemployment to labor markets rigidities. These include high labor taxes, strict labor market regulations, strong employment protection, trade union strength, high unemployment benefit, etc. Labor market reform to eliminate these institutional rigidities is therefore the potential cure. The alternative argument focuses on adverse macroeconomic shocks. From this perspective, various shocks which have hit German economy are responsible for the dramatic rise in unemployment. Oil price shocks, productivity slowdown and inadequate aggregate demand due to restrictive monetary/fiscal policies are quite often cited shocks. Besides other factors, more appropriate macroeconomic policies to stimulate aggregate demand are thought to be necessary to struggle against unemployment.

However, both explanations have been criticized as unable to account for the tragic unemployment evolution in Germany plausibly. The traditional ‘European sclerosis’ argument is not convincing since many of these labor market rules have been in place since the 1960s when German unemployment rate was very low. In addition, the movement of labor market institutions since the early 1980s has been in the direction of making labor market more flexible. As regards the explanation emphasizing adverse shocks, such shocks may have led to the rise in the unemployment rate but it is not plausible that they could by themselves account for the persistence of unemployment evolution over three decades.

Although neither the explanation based on rigid labor institutions alone nor that emphasizing only adverse macroeconomic shocks can provide a convincing account, a synthesis of them is quite promising. These two positions should be seen as complementary. One should consider the interaction of effects of adverse shocks and labor market institutions which prevent the proper working of self-equilibrating mechanisms. In fact, the observed upward jump of the unemployment rate and apparent increasing proportion of long term unemployment have promoted the opinion that the interaction between negative shocks hitting the economy and structural elements in the labor market hindering the self-equilibrating process has resulted in the persistently high unemployment in Germany. Due to the existence of labor market rigidities, hysteresis mechanism comes into being which has made adverse shocks to have long-lasting effects in influencing the unemployment rate.

Based on such a theoretical framework, this thesis provides a thorough analysis concerning sources of persistently high unemployment in Germany by investigating macroeconomic shocks and their persistent effects due to structural rigidities. Because of the focus on macroeconomic shocks, structural vector autoregressive (SVAR) approach is especially appropriate.

Promoted by both the inability of economists throughout the 1970s to agree on the true underlying structure of the economy and the Lucas critique, VAR models in line with Sims (1980) have become popular in empirical macroeconomics. In order to avoid ‘incredible identification restrictions’ in traditional macroeconometric models, particularly the determination of exogenous variables, the VAR approach regards all variables as endogenous. Concentrating on shocks, VAR models are well-suited to ascertain relative contribution and propagation mechanism of certain shocks hitting the economy.

However, this traditional VAR approach which is of a reduced-form has been criticized as being a-theoretic and having no sensible economic interpretation. Such criticisms inspired structural approaches to VAR modeling to recover the underlying structural shocks. SVAR analysis is an extension of traditional unstructured VAR analysis which imposes a certain structure derived from the economic theory.

7.2 The main results

In this thesis we have analyzed German labor market for the period from 1970:1 to 2001:2. The primary aim is to disentangle structural shocks as main driving forces behind the rise in German unemployment rate and their propagation mechanism.

A small macroeconomic model serves as the theoretical basis which is in line with the approach of Layard *et al.* (2005). The model contains an aggregated demand function, a production function, a price setting relation, a wage setting relation, a labor supply function and a definition equation of unemployment. In accordance to the insider-outsider model, the wage setting rule states that nominal wages are chosen one period in advance and are set to make expected employment to be a weighted combination of lagged labor supply and employment. Full hysteresis corresponds to the extreme case where exclusively lagged employment (insiders) is considered in the wage bargaining process. These relations are influenced by exogenous variables, capturing the effects of various structural shocks. Institutional rigidities strengthen the power of insiders and thus exacerbate the inertia in the wage bargaining framework. Such labor market institutions have set the conditions to make the effects of adverse shocks very persistent and produce a very long-lasting rise in the unemployment rate.

SVAR analysis with long run restrictions originated from Blanchard and Quah (1989) is carried out. As compared with previous SVAR analysis of labor markets, novelties of this empirical work are the assumption of full-hysteresis in the unemployment rate, which is supported by the presence of a unit root in the unemployment series according to Perron tests, and the identification of price shocks as one further structural shock.

Using long-run identifying restrictions achieved from the theoretical model, four structural shocks (price, productivity, aggregate demand and labor supply shocks) are recovered. With the help of impulse response analysis and forecast error variance decompositions, the contributions of various shocks to unemployment evolution in Germany are evaluated and the part of institutional rigidities is captured by hysteresis mechanism.

Empirical results show that no single factor for itself has caused the rise in unemployment. The persistently high unemployment is instead the result of a combination of various shocks as well as hysteresis mechanism.

As regards the structural shocks under investigation, demand shocks are shown to be dominant in accounting for unemployment evolution even in the long run. Deficient aggregate demand and thus labor demand is no doubt an important reason for the miserable unemployment development in Germany. Although price shocks do not influence unemployment in the long run, they lead to a rise in the unemployment rate in the short/medium run. Since the impact of price shocks is significant and long-lasting, they can to some degree explain the unemployment persistence in Germany. Just like many theoretical and empirical literature about the effect of productivity shocks on the unemployment rate, this thesis does not provide a clear-cut picture concerning productivity shocks either. However, productivity shocks seem to influence unemployment in the short/medium run. Finally, labor supply shocks are shown to have an effect on the unemployment rate.

In addition to various structural shocks, sluggish propagation mechanisms make transitory shocks have quite long lasting effects. There is rather high degree of inertia in German labor market as supported by the empirical result that the unemployment series seems to follow an I(1) process. Labor market institutions, as represented by the insider-outsider model, are important factors in explaining the hysteresis mechanism.

It can be concluded from the empirical work that it might be too simple blaming solely insufficient effective demand or labor market rigidities for persistently high unemployment in Germany. The sources of unemployment appear to be a mixture of different factors from demand as well supply side. From the impulse response analysis, shocks of price, productivity, aggregate demand and labor supply are all important determinants of unemployment. Due to the introduction of hysteresis mechanism, all these shocks exert long-lasting effects on the rate of unemployment. Especially aggregate demand shocks influence unemployment even in the long run. Forecast error variance decomposition shows that price and aggregate shocks account for most part of the variation of unemployment, whereas productivity shocks have relatively small influence on the forecast error variance of unemployment and the influence of labor supply shocks is negligible.

Based on these results, we can interpret the unemployment development over the last decades as follows: price shocks like the two oil price crises in the 1970s together with a large productivity slowdown also in the 1970s certainly contributed to the initial rise of the unemployment rate during that period. In the early 1980s, when Monetarism and Supply-Side Economics were dominated, Bundesbank decided to disinflate German economy to overcome the stagflation in 1970s. Bundesbank thus raised the short-term interest rate, which resulted in lower output and hence higher unemployment. This led to lower inflation according to the Phillips curve. With inflation falling and unemployment rising, the central bank lowered the interest rate. However, as compared with the Fed in U.S., Bundesbank chose to disinflate very gradually. Bundesbank thus maintained tight conditions over a long period of time, with the consequence of equilibrium unemployment rate following actual unemployment rate (hysteresis mechanism). When the central bank finally lowered its interest rate, this did not have any significant effects on the unemployment rate, because the equilibrium rate has risen as well by then. That means, the disinflationary process initiated by Bundesbank lasted too long such that hysteresis effects could arise. Moreover, adverse aggregate demand shocks from tight macroeconomic policy in the post unification era might have played a dominant role in explaining high unemployment in the 1990s.

The analysis casts some doubt on the popular blame accounting for high and persistent unemployment in Germany entirely by rigid wages and labor market institutions. This work illustrated that macroeconomic shocks can very well explain rising unemployment over the sample period. In fact, macroeconomic shocks are able to explain large fluctuations and upward jumps in unemployment quite well. Such sudden changes, however, 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. More generally, 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.

To recap, the results of the analysis are satisfactory in that the 'theory-guided' view on data yields reasonable results regarding impulse response functions and forecast error variance decompositions. Empirical results obtained are generally plausible and hence the advantages of this approach are confirmed in comparison with other standard techniques adopted to explain unemployment development.

However, the SVAR approach has also its limitations despite its rapid development in the empirical research. SVAR models are usually small, with some even important factors neglected. Interpreting residuals in such low-dimensional models as 'structural' disturbances is always perilous. Identifying assumptions may be quite controversial when the model is large. Over-parameterization of the reduced form model also affects the precision of the estimates.

7.3 The role of macroeconomic policies

The empirical results convey strong implications for economic policy. Since unemployment is the result of interactions of several structural shocks (impulse mechanism) and hysteresis effects (propagation mechanism), policy implications involve both aspects.

As structural shocks are concerned, the role of aggregate demand shocks and price shocks in influencing German unemployment evolution provides rather important insight for macro policies design. Starting from the role of aggregate demand shocks, the findings offer new evidence on the strong long run relationship between demand policies and unemployment. If hysteresis is a relevant phenomenon, the analysis implies that demand-side policies matter for output and unemployment not only in the short run, but also in the long run. This finding is in line with other recent empirical evidence stating that aggregate demand affects unemployment even in the long run.[1]

As regards price shocks, since they do play a role in explaining high unemployment in the short/medium run, policies which lower mark-up contribute to reducing the unemployment rate. These so-called deregulation policies operate primarily through the regulation of product market with the aim of increasing the degree of competition among firms. In the context of European integration, such policies may include for example the reduction of tariff barriers or standardization measures. Deregulation policies that are intended to reduce entry costs may consist of the elimination of state monopolies or the reduction of red tape, associated with the creation of new firms. If the number of firms is not fixed in the long run, a reduction in entry costs leads to an entry of new firms and unemployment will hence be lowered and a higher real wage comes into being.[2] This mechanism is captured by our empirical work, since a reduction in mark-up causes a sharp reduction in German unemployment rate at a higher real wage level.

In addition, this empirical analysis has also important policy implications concerning hysteresis effects as propagation mechanism. Since hysteresis effects arising from the insider-outsider framework make adverse shocks to have quite long lasting influences, the insider-outsider theory plays a crucial role in eliminating unemployment persistence. Despite the diversity of political implications in this respect, the common emphasis is the creation of a more level playing field in the labor market. So long as insiders have more favorable opportunities than outsiders, policies that guarantee a more level playing field between insiders and outsiders can improve efficiency and equity. Generally, two broad types of policies can be identified in this context: power-reducing policies that reduce insiders' market power and enfranchising policies that strengthen outsiders' voice in the wage bargaining process.

Power-reducing policies range from restrictions on strikes to relaxing job security legislation. For example, laws simplifying firing procedures, reducing litigation costs and reducing severance pay. These policies tend to reduce insiders'

[1] See, for example, Fortin (1996) for Canada; Blanchard and Giavazzi (2003) for OECD countries.
[2] Blanchard and Giavazzi (2003) have stressed the mechanism through which deregulation policies affect unemployment in the long run.

welfare. Therefore insiders may resist these policies which will limit the effectiveness of power-reducing policies.[3] The general form of enfranchising policies is vocational training programs and job counseling for the unemployed, schemes to convert wage claims into equity shares, policies to reduce the occupational, industrial, and geographic coverage of union wage agreements and again policies to reduce barriers to the entry of new firms.[4]

The insider-outsider theory has another policy implication regarding the magnitude of required policy change. Labor turnover costs discourage firms from hiring and firing, bringing about a corridor of wages within which employment is not responsive to policy stimuli. As a result, labor market reforms in which policy parameters are changed by only small amounts are likely to be ineffective in labor markets with significant labor turnover costs. In this case, only 'bold' reforms can stimulate employment.

In short, the crucial point of this empirical work is the role of adverse shocks interacted with hysteresis effects arising from labor market institution in the unemployment evolution. Therefore, any policy measure aimed at only one side of the coin may be ineffective in solving the problem.

This insight is rather important in the light of the recent debate on potential strategies to fight against high unemployment in Germany. Two central views can be summarized in the discussion which are thought to be opposite: structural reform (consisting of for example wage bargaining decentralization, reduction of hiring and firing costs and of the barriers to labor mobility) versus aggregate demand management policies (through monetary and/or fiscal policies).[5] The empirical evidence in this work suggests that such positions should not be seen as exclusive but rather as complementary. Indeed, within a theoretical framework where the labor market is rigid and structural reform can play a role, certain monetary/fiscal policies are very powerful. The reason why such policies are important instruments for the reduction of unemployment, namely the rigidity in the labor market, exactly justifies structural reforms for its part. Hysteresis in the unemployment rate makes economic policies effective, not only in the short run but also in the long run. Therefore, aggregate demand policies should be

[3] Insiders do this through the political process or through rent-creating activities at the work place.
[4] For example, dismantling of government regulation concerning creation of new firms, tax reforms that put new firms at less of a disadvantage *vis-à-vis* established firms.

considered as useful instruments to tackle unemployment and are complementary rather than contrasting with structural labor market reforms. According to Solow (2000), policies relying merely on labor market reform work inevitably very slow and are bound to be social divisive. Simultaneous expansion of demand will make labor market policies more effective and less divisive.

In summary, the effects on unemployment of any partial policy depend on the whole economic circumstances. Monetary, fiscal and deregulation policies have a common responsibility for the employment issue. Macro policies should be coordinated in order to cure the problem of persistently high unemployment in Germany. Only a general approach, producing a thorough and full reform of labor markets, goods markets and welfare state can get satisfactory results.

[5] See e.g. OECD (1994) and Bean (1994).

Appendix

A Hysteresis Mechanism

Hysteresis in unemployment is indicated as follows:

$$U^*_t=\bar{U}^*+h(U_{t-1}-\bar{U}^*)+b_t \qquad (A.1)$$

where U^*_t: the natural rate of unemployment in the current period

$\bar{U}^*$: the steady-state natural rate of unemployment[1]

U_{t-1} : the actual rate of unemployment in the previous period

b_t : other influences on the natural rate

h: hysteresis parameter, $0 \le h \le 1$.

By assuming $b_t = 0$, equation (A.1) can be rearranged to get:

$$U^*_t-\bar{U}^*=h(U_{t-1}-\bar{U}^*) \qquad (A.2)$$

According to different values of hysteresis parameter h, there are three possible scenes:

1. If $h = 1$ then there is full hysteresis: $U^*_t=U_{t-1}$. The natural rate of unemployment U^*_t exactly equals the actual rate of unemployment in the previous period. Here a temporary rise in the rate of unemployment has permanent effects. Following an exogenous disturbance, the natural rate of unemployment itself rises and does not return to its old level. In other words, a new equilibrium comes into being which does not correspond to the old one. In this case, the rate of unemployment follows a random walk.

[1] The steady-state natural rate of unemployment $\bar{U}^*$ represents the outcome of the long-run structural determining factors of unemployment.

2. The case of $0 < h < 1$ accords with partially hysteresis, or the so-called persistence. Equation (A.2) predicts that if $U_{t-1} > \bar{U}^*$ then $U^*_t > \bar{U}^*$. In a system with persistence, the natural rate of unemployment itself does not change after an exogenous disturbance, which is in contrast to hysteresis. However it lasts sometime for the natural rate of unemployment to restore to its equilibrium level again. Equation (A.2) can also be expressed as: $U^*_t = hU_{t-1} + (1-h)\bar{U}^*$, where $0 < h < 1$. Thus the long-run (equilibrium) natural rate of unemployment is determined not only by exogenous structural variables, but also by the time path of actual rate of unemployment till equilibrium.

These two cases imply path dependency of the unemployment rate. Past disturbances do not lose their influences on dependent variables as time passes. Analogous to hysteresis effects in physics, the shifting of actual rate of unemployment here acts like a magnet, which exercises some drawing force on the natural rate of unemployment in the same direction.

3. The extreme case of $h = 0$ indicates that there is no hysteresis effects. This is consistent with the traditional wisdom that the natural rate of unemployment (or NAIRU) does not change as time goes on.

B The Unit Root Assumption on Structural Shocks

This thesis focuses on the persistence of unemployment in explaining the sources of high unemployment in Germany. The structural shocks (aggregate demand, productivity, price and labor supply) are assumed to have a unit root in the theoretical model. One possible criticism is that the assumption of such an extreme form of persistence might be excessive. Following points are relevant in this respect:

● At first, the hypothesis of I(1) shocks does not necessarily imply extreme persistence of shocks on unemployment in the theoretical model. The degree of unemployment persistence is instead captured by λ. If $\lambda \neq 0$ (the case of partial-hysteresis in unemployment), structural shocks have no permanent effect on the unemployment rate even if they are assumed to be I(1).

● Applying Perron test for unit roots, the wage share, real wages and employment are shown to be all I(1) process. The unemployment rate seems to be non-stationary as well. The assumptions in the theoretical model can accommodate even this extreme case although it is not quite consistent with standard economic theory.

● Unit root assumption of structural shocks is usual in both the theoretical and the empirical literature. Example for the theoretical literature are Kydland and Prescott (1982), Plosser (1989), King *et al.* (1991), Christiano and Eichenbaum (1992), Galí (1999), Blanchard (1997) and Nickell (1998). Empirically, the unit root assumption is typical of a large number of VAR literature, see for example Blanchard and Quah (1989), Gamber and Joutz (1993), Rotemberg and Woodford (1996) and Balmaseda *et al.* (2000).

C Data and Variables

The data set consists of quarterly observations covering the period 1970:1 to 2001:2. They are seasonally adjusted and constructed from DIW (Deutsches Institut für Wirtschaftsforschung) database (which is based on the report of Statistisches Bundesamt and German Bundesbank) and author’s calculation. All VGR-data are of ESVG 95 basis. The data refer to West Germany until 1990:4 and unified Germany afterwards.

Real output Y is given by real GDP, prices P are given by GDP deflator, wages W are given by the compensation of employees from German national accounts and divided by the number of employees; employment N is given by employees in total employment; the unemployment rate u is calculated as percentage of the sum of employees and unemployment.

Time series in the SVAR model are constructed as follows:

log (the wage share): log(W*N/(Y*P)) = (w+n)-(y+p)

log (real wages): log(W/P) = w-p

log (employment): log N = n

the unemployment rate u ≈ -log(1-u) = -log(N/L) = $\tilde{l}$ -n

The vector of time series for the SVAR analysis is thus [(w+n)-(y+p), w-p, n, u]’.

Table C.1 The Data

Variables	Real GDP (Billion DM)	GDP deflator (1995=100)	Compensation of employees (Billion DM)	Employees (1000)	Unemployment (1000)
Symbols	Y	P	W*N	N	L-N
1970:1	423.1972	37.84467	84.19274	21931.46	141.5054
1970:2	433.4337	38.73413	88.66442	22087.49	145.8536
1970:3	435.5151	39.34682	91.49213	22230.22	150.0200
1970:4	440.9698	39.95485	94.69634	22330.48	149.8894
1971:1	443.1406	40.91765	97.71217	22446.22	149.4368
1971:2	443.9376	41.66127	100.1480	22488.32	177.8258
1971:3	449.1877	42.34931	103.4333	22522.16	194.8647
1971:4	450.8900	42.96974	105.1546	22571.67	216.3407
1972:1	457.0135	43.33142	107.8015	22620.82	242.6175

Variables	Real GDP (Billion DM)	GDP deflator (1995=100)	Compensation of employees (Billion DM)	Employees (1000)	Unemployment (1000)
1972:2	461.6489	43.86956	110.7695	22701.04	243.4351
1972:3	467.0718	44.53090	113.8946	22774.22	255.0128
1972:4	475.8251	45.04396	117.1147	22863.84	251.5412
1973:1	483.4690	45.99662	122.7487	23020.54	216.0303
1973:2	486.1673	46.61840	125.7030	23114.53	251.1522
1973:3	488.0879	47.26557	129.3477	23175.12	299.1739
1973:4	490.3177	48.09507	132.8699	23176.17	350.3966
1974:1	491.4770	48.77557	135.7551	23117.99	437.1713
1974:2	489.0763	49.83714	140.4845	23016.91	509.3005
1974:3	488.9340	50.90879	143.2804	22890.64	616.5931
1974:4	482.2883	51.77506	145.3098	22730.20	785.2971
1975:1	475.8441	52.46294	145.2632	22533.11	945.6039
1975:2	479.0638	53.01233	146.3966	22401.55	1073.369
1975:3	484.2230	53.28905	148.2484	22300.62	1135.661
1975:4	489.3371	54.02136	150.3056	22256.40	1142.672
1976:1	499.9267	54.37502	153.9908	22306.77	1122.142
1976:2	506.0005	54.86474	157.6455	22388.73	1063.261
1976:3	508.6021	55.59607	161.1325	22456.28	1030.541
1976:4	515.9552	55.71910	164.1563	22511.45	1016.840
1977:1	517.8807	56.33983	166.8845	22522.24	1013.978
1977:2	518.5659	56.97103	170.0386	22549.93	1032.723
1977:3	523.1071	57.28928	172.2762	22618.38	1039.418
1977:4	528.1895	58.13465	175.0466	22692.71	1028.911
1978:1	531.3862	58.71305	177.6799	22754.61	1015.458
1978:2	534.8126	59.39841	180.9857	22818.42	1007.386
1978:3	539.9700	60.00345	184.4945	22910.57	983.9218
1978:4	545.4332	60.36125	187.4377	23008.02	961.1889
1979:1	549.2188	60.90326	191.3901	23151.12	936.2823
1979:2	562.1776	61.30673	195.1778	23312.20	883.7174
1979:3	563.9441	62.26250	199.5783	23463.08	855.1595
1979:4	567.7644	63.02449	203.9762	23623.34	827.0119
1980:1	571.6536	63.90544	209.3860	23744.20	806.9841
1980:2	564.4261	64.81939	213.5354	23803.71	856.1030
1980:3	564.7420	65.33237	216.6983	23841.12	916.6080
1980:4	563.0065	65.87011	219.4416	23868.13	985.9617
1981:1	563.9680	66.43405	220.5563	23895.38	1069.990
1981:2	565.2958	67.27255	224.8308	23858.19	1197.648
1981:3	568.9019	68.01328	227.0738	23792.26	1346.021
1981:4	567.6843	69.00191	228.6336	23716.60	1496.836
1982:1	563.5305	69.68315	230.4081	23647.80	1648.413
1982:2	563.0091	70.39393	231.8099	23609.56	1755.025
1982:3	559.5392	71.16709	233.1108	23511.89	1887.639
1982:4	559.1022	71.60866	233.6590	23372.02	2058.406
1983:1	562.9577	72.26615	232.8262	23231.77	2197.986
1983:2	570.5706	72.69238	236.4744	23175.03	2270.491
1983:3	571.7241	73.28790	239.1088	23185.56	2290.203
1983:4	577.6547	73.71101	239.9537	23189.88	2275.569
1984:1	585.7344	74.04076	245.0311	23214.37	2247.062
1984:2	581.0300	74.35332	242.1924	23232.84	2256.019
1984:3	587.1599	74.57996	245.6328	23247.24	2278.378
1984:4	591.0842	75.05927	249.6477	23319.35	2282.138
1985:1	592.6732	75.26476	250.0937	23360.49	2304.880
1985:2	596.9954	75.68106	254.5955	23416.01	2311.594
1985:3	601.6763	76.34469	256.3723	23487.92	2302.627
1985:4	601.5015	76.93398	259.0337	23559.38	2305.014

Variables	Real GDP (Billion DM)	GDP deflator (1995=100)	Compensation of employees (Billion DM)	Employees (1000)	Unemployment (1000)
1986:1	605.0025	77.64048	263.5745	23670.08	2282.986
1986:2	614.1788	78.24169	266.7948	23760.29	2238.886
1986:3	614.5054	78.83443	270.4365	23858.56	2205.750
1986:4	617.8258	79.19080	272.5768	23944.49	2182.990
1987:1	614.1860	79.63380	273.9212	23959.95	2200.971
1987:2	619.5263	79.88508	279.1953	24022.34	2219.466
1987:3	625.1707	79.95485	281.3334	24067.22	2233.850
1987:4	632.0274	80.31321	284.4569	24117.51	2242.509
1988:1	639.3995	80.50979	286.6605	24167.45	2265.730
1988:2	639.8241	80.97621	288.8318	24220.12	2264.374
1988:3	650.0133	81.32205	292.6584	24301.81	2236.585
1988:4	655.7196	81.83081	296.0258	24400.06	2178.240
1989:1	660.2524	82.31013	298.7721	24481.58	2096.497
1989:2	669.0370	82.75403	301.0103	24580.03	2048.242
1989:3	669.1311	83.37159	306.2453	24702.47	2004.667
1989:4	678.0482	84.07723	310.5454	24849.30	1996.099
1990:1	692.4487	84.81754	317.6011	25128.97	1954.699
1990:2	698.2241	85.52539	325.3732	25328.64	1923.183
1990:3	713.7843	86.28381	330.5355	25554.17	1880.267
1990:4	723.4049	86.45882	341.8280	25806.58	1780.771
1991:1	828.5715	85.91515	401.6107	35233.85	2387.000
1991:2	839.1465	87.14090	413.1036	34978.42	2524.000
1991:3	836.9410	88.23643	413.2629	34705.13	2707.000
1991:4	840.8325	89.82041	422.1417	34586.40	2787.000
1992:1	858.1279	90.60047	436.7599	34434.08	2882.000
1992:2	852.8746	91.78569	442.4817	34315.24	2950.000
1992:3	853.6654	92.92419	454.0734	34192.12	2997.000
1992:4	853.4059	93.57930	455.7412	34013.80	3085.000
1993:1	838.9464	94.63448	453.0674	33862.47	3185.000
1993:2	844.1572	95.31268	458.0349	33725.69	3326.000
1993:3	848.6276	95.89979	459.1533	33606.34	3503.000
1993:4	850.6146	96.52771	462.7536	33504.30	3669.000
1994:1	860.1371	97.15177	467.3853	33507.70	3749.000
1994:2	862.7084	97.65800	466.7484	33478.54	3761.000
1994:3	867.5890	98.17943	470.0086	33505.52	3695.000
1994:4	872.5539	98.94814	475.1104	33540.80	3604.000
1995:1	878.3337	99.28606	480.2854	33548.29	3533.000
1995:2	880.5289	99.88103	486.8391	33545.46	3556.000
1995:3	878.7416	100.3995	489.6712	33533.23	3642.000
1995:4	881.6835	100.3995	492.1374	33541.96	3744.000
1996:1	883.3172	100.7971	491.0693	33497.02	3855.000
1996:2	884.0427	100.8799	490.9097	33488.69	3933.000
1996:3	890.4804	101.0336	493.1140	33407.01	3992.000
1996:4	890.9298	101.3808	492.8521	33320.13	4096.000
1997:1	888.1378	101.4639	493.9549	33285.79	4242.000
1997:2	902.3647	101.5080	493.8049	33271.93	4341.000
1997:3	902.6603	101.7347	493.2144	33289.75	4457.000
1997:4	908.4189	102.0399	495.2381	33302.82	4496.000
1998:1	917.6246	102.3660	498.8641	33377.20	4438.000
1998:2	913.7516	102.7663	501.9683	33575.67	4343.000
1998:3	918.7479	102.9870	506.3046	33705.20	4204.000
1998:4	920.4715	103.1465	509.8326	33877.45	4120.000
1999:1	922.1950	103.3005	511.8150	33968.52	4112.000
1999:2	927.8463	103.4272	517.0081	33991.69	4101.000
1999:3	938.5872	103.2416	519.5908	34219.66	4101.000

Variables	Real GDP (Billion DM)	GDP deflator (1995=100)	Compensation of employees (Billion DM)	Employees (1000)	Unemployment (1000)
1999:4	948.7142	103.2566	523.4609	34361.18	4066.000
2000:1	956.6790	102.9359	528.0221	34561.39	3975.000
2000:2	963.8723	102.7669	531.2546	34738.44	3918.000
2000:3	964.1955	102.9760	535.4993	34752.62	3855.000
2000:4	965.4995	102.9369	538.2919	34821.42	3802.000
2001:1	969.3926	103.8106	541.2219	34794.98	3798.000
2001:2	968.5132	104.2118	542.3157	34784.78	3824.000

Note: The data refer to Western Germany prior to 1991; they refer to unified Germany since 1991.

Source: DIW database.

D Perron Unit Root Test

In his influential paper, Perron (1989) considers the null hypothesis that a time series has a unit root with possibly nonzero drift against the alternative that the process is 'trend-stationary'. He is interested in the case where both the null and alternative hypotheses allow for the presence of a one-time change in the level or the slope of the trend function. He demonstrates reasons for spurious unit roots. That means, it is possible that standard tests for a unit root cannot reject the unit root hypothesis if the true data generating process is that of stationary fluctuations around a trend function which contains a one-time break. He further suggests an alternative test procedure which enables us to distinguish the two hypotheses when a break is present.

Perron identifies three models that characterise various kinds of change in time series process:

1. Model A is referred to as the 'crash' model. There is an exogenous change in the level of the series, whereas the slope of the trend remains unchanged.
2. Model B describes the so-called 'changing growth' model, where an exogenous change in the trend function is allowed without any sudden change in the level.
3. Model C allows both effects to take place simultaneously, i.e., a sudden change in the level followed by a different growth path.

Perron considers different parameterisation of the structural break under the null and alternative hypothesis. In the following formula, T_B refers to the time of break, i.e., the time at which the change in parameters of the trend function occurs.

For the null hypothesis of a unit root process:

Model A: $y_t = \mu + y_{t-1} + dD(TB)_t + e_t$ (D.1)

Model B: $y_t = \mu_1 + y_{t-1} + (\mu_2 - \mu_1)DU_t + e_t$ (D.2)

Model C: $y_t = \mu_1 + y_{t-1} + dD(TB)_t + (\mu_2 - \mu_1)DU_t + e_t$ (D.3) where $D(TB)_t = 1$ if $t = T_B+1$, 0 otherwise;

$DU_t = 1$ if $t > T_B$, 0 otherwise;

$A(L)\, e_t = B(L)\, v_t$, $v_t \sim$ i.i.d.$(0, \sigma^2)$, with $A(L)$ and $B(L)$ pth and qth order polynomials, respectively, in the lag operator L.

For the alternative hypothesis of a trend-stationary process:

Model A: $y_t = \mu_1 + \beta t + (\mu_2 - \mu_1) DU_t + e_t$ (D.4)

Model B: $y_t = \mu + \beta_1 t + (\beta_2 - \beta_1) DT_t^* + e_t$ (D.5)

Model C: $y_t = \mu_1 + \beta_1 t + (\mu_2 - \mu_1) DU_t + (\beta_2 - \beta_1) DT_t + e_t$ (D.6)

where $DT_t^* = t - T_B$ and $DT_t = t$ if $t > T_B$ and 0 otherwise.

Perron proposes the following two-step procedure as an alternative test for unit roots:

1. Eliminate deterministic terms from the time series according to
   - Model A: $y_t = \tilde{\mu} + \tilde{\beta} t + \tilde{\gamma}\, DU_t + \tilde{y}_t$ (D.7)
   - Model B: $y_t = \tilde{\mu} + \tilde{\beta} t + \tilde{\gamma}\, DT_t^* + \tilde{y}_t$ (D.8)
   - Model C: $y_t = \tilde{\mu} + \tilde{\beta} t + \tilde{\gamma}_1\, DU_t + \tilde{\gamma}_2\, DT_t + \tilde{y}_t$ (D.9)

   where $\tilde{y}_t$ denotes residuals from the regression.
2. Apply Augmented Dickey-Fuller (ADF) test to the residuals $\tilde{y}_t$:

   $$\tilde{y}_t = \tilde{\alpha}\, \tilde{y}_{t-1} + \sum_{i=1}^{k} \tilde{c}_i\, \Delta y_{t-i} + \tilde{e}_t \quad \text{(D.10)}$$

   For quarterly data maximal 12 lags and for yearly data maximal 8 lags go initially into the ADF test. If the t-statistic of $\tilde{c}_i$ is smaller than 1.60, corresponding lag term $\tilde{c}_i\, \Delta y_{t-i}$ will be eliminated.

The calculated t-statistic can be compared to the critical values provided by Perron, which depend on time of the structural break. If t-statistic is greater than the critical value, the null hypothesis of a unit root cannot be rejected.

E The Solution of the Model under Full Hysteresis

Under full hysteresis hypothesis ($\lambda = 0$), the setting of targeted nominal wages w^* can be simplified as equation (6.13):

$$w^*: n^e = n_{-1} \qquad (6.13)$$

Replacing equation (6.6) with equation (6.13), the theoretical model under the assumption of full hysteresis is presented below:

Table E.1 The Theoretical Model under Full Hysteresis

$y=ø(d-p)+a\theta$	(6.1)
$y=n+\theta$	(6.2)
$p=w-\theta+\mu$	(6.3)
$\tilde{l}=\alpha(w-p)-bu+\tau$	(6.4)
$w = w^* + \gamma_1\varepsilon_d + \gamma_2\varepsilon_p$	(6.5)
$w^*:n^e=n_{-1}$	(6.13)
$u=\tilde{l}-n$	(6.7)
$\Delta d=\varepsilon_d$	(6.8)
$\Delta\theta=\varepsilon_s$	(6.9)
$\Delta\mu=\varepsilon_p$	(6.10)
$\Delta\tau=\varepsilon_l$	(6.11)

To solve $\Delta(y+p)-\Delta(w+n)$:

equation (6.3) gives $\quad p-w+\theta = \mu \qquad$ (E.1)

from (6.2) $\quad \theta = y-n \qquad$ (E.2)

replacing θ in equation (E.1) with (E.2) yields

$$(y+p)-(w+n) = \mu \qquad (E.3)$$

$$\Rightarrow \Delta(y+p)-\Delta(w+n) = \Delta\mu$$

$$\Rightarrow \Delta(y+p)-\Delta(w+n) = \varepsilon_p \qquad (6.14)$$

To solve $\Delta(w-p)$:

equation (6.3) gives $w-p = \theta-\mu$ (E.4)

$\Rightarrow \Delta(w-p) = \Delta\theta-\Delta\mu$

$\Rightarrow \Delta(w-p) = -\varepsilon_p + \varepsilon_s$ (6.15)

To solve Δn:

equation (6.2) gives $n = y-\theta$ (E.5)

replacing y in equation (E.5) with (6.1) yields

$n = ø(d-p)+(a-1)\theta$ (E.6)

replacing p in equation (E.6) with (6.3) yields

$n = ø(d-(w-\theta+\mu))+(a-1)\theta$ (E.7)

replacing w in equation (E.7) with (6.5) yields

$n = ø(d-(w^*+\gamma_1\varepsilon_d+\gamma_2\varepsilon_p+\mu))+(ø+a-1)\theta$ (E.8)

$\Rightarrow \Delta n = ø(\Delta d-\gamma_1\varepsilon_d-\gamma_2\varepsilon_p-\Delta\mu)+(ø+a-1)\Delta\theta$

$\Rightarrow \Delta n = -ø(1+\gamma_2)\varepsilon_p + (ø+a-1)\varepsilon_s + ø(1-\gamma_1)\varepsilon_d$ (6.16)

To solve Δu:

replacing $\tilde{l}$ in equation (6.7) with (6.4) yields

$u = \alpha(w-p)-bu+\tau-n$

$\Rightarrow (1+b)u = \alpha(w-p)+\tau-n$

$\Rightarrow (1+b)\Delta u = \alpha\Delta(w-p)+ \Delta\tau-\Delta n$ (E.9)

replacing $\Delta(w-p)$, Δn in equation (E.9) with (6.15), (6.16) yields

$\Delta u = (1+b)^{-1}\{[ø(1+\gamma_2)-\alpha]\varepsilon_p + (1+\alpha-ø-a)\varepsilon_s -ø(1-\gamma_1)\varepsilon_d + \varepsilon_l\}$

(6.17)

F Lag Exclusion Tests

VAR Lag Exclusion Wald Tests
Sample: 1970:1 2002:4
Included observations: 120

Chi-squared test statistics for lag exclusion:
Numbers in [ ] are p-values

	Δ(y+p)-Δ(w+n)	Δ(w-p)	Δn	Δu	Joint
Lag 1	1.554070 [0.817022]	14.53395 [0.005772]	70.11315 [2.15E-14]	185.4253 [0.000000]	281.4233 [0.000000]
Lag 2	26.90572 [2.08E-05]	19.36651 [0.000666]	20.26196 [0.000443]	13.57658 [0.008777]	60.24013 [4.77E-07]
Lag 3	7.892106 [0.095611]	25.08545 [4.84E-05]	10.42578 [0.033835]	18.60887 [0.000938]	48.04194 [4.68E-05]
Lag 4	20.40219 [0.000416]	25.69285 [3.65E-05]	18.46471 [0.001001]	17.07508 [0.001869]	102.6486 [1.10E-14]
Lag 5	18.27090 [0.001092]	31.21891 [2.76E-06]	13.88414 [0.007674]	18.49760 [0.000986]	84.90649 [2.15E-11]
df	4	4	4	4	16

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Hiermit versichere ich eidesstattlich, dass ich die vorliegende Arbeit selbständig und ohne Benutzung anderer als der angegebnen Hilfsmittel angefertigt habe. Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Die Arbeit wurde bisher in gleicher Form keiner anderen Prüfungsbehörde vorgelegt und auch nicht veröffentlicht.

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Li Su