TIME SERIES REPRESENTATIONS OF THE AUSTRIAN LABOR MARKET

Klaus NEUSSER

Forschungsbericht/
Research Memorandum No. 200

Mai 1984

ABSTRACT

This paper explores the time series properties of wages, prices, unemployment rate and interest in Austria. In the first part, uni- and multivariate ARMA representations are estimated, where the order of the lag-polynomial is estimated. Then the causal ordering of this variables is considered. The main results can be summarized as follows: the interest rate (nominal or real) is exogeneous to the others three variables and causes the unemployment rate (or equivalently employment) which in turn causes the wage (nominal or real) and the price. Whereas prices do cause the unemployment rate to some extent, there is no evidence of a feedback from wages to the unemployment rate. Furthermore, wages and prices do cause each other. Finally, these results are confronted with Lucas and Rapping's intertemporal substitution model and J.B. Taylor's staggered wage contract model. In contrast to recent findings for the U.S. the Austrian data are not in contradiction to the first model and present some support for the latter one.

TABLE OF CONTENTS

1. Introduction

The common practice of imposing spurious a priori restrictions in order to achieve identification of structural econometric models has been severely criticized. In particular, the inadequacy of building up a system incrementally from partial equilibrium models has been demonstrated by Sims (1980). His alternative strategy consists of estimating unconstrained vector autoregressive models in a first stage, treating all variables as endogeneous in order to avoid arbitrary a priori restrictions. After having summarized in this way the "facts" about the time series, hypotheses with economic content are formulated and tested.

Recently, this strategy has been employed by Ashenfelter and Card (1982) to investigate aggregate labor market time series. They show that the "facts" encountered in the US labor markets are not consistent with models "based on intertemporal substitution in labor supply, nor explicit models of wage and price stickiness". In this paper an attempt is made to extend their analysis and to apply the methodology to Austrian data. The first part presents estimation results of univariate and vector autoregressive models of the nominal wage, the price level, the unemployment rate, and the interest rate, and the causal relationships among these variables. This basic model is then modified by replacing the nominal wage by the real wage, and the nominal interest rate by the real interest rate. In contrast to Ashenfelter and Card, the order of the autoregressive processes is based on the principle of parsimony. In this empirical analysis emphasis is given to the unemployment-real wage relationship, which was found to be positive. In addition, employment is found to Granger cause the real wage. The Austrian evidence therefore does not confirm with the recent findings of Neftci (1978) and Sargent (1978), who obtained for the U.S. a negative causation of employment by the real wage, and of Geary and Kennan (1982), who found using data for 12 OECD countries (including Austria) that the two variables are approximatively independent of each other.

The second part is devoted to the confrontation between these results and the implications of the intertemporal substition model of Lucas and Rapping (1969) and the "long term wage contract" model of Fischer (1977) and Taylor (1980). It is found that the "facts" encountered in the Austrian labor market do not falsify the intertemporal substitution model. The wage contract model, on the other hand, is only partly supported by the Austrian data.

Since, in contrast to the U.S., Austria is a small open economy with a highly institutionalized wage-price setting process governed by social partnership ("Sozialpartnerschaft"), it should be no surprise that different conclusions have been reached out of the empirical analysis. The last part therefore explores the question, to what extent can the differences in the conclusions be attributed to the different institutional and economic environment.

2. Time series analysis of nominal wage, price, unemployment rate and interest rate

Since it is thought that many economic time series can be well approximated by low order mixed autoregressive-moving average models, time series analysis seems able therefore to summarize the cyclical movements inherent in economic data. In this way, guidance for specifying truly dynamic relationships is provided. This is important since economic theory, usually, is not very specific on this issue. Because building unrestricted vector autoregressive models by treating all variables as endogeneous requires the estimation of many parameters thereby exhausting quickly the available degrees of freedom, the order of the ARMA processes was kept "as low as possible". This principle of parsimony is reflected in the minimization of the BIC criterion (see Hannan and Rissanen (1982)) which is used to estimate the order of the approximating ARMA processes:

$$\log \sigma_{pq}^2 + (p+q)\,\frac{\log T}{T} \tag{2.1}$$

In the above, σ_{pq}^2 is the estimated variance of the innovations in the ARMA process of order (p,q) and T is the sample size. The idea behind this criterion is to penalize higher order models by (p+q) log T/T. This penalty compensates for the reduction in the variance of the innovations which is always brought about by an increase in the order of the model. It has been shown by Hannan and Rissanen (1982) that this procedure leads to consistent estimates of p and q.

In the study of causal orderings the principle of parsimony is not undisputed. Sims (1972) for example, chose a profligate parameterization in order to avoid a misspecification of the lag pattern which can result in serial correlation of the error term. Geary and Kennan (1982, p.856, fn.3) therefore conclude that "a parsimonious model tends to reject independence too often". However, as Hsiao (1981, p.86) pointed out test results are difficult to interpret in a profligately parametarized model: "Firstly, the tests are non-robust, namely, highly sensitive to nonnormality. Secondly, different but apparently reasonable and asymptotically equivalent formulas for the test statistic may give very different apparent significance levels for the same data. Thirdly, the distribution of test statistic is sensitive to the order of lags fitted to the first stage model."

2.1 Univariate AR and ARMA representations

The empirical analysis will be started by estimating ARMA models[1)] of the logarithm of the nominal wage (W), the logarithm of the consumer price index (P), the unemployment rate (U), and the interest rate on long term government bonds (R), where the order is estimated by using the BIC criterion. In this study quarterly averages of monthly gross earnings in manufacturing are used as an index of aggregate wages. Table 1 presents the univariate autoregressive representation of these four variables. The deterministic parts have been removed before by regressing all four series on a linear and a quadratic trend and on seasonal dummies. Even from this simple analysis it is apparent that the four series have quite different properties. Whereas the interest rate and the price admit an AR representation of order 2 and 1 respectively, the other two variables are best approximated by AR processes of order 6 and 4.

Because the estimated lag polynomials do admit complex roots, the AR models are able to generate cycles in response to innovations. It may therefore be useful to examine the spectra of the de-trended and de-seasonalized time series. For the wage the spectrum is concentrated at low and high frequencies thereby exhibiting a U shaped form. The spectrum of the unemployment rate exhibits peaks at $\pi/2$ and $\pi/6$, where the first one is higher. The corresponding length of the cycles are 1 and 8 years.

Table 1: Univariate autoregressive representation of wage, price, unemployment rate and interest rate

Parameters	Dependent variable W	P	U	R
AR1	-.43 (4.09)	-.96 (29.95)	-.65 (7.09)	-1.23 (11.45)
AR2	-.51 (4.40)		.07 (.85)	.38 (3.54)
AR3	.30 (2.87)		.06 (.68)	
AR4	-.68 (6.51)		-.73 (8.66)	
AR5	.12 (1.00)		.57 (6.18)	
AR6	.31 (2.97)			
Estimation period	63.1-83.1	63.1-83.1	63.1-83.1	64.4-83.1

t-values in parenthesis

When moving to ARMA representations[2], a very similar picture emerges. Again, the interest rate and the price are well approximated by a low order ARMA process, whereas the wage and the unemployment rate need higher order processes. With the exception of the interest rate the AR and the ARMA representations are of equal order. Also the spectra do not change very much. The only interesting change is the nearly complete disappearance of the 8 year cycle for the unemployment rate.

After having discussed the results for a particular time period, it is important to study whether the results do carry over to other periods. AR and ARMA models were therefore estimated over different periods and the results are given in table 3, where each entry consists of two numbers representing the estimated orders of the AR and the ARMA process. Unfortunately, the data for the interest rate only start at the last quarter of 1964, so that it was not possible to examine whether the low order representation does extent to longer time periods. The order of the AR and the ARMA model for the unemployment rate is not very sensitive to the estimation period; the order of the AR process remains always the same, only the order of the ARMA process does exhibit changes over time. For the two remaining time series changes in the estimated order are not very important. The only interesting observation is the lengthening of the order of the AR and ARMA models for the wage, when more recent observations are taken.

Table 2: ARMA representations of wage, price, unemployment rate and interest rate

Parameters	Dependent variable W		P		U		R	
AR1/MA1	-.41	-.05	-.96	.0007	-.49	.35	-1.40	-.39
AR2/MA2	-.57	-.15			.10	.07	.18	-.65
AR3/MA3	.21	-.21			.16	.19	.35	.54
AR4/MA4	-.67	-.02			-.59	.55		
AR5/MA5	.22	.47			.39	-.20		
AR6/MA6	.34	-.08						
Estimation period	63.1-83.1		63.1-83.1		63.1-83.1		64.4-83.1	

Table 3: Estimated order for AR and ARMA representations of W, P, U and R for different time periods

Estimation period	Time Series W	P	U	R
55.1-83.1	5,5	1,1	5,5	-
60.1-83.1	6,5	1,1	5,5	-
63.1-83.1	6,6	1,1	5,5	2,3
70.1-83.1	7,7	2,11	5,4	2,3
73.1-83.1	-	-	-	2,9
55.1-69.4	1,0	1,1	5,11	

In the tables 4a, 4b, and 4c, parameter estimates of AR models for the wage, the price, and the unemployment rate over different estimation periods are presented, where the order has been constrained to 7, 4, and 5, respectively. For the wage a decline in absolute value for AR1 can be observed, when the estimation period is successively reduced from 55.1-83.1 to 70.1-83.1; for AR2 an opposite movement is taking place. Furthermore, the increasing importance of the wage lagged 6 quarters should be noted.

By comparing the period 55.1-69.4 and 70.1-83.1 it is obvious from table 4b that for the representation of the price important changes have also taken place. The coefficient of P_{-1} changed from -.34 to -1.10, when at the same time AR4 changed from a significant coefficient of -.26 to an insignificant one of .17.

For the unemployment rate the invariance of the estimated order is to some part reflected in stable coefficients. The only important changes implied by table 4c are respectively the increase and the decrease in absolute value of AR1 and AR4.

Table 4a: Estimated parameters of an AR(7) process fitted to W over different estimation periods

Parameters	Estimation period				
	55.1-83.1	60.1-83.1	63.1-83.1	70.1-83.1	55.1-69.4
AR1	-.50	-.43	-.39	-.08	-.26
	(5.38)	(4.12)	(3.54)	(.65)	(2.06)
AR2	-.32	-.46	-.49	-.64	.02
	(3.07)	(4.17)	(4.28)	(5.60)	(.12)
AR3	.16	.24	.21	.22	.07
	(1.49)	(2.02)	(1.63)	(1.74)	(.57)
AR4	-.63	-.68	-.64	-.23	-.33
	(7.13)	(6.86)	(5.89)	(1.89)	(2.71)
AR5	.27	.14	.05	-.53	.16
	(2.58)	(1.22)	(.37)	(4.29)	(1.26)
AR6	.06	.25	.26	.31	.01
	(.57)	(2.29)	(2.23)	(2.73)	(.10)
AR7	.09	.04	.13	.48	.21
	(.92)	(.40)	(1.21)	(3.95)	(1.69)

t-values in parenthesis

Table 4b: Estimated parameters for an AR(4) process fitted to P over different estimation periods

Parameter	Estimation period				
	55.1-83.1	60.1-83.1	63.1-83.1	70.1-83.1	55.1-69.4
AR1	-.73	-1.04	-1.09	-1.10	-.34
	(7.82)	(10.10)	(9.89)	(8.10)	(2.74)
AR2	.00	.25	.26	.01	.07
	(.03)	(1.69)	(1.59)	(.05)	(.50)
AR3	-.11	-.26	-.22	.06	-.07
	(.94)	(1.78)	(1.34)	(.31)	(.54)
AR4	-.09	.11	.10	.17	-.26
	(.96)	(1.03)	(.88)	(1.23)	(2.11)

t-values in parenthesis

Table 4c: Estimated parameters of an AR(5) process fitted to U over different estimation periods

Parameters	Estimation period				
	55.1-83.1	60.1-83.1	63.1-83.1	70.1-83.1	55.1-69.4
AR1	-.58 (7.73)	-.56 (6.29)	-.65 (7.09)	-.73 (5.90)	-.52 (4.86)
AR2	.07 (1.44)	.05 (.59)	.07 (.85)	.20 (1.31)	.09 (1.01)
AR3	.05 (.99)	.03 (.42)	.06 (.68)	-.11 (.75)	.11 (.07)
AR4	-.82 (15.73)	-.70 (9.01)	-.73 (8.66)	-.39 (2.61)	-.70 (7.72)
AR5	.60 (8.00)	.51 (5.73)	.57 (6.18)	.44 (3.52)	.55 (5.09)

t-values in parenthesis

2.2 Vector autoregression

In this section the vector autoregressive representation of W, P, U, and R is presented. The estimated order of its univariate autoregressive representation was taken as the lag length for each variable. The results for the estimation periode 65.2-83.1 are reported in table 5. Since in the following F tests (which in our case have to be considered asymptotically) will be used, it is important, in order to assess their validity, that the disturbance terms are normally distributed with no autocorrelation. For this end, a series of test statistics have been computed. Because the estimated equations contain lagged endogeneous variables on the right hand side, the usual Durbin-Watson test can be misleading. Therefore, two test procedures proposed by Bre sch and Pagan (1980) and Godfrey (1978) which take into account this fact are computed. In the rows labeled LM1 and LM4 the results of the former procedure which test for first and fourth order autocorrelation respectively are listed. Under the null hypothesis that there is no autocorrelation this test statistic is normally distributed with mean zero and unit variance. The second procedure whose results are reported in the row labeled GODFREY, tests the hypothesis that there is no autocorrelation of first, second, third and fourth order against the alternative that there is at least one non-zero autocorrelation coefficient. This test statistic is distributed as a χ^2 with 4 dregrees of freedom under the null hypothesis. The normality of the disturbance term is assessed by a test proposed by Jarque and Bera (1980) which is based on measures of skewness and kurtosis of the resid als. The test statistic is distributed as a χ^2 with 2 degrees of freedom under the null hypothesis that the residuals are normally distributed. Its value is reported in the row labeled NORMAL.

Since the estimation period covers nearly 20 years attention is called to the question of structural homogeneity of the estimated regressions. A method which does not presuppose, as for example the Chow test does, that the investigator knows the point in time where a structural break might have occured, is to compute the so-called Quandt-ration (see Quandt (1960)). For any given time point in the estimation period this value is defined as the logarithm of the ratio of the maximum of the likelihood under the null hypothesis over the maximum of the likelihood under the alternative hypothesis, where H_0 is the hypothesis that no break has occured at this time point and H_1 is the hypothesis that there has been a break. The Quandt-ratio is then computed for all possible time points in the estimation period and an estimate of the time point where a structural might have occured is provided by the time point at which the minimum of these ratios is obtained. The row labeled QUANDT lists this time points and underneath in parenthesis the corresponding value of the Chow-test.

In the wage equation the statistics indicate that the disturbance term is normally distributed with no autocorrelation present. Furthermore, the CHOW and the QUANDT test do not reject the hypothesis of structural homogeneity over time. Except for the interest rate, each variable has some significant coefficients at some lag.

The results for price equation are not that satisfactory. Formally, the LM and the GODFREY statistic do not imply, at a significance level of 5 per cent, the presence of autocorrelation. But, since these test are conservative, the hypothesis of no autocorrelation should not be accepted without reservation. Furthermore, the assumption of a normally distributed disturbance term must be rejected. Therefore, the F tests which will be carried out in section 2.3 have to be interpreted with caution. A further indication of the poor performance of this regression is that the hypothesis of stability over time must be rejected. One reason for the deficiency of this equation may lie in the extremely short lag length of the price variable. By increasing its lag length, the problem of autocorrelation disappeared but the disturbances remained highly non-normally distributed.

For the unemployment equation similar problems - although not too severe -arise concerning the properties of the disturbance terms. LM4 indicates the presence of fourth order autocorrelation. Also the normality of the error term must be rejected given a significance level of 5 per cent. With respect to stability over time, there is no indication of a structural break. Apart from the lagged endogeneous variable, only the interest rate has a coefficient with a significant t-value.

Table 5: Vector autoregressive representation of wage, price, unemployment rate and interest rate

Regressors	Dependent variable W	P	U	R
W_{-1}	.39 (3.17)	.10 (2.06)	-1.37 (.81)	1.41 (.85)
W_{-2}	.19 (1.46)	.07 (1.45)	.15 (.08)	-.22 (.12)
W_{-3}	-.39 (3.51)	-.07 (1.79)	1.03 (.68)	-1.85 (1.24)
W_{-4}	.63 (6.07)	.07 (1.74)	1.50 (1.05)	-1.90 (1.36)
W_{-5}	-.08 (.72)	.03 (.66)	1.31 (.81)	.92 (.59)
W_{-6}	-.37 (3.50)	-.06 (1.50)	.29 (.20)	.75 (.52)
P_{-1}	.81 (3.03)	.78 (7.65)	-6.36 (1.72)	.56 (.15)
U_{-1}	-.021 (2.30)	-.003 (.89)	.49 (3.94)	-.20 (1.61)
U_{-2}	.022 (2.62)	.000 (.02)	-.13 (1.10)	.07 (.58)
U_{-3}	-.030 (3.48)	-.000 (.06)	.00 (.03)	-.17 (1.47)
U_{-4}	.007 (.77)	-.007 (2.18)	.70 (5.71)	.00 (.01)
U_{-5}	.004 (.48)	.011 (3.34)	-.42 (3.45)	.10 (.87)
R_{-1}	-.005 (.50)	.003 (.73)	-.16 (1.22)	1.33 (10.59)
R_{-2}	.004 (.37)	.000 (.06)	.41 (2.89)	-.43 (3.07)
R^2	.912	.958	.812	.902
SE	.01877	.00715	.25913	.25464
LM1	1.082	1.624	.090	1.275
LM4	.821	1.555	2.262	.276
GODFREY	5.406	8.685	8.520	3.931
NORMAL	.256	50.807	6.042	.721
QUANDT	79.2 (1.310)	69.1 (4.566)	79.3 (1.061)	69.1 (.993)

t-values in parenthesis

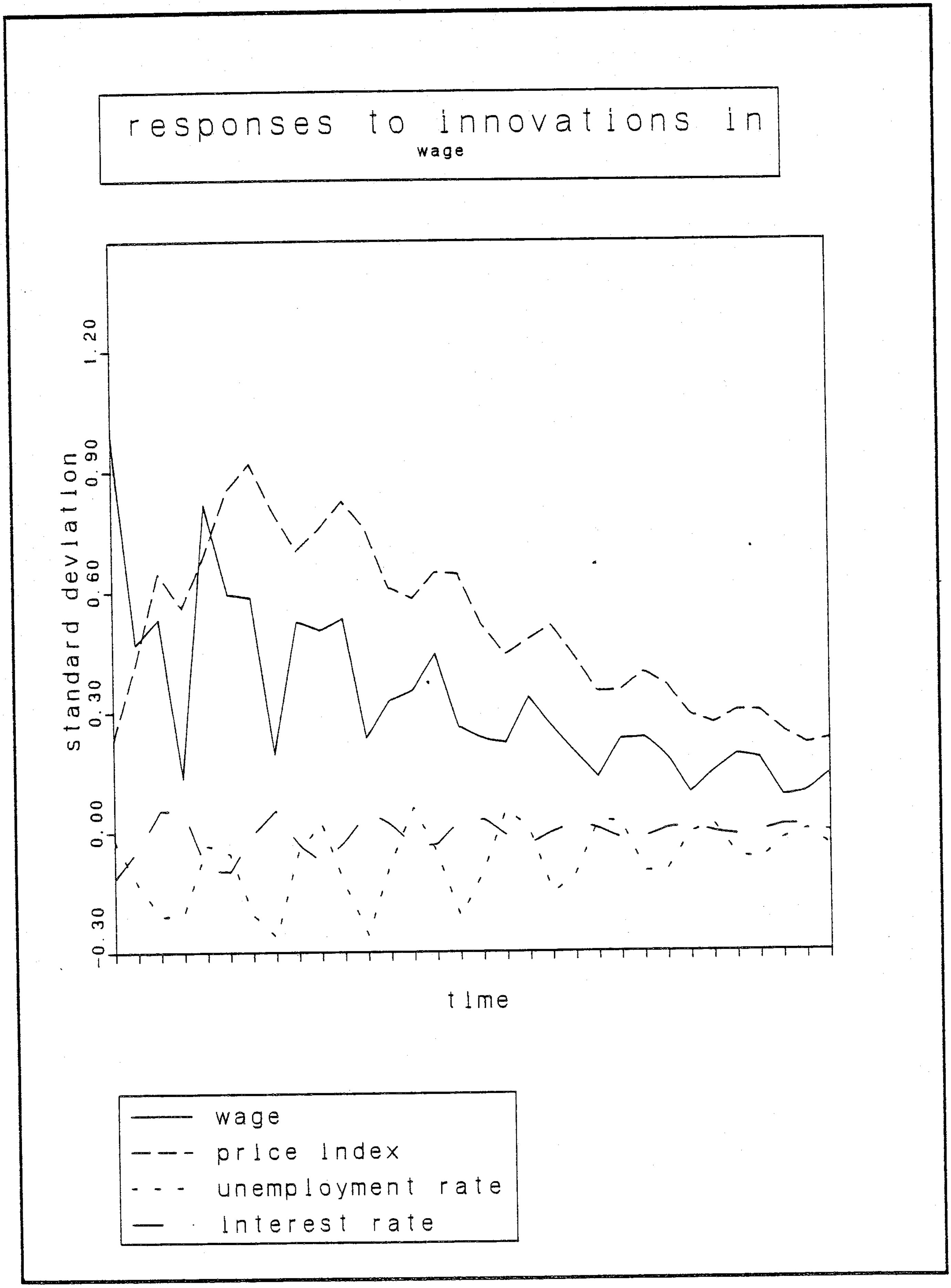
Table 6 provides estimates of the correlation among innovations derived from the regression results in table 5. In sharp contrast to Ashenfelter and Card (1982, p.765) only the correlation between the innovations of P and W, and U and P are of sizeable magnitude. Price surprises are positively correlated with the unemployment rate.

Table 6: Correlation matrix of innovations in vector AR

		Innovations in			
		W	P	U	R
Innovations in:	W	1.0			
	P	.225	1.0		
	U	-.017	-.289	1.0	
	R	-.118	.091	-.110	1.0

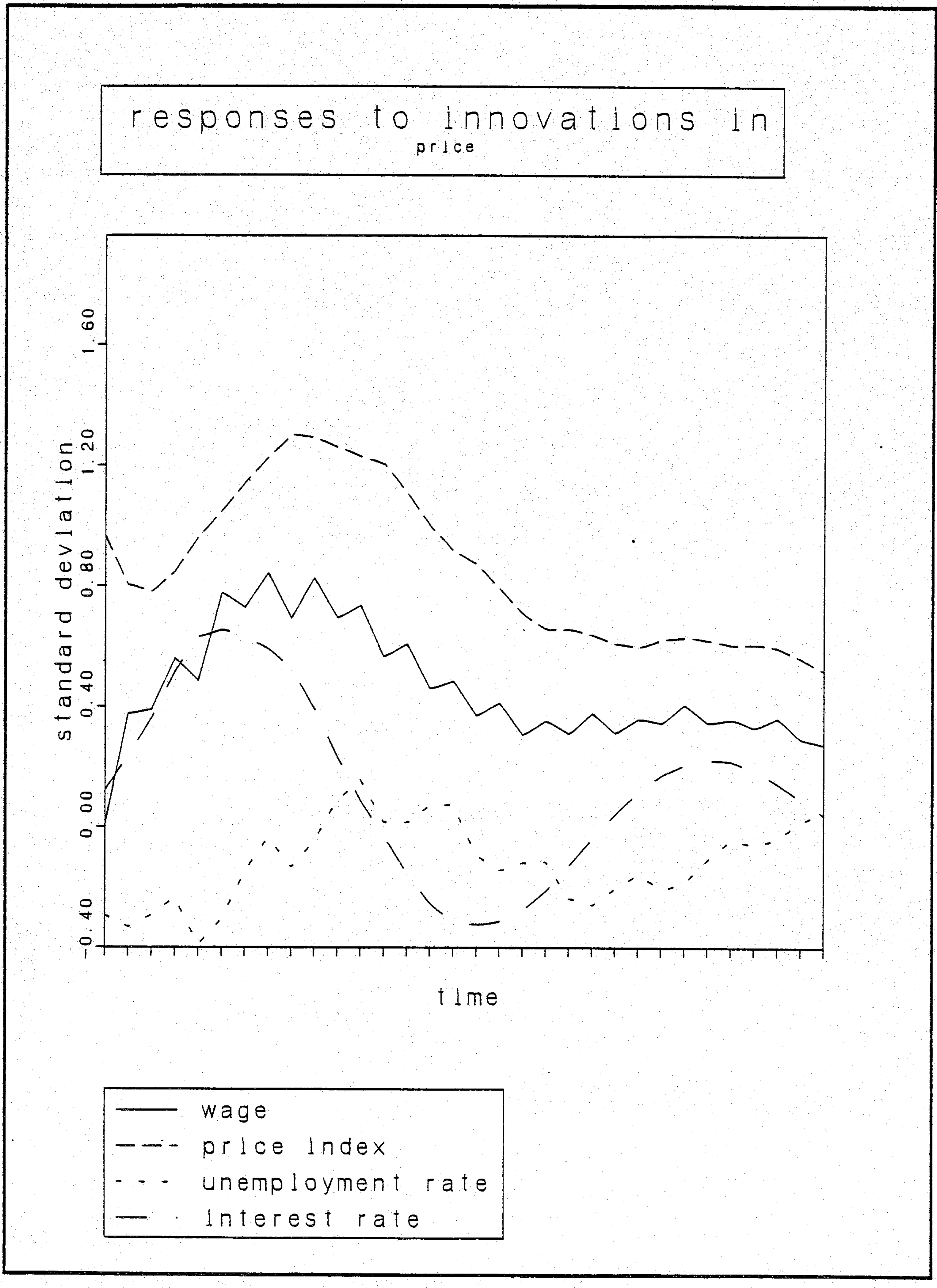
In order to understand the dynamic interactions of the system presented in table 5, its response to "typical random shocks" will be analyzed. Using the technique introduced by Sims (1980), this corresponds to tracing out the systems moving average representation. The ordering in these simulation experiments has be set a priori to W, P, U, R. Consider first the response to an innovation of one standard deviation in the wage (see figure 1). The immediate reaction in the next quarters is a rise in price and a fall in wage which tend to reduce the initial increase in the real wage; but will not offset it completely. Due to the price increase unemployment declines slightly. The effect on the interest rate is small. A positive price innovation (see figure 2) is followed by a rise in wage and a fall in price, which more then offsets the decline in real wage. This development leads to a pronounced reduction in unemployment for nearly 3 years, despite the higher real wage. An improvement in competitiveness seems therefore to have a strong effect on the Austrian economy. Consider now a positive shock to the unemployment rate (see figure 3). This will be followed by a reduction in wages, prices and interest rate; wages thereby falling more than prices. An interest rate shock (see figure 4) leads to a deterioration of the real wage, since price increses but nominal wage remains nearly constant. At the same time a considerable increase in the unemployment rate is observed, which is reversed only after three years.

Figure 1



responses to innovations in
wage
standard deviation
1.20
0.90
0.60
0.30
0.00
-0.30
time
wage
price index
unemployment rate
interest rate

Figure 2



responses to innovations in
price
standard deviation
1.60
1.20
0.80
0.40
0.00
-0.40
time
wage
price index
unemployment rate
interest rate

Figure 3

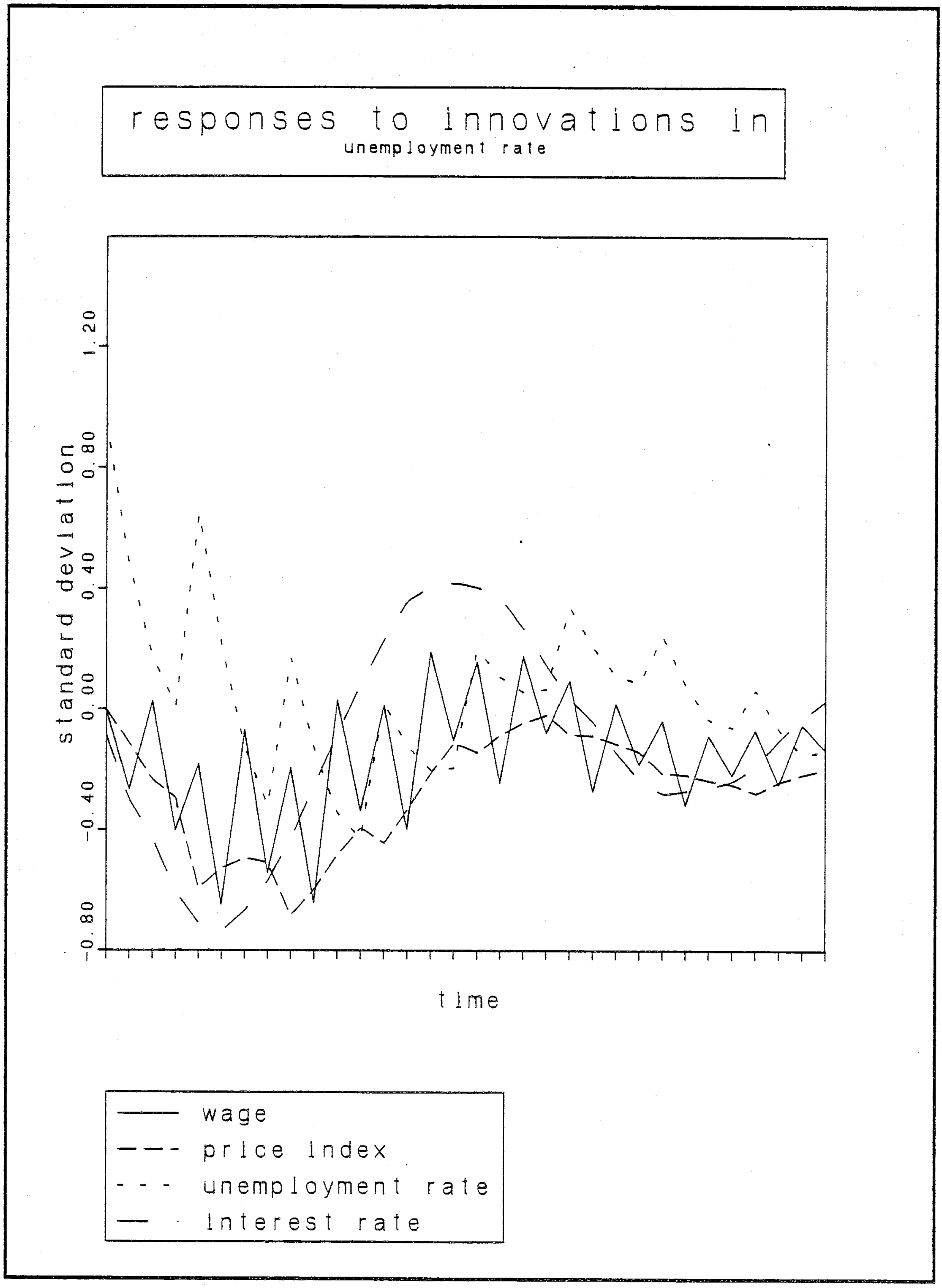
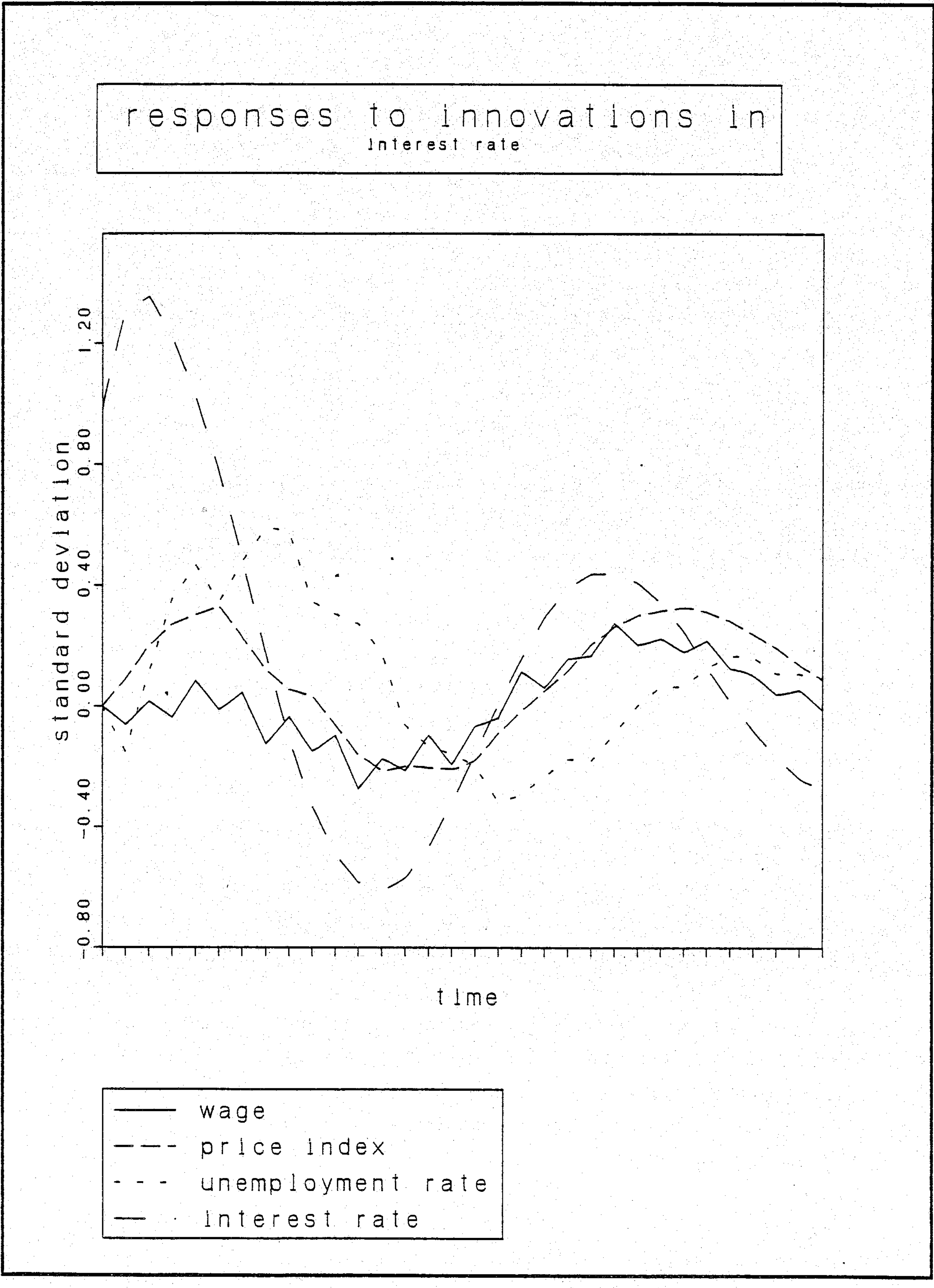

responses to innovations in
unemployment rate
standard deviation
1.20
0.80
0.40
0.00
-0.40
-0.80
time
wage
price index
unemployment rate
interest rate

Figure 4



responses to innovations in
interest rate
standard deviation
1.20
0.80
0.40
0.00
-0.40
-0.80
time
wage
price index
unemployment rate
interest rate

2.3 Causal ordering

After the four time series have been represented as a vector autoregressive process, it is now possible to test for the presence of Granger-Wiener causality between them. As was emphasized by Hansen and Sargent (1980), the concept of Granger-Wiener causality arises naturally in formulating and estimating dynamic equilibrium models of economic time series, "as it is coincident with the condition for the appearence as an information variable in an agent's decision rule of a variable not otherwise in the agent's criterion function or constraints." (Sargent (1981), p.217). The causal relations or the lack thereof will therefore have important implications for the validity of the rational expectations models discussed in section 3.

Formally, Granger's (1969) definition of causality can be expressed as follows. Let (x,y) be a purely non-deterministic bivariate process. Then x is said to cause y, when the knowledge of past realisations of x will help to better predict y, given part realisations of y. In the context of a vector autoregressive model this amounts to test whether all coefficients related to a particular variable in a particular equation are simultaneously equal to zero. If this hypothesis is rejected, the variable to which the coefficients belong is said to cause the variable on the left hand side of the equation under consideration. The tests of these hypothesis will be carried out usin the usual F-statistics which have to be interpreted asymptotically. Other theoretically equivalent methods are discussed in Pierce and Haugh (1977).

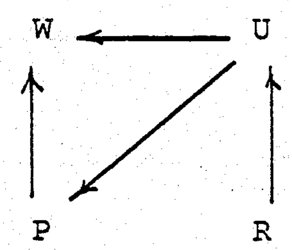
But before proceeding further it should be pointed out that the notion of causality only has a meaning within a given theoretical framework (see Zellner (1979)). Otherwise, the investigator is not sure that the detection of causal relationship between two variables is not just a reflection of a third variable causing the other two. The problem is very similar to the spurious correlation problem in regression analysis. To overcome this difficulty the class of models which are intened to be confronted with the "facts" has been restricted a priori.

By setting the significance level to 1% it is possible to detect four causal relationships in the autoregressive representation of W, P, U, and R. They are summarized in Figure 1a, where a causation running from x to y is designated by "$x \rightarrow y$". From there it can be deduced that wages are caused by prices and unemployment but not by the interest rate. Prices are caused by unemployment.

This relationship corresponds well to the strong negative correlation between the innovations in these two variables. Unemployment is caused solely by the interest rate. The interest rate on the other hand is caused neither by W, P or U. R is therefore exogeneous to this system.[4] Figure 1a suggests on the one hand that by influencing R monetary policy can have important effects on the real economy, but on the other the exogeneity of R implies that the monetary authority did not react or, because of the openess of the economy, could not react to real shocks.[5]

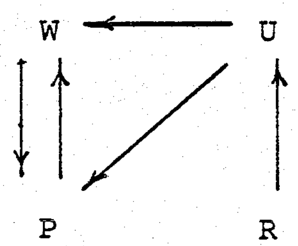
The increase of the significance level to 5%, leads to a feedback from W to P (see Figure 1b). Increasing the significance level again to 10%, a feedback from P to U is detected (see Figure 1c) which reinforces again the close relationship between prices and unemployment.

Figure 5: Causality relationship between W, P, U and R



Significance level 1 %

(a)



Significance level 5 %

(b)

$$
\begin{tikzcd}
W \arrow[d, shift right] & U \arrow[l] \arrow[dl, shift left] \\
P \arrow[u, shift right] \arrow[ur, shift left] & R \arrow[u]
\end{tikzcd}
$$

Significance level 10 %

(c)

2.4 Replacing the nominal wage by a real wage

Until now only nominal magnitudes have been analysed. In this section it is intended to expand the analysis to include a real wage. The real wage has been computed by deflating the quarterly average of monthly gross earnings in manufacturing by the consumer price index. The de-trended and de-seasonalized logarithm of this variable is then denoted by WR. Its AR and ARMA representations are reported in table 7. The estimated order of the approximating autoregressive process is 4 and therefore lower than the order of W but higher than the order of P. From the four parameters only AR2 and AR4 are significant at a 5% significance level. The estimated order of the ARMA representation is (6,6), which is equal to the order of the process approximating the nominal wage. However, it should be mentioned that by changing the estimation period to 55.1-69.4 or 70.1-83.1 WR seems to be white noise.

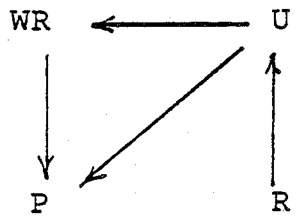
Table 7: Univariate AR and ARMA representations of the real wage

Estimation period: 63.1 - 83.1

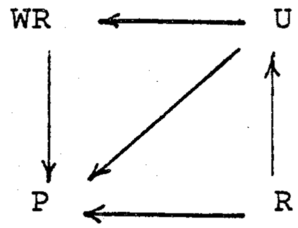
Parameters	AR	ARMA
AR1	-.15 (1.52)	.26
AR2	-.32 (3.37)	-.24
AR3	.18 (1.95)	-.06
AR4	-.51 (5.41)	-.62
AR5		.14
AR6		.31
MA1		.62
MA2		.40
MA3		-.07
MA4		.02
MA5		.52
MA6		.52

t-values in parenthesis

Figure 6: Causality relationship between real wages, prices, unemployment and interest rate



(a)

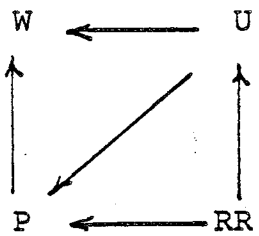


(b)

Significance level 1 %

Significance level 5 %

Figure 7: Causality relationship between wages, prices, unemployment and the real interest rate



Significance level 1 %

In the remainder of this section the relationship between employment and real wage is analyzed, which has puzzled economists at least since the time of Keynes. Assuming that the labor demand schedule, which has been derived from marginal productivity conditions and is therefore downward sloping, is fixed in the short run - because of unchanged technology and capital stock -, an increase in employment should be accompanied by a decrease in the real wage. (Keynes (1936), p.17, p.289). This implication was contradicted by early empirical studies (Bodkin (1969)). They found, if anything, a positive correlation between employment and the real wage. In more recent studies, Sargent (1978) and Neftci (1978) claimed that by appropriately specifying the dynamics of the underlying problem the observations on real wage and employment are indeed lying on the negatively sloped demand schedule. However, Geary and Kennan (1982) showed that the results of Neftci and Sargent are an implication of deflating the nominal wage by the consumer price index and not by the whole sale price index, which in their view is a better measure of the firm's demand price for labor. There findings suggest that employment and real wage are approximately independent. A fact which can not be explained using the equilibrium labor market model developed by Sargent (1979, p. 370-378) (see Geary and Kennan (1982), p. 866).

Since the Geary-Kennan empirical analysis was conducted for 12 OECD countries including Austria, it is interesting to reconsider their results. The nominal wage has therefore been replaced by the real wage (denoted by WR), where the consumer price index has been used as a deflator. Using the same methodology as in the previous paragraphs, the following relationships, which are described in figure 2, can be detected. Setting the significance level to 1 per cent, the real wage causes price and is caused by the unemployment rate, which is independent of the real wage and only caused by the interest rate. Since the relationship between WR and U is significantly negative in the short-run as well in the long-run, the Austrian experience seems to support the view that it is not the supply curve which moves along a stable demand curve, but that instead the demand schedule is moving along a relatively stable supply curve. This conclusion, however, presupposes that innovations in demand and supply are uncorrelated, since under this assumption partial identification can be achieved. This has been pointed out by Leamer (1981, p.326): "... it does make sense to regress quantity on price and then to take the estimated function to be a supply curve or a demand curve depending on the sign of the estimated elasticity." These results do not change when the unemployment rate is replaced by total employment. But, the use of employment in industry, leads to a feedback from the real wage, which exhibits long-run homogeneity. This results are not altered, when the suggestion of Geary and Kennan is followed of deflating the nominal wage by a manufacturing price index.[6)]

Since the empirical studies mentioned above have not controlled for lagged price and interest rate effects, bivariate representations of the different measures of the real wage and employment have also been estimated. With one exception the causal relations between these variables are not changed. This exception concerns the causation for the real wage by industrial eymployment, where the real wage has been computed by deflationing the nominal wage by the wholesale price index.

The Austrian data therefore seem to contradict the results of Geary and Kennan in that real wage and employment are not independent of each other and the results of Neftci and Sargent, because the relation between these two variables are not negative but positive. Since labor has been hoarded during the recessions of the 1970's, at least in the nationalized industry which have substantial share of total output, the models proposed by Lucas (1970) and Sargent (1979, p.388 ff.) seem to be relevant for the Austrian case, since they are based on variations in the rate of capital utilization and on increasing costs of increasingly rapid adjustment of straight-time labor.

2.5 Replacing the nominal interest rate by a real interest rate

Finally, the nominal interest rate is replaced by a real one. It is defined as the nominal interest rate prevailing at time t minus the expected inflation rate from time t to time t+4 (time is measured in quarters). Because the expected inflation rate is unobservable, it will be replaced by its actual realization to give the ex-post real interest rate. "Under the assumption of rational expectations, the deviation of ex-post and ex-ante real interest rates is therefore serially uncorrelated and orthogonal to information available at the start of the holding period." (Ashenfelter and Card (1982), p.768). Causality tests by W, P, U on the ex-post real interest can therefore be interpreted as causality tests on its ex-ante counterpart. The univariate AR and ARMA representations of the ex-post real interest rate are presented in table 8. Like the nominal interest rate its real counterpart is best approximated by an AR process of very low order.

Table 8: Univariate AR and ARMA representations of the ex-post real interest rate

Estimation period: 64.4 - 82.3

parameters	AR	ARMA
AR1	-.84 (13.4)	-.84
MA1		.12

t-value in parenthesis

The causal ordering in this case can be depicted in figure 3. At a significance level of 1%, the results derived previously are not altered substantially. Like the nominal interest rate its real counterpart can be considered as exogeneous to W, P, and U. The only difference is that the price is now caused by the real interest rate and the unemployment rate but no longer by the wage. An increase in the significance level does not generate additional relationships.

3. Models of the labor market

Having summarized the "facts" encountered in the Austrian labor market, two alternative theoretical models will be discussed. The first one is the intertemporal substitution model proposed by Lucas and Rapping (1969), the second one is Taylor's (1980) model of staggered wage contracts. The former model has only recently been the subject of empirical investigations (see Altonji and Ashenfelter (1980), Altonji (1982), Ashenfelter and Card (1982) and Clark and Summers (1982)). The results have not been in favour of the intertemporal substitution model. A similar statement can be made for the staggered wage contract model, according to Ashenfelter and Card (1982). These disappointing results suggest that simple models based only on one facet are not able to explain aggregate labor market behavior.

The difficulty in trying to confront the "facts" with these models is that the latter are not formulated in a way to make such a discrimination directly possible. The models are therefore recast in terms of time series methodology and causal ordering.

3.1 The intertemporal substitution model

In the Lucas and Rapping (1969) model today's labor supply decision is made dependent on the expected future relative price between consumption and leisure. It is asserted that households will increase their labor supply in periods where they perceive relatively high real wages and reduce it in periods of relatively low real wages. Under the assumption that the household can borrow or lend all the amount it desires at the given market determined interest rate, the following labor-supply schedule can be derived (see Sargent (1979), p.368-370):

$$\begin{aligned} l_t = a_0 + a_1 \ln\left(\frac{A_t}{P_t}\right) + \sum_{j=0}^{\infty} h_j E_t w_{t+j} \\ + \sum_{j=0}^{\infty} g_j E_t [r_{t+j} - \pi_{t+j+1}] + e_t \end{aligned} \tag{3.1}$$

where l_t and w_t are the logarithm of the labor supply and the real wage in period t, A_t is the nominal quantity of assets held by the household in period t, P_t the price level in period t, r_t the nominal one-period interest rate, π_{t+1} the inflation rate between period t and t+1 and e_t a random process. E_t denotes the expectation given the available information set at time t. So that, $E_t\ r_t - \pi_{t+1}$ is the expected real interest rate.

The pattern of labor supply described above will imply that for a low index j h_j is positive and that for a high index j h_j is negative. Especially it is assumed that a temporary increase in the current real wage induces a higher labor supply. The presence of the expected real interest rates in the labor supply schedule (3.1) is a consequence of the assumption that the household is able to transform today's labor via the asset market into tomorrow's consumption. The impact of these explanatory variables is not restricted a priori. However, under the assumption that current leisure is a substitute for leisure and consumption in every future period, it is possible to demonstrate that the g_j should be positive and non-increasing. A rise in the expected inflation rate which is not reflected in a one-for-one change in the nominal interest rate will lower the real return on today's labor and will, consequently, lead to a reduction in current labor supply.

The equation (3.1) can be simplified under certain assumptions. First of all, the real wealth term is dropped from the labor supply schedule. A second qualification, which is often made in this context, is that labor supply is perfectly inelastic with respect to changes in real wages, which are perceived to be permanent. This implies that the sum of the h_j is equal to zero. It is then legitimate to summarize all expected future real wages into a single index w_t^*, which can be interpreted as the average long-run expected future real wage. Equation (3.1) can therefore be simplified to:

$$l_t = a_0 + h_0(w_t - w_t^*) + \sum_{j=0}^{\infty} g_j\, E_t\, [r_{t+j} - \pi_{t+j+1}] + e_t \qquad (3.2)$$

where w_t^* is defined as

$$-\frac{1}{h_0}\sum_{j=1}^{\infty} h_j \, E_t \, w_{t+j}$$

Following the rationale of Lucas and Rapping, workers who choose not to work because of low transitory real wages will show up as unemployed. The deviation of labor supply from its trend can therefore be interpreted as a measure of unemployment. This reasoning allows to use the labor supply interchangeably for the unemployment rate. A fact that is supported by the empirical results of the previous section.

A further simplification which is often made in this context is to treat expected real interest rates as constant. There has been some empirical support for this assumption for the period of the early 1950's to the early 1970's (see Fama (1975) and Mishkin (1983)). But since the estimation period in this study includes the period after the oil-price shock, where real interest rates started to rise dramatically, this assumption can not be maintained. Potentially there are two ways in which the real interest rate can cause employment. The first one operates directly by determining labor supply according to equation (3.2). Since the case of a constant real interest rate has been ruled out, this line of causation is expected to prevail. The other way is by improving the forecast of future real wages. In this case real wages should be caused by the real interest rate; an assumption which is not true in the Austrian case.

For most economic time series the current value of a variable is to a large extent determined by its own past. A fact that is also true for the labor supply time series in Austria and the United States. Any labor market model must therefore explain the causation of l_t by l_{t-j} $(j \geq 1)$. One way to rationalyze this has been presented by Sargent (1979). He assumes that individuals are cut off from the loan market and that the adjustment in labor supply is costly. But this explanation is ruled out in the intertemporal substitution model since the underlying utility function is assumed to be time-separable (see Kennan (1983)). . Another way is to assume that the errors in the labor supply are serially correlated. This assumption is ad hoc and therefore not satisfactory. A third way is to assume that labor supply is causing the real wage, so that the knowledge of past labor supply is improving the forecasts of future real wages. This is the only explanation which is inherent in the Lucas and Rapping model. In contrast to evidence found for the USA (see Geary and Kennan (1982), Ashenfelter and Card (1982)), the Austrian data do show a causation of the real wage by lagged labor supply. This reflects the fact that the situation in the labor market influences the bargaining power of the social partners which are involved in the wage and to some extend also in the price setting process.

By and large it is not possible to reject the intertemporal substitution model for Austria on the grounds of causal orderings. What is necessary in a next step is to implement and test restrictions implied by an explicit equilibrium model of the labour market. A first step in this direction has already been made by Kennan (1983).

3.2 The staggered wage contract model

An alternative to the intertemporal substitution framework, which is based on an instantaneously clearing labor market, is given by models incorporating wage rigidities. Two promiment examples of such models have been presented by Fischer (1977) and Taylor (1980). The discussion in this paper will follow only the latter one because of its stringent implications for the ARMA representations of the wage, the price and the unemployment process.

In Taylor's model the rigidity arise from overlapping wage contracts. The two principle assumptions underlying this model have been summarized by Taylor (1980, p.2) as follows: "(1) wage contracts are staggered, that is, not all wage decisions in the economy are made at the same time; and (2) when making wage decisions, firms (and unions) look at the wage rates which are at other firms and will be in effect during their own contract period". Although Taylor does not give a theoretical rationale for the existence of such contracts, it is clear that their presence is an important ingredient governing the economic process. This is especially true for a country like Austria, which is highly unionized and where wages are centrally negotiated.

From the Taylor model four important implications can be derived (see Ashenfelter and Card (1982, p.775-776). First, the orders of the AR and MA parts in the univariate ARMA representation of the nominal aggregate wage are both equal to the lenght of the underlying contracts. An examination of the different wage rounds shows that contracts have usually been in place for twelve to fifteen months; but duration up to 22 month have also been observed. In more recent years contract length show a tendency to be in effect twelve months. Since the model has been estimated using quarterly time series, the order of the ARMA representation of the nominal wage is to be expected 5 or 6. The examination of table 3 reveals that the estimated orders are indeed lying in that range.[3)]

Second, unemployment should have the same stochastic structure as nominal wages and prices. This is approximatly true for the unemployment rate (see tables 1,2,3,4a and 4c), but not for prices which are governed by a completely different process (see tables 1,2,3,4b).

Third, "if workers fail to consider the aggregate consequences of their wage demands, or if the monetary authority fully accomodates their wage demands, then the nominal wage process will be non-stationary" (Ashenfelter and Card (1982, p.776). This means that the polynomial derived from the univariate AR representation of wages has a unit root. The moduli of the six roots implied by the coefficients of the AR representation of W in table 1 are .882, .883, .952, .878, .879, and .549. Since the modulus of the third root is close to one, the possibility of a non-stationary wage process can not be excluded.

Fourth, unemployment should not cause the nominal wage currently negociated. However, this does not exclude the possibility that the aggregate nominal wage, which is a weighted average of currently negotiated and past wages, is caused by unemployment. This question must be left open, since the causation of currently negociated wage settlements has not been treated here.

All in all, the empirical results for the staggered wage contract model are less satisfactory than for the intertemporal substitution model. But it should be mentioned that the implications for the former model have been derived under several important qualifications. First, the distribution of contract expirations is not uniform; contracts are rarely negociated in summer. Second, the stochastic nature of the shocks in the wage setting equaton or the aggregate demand equation can be modified. Third, the relative wage setting rule can be replaced by a purely forward looking real wage setting rule. This rule may be a good description of Austrian wage settlements. The unions' target has usually been to get compensation for the expected price increases and for productivity growth.

4. Comparison of the results for the United States and Austria

After having followed the paper of Ashenfelter and Card very closely, it is now time to compare their findings with the ones reported here. Since their results are not consistent with either the intertemporal substitution model or the wage contract model, it is interesting if these negative results do carry over to other countries. The Austrian case may be very interesting in this context, since in contrast to the United States it can be characterized as a small open, socially oriented free market economy with a highly institutionalized wage-price setting process. A discussion of the Austrian economic process can be found in Arndt (1982).

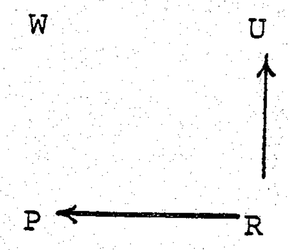
Apart from the unemployment rate, the univariate autoregressive representations of wage, price, and interest rate have quite different properties in the two countries. Whereas in the United States P and R are best approximated by a high order autoregressive process the contrary is true for Austria; and the reserve is true for the wage. The same remarks extend to the ARMA representations.

Before comparing the causal relationships, it is first useful to summarize the Ashenfelter and Card results by applying the same terminology used in the construction of figure 1. To achieve comparability with figure 1 only the test results computed from a regression which includes all variables have been used. An exception to this is the weak causation running from P to W. The results from this procedure are reported in figure 4. Comparing it with figure 1 it is apparent that the only similarities between the two economies are that wages and prices are more a less interdependent and that unemployment rate is caused by the interest rate.

A major difference seems to lie in the causal relationships between prices and unemployment which are highly significant in Austria. A further important issue are the different roles played by the wage and interest rate. Whereas R is exogeneous in Austria it is endogeneous for the United States, being caused by W and U and to a weaker extent by P. A similar statement caries over to the analysis of real interest-rates. On the other hand the hypothesis of an exogeneous wage must be rejected for Austria since it is caused by P and U. In the United States wages can - excluding the weak causation from P - be considered as exogeneous.

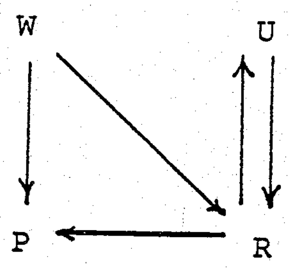
The differences may be attributed to the different roles played by the monetary authorities in the two countries. In Austria, wage setting behavior and monetary policy are strongly connected, the latter on playing a more positive role - given its exchange rate goal. In the US, on the contrary, the monetary authorities policy is to a large extend governed by the behavior of prices. One reason for the difference in the relation between wages and employment may be due to the dominance of shifts in labor supply in Austria and to the equal importance of shifts in labor demand and supply in the US.

Figure 8: Causality relationship between W, P, U and R in the United States as inferred from Ashenfelter and Card (1982)



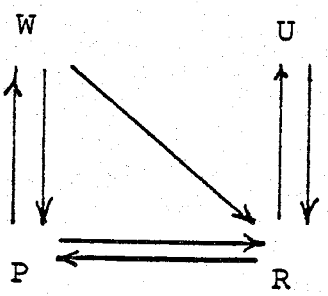
Significance level 1 %

(a)



Significance level 5 %

(b)



Significance level 10 %

(c)

5. Conclusions

In the first part of the paper ARMA representations of nominal wages (real wages), prices, unemployment (employment), and interest rate (real interest rate) have been estimated for Austria together with the corresponding orders of the stochastic processes. In a second stage the causal relationships among these variables have been analyzed. The results suggest that the interest rate (real or nominal) is exogeneous to the other variables and is only causing unemployment (or employment). Furthermore, this latter variable is causing nominal or real wages and prices. This results are in sharp contrast to the findings of Ashenfelter and Card (1982) for the United Stated and may be due to the different socio-economic environment; Austria being a small open socially oriented free market economy. It seems especially important to stress the different roles of the monetary authority in the two countries. In future research this role should therefore be made more explicit.

In the second part two labor market models have discussed: the intertemporal substitution model and the staggered wage contract model. Contrary to Ashenfelter and Card (1982), the empirical "facts" for Austria do not reject the former model and present some support for the latter one. However, the analysis of causal ordering can only be a first step in assessing the validity of these models.

Notes

*) Institute for Advanced Studies, Stumpergasse 56, A-1060 Vienna. The IAS-SYSTEM was used for computation and simulation. The paper profited from discussions with Andrew Policano.

1) The AR and ARMA models for a variable y are specified in the following way:

$$\sum_{k=0}^{p} a_k y_{t-k} = \sum_{l=0}^{q} b_l u_{t-l}$$

where u_t is a white-noise error term. Furthermore the upper bound for the orders p and q was set to 12.

2) In estimating the order of the ARMA processes the restriction p=q was imposed. This has the advantage that the estimation procedure can be performed recursively (see Hannan and Rissanen (1982)).

3) A similar method has been employed by Hsiao (1981).

4) The relation between the Granger-Wiener causality and the econometric exogeneity has been studied by Sims (1972).

5) Given the "hard currency" policy followed by the Austrian Nationalbank (which means in practice that the Deutschemark/Austrian Schilling relation is constant), there remains only a small room for pursuing an autonomeous interest rate policy via sterilization (see Neusser and Winckler (1984)). The inclusion of the monetary base as a fifth variable does not alter the causal ordering of the other four variables. It is not related to P but is caused by W and causes R.

6) Since in Austria no such index is available, the whole sale price index was chosen instead.

Bibliogaphy

ALTONJI, J.G. The intertemporal substitution model of labour market fluctuations: An empirical analysis. Review of Economic Studies (1982), Vol. XLIX, 738-824.

ALTONJI, J.G., O. ASHENFELTER. Wage movements and the labor market equilibrium hypothesis. Economics (1980), Vol.47, 217-245.

ARNDT, S.W. The political economy of Austria. American Enterprise Institute. Washington and London 1982.

ASHENFELTER, O., D. CARD. Time series representations of economic variables and alternative models of the labour market. Review of Economic Studies (1982), Vol. XLIX, 761-782.

BODKIN, R.G. Real wages and cyclical variations in employment: A re-examination of the evidence. Canadian Journal of Economics (1969), Vol.2, 353-374.

BREUSCH, T.S., A.R. PAGAN. The Lagrange multiplier test and its application to model specification in econometrics. Review of Economic Studies (1980), Vol. XLVII, 239-253.

CLARK, K.B., L.H. SUMMERS. Labour force participation: Timing and persistence. Review of Economic Studies (1982), Vol. XLIX, 825-844.

DHRYMES, P. Introductory econometrics. Springer, New York 1978.

FAMA, E.F. Short term interest rate as predictors of inflation. American Economic Review (1975), Vol. 65, 269-282.

FISCHER, S. Long-term contracts, rational expectations, and the optimal money supply rule. Journal of Political Economy (1977), Vol. 85, 191-205.

GEARY, P.T., J. KENNAN. The employment-real wage relationship: An international study. Journal of Political Economy (1982), Vol.90, 854-871.

GODFREY, L. Testing for higher order serial correlation in regression equations when the regressors include lagged endogenous variables. Econometrica (1978), Vol.46, 1303-1311.

GRANGER, C.W.J. Investigating causal relations by econometric models and cross-spectral methods. Econometrica (1969), Vol.37, 424-438.

HANNAN, E.J., J.RISSANEN. Recursive estimation of mixed autoregressive-moving average order. Biometrika (1982), Vol.69, 81-94.

HANSEN, L.P., T.J. SARGENT. Formulating and estimating dynamic linear rational expectations models. Journal of Economic Dynamics and Control (1980), Vol.2,

HSIAO, C. Autoregressive modelling and money-income causality detection. Journal of Monetary Economics (1981), Vol.7, 85-106.

JARQUE, C.M., A.K. BERA. Efficient tests for normality, homoskedasticity and serial independence of regression residuals. Economic Letters (1980), Vol.6, 255-259.

KENNAN, J. An econometric analysis of equilibrium labor market fluctations. Working Paper Series No. 83-16 (1983), University of Iowa.

KEYNES, J.M. The general theory of employment, interest and money. Macmillan Press, London 1936.

LEAMER, E.E. Is it a demand curve, or is it a supply curve? Partial identification through inequality constraints. The Review of Economics and Statistics LXIII (1981), 319-327.

LUCAS, R.E. Capacity, overtime, and empirical production functions. American Economic Reiew (1970), Vol.60, 23-27.

LUCAS, R.E., L.RAPPING. Real wages, employment, and inflation. Journal of Political Economy (1969), Vol.77, 721-754.

MISHKIN, F.S. A rational expectations approach to macroeconometrics, testing policy ineffectiveness and efficient-markets models. The University of Chicago Press, Chicago 1983.

NEFTCI, S.N. A time-series analysis of the real wages-employment relationship. Journal of Political Economy (1981), Vol.86, 281-291.

NEUSSER, K., G. WINCKLER. Financial flow variables and the short-run determination of the loan rate. University of Vienna 1984.

PIERCE, D.A., L.D. HAUGH. Causality in temporal systems. Journal of Econometrics (1977), Vol.5, 265-293.

QUANDT, R.E. Tests of the hypothesis that a linear regression system obeys two separate regimes. Journal of the American Statistical Association (1960), Vol.55, 324-330.

SARGENT, T.J. Estimation of dynamic labor demand schedules under rational expectations. Journal of Political Economy (1978), Vol.86, 1009-1044.

SARGENT, T.J. Macroeconomic theory. Academic Press, New York 1979.

SARGENT, T.J. Interpreting economic time series. Journal of Political Economy (1981), Vol.89, 213-248.

SIMS, C.A. Money, income, and causality. American Economic Review (1972), Vol.62, 540-552.

SIMS, C.A. Macroeconomics and reality. Econometrica (1980), Vol.48. 1-48.

TAYLOR, J.B. Aggregate dynamics and staggered contracts. Journal of Political Economy (1980), Vol.88, 1-23.

ZELLNER, A. Causality and Econometrics. In: K. Brunner and A.H. Meltzer (eds.) Three Aspects of Policy and Policymaking. North-Holland, Amsterdam 1979,