Kiel Institute of World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

Kiel Working Paper No. 1067

Measuring Expected Inflation and the Ex-Ante Real Interest Rate in the Euro Area Using Structural Vector Autoregressions

by

Jan Gottschalk

July 2001

Measuring Expected Inflation and the Ex-Ante Real Interest Rate in the Euro Area Using Structural Vector Autoregressions*

Abstract:

In this paper, the structural vector autoregression methodology is used to decompose the euro area nominal short-term interest rate into an expected inflation and an ex-ante real interest rate component. The latter may be a useful indicator of the monetary policy stance of the ECB. To this end, a vector autoregression model comprised of the differenced interest rate series and the stationary component of the real interest rate is estimated and shocks to expected inflation and the ex-ante real rate are identified using the long-run restriction that only shocks to expected inflation have long-run effects on the nominal interest rate.

Keywords: Monetary policy stance, Inflation expectations, Structural vector autoregressive model

Schlüsselworte: Kurs der Geldpolitik, Inflationserwartungen, Strukturelles Vektorautoregressives Modell

JEL classification: C32, E52

Jan Gottschalk
Institut für Weltwirtschaft
24100 Kiel
Phone: +49 431 8814 367
Fax: +49 431 8814 525
E-mail: jan.gottschalk@ifw.uni-kiel.de

* I am grateful to Jörg Döpke, Robert Kokta and Joachim Scheide for helpful comments. All remaining errors are mine alone.

Contents

I. Introduction

The analysis of the monetary policy course in the euro area is an integral part of many business cycle reports. To this end, the monetary policy section of a business cycle report is typically comprised of an analysis of the monetary policy stance of the European Central Bank (ECB), which focuses on the movements of the policy instrument. The monetary conditions are of interest too, which include in addition to the policy instrument also variables such as exchange rates or long-term interest rates which are part of the monetary sphere but are not directly controlled by the central bank. Assessments of the ECB's monetary policy stance seek to determine in which direction the central bank attempts to steer the economy. Analysis of monetary conditions, on the other hand, go beyond the direct effects of central bank actions and aim to summarize the effects of *all* developments in the monetary sphere on aggregate demand conditions.

This paper is concerned with the assessments of the monetary policy stance. Since the ECB employs the nominal short-term interest rate as its policy instrument, this variable is a natural indicator of the policy stance. A widely used alternative is the real short-term interest rate, with the equilibrium real rate as the relevant benchmark. The studies of the transmission mechanism in the euro area by Coenen and Vega (1999) and Monticelli and Tristani (1999) show that the real short-term interest rate indeed plays an important role in the transmission of monetary policy shocks. This provides a strong justification for considering this variable as an additional indicator to supplement the analysis of the monetary policy course. Moreover, the real short-term rate has the advantage that it controls for the effects of inflation. For instance, if inflation increases and the central bank raises the nominal short-term rate by less than the increase of inflation, this is usually taken to mean that monetary policy has adopted a looser policy stance. The easing of policy is picked up by the falling real short-term rate, but not by the nominal short-term rate which indicates a tighter stance. Thus, by controlling for the effects of inflation on the nominal short-term interest rate, the real short-term interest rate is sometimes a more reliable indicator of the policy stance than the policy instrument itself.

A problem with the use of the real short-term rate as an indicator of the policy stance is that this variable turns out to be a lot more volatile than the nominal short-term rate. This can be seen in figure 1, where it becomes apparent that the variability of the inflation rate leads to considerable extra volatility of the real rate compared to the nominal rate. Since interest rate smoothing is generally thought to be an important part of policy procedures, the fluctuations of the real rate shed some doubt on the reliability of this variable as a suitable measure of the policy course.[1]

To address this problem, it is useful to make a distinction between the ex-post real rate, which is the series plotted in figure 1, and the ex-ante real rate. While the ex-post real rate is simply the difference between the nominal interest rate and actual inflation, the ex-ante real rate is defined as the difference between the nominal rate and the expected inflation rate. Given that monetary policy makers cannot observe inflation within the period, they have to base their interest rate decisions on the expected inflation rate. Thus, the ex-ante real rate is presumably a better indicator of the policy stance. The ex-ante real rate is also less volatile than the ex-post real rate if expected inflation changes more smoothly than actual inflation. In applied work, the core inflation rate, which fluctuates less than the consumer price inflation index, is often used to deflate the nominal interest rate in order to obtain a less volatile measure of the real short-term interest rate.[2] Since core inflation is also used as a proxy for the underlying inflation expectations, the real rate calculated in this way can be seen as a measure of the ex-ante real rate. Nevertheless, core inflation is at best a first approximation of expected inflation.

To provide an alternative, the remainder of this chapter is going to present an approach proposed by St-Amant (1996), who derives an estimate of expected inflation on the basis of economic agents' behavior reflected in market prices using the structural vector autoregression (SVAR) methodology.[3] This approach can be implemented for euro area data in a simple manner; the RATS program implementing this procedure is available from the author upon request.[4]

---

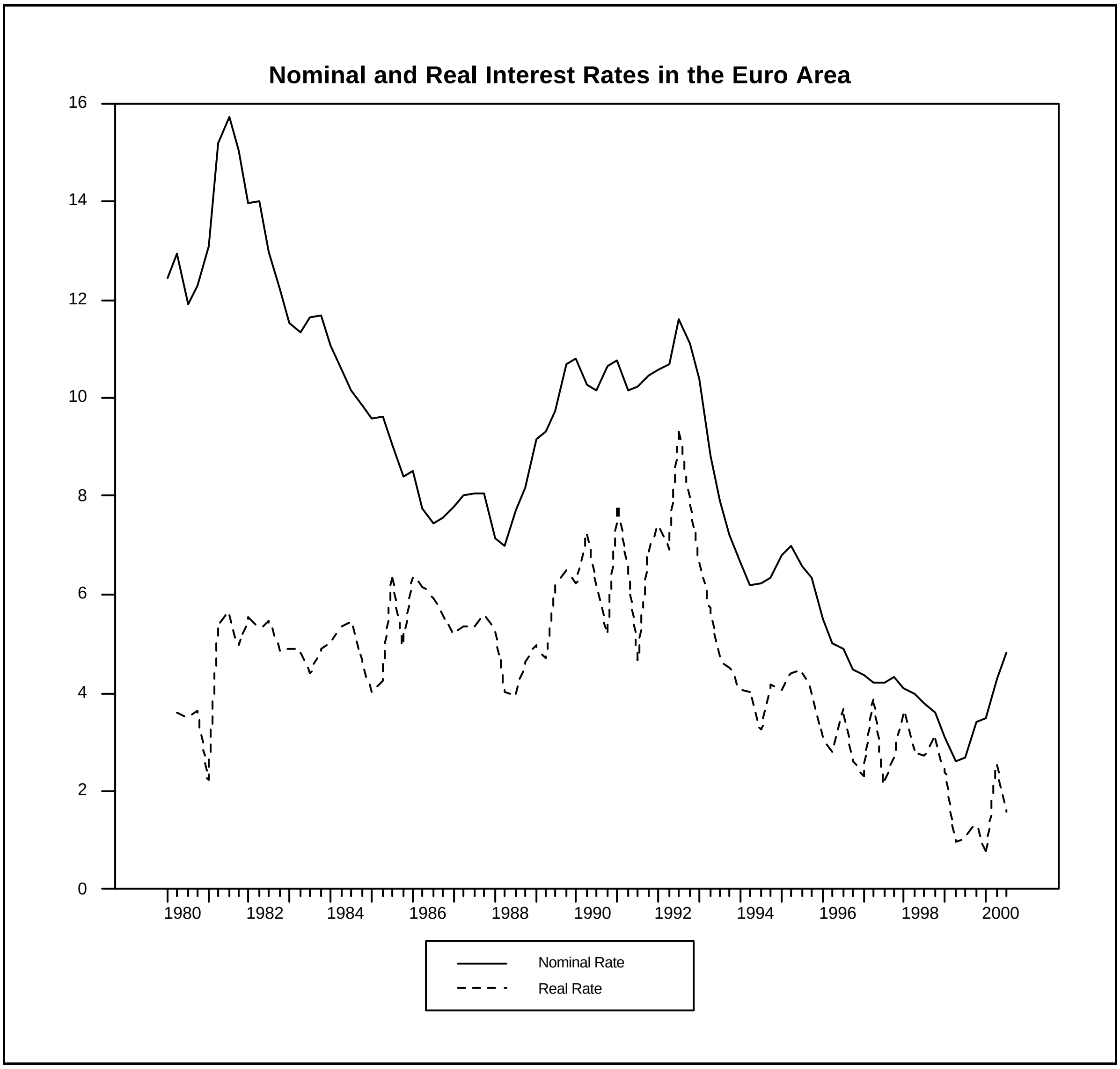
1 For a discussion of the role of interest rate smoothing in monetary policy see Clarida et al. (1999).

2 The core inflation is computed by removing the effects of the particularly volatile energy and food prices from the consumer price index.

3 In a companion paper Gottschalk and Schumacher (2001) employ the multivariate Beveridge-Nelson decomposition technique for the same purpose. This methodology has the advantage that it employs a larger data set, but is more demanding in its implementation.

4 In addition, the program Malcolm is required.

Figure 1: Nominal and Real Short-Term Interest Rates in the Euro Area



The paper is organized as follows. Section 2 provides a discussion of the theoretical model underlying the empirical analysis. Section 3 discusses the data and presents the results of unit root tests. In section 4 the structural vector autoregression methodology is introduced and applied to euro area data. The results are reported in section 5, including the estimated series of expected inflation and the ex-ante real interest rate. The final section contains a brief summary of the procedure proposed in this paper.

1. The Theoretical Model

The starting point of the St-Amant model is the Fisher relation, which states that the nominal interest rate is the sum of expected inflation and the ex-ante real interest rate,

(1) $$i_{t,k} = rr_{t,k} + E(p)_{t,k},$$

where $i_{t,k}$ is the nominal interest rate at time t on a bond with k periods till maturity, $rr_{t,k}$ is the corresponding ex-ante real rate and $E(p)_{t,k}$ denotes the inflation expectation for the time from t till $t+k$. The second equation defines the inflation forecast error $e_{t,k}$ as the difference of actual and expected inflation,

(2) $$e_{t,k} = p_{t,k} - E(p)_{t,k}.$$

It is assumed that the forecast error $e_{t,k}$ is I(0), which is the case under rational expectations. Solving (2) for $E(p)_{t,k}$ and inserting into (1) gives the following equation,

(3) $$i_{t,k} - p_{t,k} = rr_{t,k} - e_{t,k},$$

which shows that the ex-post real rate $i_{t,k} - p_{t,k}$ can be expressed as the sum of the ex-ante real rate and the inflation forecast error. For US data St-Amant finds that the nominal interest rate and the inflation rate are both I(1) variables and that the ex-post real rate $i_{t,k} - p_{t,k}$ is a stationary variable, which implies that both variables are cointegrated with the coefficients (1,-1) as predicted by the Fisher relation. Since the inflation forecast error is assumed to be an I(0) variable, the ex-ante real rate is stationary, too.

These findings have several implications. First, the non-stationarity of the nominal interest rate implies that this variable can be decomposed into a non-stationary component comprised of changes in the nominal interest rate with a permanent character and a stationary component which is comprised of transitory fluctuations in the interest rate. Second, the cointegration relationship of the nominal interest rate with the inflation rate implies that both variables share a common stochastic trend. This stochastic trend is the source of the non-stationarity of both variables and can be interpreted as the nominal trend in the economy which is responsible for the underlying trend in inflation and the nominal interest rate. Since the real interest rate is stationary, the nominal trend has no long-run effect on this variable. Third, the finding that the nominal interest rate and the inflation rate are cointegrated (1,-1) provides evidence for the Fisher relation to hold in the long-run. In particular, this finding is consistent with the prediction of the long-run Fisher effect that inflation expectations and nominal interest rates move one-for-one in the long-run. An implication of the long-run Fisher effect is that a change in inflation expectations, for example due to a perceived change in the monetary policy regime, leads in the long-run to a permanent equiproportional change in the nominal interest rate.

In the present paper, the structural vector autoregression (SVAR) methodology is used to obtain an estimate of the permanent component of the nominal interest, comprising of all movements of the nominal interest rate which are permanent. Since the Fisher relation identifies changes in inflation expectations as the source of those permanent movements of the nominal interest rate and, moreover, postulates a one-for-one relationship between the two, these movements in the nominal interest rate can be considered to be the mirror image of shifts in inflation expectations. Accordingly, an empirical estimate of the permanent component of the nominal interest rate can be employed as an useful tool to track the movements of inflation expectations, which are otherwise unobservable.

For the interpretation of the permanent component of the nominal interest rate as a measure of expected inflation to be valid, it is necessary to rule out that there are other permanent influences on the nominal short-term interest rate. In particular, one may suspect that factors like fiscal policy are likely to have permanent effects on the real interest rate and hence on the nominal interest rate too. However, since the real interest rate is found to be a stationary variable, shocks to this variable have transitory effects only. Interpreting permanent changes in the nominal interest rate as reflecting only changes in inflation expectations appears therefore to be justified. With the permanent component of the nominal interest rate corresponding to expected inflation, the stationary component can be interpreted as a measure of the ex-ante real interest rate.

To summarize, according to the Fisher relation the nominal interest rate is comprised of the ex-ante real interest rate and expected inflation. St-Amant proposes to employ the structural vector autoregression methodology to decompose the nominal interest rate into a non-stationary permanent component and a stationary component. On the basis of the long-run Fisher relation he argues that inflation expectations are best characterized as the stochastic process corresponding to the permanent component of the nominal interest rate, whereas the ex-ante real rate corresponds to the stationary component. This assumption implies that shocks to the ex-ante real rate have only a transitory effect on the nominal interest rate, while shocks to inflation expectations induce a permanent change in the nominal interest rate. The different long-run implications of the two shocks will be used as an identifying restriction in the following SVAR analysis.

2. The Data

The data set is comprised of aggregated quarterly data for the euro area, with data available for a time span beginning in 1980:1 and ending in 2000:3. It consists of the short-term interest and the consumer price index. The short-term (3 month) interest rate was obtained from Datastream for the time period beginning in 1998. A backward estimate was computed using historical data provided by Coenen and Vega (1999). A historical estimate of the consumer price index for the euro area is also available from Datastream. The inflation rate is calculated as the annualized rate of change of the consumer price index over the previous quarter.

The approach proposed by St-Amant is based on the assumption that the nominal interest rate and the inflation rate are both integrated of order one and that the two variables are cointegrated (1,-1). The stationarity properties of the nominal short-term interest rate (i) and the inflation rate (Δcpi) in the euro area are investigated using the Augmented Dickey Fuller test (ADF), the Phillips-Perron test and the KPSS test statistic proposed by Kwiatkowski et al. (1992). The ADF test and the Phillips-Perron test have the null of non-stationarity, while the KPSS test has the null of stationarity. The results are reported in table 1.

Regarding the level of the consumer price index, the ADF test does not reject the null of non-stationarity for this series, whereas the Phillips-Perron test does so at the 5% significance level. Since the KPSS test clearly rejects the null of stationarity, this time series is assumed here to be non-stationary. For the inflation series, Δcpi, all three tests agree that this series is non-stationary. The twice differenced price series is found to be stationary, which suggests that the inflation series is integrated of order one. For the nominal short-term interest rate both the ADF test and the Phillips Perron test agree that this series is non-stationary, whereas the KPSS test does not reject the null of stationarity at the 10% significance level. However, the test statistic is close to the corresponding critical value. On balance, the evidence suggests that this time series is non-stationary, too. The differenced interest rate is clearly stationary, implying that the nominal interest rate can be treated as an I(1) variable. These results are in accordance with evidence in other studies on the time series properties of these variables.[5]

Table 1: Unit root tests

Variable	Unit root tests			Order of Integration
	ADF Test	Phillips-Perron Test	KPSS Test	
cpi	-2.50 (c,t,4)	-3.95^{**} (c,t)	$0.22\ (\tau)^{***}$	at least I(1)
Δcpi	-2.20 (c,t,3)	-2.51 (c,t)	$0.15\ (\tau)^{**}$	I(1)
$\Delta^2 cpi$	-10.38^{***} (c,1)	-12.87^{***} (c,t)	0.26 (μ)	I(0)
i	-2.42 (c,t,1)	-2.03 (c,t)	0.10 (τ)	I(1)
Δi	-5.61^{***} (c,0)	-5.29^{***} (c)	0.07 (μ)	I(0)

Asteriks denote: * = significant at 10% level; ** = significant at 5% level; *** = significant at 1% level. Δ is the first difference operator and Δ^2 is the second difference operator. The brackets indicate the inclusion of a trend (t) and/or a constant (c) and the lag length. The lag length has been chosen in the case of the ADF test with the help of a LM-test testing for freedom of autocorrelation up to order 12. In case of the Phillips-Perron test and the KPSS test a lag truncation of 8 has been chosen. Regarding the KPSS test, the brackets indicate whether the null of stationarity around a level (μ) or trend-stationarity (τ) is tested.

Since the nominal interest rate and the inflation rate are both integrated of order one, the question arises whether they are cointegrated. Using multivariate cointegration analysis, Coenen and Vega (1999) find that these two variables are cointegrated with the coefficients (1,-1), which suggests that the long-run Fisher relation holds in the euro area. A similar result for the long-term interest rate and inflation is obtained by Gottschalk (1999) and Hahn and Müller (2000). Brand and Cassola (2000), using a data set covering the time period after the beginning of the third stage of European Monetary Union (EMU), also report that the nominal interest rate and the inflation rate are cointegrated but find that the homogeneity restriction is rejected. However, Gottschalk and Schumacher (2000) revisit the money demand system of Brand and Cassola and show that the homogeneity restriction holds if one takes into account that the beginning of EMU led to a structural break in the Fisher relation. They argue that with the ECB taking responsibility for monetary policy, a number of countries in the euro area have experienced a transition from a high- to a low-inflation environment. This was

5 See for instance Coenen and Vega (1999), Gottschalk (1999), Hahn and Müller (2000) or Brand and Cassola (2000).

accompanied by a reduction in the risk premium, which led to a lower equilibrium real interest rate.[6] If one does not control for this structural break, the stationarity hypothesis for the real short-term series is likely to be rejected. To account for this shift in the equilibrium real interest rate, the following model for the ex-ante real interest rate is used,

(4) $$rr_{t,k} = c + Shift + a \cdot rr_{t-1,k} + e_{rr_{t,k}} \text{, with } a < 1,$$

where the term $e_{rr_{t,k}}$ is a stationary ex-ante real interest rate shock, c denotes a constant and $Shift$ is a term that models the change in the equilibrium real short-term rate due to EMU. According to equation (4), the ex-ante real rate is a stationary variable, and the equilibrium real interest rate is modeled as $c + Shift$.[7] To obtain an empirical measure of the latter variable, the band-pass filter methodology proposed by Baxter and King (1995) is employed. That is, the equilibrium real interest rate is approximated with the underlying trend in the real interest rate, which is estimated with the band-pass filter. The band-pass filter is chosen because this methodology ensures by construction that the deviations of the ex-ante real short-term rate from the trend path are stationary. Thus, further stationarity tests for this variable can be omitted.

3. The SVAR Methodology

Having established the theoretical background and the stationarity properties of the variables, the discussion turns now to the structural VAR model employed by St-Amant to estimate expected inflation. As discussed earlier, the key assumption is that nominal interest rate fluctuations are a function of inflation expectation shocks e_p and shocks to the ex-ante real rate e_{rr}. Both shocks are assumed to be orthogonal and non-autocorrelated, which is a standard assumption in the structural VAR literature. The objective is to identify these two shocks and subsequently to compute empirical measures of the ex-ante real rate and the inflation expectation components of the nominal interest rate. For this purpose this paper

---

6 For empirical evidence see also Gerlach and Schnabel (1999).

7 The assumption of $a < 1$ ensures together with the assumed stationarity of $e_{rr_{t,k}}$ that the effects of ex-ante real rate shocks die out eventually. But the variable does not revert in time to a constant mean, but is stationary around the term $c + Shift$.

employs a bivariate model comprised of the nominal interest rate and the stationary component of the real interest rate, where the nominal rate is differenced (Δi) so that both variables are stationary. More specifically, Δi is the differenced short-term interest rate with a maturity of 3 months. This implies that expected inflation refers to expectations formed in time t with respect to the annualized inflation rate in the next three months.[8] The second variable, denoted as r_{bp}, is the deviation of the real short-term rate from its underlying trend, which is measured with the help of the band-pass filter. As been pointed out above, this method ensures the stationarity of the variable r_{bp}.

To understand the intuition of the structural VAR methodology, the moving-average representation of the model is a useful starting point,[9]

(5) $$x_t = A_0 e_t + A_1 e_{t-1} + \ldots = \sum_{i=0}^{\infty} A_i e_{t-i} = A(L) e_t ,$$

where $e_t = \begin{bmatrix} e_p \\ e_{rr} \end{bmatrix}$ and $x_t = \begin{bmatrix} \Delta i \\ r_{bp} \end{bmatrix}$. The variance-covariance matrix of e_t is normalized so that $E(e_t e_t) = I$. The moving-average form of the system shows that the history of the interest rate variable can be represented as a function of the two structural shocks hitting the economy. This allows to decompose the fluctuations of the nominal short-term rate into a part attributable to shocks to expected inflation and a part due to ex-ante real rate shocks.

To obtain the historical decomposition given by (5), the reduced form of the system is estimated:

(6) $$x_t = \Pi_1 x_{t-1} + \ldots + \Pi_q x_{t-q} + e_t ,$$

where q denotes the lag length of the system and e_t is a vector of estimated reduced form residuals with variance-covariance matrix $E(e_t e_t) = \Sigma$. For the euro area data set, a lag length of three, which was selected on the basis of Akaike information criterion, has proven to be

---

8 In principle this method is also suitable to compute the inflation expectation for other horizon, which can be done by using an interest rate series with the corresponding maturity instead of the 3 months rate employed here.

9 For simplicity the deterministic components are suppressed in the following presentation of the methodology.

sufficient to ensure that the residuals of (6) have white noise properties.[10] Next, the system is inverted to obtain the moving-average representation given by

(7) $$x_t = e_t + C_1 e_{t-1} + \ldots = \sum_{i=0}^{\infty} C_i e_{t-i} = C(L) e_t .$$

A comparison of (7) with (5) shows that the estimated reduced form residuals are related to the structural form shocks according to

(8) $$e_t = A_0 e_t ,$$

which implies that $E(e_t e_t') = A_0 E(e_t e_t') A_0'$ and thus, $A_0 A_0' = \Sigma$. The matrix given by $A_0 A_0'$ has four elements, but the estimated variance-covariance matrix Σ has only three elements. Hence, the estimation of (5) requires one more identifying restriction. As discussed above, both the Fisher relation and the time series properties of the variables considered here suggest that inflation expectations can be characterized as a stochastic process corresponding to the permanent component of the nominal interest rate, whereas the ex-ante real rate corresponds to the stationary component. This leads to the long-run restriction that only shocks to inflation expectations have a permanent effect on the nominal interest rate, whereas ex-ante real rate shocks have a transitory effect on the nominal interest rate.[11] To show how this restriction is imposed on the system, the long-run effects of the structural and reduced form shocks on the nominal interest rate are denoted as *A(1)* and *C(1)* respectively. By comparing (5), (7) and (8) it can be seen that the following condition holds:

(9) $$A(1) e_t = C(1) e_t = C(1) A_0 e_t .$$

Estimation of the reduced form yields the matrix *C(1)*. Restricting the long-run effect of an ex-ante real rate shock on the nominal rate to zero implies that the corresponding element in the *A(1)* matrix is set to zero, which in turn imposes via (9) one restriction on the matrix A_0. This way the identifying restriction necessary for the estimation A_0 is obtained.[12] Since the

---

[10] To preserve space the results of the specification tests are not reported here, but are available from the author upon request.

[11] If shocks to the ex-ante real rate had a permanent effect on the real interest rate (and hence on the nominal interest rate too), the real interest rate would not be stationary. Here, this variable is stationary by construction.

[12] The use of long-run restrictions for identification in SVAR models has been popularized by Blanchard and Quah (1989).

parameters in *A(L)*, which are of interest here, are related to the estimated coefficients *C(L)* by $A(L) = C(L)A_0$, it is now possible to compute the following decomposition of the nominal interest rate:[13]

(10) $$\Delta i = A_p(1)e_{p_t} + A_p^*(L)e_{p_t} + A_{rr}^*(L)e_{rr_t}\ .$$

The first two terms on the right hand side of (10) show the effect of the inflation expectation shock on the change of the nominal interest rate; the first term gives the permanent effect, while the second term represents the transitory component of this shock, which models the adjustment process until the new equilibrium is reached. The third term represents the effects of a shock to the ex-ante real rate. This shock only has a transitory component, since permanent effects have been ruled out. While equation (10) gives the effects of the two shocks on the change of the nominal interest rate, cumulation of the effects yields the level of the short-term rate as a function of the inflation expectation and the ex-ante real rate shocks.[14]

4. The Ex-Ante Real Interest Rate and Expected Inflation

The estimate of the ex-ante real rate is obtained by computing first the effects of the ex-ante real rate shocks on the level of the nominal interest rate, which yields a stationary time series representing the fluctuations in the nominal interest rate due to this type of shock. This is a measure of the deviations of the ex-ante real rate from the equilibrium real interest rate. The equilibrium real rate is approximated in the empirical investigation with the band-pass filter estimate of the trend component of the real interest rate. The ex-ante real rate is obtained by computing the sum of both series. Since the Fisher-relationship gives the nominal rate as the sum of the ex-ante real rate and expected inflation, subtracting the estimated ex-ante real rate

---

13 In equation (10) the matrix *A(L)* is decomposed into a component giving the permanent effects of a shock and a component giving the transitory effects. The latter is marked with an asterisk.

14 The dynamics of the system could be illustrated by presenting results for the impulse response functions and the variance decomposition. Since these are not essential for the purpose at hand, this is omitted here to preserve space, but results are available from the author upon request.

from the nominal interest rate yields the expected inflation series. The resulting time series for expected inflation and the ex-ante real interest rate are reported in figure 2.

The first panel compares expected inflation to the actual inflation series, which is represented by the dotted line. It is apparent that expected inflation is less volatile than observed inflation. As a consequence, the ex-ante real rate, corresponding to the difference of the nominal interest rate and expected inflation, is considerably more smooth than the ex-post rate, which is plotted as the dotted line in the second panel. From the viewpoint of using the ex-ante real rate as a measure of the policy stance, this is an advantage since it corresponds better with the tendency of the monetary authorities to smooth interest rates.

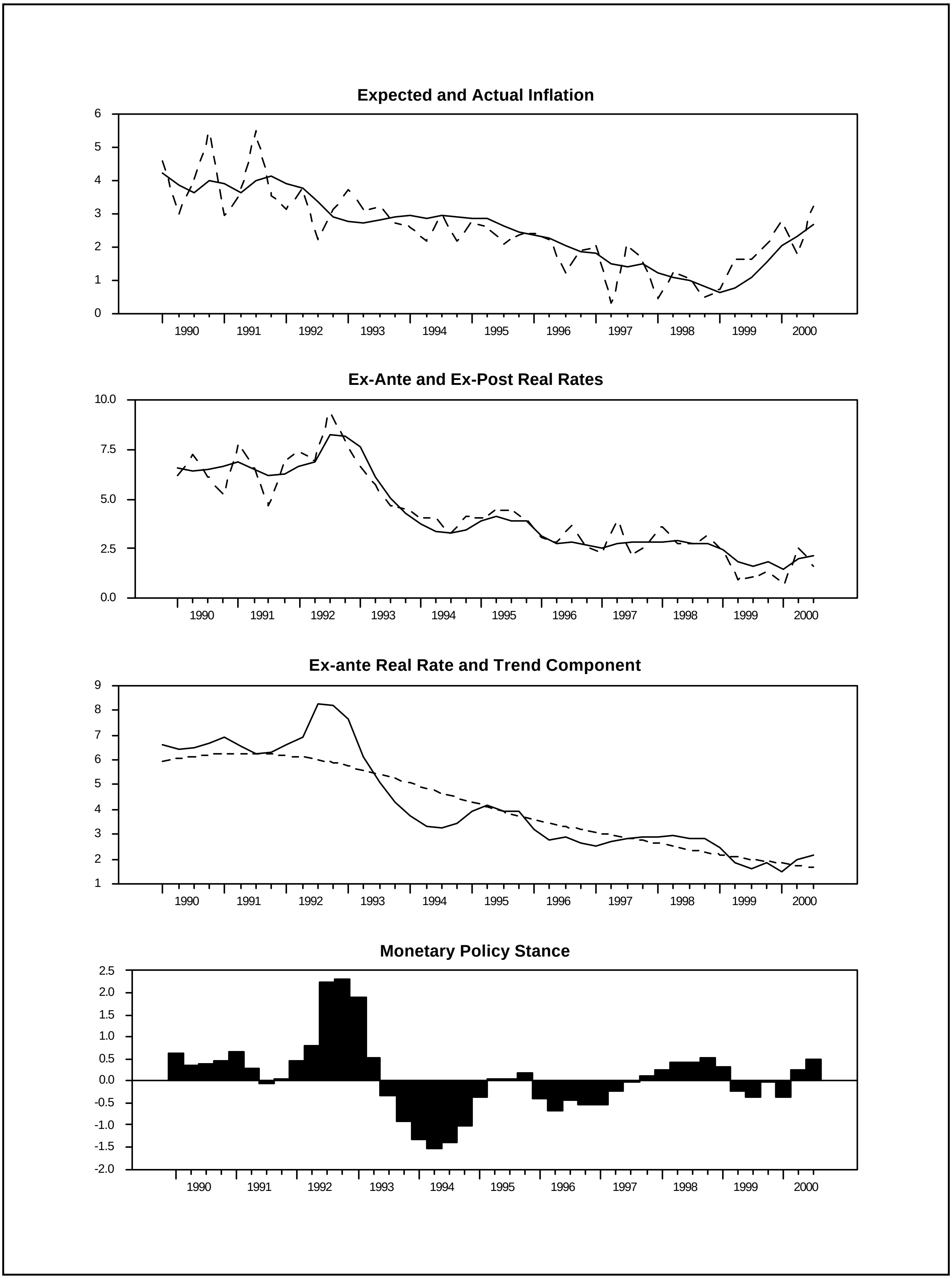
Another noticeable result is that in 1999 the ex-ante real rates are somewhat higher than the ex-post rates. This is a reflection of actual inflation rising faster than expected due to the unexpected strong increase in oil prices during 1999. Thus, the inflation forecast error has led to a marked decline in ex-post real rates compared to the ex-ante real rates. This illustrates that the ex-post real interest rate may give at times a misleading picture of the monetary policy stance.

The third panel compares the ex-ante real rate to the underlying trend (dotted line), which is interpreted here as a measure of the equilibrium real rate. The deviation of the ex-ante rate from this measure is due to the ex-ante real rate shocks identified here. If these shocks reflect mainly monetary policy shocks, the difference between the ex-ante and the equilibrium rate can be interpreted as a measure of the monetary policy stance. The resulting time series for the monetary policy stance is plotted in the fourth panel.[15]

---

[15] In principle, the ex-ante real rate shocks could also reflect also shocks to fiscal policy or technological shocks. However, since these two types of shocks are likely to have rather persistent effects on the real interest rate, their effects are probably captured to a large extent in the trend component of this series and, hence, do not contribute much to the cyclical variability of the real interest rate. The assumption that the series given in the last panel in figure 2 corresponds to a measure of the monetary policy stance is therefore maintained.

Figure 2: Inflation Expectation and Ex-Ante Real Interest Rate



Regarding the monetary policy stance of the ECB, the first half of 1999 was marked by an easing of policy according to the measure proposed here. This is a plausible result, since the ECB responded to subdued inflationary pressures and weak economic activity in the euro area by easing policy.[16] With inflation subsequently rising due to the oil price shock and the output gap becoming positive, the monetary policy course became gradually more restrictive. According to the results shown in figure 2, policy was tightened since the beginning of the year 2000 by 100 basis points. At the end of the sample period, the ex-ante real rate is 50 basis points above its neutral level.[17]

II. Summary

In this paper, the structural vector autoregression methodology is used to decompose the nominal short-term interest rate in the euro area into an expected inflation component and an ex-ante real interest rate component. To this end, a vector autoregression model comprised of the differenced interest rate series and a stationary component of the real interest rate is estimated. The stationary component of the real interest rate is obtained with the band-pass filter developed by Baxter and King (1995). Using a SVAR model with long-run restrictions, shocks to expected inflation and the ex-ante real rate are identified using the restriction that only shocks to expected inflation have long-run effects on the nominal interest rate. After identifying the two shocks, the time series for expected inflation and the ex-ante real interest rate implied by this model rate are derived. The resulting time series for the ex-ante real rate is employed as an indicator of the monetary policy stance. The advantage of this approach is that it is simple and can provide timely estimates of inflation expectations and the corresponding ex-ante real rate.

---

[16] See ECB (1999: 5).

[17] The last available observation is the third quarter of 2000.

III. References

Baxter, M., and R.G. King (1995). Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series. NBER Working Paper No. 5022.

Blanchard, O.J., and D.T. Quah (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. *The American Economic Review* 79 (4): 655–673.

Brand, C., and N. Cassola (2000). A Money Demand System for Euro Area M3. ECB Working Paper No. 39.

Clarida, R., J. Gali and M.L. Gertler (1999). The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature* 37 (4): 1661–1707.

Coenen, G., and J.-L. Vega (1999). The Demand for M3 in the Euro Area. ECB Working Paper No. 6.

European Central Bank (1999). *Monthly Bulletin*. April. Frankfurt am Main.

Gerlach, S., and G. Schnabel (1999). The Taylor Rule and Interest Rates in the EMU Area. CEPR Discussion Paper Series No. 2271.

Gottschalk, J. (1999). On the Monetary Transmission Mechanism in Europe. Results from a Cointegration Analysis of a Money Demand System. *Journal of Economics and Statistics* 219 (3+4): 357–374.

Gottschalk, J., and C. Schumacher (2001). Measuring the Monetary Policy Stance in the Euro Area – An Application of the Multivariate Beveridge-Nelson Decomposition. mimeo.

Hahn, E., and C. Müller (2000). Money Demand in Europe: Evidence from the Past. DIW Discussion Papers No. 204.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt and S. Yongcheol (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root. *Journal of Econometrics* 54: 159–178.

Monticelli, C., and O. Tristani (1999). What Does the Single Monetary Policy Do? A SVAR Benchmark for the European Central Bank. ECB Working Paper No. 2.

St-Amant, P. (1996). Decomposing U.S. Nominal Interest Rates into Expected Inflation and Ex Ante Real Interest Rates Using Structural VAR Methodology. Bank of Canada Working Paper 96-2.